Manager's Guide to Refuge Vulnerability Assessment & Alternatives:

Overview and Practical Considerations

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Cover Photo

Sunset on Aransas Bay, TX. Patrick Crist.

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INTRODUCTION

This guide introduces and summarizes a comprehensive approach for assessing refuge vulnerability and developing adaptation strategies and alternatives, known as the "RVAA." It provides practical considerations for National Wildlife Refuge and other land managers interested in scoping and initiating such a project. It also serves as an introduction to the TECHNICAL GUIDE FOR ASSESSING VULNERABILITY FOR REFUGES AND LANDSCAPES AND DEVELOPING ALTERNATIVES FOR MANAGEMENT (Technical Guide) found at *www.fws.gov/home/climatechange/[subpage]*.

What is Refuge Vulnerability Assessment and Alternatives?

A Refuge Vulnerability Assessment and Alternatives (RVAA) is an assessment of the vulnerability or susceptibility of a refuge's biological and **infrastructure**[1] resources to a range of **stressors**, such as **development**, invasive species, and climate change. While focusing on these resources, other resources are readily incorporated such as historical and recreational resources. Assessing refuge vulnerability involves a series of steps: gathering information on refuge resources and stressors, analyzing current and predicted relationships between resources and stressors, and interpreting that information to identify specific ways in which resource management could be adapted or altered to maintain resource health in the face of predicted stressors. The overall goal of an RVAA is to provide information on current and future predictions of conditions of refuge resources to help managers make better-informed decisions around refuge management and planning. Beyond individual refuges, the RVAA process can help address the need of the National Wildlife Refuge System to identify and meet its conservation and management goals in the face of climate change and other stressors and facilitate landscape-scale collaborative planning.

The Technical Guide describes the RVAA process in detail. It is designed for the scientific and technical staff who coordinate and conduct the actual assessment. The process is derived from widely used conservation planning and management concepts and approaches such as vulnerability assessment, cumulative effects assessment, **ecosystem-based management**, and adaptive management. The RVAA therefore is intended to be integrative of various methods and approaches; for example, non-spatial scenario-based planning can be an important component of an RVAA and separate guidance for such approaches is referenced in the Technical Guide.

What is the Spatial Extent of an RVAA?

The condition and management of surrounding lands has an influence on the ecological health of refuge resources. Therefore, RVAAs are focused not only on the refuge or grouping of refuges of interest, but also on the **supporting landscape** and the larger **ecoregion** in which the refuge is located. The refuge is the focus of the RVAA, but understanding the condition of its resources and how they are managed at these broader scales provides additional critical context to inform management decisions. As a result,

[1] Glossary terms are indicated in **bold** the first time they appear in the text.

RVAAs can help inform management and conservation decisions at scales ranging from individual refuges or groupings of refuges to landscapes and ecoregions.

> The supporting landscape in an RVAA is defined by the area surrounding the refuge that contributes to the viability of the refuge's biological resources or influences refuge resources due to the stressors present within it. It encompasses the refuge(s) being evaluated and provides a broader geographic context for identifying the most relevant conservation and management issues and appropriate locations for potential action within and around the Refuge Complex.

How Do RVAAs Relate to Other Planning and Assessment Processes?

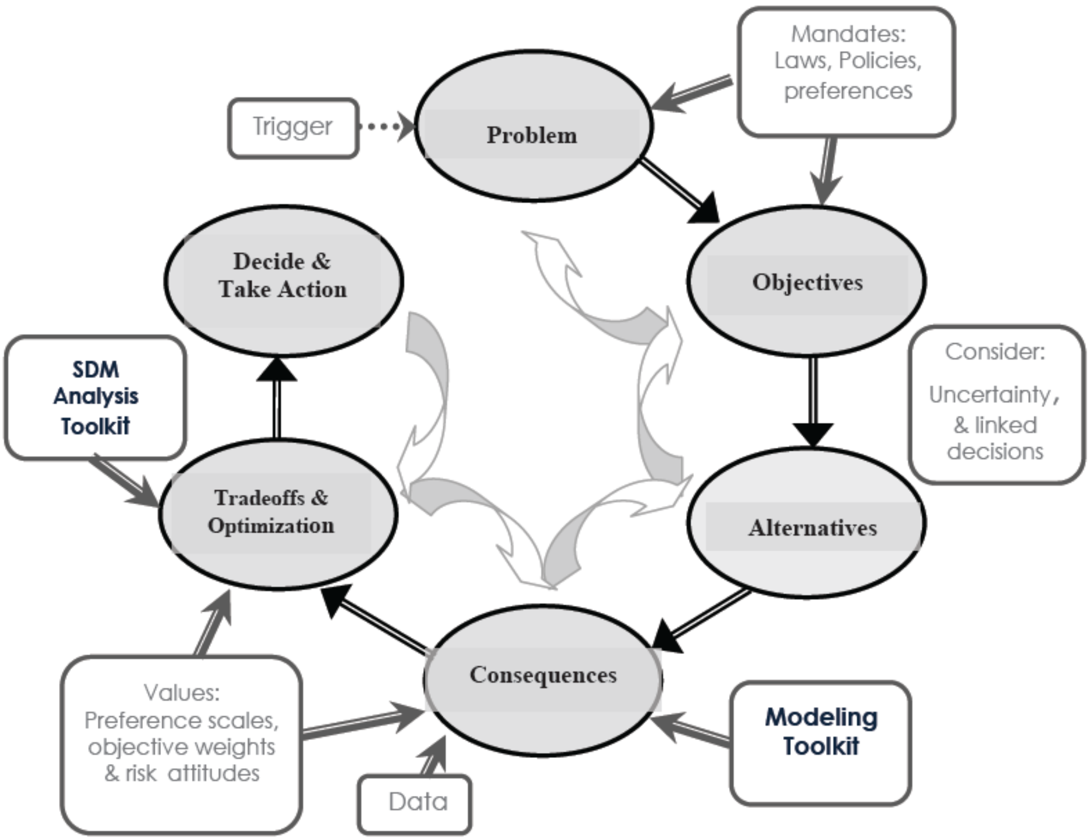
RVAAs are intended to make important contributions to the development of **Comprehensive Conservation Plans** (CCPs) and **Step-down Management Plans**. For example, forecasts of changes in stressors, resources, and infrastructure can help identify significant issues during pre-planning. RVAAs conducted at landscape levels can inform the broader goals and objectives of a refuge's ecosystem and watershed by providing scientifically based predictions of future conditions. The projections of future conditions of refuge resources and related information resulting from an RVAA can also be used to improve development of CCP alternatives. An RVAA can help refine objectives and strategies in step-down management plans that are based on general goals and objectives in the CCP.

RVAAs integrate well into the **Strategic Habitat Conservation** (SHC) approach. SHC is an adaptive resource management framework designed to help make better management decisions about where and how to deliver conservation efficiently to achieve specific biological outcomes.[2] It is an ongoing, iterative planning and decision-making process built around five key principles: 1) biological planning, 2) conservation design, 3) conservation delivery, 4) monitoring and **adaptive management**, and 5) research. The results of an RVAA can provide important information for biological planning by identifying threats and limiting factors, and using **models** to describe the relationship of **populations** to habitat and other limiting factors. It can support conservation design by identifying priority geographic areas for conservation or other management options and determining population-based objectives for habitat or other limiting factors. An RVAA can also help support conservation delivery. As an assessment of available science derived from scientific literature, on-site refuge data, expert opinion, and sound professional judgment, an RVAA brings scientific credibility to management decisions.

As with SHC and other planning and assessment frameworks, the RVAA framework embodies key elements of a **structured decision-making** (SDM) process[3] as illustrated in Figure 1. Climate change and other stressors on refuge resources are the problem to be addressed, conservation goals of the refuge and its resources are the objectives, and the RVAA process provides information that can be used to inform management alternatives as well as predict the consequences of those options. As with the feedbacks built into the SHC framework, the RVAA process similarly has logical points where previous steps may be revisited.

[2] See SHC summary at *www.fws.gov/science/shc*.
[3] See SDM fact sheet at *www.fws.gov/science/doc/structured_decision_making_factsheet.pdf*.

Figure 1. The structured decision-making process (courtesy FWS/National Conservation Training Center).



How Can RVAAs Support Collaborative Landscape Management?

