

FINAL REPORT

DoD Land Management and Natural Capital/Ecosystem Services:
Research on the Efficacy of Applying a Supply Chain Paradigm and
Economic Valuation Tools to Optimize Management Decision-Making
and Enable Quantification of DoD Stewardship Value

SERDP Project RC18-1615

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Acronyms and Abbreviations

AFB	Air Force Base
BCA	benefit-cost analysis
CH2M	CH2M HILL Engineers, Inc.
CV	contingent valuation
DOC	U.S. Department of Commerce
DoD	U.S. Department of Defense
DOI	U.S. Department of the Interior
DRMO	Defense Reutilization and Marketing Office
dSAY	discounted service-acre-year
E&S	Environmental and Social
EDYS	Ecological DYnamics Simulation
EPA	U.S. Environmental Protection Agency
ERDC	Engineering Research and Development Center
ESG	Environmental, Social, and Governance
ETTC	Eglin Test and Training Complex
GAO	Government Accountability Office
HEA	Habitat Equivalency Analysis
INRMP	Integrated Natural Resources Management Plan
InVEST	Integrated Valuation of Environmental Services and Tradeoffs
IRP	Installation Restoration Program
Jacobs	Jacobs Engineering Group Inc.
LCPA	Life-Cycle Perspective Analysis
LCTA	Land Condition Trend Analysis
NAS	Naval Air Station
NCP	Natural Capital Protocol
NEBA	Net Environmental Benefit Analysis
NOAA	National Oceanic and Atmospheric Administration
NRO	Natural Resource Office
OMB	Office of Management and Budget
RBA	recreation benefits assessment
SAY	service-acre-year
SERDP	Strategic Environmental Research and Development Program
TES	threatened and endangered species
USACE	U.S. Army Corps of Engineers
WTP	willingness to pay

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1. Introduction

U.S. Department of Defense (DoD) management efforts at test and training lands produces a product – readiness – with co-benefits in the form of stewardship value, ecosystem services, and the maintenance of options for future re-use. The management of these lands can be complex, with a need to balance test and training, environmental compliance, impacts, and costs associated with modernization and maintenance of deteriorating natural capital needed for the mission, encroachment, impacts on the public, property use agreements, new listings of threatened and endangered species (TES), and increasing shared use of test and training lands (DoD 2017; GAO 2005). The Sikes Act (United States Code Title [16, Parts 670a through 670f](#)) recognizes the military's natural resource stewardship responsibilities and enables the military to provide co-benefits as follows: 1) the conservation and rehabilitation of natural resources on installations; 2) the sustainable multipurpose use of the resources on installations, which shall include hunting, fishing, trapping, and nonconsumptive uses; and 3) subject to safety requirements and military security, public access to military installations to facilitate such use. Assessments to date have not fully captured the value of the DoD's environmental stewardship, and there are gaps related to the ability to fully incorporate natural capital considerations to optimize decision making, including a systematic way of identifying risks and opportunities inclusive of system dynamics.

The objective of the research was to evaluate the efficacy of the following toward improving the incorporation of natural capital into valuation and management of DoD test and training infrastructure:

- Business supply chain assessment tool
- Contingent valuation (CV)
- Net Environmental Benefit Analysis (NEBA)

Beyond assessing the efficacy of these tools, the research identified potential missed opportunities, misalignment, inefficiencies and fatal flaws, refinements to the approaches, and as appropriate, next phases of work.

A key component of the research effort was a workshop held at Eglin Air Force Base (AFB) to discuss the potential for the tools to be explored as part of research to fill the DoD natural capital gaps. We are grateful to the Eglin AFB staff for providing us with their planning documents, participating in the planning and execution of the workshop, responding to follow-up queries, and providing valuable contributions to the assessment. To place the discussion of the assessed tools into a military perspective, they are described in the context of Eglin AFB wherever feasible.

1.1 Literature Review Summary

The DoD has been actively engaged in research on tools and approaches toward accounting for natural capital and ecosystem services in decision making. One early tool that continues to be used today is Land Condition Trend Analysis (LCTA) (Price et al. 1995). This tool uses data collected over time to estimate correlation coefficients to measure the relationship between military and non-military disturbances and the amount of vegetation cover needed for sustaining the mission as well as for providing habitat for TES (Bakker 2015). The increased understanding of such relationships is the first step toward developing management actions to restore the desired vegetation.

Another tool, the Ecological DYnamics Simulation (EDYS) model developed by the U.S. Army Corps of Engineers (USACE) has been applied at multiple test and training lands to predict responses to military and non-military stressors, facilitating the linking of the cost of training and testing land maintenance to the level of training (McLendon et al. 1998; Childress et al. 1999). EDYS is an ecosystem simulation model that accommodates process complexities of ecological dynamics at spatial and temporal scales and evaluates management alternatives by assessing changes in landscape components (USACE 2012a). As such, it can inform natural resource management actions necessary for maintaining certain natural features (for example, vegetative cover), which are direct inputs to supporting test and training objectives (Childress et al. 1999). Similarly, this tool has been applied on multiple training lands to understand the risks to TES and other protected natural resources from test and training operations. This

has enabled appropriate management actions to be developed that pave the way for operations to advance without jeopardizing compliance with natural resource management requirements. Applications include Fort Hood, Fort Bliss, and Jack's Valley Training Area at the U.S. Air Force Academy (Childress et al. 1999).

Due to federal agency requirements to protect TES under the Endangered Species Act, the Engineering Research and Development Center (ERDC) of the USACE has conducted extensive research with the aim of contributing toward improving management of DoD land areas that support TES such that the sustainable training and combat readiness mission is not compromised (USACE 2012b). As stated in USACE (2012b), "ERDC research has shown that in many cases TES conservation and recovery is compatible with ongoing military training requirements and that in most cases risks to TES are non-military related. It has been shown that habitat management for some TES provides vegetative structure and composition that is desirable for field training activities. ERDC TES research approaches and technologies have allowed an integrated evaluation of stressors on TES that places military-related activities in a proper context relative to other TES risk factors." This research has enabled the ERDC to support military installations such as Eglin AFB, working proactively and in consultation with U.S. Fish and Wildlife Service, to develop innovative solutions that dramatically reduce the percentage area of restricted training access (USACE 2012b).

Through 2012, most of the research focused on two primary uses of military lands: test and training for combat readiness and habitat for protected species. Work by Dissannayake, Onal and Westervelt, (2013) introduced a third good: renewable energy. They developed a modeling framework, which includes a table of land-use needs, land-use suitability maps, and a land-use compatibility matrix. The authors proposed developing a numerical model to include a time domain with the intent of supporting the scheduling military training and testing activities "to avoid interfering with certain essential but conflicting factors such as endangered species breeding cycles or the seasonal availability of solar exposure for photovoltaic production" (Dissannayake et al. 2013). To our knowledge, this tool has not yet been published.

The trend toward considering a broader array of ecosystem services in management of military lands has continued. Most notable is a series of research reports on using the Integrated Valuation of Environmental Services and Tradeoffs (InVEST) software tool to quantify and value ecosystem services to include carbon sequestration, timber management, prevention of soil erosion, habitat for TES and biodiversity, for a more complete assessment of the inter-relationships between changes in the value of ecosystem services and test and training operations (SERDP 2015; Duggan et al. 2015; Ma et al. 2016; and Natural Capital Project 2017). InVEST is a software tool coupled with geographic information system software packages to integrate ecosystem services values into decision making. This open-source software includes a suite of models to assist with quantifying and valuing specific ecosystem services (Duggan et al. 2015; Ma et al. 2016; and, Natural Capital Project 2017). For example, the Habitat and Risk Assessment model aids in assessing biodiversity and habitat quality and is used to calculate changes in risk to a species or its habitat in response to changes in stressors or management actions. Another example is the evaluation of ecosystem service changes using a timber production model and carbon storage and sequestration model. Applications include Joint Base Lewis-McCord, Fort Pickett, and Fort Benning (SERDP 2015).

Despite these and other considerable advances in valuing natural capital, the DoD pointed out several knowledge gaps such that "full consideration of natural capital in environmental management and decision-making has not been realized" (SERDP 2017). Furthermore, "quantitative approaches have been developed for substantiating these benefits yet none of these approaches focus on the dedicated environmental stewardship at defense installations" (SERDP 2017). To address these gaps, the present research investigated the applicability of three tools that have been employed successfully in other contexts to evaluate their suitability toward meeting DoD needs.

1.2 Report Organization

This report is organized into the following sections:

- **Section 1 – Introduction.** This section describes the context and objectives of the research and summarizes prior DoD efforts with regard to accounting for natural capital and ecosystem services.
- **Section 2 – Application of a Business Supply Chain Tool to Integrate Natural Capital into Valuation and Management of Department of Defense Lands.** The research objective was to test whether a business supply chain paradigm can provide a consistent framework for standardizing the process of identifying and accounting for risks, threats, conflicts, opportunities, system dynamics, boundaries, and scale associated with natural capital managed by DoD to meet its mission. We initially tested one type of business supply chain assessment tool: Life-Cycle Perspective Analysis (LCPA). Section 2 summarizes what was presented and learned at the workshop, our application of LCPA to the Eglin AFB setting, and the conclusion that a different tool applicable to business supply chains called the Natural Capital Protocol (NCP¹) could potentially address the gap related to a consistent, repeatable framework to optimize decision making through full incorporation of natural capital considerations.
- **Section 3 – Application of Contingent Valuation Methods to Develop Comprehensive Value Estimates and Inform Decision Making.** This section examines the efficacy of applying stated preference/CV methods to fill the gap related to the ability to assess the stewardship value derived from restoring and protecting unique natural resources including, but not limited to, TES and their habitat. Two scales are considered: 1) individual military installations; and 2) across all DoD land holdings. The steps required to conduct such a CV study are outlined in detail in this section.
- **Section 4 – Application of Net Environmental Benefit Analysis to Project-Level Decision Making.** This section is devoted to NEBA, a tool that is most often applied to project-level decisions involving tradeoffs affecting natural resources. This section considers how this tool can be cost-effectively applied to identify and defend solutions consistent with sustaining test and training operations while maximizing environmental benefits or minimizing environmental losses. The section includes background on NEBA, what was learned at the Eglin AFB workshop regarding NEBA applications, and a review of historical DoD applications and key situational characteristics where NEBA may provide value, including an example. In addition, the results of an Eglin AFB recreation benefits assessment (RBA) and a related example NEBA are presented. The Eglin-specific work was completed as part of this research project.
- **Section 5 – Summary.** This section summarizes what we learned from the assessment of each of the tools, provides a recommendation on use and further study and discusses the potential for synergies that might be captured through use of the tools in a combined manner.
- **Section 6 – References.** This section provides the references to the works cited in this report.

¹ The free NCP framework is available to users by download from <https://naturalcapitalcoalition.org/natural-capital-protocol/>

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2. Application of Supply Chain Tools to Integrate Natural Capital into Valuation and Management of Department of Defense Lands

2.1 Background

Supply chain is commonly considered a sequence of steps to deliver a product or service, where inputs are purchased goods or services. Businesses go to great lengths to identify and manage supply chain risks and leverage opportunities, so they can maintain “business continuity.” For DoD, delivery of its product – readiness – requires purchased goods and services, but also natural capital including air, water, terrain, and organisms for test and training to occur. DoD lands may also provide important ecosystem services in the public’s supply chain, for example, drinking water to local communities.

The research objective was to test the hypothesis that a business supply chain assessment tool can provide a consistent framework for standardizing the process of identifying and accounting for risks, threats, conflicts, opportunities, system dynamics, boundaries, and scale associated with natural capital managed by DoD to meet its mission.

Methods involved include the following tasks:

- 1) Applying a business supply chain assessment tool to a specific range, with natural capital as the focal supplier category;
- 2) Sharing the resultant identification of risks and opportunities at a workshop to gather feedback; and
- 3) Defining the list of decision points (that is, tradeoffs involving natural capital and ecosystem services) of greatest interest for further exploration, the most important natural resource assets that may be valued by the public, and the natural resource assets that could present a conflict with military test and training use.

In addition, the workshop was used to better understand the potential synergies between the supply chain paradigm and the two natural resource economic models (NEBA and CV) with respect to facilitating decision making and revealing new insights into the relationship between natural capital and DoD land management. The premise is that there are multiple points in the supply chain management process where decisions can be improved by better information about tradeoffs. The relationships between these elements is explored in Section 5 – Summary.

2.2 Workshop at Eglin Air Force Base

The workshop at Eglin AFB was held on December 12, 2018 and included several Eglin AFB staff (Appendix A). During the supply chain portion of the workshop, Jacobs Engineering Group Inc. (Jacobs) presented a business supply chain assessment tool called LCPA. Topics addressed in LCPA included boundaries and values, organizational “maturity” spectrum, context systems map, issues identification, stakeholder review, risk and opportunity assessment, and business case for preliminary solutions. In addition, based on a limited review, these topics and environmental and social (E&S) indicators were discussed in relation to the Santa Rosa Island Range, using natural capital as a supplier category.

While LCPA is a tool, it is also part of a paradigm that companies operationally integrate into investment processes and decision making. This involves adopting a set of standards around environmental, social, and governance (ESG), with the intent of maintaining a “license to operate.”

Supporting information for the workshop discussion was obtained from the Eglin AFB *Integrated Natural Resources Management Plan* (INRMP; Eglin AFB 2017) and Eglin AFB *Santa Rosa Island Final Range Environmental Assessment* (Eglin AFB 2012), and a review of recent articles available on the internet. The two Eglin AFB documents provide key information on the process, procedures, and governance for

maintaining natural capital as a viable input into the military mission at Eglin AFB, and Santa Rosa specifically.

