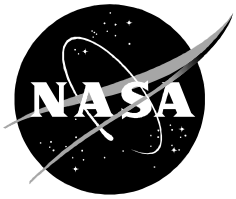

Evaluation of the NatureServe Vista Decision Support System and its Suitability for Supporting Resource Management Plan Development of the Bureau of Land Management Grand Junction Field Office

FY 2009 Benchmarking Final Report
February 27, 2009

Patrick Crist, Principal Investigator
NatureServe
703.797.4810; patrick_crist@natureserve.org
4001 Discovery Drive, Suite 2110
Boulder, CO 80303

1.1 Citation

This report should be cited as:

Crist, Patrick J., M. Anderson, and A. Young. 2009. Evaluation of the NatureServe Vista Decision Support System and its Suitability for Supporting Resource Management Plan Development of the Bureau of Land Management Grand Junction Field Office. NatureServe, Arlington, VA.

1.2 Acknowledgments

This report was prepared by NatureServe and the BLM Grand Junction Field Office (GJFO). The authors and contributors to this report include the following individuals:

- Mathew Anderson, GJFO
- Janny Choy, GJFO
- Pat Comer, NatureServe
- Patrick Crist, NatureServe
- Doug Diekman, GJFO
- Jon Hak, NatureServe
- Janene McCrillis, NatureServe
- Lynn Scharf, NatureServe
- Rob Solomon, NatureServe
- Christina Stark, GJFO
- Cathy Ventling, GJFO
- Aaron Young, GJFO

We also thank Gary Geller of NASA for suggestions and review.

This work was supported under NASA Cooperative Agreement MNGG04GC51A *"Delineating Ecological Systems and Advancing Decision Support Tools for Land Use Planning".*

Additional support was provided by the BLM through a contract from the Colorado Natural Heritage Program and by the David and Lucille Packard Foundation and Chevron for additional stabilization work for the Vista 2.0 release.

2 TABLE OF CONTENTS

3 TABLES

4 FIGURES

5 EXECUTIVE SUMMARY

NatureServe Vista (Vista) is a Decision Support Tool (DST) that supports a wide variety of land and aquatic use and management planning with specific capabilities for biodiversity impact assessment and conservation planning. Vista was originally built with support from The Doris Duke Charitable Foundation and other foundations and released in March 2005. With support from NASA, NatureServe completed the second version of Vista (version 1.3 released in March 2006) and engaged with the USDA Forest Service to develop requirements for the third version of Vista (2.0) which was publically released for free download at the end of the grant (January 2009). A number of functional additions and improvements to Vista were accomplished in the grant period, primarily with NASA support but also with support from other organizations (see Acknowledgements). The key functional changes were an upgrade to the scenario definition function which now allows users to attribute multiple land uses to the same location (as opposed to single land uses) and to be able to model and evaluate changes in the landscape condition of conservation elements (species, ecosystems, etc.).

Due to legal and capacity impediments with USDA, NatureServe partnered with the Bureau of Land Management (BLM) to conduct the benchmark evaluation of Vista at the Grand Junction Field Office (GJFO) in Colorado. The intent was to evaluate Vista's ability to support development of the Resource Management Plan (RMP) primarily by analyzing the current management condition. Because the RMP had not been updated in approximately twenty years, there was no routine business process to benchmark against; rather Vista was evaluated against its ability to provide outputs necessary or useful to developing the RMP and efficiency relative to performing the necessary analyses using only manual GIS means.

NatureServe Vista demonstrated its potential for broad application by BLM in its RMP activity and likely activities to implement the RMPs such as project level environmental impact assessment. Evaluations of Vista concluded that the DST performs adequately to significantly better than minimum requirements for nearly all functions across eight criteria. The only areas identified by BLM as requiring moderate to minor changes are improvements to ease of use in the most advanced functions around scenario definition, evaluation, and landscape condition modeling. Although BLM has not historically made use of large volumes of NASA data, Vista's relatively open information framework provides the potential for BLM, as well as other user groups, to make greater use of NASA products. Vista can be characterized as a "downstream" DST meaning that it directly supports the integration of data for plan development as opposed to "upstream" systems that convert NASA sensor outputs into derivative products of direct application in Vista. This two-stage approach to developing and applying NASA product derivatives also holds great promise for assessing and planning for climate change phenomena such as sea level rise and habitat alteration. Vista is a tool that is both unique and flexible, allowing the user to develop and model various current and potential scenarios providing a solid foundation to determine the impacts of various land uses and policies on the landscape and create alternatives to them.

6 INTRODUCTION

6.1 Purpose of This Report

This report describes the development of the decision support tool (DST) NatureServe Vista 2.0 (Vista) and the benchmark evaluation of the DST conducted by the Bureau of Land Management (BLM) Grand Junction Field Office (GJFO). This report was written jointly between NatureServe and GJFO staff although NatureServe, as the publisher, takes full responsibility for its content. The term "we" is used when describing joint activities, otherwise specific institutional names are used to describe activities of those institutions. We focus on the GJFO's data and analytical requirements relative to planning for biodiversity sustainability in their Resource Management Plan (RMP) revision process. While the RMP addresses a wide variety of uses and indicators and Vista is capable of incorporating many more besides biodiversity; we focused on this aspect consistent with the primary objectives of the Vista DST. After this introduction, Section 7 describes the initial state of RMP development, data, and tools employed; Section 8 describes the requirements, methods, and engineering of the decision support tool NatureServe Vista 2.0; Section 10 describes our approach to developing the Benchmark Evaluation Metrics and the results of the evaluation; Section12 contains our conclusions and recommendations; and Section 15 contains NatureServe's Verification and Validation study results.

6.2 Project Origins & Purpose

NatureServe began work on Vista in 2001 and released v1.0 in March 2005. Version 1.3, partially funded by this grant, was released in March 2006. Vista is designed to support a broad range of users both in conservation planning and land use or resource management planning and assessment. NatureServe originally proposed for this grant improvements to Vista to support integrated planning among federal and local government jurisdictions in the Greater Yellowstone Ecoregion (GYE). After the grant award, however, NASA requested reorientation to supporting federal agency needs so NatureServe refocused on the USDA Forest Service Resource Management Plan (RMP) revision process as a timely and appropriate activity for which to develop software requirements. Subsequently NatureServe partnered with the Bridger-Teton National Forest (BTNF) in Wyoming. NatureServe worked with that partner throughout the requirements development process for Vista 2.0 but after a number of delays in attempting to initiate the Benchmark Evaluation, NatureServe took advantage of a partnership with the BLM to fund a Vista pilot project with one of their field offices. BLM is also undergoing system-wide revisions of their RMPs and, as part of that effort, the Grand Junction Field Office of BLM offered and was selected to serve as both the BLM Vista pilot site and the Benchmark Evaluation partner on this NASA grant. The Grand Junction Field Office (GJFO) administers several million acres of land in western Colorado. They are responsible for all land use planning, management, and project review and oversight on their lands. Because the RMP revision process for USDA Forest Service and BLM are very similar the requirements developed with BTNF were directly translatable to BLM application.

Benchmark Evaluation of Vista's utility for GJFO's RMP included qualitative, measured, and estimated performance comparisons with other analytical methods. An RMP had not been conducted by GJFO

since 1987 and therefore contemporary NASA data and decision support tools were not in existence at that time. Furthermore, BLM has not adopted any DST as a standard for conducting RMPs. Those limitations resulted in a complicated Benchmark Evaluation since we could not directly compare Vista's performance to other planning tools or established methods. Instead we directly used a variety of comparisons including manual GIS methods (without special decision support tools) and estimations of what such methods may have required.

6.3 Resource Management Plan Process

The RMP process requires BLM to analyze land uses and resources across the field office area and determine management for approximately 20 years. The 1987 GJFO RMP used minimal GIS support and analyses. The majority of BLM's current management analyses and planning relies heavily on mapping tools to analyze, manage, and implement land management decisions. However, spatial analysis has not been utilized across the landscape. GJFO recognizes the need for this type of analysis in order to maintain and improve resource values within the field office planning area.

Current GIS technologies have been applied to RMP revisions throughout the BLM; however DSTs have not been utilized in BLM planning efforts to our knowledge. The most difficult part of BLM RMP processes is setting resource objectives and goals while allowing for multiple uses of resources such as grazing, energy development, and recreation. This fundamental need was the basis for GJFOs interest in the Vista DST.

The BLM conducts an alternative development process, referred to as Chapter 2 of an EIS (Bureau of Land Management 2005), where different land uses are prescribed for different sections of the field office planning region. Typically, the range of alternatives are constructed from a "no action alternative", a "conservation focused alternative", a "resource use focused alternative" and variations in between. Once alternatives are developed, an impact analysis is conducted on each alternative.

In order to conduct an impact analysis, an assessment of the affected or existing environment must be conducted, referred to as Chapter 3 of an EIS (Bureau of Land Management 2005). Chapter 3 examines the current conditions for land uses and resources within the planning area under current management or the no action alternative which provides the baseline for all future impact analyses. Impacts are typically gleaned from tabular data, field notes, reports, and peer reviewed studies and then described in a narrative, with charts, maps, and graphs. A model is used to quantify impacts to air quality. During the RMP process BLM also analyzes impacts within a Cumulative Impact Analysis area (CIA), referred to as Chapter 5 in an EIS (Bureau of Land Management 2005). The CIA is a regional assessment of how the impacts from BLM decisions along with all other sources of impacts affect resources within the CIA.

6.4 NASA Inputs Traceability

NASA data products offer key inputs to the land use planning process. Because the planning process and Vista utilize "secondary" products developed by others from NASA sensors (e.g., vegetation cover types developed from satellite imagery or predicted species distribution maps modeled from a large variety of biogeophysical and climatic data) it is difficult to trace all inputs to their original sensor

products. Specific NASA inputs are identified in Section 7.1 and further discussed in the section Appendix 1 Verification and Validation. While BLM made only indirect use of NASA products (e.g., vegetation cover type map from Landsat imagery), the breadth of data that can be input to Vista facilitates use of a very broad array of data products derived from NASA products.

7 DESCRIPTION OF THE INITIAL STATE

7.1 Background on the Resource Management Plan

The Resource Management Plan (RMP) is not an ongoing business practice but rather a periodic activity conducted by each BLM field office to update the plans and policies which guide the management practices and related operational activities. Normally the RMPs are revised every 20 years. In the intervening years, policies and guidelines change along with planning and scientific methodologies, data, and technical capabilities. Here we describe the essential requirements of the current plan revision process with a particular focus on the inclusion of biodiversity sustainability issues addressed or that may be addressed by Vista. Because GJFO's RMP process was only recently initiated, complete applicability of Vista is somewhat speculative at this time.

7.1.1 Steps in the RMP process

Note that steps identified to be supported by Vista are identified and bolded.

1. Develop the Analysis of the Management Situation (AMS). This document determines the current management policies and current situation of the resources within the planning area, in order to determine what resource and land use issues the RMP revision may need to address.

2. **Develop the Existing Environment for the Draft Environmental Impact Statement (Vista identified to support this process) by:**

    2.1. **Map resources of consideration in the RMP e.g., biodiversity, cultural features, etc. (Vista identified to facilitate mapping and characterizing resources).**

    2.2. **Intersect resource feature maps with the current management plan which specifies land use types (Vista identified to facilitate characterizing management plans for land use types and conducting the spatial intersect with resources).**

    2.3. **Identify resources that would not meet current objectives for resource quantity and condition and areas of the management plan that are in conflict with resource goals. (Vista identified as a tool to quantify the conflict with resource goals).**

3. **Develop a range of alternatives for management within the planning area (Vista identified to be used to structure alternatives in order to meet resource objectives).**

4. **Analyze the range of alternatives to determine land use objectives and resource sustainability objectives (Vista identified to provide quantification and map results of each alternative to facilitate comparison among resource objectives achievement).**

5. **Release Draft Environmental Impact Statement to the public for review (Vista identified to support reallocation of land uses or resource objectives within the alternatives based on public concerns).**

6. **Develop and release Final Environmental Impact Statement for public Review**

7. **Develop, sign, and implement the Record of Decision for management of the Grand Junction Field Office (Vista is expected to be used as an implementation and tracking tool to ensure adequate resource protection is being met throughout the resource area as determined by the ROD).**

7.1.2 Data Applied in the Project

NatureServe Vista does not use direct sensor inputs to derive map products but rather uses derived products developed by other tools or methods as inputs for analyses. Here we describe inputs used in the benchmark evaluation and identify those with NASA traceability:

Data Input	**Source**
Regional vegetation distribution raster Aspen/Cottonwood/Douglas Fir/Gambel Oak/Juniper/Pinon Juniper/Ponderosa Pine/Sagebrush/Saltbrush	Colorado Gap Analysis Project / Landsat
Urban/Commercial/Agricultural/Residential	Colorado Gap Analysis Project / Landsat
Rivers & Streams	USGS National Hydrography Dataset
Roads & Trails	USGS 7.5' quads & GPS data
Surficial land ownership	Master Title Plats 7 USGS 7.5' quads
Biodiversity data 2008 CNHP database of species occurrence Threatened & Endangered Species Wildlife Habitat	2008 Colorado Natural Heritage Program GJFO field observations & GPS data BLM Staff, CDOW, CNHP & BLM Contractors
Conservation & Recreation Areas	BLM Staff & USGS 7.5' quads
Range Allotments	BLM Staff & USGS 7.5' quads

Data Input	Source
BLM Springs	Spring atlas, RIPS data and water rights files
Infrastructure Corridors	BLM & Master Title Plats

7.1.3 Analysis and Modeling Tools

A variety of tools are available to BLM Planners to address the plan requirements. In this section we describe the tools used by GJFO with some relevance to biodiversity analysis. Note that the RMP analytical process is not prescriptive and planners are free to develop the analyses they believe will produce the requisite interim and final products. Because no existing tools replicate the package of functions of Vista, replicating most of its functionality would require manual GIS. Other tools may produce analytical products that can also lead to the desired products or they may provide inputs to Vista or make use of outputs generated by Vista. Tools used by GJFO:

- GIS: GJFO makes routine use of ESRI's ArcGIS 9.2 ArcInfo Software for a variety of GIS related activities, including but not limited to data creation, manipulation and updating, manual analyses through ESRI extensions, cartographic design and as a platform for NatureServe Vista.

- Other tools: Besides air quality models (see below), the GJFO does not currently have any other tools to model the environment beyond the standard GIS toolset that most GIS practitioners use. A brief ad hoc review of other field offices that have recently completed a RMP process was undertaken to determine what GIS tools and functions were found to be useful. GJFO concluded that GIS analysis and modeling was not extended beyond the standard range of ESRI ArcInfo functions and extensions and that a comparable tool to Vista was not used in any other RMP.

- The Grand Junction RMP effort will use an EPA approved air quality model, such as AERMOD, to determine near and far field impacts, a photochemical grid model, such as CMAQ or CAMx for all air pollutants, and a visibility model, such as CALPUFF, to determine impacts to Class I air sheds.

8 SYSTEMS ENGINEERING DESCRIPTION

8.1 NatureServe Vista 2.0 Decision Support Tool Requirements

Beginning with a workshop in July 2004, NatureServe began meeting first with the USDA Bridger Teton National Forest (BTNF) planning staff and reviewing RMP planning documents and guidelines to identify key areas of Vista improvement to support RMP revision. NatureServe and BTNF identified a large

number of potential improvements to Vista and settled on these priority areas that could enhance Vista's utility in federal land and resource planning:

1. Assisted biodiversity data import and characterization through an import filter from the Natural Heritage Data Management System Biotics 4.0. Heritage data is the primary data source for rare and imperiled species analyses in all federal land use planning. The previous version of Vista (1.3) required each conservation element (e.g., species, ecosystem) to be input one at a time through the element interface. Additionally we added the ability to assign various element attributes (categories, weights, goals, etc.) to elements by groups (e.g., same response to roads for all reptiles) rather than having to open each element property and assign attributes individually.