Integrating climate change vulnerability assessment and adaptation strategy development into U.S. Fish and Wildlife Service (FWS) practices was a primary reason for developing the RVAA framework. While the RVAA guidance is oriented to FWS refuge processes and terminology, the approach is globally applicable and many different agencies and organizations should find it useful. Its broad applicability is important because a key part of the RVAA approach is the optional-but-useful collaboration with other organizations in the assessment area. Given the distribution and movement of resources and stressors across jurisdictional boundaries, it is increasingly necessary to take a collaborative approach to mitigate stressors and retain resources. A fairly complete RVAA is also cost-prohibitive for most individual refuges and thus a key benefit of a collaborative approach is the potential to share the cost of an RVAA among the relevant partners. Moreover, the process identifies specific locations within the supporting landscape where conservation and management issues are of highest concern, whether or not refuges have a formal presence there. This provides critical information for the National Wildlife Refuge System (or other land-management agencies or organizations using the RVAA process) to maximize achieving their mission, objectives, and influence within and beyond present borders.

How Can RVAAs Help Make Better Conservation Decisions?

In providing refuges with information on resource status and conditions, susceptibility of those resources to climate change and other stressors, and predictions of future resource conditions, both within and around a refuge, RVAAs can help inform decision-making by:

- **Quantifying the amount and diversity of habitat types that refuges contribute to the larger landscape, and how climate change and other stressors are predicted to affect each habitat over time.** Understanding how habitats and other refuge resources may be impacted both beyond and within refuge boundaries may shift or influence how we manage those resources on the refuge.

- **Identifying which management actions can mitigate the changing condition and extent of these habitats in the face of climate change or other stressors, and which management approaches may be ineffectual or have negative effects.** We may not be able to stop the loss of some habitats, but we can see where we should concentrate on conserving remaining high-quality areas and what actions would most effectively achieve this.

- **Identifying stressors (such as energy development) that are expected to have the greatest future impacts on biological resources on lands surrounding refuges.** This information could inform, for example, evaluations of the potential effects on sensitive or threatened and endangered species that may result from permitting an activity in important habitat.

Photo: Gail Collins.

- **Identifying, quantifying, and ranking stressors preventing the achievement of refuge conservation goals.** This will enable refuges to focus first on reducing impacts of the most serious stressors and to plan for subsequently addressing the second tier of stressors. For instance, an RVAA may support a decision to exclude grazing from an area to meet wildlife conservation goals and objectives. We may also identify areas where protective measures, such as constructing fire breaks along a boundary increasingly threatened by cheat grass wildfires, would be most effective.

- **Assessing hypothetical scenarios in which lands around refuges or other protected areas are managed with a greater emphasis on resource conservation to identify which habitats and species might benefit most from such altered management**. For example, a scenario where land between refuges is managed as a wildlife migration corridor could be analyzed to see whether and to what degree this might benefit the wildlife in question.

- **Prioritizing areas to establish new refuges, conservation easements, or cooperative agreements with conservation partners.** RVAAs can highlight specific areas that are not part of the refuge, but whose acquisition or compatible management through partnerships would contribute to refuge resource goals as well as the broader goals of the National Wildlife Refuge System.

- **Enhancing the scientific credibility of the wealth of practical knowledge of refuge staff regarding habitat changes, movement of species, or increasing threats, thereby bolstering our justifications for choosing particular management actions.**

- **Identifying infrastructure most at risk from climate change or other stressors so we can plan accordingly.** For example, understanding projections of sea-level rise or increased fire frequency in certain habitats can inform planned maintenance of, improvements to, or even relocation of visitor facilities, roads, fences, and other infrastructure.

- **Informing monitoring and timing of management actions relative to plans and forecasts of stressors.** Forecasts of stressors such as climate change and development can and should substantially influence what and where to monitor for ecological changes and the timing of when management interventions should be conducted. While it may be tempting to "give up on" resources that are forecast to disappear from the refuge, it is important to maintain resource viability so populations have a chance to adapt.

Where Have RVAAs Been Conducted?

Using the process outlined in the technical guide, RVAAs have been completed for two refuge complexes in 2010 and 2011: the Eastern Shore of Virginia NWR (which included Fisherman's Island NWR), and the Sheldon-Hart Mountain National Wildlife Refuge Complex. These provide examples of what an RVAA might look like and how it can be used.

These two assessments were used to develop and test the RVAA process and illustrate the RVAA Technical Guide (as well as steps in this managers' guide). The experience in conducting these pilots also informed the suggestions provided in this guide for scoping and efficiently conducting an RVAA. The reports produced for these pilots can be found at *www.fws.gov/home/climatechange/[subpage]*. Many other refuges and regions are engaging in climate vulnerability assessments and adaptation planning, and these efforts will be an important source of additional examples for conducting assessments and developing adaptation strategies.

When Should an RVAA Be Conducted?

All refuges and landscapes can benefit from conducting and RVAA; however, the expense of a complete RVAA may not be feasible for all areas. Understanding climate change trends and forecasts, synergies with other stressors, and potential vulnerability of resources can inform the utility of proceeding with a detailed spatial assessment. The box at right identifies some "filters" that could be used cost-effectively at a regional basis to determine landscapes that would especially benefit from a complete RVAA process.

Regional analyses can help identify the highest-priority areas for conducting comprehensive RVAA projects.

- Climate change trend analyses can determine areas likely to experience the greatest changes
- Species climate change vulnerability analyses can identify refuges that have highly vulnerable species
- Plans and forecasts of other stressors such as urban and energy development, fire regime change, and invasive species spread may suggest the need for an RVAA

Photo: Patrick Crist.

How is an RVAA Conducted?

RVAA Process Overview

The RVAA process is intended to be flexible to available time, resources, expertise, and starting point relative to previous work. An RVAA can be a relatively simple assessment completed internally by refuge staff or it can be an in-depth assessment utilizing a range of analytical tools and engaging with a variety of partners. Refuge staff capacity and funding, potential for conducting the RVAA among a group of partners, planning timelines, and other factors will inform the degree of complexity of the assessment.

Regardless of the complexity of the chosen approach, the basic components of an RVAA include:

1) Confirming the conservation objectives for the refuge(s) of interest and the supporting landscape
2) assessing the influence of climate change and other stressors in meeting those conservation objectives by projecting likely changes to refuge resources (biological, infrastructure, cultural) under a range of future scenarios
3) identifying options to help the refuge meet its conservation objectives in the face of the projected changes

Some potential previous work to draw upon for an RVAA includes:

- Climate change downscale modeling and trend analyses
- Climate scenario workshops that visualized climate effects and brainstormed strategies
- Climate change vulnerability assessments for individual species or habitats

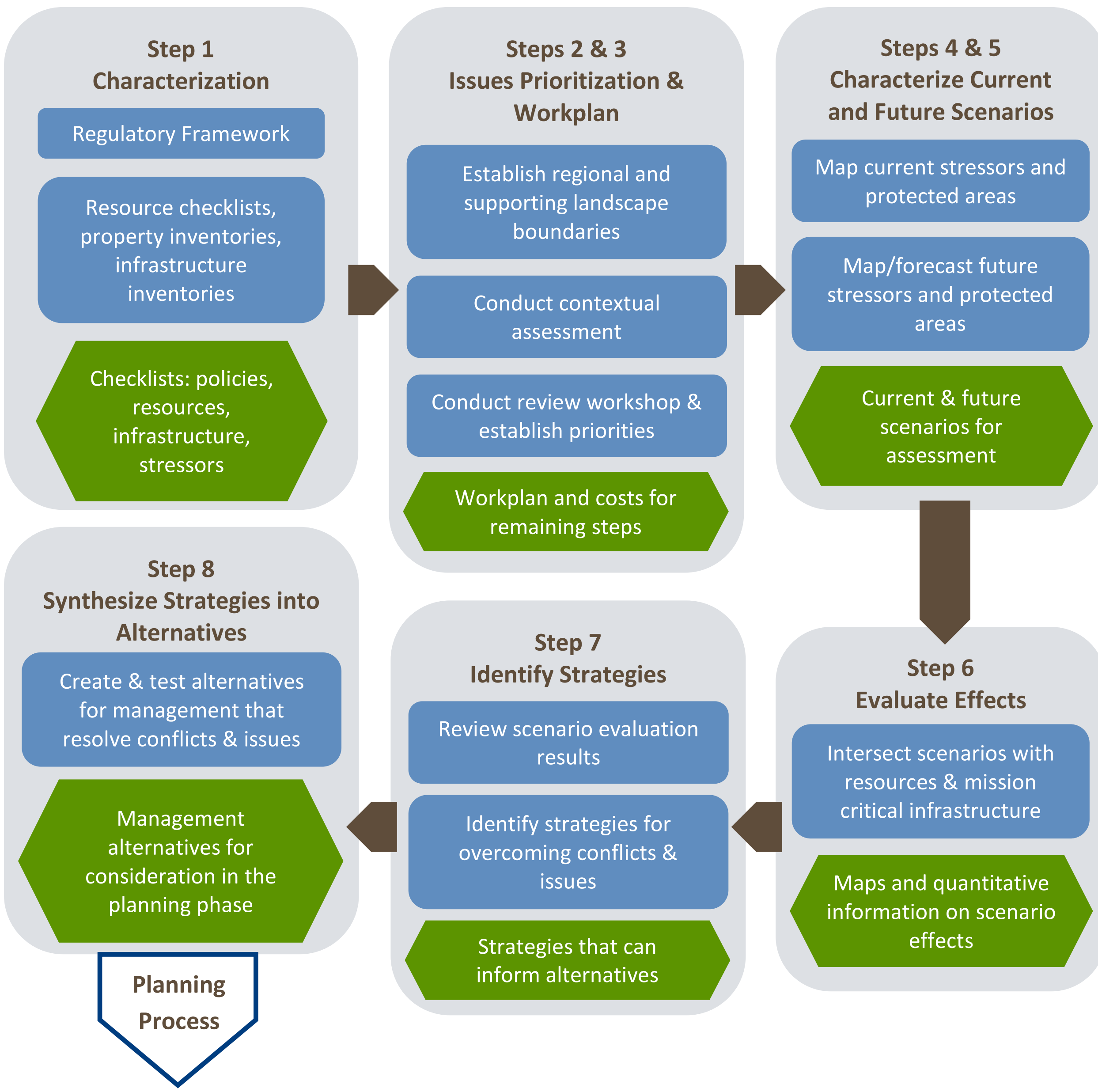
Figure 2 illustrates the specific steps in the process.