As part of the process, we learned several key points regarding managing natural capital risks at Eglin AFB that could be generalized within a consistent framework to transfer to other military installations and form the basis for establishing a standard set of guidelines:

- Eglin AFB has an effective system for managing risk associated with access to the natural capital needed to sustain the mission. The base has strategies and objectives, roles and responsibilities, defined processes and procedures, and quality assurance steps. To ensure optimal mission support and reduce undesired impacts, the Natural Resource Office integrates with military operators and planners. They participate in Range Configuration Control Committee, Installation Encroachment Management Team, Maintenance of Land Test and Training Areas Program, and Unit Environmental Coordinator meetings. An example of the program's proactivity is the management of the Gopher Tortoise population, where a risk to the availability of range land for training was turned into an opportunity that has created an asset for Eglin AFB and stakeholders.
- There is an opportunity to develop more information to help tell the Eglin AFB story of stewardship to a mix of stakeholders. For example, Eglin AFB meeting attendees were interested in defining the economic benefit of their public recreation program. A lack of this type of information can be a social risk; developers, outdoor recreation groups, environmental non-profits, or neighborhood associations that craft better stories may lead to supply disruption of natural capital to the military.
- We identified that, within the INRMP, Eglin AFB specifically accounts for the natural capital (referred to as "natural resources") that it uses in support the mission and the ecosystem services it protects through its management efforts:

- Natural Resources Needed to Support the Military Mission (Eglin AFB 2017, page 83)

Eglin NRO [Natural Resource Office] integrates and prioritizes wildlife, fire, and forest management activities to protect and effectively manage the Complex's aquatic and terrestrial environments to ensure long-term mission sustainability. Eglin NRO works with mission groups to address issues of mutual concern, such as management options to create desired testing/training conditions. The goal is to establish processes for information exchange and coordination to minimize conflicts and maximize the effectiveness of both mission and natural resource management activities.

The variety of missions conducted at the ETTC [Eglin Test and Training Complex] requires a diversity of natural environments. The testing, development, and evaluation of weapons systems and methods of warfare require open test areas and water ranges. Multiple mission types utilize the DoD-unique land-sea interface areas; NRO ensures continued use of these areas by controlling erosion and minimizing conflicts with protected species in these sensitive habitats. Due to large safety footprints and noise issues, large buffer areas of natural vegetation must be maintained around test areas. It is necessary to ensure the fuel loads in forested areas around test areas are kept low to prevent large wildfires from test activities. Armament and multispectral test and training require contrasting background and clutter environments. Military tactical maneuvers require natural vegetation be managed to simulate various environments that may be encountered during deployments. Survival training missions benefit from the habitat and wildlife management conducted by Eglin NRO.

- Ecosystem Services (Eglin AFB 2017, page 61)

The natural environments on Eglin provide numerous ecosystem services. It is difficult to assign a monetary value to the majority of these services, so many times they are not adequately valued against other competing demands that provide a clear economic benefit. For the cost of a general recreation permit, members of the public can enjoy a multitude of recreational activities, including swimming, hiking, biking, canoeing, and just the simple pleasure of listening to calling frogs at sunset by the creek. Hunting and fishing opportunities provide both recreational and provisioning services. The same forests and waters used by recreationists also provide supporting services such as nutrient cycling, water filtration, air purification, and pollination opportunities. The

activities detailed in this INRMP strive to maintain and improve these valuable ecosystem services.

Except for a few pilot studies, including those referenced in Section 1.1 Literature Review Summary, our experience suggests this specific treatment is not uniform practice at military installations and might be somewhat unique. This specific acknowledgment of natural capital supporting the mission and ecosystem service provision within an INRMP is something that installations could undertake with relatively little effort to enhance understanding of the relationship between installation activities and natural capital. It may not be practical for all military installations to develop detailed models of their ecosystem services and the feedback loops between military operations, natural resources, and ecosystem services. However, they can document that they have investigated any such linkages and considered the risks and opportunities.

2.3 Life-Cycle Perspective Analysis

The concept of LCPA presented at the workshop was that a broad set of E&S factors (Table 2-1) material to a specific supplier category – in this case natural capital – might serve as metrics to manage and improve sustainability and resiliency in the supply chain, ensuring access to natural capital as a critical component to training warfighters and evaluating warfighting systems.

Based on our initial research and discussion at the workshop, we concluded that LCPA as applied in the private sector did not seem to be a good fit for Eglin AFB and other military installations. Reasons for this conclusion include the following:

- The tool and broader paradigm are geared to maintain a “license to operate” that is less relevant to the military.
- The ESG concept might not be understood as widely in government, without considerable introductory efforts.
- Bundling E&S elements can be confusing and not readily relatable to military readiness.
- There are no uniform metrics for the social and governance aspects.
- Valuation is not a strong aspect of LCPA.

Table 2-1. Examples of Environmental and Social Factors

Environmental	Social
Air quality	Employment and opportunity
Land/ecosystems health/habitat for TES	Community trust and relations
Water quality	Health and safety
Energy reliability	Security: physical and cyber
Climate change and extreme weather	Compliance, regulatory license to operate
Pollution (emissions, effluent, and waste)	Public interest of product
Materials (linkage to waste, product end-of-life)	Stakeholder reputation/trust
Suppliers and product environmental performance	Suppliers social performance and reputation

TES = threatened and endangered species

2.4 Natural Capital Protocol

After considering everything that was learned during the workshop regarding the LCPA alignment with the military needs related to natural capital, Jacobs considered using the NCP (Natural Capital Coalition 2016a) as an alternative framework to potentially integrate natural capital into valuation and management of DoD training and testing lands. The NCP is being used by the business sector to identify natural capital

impacts and dependencies so that actions, where necessary, can be taken to ensure continued access to natural capital that support the business and address impacts that pose a business risk. NCP is also used to identify positive impacts and opportunities. NCP focuses on natural capital as it relates to operational risk reduction and public benefits identification (as opposed to evaluating natural capital as a supplier category using a set of ESG standards, as discussed for LCPA). Operational risk reduction and public benefits identification are both important objectives for sustaining test and training operations on military installations. In addition, the NCP is a publicly available flexible framework, investments continue to be made to improve it, it would provide a consistent, repeatable methodology, and its use in industry is increasing.

The NCP is a decision-making framework that enables organizations to identify, measure, and value their direct and indirect impacts and dependencies on natural capital. It was developed by the Natural Capital Coalition, an international collaboration of almost 300 organizations representing business, finance, conservation and civil society, government and policy, science and academia, standard setters and disclosure and membership organizations (Natural Capital Coalition 2016a). The protocol can be implemented by DoD personnel and the questions are designed to assist in identifying which stakeholders to engage both within and external to the base. Thus, it provides a standardized process for guiding and documenting how natural resource impacts and dependencies are integrated into planning, while enabling flexibility in implementation. The concept is that a better understanding of the complex and dynamic relationships between organizations and the health of natural assets and the ecosystem services they provide can enable organizations to make more informed decisions that benefit their interests as well as society. This aligns well with some of the DoD gaps identified in Strategic Environmental Research and Development Program (SERDP; 2017) related to the ability to fully incorporate natural capital considerations to optimize decision making and the existence of a systematic way of identifying risks and opportunities inclusive of system dynamics. The other major gap identified in Strategic Environmental Research and Development Program (SERDP [2017]) was that assessments to date have not fully captured the value of the DoD's environmental stewardship. The NCP provides a process and pathway to address that issue. Within this research report, the benefit of NEBA and CV are discussed in relation to the process point at which environmental cost/benefit or value may be quantified. As mentioned in the literature review, DoD has developed a range in tools that provide detailed information for specific contexts involving the dependencies of critical national defense capabilities on maintaining certain natural resources, for example. The NCP protocol can be refined for DoD to capture in one place the suite of tools and case studies with recommendations for their applicability, thus making them more accessible to all military installations and reducing redundancy.

The Protocol Framework covers four stages, "Why", "What", "How," and "What Next," which are further broken down into nine Steps (Figure 2-1). The steps contain specific questions to be answered when integrating natural capital into organizational processes. Although it is a linear presentation, the Protocol is an iterative process which allows users to adjust and adapt their approach as they progress through the framework. The Protocol is not prescriptive and all available natural capital tools and methodologies are compatible with an application.

As they are presented by the Natural Capital Coalition (2016b), the templates that were developed to structure the output from each step have been included in Appendix B. Beyond the step-by-step questions in Figure 2-1, the templates include the step-by-step general actions, a list of outputs, and a series of questions and directives to generate the outputs. With some modification for military use, the templates would provide a structured road map to more comprehensively integrate natural capital consideration into decision making and reduce operational risks.

To address the gaps that have been identified for DoD, optimal application would likely require consideration of natural capital from multiple perspectives. These are outlined below, with the first being the likely priority. However, to some extent, they are all interrelated physically and consequently, linked with stakeholder feedback loops when changes are anticipated or occur:

- **Military Dependency on Natural Capital.** Understanding DoD dependencies (current and potential future) on natural capital and related threats is the priority, because retaining access to the necessary types of natural capital will help ensure the continuation of current missions and the ability to execute future missions. An example is the land area used for range buffers. The military depends on that natural capital to provides for the safety of the public.

- **Public Dependency on Ecosystem Services from Military Lands.** Natural capital supports the mission, but DoD lands also provide ecosystem services to surrounding communities. For example, around 180 million people in over 68,000 communities rely on U.S. Forest Service lands to capture and filter their drinking water (U.S. Forest Service 2019). An understanding of public dependencies is critical to identifying military impacts that could pose a threat to mission. As these public dependencies are also public benefits, the analysis could also be valuable for identifying and conveying additional positive aspects of DoD land stewardship beyond defense.
- **Military Impacts on Natural Capital.** On lands owned or controlled by the government, changes can result in decreases in the quality or quantity of ecosystem services the public benefits from on or off military lands. By understanding natural capital impacts, including those related to public dependency, potential sources of conflict with the public are identified, thus enabling efforts to manage them before they impact mission. Applying the NCP can also identify and highlight the positive impacts the military creates via meeting their natural resources management responsibilities.

The NCP provides a useful framework and practical process that could be adapted to the military context to develop guidance applicable to all military installations responsible for managing natural resources while achieving readiness. Although the specific measurement approaches, valuation tools, decision contexts, and long-term strategies are expected to differ across military installations, a standardized process for identifying and assessing risks and opportunities and convenient access to information about the suite of tools and methods that have been applied by business and government in support of natural capital analyses would go a long way toward advancing DoD's natural resource management objectives.

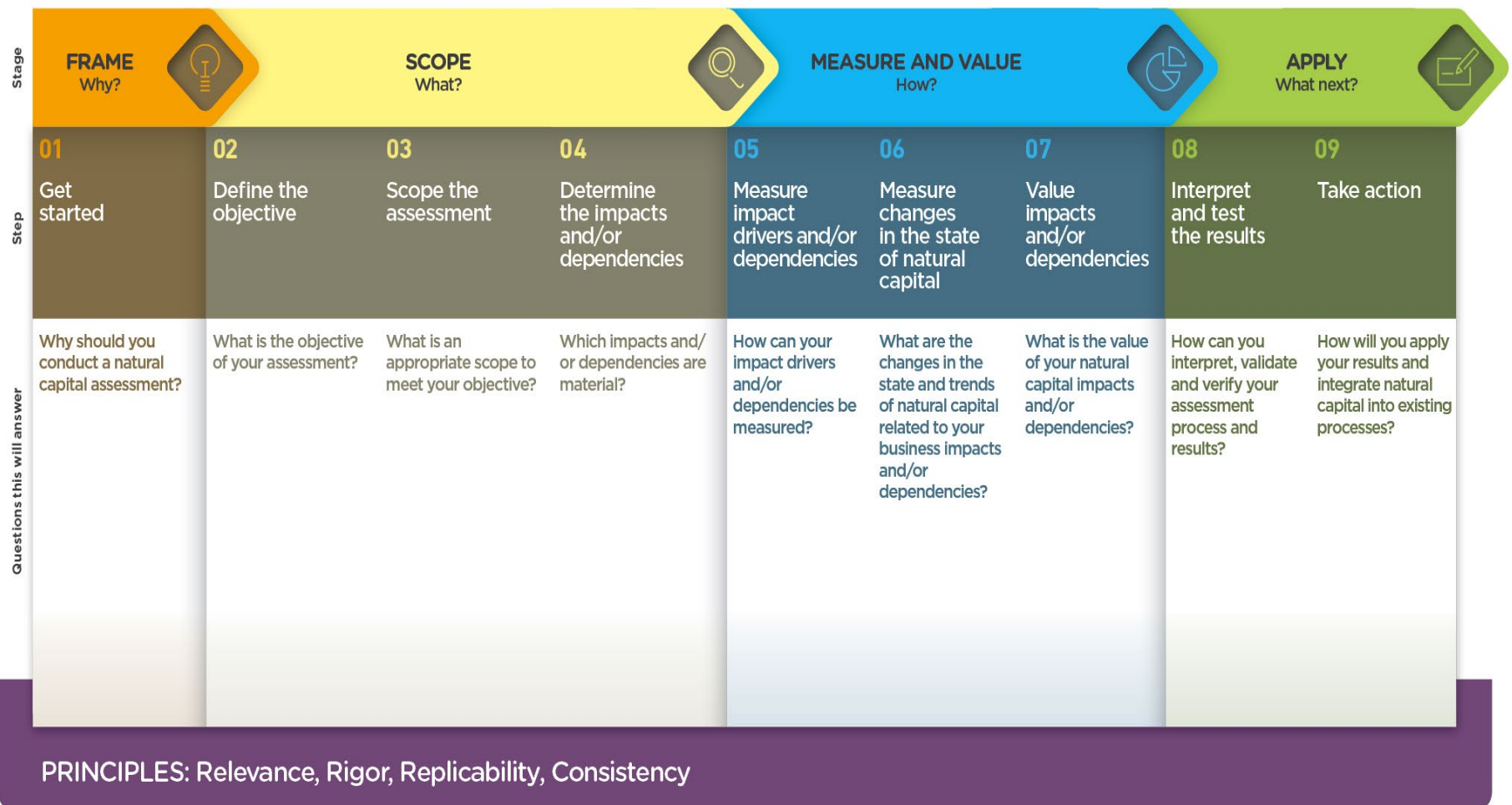


Figure 2-1. Natural Capital Protocol Framework

Source: Natural Capital Coalition (2016a).