2. The ability to introduce complex land use scenarios with multiple uses, management practices, and natural disturbances attributed in each location to provide a more complete and precise evaluation of effects on biodiversity. The previous version of Vista (1.3) only allowed one land use attribute per location.

3. Enhanced element response capability that allows a user to specify an element's response to land use and other disturbances and management practices along a continuum of customized responses. For instance: Very poor, poor, neutral, beneficial, or very beneficial. The previous version of Vista (1.3) only allowed a binary "compatible" or "incompatible" response. The default but editable values in Vista are "negative," "neutral," or "beneficial."

4. The ability to model current habitat condition and predict the effects on condition from proposed alternative future scenarios. The previous version of Vista (1.3) allowed import of static condition models (or assigned occurrence condition scores) developed manually but did not support modeling and did not support updating of models to automatically predict future condition. Availability of this function also can support setting condition thresholds for meeting retention targets for conservation elements. This requirement was deemed highly important because land management agencies tend to manage for maintaining or improving condition as opposed to strictly relying on a target-based approach like most conservation NGOs.

5. Increased support for analyzing subregions (e.g., management units) within a planning region (e.g., a BLM Field Office or National Forest). The previous version of Vista (1.3) could generally support this functionality but required more cumbersome steps to achieve it.

8.2 NatureServe Vista Functional Development Methods

Following development and prioritization of requirements, NatureServe separated functional improvements into three categories; 1) those requiring development of analytical methods (e.g., process models) and GIS prototypes prior to engineering; and 2) those only requiring engineering changes; and 3) functions to be provided by geoprocessing tools outside of Vista but integrated with Vista through import/export interfaces.

Category 1 improvements were conducted by the Vista methodology team through development of analytical process models identifying needed outputs and the chain of inputs and analyses necessary to

develop them. These were then prototyped with manual GIS functions to supply spatial analyses engineering requirements. Periodic meetings were held with BTNF staff to describe proposed changes and receive feedback in terms of their utility and design. Engineering methods for completing Category 1 and 2 improvements included mocking up interfaces and reports and reviewing these in "feature team meetings."

Testing efforts were maintained throughout the development process. Q&A as well as stability and usability issues were tested, logged and prioritized in Solobug, a tool used for reporting software bugs. Ongoing communication between engineering and testing staff allowed for immediate bug fixes for critical bugs as staff time allowed. Impediments to this process occurred, however, which resulted in delayed testing and completion and a greater number of bugs being detected in the evaluation. These impediments included:

- Loss of all original engineering staff during the late stages of 2.0 development although one principal engineer was rehired as a consultant and an existing NatureServe engineer was re-tasked as the new Vista lead engineer.
- Loss of primary testing and support staff at the start of the evaluation period and incomplete internal testing
- Exhaustion of primary funds for testing and refinement though additional funds were obtained from other sources to partially fulfill this work

8.3 NatureServe Vista 2.0 Technical Description

By integrating GIS technology (ESRI ArcMap 9.2) with a solid foundation of conservation biology, NatureServe Vista facilitates analyses of biological information such as the distribution of sensitive species and habitats with policy frameworks such as ownership, land use, and land management regimes. For the past seven years NatureServe has been leading a multi-disciplinary team of scientists, conservation planners, economists, GIS specialists, and software engineers to create the software, documentation, training, and scientific support services. Vista version 1.0 was released in March 2005, and was followed by Vista 1.3 in March 2006 to help land-managers assess local ecosystems, identify high-priority habitat, and evaluate competing land-use plans and create alternative plans and mitigations.

NatureServe Vista has been designed as a "framework" DST technology meaning that it covers a broad section of the assessment and planning process but draws inputs from many other sources and DSTs (see Figure 1). Vista utilizes a relatively simple data model and analytically strikes a balance between scientific defensibility and practicality suited to landscape scale analyses and planning. Vista is designed as a two-stage application in that an expert group of GIS analysts, modelers, and biologists is required to populate the Vista database and parameterize models and the in the second stage the tool and database can be handed off with a modicum of training to planners and managers. Vista's data model uses the conservation "element" as the basic unit of conservation analysis and planning to compare against "scenarios" which describe the current, proposed, or expected combination of land use and

policy mechanisms in the landscape. Once the element database is developed, the Vista DST provides a foundation for efficient, repeatable analysis, lowering the unit-cost of each new land use scenario evaluation. In effect, the database design and software methodology of Vista drive demand for improved data sources to create more robust and precise results for implementing large area plans at landscape and site levels.

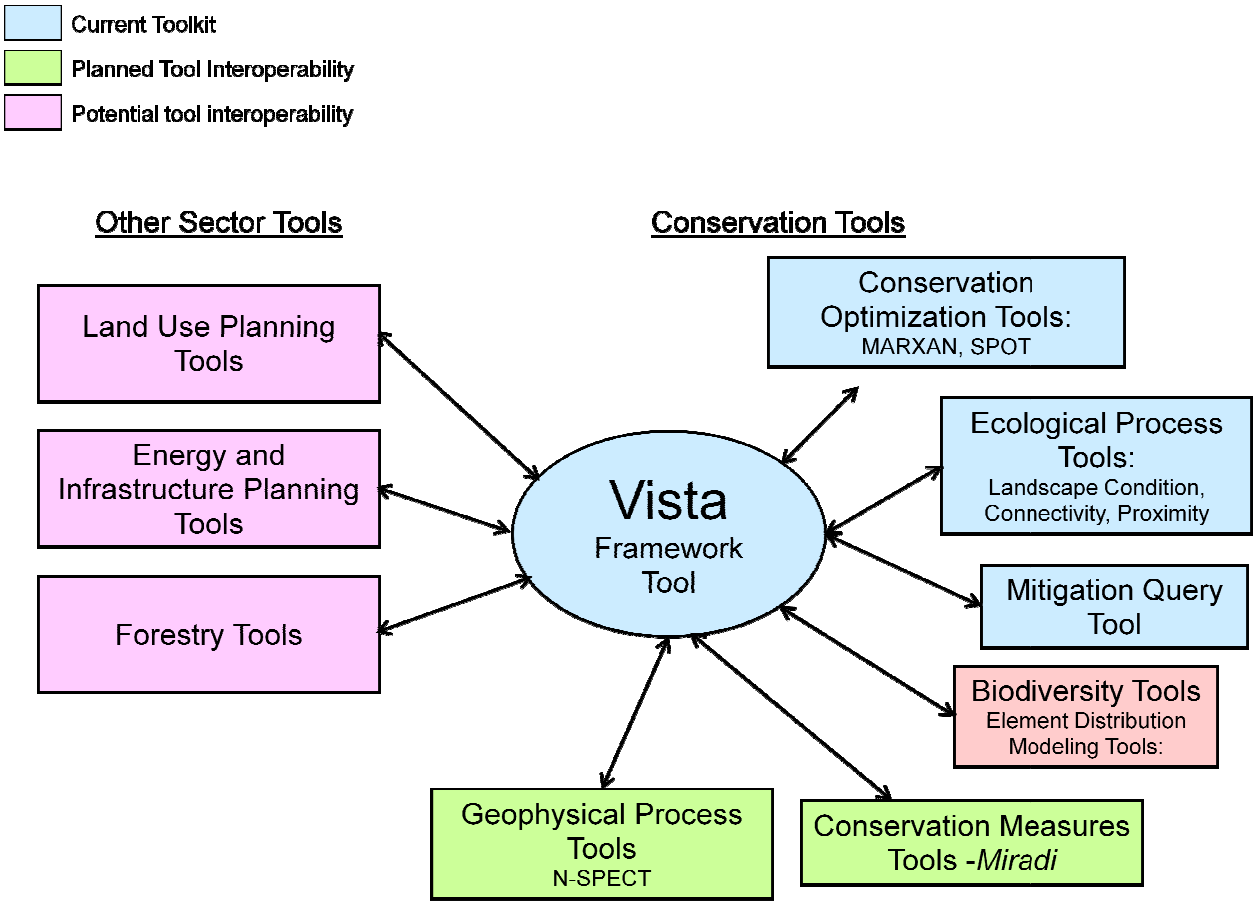

Figure 1. Interoperability framework for Vista.

Vista provides a broad range of software capabilities to support regional conservation planning needs and thousands of additional users including BLM, USFWS, state and local government, NGOs, tribes, and others.

Here NatureServe describes the specific analyses and data requirements of Vista currently conducted by version 2.0. We describe each capability below (followed by the function reference name if any as used in the Benchmark Evaluate see Table 2 and Table 3) and include a brief description of the function followed by input requirements that include spatial, tabular, and expert or user knowledge. Functions not directly scored in the Benchmarking section are labeled as Ancillary Function. This narrative is also supported by diagrams of the processes supported in Appendix 2.

1. Map, query, and report on conservation elements (Element Information & Mapping). Conservatoin elements include things like ecological systems, plant communities, plant or animal species and non-biological elements such as viewsheds, soils, historic sites, etc. and increasingly, competing land uses (see Figure 2): these elements can be imported from specifically formatted Biotics shapefiles through Web Services or imported manually from any source. All elements can be edited by groups (e.g., all birds), using Vista's 'Edit Multiple' function. Inputs:

    - Shapefile distribution map, polygon only. Preferably map resolution supports determination of element occurrences defined by minimum patch size and separation distances from other patches representing different populations for species elements (NatureServe 2002). A number of NASA Earth Science Results can serve as inputs to Vista when converted to element themes (e.g., convert satellite imagery to land cover types) and reformatted to polygon shapefiles. NatureServe has also developed geoprocessing tools to automate conversions of raster ecosystem maps into Vista inputs.

    - Minimum occurrence viability size. Users may specify (strongly encouraged) an area measurement below which element occurrences will not be counted toward conservation goal retention and will be marked as non-viable (NatureServe 2002).

    - Viability/integrity occurrence attributes input as values between 0.0 and 1.0 typically provided by a raster index of landscape integrity. This index is flexibly defined based on the factors influencing the condition of any particular element such as road density. Because the list of inputs is large, we provide further detail in Table 1. The concept for these attributes originates from NatureServe's Natural Heritage Element Occurrence Rank methodology and data model (NatureServe 2002).

    - Confidence in occurrence input as values between 0.0 and 1.0. This measure is also flexibly provided by a variety of sources appropriate to the input type. For example the confidence level for an ecological system type derived from Landsat mapping frequently has a thematic accuracy assessment rating based on field verification (e.g., Crist and Deitner 1997) whereas Natural Heritage element occurrence confidence is specific to each occurrence based on measurement precision, age, and results of follow up surveys (NatureServe 2002).

    - Condition Threshold input as values between 0.0 and 1.0. This refers to the condition or quality of an element as designated in the Viability/integrity score, or as modeled, later in Scenario Evaluations. If an element's condition falls below this user-specified threshold it will be marked as 'non-viable' and no longer count toward the element's conservation goal.

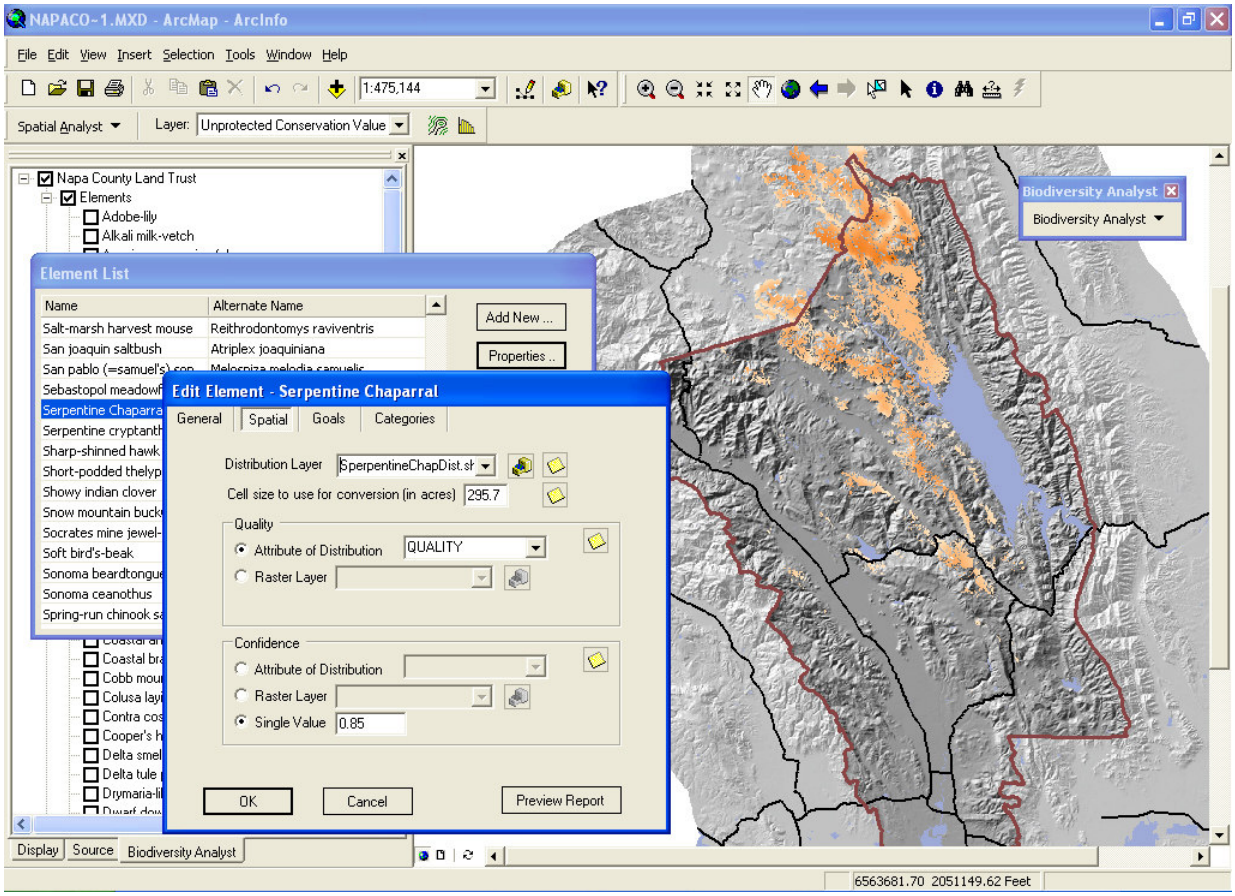

Figure 2. Screenshot from NatureServe Vista depicting the element properties interface and outcome Element Conservation Layer showing distribution and condition.

2. Weight elements relative importance (Ancillary Function): the user can develop any number of weighting systems such as by ESA status or economic value. Inputs:

    - User-defined values from 0.0-1.0 with default weights provided based on NatureServe's global ranking.

3. Calculate conservation value (Conservation Value Summary) (see Figure 3): allows the user to aggregate elements' distribution and attributes to form an index of conservation value. The user can choose among eight options for weighting the grid cell scores based on, importance (weighting), Viability/integrity, and confidence (all described above). Choosing no weighting attributes results in an index based on element richness (number of elements co-occurring in a grid cell).