Key climate change concepts integrated in the RVAA process are: that stressors such as climate change, development, and certain management actions will lead to **exposure** of resources to stresses; that resources have individual responses to stressors that define their **adaptive capacity**; and that the effect of stressors on the resources results in their **vulnerability**. Also, that certain adaptive actions to mitigate impacts on one resource may have a **maladaptive response** and cause stress to another resource.

Depending on what assessments or plans have been completed for a particular refuge or group of refuges, and how recently, *refuges and regions will start at different points* in the RVAA process. If any RVAA steps have already been accomplished through recent work, they can be skipped or updated with minor revision or additions as appropriate.

Figure 2. The RVAA process.

In the figure, boxes represent steps in the RVAA process and hexagons represent products or results of those steps. Checklists document the candidate resources and infrastructure; decisions by refuge staff and other RVAA participants then determine the list of resources and **mission-critical infrastructure** (MCI) to be assessed, and infrastructure that should be treated as a stressor (infrastructure is often in both categories). Stressors inform development of multiple scenarios characterizing different points in time in conjunction with different management proposals or assumptions. Scenarios and resources are combined in the RVAA to produce cumulative-effects assessments that are combined with regulatory policies to inform the development of alternative strategies and management scenarios which can then inform the remaining planning steps following the RVAA such as development of the preferred alternative.



Steps of the RVAA Process

There are eight major steps for completing an RVAA. They are briefly summarized below and described in detail in the Technical Guide, including detailed outlines of substeps or activities associated with each of the steps.

Step 1: Characterize the refuge(s)' regulatory/policy framework, resources, mission-critical infrastructure (MCI), and stressors. This information is the foundation for identifying the resources and stressors to be evaluated in the RVAA and the data and other information needed to conduct the assessment. Much of the work of compiling this information may have been completed as part of an existing or in-process CCP; otherwise, it primarily entails refuge staff compiling existing documents and expert knowledge. The RVAA framework recommends this information be tracked in a series of checklists; an example is provided in Appendix A.

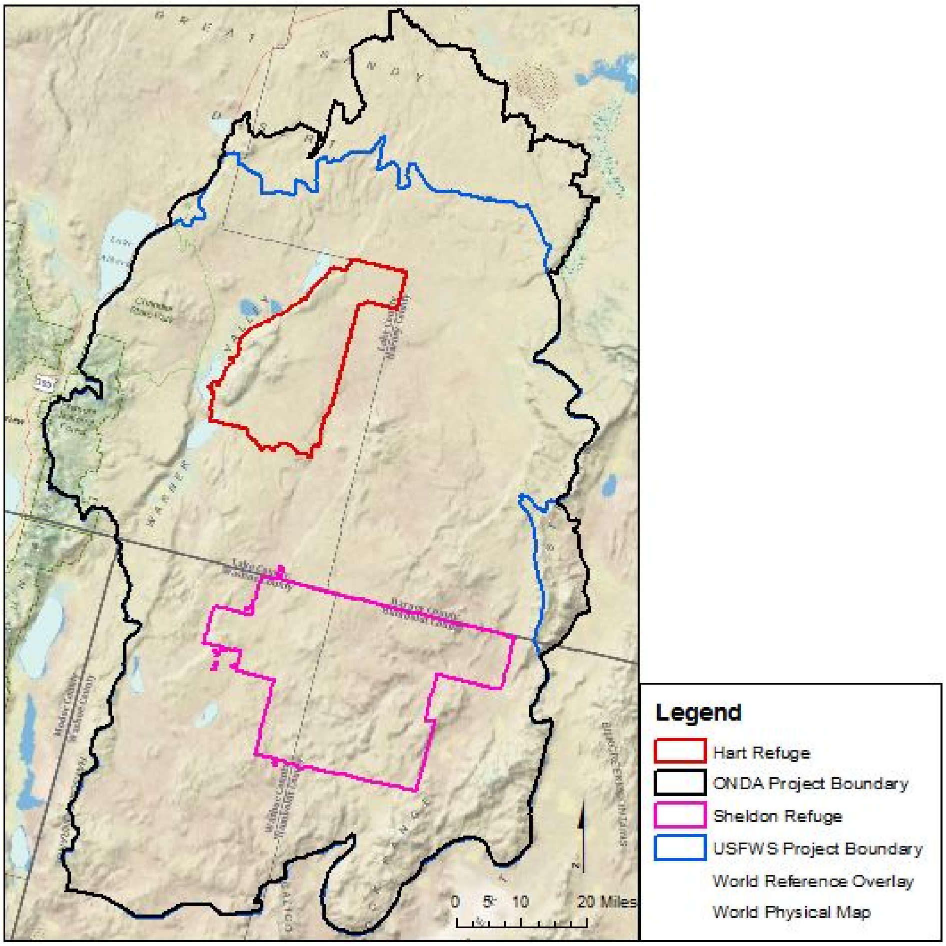
Frequent communication and workshops are critical to a successful RVAA process. Besides being part of any good collaborative process, workshops are important in an RVAA because:

- Climate change represents a novel aspect to refuge planning and considerable time for presenting and discussing the work is needed
- Many science and planning staff are not experienced in spatial analyses and will have many questions; likewise, they have knowledge that can validate, improve, and supplement spatial data
- RVAAs typically deal with modeled and forecast information with varying degrees of uncertainty; staff need time to understand and become comfortable with such information

Step 2: Identify resource conservation priorities and issues. The list of resources to be evaluated and the key issues affecting those resources are refined through workshops and using analyses of the broader refuge context. These contextual analyses clarify the refuge's relative contribution to resources in the supporting landscape and the broader region. Lists of resources and issues to be assessed may have already been refined as part of an existing or in-process CCP, although analysis of the refuge's regional context has probably not been previously conducted. The contextual analyses are readily completed using a **geographic information system** (GIS), while the identification of priorities and issues is conducted by the RVAA project participants, including partners. Reviewing the contextual analyses results and finalizing the priorities is best accomplished in a workshop. Figure 3 illustrates the refuge complex and the supporting landscape of the Sheldon-Hart Mountain Refuge Complex that was assessed in that RVAA.

Figure 3. Example of refuge complex and associated supporting landscape.

This example figure shows Sheldon-Hart Mountain Refuge Complex within the context of its supporting landscape. The supporting landscape is part of the broader context that is evaluated in the preliminary contextual analyses as well as the overall RVAA. The boundaries of the supporting landscape were derived by aggregating ecoregion subsection and watershed boundaries to reflect species populations and ecosystem processes. The broader (black) boundary reflects the expansion of the area through partnership and supplemental funding with a regional conservation group.



Step 3: Identify data needs for the assessment. Identify the needed data, sources of existing data, and data costs, and calculate the cost of conducting the remaining steps. This includes identifying data sets or analyses that may be in development and are relevant to the project area. It is critical to identify such in-progress efforts to avoid duplication of effort. GIS staff in regional and partner offices will be invaluable for this step. This work can be completed through a workshop or through individual review of the lists of resources and issues to be assessed. An example of data needs and sources compiled for the Sheldon-Hart RVAA is provided in Appendix B (also see box below).