3. Efficacy of Applying Contingent Valuation Methods to Develop Comprehensive Value Estimates and Inform Decision Making in the Context of Military Installations

3.1 Introduction

The DoD's management efforts at test and training lands produces a product – readiness – with co-benefits in the form of stewardship value, ecosystem services, and the maintenance of options for future re-use. There are more than 4,800 defense sites worldwide that range in size from small parcels (less than an acre) to the 3.1 million acres (including some leased land) of the Nellis Air Force Range in Nevada (Vincent et al. 2014). In total, the DoD administers and manages 14.4 million acres on its military bases, training ranges, and other U.S. holdings. The management and stewardship of these lands is complex, with a need to balance test and training, environmental compliance, impacts and costs of modernization and maintenance of deteriorating, mission-required natural capital, encroachment, impacts on the public, property use agreements, new TES listings, and increasing shared use of test and training lands. Land value assessments to date have not fully captured the value of the DoD's environmental stewardship, which puts preservation of DoD's holdings at a disadvantage where competing private uses are concerned, especially encroaching development.

In making the case for the continued withdrawal from the private domain of DoD lands to ensure adequate test and training capabilities necessary for readiness, the value of the mission lands to the local community and the broader region is nonetheless compelling to local authorities and policy-makers. Statistics on the contribution of the base to the regional economy are generally readily available. Less accessible is the stewardship value from protecting, restoring, and enhancing the natural resources managed by DoD. The stewardship value can include the enjoyment that the public receives from access for recreation, and from protecting and preserving natural resources for future generations. These natural resources can include thousands of acres of unique ecosystems, habitat for a variety of TES, vast stretches of open space, and areas of scenic beauty that have grown increasingly scarce outside of the nation's system of national and state parks. Directly or indirectly these ecosystems may provide additional benefits to people by sequestering carbon, removing excess nutrients from surface waters, and supplying water. However, individuals may hold passive use value for sustaining these resources. Passive use value is defined as the value that individuals place on natural resources independent of their direct use and enjoyment. It is motivated by the desire to steward these resources for future generations, for example.

This stewardship value is relevant to policy-making at the national, state, and local levels where decisions are made about funding, land use, air space, noise restrictions, coastlines, and waterways. Knowledge about stewardship value can play a role in such decisions that threaten that value. Given the complementarity between DoD's readiness mission with protecting and restoring the natural resources under its management, this knowledge is expected to strengthen the case for keeping those resources under DoD management for the long term and minimizing concessions to encroachment.

If it is important for the DoD to better understand and communicate the stewardship value of its natural resource assets, then CV methods should be used. Furthermore, for installations that may be considering acquisitions, divestitures, re-use, land swaps, leases or lease renewals, land withdrawals or land withdrawal renewals, or other activities involving significant changes in the quantity or quality of relatively unique habitats, CV can improve decision making by understanding the incremental benefit of the various natural resource asset types. Finally, CV techniques can be applied to evaluating off-installation activities that may impinge upon national parks, wilderness areas, and other valued natural resources. In all cases, the objective is to improve decision making by monetizing benefits for balancing training requirements, land stewardship, and costs. The following discussion describes the efficacy of applying CV methods to develop comprehensive value estimates to inform decision making in the context of military installations.

This CV class of valuation methods (also known as stated preference methods) is the most versatile option for obtaining monetary estimates for those decisions where the monetary value of tradeoffs is

deemed important to the decision. There is a suite of other tools suitable for valuing the economic benefits derived from separate ecosystem services (for example, carbon sequestration, water supply, and increased recreation opportunities). These valuation methods can be applied separately for each direct human-use benefit and then summed to estimate the total direct human use benefits. However, CV methods are the *only* way to estimate the monetary value of passive use value from preserving scarce natural resource assets, including but not limited to habitat for TES, which the public may value for their existence independent of their direct use and enjoyment (Mitchell and Carson 1989; Arrow et al. 1993; EPA 2000; Carson 2011). CV methods do not rely upon observed behavior whereby people reveal their willingness to pay through their actions. Instead, CV methods use surveys that are designed with the intent to elicit respondent's true preferences.

This section provides a brief background on CV methods, including strengths and weaknesses and empirical examples with similarities to DoD resource management contexts. Next, is a description of the scenario selected and a detailed discussion of the steps necessary to apply a CV methodology to address the stewardship valuation question. This is followed by an estimated range in cost and the time needed to complete analyses of this nature. The concluding section is devoted to a discussion about how the results can be used to support decisions pertinent to the scenario as well as the points to consider before embarking on such a study.

3.2 What are Environmental Benefits?

An environmental benefit occurs when a natural resource produces services that provide for human needs and wants. The essential problem is tracing through the ecosystem processes to identify how they ultimately benefit humans and then quantifying the magnitude of these environmental benefits. The basis for measuring economic benefits is accomplished in two steps. The first step is to determine economic value for the average individual; the second step is to aggregate the individual benefit values by the number of people who hold that value. For a natural resource, this exercise can be repeated for each separately identified benefit or in some cases, the natural resource can be valued in its entirety for all the benefits it provides. Hybrid approaches whereby some benefits are estimated separately and other are grouped, offers a third possibility.

A fundamental economic assumption is that individuals can trade money or things for objects they desire and maintain the same level of utility. The amount they are willing to trade in return for receiving the good or service is called their willingness to pay (WTP). Among economists, the public's WTP is a metric commonly used to assign value to environmental benefits. This is because society, as a whole, will ultimately sacrifice other goods and services to achieve an increase in environmental benefits. Society's WTP is usually considered to be the sum of WTP for all individuals who comprise the public.

In the case of market goods, society's WTP is represented graphically by the area under the aggregate demand curve for the good or service. A market demand curve shows the quantity of goods or services that consumers are willing to buy at different prices. For a measure of net benefits, the cost to the consumer (price) is subtracted from total WTP. This net WTP is called consumer surplus. It is the net benefit received by the consumer.

Economic valuation methods have their theoretical foundations in benefit-cost analysis (BCA), where the preferred metric is dollars. In this way, the different benefits can be aggregated using a common metric for ease with comparison to costs. The public is made better off when the discounted stream of future benefits exceeds the discounted cost stream (that is, net present value). When choosing among alternatives, the option that maximizes net present value is preferred. This is not to say that it is always reasonable or necessary to monetize all the environmental benefits. For example, as shown elsewhere in this report, there are many circumstances where it can be beneficial to quantify gains and losses in ecosystem services using an ecological metric such as when the objective is to determine the most cost-effective alternative for restoring a wetland or remediating a site.

3.3 Contingent Valuation Stated Preference Methods

CV methods rely upon stated preferences, which are collected along with other information using surveys. These stated preference surveys differ from strictly opinion surveys in that respondents are presented with choices involving hypothetical situations. Their observed choices are contingent on scenarios posed in the survey; hence the term CV to describe the process of using stated preference data for valuation. A distinct advantage of the CV method is its versatility. It can be applied to value any good or service that can be described to respondents in a survey setting. As such, the CV method is uniquely suitable for assessing stewardship value, which is likely to be comprised primarily of passive use value but may also include some direct use value. Specifically, the natural lands managed by DoD include hundreds of thousands of acres of unique ecosystems, habitat for many species including TES, as well as areas of historical, cultural, and archeological significance. The primary responsibility of the DoD personnel entrusted to manage natural resources is to facilitate test and training in support of the national defense interests while not endangering the local community. They also manage outdoor recreation (a direct human use) where it is compatible with the mission. Indeed, the DoD receives revenue from permit sales for public access to recreation and from timber harvest, and these funds provide a means to financially steward these resources. However, by far the largest value to the public is likely to be the passive use value from protecting and restoring the varied ecosystems. Any member of the public may hold passive use value for the natural resources at DoD lands; whereas, recreation value is only held by the people who engage in outdoor recreation on the DoD land. For those individuals who have enjoyed or expect to enjoy DoD lands for recreation, their stewardship value may be due in part to their direct use, which may be difficult to disentangle from any passive use value they have for DoD lands. To some, the term stewardship value may be comprised of only passive use value, but it can be inclusive of direct human uses such as recreation and water supply.

Sometime after the early researchers devised the CV method (Davis 1963; Knetsch and Davis 1966), it appeared in federal guidelines in the 1983 version of the U.S. Water Resources Council's *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* to support decisions on the basis of relative costs and benefits of alternatives. Around the same time, the U.S. Environmental Protection Agency (EPA) supported a major research program to advance the field of valuing natural resources and environmental benefits. This program included seminal work by Mitchell and Carson (1989) and many others on CV methods and empirical applications to support rule-making. A burst in research and publications followed the application of the CV method to assess the economic damages from the 1989 Exxon Valdez oil spill (Carson et al. 2003) and a blue-ribbon panel including Nobel laureates convened by the National Oceanic and Atmospheric Administration (NOAA) to consider its merits for assessing monetary damages to natural resources from oils spills (Arrow et al. 1993). Since then, the CV method survived several critiques and challenges to its validity (Desvousges et al. 1993; Diamond 1996; Diamond and Hausman 1994; Hausman 1993; Carson et al. 2001) and has undergone numerous improvements and variations to increase its validity and utility (Louviere et al. 2000; Carson and Groves 2006; Vossler and Evans 2009; Herriges et al. 2010; Carson 2011; Carson and Louviere 2011; Poe and Vossler 2011; Vossler et al. 2012; Vossler and Watson 2013; Interis and Petrolia 2014; Hwang et al. 2014; Carson et al. 2014).

Today, there are many ways to elicit preference information in a CV study and the one most commonly used for complex scenarios are *discrete choice experiments*. Respondents are presented with either a binary or multinomial choice or a sequence of such choices, where attributes of the public good are varied and one of the variables includes the cost to the individual to fund the program or public good. The survey participants are made to understand that there are consequences to their responses both in terms of influencing decisions about policies and programs and paying for them. The responses to these choices are analyzed to provide estimates of the individual's willingness to pay for the program or public good and how that changes with alterations in the attributes of the public good. For example, one can value the preservation and protection of the entire natural resource holdings of Eglin AFB, as well as the willingness to pay to protect Santa Rosa Island from development, to increase acreage of habitat for certain TES, and/or to acquire additional acres of habitat to expand the buffer and avoid future encroachment. Similarly, at the national level, advocates of retention of federal lands and federal acquisition of additional lands view federal ownership as necessary to protect and preserve unique natural and other resources (Vincent et

al. 2014). Information obtained from a CV study related to the value of retaining such federal lands can inform that debate and provide support for public ownership to protect lands from unregulated development.

Although the theoretical and empirical literature on CV/stated preference methods is extensive, evidence regarding the stewardship value of DoD holdings is lacking. The Carson (2011) bibliography includes over 7,500 papers in 130 countries. Studies covering other federal lands are also sparse, but there have been a few to fill the gap in knowledge, including some in recent years (Schulze et al. 1983; Duffield 2006; Heberling and Templeton 2009; Choi and Marlow 2012; Turner 2012; Henrickson and Johnson 2013; Turner and Willmarth 2014; and Haefelle et al. 2016). Most of this research has focused on valuing park attributes such as visibility (Schulze et al. 1983) and historical and natural resources at a single park (Turner and Willmarth 2014) or a system of parks in a single geographic region (Duffield 2006). A particularly ambitious study is directed toward estimating the value of all National Park Service holdings and programs (Haefelle et al. 2016). The exceptional ecosystems protected by DoD ownership and the unique role they play in supporting test and training missions have yet to be valued.

The following sections describe the process for conducting a CV/stated preference study. The procedure is similar whether the study is for a single base or all DoD land holdings. The biggest factor affecting the scale of the study is the number of distinct outcomes and/or attributes to be valued as this affects the complexity of the design and the number of survey responses needed for statistical validity. Thus, great care goes into defining the scenarios (that is, the resources and attributes to be valued) that are most important to DoD.

For example, a significant portion of Eglin AFB is globally significant due to its biodiversity, including over 75,000 acres of unique high-quality natural communities notable for the presence of rare species contributing to the unusual species diversity. These areas represent an “attribute” of the natural resource holdings of the Eglin AFB. A second attribute is encompassed by the habitats that support rare plants (that is, Significant Botanical Sites). A third attribute is the outstanding waters of the Eglin AFB, and a fourth might be the contribution of groundwater resources to water supply, and so on. The CV survey may be designed to value these resources in their entirety and to estimate the value of changes in acres of high-quality habitat for rare species and/or of protecting groundwater supply, for example. By including quantities of the specific attributes managed by the natural resources personnel, it is possible to value changes in the quantities in response to their management actions. This is especially compelling when used to illustrate the complementary benefits of supporting the mission and creating stewardship value.

3.3.1 Stewardship Valuation Scenarios

In the workshop with Eglin AFB (Jackson Guard) personnel, two primary types of scenarios emerged for valuation:

- 1) The natural resources managed by a single base
- 2) The natural resources managed by DoD

These scenarios differ in scale and in terms of the questions that they would be best suited to address. If DoD is primarily interested in the stewardship value of their holdings in their entirety, then Scenario 2 is the obvious choice. This may be the case if the data are needed to inform national decisions about funding and/or communicating with the public. The marginal value of increases or decreases in holdings could be evaluated as well as changes in federal land management policies and programs, such as public access for recreation in formerly restricted areas or new restrictions on air, land, or water resources that improve habitat for TES while enabling test and training operations.