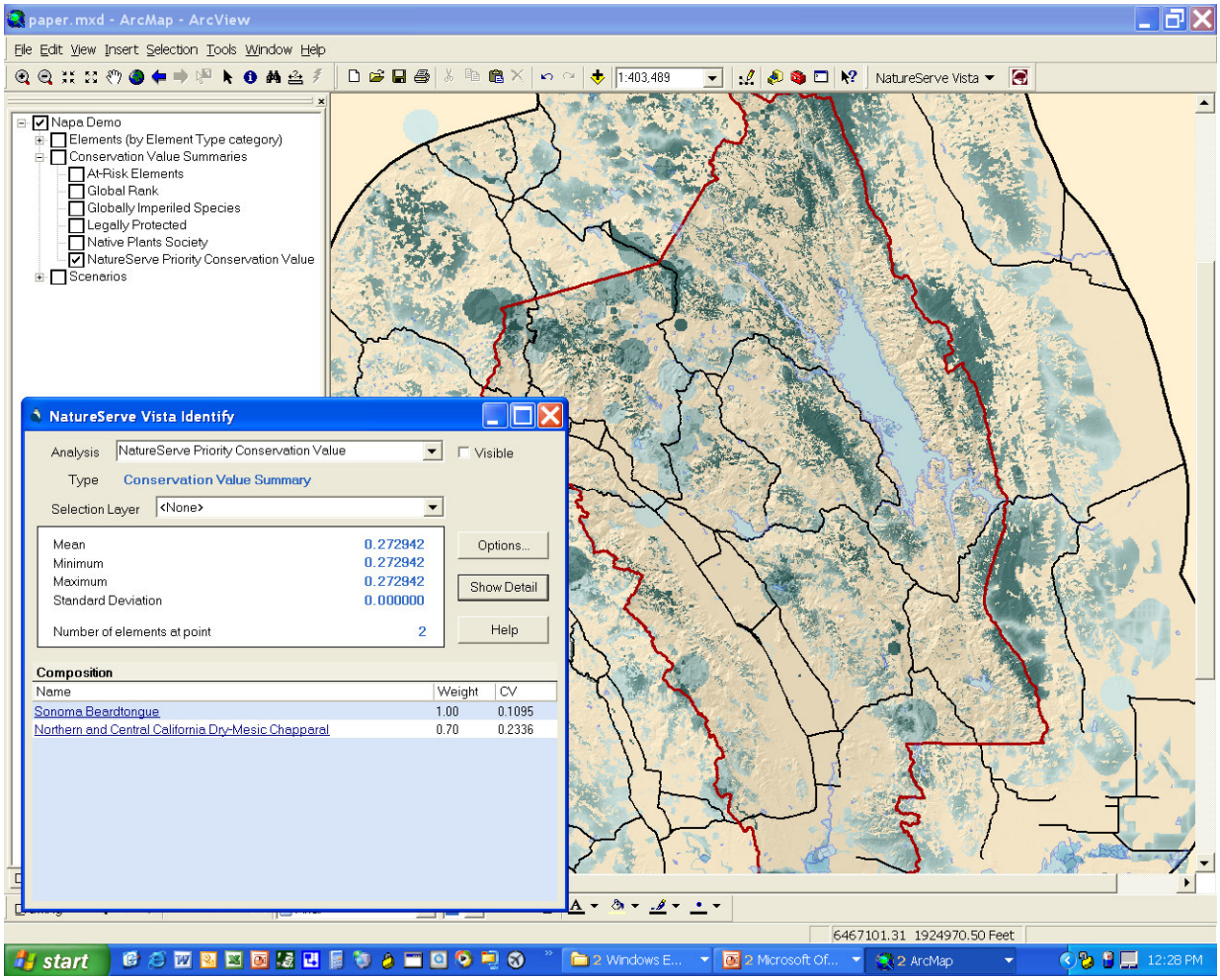

Figure 3. Screenshot from NatureServe Vista depicting a Conservation Value Summary that combines element distribution maps and user-selected attributes such as importance weightings. Darker shades indicate areas of relatively higher value. GUI inset depicts a selection report for a particular site that provides a site inventory of elements and values statistics.

4. Assign element responses (Element Information and Mapping): allows users to assign how elements respond to a project classification of land use types defined as land uses, management practices, and other threats such as invasive species or wildfire. Default response options are "negative," "neutral," or "beneficial" but users can specify a range of customized responses e.g., "very poor, poor, neutral, beneficial, very beneficial." Inputs:

    - Responses based on and documented from knowledge and opinion provided and documented by element experts.

5. Set quantitative conservation goals (Ancillary Function): allows users to specify retention goals for elements in terms of percent or number of occurrences or area (acres or hectares). These can be subject to minimum occurrence size requirements for viability (see above). Any number of goal sets can be created but most commonly would include a "minimum" set for retaining element

representation, and a "preferred" set for retaining or restoring full ecosystem functioning or different goal levels representing different levels of risk of extirpation. Concepts and guidance on goal setting are described in numerous publications, e.g., Groves 2003. Inputs:

- Knowledge and opinion provided and documented by element experts.

6. Define and import scenarios (Scenario Definition): allows users to import any number of vector or raster layers representing different land use and management policies, plans, current uses, modeled futures, and other threats such as invasive species or sea level rise. These layers are combined into a map of "land use intent" and map of "policy types" which represent the policy mechanisms used to carry out the intended land use (regulation, incentive, easement, legislative designation, etc. or even "natural succession"). The many land use and management classifications imported into the system are then translated interactively via Vista functions to a single project-wide classification to match up to element responses. These translations are saved to facilitate easy updating and ongoing maintenance of a "baseline" scenario of current policies and conditions. New alternative scenarios can easily be created from the baseline to reflect plan or policy change proposals, development proposals, emerging modeled threats, etc. This function has been expanded in version 2.0 to allow multiple land use attributes for a single location to facilitate more realistic scenarios of typical landscape condition and policy complexity. Inputs can vary tremendously based on the evaluation to be conducted and available information. For the GJFO pilot, similar layers were used on the landscape integrity generation (see Table 1) in addition to the following specific GJFO inputs:

    - Land use capability maps, e.g., oil and gas areas, designated and dispersed camping areas, livestock grazing, surface and subsurface mineral mining, pipeline and powerline transmission corridors, and motorized and non-motorized recreation areas.

    - Predicted areas of future growth in urban interface with BLM lands and mineral activity.

    - Existing permanent conservation areas (wilderness areas, research natural areas, botanical reserves, etc.).

    - Existing Oil and Gas lease stipulations designated by the 1987 Resource Management Plan and any subsequent amendments.

    - Other spatially defined regulations that specify or limit land use and management activities in mapped areas.

7. Evaluate scenarios (Scenario Evaluation) (see Figure 4, Figure 5): allows the user to select the elements to be evaluated, the goal set to be used for the evaluation, which policy mechanisms in a scenario that the user considers reliable, and now, in version 2.0 the user may also develop a landscape condition model that will model the impact on elements' landscape condition from the land uses included in the scenario. Any scenario can be evaluated with different assumptions about these inputs (which elements, which goals, which policies are reliable). During the evaluation, Vista intersects the land use and policy type maps of the scenario to be evaluated with the selected

elements. The comparison uses the specific goals, minimum required areas, and condition threshold of the elements or compares their compatibilities with the scenario's land use intent map in a categorical rather than condition-based assessment. The result is a series of maps and tables that provide the statistics for each element of area and number of occurrences currently existing, the stated goal, the area and occurrences in compatible land use/management and the area and occurrences in compatible land use/management and supported by reliable policy mechanisms. Maps include (see also figures following this section): a) an overall compatibility conflict map which shows in shades of red the areas where elements that have not met their goals and are in conflict with intended land use/management (with darker shades indicating multiple elements in conflict); b) same as "a" but for policy mechanism conflicts, shading indicates compatible land use but supported by unreliable policies; c) individual element maps showing their areas of distribution as incompatible, compatible, compatible and supported by reliable policies. Inputs:

- User-defined evaluation parameters described above.

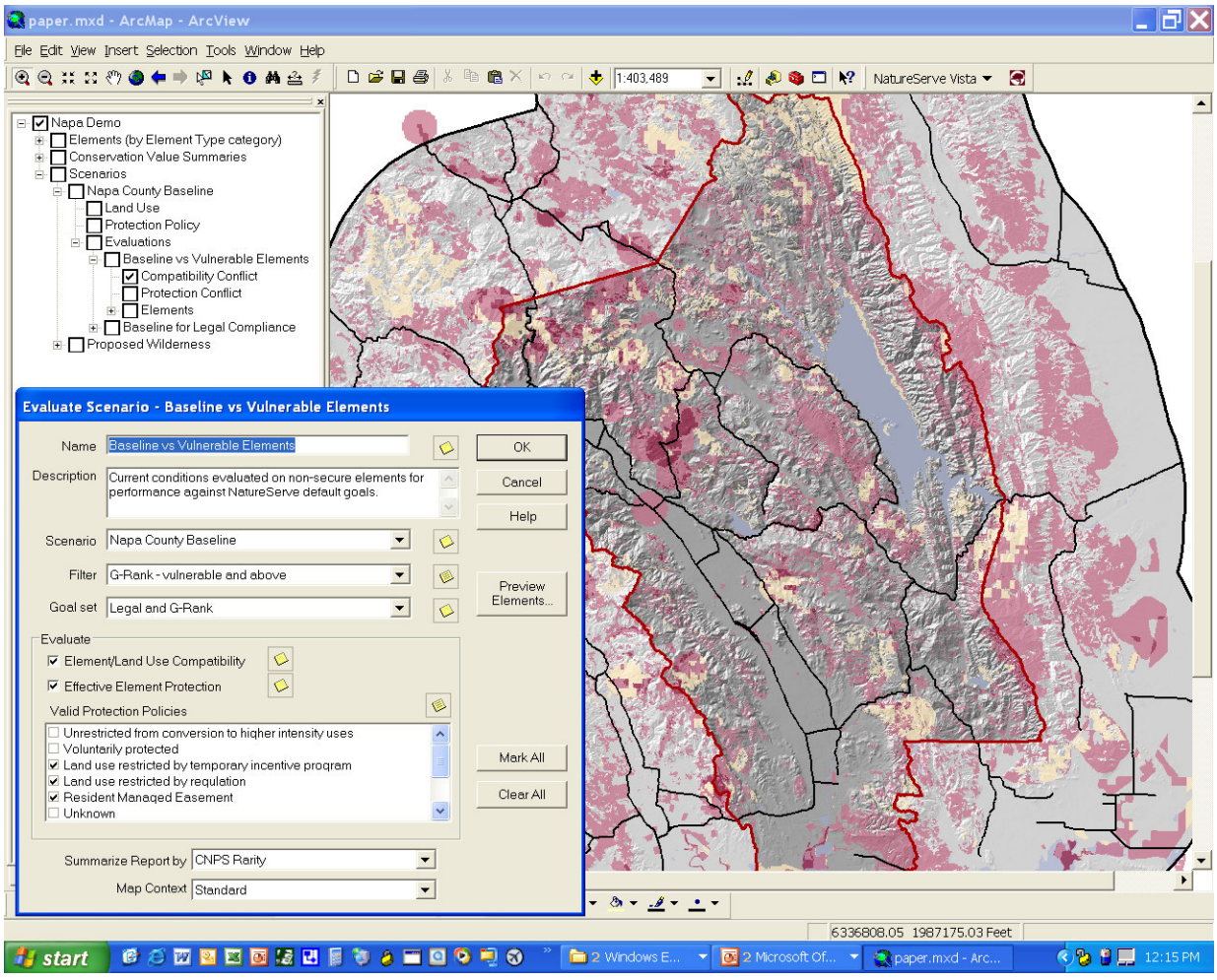

Figure 4. Screenshot from NatureServe Vista depicting a Compatibility Conflict map from a scenario evaluation. Tan shades indicate areas supporting element goal achievement while red shades indicate elements that haven't met goals and have conflicts with the land use(s) at those locations.

Terrestrial Ecological System (33 elements)

Name	Distribution Area (hectares)	Occs	Protected and Compatible Goal	Goal Met	Area (hectares)	Occs	Percent of goal	Compatible Goal	Goal Met	Area (hectares)	Occs	Percent of goal
Caribbean wet montane forest- Sierra Palm alliance	11,965.95	1	2,481 hectares	Y	4,151.52	1	167.33%	Y	9,589.14	1	386.5%	
Caribbean wet montane forest - Palo Colorado alliance	3,713.49	1	762 hectares	Y	3,577.32	1	469.46%	Y	3,713.13	1	487.29%	
Caribbean seasonal evergreen submontane-lowland forest (young secondary)	97,270.47	1	10,862 hectares	N	1,092.87	1	10.06%	Y	88,590.6	1	815.6%	
Caribbean wet submontane lowland forest (young secondary)	1,877.22	1	9,482 hectares	N	73.44	1	0.77%	N	1,795.86	1	18.94%	
Caribbean montane submontane karst forest (young secondary)	15,690.96	1	0 hectares	Y	235.26	1	100%	Y	7,782.57	1	100%	
Caribbean montane wet serpentine woodland (young secondary)	1,001.25	1	0 hectares	Y	573.3	1	100%	Y	937.08	1	100%	
Caribbean lowland moist serpentine woodland (young secondary)	1,951.38	1	0 hectares	Y	943.56	1	100%	Y	1,757.7	1	100%	
Caribbean lowland dry semideciduous forest (young secondary)	19,810.44	1	7,283 hectares	N	2,025.63	1	27.81%	Y	11,030.67	1	151.46%	
Caribbean lowland dry riparian woodland and forest	1,231.2	1	1,229 hectares	N	93.6	1	7.62%	N	545.4	1	44.38%	
Caribbean lowland dry limestone semideciduous forest (young secondary)	3,919.32	1	0 hectares	Y	142.38	1	100%	Y	2,272.59	1	100%	
Caribbean lowland dry limestone semideciduous forest	10,679.4	1	8,500 hectares	N	3,058.74	1	35.99%	Y	8,894.97	1	104.65%	
Caribbean floodplain forest (young secondary)	11,768.58	1	0 hectares	Y	436.5	1	100%	Y	4,831.02	1	100%	
Caribbean coastal dry evergreen forest	1,002.78	1	196 hectares	N	160.92	1	82.1%	Y	841.95	1	429.57%	

Figure 5. Screenshot from NatureServe Vista depicting a partial scenario report. Quantitative performance for each element is reported. Elements are hyperlinked to more detailed maps and reports for each element.

8. Generate scenarios (Ancillary Function): allows the user to automatically develop input data for two optimization algorithms, Marxan (University of Queensland http://www.uq.edu.au/marxan/) and SPOT (The Nature Conservancy http://www.conserveonline.org/workspaces/spot) that identify a set of planning units (e.g., management units, forest stands) that can satisfy conservation goals for all elements. Inputs:

    - Spatial inputs include those previously described for elements and goals; the condition map can also be used as a "cost surface" with additional manual transformation.

9. Evaluate sites and specify alternative land use and policy (Site Explorer/Mitigation Development) (see Figure 6): allows the user to select a site (parcel, management unit, watershed, etc.) view its biodiversity content and intended land use/management and policy regime and the effect on viability and goal achievement for each element across the planning region and within the site. The user can then conduct "what if" queries by substituting different land use/management regimes and implementation or policy mechanisms. The result is an instant report of effect on goal achievement of such changes for each element in the site. If the outcome is desirable, the user can save each site modification to a new scenario, thus creating a conservation or mitigation plan on the fly which specifies the desirable land use/management for each site and the mechanism to be used for implementation. This function is often used in conjunction with the "generate scenarios" function to guide users to creating alternative land use and implementation policies for those sites that can most efficiently meet the goals. Inputs:

    - User-defined inputs described above.