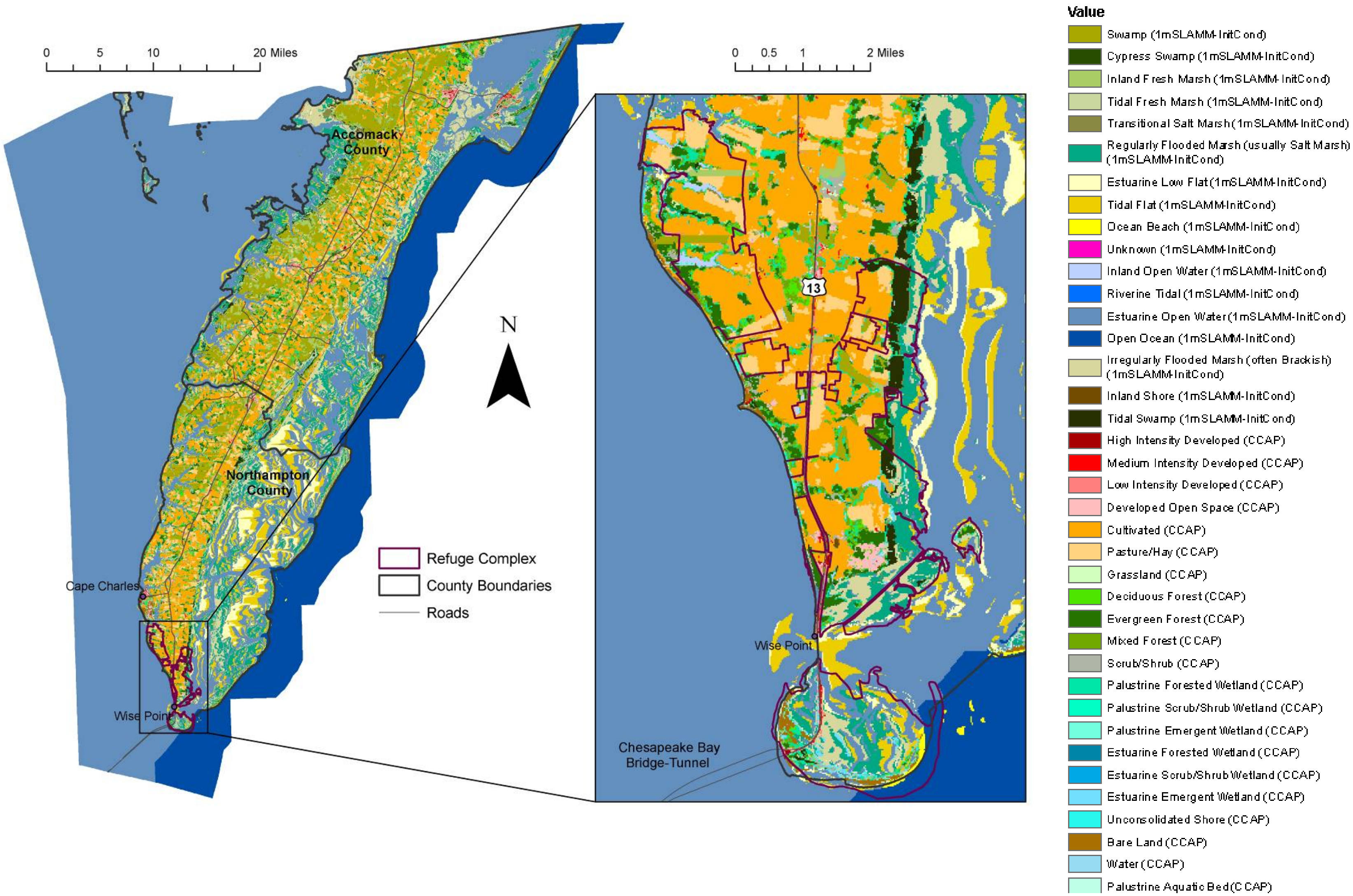
Step 4: Characterize current conditions, management regimes, stressors, and resource response. Use expert knowledge to identify resource **conservation requirements** and compile spatial data on infrastructure features, land management, and other data reflecting current conditions. These data and information are used to create a scenario that describes the current land use, management regime, stressors, and beneficial practices on the refuge and throughout the supporting landscape. Gathering expert knowledge can be efficiently completed through workshops facilitated by taxonomic experts and ecologists, but may also be compiled through individual requests to experts. Characterizing the scenario of current conditions is most effectively completed in a GIS.

Step 5: Characterize planned and forecast scenarios. This step follows the same process as Step 4, but characterizes alternative *future* scenarios based on plans, proposals, and forecasts, including expected climate change effects. It may require more advanced GIS skills to adequately characterize the future scenarios and further participant involvement to define the scenarios. Figure 4 illustrates a land-cover data set containing predicted locations of coastal ecosystems under projected sea level rise resulting from climate change; this input was used to define the 2025 scenario for the Eastern Shore RVAA.

Recent data compilation and forecasting activities that provide useful starting points for RVAAs include:

- Landscape Conservation Cooperatives (LCCs) are collecting data and funding many relevant forecasting and data development activities.
- Bureau of Land Management Rapid Ecoregional Assessments (REAs) are collecting extensive data on resources, stressors, and conducting relevant assessments.
- DoD-lead regional partnerships such as the Southeast Regional Partnership for Planning and Sustainability (SERPASS) and the Western Regional Partnership (WRP) are collecting extensive data sets.
- The Western Governors Association Crucial Habitat Assessment Tool (CHAT) initiative is developing consistent state fish and game data across the western states.

Figure 4. Example of a land-cover input representing future sea level rise under climate change used to define a 2025 scenario in the Eastern Shore RVAA.



Step 6: Evaluate effects. Information on the resources and infrastructure are combined with the current and alternative future scenarios to quantify how well resources are maintained under each scenario. Locations where stressors are or could be hampering the retention of resources are identified, and the extent of stressor impacts is quantified. Figure 5 shows the result of intersecting a 2050 scenario combining urban growth and sea level rise with resources to form a conflict index. This step may only require basic GIS skills utilizing decision-support tools, but could also require advanced GIS and modeling skills. Biologists and ecologists are needed to review the results to ensure they are correct. Figure 6 is an example of a graphic illustrating more advanced modeling of vegetation change under combined stressors of grazing and climate change in the Sheldon-Hart RVAA.

Figure 5. Example of a resource conflict map from the Eastern Shore of Virginia RVAA.

Red shades indicate areas where resources are incompatible with scenario features in 2050; the darker the shade, the more resources there are in conflict with the projected features of the 2050 scenario. Most coastal conflicts are caused by forecast sea level rise.