Alternatively, if highly specific valuation information is needed to inform decisions about a range or base, then Scenario 1 is the preferred approach. This can include acquisitions, divestitures, re-use, land swaps, leases or lease renewals, land withdrawals or land withdrawal renewals, and natural resource restoration to support testing or training, to name a few examples. One issue common to many bases is encroachment, which can take many forms, be it air space, residential development pressure, competing industries such as tourism and oil and gas leases and exploration, navigation traffic, or rights-of-way.

Although interference with the base's mission including infringement into safe operational zones is a compelling argument for restraining encroachment, the loss of highly valued natural resources due to encroachment can tip the economic balance in the base's favor. This scenario can only grow in importance over time as population growth continues, especially along the nation's coastlines and near urban areas. Maintaining vast areas of open space or even relatively small buffers around mission-sensitive areas will be a growing challenge in the years to come (Vincent et al. 2014). Engaging with the local community and larger public about their safety and the natural resources managed and protected by the DoD is a step in the right direction. One way to accomplish this is through surveys that present respondents with realistic scenarios about the base's natural resources and the threats to those resources that must be managed to avoid the risk of loss. This discussion has focused on encroachment risks, but other risks such as climate change, natural disasters, and budgetary concerns are equally relevant. As previously mentioned, the CV or choice experiment survey instrument is designed to elicit responses whereby respondents reveal their willingness to pay for the natural resources as described in the scenarios.

3.3.2 Steps in Applying a Contingent Valuation Stated Preference Method

The steps in applying survey development and implementation methods as well as the analysis methods are similar at the individual base and national scale. Thus, while this discussion references an AFB-level analysis, it can be scaled up to the national level.

3.3.2.1 Step 1. Review Literature

The initial step in the process is to review the scientific literature and to identify and engage with the DoD stakeholders to select the best approach. This step overlaps with steps 2 and 3.

3.3.2.2 Step 2. Kick-off Meeting

Prior to designing the valuation scenarios, meet with relevant stakeholders to understand management needs.

3.3.2.3 Step 3. Design and Test Survey and Devise Sample Plan

The survey design phase requires great care and consultation with DoD to define the resources and attributes to be valued. The importance of the scenario descriptions cannot be over emphasized as they will drive how the results can be used to meet DoD objectives for the analysis. The research analyst will then decide how to structure the survey (and sample size) to efficiently obtain the necessary information. Once the resources and attributes for valuation are identified, it is equally important to present respondents with realistic choice situations that encourage them to provide truthful and thoughtful responses. Although the researcher will lead the effort, consultation with DoD is instrumental to the design of these choice situations.

The initial survey design is refined with the aid of focus groups. The objective of the focus groups is to determine whether respondents understand the key questions and can respond to them as intended to meet the objectives of the research. The participants provide feedback to the moderator on any aspect of the questions that trouble them or whatever else the moderator asks them to address. This can be an iterative process and can include group discussion. Multiple focus groups can be given the same questions but if there are too many questions, it will be necessary to run separate focus groups for each set of questions. The focus group sessions are usually held anywhere within the region of interest that includes representatives from the sample population and can include about 10 to 12 participants randomly selected as representative of that general population. Participants are usually paid for their time and asked to devote up to 2 hours for their effort. Not all survey questions are necessarily subjected to the rigor of focus groups. However, at a minimum, content related to the scenario descriptions and choice situations is likely necessary for designing a survey that is clear and plausible to respondents and structured to incentivize them to give truthful and thoughtful answers. For example, it is important that participants believe that their responses are consequential. Otherwise, it is not worth their effort to apply themselves. It is also important to include follow-up questions to learn about respondents' motivations or reasoning behind their answers as well as how certain they were about their responses. For example,

participants may indicate a \$0 willingness to pay, not because that is their true value, but rather because they believe that the government collects enough revenue and should be more efficient.

The results from the focus groups are used to refine the survey instrument. In addition, although the valuation scenarios and choice situations are the most complex components of the survey, the data would not be complete without including additional questions related to the respondent's attitudes, knowledge and/or experience relevant to the scenarios as well as demographic characteristics. The questionnaire can then be administered as a pretest to a small sub-sample as a final check that the instrument is working as intended. If all goes well with the pretest, the final survey is administered to the full representative sample. Otherwise, further refinements may be required before the survey is sent to the full sample.

The sample design begins with identifying the population that is expected to hold stewardship value for the natural resources in question. The entire U.S. population is relevant for national goods, including DoD natural resource holdings in their entirety. Determining the population for an individual base or group of bases is less straightforward. The research analyst must make a case for the population of interest. This is generally accomplished through a literature review and can be verified using the focus groups and/or pretest.

The next step is to devise a sampling frame that is unbiased and thus ensures that the sample is representative of the affected population (that is, each individual has an equal probability of being selected for the sample). The results of the valuation survey will then be generalizable to the population of interest. The extent to which the sample is unbiased will depend upon the method of generating the sample and of administering the survey (that is, survey mode).

For many years telephone directories were popular for drawing samples because they used to provide fairly representative lists of households in an area when most had landlines. The drawback was that there were limitations due to unlisted numbers. Today, with the reliance on cell phones, many households have dropped their landlines. Instead, random digit dialing of area codes using both landline and cell phone prefixes provides reasonably good coverage of the population in an area. For this reason, among most university survey research centers and private survey sampling companies, random digit dialing has replaced telephone directories for drawing samples for telephone surveys.

Another method is to employ internet panel surveys. Although this method requires access to the internet, this deficiency can be overcome somewhat by providing potential panel members with computers and internet connections. Nonetheless, the opinions of the people who refuse to use the internet may not be represented if they are different from internet users.

A third method is known as address-based samples. For example, the sampling frame can consist of all U.S. households with valid addresses contained in the U.S. Postal Service Delivery Sequence file or whichever geographic area holds the population of interest.

The sampling method alone does not ensure an unbiased sample, as participation in surveys is voluntary. Households choose to participate or not. If this choice is systematic this can result in sample selection bias. For this reason, it is advisable to include survey questions (or follow-up questions for a sub-sample of respondents) aimed at uncovering a respondent's reasons for agreeing or refusing to participate. The additional information can facilitate the use of statistical methods that correct for the bias.

The sample frame sometimes determines the method or methods that can be used to administer the questionnaire. There are several survey modes including personal interviews, mailed questionnaires, phone surveys, and a combination of telephone, mail, and the internet. Each has their advantages and disadvantages such that the research analyst will generally provide the rationale for selecting a mode. For example, survey response rates have decreased over the years likely due to the large number of solicitations by marketers and scammers, such that methods that produce higher response rates and that minimize sample selection bias are preferred.

3.3.2.4 Step 4. Peer Review

Coincident with Step 3, obtain and incorporate objective feedback on the survey and sampling plan from an independent peer reviewer.

3.3.2.5 Step 5. Office of Management and Budget Approval Process

Federal agencies are required to obtain Office of Management and Budget (OMB) approval prior to administering surveys to the public. For the primary purpose of reducing the paperwork burden on the public, the Paperwork Reduction Act of 1995 (44 U.S. Code § 3501.) gives the OMB authority over the collection of certain information by federal agencies. It is intended, “among other things, to ‘ensure the greatest possible public benefit from and maximize the utility of information created, collected, maintained, used, shared and disseminated by or for the Federal Government’ and to ‘improve the quality and use of Federal information to strengthen decision making, accountability, and openness in Government and society” (Sunstein 2010). The Act requires agencies to plan for the development of new collections of information and the extension of ongoing collections well in advance of sending an information collection request to OMB. Agencies must:

- Seek public comment on proposed collections of information by placing a notice in the Federal Register.
- Certify to OMB that efforts have been made to reduce the burden of the collection.
- Review and approve information collection requests internally before submitting them to OMB.

3.3.2.6 Step 6. Administer Survey

The survey administration process depends upon the survey mode. For example, a mail survey usually requires an initial letter, a first mailing of the survey questionnaire, a follow-up reminder to complete the survey, and a second mailing for those who misplaced or discarded the original questionnaire. Finally, it can be important to follow-up with non-respondents to learn about why they chose not to participate.

3.3.2.7 Step 7. Data Entry

The data entry process can occur simultaneously with administering the survey in the case of online surveys, for example. For survey modes such as mail surveys, this is a separate step, which includes a quality assurance and quality control process usually completed by the organization that conducts the survey.

3.3.2.8 Step 8. Analyze Data

The data analysis includes providing descriptive statistics, examinations to determine whether the sample is representative of the population and if there is sample selection bias present in the sample (that is, systematic reasons for opting in or out of participating in the survey) econometric methods to correct for bias and estimate economic benefits.

3.3.2.9 Step 9. Prepare Report

Step 9 is to write the draft report, circulate to DoD and others, if necessary, for comment, and finalize the report.

3.3.2.10 Step 10. Disseminate Results

The research dissemination process can include presentations to DoD and at professional association meetings and conferences as well as journal publications.

3.3.3 Example Schedules and Cost to Estimate Stewardship Value Using a Contingent Valuation/Stated Preference Approach

Example timelines to complete a CV/stated preference study for a single DoD base and for a national study are presented in Tables 3-1 and 3-2, respectively.

Table 3-1. Steps in the Contingent Valuation/Stated Preference Study and Project Timeline – Single Department of Defense Base

Step	Months after Project Initiation																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1. Review																		
2. Kick-off Meeting																		
3. Design and Test Survey and Devise Sample Plan																		
4. Peer Review																		
5. Office of Management and Budget Approval Process																		
6. Administer Survey																		
7. Data Entry																		
8. Data Analysis																		
9. Prepare Report																		
10. Disseminate Results																		

Table 3-2. Steps in the Contingent Valuation/Stated Preference Study and Project Timeline - National Scale

Step	Months after Project Initiation																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1. Review Literature																				
2. Kick-off Meeting																				
3. Design and Test Survey and Devise Sample Plan																				
4. Peer Review																				
5. Office of Management and Budget Approval Process																				
6. Administer Survey																				
7. Data Entry																				
8. Data Analysis																				
9. Prepare Report																				
10. Disseminate Results																				

These timelines are meant to be suggestive of realistic schedules for high quality studies ranging from 18 to 20 months for a single DoD base versus a national study, respectively. The slightly longer duration for the national study is based on the expectation of a more complicated study design and analytic methods. Budgets for conducting a CV/stated preference study can vary depending upon the complexity of the study. A rough order of magnitude estimate is \$300,000 to \$700,000.

3.4 Contingent Valuation Summary

This subsection describes the efficacy of applying CV methods to develop comprehensive value estimates to inform decision making in the context of military installations. CV/stated preference studies of natural resources are intensive and time consuming such that they are only undertaken when the value of the information from the study justifies their cost. The military installation context is prime for meeting these criteria because the cost of conducting the study is expected to be low relative to the value of the assets that would be protected by decisions that take stewardship value into consideration. By virtue of its readiness mission, DoD has protected unique ecosystems, habitat for TES, vast stretches of open space, and areas of scenic beauty that have grown increasingly scarce outside of the nation's system of national and state parks. As these protected areas become vulnerable from development pressure and other forms of encroachment, and as decisions involving tradeoffs must be made at the community level and as a nation, information about the stewardship value of DoD's natural resources becomes increasingly important. Furthermore, test and training requirements may necessitate land acquisitions that would expand DoD's land holdings. The CV/stated preference method provides the means whereby DoD can estimate the economic value of its stewardship of natural resources for the public, including future generations.

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4. Net Environmental Benefit Analysis

4.1 Net Environmental Benefit Analysis Introduction

A NEBA is a framework that facilitates the systematic quantification of the environmental costs and benefits of management options (EPA 2009). It is consistent with and has the same theoretical foundation as economic benefit-cost analysis (BCA), the only difference being that it is limited to environmental benefits and costs. The reason for this restriction is to evaluate actions affecting the environment to determine whether the changes lead to a net gain in the value of the environment to the public. In our proposal, we proffered that a NEBA could provide value-added information to decision makers faced with alternative test and training land management techniques and options regarding land use or the timing of actions. Specifically, it was proposed that the information could be used to rank alternatives in terms of maximizing environmental benefit, minimizing environmental losses, and achieving the greatest environmental benefit for a given budget, thus facilitating the mission and optimizing co-benefits. For example, as shown by Efroymsen et al. (2004) and EPA (2009), one of the major advantages of a NEBA is its role in identifying environmental remediation decisions that would inadvertently create more environmental harm than good, thus making the case for less invasive and less costly remediation alternatives.

As with BCA (which uses monetary units --dollars), it is advantageous to quantify environmental benefits and costs using a common metric for ease in evaluating and ranking alternatives. However, gains and losses in ecological services are not always readily transformed into their dollar equivalents. Moreover, for decisions related to ranking alternatives, it may not be necessary to monetize the gains and losses in ecological services when they can be ranked using ecological metrics, instead. An ecological metric can provide a direct measure of net environmental benefit. A NEBA can thus include two metrics:

- Dollars for the value of the direct human uses of the environment such as recreation and drinking water and for the passive use value that humans place on preserving natural resources
- An ecological metric such as service-acre-years (SAYs), which captures both the number of acres of a given type of ecosystem and its level of ecosystem function

One fully functioning acre of habitat is said to provide one SAY every year. Degraded habitats provide only fractions of a SAY. Such an ecological metric provides a measure of the relative quality and quantity of a given type of ecosystem and its ability to supply ecological services that indirectly benefit humans. For example, wetlands can sequester carbon, slow stormwater flows, regulate nutrients, and provide habitat for waterfowl. Rapid assessment protocols can be applied to quantify the changes in such functions and services of wetlands using a metric of SATs to facilitate cost-effective decisions about restoration actions to mitigate for impacts to wetlands without the need to monetize the wetland benefits. Like BCA, the NEBA ranks alternatives on the basis of net present value and provides for the maximization of net present value of environmental benefits or the minimization of environmental losses. SAYs are discounted for future benefits the same way human use benefits measured in dollars are discounted to express present dollar values. The discounted stream of future gains and losses in ecological services are called "dSAYS" for discounted SAYs.