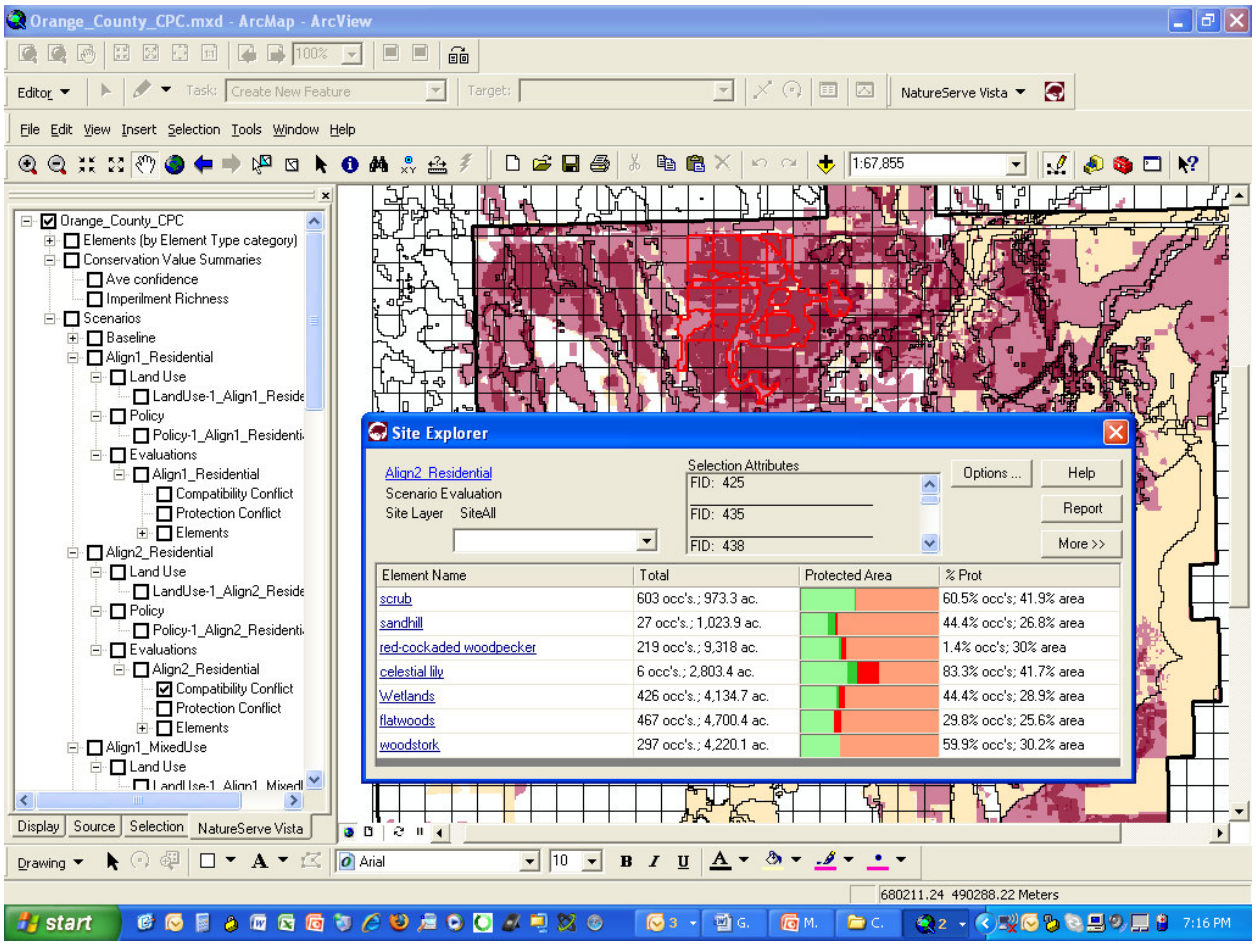

Figure 6. Screenshot from NatureServe Vista depicting the Site Explorer function. This function allows users to explore sites (parcels, watershed, management units, etc.) in Conservation Value Summaries and Scenario Evaluations. In the latter, an inventory of elements, land uses, and policy types are provided for the site with a large variety of statistics and charts available for viewing. Users can bring up any layer as a backdrop and use this information to specify alternative land uses and policies that can better contribute to goals. Those specifications are then saved into a new scenario.

10. Reports (Ancillary Function): allow users to generate standardized reports for all elements and analyses include map generation according to user preferences for map appearance. Reports are generated in XML and exportable to HTML. Users with XML editing skills can customize the report content and layout. Some typical inputs for map context include:

    - Project area boundary
    - Major roads
    - Hydrography
    - Place names
    - Shaded relief (topography)
    - High resolution color or black and white digital raster images of the earth's surface

Table 1. Layers for landscape condition modeling

Layer	Potential source
Roads Highways, Secondary, Light Duty, Off Road, Single Track, Unimproved, Footpath, Equestrian, Mountain Bike, Motorcycle, ATV	USGS 7.5' quads, aerial photography & GPS data
Shooting Ranges	Staff created layer, Aerial imagery
Designated Camping	Staff created layer, Aerial imagery/GPS data
Livestock Grazing	Staff created layer, USGS 7.5' quad
Irrigation Canals / Ditches	USGS NHD
Reservoir / Evaporation Ponds	Staff created layer, USGS 7.5' quad
Landfills	Mesa County Tax Parcels
Abandoned Mines	Staff created layer, USGS 7.5' quad
Powerlines (residential/transmission), Pipelines	USGS DLG & Power companies
Stock Trails	7.5' USGS quads & BLM range allotment files
Oil & Natural Gas Wells	COGCC Well Information Spotting Program (pre-2005) & field surveying/GPS data (post-2005)
Urban, Commercial, Agriculture, Residential	Colorado gap analysis, LandSAT 7 derived
Trailheads	Staff created layer, Aerial imagery
Toilets	Staff created layer, Aerial imagery
Surface/Subsurface Minerals	Master Title Plats

9 STATUS OF NATURESERVE VISTA

Vista version 2.0 Beta was installed and training was provided to GJFO GIS staff upon request in September-October 2008. In November GJFO began benchmark evaluation of the beta software using a field office-wide database. Formal use and evaluation of Vista was conducted periodically over a 10 week period. No-cost public release was made of Vista 2.0 (but still in beta form) on January 30, 2009 following a final round of bug fixing informed by GJFO evaluation and NatureServe internal testing. Most importantly, GJFO, while still fairly early in their RMP process, plans to continue its use for the RMP.

Vista 2.0 is currently a stable and distributed product. Several known issues persist in Vista 2.0, including processing time limitations, ESRI-based legend issues, and some potential stability bugs, particularly with the condition modeling function. However, key structural issues have been addressed to a level that allows public distribution as a beta tool.

Additional development work on the tool or interoperating tools is underway. This includes:

- Interoperability with NOAA's N-SPECT tool (nonpoint-source pollution and erosion comparison tool): In partnership with NOAA and with funding from the David and Lucille Packard Foundation, this project first evaluated and then will engineer automated interoperability between the tools. This will provide hydrologic modeling of threats to aquatic element condition in Vista and a companion capability for creating and exchanging mitigations. Engineering will begin February 2009 with expected release in May 2009 as Vista 2.5. During those months NatureServe intends to release interim versions with improved stability and functionality particularly for the condition modeling function.

- Mitigation query and planning: NatureServe built a series of custom tools for The Nature Conservancy in Brazil that extend the capability of Vista to identify and rank offsite mitigation parcels using concepts of diversity, connectivity and buffer potential for existing reserves, and cost. Further funding by TNC in Colombia will generalize and stabilize the tools. Release is expected between May and September 2009.

9.1 Other Applications of Vista

Several other project applications have been conducted or are underway by NatureServe and other independent users. Here NatureServe provides brief descriptions of a sample of projects (in chronological order from oldest to newest) where NatureServe has direct involvement with the client and is able to gain information about performance of the software. NatureServe provides the user organization name, primary decision purpose of the application, and status. Note that in several applications, NatureServe or another expert provider is conducting the initial database development and analyses using Vista with a planned transfer to the client organization for ongoing use of the decision support system:

1. **Conservation Trust of Puerto Rico (2004-2007)**: NatureServe conducted biodiversity analyses using Vista from 2005-2007. The Trust coordinates the Biodiversity Conservation Initiative (BCI) for Puerto Rico and contracted with NatureServe to use Vista/Marxan to identify priority conservation areas and assess plans such as the new national land use plan for potential conflicts with biodiversity conservation priorities. In December 2007 NatureServe provided the Vista 2.0 project to them and provided some basic training. NatureServe is also using Puerto Rico as the test bed for interoperating Vista with NOAA's N-SPECT software to include better aquatic biodiversity analysis in the tool. Currently the client is not using Vista as they are busy with other initiatives but have indicated interest in beginning to use the program for watershed level assessments. The project database that covers all of Puerto Rico is very large and complex with nearly 400 elements and so it has experienced performance problems.

2. **Bureau of Land Management: Jarbidge Field Office, Idaho (2005-ongoing)**: Vista 1.3 is being used in a pilot project to test the usefulness of the tool for developing its Resource Management Plan. This project, conducted in partnership with the Idaho Conservation Data Center (a NatureServe Network member) is using Vista to identify areas of biodiversity importance, evaluate proposed plan alternatives, and identify needs for plan revisions to meet biodiversity objectives. This project was begun before and independent of our BLM evaluation with GJFO and NatureServe understands it has been stalled because of legal issues about the planning process.

3. **San Martin Departamento, Peru (2004-2006)**: Vista 1.3 was used in an initial pilot project in cooperation with many partners to identify areas of high biodiversity importance and then in conjunction with an interoperating tool, Marxan, to reveal conflicts between land use objectives of conservation and economic development. A bug in the Marxan interoperability was found and fixed in version 2.0. Further work and transfer to the local agencies is desired and pending funding under submitted proposals. This work did stimulate interest and funding for the Peru project described at the end of this list.

4. **Lake Erie Alleghany Partnership (2006-ongoing)**: this 40 organization partnership spanning 3 states is using Vista 1.3 in an initial 100,000 acre watershed pilot project to evaluate feasibility of applying Vista throughout the region. They concluded the initial project and developed an evaluation report that is included as an attachment to this report (see Appendix 4: LEAP Evaluation Report)

5. **San Francisco Bay Area Uplands Conservation Plan (2007)**: GreenInfo Network and consultants for the Bay Area Open Space Council attempted to use Vista 1.3 to develop upland biodiversity conservation priorities for this 9 county region. After some initial database development they concluded that Vista is not able to efficiently support such a large regional project at the high resolution desired because of computing limitations of the ArcView environment, but they plan to implement Vista in subregion projects if local interest and funding can be obtained. This and two other conclusions from large regional projects have lead us to seek funding for a "power user" version that can utilize ArcInfo rather than the ArcView platform.

6. **El Paso and Pueblo Counties Councils of Government (2007)**: Vista 2.0 was employed by the Colorado Natural Heritage Program and NatureServe to conduct a demonstration project that would identify areas of irreplaceable and legally protected biodiversity and to iteratively evaluate and create alternative transportation and land use scenarios in conjunction with CommunityViz (http://www.communityviz.com/), another decision support system used for land use planning. NatureServe completed the initial analyses and demonstration in December 2007 which required some manual workarounds due to problems discovered in the Vista 2.0 alpha version at the time. NatureServe is currently contracted to demonstrate the applicability of Vista for regional cumulative impact assessment as part of a Transportation Research Board grant using this same project plus Denver Region Metropolitan Planning Organization. That work is planned for completion by June 2009.

7. **Mission-Aransas National Estuary Research Reserve (MANERR) (2007-ongoing)**: Vista 1.3 is being used in a pilot project funded by the Packard Foundation to develop and test interoperability among Vista, CommunityViz (http://www.communityviz.com/), and N-SPECT to support integrated land-sea planning. The MANERR GIS staff was trained in the use of the tools with ongoing support by the tool providers. MANERR staff completed an initial round of planning applying the full toolkit. Community engagement workshops are scheduled for April, 2009. Results of the toolkit integration were demonstrated at the Coast to Coast conference in Darwin, Australia and the South Pacific EBM Tools Training in Townsville, Australia in August 2009. Those demonstrations resulted in requests for training proposals from CSIRO Australia and the nation of Palau which are pending.

8. **Charleston, SC regional planning project (2007-ongoing)**: Vista 2.0 is being used in conjunction with CommunityViz (http://www.communityviz.com/) to incorporate and spatially enable NOAA's Community Vulnerability Assessment process (http://www.csc.noaa.gov/hat/) in a coordinated 3 county regional plan. Vista work is about to initiate at the time of this writing with planned training of a local user to engage the community in interactive workshops.

9. **Colombia Mega-Projects Mitigation Toolkit (2008-ongoing)**: NatureServe Vista 2.0 is the centerpiece of a multi-tool toolkit that is being developed for the Ministry of Environment (with funding from The Nature Conservancy) to assess mega-projects and design mitigations for them. This project is funded and being done in collaboration with The Nature Conservancy and the Ministry with additional partner involvement from World Wildlife Fund and Conservation International. Vista work is commencing at the time of this writing and is expected to be completed by September 2009.

10. **Support for Land-Use Planning in Peru (2008-ongoing)**: The Interoceanic Highway is a massive infrastructure project to connect Peruvian and Brazilian ports to support the transportation of products to and from global markets. In southern Peru, the highway is routed through the heart of one of the most biologically diverse places on Earth, creating the potential to cause significant ecological destruction. Like many Andean countries, Peru is transferring increasing responsibility for enforcing environmental regulation, performing land-use planning, and employing mechanisms for natural resource management to departmental governments. To enhance local capacity to carry

out these new functions, NatureServe is providing technical planning assistance to two of the departmental governments where the Interoceanic Highway is being built. Using NatureServe Vista, NatureServe is integrating conservation planning methods and biodiversity information in regional land-use assessments and plans. The spatial analyses integrate economic factors with biodiversity and cultural values to evaluate various land use scenarios, then assist with identifying alternatives to minimize and/or mitigate unavoidable conflicts. As of this writing, this project has developed two Vista databases and conducted initial assessment analyses. After the initial work is done by NatureServe, local organizations will be trained to take over the project.

9.2 Target Customers

NatureServe Vista was consciously designed from the beginning to serve all those making land/water decisions that affect conservation. NatureServe's initial funder, the Doris Duke Charitable Foundation was particularly concerned about groups such as local government land use planners whose actions can have large and long-lasting effects on biodiversity but lacked easy to use tools to support a scientifically defensible process for conservation.