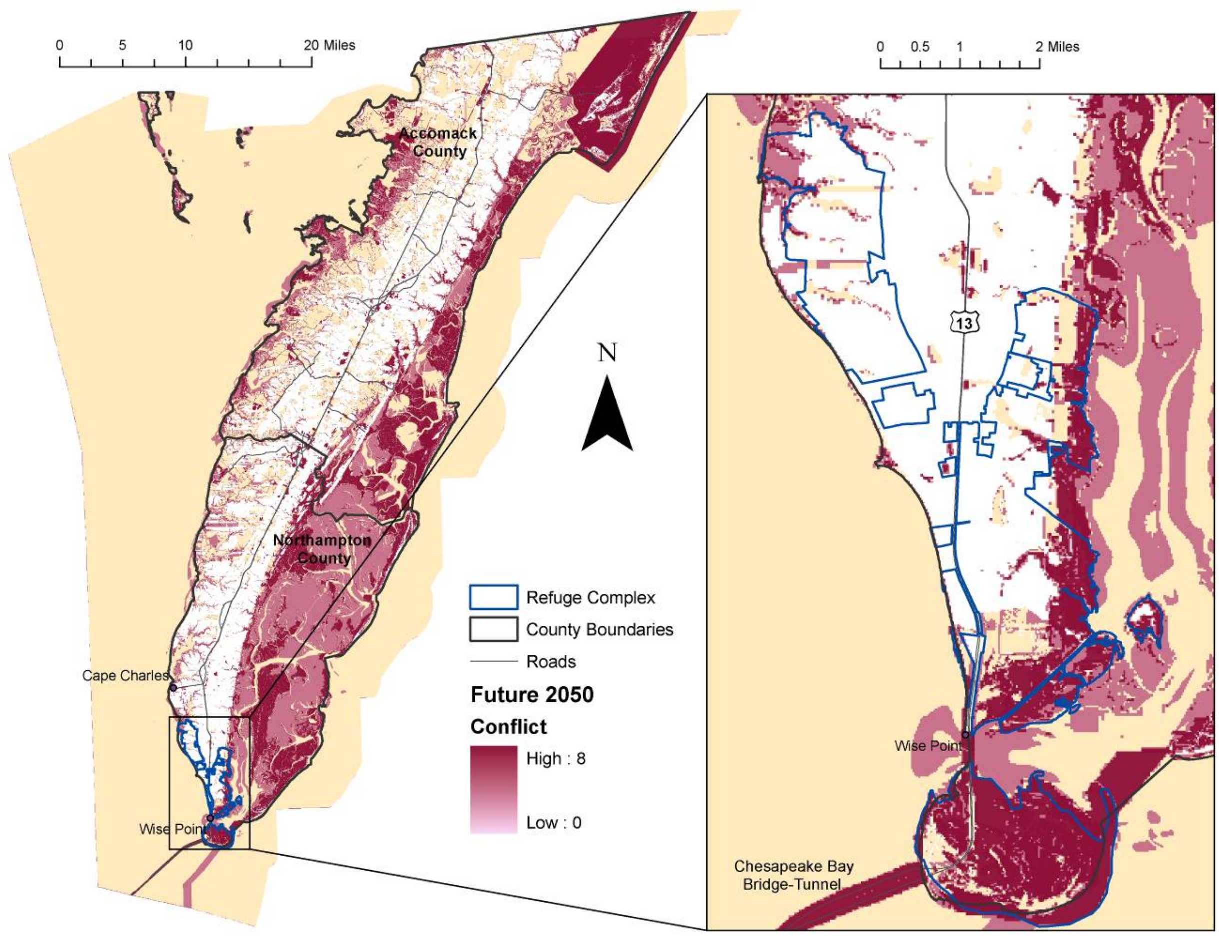
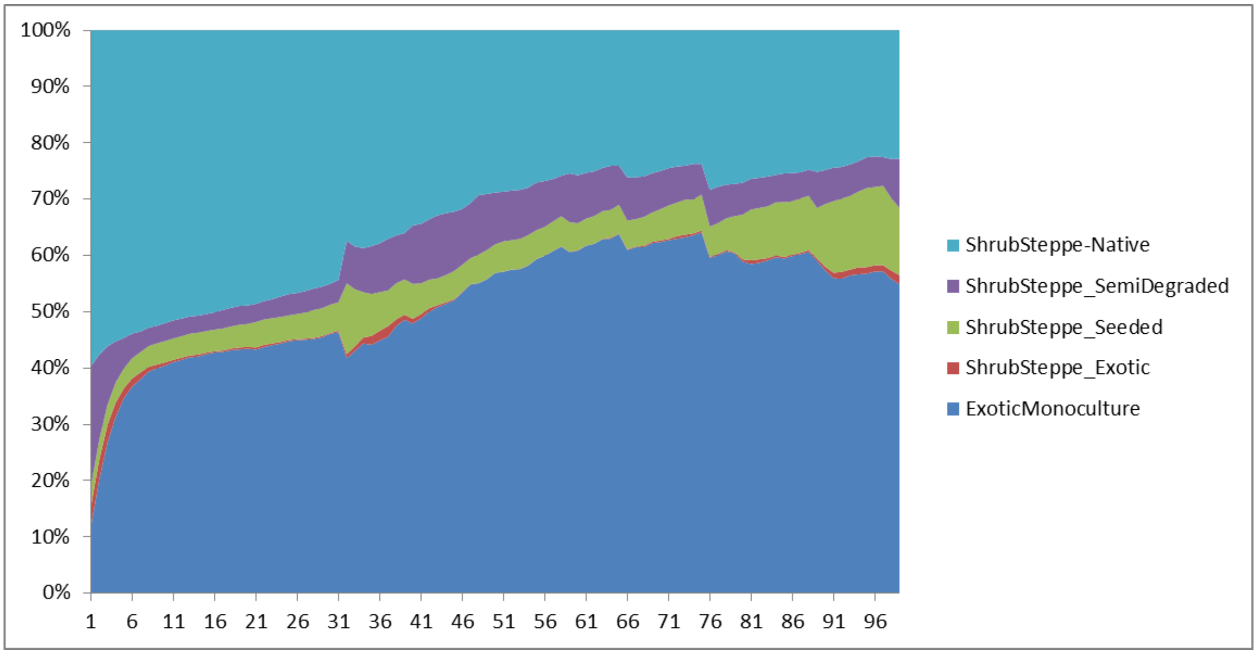


Figure 6. Example of predicted climate change and management effects on vegetation resources in the Sheldon-Hart RVAA.

In this example, the vegetation resource Wyoming sagebrush present in the Sheldon-Hart Mountain NWRC (as represented by “shrub-steppe – native”) decreases in relative proportion to invasive vegetation classes under the combination of management for livestock grazing and climate change. When compared to results where grazing is removed, the assessment illustrates the potential for managing grazing to improve the condition and relative proportion of native vegetation resources.



Step 7: Identify robust strategies. Using the results of the previous step, identify key current stressors, as well as those expected in the future, and describe strategies that can address the stressors and their negative effects on resources. The full team should be involved in this step, preferably in one or more facilitated workshops to review results and develop written strategies.

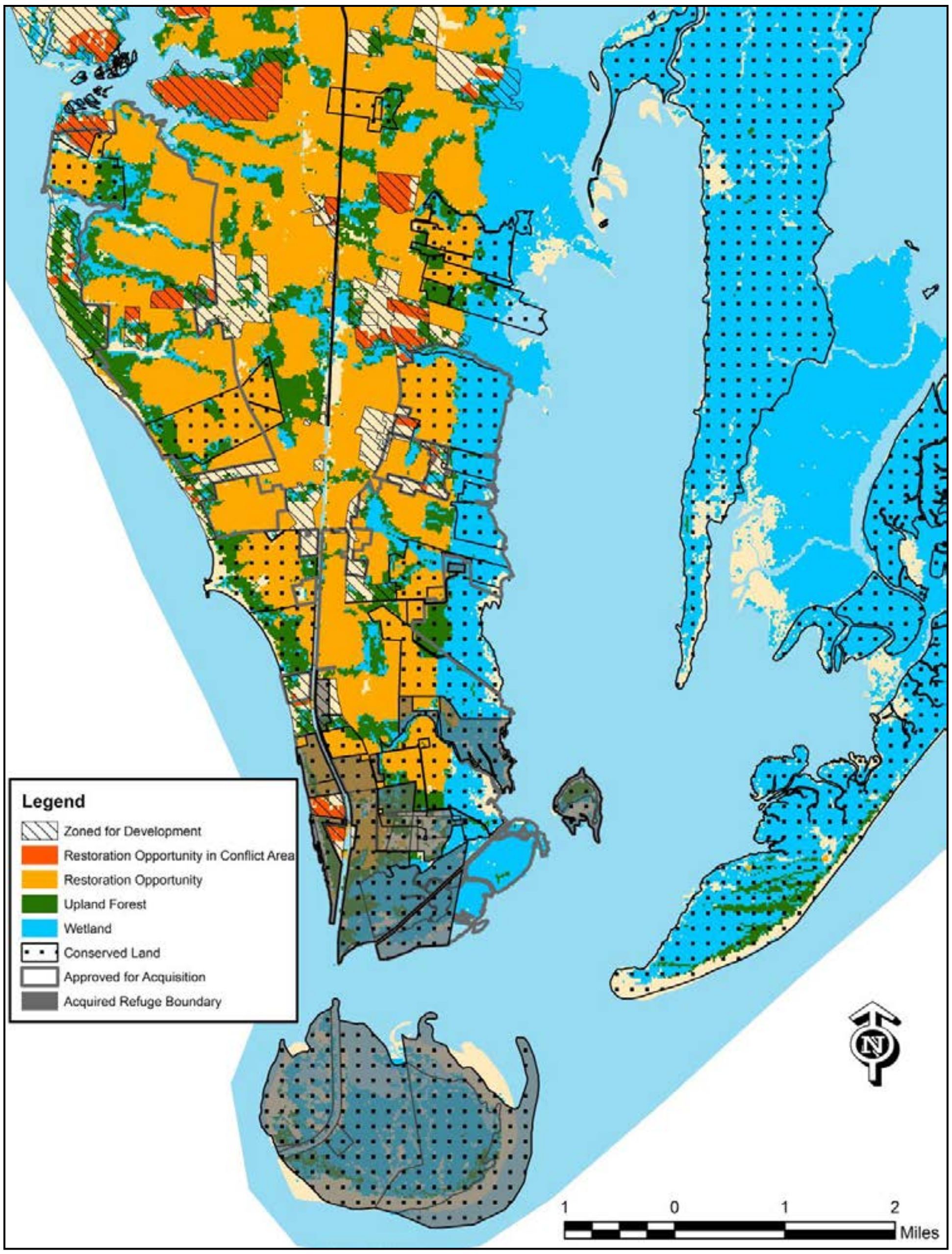
Step 8: Synthesize strategies to develop refuge options that inform development of alternatives. Create one or more maps showing the application of the strategies to particular places (Figure 7 provides an example of this), and describe non-spatial alternatives that will help retain refuge resources in the face of the key stressors. Basic GIS skills are necessary to translate strategies into spatial alternatives, but the full team should review the results to ensure they properly reflect the strategies developed in Step 7. Documenting the entire RVAA process and results in an RVAA report is strongly recommended.