For many environmental benefits, such as improved outdoor recreation opportunities and avoided damages due to protection from floods, their expression in monetary units is relatively straightforward and useful for decision making. However, for other environmental benefits involving ecological changes, such as improved wildlife habitat, nutrient uptake capacity, and stream integrity, the translation to dollars is not straightforward. It may benefit decision makers to know whether the ability of the ecosystem to provide ecosystem support services is increasing or diminishing due to an action. For military applications on an installation where the area being evaluated has limited direct human use apart from the military mission, the focus of NEBA is often to quantify gains and losses in dSAYS only. The primary NEBA tool for quantifying ecological benefits using dSAYS is called Habitat Equivalency Analysis (HEA); (Unsworth and Bishop 1994). This approach, known as the service-to-service approach, is supported by many federal agencies (DOC 1996; DOI 1995; NOAA 1995; NOAA 1997; EPA 2006).

As proposed, this research project was intended to:

- Test the hypothesis that NEBA can be effectively used from a cost and time perspective to provide decision makers the necessary information to assess environmental tradeoffs, balancing training requirements, land stewardship, costs, and legal drivers.
- Evaluate whether there are synergies between the supply chain paradigm and NEBA with respect to facilitating decision making and revealing new insights into the relationship between natural capital and DoD land management.

Finally, the next research steps required to deploy the technique would be identified.

The workshop held at Eglin AFB was influential in shaping the subsequent NEBA research. The participants were given an overview of NEBA and potential application contexts. Some past projects where NEBA may have provided value were identified, but opportunities for a current case study on an active project were limited. Potential options included:

- Prioritization of restoration projects (for example, borrow pits and rights-of-way)
- Closing or opening roads with degraded water-crossings
- Options to address the downed timber and restoration of affected lands at nearby Tyndall AFB in the aftermath of Hurricane Michael
- The economic value of Eglin's recreation program

Upon consideration, the first option was not adopted. While prioritization of habitat restoration projects is a context in which NEBA can provide value, in this case there was limited overlap with test and training. For the second option, a combination of a binary decision, a limited spatial footprint, and a variety of non-environmental consequences of road closure/opening made it unlikely that a quantification of environmental cost/benefit would provide significant value. In contrast, questions around the hurricane-impacted forest fit well with the conditions under which a NEBA can provide valuable information to support decision making. However, it is a complicated problem set. To address it properly would have required significantly more investment than available under the SERDP grant.

The fourth option involved analysis of the economic benefits of Eglin's recreation program. Base representatives were interested in understanding the value of the recreational use because it would document the value of an important aspect of their management of natural resources, which would be useful in communicating with the local authorities, particularly as it pertains to such co-benefits of Eglin's test and training mission.

As a result, it was planned that a recreational benefit assessment (RBA) would be conducted for the current program. The analysis would serve as the baseline for a future NEBA, whereby changes to the program, such as eliminating access to areas, opening new areas, or changing the allowable recreation uses, could be assessed from the perspective of economic benefit. A hypothetical example NEBA involving lost public access to beach recreation on Santa Rosa Island was prepared as a case study illustration for demonstration purposes.

In addition, based on communication with the Eglin staff during and after the workshop, it was clear that defining the types of contexts in which a NEBA could provide value to decision makers would be helpful. As a result, that review is included in the next section.

As previously mentioned, one of the objectives of the research was to evaluate the synergies between the business supply chain paradigm and NEBA. As noted in Section 2, the supply chain paradigm was determined to not be a viable option to fill the DoD identified gaps with regard to natural capital.

4.2 Net Environmental Benefit Analysis Applications

This section summarizes historical DoD applications, reviews the key situational characteristics where NEBA may provide value, and presents an example of a NEBA using Habitat Equivalency Analysis and the ecological metric, dSAYs.

4.2.1 Historical, Current, and Potential Applications

Over a period of approximately 20 years, NEBA has been applied in several contexts at DoD installations. The historical and current applications, presented by branch, in Table 4-1 are based on Jacobs' experience and internet research. There may be other examples not included in the list.

Table 4-1. Summary of NEBA Applications at DoD Facilities^a

Context	Description	Branch			
		Air Force	Army	Navy	Marine Corps
Remediation	- Evaluation of alternatives to address contamination posing a risk to human health or the environment - Examples of sites include landfills, maintenance shops, and closed or inactive ranges	Edwards AFB; Joint Base Andrews; Homestead Air Reserve Base; Joint Base Langley-Eustis	Camp Edwards	NAS Patuxent River; Naval Weapons Station Seal Beach; Norfolk Naval Shipyard	Marine Corps Base Quantico
Compensation	- Evaluation of options to compensate for permitted impacts to protected habitats - As part of the analysis, the proper amount of compensation is quantified, considering time and the quality and quantity of impacted habitat.	Grand Forks AFB		NAS Patuxent River	
Infrastructure	Evaluation of capital project alternatives (the single case evaluated shoreline stabilization options)	MacDill AFB			
Lease Assessment	To support lease fee negotiations, evaluation of potential ecological and/or human use service losses associated with the proposed use (the single case involved an oil and gas lease)	Barksdale AFB			
Remediation and Redevelopment for Public Use	- Applied at Base Realignment and Closure sites, evaluation of alternatives to address contamination and risk associated with multiple non-military future use options - Some NEBAs have included an assessment of munitions and explosives of concern.		Camp Bonneville; Fort Ord, Savanna Army Depot; Fort McClellan; Rocky Mountain Arsenal		

^a The list of applications is likely not exhaustive.

AFB = Air Force Base

NAS = Naval Air Station

NEBA = Net Environmental Benefit Analysis

Application contexts have included remediation, compensation, infrastructure, lease assessment, and redevelopment. The dominant application is the evaluation of remedies for contaminated soil, surface water, sediment and groundwater, including at closed and inactive ranges. In these cases, the analyses have identified the protective remediation alternatives that provide the greatest net environmental benefit (or least loss) at the lowest cost. The core purpose behind these NEBAs was to facilitate acceptance of a cost-effective path forward to site closure. Contaminated site NEBAs are currently being conducted at Marine Corps Base Quantico and Naval Air Station (NAS) Patuxent River.

Following are contaminated site characteristics that indicate a NEBA may provide significant value:

- Limited ecological risks over a large area
- Potential for remediation-related impacts to habitat
- Presence of high-value habitat
- Expected disproportionate cost to benefit for a remedy
- Difficulty reaching resolution
- Costly remedy
- Large and complex site
- Need to prioritize actions
- Risk of recontamination
- Ongoing anthropogenic degradation

To our knowledge, NEBA has not been applied at active ranges to address chemical contamination, unspent munitions, or accumulated debris. However, the same candidate characteristic list above would apply. Application to active ranges would provide military decision makers with value-added information regarding the management options that would achieve protection and safety objectives with the least environmental impact, and at the lowest cost.

NEBA has also been used to scale the proper amount of compensation for permitted impacts to protected habitats. The regulatory frameworks dictating the amount of compensation for permitted impacts varies across the U.S. Sometimes the frameworks are prescriptive, and in other cases they are vague and open to individual interpretation. Some frameworks do not adequately consider the quality of impacted habitat or time to recovery. NEBA provides a framework to scale the proper amount of compensation. The outcome is that the public is accurately compensated for the loss, not under- or over-compensated. Compensation alternatives can be compared to understand which alternative provides the highest amount of credit per dollar spent, minimizing the cost of achieving compliance. NEBA can also help facilitate the consideration of what is referred to as “out-of-kind” compensation (that is, mitigating for impacts to one type of habitat with provision of a different type of habitat). This can also be important for containing compensation costs, but more importantly, can help land or opportunity-constrained facilities comply.

Single use applications have been the assessment of the adequacy of lease agreement fees to cover environmental impacts and an evaluation of shoreline stabilization alternatives. Of these two applications, the use of NEBA to evaluate capital projects (that is, new construction, renovation, and improvement) has the potential to provide value across military installations. The suite of characteristics of capital projects that are indicative a NEBA may provide significant value include:

- Two or more alternatives that would meet project objectives
- Potential effects on ecological functions or passive or active human use value
- Differing type, or scale, of environmental impacts by alternative
- A project cost that would justify the funding for a NEBA

4.2.2 Example Net Environmental Benefit Analysis Using Habitat Equivalency Analysis

A NEBA was conducted for alternatives to compensate for 3.6 acres of wetland filling that occurred as part of remediation efforts at Fishing Point Landfill, NAS Patuxent River (CH2M 2001). An ecological functional assessment showed that the important attributes of the impacted wetland were flood flow

alteration, sediment/toxicant retention, and nutrient removal/transformation. The wetland was ranked low for wildlife and aquatic diversity and abundance. Using HEA, the ecological service loss was quantified at 127 dSAYs.

The Navy identified the following three potential compensation options (CH2M 2001):

- 1) Farm Field Freshwater Wetland
- 2) Defense Reutilization and Marketing Office (DRMO) Tidal Wetland
- 3) West Cuddihy Stream Restoration

For each option, the estimated ecological services gain in dSAYs was calculated using a set of input parameters. For example, parameters used to calculate the level of ecological service gain for the Farm Field Freshwater Wetland were as followings:

- The service gain begins January 2003, after the completion of construction
- A 200-year period, starting in January 2000 (also used for Fishing Point Landfill loss calculation)
- A 3-year period for the compensation alternative to become fully functional
- The project replicates one half of lost water quality services
- A 3% discount rate (also used for Fishing Point Landfill loss calculations)

The DRMO Tidal Wetland was scaled to the Fishing Point Landfill wetland loss using the size and habitat quality for marsh wren (*Cistothorus palustris*). The West Cuddihy Stream Restoration was scaled to the Fishing Point Landfill wetland loss based on a “freshwater wetland credit dollar value to instream restoration” conversion factor provided by the State of Maryland, the size and ecological value of the propose detention basins, and water flow control quantity. Using these inputs enabled the translation from the freshwater wetland loss to “out-of-kind” compensation in the forms of tidal wetland and stream restoration and.

After the initial analysis, the Farm Field Freshwater Wetland was discarded as an option because it would produce only 56 dSAYs of credit, less than half the need. A detailed comparison of the DRMO Tidal Wetland and the West Cuddihy Stream Restoration is presented in Table 4-2. The comparison showed that while both options would satisfy the need, the stream restoration project would cost less overall, and the cost per credit was lower. Ultimately, the State of Maryland agreed to satisfying one half the compensation obligation through stream restoration and the other half via creation of 1.8 acres of freshwater wetland at a location that had not been considered in the initial analysis. Using NEBA was effective in that it drove compensation funding to restore a degraded stream that would not have otherwise been improved, and it reduced the overall use of buildable land at NAS Patuxent River, a facility that was actively gaining missions at the time.

As indicated, in this case, the NEBA results were used to facilitate acceptance of a negotiated wetland mitigation package that included “out-of-kind” mitigation (for example, stream restoration to compensate for wetland impacts). Following are two other examples of how the metrics have been used to make decisions:

- At Base Realignment and Closure sites, NEBAs assisted the Army by identifying the combinations of cleanup and land-use controls that would provide the greatest net environmental benefit while protecting human health and the environment. Expected changes in both human use and ecological service value were quantified, enabling the environmental tradeoffs to be considered.
- At an Edwards AFB site with contaminated groundwater, NEBA results helped the stakeholder team identify a less expensive groundwater remedy as the preferred option. The NEBA demonstrated that the added cost of shortening the time period for cleanup with the most aggressive remedy was substantially greater than the lost irrigation value of the groundwater.

Table 4-2. Comparison of Fishing Point Wetland Compensation Alternatives

Metric	DRMO Tidal Wetland	West Cuddihy Stream Restoration
Compatibility with NAS Mission	Outside of airfield clear zones; 0.8 acre of open water creation	Outside of airfield clear zones; 0.75 acre of open water creation
Constructability	Moderate level of difficulty. Dewatering possibly necessary. Four to one slopes around southern perimeter. Good access.	Moderate level of difficulty. Limited space. Access difficult. Detention basin construction disruptive to traffic.
Likelihood of Success	High	High. Future land development proposals need to be tracked and respective impacts assessed.
Cost Risk	Minimum dewatering assumed in cost estimate. Character of fill material unknown. Cost estimate assumes that seawall outlet would be funded by NAS Patuxent River.	Low
Operations and Maintenance	No regular operations or maintenance required.	Northeast detention basin would require excavation on about a 5-year cycle dependent on sediment loading. Outlet structure would need to be checked and vegetation would need to be mowed periodically. No in-stream operations or maintenance activities.
Monitoring	Need to monitor health of plantings, bank stability, and colonization by invasives.	Need to monitor for proper operation of engineered structures and health of any in-stream plantings.
Relationship to Impact	Alternative not based on highest quality attribute of lost wetlands (that is, water quality services). Major benefit is habitat.	Alternative primarily based on water quality services. Alternative also provides habitat for amphibians.
Flexibility to Change Project Size^a	Yes	Yes
Expandable in Future?	No	Yes
Credit Gain	624 dSAYs	216 dSAYs
Cost	\$1,386,000	\$385,000
Cost Range	\$970,000 to \$2,079,000	\$269,000 to \$577,000
Cost per Credit	\$2,221	\$1,782
Cost per Credit (minimum)	\$1,554	\$1,245
Cost per Credit (maximum)	\$3,332	\$2,671
Excess credit available to offset additional IRP-related impacts	Yes	Yes

Source: CH2M (2001).