While NatureServe's focus on requirements for Vista 2.0 was public land resource management planning, NatureServe built the enhancements in generalized ways to continue serving a broad spectrum of users including:

- **Public land management agencies:**
    - Bureau of Land Management
    - National Park Service
    - State Fish and Game/Parks/Natural Resources Departments
    - State Natural Heritage Programs
    - U.S. Fish and Wildlife Service
    - U.S. Forest Service
    - Department of Defense
    - International counterparts of these organizations
- **Regional and local government land use and transportation planning agencies:**
    - Councils of Government
    - Metropolitan Planning Organizations
    - County and Municipal Planning Departments
    - State Departments of Transportation

  - International counterparts of these organizations
- **International, National, and regional non-governmental conservation planning organizations e.g.,:**
  - Conservation International
  - The Nature Conservancy
  - Wildlife Conservation Society
  - World Wildlife Fund
  - Regional, national, and local conservation organizations/land trusts
- **Environmental, land use, and infrastructure consulting companies**
- **Industry**
  - Energy development companies
  - Infrastructure development companies
  - Forest products industry

10 BENCHMARKING

10.1 Overview of operational environment

The GJFO operational environment consists of an interdisciplinary RMP team of approximately 20 biologists, ecologists, botanists, hydrologists, geologists, natural resource specialists, environmental planners, range specialists, recreations specialists, and GIS specialists. The GJFO RMP team also receives support from realty specialists, haz-mat specialists, law enforcement officers and managers. Additional specialist staff members are included in the planning team but do not work directly with spatial planning tools. The computing environment to support the use of Vista and other tools includes GJFO Information Technology staff and GIS Specialists to perform benchmarking on a Dell Optiplex GX620 Desktop computer with the following configuration: 3.6Mhz Intel Pentium 4 HT running Windows XP Professional Service Pack 2 Build 2600. The computer has total physical memory of 4 gigabytes and total virtual memory of 2 gigabytes. Video card profile is 256MB ATI RADEON X600. NatureServe Vista was initially evaluated using Vista version 1.3.2.0 running under ESRI ArcMap 9.1.0.722 service pack 2. In October of 2008, the GJFO began evaluating Vista version 2.0.0.24495 running under ESRI ArcMap 9.2 service pack 2. November 2008, the GJFO upgraded to Vista 2.0.0.25140 and in January nightly builds were provided that corrected bugs identified by GJFO and NatureServe testers. Spatial Analyst was installed and used for each instance of ArcMap using Vista. It is expected to begin running Vista under ArcMap 9.3 in 2009.

10.2 Benchmarking Activities

10.2.1 Planning & Design

10.2.1.1 History

Initial benchmark evaluation planning was conducted with the USDA Forest Service partner (BTNF) which, because of staff and computing limitations, was unable to conduct the evaluation in a timely manner. Concurrent with this development, NatureServe sought engagement with BLM in development of one or more Vista pilot projects with their field offices. After some initial demonstrations of Vista, the GJFO enthusiastically volunteered to serve as the BLM pilot project and the NASA grant benchmark evaluation site. The original benchmark evaluation plan was submitted to GJFO and minor adjustments were made and accepted.

10.2.1.2 Description of methods and metrics used

As previously described, developing performance metrics for this evaluation was difficult due to the periodic rather than routine RMP activity (~20 year revision timetable) and the lack of established methods or existing tools for conducting this work. The lack of time and resources by the GJFO planning team also limited their ability to conduct comparative tests of Vista relative to alternative means of developing required planning products. We therefore focused the evaluation on:

1. The physical capability of Vista to generate the required planning products (binary assessment)
2. The quality of the Vista products to the degree they fit the ideal outputs desired (qualitative assessment)
3. The estimated improvement in efficiency of generating the outputs compared to expected time and effort to generate these through other means (timed and estimated quantitative assessment)

10.2.2 User Training & Support

The Colorado Natural Heritage Program supplied GJFO with an initial project database of biodiversity observations and NatureServe supplied Vista 2.0 and all associated documentation and user guides. A series of informal web-based modular trainings were planned by NatureServe staff to illustrate Vista functions and answer questions that arose during GJFO Vista project development and initial analysis. Unfortunately, the primary Vista trainer departed the organization shortly after the BLM GIS staff (A. Young) arrived so initial training was limited to overviews of the DST capabilities. Technical support through telephone and email was supplied to GJFO staff during the course of their use of Vista typical of how NatureServe would support other users with funding for advanced support. Additionally, a one day workshop was conducted in early January 2009 which included further overview training on the purpose of various Vista functions which helped provide more context for the use of the DST.

10.2.3 Benchmark Data Gathering & Management

We used the following methods of gathering evaluation data:

1. Verbal and written comments provided by GJFO to NatureServe staff in the course of training and supporting their use of the tool will be documented.
2. NatureServe staff working directly with GJFO also collected observations of tool performance.
3. A digital response form was provided that facilitated GJFO real time capture of their evaluation of functions during the course of their work with Vista using Solobug software (provided by NatureServe) to log comments but technical problems resulted in reliance primarily on sending error messages to NatureServe via email.
4. The workshop in January 2009 also provided an opportunity to gather additional evaluation impressions and target specific evaluation foci.

10.3 Benchmark Tests

10.3.1 Baseline of Comparison

The current Resource Management Plan process differs substantially from that used to develop the original plan. The majority of the data and tools currently available to the GJFO staff were not available in 1987 when the previous Resource Management Plan was originally produced. The basic approach and tools used in the last RMP consisted of mapping efforts using resource data mapped on USGS 7.5' quads by resource specialists and the majority of analysis was qualitative in nature. In the current RMP, the tools and approach use a central GIS dataset established by the GJFO as being reliable and accurate for planning purposes. This includes, but is not limited to, the use of standard GIS analyses in ArcMap for cartographic representation, the use of ArcMap extensions such as Spatial Analyst to perform more advanced modeling of current and future conditions within the field office, and custom built applications such as Vista and others to fulfill GIS requirements that may arise during the planning process.

The majority of resources in the GJFO has been mapped and is currently in GIS available for analyses. For the analyses and products that Vista supports, the GJFO identified outputs of Vista that would be useful in the planning process and attempted to recreate those outputs through standard GIS tools. It was determined that the Vista workflow offers a tool that is unique in its analysis and a practical baseline tool or process for comparison was not identified by the GJFO staff.

10.3.2 Test Approach

We summarize the functional areas of Vista tested and the types of tests conducted in Table 2. We also further define each category of test below. Sub functions of Vista are not listed in Table 2 but some evaluation of them is included in the interpretation. Because of the very long time since development of the last GJFO RMP, no baseline tool or method was available to benchmark Vista against. BLM field offices are largely creating new approaches to develop their RMPs so Vista was evaluated by making assessments of the suitability of Vista to do the job as well as by comparison with alternate methods of generating the needed outputs.

10.3.2.1 Scoring

The evaluation entailed both quantitative and qualitative assessments. For quantitative assessments the units of measure are described for each test. For qualitative assessments a 5 point relative value scale

was employed as follows but evaluators added further description to define what the score means for the individual tests:

1. DST would require substantial changes to meet minimum requirements
2. DST would require moderate to minor changes to meet minimum requirements
3. DST meets minimum requirements
4. DST exceeds minimum requirements
5. DST significantly exceeds minimum requirements

Table 2. Benchmark Test reference codes identifying NatureServe Vista functions to be tested by type of test to be performed.

Vista Function / Type of Test	Element Information & Mapping	Conservation Value Summary	Scenario Definition	Scenario Evaluation	Condition Modeling	Site Explorer/ Mitigation Development
1.Overall evaluation	EL1	CVS1	SD1	SE1	CM1	EXP1
2.Value to planning process	EL2	CVS2	SD2	SE2	CM2	EXP2
3.Interaction efficiency	EL3	CVS3	SD3	SE3	CM3	EXP3
4.Computational performance	EL4	CVS4	SD4	SE4	CM4	EXP4
5.Response time (user assessment)	EL5	CVS5	SD 5	SE5	CM5	EXP 5
6.Communication Effectiveness	EL6	CVS6	SD6	SE6	CM6	EXP6
7.Accuracy for purpose	EL7	CVS7	SD 7	SE7	CM7	EXP 7
8.Ease of use	EL8	CVS8	SD 8	SE8	CM8	EXP 8

Following are the categories of tests with specific descriptions for individual tests where warranted, to clarify the intention of the test:

1. Overall evaluation

This evaluation is ranked on the 5 point scale to summarize the value and performance of the function. The score may be accompanied by comments that clarify what characteristics most influenced the score so as to inform how the tool might be improved.

2. Value to the planning process

This test employs the 5 point scale to evaluate the degree that the product of a function or the function itself (where it supports other functions that develop outputs) is useful to the RMP process. This is considered the primary test to determine which functions of Vista are applicable to the Resource Management Plan process. The other categories of tests identify specifics about needed improvements in Vista to improve performance, accuracy, comprehension, etc.

3. Interaction efficiency

This test provides a quantitative measure or estimate of the amount of staff time required to carry out analyses for comparable functions in Vista using other tools and methods. For some functions this primarily assesses tool operator time to set up the analyses and derive results. For some functions this also includes other staff time normally needed to parameterize inputs and models, validate and interpret results, or incorporate results into other processes.

4. Computational performance

This test provides a quantitative measure or estimate of time to compute the output products of the analysis for comparable functions in Vista by other tools and methods. This test measures computer processing time only; staff interaction time is measured in evaluation 3 above.

5. Response time

This test employs the 5 point scale to evaluate the degree that computational performance is adequate for the RMP planning process.

6. Communication effectiveness

This test employs the 5 point scale to provide a qualitative evaluation of the comprehensibility of the outputs of the Vista functions to staff and or stakeholders, leaders, or the public. Evaluation is made to comparable products produced by other tools/processes.

7. Accuracy: products were sufficiently accurate/precise for purpose

This test is intended to provide either quantitative or qualitative evaluation of the accuracy and precision of products from Vista. Specific test criteria:

- EL7: Intent is to evaluate the ability to define the element and its conservation requirements with sufficient precision for the plan development.

- SD7: Intent is to evaluate the ability to define the scenario in ways that are sufficient in terms of thematic and spatial detail.
- EXP7: Intent is to evaluate the ability to sufficiently/precisely map and define a change to the land use within a planning unit.

8. Ease of Use

This test employs the 5 point scale to provide a qualitative assessment of the general ability to apply the functions which may incorporate a number of usability issues such as:

- User interface design
- Software documentation quality and applicability
- Input preparation

10.3.3 Preparatory activities

Several steps were undertaken to prepare GJFO for use of Vista and conducting of the benchmark evaluation:

1. NatureServe, with the Colorado Natural Heritage Program (CNHP) first worked with GJFO to conduct components of TNC's Conservation Action Plan (CAP) process (TNC 2007) to identify biological resources to be considered in the planning process. CNHP then provided a database of element observations to GJFO to develop the conservation parameters needed for Vista.
2. NatureServe consulted with GJFO on development of the "land use intent" and "policy type" lists which serve as Vista inputs that link land use scenarios to conservation element responses so scenarios could be evaluated and guidance can be gained from the tool in appropriate alternative scenario development. This activity required several meetings and proved to be somewhat of a challenge for GJFO and a few other current Vista users. Distinguishing between land use types (what happens on the ground) and policy types (what causes them to happen) sounds simple but in practice is not a trivial activity.
3. NatureServe then conducted telephone and web-based training modules to train GJFO staff in the various components of Vista upon request of the GJFO staff.
4. NatureServe installed Solobug software with GJFO to facilitate their capture of validation comments during the benchmarking process but technical problems led to use of email as the preferred method. Most scoring and comments were provided directly in this document by GJFO as they conducted the evaluation.

10.4 Implementation of Vista at GJFO

Any decision support system includes not only the software itself but a database and associated user inputs in terms of expert knowledge, models, and values. For the benchmark evaluation GJFO was provided with:

1. NatureServe Vista 1.3 and 2.0 beta versions
2. NatureServe Vista Documentation provided as UI context help and as a separately accessible PDF.
3. An element observation conservation database for the entire GJFO which included:
    a. Direction as to what base data would be appropriate for geographic reference and basic analysis using GJFO internal GIS datasets (i.e.: roads, rivers, conservation areas, etc.)
    b. Element Data: Spatial data for conservation elements (to which GJFO added elements of their own choosing and distinct from those existing in the CNHP database from GJFO GIS datasets)
    c. Conservation requirements (expert knowledge) inputs were and are continuing to be developed by GJFO resource staff to ensure accuracy of Vista analysis results. These inputs include the following categories that are used by Vista 2.0:
        i. Element goals
        ii. Element weights
        iii. Element occurrence minimum area requirements
        iv. Element occurrence condition thresholds
        v. Element responses to land uses
    d. Default list of land use and policy types agreed upon by GJFO and NatureServe staff to be appropriate for use during the benchmark testing phase

NatureServe supported GJFO during the evaluation phase similar to the type of technical support offered to other Vista clients and added our own comments from that support as it related to benchmarking.

11 BENCHMARK RESULTS

Vista is a novel tool that supports analytical capabilities of a breadth and complexity that, when coupled with novel data products such as synoptic high resolution (satellite-based) vegetation map data, preclude to a large degree direct comparison of previous methods conducted without this DST and data. In other words, Vista coupled with NASA data created entirely new types of analyses not conducted and largely not feasible in previous planning processes.

Example of a benchmark test procedure: Creating a Conservation Value Summary

In order to test the benefits of Vista outputs, the GJFO created various Conservation Value Summaries (CVS) in order to understand areas of element richness. These CVS have been filtered based on species type, such as Avian, Mammals, Aquatic, etc. GJFO recreated a CVS based on avian species in order to determine the value of Vista to this type of analysis as opposed to standard GIS functionality. Nine shapefiles were converted to rasters similar to how Vista prepares input data for analysis. The avian rasters were than summed together using ESRI Spatial Analyst extension in order to develop a richness index similar to the Vista CVS. The Vista CVS took 36 minutes to process completely from shapefile to final Richness CVS. The manual process, including the additional time the analyst had to spend to research an adequate argument to summarize the rasters (Vista does this internally) took about 3 hours overall. It should also be noted that the output of the manual process does not provide site level detail as is offered by Vista's Site Explorer, relevant to the area of concern.