Strategies identified in the Sheldon-Hart Mountain Refuge Complex RVAA include:

- Remove horse/burros, control juniper, manage non-native annual grasses
- Cooperate with neighboring public lands agencies to expand these management practices to areas adjacent to the refuges
- Outreach to private land owners and conservation groups: preserves, conservation easements, land swaps, voluntary management changes, etc.
- Create corridors between refuges as paths for species to migrate with potential climate and vegetation changes
- Participate in public comment and review of energy developments to site in areas already impacted by other stressors
- West Wide Energy Corridor – proposed, but could comment for buried line versus above-ground line, timing of construction, etc.

Figure 7. Example of a spatial configuration of a restoration strategy in the Eastern Shore RVAA.

This figure illustrates how RVAA results might be used to develop a strategy for pursuing CCP objectives for the Eastern Shore of Virginia Refuge Complex. This map uses predicted 2050 land cover and contains spatial representations of managed lands and other intact priority habitats, as well as opportunities for restoration of habitat based on current land cover and zoning. Win-win opportunities for collaborative planning with the local government are illustrated in the orange cross-hatched areas representing areas zoned for future development that are forecast to become wetlands under sea level rise forecasts for 2050.



As described here, the RVAA process includes significant spatial analysis components. Non-spatial assessments are also important when spatial data or appropriate modeling tools aren't available, resources or stressors aren't readily mapped due to insufficient knowledge or high levels of uncertainty, or strategies have pervasive and consistent influence across the assessment area (for example, federal policies).

Photos: FWS.

What is Needed to Conduct an RVAA?

Extensive guidance on general project planning, organization, and coordination are widely available; therefore, those important topics are addressed briefly in this section as they apply to an RVAA. (The Technical Guide does not cover them.) Drawing on the two pilot RVAAs and other relevant experience, guidance on the time, cost, staffing, and expertise, and information needed to conduct an in-depth RVAA are summarized here, along with key suggestions for an effective and efficient project. However, as mentioned earlier, the time, effort, and cost to conduct an RVAA depend on several factors; the RVAA process is readily adapted to fit the needs and resources available to a particular refuge or other management area of interest. Several factors can significantly affect time and cost:

- Timeframe within which RVAA results are needed to inform a planning effort with a set deadline, such as a CCP update
- Available resources including FWS funds, partner funds, and in-kind contributions
- Existing staff capacity and expertise and availability of resources to supplement with outside expertise if needed
- Geographic scope and complexity of the project
- Availability of existing relevant analyses, data, and other information
- Available hardware and software (although with the increasing availability of basic GIS capability within the NWRS, this is a less-frequent limitation)
- Number of partners and the relative benefits of their participation and contributions (a larger number of partners increases the complexity of coordinating the partnership and making decisions)

The guidance provided here is for conducting an in-depth RVAA project without the benefit of any significant existing analyses. Such a project (referred to as "example project") is assumed to have the following characteristics:

- Adequate refuge/regional staffing exists or can be provided in kind to manage the overall project, provide data held by the NWR (or regional office), provide taxonomic expert input, conduct review of draft products, and participate in meetings and development of strategies and alternatives
- Technical, planning, and ecological services capacity or expertise is not available internally and the refuge needs to engage a contractor or key partner(s) to perform these functions
- A single refuge or refuge complex is conducting a complete and detailed RVAA independently (costs are not shared with other public land-management entities)

- The supporting landscape is from one to five million acres in size
- Information and data on biotic resources, stressors (such as SLAMM[4] analyses for sea level rise and marsh migration for coastal NWRs) and relatively fine-scale climate change data are readily available or planned and do not need to be funded by the RVAA project
- No other relevant assessments have been completed that address one or more of the RVAA steps

We also assumed the example project will be conducted independently of potential partners because the feasibility of such partnerships is variable. For projects that do not meet these assumptions, time and resources will need to be added or subtracted as appropriate.

Timeframe

The example project is estimated to take 12 to 18 months assuming there is a core, dedicated team and that staff and other experts can provide timely inputs and review so the assessment can progress without delays. An example of a general project timeline for such a project is shown in Appendix C.

Cost

The example project is estimated to cost in the range of $150,000–200,000 (2012 U.S. dollars); details are listed in Appendix D. This estimate only covers the direct costs for external technical, planning, and ecological services, based on the assumptions above. Given the assumption that this cost is prohibitive for most individual refuges, it is strongly advised to share the cost among multiple partners.


Photo: Patrick Crist.

The Project Team

This section describes the set of roles and skills needed to conduct an RVAA. A single project team member may have more than one of these skill sets; for example, a staff member managing the project may also write and edit the final report. A refuge may have internal capacity to cover these skills or it may need to look to partners or an external contractor. A very rough approximation of the amount of time that might be needed from the team member filling the specified role during the course of the project is included. The time estimates are provided as time units/month

[4] SLAMM stands for Sea Level Affecting Marshes Model. See *warrenpinnacle.com/prof/SLAMM/*.

for ongoing involvement, assuming an 18-month project timeline, or a total amount of time units for one-time or periodic involvement.

- **Project Management** (6 days/month): Oversees all aspects of the project, assuring participants understand and perform their roles, secure bids and manage consultant contracts, coordinate all communication, and manage the budget and schedule. While Project Management needs will vary during different phases of the project, this estimate is an average over the entire project with most time likely required at project startup and near its conclusion.

- **GIS/Data Manager/Lead** (2 days/month): Oversees all spatial data management and GIS work. May be same position as the individual conducting geospatial analyses (see below).

- **Lead Biologist** (2 days/month): Coordinates all biological input to the analyses and participates in scoping, review, strategies, and alternatives development. May review geospatial results and develop interpretations and conclusions.

- **GIS Analyst** (4–5 days/month): Acquires and processes data, conducts all geospatial analyses, develops interpretive products, presents results, writes methods and documentation for report, and works with staff to convert strategies into spatial alternatives. This work will be concentrated in the center phase of the project. For projects pursuing advanced modeling, a broader team of analysts/modelers will be required and time requirements may be substantially higher.

- **Report Editor** (10 days): Develops report outline, compiles contributions from participants, and edits report.

Key Information Inputs

Information needed to conduct an RVAA includes spatial and non-spatial data from a large variety of sources depending on the nature and location of the project. The Technical Guide provides much more detail on specific data and sources for each step; Table 1 provides a general summary of the types of data needed and ideas for information gathering, highlighting where these efforts may be challenging and require thoughtful budgeting.

Table 1. Key information inputs, sources, and comments.

Information Type	Typical Sources	Comments
Resource distribution maps	NWR/regional office databases, state GAP or wildlife division databases, **natural heritage program**	Available data are generally relatively good nationally, but **downscaling** GAP ecological systems maps to more localized habitat maps may be needed/desirable. Species distribution modeling should be considered for key species.
Resource conservation requirements	Expert knowledge is the primary source; some useful information can be found in scientific literature or technical reports	It is a substantial effort for NWR biologists and those from natural heritage programs, other agencies, and universities to establish thresholds, goals, **indicators**, etc. for refuge resources.
Physical stressors & infrastructure distribution data (development)	NWR/regional offices for NWR infrastructure, DOTs, local government planning offices, NRCS, CCAP, GAP	This information is typically readily available. If NWR infrastructure has not been adequately mapped, this work should be conducted
Climate change stressors data	Regional climate science centers/USGS, NOAA, universities, Climate Wizard, SLAMM[1] outputs.	Downscaled climate change data and secondary effects models (e.g., soil moisture changes) are highly dynamic but are increasingly being developed more consistently and at finer scales. For coastal NWRs, FWS has invested in generating SLAMM[1] analyses for many areas.
Other stressors (e.g., invasive species, wildfire)	Landfire program, BLM **Rapid Ecoregional Assessments** in the west, USFS, USGS, NatureServe, natural heritage programs, universities	This information is highly variable in its availability nationally. Effort should be expended to research its availability locally and consider modeling efforts to generate it. If modeling is needed, the effort required may be substantial, especially in combination with climate change forecasts.