^a Project area maximized for available parcel.

DRMO = Defense Reutilization and Marketing Office

IRP = Installation Restoration Program

NAS = Naval Air Station

4.3 Recreation Benefit Assessment for Eglin Air Force Base

This section presents the results of the RBA and an example NEBA for the Eglin AFB recreation program.

4.3.1 Background

As described in the Eglin Air Force Base Outdoor Recreation Component Plan, the base encompasses more than 464,000 acres primarily within Santa Rosa, Okaloosa, and Walton Counties in Northwest Florida, including a portion of Santa Rosa Island. Consistent with the Sikes Act, “Eglin’s NRO outdoor recreation team strives to promote and develop quality sustainable recreational opportunities, which include hunting, fishing, trapping and non-consumptive uses in a manner compatible with the military mission and subject to safety and security requirements” (Natural Resource Management, Jackson Guard 2017). Eglin AFB has enjoyed strong support for the military mission from the local community, which has developed deep-seated bonds for the natural areas under Eglin’s management. However, a gap in information exists in that the value of public access for outdoor recreation at Eglin AFB has not been expressed in economic terms. The purpose of this RBA is to close that gap.

This RBA also serves as a baseline for a NEBA. It could be used by the base in the future to understand the economic benefit implications of changes to the outdoor recreation program (for example, eliminating access to areas, opening new areas, or changing the allowable recreation types). At the end of the RBA, a hypothetical NEBA is presented as an example. The example involves an analysis of the change in economic benefit if the Santa Rosa Island was no longer available for recreation, for a variety of possible reasons, such as thorough change in military policy, development, or loss to sea level rise. This type of evaluation (that is, quantifying the change in environmental benefit between baseline and a different condition) can be completed to help inform decision making.

The RBA begins with a description of public access for outdoor recreation at Eglin AFB. For the public who do not live near a military base, the fact that recreation is encouraged, yet alone allowed, may be surprising. The public owes this privilege to the Sikes Act (Public law 86-797) passed in 1960, which authorizes public access to military lands for recreation in ways that do not compromise the mission and that are consistent with protecting and enhancing the natural resources and habitat for wildlife. Thus, the description of public access includes the restrictions as well as the recreation opportunities.

4.3.2 Public Access for Outdoor Recreation at Eglin Air Force Base

All Air Force-managed lands are categorized by degree of public access for the areas that are identified as suitable for outdoor recreation (Air Force Instruction 32-7064). The categories from A to E are not mutually exclusive such that an area may have multiple designations depending upon the type of recreation opportunities it supports. These categories are defined as follows:

- **Category A** is open to the public regardless of association with the military or other DoD agencies.
- **Category B** is open to DoD employees, guests, family members, and retirees only.
- **Category C** is open to installation personnel and guests, permanent change of station or temporary duty personnel and their family members only. This category does not include retirees or DoD employees from other installations or military services not on permanent change of station or official temporary duty, except as guests.
- **Category D** is open to installation military and civilian personnel only. This category includes only those personnel assigned permanent change of station or official travel duty at the installation. It excludes family members, guests, retirees, and other DoD employees.
- **Category E** is closed. Category E areas are closed to avoid conflicts with the mission and to ensure public safety. Examples of such closed areas on Eglin include: test ranges and adjacent buffer zones, sections with unexploded ordnance concerns, and other areas such as sewage sprayfields and landfills.

Whereas the above list of categories defines public access, a separate scheme identifies the types of recreation activities that are allowed within the areas that are accessible. Eglin AFB has approximately 250,000 acres of publicly accessible outdoor recreation lands. These spaces are categorized by class of recreation area as follows:

- Class I areas (general outdoor recreation areas) are suitable for intensive recreational activities such as camping, picnic areas, and water sports. Several such areas are designated on the Eglin AFB.
- Class II areas (natural environmental areas) can support dispersed recreational activities such as hunting, fishing, birding, hiking, sightseeing, jogging, climbing, and riding. Most of the outdoor recreation zones at Eglin AFB correspond to Class II areas.
- Class III areas (special interest areas) contain valuable archeological, botanical, ecological, geological, historic, zoological, scenic, or other features that require protection. Eglin AFB has many locations that contain rare and sensitive plant and animal communities.

Only a subset of the recreation activities, specifically hunting and fishing, are actively managed at Eglin AFB. For example, given the large size of the installation, and the realities of the test and training mission priorities, sustaining high quality habitat for wildlife and providing a quality hunting experience requires thoughtful and detailed management measures. At Eglin AFB this is accomplished by dividing the installation into Management Units and subdividing by Tactical Training Areas, each with their own set of rules to manage conflicting public uses and to ensure safety and a quality recreation experience.

By access category, the areas managed for hunting and fishing are shown in Table 4-3.

Table 4-3. Available Areas for Hunting and Fishing on the Eglin Air Force Base

Category	Hunting	Fishing
A	250,743 acres	19 impoundments – certain streams, rivers, estuaries, portions of Gulf of Mexico
B	1,321 acres (Main Base)	Five impoundments – streams and estuarine shoreline at Main Base
C	0	0
D	0	0
E	210,402 acres	Waters within 210,402 acres

4.3.3 Outdoor Recreation Offerings at Eglin Air Force Base

Numerous outdoor recreation activities are offered at Eglin AFB. Primitive camping is permitted at 14 designated locations, where some sites include tent pads, fire rings, and/or picnic tables. Thirteen exceptional areas are accessible for day use for general recreation such as swimming and picnicking. Hiking is popular, and 67 miles of the Florida National Scenic Trail traverse the base. The Florida National Scenic Trail extends for approximately 1,000 miles, connecting the Big Cypress National Preserve near Naples to the Gulf Islands National Seashore at Fort Pickens, south of Pensacola. Thus, the Eglin AFB provides an important link for nonmotorized travel across some of the most beautiful, unique landscapes in the United States. Two types of biking are available on Eglin AFB, road biking on sparsely traveled paved roads and mountain biking on approximately 20 miles of trails, which are shared with runners and hikers.

Water-based recreation is also popular in several waterways including 186 miles of steephead and seepage streams and the waters of the Yellow and East Rivers. These pristine, cool waters provide shade from above and a sandy stream bed underneath and are used for canoeing, kayaking, swimming and shoreline picnicking. The day-use only beaches on Santa Rosa Island and Cape San Blas are a major attraction, with visitors from as far away as California due to their miles of soft white sand and turquoise waters. Visitors are often staying in nearby resort areas. Popular activities include fishing,

swimming, sun bathing, and beach walking. Also, for those who obtain a permit from Gulf County, driving on the beach of Cape San Blas is allowed except when closed due to military mission activities.

Eglin AFB is known for its recreational hunting, which is in high demand, especially for deer hunting as such opportunities in Florida are limited. Florida's reputation for relatively low-quality deer hunting is counter-balanced by Eglin AFB, which actively manages for deer hunting to improve the quality of the experience. In addition to deer hunting, several game birds such as wild turkey, bobwhite quail, and dove and other small game (grey squirrel, rabbit) are actively managed. As shown in Table 4-3, hunters have access to more than 250,000 acres of Eglin AFB.

Freshwater fishing at Eglin is enjoyed in 226 acres of managed ponds, at least 14 other ponds, and in the outstanding rivers and streams on the open portions of the base. Saltwater fishing is accessible from the 20 miles of Gulf of Mexico shoreline and several estuarine bays along the Gulf of Mexico. Both types of fishing are popular, but only freshwater fishing requires a permit from Eglin AFB.

4.3.4 Recreation Benefit Assessment Methodology

Several economic benefit assessment methods are available for estimating the value of goods and services, such as outdoor recreation opportunities on public lands. Using market data is not an option because for public goods such as outdoor recreation on public lands, there are no market data. Instead, academic economists have devised valuation methods that rely upon collecting data on the public's recreation activities and expenditures to estimate demand curves for and economic benefits from visiting recreation areas. The measure of economic benefits is called "consumer surplus" because it is the net amount that the individual is willing to pay for the recreation experience over and above their cost. Usually, the cost of recreating on public lands is equal to the cost of travel, a modest entrance fee, and perhaps some supplies.

Conducting a survey to collect and analyze data on recreation trips and expenditures can be costly and time consuming. For this reason, considerable effort has been invested by EPA, U.S. Forest Service, and other federal agencies and countries in compiling and assessing the existing body of literature for its transferability to new contexts (EPA 2000). The benefit transfer class of economic valuation methods relies upon the empirical and methodological literature involving natural resources offering similar recreation experiences to develop estimates for new situations. The empirical literature on the value of such recreational opportunities in other areas is used in combination with site-specific information and best professional judgement to develop defensible estimates of the economic benefits applicable to the study site. The approach taken in this study is to estimate the economic benefits of the outdoor recreation opportunities supported by Eglin AFB using a benefit transfer method.

The two key parameters in estimating recreation benefits are the quantity of recreation visitor days (or trips) by type of recreation activity and the dollar value per visitor day or trip. The latter parameter depends upon factors such as the type of recreation activity (for example, hiking, biking, wildlife viewing), the quality of the recreation destination (for example, scenic beauty, lack of congestion, uniqueness), and availability of substitutes. For estimating the quantity of recreation visits by type of activity it is helpful that Eglin AFB requires permits for most activities. The occasional visitor may purchase a daily permit or, for camping and hiking the scenic trail, they may purchase a single-use but multiple day permit. In the case of these one-time use permits, the number of permits sold is equivalent to the number of known recreation visits. Intensive users purchase annual passes, which complicates the quantification. To estimate the number of visits by annual pass-holders, we relied upon data compiled by the U.S. Department of Interior et al. (2018), the Outdoor Foundation (2018), personal interviews with Mr. Chris Johansen, Outdoor Recreation Manager at Eglin AFB, as well as expert opinion. For people who participated in a recreation activity such as freshwater fishing, hunting, and hiking, these data sources provided estimates of the average number of days they spent in the activity and the share of those days within 10 miles of their home. These data combined with information on the length of the recreation season and personal observations on visitation were used to construct a lower bound, an upper bound, and a best estimate. The best estimate is used for this assessment.

The estimates of dollar value per visitor day are based upon the Recreation Use Value Database, which currently contains results from 421 economic valuation studies covering all 50 states and Canada from 1958 to 2015 (Rosenberger 2016). National and state parks and other high-quality recreation destinations dominate the database. For the purposes of Eglin AFB, the activities of greatest interest are hunting, freshwater fishing, beach visits, hiking, camping, and gathering forest products, as well as a general recreation category with multiple activities including wildlife viewing, non-motorized boating, leisure biking, and picnicking. Within the general recreation category, it was not possible to separately identify the number of visits by type of recreation activity as the general permit for public access recreation at the Eglin AFB covered each of these activities.

4.3.5 Recreation Benefit Assessment Results

For each activity, the list of included valuation studies was based upon relative similarity to the Eglin AFB. Studies covering Florida, Georgia, and Alabama were generally included, as were national averages. After adjusting the values to 2018 dollars, the dollar per visitor day statistics corresponding to each of the recreation activities are reported in Table 4-4, including the mean, standard deviation, median and 25 percent and 75 percent quartiles. The median is the preferred estimate as it is not overly sensitive to the tails of the distribution. The medians range from a low of \$19 for camping to a high of \$107 for a day at the beach.

Table 4-4. Estimates of Dollars per Visitor Day by Recreation Activity

	Hunting	Fishing	Beach	Hiking	Camping	Forest Products	General
Number of Estimates	42	60	16	7	6	9	76
Mean	\$111	\$64	\$112	\$54	\$17	\$70	\$60
Standard Deviation	\$79	\$50	\$104	\$43	\$9	\$56	\$54
Median	\$85	\$43	\$107	\$45	\$19	\$62	\$44
25 Percent Quartile	\$58	\$30	\$26	\$22	\$10	\$31	\$25
75 Percent Quartile	\$156	\$84	\$149	\$73	\$23	\$90	\$74

Source: Rosenberger (2016).

To complete the RBA, the other necessary component is the number of Eglin AFB visitor days per activity. These are summarized in Table 4-5, with supporting information provided in Appendix C, Table C-1 Eglin AFB Recreation Visitor Data. In total, it was estimated that Eglin AFB has roughly 500,000 recreation visits per year.

The median consumer surplus values per visitor day are multiplied by the best estimates of the number of outdoor recreation visits corresponding to each recreation activity and summed across activities to arrive at the assessment of the annual value of outdoor recreation. Based on the RBA, the total annual value across all recreation activities is approximately \$32 million (Table 4-5). If visitation continues at this rate over the next 30 years, at a 3 percent discount rate, the net present value is approximately \$641 million. The 3 percent discount rate represents individuals time rate of preference for consuming goods and services now rather than later and it is estimated by the risk-free long-term rate on U.S. Treasury bonds.

Table 4-5. Annual Value and Net Present Value of Outdoor Recreation at Eglin Air Force Base

	Number of Visits Per Year	2018 Dollars per Visit	2018 Dollars per Year	Net Present Value at 3 Percent
Hunting	8,5748	\$85	\$7,288,580	
Fishing	30,598	\$43	\$1,315,719	
Beach	117,744	\$107	\$12,598,608	
Hiking	364	\$45	\$16,380	
Camping	1,530	\$19	\$29,070	
Forest Products	817	\$62	\$50,654	
General	258,669	\$44	\$11,381,425	
Total	495,470		\$32,680,435	\$640,550,956

\$ = U.S. dollars

At present, there are no direct threats such as from commercial or residential development that would jeopardize public access to Eglin AFB for outdoor recreation. As previously mentioned, the Eglin AFB enjoys an excellent relationship with the community and with local authorities, who recognize the importance of the base to the local economy and to quality of life through maintaining and protecting, open space, habitat for wildlife, and recreation opportunities. Nonetheless, the area south of the base continues to develop and Santa Rosa Island is an exquisite resource that some would like to develop. Sea level rise and climate change provide a different source of threat. One only need look at the destruction that befell Tyndall AFB from last year's storms to comprehend the vulnerability of the coastal resources in the region. Historically, Santa Rosa Island has been struck by several hurricanes. Thus, the potential loss of Santa Rosa Island provides a plausible example for illustrating the resultant losses in recreation benefits to the public – in other words, the net environmental benefit, which, in this example, would be negative. From Table 4-5, the estimated annual recreation losses would be approximately \$12.6 million. At a 3 percent discount rate, and a 30-year time horizon, this comes to approximately \$247 million in net present value.