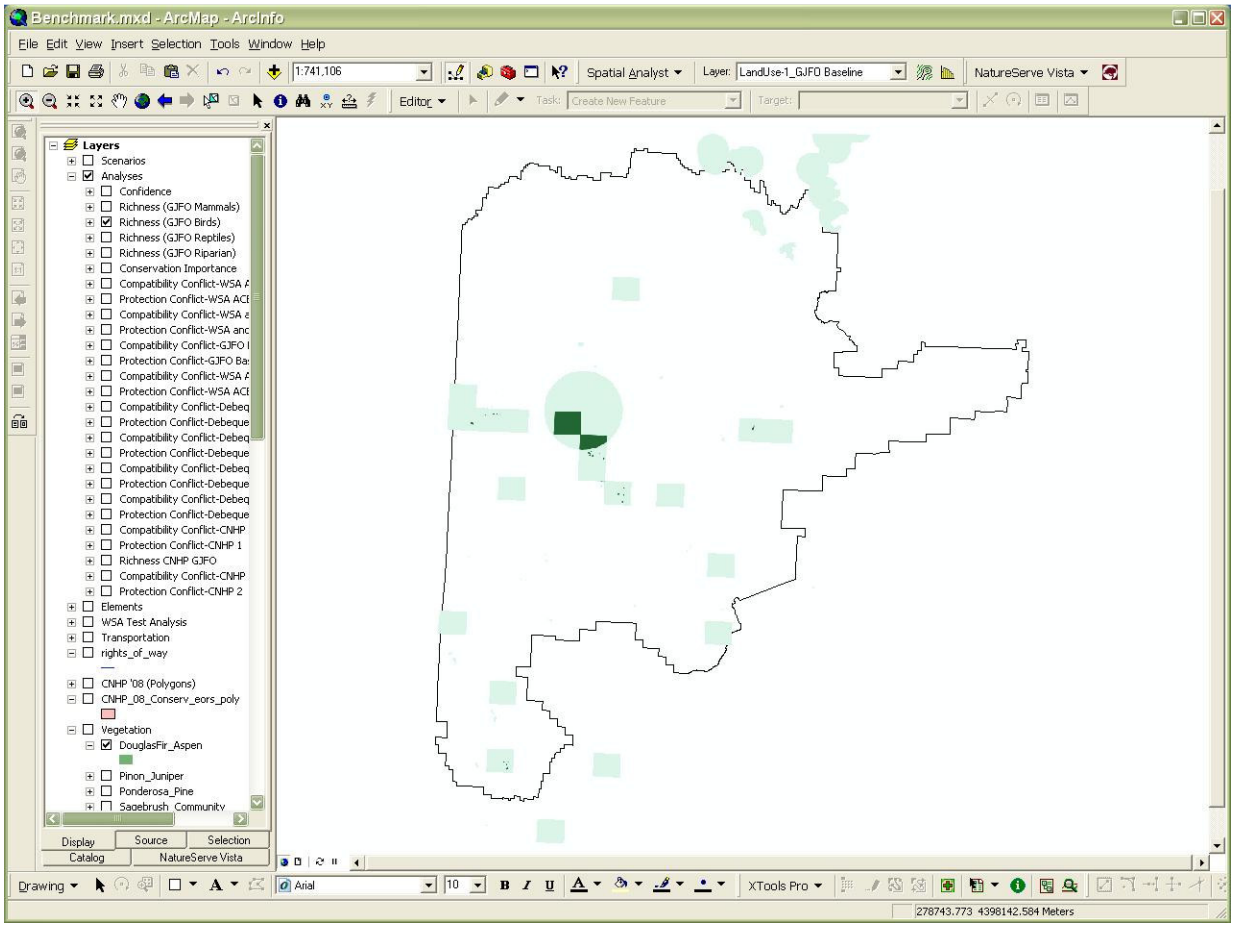

Figure 7. Conservation Value Summaries developed using Vista and manual methods in ArcGIS. These produced identical results with similar computation time but use of Vista saved approximately 2.5 hrs of human interaction time over manual

11.1 Benchmark Scores by Function

GJFO staff compiled all comments and measurements from the benchmark evaluation directly in Table 3 and synthesis suggestions below (NatureServe staff contributed to some synthesis, interpretation, and

recommendations but not evaluation scores). We categorized the responses according to the specific tests and analyzed the results as appropriate to the type of test (i.e., qualitative vs. quantitative). Specific results by test are presented here; summary results are described in section 11.2. More detailed results and comments regarding computation time performance are presented in Appendix 3.

Table 3. Results of Benchmark Evaluation Tests. For each cell, the test reference code is provided at the top followed by the score. Scores range from 1 (DST would require substantial changes to meet minimum requirements) to 5 (DST significantly exceeds minimum requirements).

Vista Function Type of Test	Element Information & Mapping	Conservation Value Summary	Scenario Definition	Scenario Evaluation	Condition Modeling	Site Explorer/ Mitigation Dvpmt	Ave
1. Overall evaluation	EL 1 3	CVS 1 4	SD 1 4	SE 1 4	CM 1 3	EXP 1 5	3.8
2. Value to planning process	EL 2 3	CVS 2 4	SD 2 4	SE 2 5	CM 2 4	EXP 2 5	4.2
3. Interaction efficiency	EL 3 3	CVS 3 3	SD 3 3	SE 3 3	CM 3 3[1]	EXP 3 4	3
4. Computational performance [2]	EL 4 4	CVS 4 4	SD 4 4	SE 4 3	CM 4 4	EXP 4 4	3.8
5. Response time (user assessment)	EL 5 5	CVS 5 5	SD 5 4	SE 5 4	CM 5 5	EXP 5 4	4.5
6. Communication Effectiveness	EL 6 3	CVS 6 3	SD 6 4	SE 6 4	CM 6 3	EXP 6 4	3.5
7. Accuracy for purpose	EL 7 4	CVS 7 3	SD 7 4	SE 7 4	CM 7 4	EXP 7 5	4.0
8. Ease of use	EL 8 4	CVS 8 4	SD 8 2	SE 8 3	CM 8 2	EXP 8 4	3.2
Average Score	3.6	3.8	3.6	3.8	3.5	4.4	3.8

Notes:

1. Staff time to determine condition modeling values was fairly substantial and while simpler than other models like EMDS it would be very useful to provide an interface to bring them in from other methods that specialists would use to agree upon those values.

2. Appendix 4 contains specific times clocked for functions, sub functions, and associated tools.

11.2 Synthesis and Interpretation

In this section we synthesize and interpret lessons learned according to the functional performance of the DST (the columns in the table above) and the test criteria (the rows in the table above).

11.2.1 Interpretation of Functional Performance

In this section we summarize and interpret findings relative to Vista functions. Overall, Vista scored well with all functions scoring between 3.5 (meets requirements) to 4.4 (exceeds requirements). Overall, the functions deemed most useful for RMP development in Vista are Scenario Evaluation and Site Explorer (see bullet below). These functions work hand in hand and produce the map and quantitative outcomes most directly applicable to EIS requirements. Only two functions had individual criteria scores below adequate—Scenario Definition and Condition modeling under the ease of use criteria—see bullets below. Some additional specific observations include:

- A key need for BLM in developing its RMP is documenting the thought process and rationale as you move through the planning process and to create a record for why a given action or policy was taken. Vista's note-capturing feature is ideal for documenting data and other input sources and also justifications for analytical processes. Having those notes both stored in the database and also placed in the corresponding reports is a significant contribution of Vista to the RMP process.

- Site Explorer was highest ranked because the reports are clear and the function saves time in gathering an extensive amount of information for the end user. Mitigation development is fairly fast and clear using this function as well.

- Scenario Definition was ranked at a 2 for Ease of Use. This was due to BLM staff considering that the time to understand and properly use this function in Vista may be high and additional support to ensure that scenarios are created accurately may be needed during the planning process.

- Condition Modeling was ranked at a 2 for Ease of Use. The recommendation was to alter the input menu structures to be more concise and more editable, thus preventing user confusion. This was given as a minor change recommendation in the tool from the BLM staff.

11.2.2 Interpretation of Test Criteria Performance

All test criteria achieved average scores between 3 (meets requirements) and 4.5 (exceeds requirements). Interaction efficiency scored lowest due to the amount of expert knowledge gathering required to use Vista in its most rigorous application though GJFO also provided recommendations for some interface streamlining to improve this criteria. Response time scored highest because, even though computing performance is slow due to the ArcView platform, results are delivered far more quickly than can be expected to be produced without the DST using manual GIS methods.

- Vista 2.0 needs additional "getting started" guidance and additional help with workflow using the tool in the form of additional documentation and training will be important for extending the tool.

11.3 Lessons Learned from Other Vista Applications

Vista has or is being applied in a number of other organizations and decision environments as described in section 9.1. NatureServe is actively engaged in several of these in roles ranging from technical support to project advising to being the initial primary operator of the DST. NatureServe notes, however, that most applications of the tool are still in a sufficiently early stage that a full evaluation (especially of the new 2.0 functionality) has not been done. That said, from these activities NatureServe has learned the following additional lessons (see also Appendix 4 for a formal evaluation report on the application of NatureServe Vista in a demonstration watershed for the Lake Erie Alleghany Partnership project):

1. Performance findings

1.1. Performance of the tool can be unacceptably slow when the user has a combination of large project areas with high complexity (number) of elements at high resolution and with a large number of analytical units (sites). The physical memory limits of ArcView, Windows, Microsoft Access, and Vista can result in either unacceptably slow performance or even inability of the DST to complete analyses. Generally, projects with analyses that require processing more than 1 billion cells in a single batch will cause ArcMap and Vista to deplete RAM and crash. NatureServe now provides guidance on how to calculate these limits for users prior to engaging in a Vista project. Otherwise it is important to set appropriate expectations; the most demanding Vista analyses may take up to 3 days to process, however, conducting identical analyses manually NatureServe expects would take several weeks.

1.2. In one anecdotal case, NatureServe's Pennsylvania Heritage Program compared a manual process to Vista for generating a CVS. Vista was estimated to take 8 hrs to perform this analyses while the manual method took 3 days (see actual timed results from GJFO in this report)

1.3. Vista runs too many data validation checks which cause user interface response delays and processing delays. Users recommend having Vista only conduct validations at the start of sessions or when new information is introduced.

2. Stability findings

2.1. Modifying the Vista database manually via Microsoft Access instead of operating the tool through the provided interfaces will cause long-term, unfixable stability issues within that project.

2.2. Some users have encountered errors that are project-specific to their data, meaning they could not be replicated with other data sets.

11.4 Benchmarking Gaps

As described earlier, several factors about the RMP process and specifics of GJFO implementation precluded a strong quantitative evaluation in all areas. Areas inadequately tested by GJFO include:

1. Scenario Evaluations of the entire planning area with all elements included in the analyses. The process failed each time and the evaluation could not be created, and thus could not be benchmarked. GJFO was able to evaluate scenarios for smaller filtered lists such as Reptiles or Mammals, which lead to a limited perspective on their respective impacts. This is due to the high number of element occurrences input when using ArcView that ESRI does not support. A "Power User" version utilizing ESRI ArcInfo software is recommended to address this issue for larger planning areas with high element occurrences.

2. Condition System did not function through the entire time that GJFO used Vista so could not be evaluated. Incorrect functionality within Vista would not allow saving of Conditions in lists to be used during scenario evaluations, however this was addressed by NatureServe to allow for limited testing of the feature for this report.

3. The MARXAN/SPOT input creator was not fully tested due to the unclear utility it would bring to the planning process at the time of VISTA evaluation.

12 CONCLUSIONS AND RECOMMENDATIONS

12.1 Summary of benchmarking results

NatureServe Vista demonstrated its potential for broad application by BLM in its Resource Management Planning activity and likely activities to implement RMPs such as project level environmental impact assessment. Although BLM generally does not make and thus did not demonstrate a high degree of use of NASA products thus far, Vista's relatively open information framework provides the potential for BLM (and or other users) to make considerably greater use of NASA products. Vista can be characterized as more of a "downstream" DST meaning that it directly supports the integration of data for plan development as opposed to "upstream" systems that convert NASA sensor outputs into derivative products of direct application in Vista. For example, recent NASA grant work converts remote sensing data into predictive models of invasive species spread (http://invasivespecies.gsfc.nasa.gov/index.html); Vista can then import such models to assess planning ramifications. This two-stage approach to developing and applying NASA product derivatives also holds great promise for assessing and planning for climate change phenomena such as sea level rise and habitat alteration.

Although there are limitations to the Vista software such as remaining bugs and a steep learning curve for the average GIS user and planner, it is believed that Vista will hold value in the development and analysis of alternatives during the Grand Junction RMP revision. Vista is a tool that is both unique and flexible, allowing the user to develop and model various current and potential scenarios providing a solid foundation to determine the impacts of various land uses and policies on the landscape. Vista also provides the means to document, through its notes functionality, the reasons and thought processes of specialists as to why a land use or policy was evaluated. In addition, the ability to calculate statistics and reports that can provide details for each element is predicted to be extremely valuable to planners and resource specialists as they develop management strategies in the RMP.

12.2 Recommendations for Improvement of NatureServe Vista

These recommendations are synthesized from our GJFO Benchmark Evaluation as well as NatureServe's experience with other Vista applications.

1) Improve performance:

Performance is affected by several factors and therefore several solutions from relatively minor code clean up to complete software rewrite on new platforms can be proposed:

a) ArcInfo Version

Performance for large, complex regional projects that are conducted at fairly fine resolution is currently poor owing to the ArcView platform of Vista. While Vista was intended primarily for county/landscape scale applications, there currently is greater demand for larger regional applications. Performance for such projects could be profoundly improved by migrating Vista onto the ArcInfo platform for what we term a "power user version." The majority of the current performance issues are caused by limitations of the ArcMap and Spatial Analyst code that Vista is built upon. Because Vista has proved to be a desirable tool for large scale, complex planning processes, it must have a commensurate code platform and ArcInfo is currently the best choice. However, NatureServe will retain an ArcView platform version as well because the majority of NatureServe Vista's potential market does not use the more expensive ArcInfo software.

2) Code overhaul

Vista has been developed by several engineers over a period of nearly 7 years. This has lead to a variety of infrastructure problems of redundancy (e.g., in validation checks), old workarounds to ESRI limitations that may no longer be required, etc. Some partial fixes such as validation clean up could be performed in a couple person months of work while others would require wholesale reengineering. Our future (unfunded) plans would combine development of an ArcInfo version with a code overhaul. We are also interested in investigating other open source platforms which are becoming popular for some DSTs but migrating to these would require reengineering Vista from the ground up.

3) Improve Usability:

As Vista has evolved over the past 5 years, valuable features have been added, however, usability limitations in Vista exist because of this incremental development process.

a) Workflow streamlining

Specifically, the Vista workflow is extremely complex and current user interfaces do not help the user understand underlying dataset relationships and typical workflows. These interfaces and the actual code base should be streamlined to reflect a more intuitive, efficient workflow. A challenge, however, is that Vista was designed to be applicable to the entire breadth of land and water planning and management activities (e.g., conservation and land use planning, public land management, infrastructure and energy development planning, etc.). Therefore, there is no single way to

communicate the workflow and NatureServe is often asked to develop custom workflows for projects. One solution may be to generalize these custom workflows to particular sectors and offer these through Vista's online guides.

b) Condition modeling for starting condition

Currently in Vista 2.0 condition models can only be developed after elements are entered and models will only apply to future scenarios. In other words, you are unable to use the automated condition modeling function to assign the starting condition to elements and must run the standalone Arc Toolbox model that NatureServe provides to establish starting condition. While there are manual workarounds to this shortcoming, it is recommended for version 2.5 that Vista support modeling starting condition.

4) Modular implementation

Vista could be rebuilt in a modular format that would allow new improved or user-specific analytical modules to be written and plugged into the framework.

5) Improve Input Data Compatibility

Vista is currently built to use ESRI Shapefile as its sole data type input for conservation elements. Although this is a widely used type of GIS data storage format, newer more robust formats are being implemented by the BLM such as File Geodatabases. The ability to input data from a geodatabase would allow larger organizations a simplified way for initial Vista project creation. Currently, GJFO has to convert current GIS data in File Geodatabases to Shapefiles for each element or landuse/policy before beginning to create a project or element list.

6) Importation of Specialist Values from BLM Resource Management Planning Workbook

In order to increase efficiency with other planning processes being utilized within the GJFO, an interface to import specialist values from the BLM Resource Management Planning Workbook (developed by the Nature Conservancy and allows coordination between different disciplines to occur for required Vista elements), would be useful. NatureServe has an evaluation project with TNC that will investigate the linkage between TNC tools and Vista. TNC, however, is moving from the Excel Workbook to new software called Miradi (www.miradi.org) and NatureServe anticipates future integration with that tool.

7) Subregional Spatial Filter

Allow the ability to create a subregion spatial filter (that allows analyses within the subregion unit) by identifying a polygon from within an existing shapefile (e.g., one basin from a regional map of watersheds). Currently the subregion filter must be created by manually selecting the unit (e.g., basin) of interest and creating a shapefile of it for input to Vista. Additionally, this function currently still requires processing across the entire extent of the planning region, not just within the extent of the subregion so performance is not improved by using this function.