Suggestions for an Effective and Efficient Project

Determine the scale of the project

RVAAs are highly scalable and can range from relatively simple workshop-based efforts that review data products (e.g., climate change forecasts) and develop written strategies to detailed geospatial analyses as described in the Technical Guide and the two RVAA pilot projects. Managers should consider what is really needed in terms of products to make management decisions, the level of precision required of the RVAA results, and the available time, funding, and staff for a successful project. The following two suggestions also will have a bearing on these issues.

Conduct a multi-partner landscape project

A key recommendation resulting from the pilot projects is that an RVAA be conducted over a large supporting landscape and involve a partnership with other refuges and/or state and federal land management units. The rationale for this recommendation is that the cost of the technical work of conducting the RVAA will be minimally increased over that for an individual refuge and those costs can be distributed over multiple partners, thus realizing substantial cost savings for each participant. There are other benefits to this approach as well, such as:

- Gaining access to a broader set of knowledge, data, and expertise which may streamline many tasks and allow them to be conducted through in-kind contributions
- Developing a much deeper shared understanding of each partner's objectives and how those objectives and resources are inter-related, and a solid foundation for on-going collaborative planning and implementation

It is important, however, that the size of the supporting landscape is manageable relative to the desired precision of spatial products and the computing power needed to process information at the desired resolution. For example, an ecoregion-size area (like most LCCs) would likely require sacrifices in spatial detail. It is also important that the area be relatively homogenous with respect to resources and stressors to limit the complexity and number of different science specialists involved. For example, a supporting landscape containing both montane and lowland areas would include very different ecosystems and species that would require different expertise.

Determine your starting point

The Technical Guide for conducting an RVAA assumes that none of the steps has yet been completed. Typically, especially for refuges with a contemporary CCP, all or parts of some steps have likely been completed. Many climate change efforts are currently being completed or planned and these will likely represent useful starting points as well. In the process of scoping an RVAA, it is important to research existing work for the refuge and for the landscape area to understand what relevant data and analyses already exist. Sources for such information can include:

- Refuge and regional staff
- LCC coordinators
- Climate Science Centers
- Partner agencies, NGOs, and universities

Schedule key workshops

RVAA work is technical and requires review of both inputs and outputs of the assessment analyses. Over the course of the project it is easy for staff to become disconnected while technical work is being completed. The use of strategic, periodic workshops is recommended to keep the technical team and staff connected, to keep everyone informed about the work, and to keep the technical team on track to provide useful outputs.

GETTING STARTED

As noted above, determining your starting point in the process is critical and will have considerable bearing on how you get started on your RVAA. With that in mind, following are the basic steps to launch the RVAA process. Though these steps are presented sequentially, there are necessarily some concurrent and iterative aspects to conducting them.

1. **Secure partner commitments**. Because contributions of partners (funding or in-kind) can greatly affect the budget and activities such as project extent, scope, and need for coordination meetings, it is important to establish who the partners are and what they are contributing and expecting.

2. **Scope the project**. A general scoping developed either internally or with partners is needed to determine the higher-level criteria for the project with an understanding of the approximate resources available. Following that, a detailed technical scoping of deliverables, budget, and schedule may be completed by appropriate internal and partner staff or by a consultant following relevant portions of the Technical Guide.

3. **Obtain funding and specific in-kind commitments**. Failure to reach the estimated funding needs can result in negotiating additional in-kind support or re-scoping the project within available resources.

4. **Assemble the team**. The project team was described earlier; in this step, contracting (if needed) is completed and the team members are assembled into the desired project team structure (e.g., thematic work groups). The team should prepare information in advance to present to the full team/partners at the RVAA initiation workshop (see the Technical Guide).

5. **Conduct the initiation workshop**. At this workshop, team members and partners are introduced; purpose, objectives, and scope are reviewed; and initial information and findings are presented for discussion and initial decisions about next steps. Plenty of time should be allotted for this workshop as participants will likely have many questions requiring explanations, presentations, and discussion.

Obtaining Further Assistance

The companion Technical Guide provides considerable additional details along with useful examples, sources, and tools to conduct each step. However, if additional assistance is desired, you may contact your Regional Climate Change Coordinator, Assistant Regional Director for Science, the Office of the Science Advisor, or the NWRS Climate Change Coordinator.

GLOSSARY

Adaptive capacity: The ability of a species, ecosystem, or other feature to maintain its integrity and continue performing (or return to) its function if exposed to changes in its environment (such as climate change).

Adaptive management: A management framework founded on the concept of monitoring the outcomes or effects of management actions (and their interactions with other events) and adjusting on-going management decisions and actions based on those outcomes.

Comprehensive Conservation Plan: The term used within FWS for conservation plans for National Wildlife Refuges. According to FWS, it describes the desired future conditions of a refuge or planning unit; provides long-range guidance and management direction to achieve the purposes of the refuge; helps fulfill the mission of the Refuge System; maintains and, where appropriate, restores the ecological integrity of each refuge and the Refuge System; helps achieve the goals of the National Wilderness Preservation System; and meets other mandates. (See more at *www.fws.gov/northeast/planning/whatareccps.html*.)

Conservation requirements: The quantitative and qualitative parameters of what is needed to conserve or maintain a species, ecological system, or other biological resource within a geography of interest. An example of a conservation requirement is the minimum size of a resource occurrence that is needed for the occurrence to persist.

Development: A general term for anthropogenic structures and activities that includes urbanization, industrialization, transportation, mineral extraction, water development, or other human activities that occupy or fragment the landscape or that develop renewable or non-renewable resources.

Downscaling: The process of transferring information from a coarser resolution to a finer resolution (e.g., from 15 km pixels to 4 km pixels), commonly conducted when converting global climate model outputs to regional climate change data. Conversely, “upscaling” is the process of transferring information from a finer resolution to a coarser resolution.

Ecoregion: A geographic area with relative homogeneity in ecosystems. Ecoregions depict areas within which the mosaic of ecosystem components (biotic and abiotic as well as terrestrial and aquatic) differs from those of adjacent regions.

Ecosystem-Based Management: A holistic environmental management approach that takes into account the full array of interactions of the ecosystems and species, as well as anthropogenic activities and influences, present in the area of interest, rather than managing for resources in isolation from each other.

Exposure Generally realized through RVAA Steps 4 and 5 to characterize scenarios that map the location and type of stressors. In Step 6, resources are intersected with scenarios to map which stressors they are exposed to. Simply being exposed to a stressor does not mean any particular resource itself is stressed.

Geographic Information System (GIS): A computer system designed to collect, manage, manipulate, analyze, and display spatially referenced data and associated attributes.

Indicator: Components of a system whose characteristics (e.g., presence or absence, quantity, distribution) are used as an index of an attribute (e.g., land health) that are too difficult, inconvenient, or expensive to measure. (USDA et al, 2005.)

Infrastructure: Buildings, roads, utilities, equipment and other structures or facilities. In an RVAA, infrastructure can be considered both as a feature to preserve as well as a stressor on resources. See also *mission-critical infrastructure*.

Maladaptive response: Certain adaptive actions that might be taken to mitigate stressor impacts on one resource may cause stress to another resource. For example, engineering efforts to protect mission-critical infrastructure (e. g., primary access road to a refuge) from sea level rise, may prevent a wetland type from migrating (adapting) to the sea level rise. The impact on the wetland type would be a maladaptive response to the adaptive action taken to protect the access road. Assessing maladaptive response is equivalent to assessing vulnerability in the RVAA but happens once strategies (Step 7) are turned into alternative management scenarios in Step 8 and then reassessed for beneficial and maladaptive outcomes by revisiting Step 6.

Mission-critical infrastructure: The buildings, roads, utilities, and other infrastructure present on the refuge (or managed land) that is determined to be critical to conducting the operations and achieving the mission of the FWS (or other land manager) on the refuge. (Structures or facilities which are no longer in use or are planned for removal would not be considered mission-critical.)

Model: Any representation, whether verbal, diagrammatic, or mathematical, of an object or phenomenon. Natural resource models typically characterize resource systems in terms of their status and change through time. Models incorporate hypotheses about resource structures and functions, and they generate predictions about the effects of management actions.