Although hundreds of millions of dollars, these losses would likely be small in relation to the adverse impacts to the test and training mission, which are an issue of technical superiority and national security, but they are additive to those losses and they are felt most directly by the local community. By expressing these losses in dollars, this provides the base commander and the local community with additional basis for supporting mission assurance and defending against alternative uses of the ranges or loss of the ranges to sea level rise.

4.3.6 Discussion

Public access to military installations for outdoor recreation is encouraged by the Sikes Act and, in the case of the Eglin AFB, has strengthened ties with the local community and further secured sustained support for its test and training mission. Americans who are not fortunate enough to live near military bases may not be aware of the outdoor recreation opportunities that are made available throughout the United States. Furthermore, some local governments may not fully appreciate the public benefits provided by the military bases. This information can be especially important in situations where local authorities are facing pressure from competing uses for the military lands. There may also be local residents who are inconvenienced by military operations and it can be important to promote the public benefits as a counterpoint and broader public good consideration to their personal concerns.

Eglin AFB encompasses more than 464,000 acres and more than half of the area is open to the public for recreation. Although the base does not keep counts on the number of visitors each year, it is estimated that the Eglin AFB supports approximately 500,000 yearly visits to hunt, fish, hike, camp, picnic, canoe,

kayak, bike, view wildlife, gather forest products, or recreate at the beach. These outdoor recreation activities generate approximately \$33 million in net recreation-based economic value each year. The fees collected from the sale of permits partially offsets the cost of maintaining and managing the natural resources at Eglin AFB, which supports the mission while providing recreation opportunities. For example, some missions require long and wide expanses for testing purposes. These protected areas are nonetheless suitable habitat for wildlife, including species such as deer. This improves the hunting experience in the public access areas.

The \$33 million in annual economic value represents a net benefit to the public. This is the value of the recreation experiences over and above what is paid by them out of pocket. If this level of recreation activity were to continue over the next 30 years, it would generate more than \$640 million in net present value. This information could be useful to Eglin in communicating with local authorities and policy makers. In the course of supporting the military mission, Eglin AFB provides \$33 million in net recreation-based economic value each year, in addition to the unqualified national security and military missions.

Approximately \$12.6 million of this annual value is due to access to Santa Rosa Island, a prime destination for beach recreation. This island is a highly desired barrier island by commercial and residential property developers and is vulnerable to sea level rise and storms from climate change. The use of NEBA enables the implications of program changes to be understood. In this example, the knowledge about the recreation value enjoyed by the public could be used to strengthen the rationale for continuing to manage and protect this resource for National Security military weapons test and training.

5. Summary

The DoD has been actively engaged in research on tools and approaches to account for natural capital and ecosystem services in decision making. Despite the considerable advances in valuing natural capital, the DoD pointed out several knowledge gaps such that “full consideration of natural capital in environmental management and decision-making has not been realized” (SERDP 2017). Furthermore, “quantitative approaches have been developed for substantiating these benefits yet none of these approaches focus on the dedicated environmental stewardship at defense installations” (SERDP 2017). To address these gaps, the present research set out to investigate the applicability of three tools - business supply chain paradigm, CV, and NEBA - that have been employed successfully in other contexts to evaluate their suitability toward meeting DoD needs. The findings for each are summarized below, along with future research recommendations.

The business supply chain paradigm was considered and rejected and was replaced by the NCP. The NCP, CV method, and NEBA each have stand-alone value, but there are also linkages among these tools. As a group they address the natural capital gaps identified by DoD related to decision making and documenting the value of DoD environmental stewardship. The NCP, at a minimum, is an awareness tool geared to inform organizations about their supply chain natural capital dependences and impacts, and the associated risks. In the case of DoD, it can also be used to delineate the public-dependent ecosystem services that flow from DoD lands. CV is a method to quantify the economic value of the DoD environmental stewardship, and the NEBA framework has been demonstrated to generate value-added information to support project level decision making. Cumulatively, these tools and their outputs can help reduce operational risk and sustain support for DoD test and training missions.

5.1 Business Supply Chain Paradigm

Using an assessment tool called LCPA, we evaluated the business supply chain paradigm as a platform for “full consideration of natural capital in environmental management and decision making.” The premise was that this paradigm can provide a consistent framework for standardizing the process of identifying and accounting for risks, threats, conflicts, opportunities, system dynamics, boundaries, and scale associated with natural capital managed by DoD to meet its mission.

While LCPA is a tool, it is also part of a paradigm that companies operationally integrate into investment processes and decision making. The integration involves adopting a set of standards around ESG, with the intent of maintaining a “license to operate.” Through our analysis process, which included the workshop at Eglin AFB, we ultimately concluded that LCPA as applied in the private sector did not seem to be a good fit for Eglin AFB and other military installations because “license to operate” is less relevant to the military; ESG is a newer concept to the government; bundling E&S elements can be confusing and not readily relatable to military readiness; there is a lack of uniform metrics for the social and governance aspects; and valuation is not a strong aspect of LCPA.

Further research resulted in considering the NCP (Natural Capital Coalition 2016a) as an alternative framework to potentially integrate natural capital into valuation and management of DoD training and testing lands. The NCP is being used by the business sector to identify natural capital impacts and dependencies so that actions, where necessary, can be taken to ensure continued access to natural capital that support the business and address impacts that pose a business risk. The NCP is also used to identify positive impacts and opportunities. NCP focuses on natural capital as it relates to operational risk reduction and public benefits identification (as opposed to evaluating natural capital as a supplier category using a set of ESG standards). Operational risk reduction and public benefits identification are both important objectives for sustaining test and training operations on military installations. In addition, the NCP is a publicly available flexible framework, investments continue to be made to improve it, it would provide a consistent, repeatable methodology, and its use in industry is increasing.

For each step of the NCP process, templates are provided that include general actions, a list of outputs, and a series of questions and directives to generate the outputs. These could be adapted to the military

context in the form of guidance to provide a structured road map to comprehensively integrate natural capital consideration into decision making and to reduce operational risks. An example of adaptation would include a focus on military dependency on natural capital, public dependency on ecosystem services from military lands, and military impacts (positive and negative) on natural capital. While interrelated, each is important for sustaining test and training operations on military installations. In the “Measure and Value” steps of the NCP process, many existing tools that DoD has or is using (for example, InVEST, LCTA, and EDYS) as well as CV and NEBA, subjects of this current research project, would be applicable and beneficial.

We believe the NCP shows considerable promise as a focused framework to integrate natural capital into valuation and management of DoD training and testing lands. An NCP application pilot study on one or more DoD installations is recommended. If the results are positive, then the pilot study could be followed by guidance development.

5.2 Contingent Valuation

Due to the mission of providing the military forces needed to deter war and to protect the security of our country, the DoD generated co-benefits of environmental stewardship for the unique ecosystems, habitat for TES, biodiversity, and large stretches of relatively undisturbed open space under its management. The DoD indicated that land value assessments to date have not fully captured this environmental stewardship value.

The stewardship co-benefits have an economic value to individuals independent of their direct use and enjoyment of the resources. Referred to as “passive use value,” it is a difficult value to quantify because there are no market data or other data on peoples’ preferences that can be analyzed. To address this issue, we evaluated the CV benefit measurement method, which relies upon survey data compiled by presenting respondents with information about the natural resources and choice situations, whereby, for example, they trade off dollars for preservation.

The outputs of a CV study could: 1) Support decision making by understanding the incremental benefit of natural resource asset types when considering acquisitions, divestitures, re-use, land swaps, leases, land withdrawals, or other activities involving significant changes in the quantity or quality of relatively unique habitats; 2) Contribute valuable information to the assessment of off-installation activities that may impinge upon national parks, wilderness areas, and other valued natural resources; 3) Provide supporting information to justify natural resource management funding requests; and 4) Demonstrate DoD stewardship value to the public. In all circumstances, the objective of monetizing benefits is to support decision making when balancing training requirements, land stewardship, and costs. Given the complementarity between DoD’s readiness mission with protecting and restoring the natural resources under its management, knowledge of the stewardship value is expected to strengthen the case for keeping those resources under DoD management.

Our research provides a detailed discussion of the steps necessary to apply the CV methodology to address the stewardship valuation question, including an estimated range in cost and time needed to complete the analysis. We recommend implementation of a CV study for an installation or in support of the evaluation of a specific action being considered. The work that we have completed as part of this study could form the basis of a request for proposal.

5.3 Net Environmental Benefit Analysis

We proffered that NEBA could provide value-added information to decision makers faced with alternative test and training land management techniques and options regarding land use or the timing of actions. Specifically, we proposed that the information could be used to rank alternatives in terms of maximizing environmental benefit, minimizing environmental losses, and achieving the greatest environmental benefit for a given budget, thus facilitating the mission and optimizing co-benefits. The research tested the hypothesis that NEBA can be effectively used from a cost and time perspective to provide decision

makers necessary information to assess environmental tradeoffs, balancing training requirements, land stewardship, costs, and legal drivers.

As part of this research project, we provided a detailed description of NEBA, reviewed and summarized its historic and current DoD applications, identified situational characteristics that can be indicative that NEBA application could provide value, and presented a historical example where NEBA was used to assess mitigation alternatives. In addition, based on the input received at the Eglin AFB workshop, we prepared a recreation benefits assessment for Eglin's recreation program. Using those results, we presented a demonstration of the calculation of a net environmental benefit associated with a hypothetical change in recreation access.

NEBA application contexts for DoD have included remediation, mitigation, infrastructure, lease assessment, and redevelopment. The dominant application is the evaluation of remedies for contaminated soil, surface water, sediment, and groundwater, including at closed and inactive ranges. In these cases, the analyses have identified the protective remediation alternatives that provide the greatest net environmental benefit (or least loss) at the lowest cost. The core purpose behind these NEBAs was to facilitate acceptance of a cost-effective path forward to site closure.

Three under-served application contexts were identified where NEBA could provide additional value to DoD in the future: active ranges, compensation and capital projects. Use at active ranges would provide military decision makers with value-added information regarding the management options to address chemical contamination, un-spent munitions, or accumulated debris that would achieve protection and safety objectives with the least environmental impact, and at the lowest cost. For defining compensation for permitted impacts, NEBA can be used to scale the proper amount, define which alternative provides the highest credit per dollar spent, and enable consideration of "out of kind" mitigation, which can help land or opportunity-constrained facilities comply. For capital projects (that is, new construction, renovation, and improvement), NEBA has the potential to facilitate the minimization of impacts and capture of opportunities to create environmental value. The suite of characteristics that are indicative that a NEBA could provide significant value in capital project assessment include:

- Two or more alternatives that would meet project objectives
- Potential effects on ecological functions or passive or active human use value
- Differing type, or scale, of environmental impacts by alternative
- A project cost that would justify the funding for a NEBA

The example of a net environmental benefit calculation using Eglin AFB's outdoor recreation program began with the assessment of program benefits. Eglin AFB encompasses more than 464,000 acres and more than half of the area is open to the public for recreation. Our analysis estimated that Eglin AFB supports approximately 500,000 yearly visits to hunt, fish, hike, camp, picnic, canoe, kayak, bike, view wildlife, gather forest products, or recreate at the beach and that these outdoor recreation activities generate approximately \$33 million in net recreation-based economic value each year.

The \$33 million in net annual economic value represents a net benefit to the public. This is the value of the recreation experiences over and above what is paid by them out of pocket. If this level of recreation activity were to continue over the next 30 years, it would generate more than \$640 million in net present value. This information might be valuable to Eglin AFB in their communications with local authorities and policy makers.

For the NEBA demonstration, it was assumed that Santa Rosa Island, which is a part of Eglin AFB and a prime destination for beach recreation, would no longer be available for recreation either because of development or sea level rise. It was estimated that approximately \$12.6 million of the total annual value of the Eglin AFB recreation program is due to access to Santa Rosa Island or, using a 3 percent discount rate and a 30-year time horizon, approximately \$247 million in net present value. The potential loss of Santa Rosa Island provides a plausible example for illustrating the resultant losses in recreation benefits to the public – in other words, the net environmental benefit, which, in this example, would be negative. Although hundreds of millions of dollars, these losses would likely be small in relation to the adverse

impacts to the test and training mission, which are an issue of technical superiority and national security, but they are additive to those losses and they are felt most directly by the local community. By expressing these losses in dollars, this provides the base commander and the local community with additional basis for supporting mission assurance and defending against alternative uses of the ranges or loss of the ranges to sea level rise.

It is recommended that DoD consider developing guidance to identify and convert opportunities to use the NEBA framework and associated economic benefit assessment methods (for example, benefit transfer and habitat equivalency analysis) on a project-specific basis to evaluate environmental tradeoffs and more comprehensively integrate natural capital considerations into decision making. Outputs from tools already in use by DoD, such as InVEST, can feed into a NEBA.

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Appendix A
Eglin Air Force Base Workshop
Attendance List

SERDP Project DoD Natural Capital Workshop

Eglin AFB

December 12, 2018

Attendance List

NAME	ENTITY	ROLE	E-MAIL	Phone
Jonathon Weier	Jacobs	Project Manager	Jonathon.Weier@jacobs.com	678-451-8287
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Appendix B

Natural Capital Protocol Templates



NATURAL
CAPITAL
COALITION

Natural Capital Protocol

User Templates

13 July 2016

Note to user:

These user templates are designed to help structure your outputs for each Step of the [Natural Capital Protocol](#). You are invited to adapt and add to the tables in this document, to fit to your needs and objectives.