8) Ability to reuse Vista project components in other Vista projects

GJFO staff and other projects' staff have identified the benefit of being able to share or reuse information developed in Vista databases on other projects. Currently users can copy a Vista project which saves a good deal of the information but they have to specify new spatial data and redo the analyses. Often the need is to create a larger or smaller Vista project from an existing one within the same region which is infeasible due to ArcView limitations. GJFO specifically requested the ability to export Vista elements (all properties and spatial data) and reimport into a new Vista project in order to maintain different map projects while not needing to recreate Elements each time. This is related to the Collaborative Vista work recommendation below.

9) Support Collaborative Vista work

Developing Vista project databases and conducting planning in regions typically involves multiple collaborating parties. As a desktop product, Vista has limited ability to support collaborative work among institutions. This isn't likely a need for BLM but other regional Vista projects have suggested the ability for distributed experts to provide input either online or through emailable element objects that can be imported into Vista projects and for support for multiple users evaluating and contributing to scenarios. This was the subject of a more recent NASA proposal that was not funded.

10) Improve deletion of features between Vista and ArcMap

When deleting items in the Vista tab, items do not delete from ArcMap Display Tab. This can lead users to delete features inside the Display Tab causing incorrect functionality within Vista. The two tabs should update together to avoid user confusion and project/data corruption in Vista. In addition, ensure that when an element or scenario is deleted in the Vista tab, the datasets are deleted in the Vista database in order to save disc space and avoid complication of database.

11) Improve Filter Properties Display

Increase the viewable area of the filter expression box that displays the elements that compose the created filter. Currently, it is at a fixed height and weight which cuts out element display if you have a large filter.

12) Provide ability to compare 2 or more scenarios

This ability is currently in NatureServe's Vista "wish list" and would allow users to select 2 or more scenarios and generate comparison statistics. Currently users can readily export the tabular results to Microsoft Excel and conduct comparisons themselves.

13 NEXT STEPS

13.1.1 Next Steps for GJFO Implementation

GJFO will present its evaluation of Vista at a national meeting of BLM planners in March 2009. It is planned that GJFO will continue to build upon their current Vista project and utilize the various

functionalities as the RMP process begins alternative development and analysis in the Spring of 2009. It is also planned that the GJFO will use Vista as a monitoring tool for the field office in companion with other GIS products that may be deemed useful in assuring that the RMP is providing acceptable policy for resource management in the field office. GJFO will use Vista to model conflicts under the "no action" alternative to determine what management objectives and goals can be changed within the full range of alternatives. Vista will then be used to analyze direct, indirect, and cumulative impacts for each alternative. This information will be published in the Draft Environmental Impact Statement (DEIS).

Based on agency reviews and public input on the DEIS, GJFO will have the opportunity to re-run scenarios within alternatives to change land uses, objectives, and goals to determine the agency preferred alternative to be published in the Final EIS and Record of Decision.

13.1.2 Other Planned or Ongoing Activities

NatureServe recently decided to make Vista 2.x available for free download (previous versions required a license fee of $1500-$2500 including technical support. Support services will still be charged but NatureServe believes the free license will significantly boost adoption of the tool. NatureServe Vista is already being implemented in a number of applications spanning many regions in the Western Hemisphere and operational environments (see Section 9.1). NatureServe plans to maintain a technical support process that efficiently captures learnings from these applications in terms of software bugs, documentation needs to provide better user guidance, and new feature or usability suggestions. NatureServe also works closely with many of these users in collaborative applications where we learn of additional methodological approaches to using the tool and priority features for future versions. For implementing our recommendations NatureServe will require additional funding which is being pursued through other government and philanthropic tool support opportunities. During the course of this grant, NatureServe was successful in the following contributions to the Vista program:

- Chevron Corporation contributed approximately $50,000 to general support of the Vista program which contributed to version 2.0 development and release
- The Packard Foundation contributed $40,000 to development of version 2.0 and $85,000 to development of version 2.5
- The Nature Conservancy contributed approximately $3500 for testing version 2.0 on the ArcMap 9.3 platform

Unfortunately the economic downturn has eliminated our endowment spending for the foreseeable future depriving the program of approximately $80,000/year of core support which is impeding a number of non-project-specific activities such as marketing and outreach, full website revamping, redevelopment of training content for web delivery, developing of additional guides and FAQs, and routine code maintenance. In general, NatureServe has noticed a drop in funding availability for DST development and support and thus has launched the Tool Developers Collaborative as a working group of the EBM Tools Network (ebmtools.org). One foci of this group will be to renew DST support interest among foundations and government programs.

14 REFERENCES

Bureau of Land Management 2005. Land Use Planning Handbook 1601-1, release 1-1693. Available at http://www.blm.gov/pgdata/etc/medialib/blm/wo/Information_Resources_Management/policy/blm_handbook.Par.38665.File.dat/h1601-1.pdf

Crist, P.J. and R. Deitner. 1997. Assessing land cover map accuracy. A Handbook for Gap Analysis v 2. USGS Biological Resources Division Gap Analysis Program Home Page http://www.gap.uidaho.edu/gap.

Groves, C. 2003. Drafting a conservation blueprint. Island Press. 404pp.

Hansen, M.C., R.S. DeFries, J.R.G. Townshend, M. Carroll 2003. Earth Interactions v7-paper 010. http://glcf.umiacs.umd.edu/pdf/ei_hansen.pdf

NatureServe 2002. NatureServe Element Occurrence Data Standard. NatureServe. http://www.natureserve.org/prodServices/eodata.jsp

TNC 2007. Conservation Action Planning Handbook: Developing Strategies, Taking Action and Measuring Success at Any Scale. The Nature Conservancy, Arlington, VA

Zimmerman et.al.2000. Development of High Data Readout Rate Pixel Module and Detector Hybridization at Fermilab. http://www.ge.infn.it/Pix2000/slides/zimmerman.pdf

15 APPENDIX 1 VERIFICATION AND VALIDATION

15.1 NASA Application Mission Traceability

Vista is a "downstream" decision support tool in that it is intended to be highly flexible to inputs at a variety of scales. It is not capable of utilizing raw sensor imagery but rather utilizes information products developed from sensor imagery (e.g., ecosystem distributions, predicted species distribution models, land use, coastal inundation models, etc.). In NatureServe's initial Evaluation Report NatureServe described the potential spatial inputs to Vista supported in whole or part by NASA Earth Science Results. Note that NatureServe did not separately describe inputs to models of predicted species distributions in that report as none had been applied to date. Those are added here relative to one project in South America where such data was incorporated in Vista. After each entry below NatureServe identifies whether the input was tested and in what project environment.

1) **Land Cover/Terrestrial Ecological Systems Modeling**

Land cover, and more specifically to biodiversity conservation, ecological systems, are classifications of the landscape that can be modeled using inputs that describe the vegetation cover, biotic, and abiotic attributes of a site. These can be complex models with many inputs. NatureServe initially developed a Vista project that covered the entire Greater Yellowstone Area which utilized an ecological systems classification with the following inputs:

a) The USGS GAP landcover data set

NatureServe tested this input in the Greater Yellowstone Area database we initially assembled for the BTNF project. This data was the backbone of our Terrestrial Ecological Systems modeling efforts. That is, the GAP data coupled with the other inputs and expert knowledge were the building blocks for the Terrestrial Ecological Systems data set.

b) The Digital Elevation Model (DEM)

This is a raster data set created by the USGS.

c) The National Land Cover Data (NLCD)

This is a raster data set created by the USGS.

2) Landscape Integrity Model

The Landscape Condition Model provides a surrogate measure of landscape integrity or species habitat condition. It is a raster index layer based on the combination of data inputs that an expert has deemed

relevant for establishing integrity scores on a normalized scale. Depending on the ecosystem type or conservation element, the model may require many inputs from several sources. For this project NatureServe applied the following data sets:

a) The Dam locations data

This point feature dataset is from the USGS Geographic Names Information System (GNIS).

b) The Mine locations data

This point feature dataset is from the USGS's Geographic Names Information System (GNIS).

c) **The railroads data**

This line features dataset is from the USGS via Digital Line Graphs (DLG).

d) The roads data

This line features dataset is from the USGS via Digital Line Graphs (DLG).

e) The Coal beds, Methane, and Natural Gas wells location data

This point feature dataset is from I H S Energy Group.

f) The invasive weeds locations data

This point feature dataset is from the Fremont County, Wyoming.

g) **The National Land Cover Data (NLCD)**

This raster data set is from the USGS and is used to depict Urban and developed areas.

h) The Comprehensive Environmental Response Compensation and Liability Act (CERCLA) data

This point feature dataset is from USEPA and identifies various pollution sources.

i) The Industrial Facility Discharge (IFD) data

This point feature dataset is from USEPA and depicts discharges of various industrial pollution types.

3) Predicted Species Distribution Models

Species are a common Conservation Element in NatureServe Vista. Most species data is limited to observation occurrences (point or buffered points) representing field observations which are usually biased and highly incomplete for depicting geographic distribution of species. Alternatively these

observations can be used with large amounts of biogeophysical data themes to statistically model the probable distribution of species. Our V&V for this input was conducted using a raster dataset from the Wyoming Natural Heritage Program that depicts the probability of suitable habitat for species as a 0-1.0 value of each pixel. It is created through statistical modeling software and a large number of datasets largely drawn from those in the above list.

Further, we utilized several models in a project in Peru. That project, funded by the Gordon and Betty Moore foundation modeled the predicted distribution of 700 endemic species in the Amazon basin portion of Peru and Bolivia. The modeled distributions were then input to Vista in a demonstration project for Department-level planning. Inputs to the models are shown in Figure 8.

Table 4. Climatic, topographic, and vegetative variables used for models in the Andes/Amazon modeling project.

Variable	Source
Climate	
Topography	
Elevation Slope Topographic position index	Hole-filled seamless Shuttle Radar Topographic Mission (SRTM) 90 m digital elevation data Version 2 (srtm.csi.cgiar.org). Slope calculated as the maximum rate of change in elevation from each pixel to its neighbors. Topographic position index calculated by determining the difference between the mean elevation within a neighborhood of pixels and the center pixel (Zimmermann 2000).
Vegetation	
Percent tree cover	Moderate Resolution Imaging Spectroradiometer (MODIS) 500 m Global Vegetation Continuous Fields (Hansen et al. 2003).
Enhanced Vegetation Index (EVI) 1 Enhanced Vegetation Index 2	MODIS/Terra Vegetation Indices 16-Day L3 Global 1 km. EVI 1 and EVI 2 are the first and second principal components from a correlation matrix of EVI geotif images.

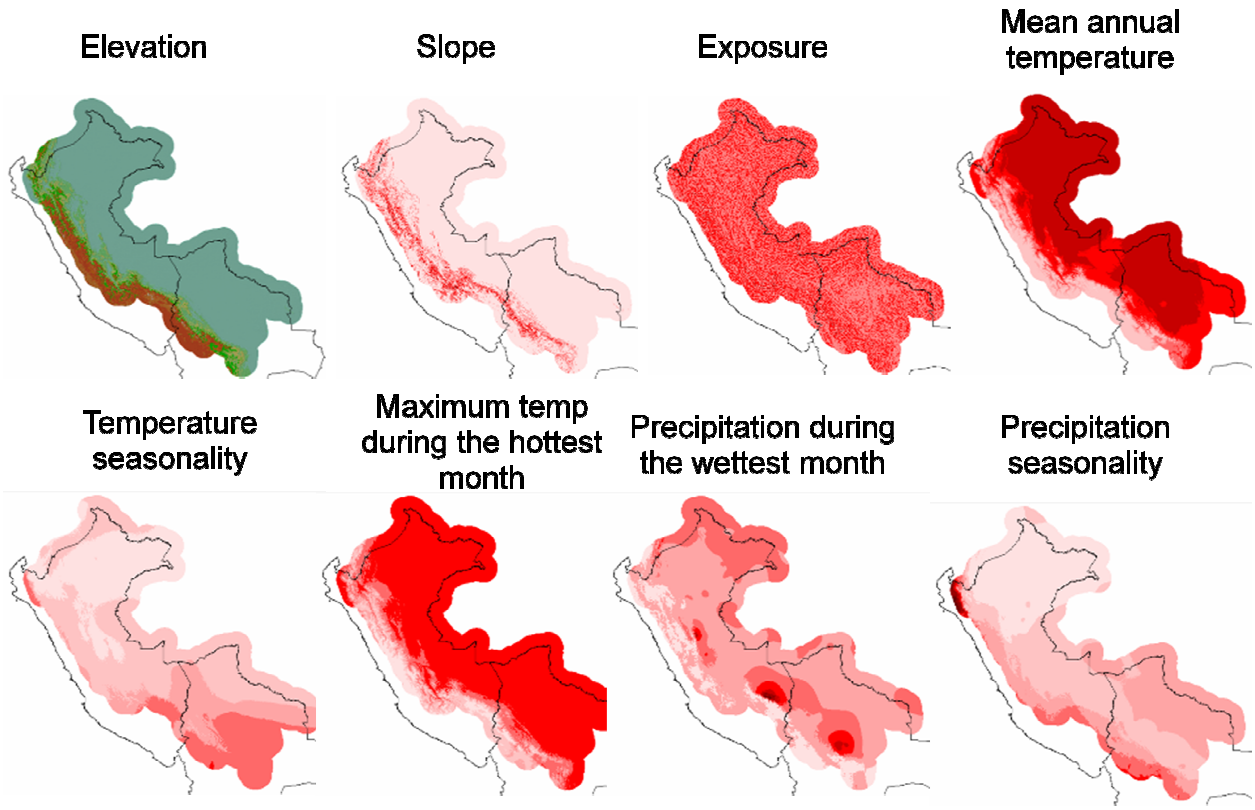

Figure 8. Inputs to predicted species distribution modeling in the Andes portion of the Amazon basin. Darker colors correspond to higher values of the input layer scaled appropriately to the input. Distribution models associate probability that the input values support the element distribution. Statistical combination of the input probabilities produce the overall probability of distribution in each pixel.