Natural heritage program: An agency or organization, usually based within a state or provincial natural resource agency, whose mission is to collect, document, and analyze data on the location and condition of biological and other natural features (such as geologic or aquatic features) of the jurisdiction. These programs typically have particular responsibility for documenting at-risk species and threatened ecosystems, and they

participate in the NatureServe network.
(See *www.natureserve.org/visitLocal/index.jsp* for additional information.)

Population: Individuals of the same species that live, interact, and migrate through the same niche and habitat.

Step-Down Management Plan: A detailed management plan containing specifics on how to meet goals and objectives identified in a more general management or conservation plan, such a Habitat Management Plan step down from a Comprehensive Conservation Plan as used by FWS. (See more at *www.fws.gov/northeast/planning/stepdown.html* and *www.fws.gov/policy/602fw4.html*.)

Structured Decision-Making Process: Carefully organized analysis of problems in order to reach decisions that are focused clearly on achieving fundamental objectives. Based in decision theory and risk analysis, SDM encompasses a simple set of concepts and helpful steps, rather than a rigidly-prescribed approach for problem solving. (FWS, 2008. See more at *www.fws.gov/science/doc/structured_decision_making_factsheet.pdf.)*

Strategic Habitat Conservation: A phased approach of biological planning, conservation design, and delivery, and monitoring and research, all at ecoregional scales. (See more at *www.fws.gov/science/StrategicHabitatConservation.html*.)

Stressor: Any feature, action, or phenomena capable of negatively affecting a resource. Factors causing such impacts may or may not have anthropogenic origins. (Note that a stressor for one resource may not be a stressor on another.)

Supporting Landscape: In an RVAA, the immediate landscape interacting with the refuge (or other area being assessed). It is the area that contributes to the viability of the refuge's biological resources or influences those resources due to the stressors present within it.

Vulnerability By coupling the exposure of resources to stressors in Step 6 with the assessment of resource responses to stressors developed in Step 4, the effect of stressors on the resources (i.e., their vulnerability) results can be calculated.

APPENDIX A. EXAMPLE OF A RESOURCES CHECKLIST

This is an example of a *subset* of a resources checklist that was created for the Sheldon-Hart RVAA. In this RVAA, the resources checklist identified the candidate and final resources that were initially identified from the draft Biological Integrity, Diversity, and Environmental Health Policy and the Conservation Targets lists for the draft Sheldon-Hart NWR CCP and were finalized during two scoping workshops with the refuge staff. The rationale for assessing each resource is typically recorded; in this subset, all resources were considered for assessment because they are a priority for the refuge complex.

Assessment status is a dynamic field used by the project team that was updated throughout the course of the study. Any resource listed was initially a candidate for assessment; those selected to be assessed were then listed as "assessment." In this way, the checklist maintained a record of the resources considered for assessment.

Resource	Identified By	Assessment type (spatial or non-spatial)	Adequate expertise and/or data	Assessment status (candidate, assessment)
Aspen Forest and Woodlands	Refuges	spatial	Y	assessment
Big Sagebrush Shrublands	Refuges	spatial	Y	assessment
Big Sagebrush Steppe	Refuges	spatial	Y	assessment
Cliffs, Canyons, and Barren Lands	Refuges, ORBIC	spatial	Y	assessment
Deciduous Shrublands	Refuges	spatial	Y	assessment
Emergent Marshes and Wet Meadows	PIF	spatial	Y	assessment
Ephemeral Wetlands	Refuges	not assessed*	n/a	candidate
Greasewood Flats	Refuges	spatial	Y	assessment
Juniper Savanna	Refuges	spatial	Y	assessment
Low Sagebrush Shrublands and Steppes	Refuges	spatial	Y	assessment
Montane Mesic Meadows	Refuges	spatial	Y	assessment
Montane Sagebrush Steppe	Refuges	spatial	Y	assessment
Mountain Mahogany Woodlands	Refuges	spatial	Y	assessment
Playa	Refuges	spatial	Y	assessment
Ponderosa Pine Woodlands	Refuges	spatial	Y	assessment
Salt Desert Scrubs	Refuges	spatial	Y	assessment
Semi-desert Grasslands and Steppes	Refuges	spatial	Y	assessment
Springs and Spring Brooks	Refuges	spatial	N	assessment
Streams and Reservoirs	Refuges	spatial	Y	assessment
Thermal Springs	Refuges	not assessed	N	candidate
Western Juniper Woodlands	Refuges	spatial	Y	assessment

*Addressed as part of playas, emergent marshes.

APPENDIX B. EXAMPLE OF A DATA CHECKLIST

This is an example of a *subset* of a resources checklist that was created for the Sheldon-Hart RVAA.

Data Theme	Data Source	Quality/Improvement Needs
Resource Distribution Data		
Ecosystems/habitat types	Refuge vegetation maps, GAP maps for OR and NV	
Biological communities	Refuge vegetation maps, GAP maps for OR and NV	Types from different sources cross-walked to NatureServe community names
Species	ORBIC, Nevada Natural Heritage Program, NatureServe, USFWS	Removed historical and locationally uncertain records. Some species not enough spatial data to include.
Sage grouse leks		Oregon leks and buffered Nevada leks
Antelope corridor data		Data are incomplete
Resource Viability Requirements		
Minimum occurrence size	NatureServe Explorer, ORBIC, reference search	Only used for species where enough data was present and existing EOs supported minimum value
Supporting landscape retention goals	Refuges, ORBIC	
Responses to stressors/management	NatureServe Explorer, ORBIC, reference search	Expert opinion used to fill in gaps where literature source not found
Infrastructure Type/Location Maps		
Roads and rail	Refuges, 2010 Census data	
Buildings	Refuges, GAP land cover map	Probably lacking some private building information
Power/transmission	USFS SageMap data, Refuges	may not have all smaller lines, especially in supporting landscape
Water control structures	Refuges	Do not have off-refuge data

APPENDIX C. EXAMPLE RVAA PROJECT TIMELINE

This example RVAA timeline, shown as a Gantt chart, assumes a complete process (without significant prior work to build upon) conducted over an 18-month period. It assumes all partnership-building activities, scoping, and contracting have been completed, but a manager should allow three to six months for those activities. Time is shown in three-month quarters.

Activity	Q1	Q2	Q3	Q4	Q5	Q6
Step 1. Characterize the refuge(s)' regulatory/policy framework, resources, mission-critical infrastructure (MCI), and stressors	■					
Step 2: Identify resource conservation priorities and issues	■					
Step 3: Identify data needs for assessment	■	■				
Step 4: Characterize current conditions, management regimes, stressors, and resource response.		■	■			
Step 5: Characterize planned and forecast scenarios		■	■			
Step 6: Evaluate effects			■	■		
Step 7: Identify robust strategies				■	■	
Step 8: Synthesize strategies to develop refuge options that inform development of alternatives and complete the RVAA report					■	■

APPENDIX D. EXAMPLE RVAA BUDGET

This budget provides some overall costs (in 2012 U.S. dollars) by steps and total based on pilot RVAA experiences and provides approximate number of personnel hours by step. Personnel costs for external consultants would include GIS analysts and scientists along with planners and consultant project managers. It assumes that project management and coordination will be provided internally and therefore focuses on outside contracting costs for the technical work and some scientific work. See other assumptions in this guide for the "example project."

Activity	Personnel effort in hours	Personnel cost	Travel	Total
General coordination and management	Planner: 144 hrs Project manager: 144 hrs Ecologist: 72 hrs	$34,000		$34,000
Step 1	Planner: 44 hrs Ecologist: 44 hrs	10,000	3,000	13,000
Step 2	Planner: 20 hrs GIS analyst: 70 hrs Ecologist: 24 hrs	10,000		10,000
Step 3	Planner: 16 hrs GIS analyst: 105 hrs Ecologist: 28 hrs	13,000	1,000	14,000
Step 4	Planner: 24 hrs GIS analyst: 70 hrs Ecologist: 70 hrs	16,000		16,000
Step 5	Planner: 35 hrs GIS analyst: 140 hrs	15,000		15,000
Step 6	Planner: 35 hrs GIS analyst: 280 hrs Ecologist: 35 hrs	29,000		29,000
Step 7	Planner: 60hrs GIS analyst: 35 hrs Ecologist: 70hrs	17,000	3,000	20,000
Step 8	Planner: 140 hrs GIS analyst: 140 hrs Ecologist: 105 hrs	38,000	3,000	41,000
Total		$182,000	$10,000	$192,000

*Based on 2012 costs for senior professionals, inclusive of benefits and overhead.