The hypothetical example, running throughout the Protocol, may also offer some inspiration and illustration of how to approach the Steps.

Step 01: Get started

Question that this Step will answer	Actions
Why should you conduct a natural capital assessment?	1.2.1 Familiarize yourself with the basic concepts of natural capital
	1.2.2 Apply these concepts to your business context
	1.2.3 Prepare for your natural capital assessment

Outputs that you should achieve from this Step:

- ☐ An understanding of the basic concepts of natural capital
- ☐ Initial ideas about which natural capital impacts and/or dependencies might present risks or opportunities for your business, now or in the future.
- ☐ Potential applications of your assessment results.
- ☐ In principle, support for the assessment from key business stakeholders.
- ☐ Initial understanding of the resources needed to carry out a natural capital assessment (to be refined in subsequent steps).

Templates that can help you reach these outputs:

1. How do the concepts of natural capital apply to your business context? What impacts and dependencies are you aware of already, and how might these manifest into risks and/or opportunities? Think about your context now, and in the future. Table 1.1 offers some examples.
2. List the potential applications of your assessment results. Table 1.2 offers some examples.
3. Which internal stakeholders could you approach for support, and why?
4. Using table 1.3 of indicative resources, what will you need to plan for your assessment?

Step 02: Define the objective

Questions each
Step will answer

Actions

**What is the objective
of your assessment?**

2.2.1 Identify the target audience

2.2.2 Identify stakeholders and the appropriate level of
engagement

2.2.3 Articulate the objective of your assessment

Outputs that you should achieve from this Step:

- ☐ The defined audience who will ultimately consider and apply the results of the assessment
- ☐ A stakeholder list and appropriate level of engagement
- ☐ The specific benefits you anticipate from the assessment
- ☐ Building on the above, you should have a defined objective for your natural capital assessment.

Templates that can help you reach these outputs:

1. Who is the target audience?
2. Who are the right stakeholders, and what is the appropriate level of engagement for each?
3. What specific benefits do you anticipate from the assessment?
4. What is the specified objective?

Step 03: Scope the assessment

Questions each
Step will answer

Actions

What is an appropriate scope to meet the objective?

- 3.2.1 Determine the organizational focus
- 3.2.2 Determine the value-chain boundary
- 3.2.3 Specify whose value perspective
- 3.2.4 Decide on assessing impacts and/or dependencies
- 3.2.5 Decide which type of values you will consider
- 3.2.6 Consider other technical issues (i.e., baselines, scenarios, spatial boundaries, and time horizons)
- 3.2.7 Address key planning issues

Outputs that you should achieve from this Step:

- ☐ A well-defined scope, that is appropriate for your assessment and objective

Templates that can help you reach these outputs:

1. What is your organizational focus?	
2. What is your value-chain boundary?	
3. What is your value perspective?	
4. What types of value?	
5. Are you assessing impacts and/or dependencies? (Component)	
6. What other technical issues do you need to consider? For example: a. Baselines b. Scenarios c. Spatial boundary d. Temporal boundary	
7. What key planning issues will you need to consider?	

Step 04: Determine the impacts and/or dependencies

Questions each
Step will answer

Actions

Which impacts and/or dependencies are material to your assessment?

4.2.1 List potentially material natural capital impacts and/or dependencies

4.2.2 Identify the criteria for your materiality assessment

4.2.3 Gather relevant information

4.2.4 Complete the materiality assessment

Outputs that you should achieve from this Step:

- ☐ A prioritized list of material impacts, dependencies and changes in natural capital to include in your assessment.

Templates that can help you reach these outputs:

Which impact and/or dependency pathways are potentially material to your business? (See Table 4.3 for a detailed example)?

Which criteria will you use for your materiality assessment?

Which internal and/or external stakeholders will you engage in your materiality assessment?

	Material issues			
Materiality Criteria	Issue 1	Issue 2	Issue 3	Expand as required
<i>e.g. operational</i>	<i>Low/medium/high</i>			
<i>e.g. legal and regulatory</i>				
<i>e.g. financing</i>				
<i>e.g. reputational and marketing</i>				
<i>e.g. societal</i>				
To include in assessment?	<i>Yes/No</i>	<i>Yes/No</i>	<i>Yes/No</i>	<i>Yes/No</i>

Step 05: Measure impact drivers and/or dependencies

Questions each Step will answer

Actions

How can your impact drivers and/or dependencies be measured?

5.2.1 Map your activities against impact drivers and/or dependencies

5.2.2 Define which impact drivers and/or dependencies you will measure

5.2.3 Identify how you will measure impact drivers and/or dependencies

5.2.4 Collect data

Outputs that you should achieve from this Step:

- ☐ A list of indicators for each material impact driver and/or dependency associated with the chosen business activities, in accordance with the chosen organizational focus and value-chain boundary.
- ☐ Available data and data gaps identified

Templates that can help you reach these outputs:

Material issue	Impact driver/dependency	Indicator	Data source	Data gaps / key uncertainties
<i>Issue 1</i>				
<i>Issue 2</i>				
<i>Issue 3</i>				
<i>Expand as required</i>				

Material issue	Indicator	Intermediate indicator if applicable	Data point
<i>Issue 1</i>			
<i>Issue 2</i>			
<i>Issue 3</i>			
<i>Expand as required</i>			

Step 06: Measure changes in the state of natural capital

Questions each Step will answer

Actions

What are the changes in the state of and trends affecting natural capital related to your business impacts and/or dependencies?

6.2.1 Identify changes in natural capital associated with your business activities and impact drivers

6.2.2 Identify changes in natural capital associated with external factors

6.2.3 Assess trends affecting the state of natural capital

6.2.4 Select methods for measuring changes

6.2.5 Undertake or commission measurement

Outputs that you should achieve from this Step:

- ☐ A list of the changes in natural capital that are material to your business, in relation to your impacts and/or dependencies, based on your chosen organization focus and value chain boundary. These changes should be expressed through qualitative or quantitative data.
- ☐ Likelihood-weighted estimates of change, where relevant.

Templates that can help you reach these outputs:

Material issue	Change in natural capital	Method to measure change	Indicator for change	Data source	Data gaps / key uncertainties	Summary of findings
<i>Issue 1</i>						
<i>Issue 2</i>						
<i>Issue 3</i>						
<i>Expand as required</i>						

Step 07: Value impacts and/or dependencies

Questions each Step will answer

Actions

What is the value of your natural capital impacts and/or dependencies?

- 7.2.1 Define the consequences of impacts and/or dependencies
- 7.2.2 Determine the relative significance of associated costs and/or benefits
- 7.2.3 Select appropriate valuation technique(s)
- 7.2.4 Undertake or commission valuation

Outputs that you should achieve from this Step:

- ☐ A completed valuation (whether qualitative, quantitative or monetary) of costs and benefits
- ☐ Documentation of all key assumptions, sources of data, methods used, and resulting values

Templates that can help you reach these outputs:

Planning to value		
Issue	Consequences of impact or dependency on business or society (depending on choice of component)	Chosen valuation technique
<i>Issue 1</i>		
<i>Issue 2</i>		
<i>Issue 3</i>		
<i>Expand as required</i>		

Results of valuation		
Issue	Value to the business (If applicable to scope)	Value to society (if applicable to scope)
<i>Issue 1</i>		
<i>Issue 2</i>		
<i>Issue 3</i>		
<i>Expand as required</i>		

If considering potential values in the future, you may also choose to add a column for probability-weighted future values. See table 7.3 for an example.

Step 08: Interpret and test the results

Question each Step will answer	Actions
How can you interpret, validate, and verify your assessment process and results?	8.2.1 Test key assumptions
	8.2.2 Identify who is affected
	8.2.3 Collate results
	8.2.4 Validate and verify the assessment process and results
	8.2.5 Review the strengths and weaknesses of the assessment

Outputs that you should achieve from this Step:

A summary of:

- ☐ Key messages, caveats, assumptions, and uncertainties, including the results of sensitivity analysis if appropriate.
- ☐ Output(s) from validation and internal/external verification (if appropriate) of the assessment process and results, including an objective acknowledgement of key assumptions and uncertainties around the results.
- ☐ Notes on the review process itself, including how critical assumptions were tested, what level of confidence was deemed necessary, and why.

Templates that can help you reach these outputs:

1. What are the findings after testing key assumptions and conducting a sensitivity analysis? What does this imply for your level of confidence, and how the results can be interpreted, communicated and used?
2. What were the key strengths of your assessment?
3. What were the key weaknesses of your assessment?
4. With who, and how, will you share these learnings and conclusions?

Step 09: Take Action

Question each Step will answer

Actions

How will you apply your results and integrate natural capital into existing processes?

- | | |
|-------|--|
| 9.2.1 | Apply and act upon the results |
| 9.2.2 | Communicate internally and externally |
| 9.2.3 | Make natural capital assessments part of how you do business |

Outputs that you should achieve from this Step:

- ☐ Actions that you will take as a result of the assessment
- ☐ A communication plan
- ☐ A plan for making natural capital assessments part of how you do business.

Templates that can help you reach these outputs:

Material issue	How will you apply and act upon the result?
<i>Issue 1</i>	
<i>Issue 2</i>	
<i>Issue 3</i>	
<i>Expand as required</i>	

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Appendix C
Estimates of Recreation Visitor Days in
the Outdoor Recreation Areas of
Eglin Air Force Base

Appendix C. Eglin AFB Recreation Visitor Data

Recreation Activity and Permit Type ^a	Number Purchased	Days Permit is Valid	Lower Bound Estimate - Number of Trips per Person	Best Estimate Number of Trips per Person	Upper Bound Estimate - Number pf Trips per Person	Lower Bound Estimate - Total Number of Trips	Best Estimate Total Number of Trips	Upper Bound Estimate Number of Trips per Person	Literature Values			
									Average Number of Days	Share Local (%)	Eglin Share of Local (%)	Best Estimate - Number of Days
Total Annual Sportsmen - Hunting activity^b	6812	Seasonal	1	12	16	6812	81744	108992	16	100%	75%	12
7 Day Sportsman's Permit	254	7	1	5	7	254	1270	1778				
Special Opportunity Hunts ^c						0	0	0				
7SFG Archery Hunt	79	4	4	4	4	316	316	316				
Turkey Lottery Hunt	24	2	2	2	2	48	48	48				
Wild Hog Dog Hunt	167	5	5	5	5	835	835	835				
Youth Lottery Hunt (Closed Area)	50	2	2	2	2	100	100	100				
Youth Weekend Hunt (Open Area)	309	3	3	3	3	927	927	927				
Mobility Impaired Hunt	50	2	2	2	2	100	100	100				
Furbearer Stamp	10	365	1	5	32	10	50	320				
Daily Dove Permits	358	1	1	1	1	358	358	358				
Total Hunting						9760	85748	113774				
Fishing^d												
Annual Permits ^e	6659	Seasonal	1	4	8	6659	27269	54537.21	13	63%	50%	4.095
Daily Permits ^f	3329.5		1	1	1	3330	3330	3329.5				
Total Fishing						9989	30598	57866.71				
General Recreation^g												
Annual Permits ^h	13471		1	19	38	13471	256299	512598	151	63%	20%	19.026
Daily Permits	600		1	1	1	600	600	600				
Special Use Permitⁱ	118	1	10	15	20	1180	1770	2360				
Total General Recreation						15251	258669	515558				
Camping^j	510		1	3	10	510	1530	5100				
Hiking Florida Scenic Trail^k	364	7	1	1	1	364	364	364				
Beach												
Eglin Annual Beach Permit ^l	5352		1	18	32	5352	96336	171264				
Undocumented beach usage ^m	5352		1	4	7	5352	21408	37464				
Total Beach Recreation						10704	117744	208728				
Personal Forest Product Permits						0						
Firewood Permits	310	3	1	2	3	310	620	930				
Christmas Tree Permit	73	3	1	1	1	73	73	73				
Pine Straw Permit	45	3	1	2	3	45	90	135				
Deer Moss Permit	17	3	1	2	3	17	34	51				
Total Personal Forest Product Recreation						445	817	1189				
						47022	495470	902580				

Notes:

^a Permit Data are from October 1, 2017 through September 30, 2018

^b Average days are from the 2016 National survey of Fishing, Hunting and Wildlife-Associated Recreation; Eglin share based on BPJ of Outdoor Recreation Office Director

^c These special hunt opportunities are over and above the regular hunts.

^d The fishing permits are also valid for general recreation

^e Assumes all annual permit holders will fish. 2016 Survey of Fishing, Hunting and Wildlife-Associated Recreation estimates 13 fishing days; whereas the outdoor recreation report estimates 18 fishing days and includes saltwater fishing.

^f Assumes Number of daily fishing permits is half of total daily permits.

^g Pleasure driving, hiking, horseback riding, boating, canoeing, kayaking, bicycling, berry picking, swimming, picnicking, and bird watching.

^h Assumes all annual permit holders will engage in one or more of the recreation activities besides fishing and hunting. Frequency estimates are from the outdoor participation survey.

ⁱ Groups, civic, church and naturalists

^j Camping trip = 14 days or less, party size ranges from 1 to 10. Average of 3 is based on BPJ.

^k Each Thru-hiker must have own permit, which is good for a one-time use for up to 7 days.

^l Assumes 2 beach visits per week for 18 weeks as this is a unique and pristine beach with no nearby substitutes with public access.

^m Estimate is based on Outdoor Recreation Officer's informal beach survey of permit holders and non-permit holders.

BPJ = Best Professional Judgement