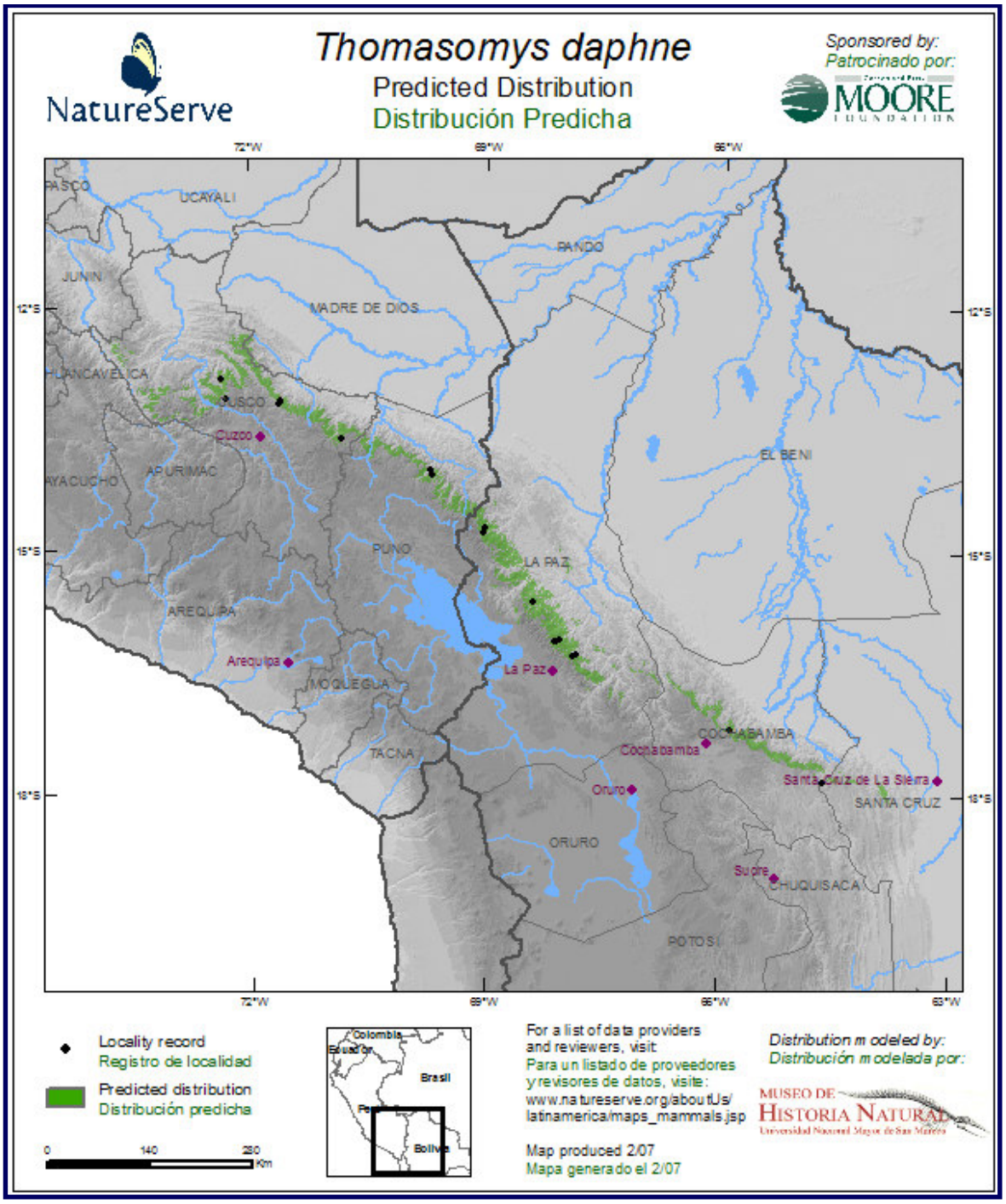

Figure 9. Example output of a species distribution model (green) overlaid with observation records (black diamonds).

15.2 V&V Gaps

15.2.1 Gaps, shortcomings, or limitations in V&V process

We were not able to proactively identify a broad variety of NASA products for testing in Vista. As indicated previously, Vista is a "downstream" DST that imports derivatives of NASA products and thus identifying such products derived from NASA sources is difficult. We do, however, envision considerable NASA and other remotely sensed inputs such as:

- Sea level rise models as scenario inputs to assess threats (in process of being verified)
- Predicted species distribution maps as conservation elements (already verified)
- Predicted distribution or modeled spread of invasive species, pests, disease as scenario inputs to assess threats
- Climatic parameters and models of change for temperature and moisture for example that can be used either in models affecting the above two inputs or directly as scenario inputs to assess threats to species or ecosystems.

15.3 Conclusions and Recommendations

15.3.1 Recommendations

We plan to opportunistically test and validate the use of inputs such as those described above in the course of conducting projects with Vista. Additionally over time we hope to continue increasing the ease for users to input such data. Specifically for element inputs only vector (shapefiles) are currently supported. We hope to facilitate input of raster-based element inputs as well (raster inputs for scenarios are already supported).

16 APPENDIX 2: VISTA PROCESS DIAGRAMS

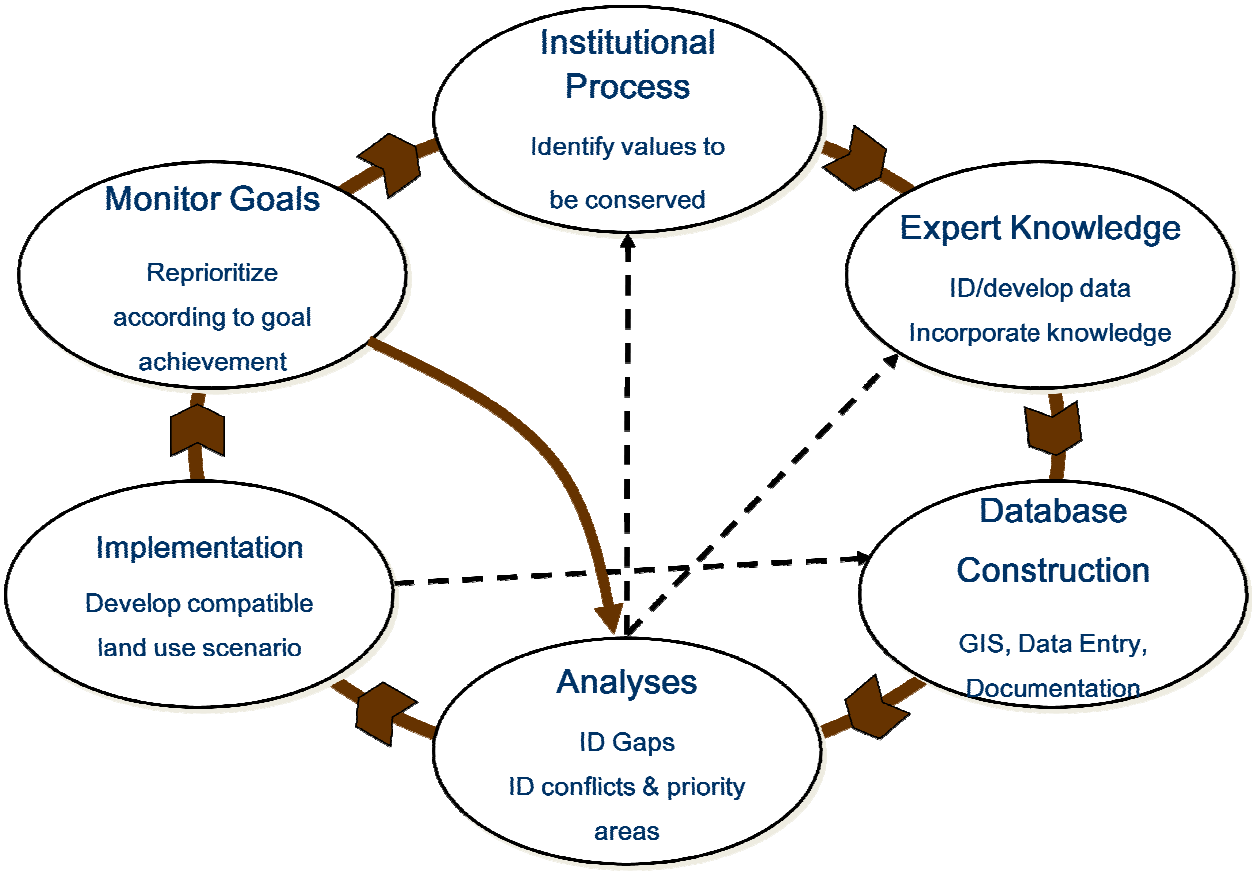

Figure 10. Process diagram of Vista activities within a typical planning process.

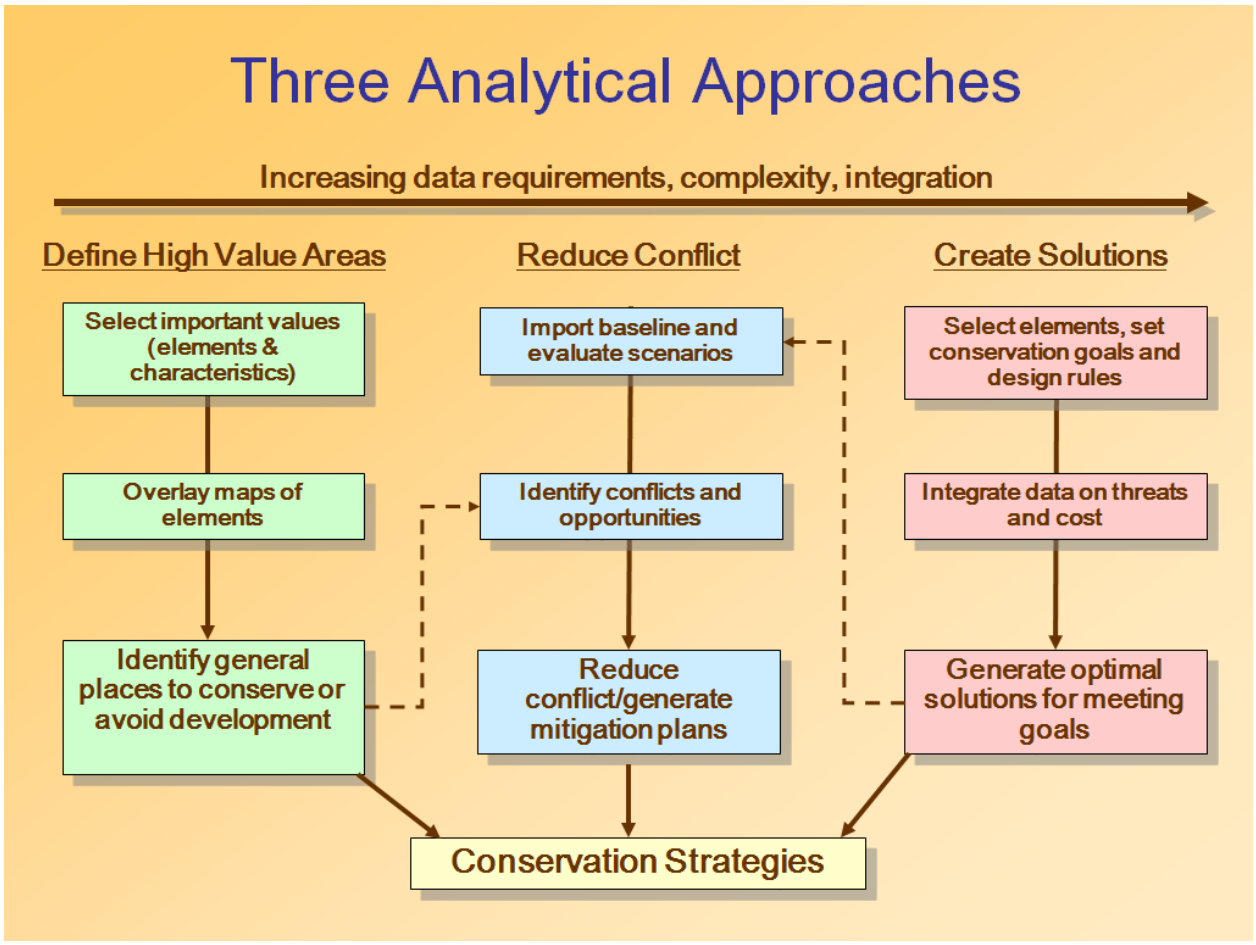

Figure 11. Three supported analytical pathways provided in Vista to develop conservation strategies. Ordered from left to right, Vista was designed to support varying levels of time, resources, and capacity in projects to do increasingly robust analyses as resources increase.

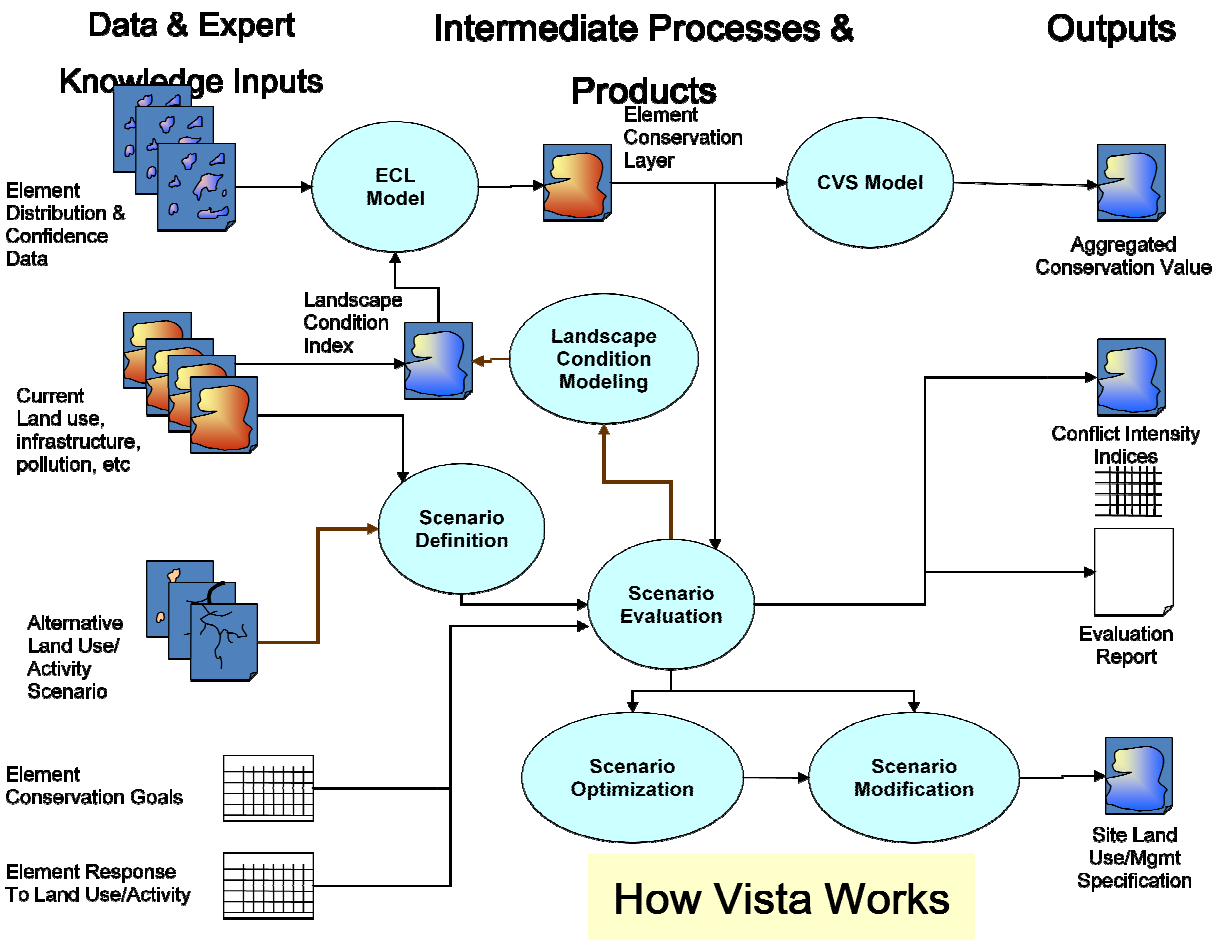

Figure 12. Vista technical process model depicting flow of information from data and expert knowledge inputs through intermediate processes and products to final outputs.

17 APPENDIX 3: COMPUTATIONAL TIME RESULTS

Elements (time to process element conservation layers)
LandSAT data :
Aspen: 7 minutes
Cottonwood: 5 minutes
Douglas Fir/Aspen Mix: 8 minutes
Process all LandSAT derived elements: 57 minutes (10 elements)

CNHP data:
Canyonlands Lomatium: 1 minute
Humpback Chub: 1 minute
Debeque Milkvetch: 2 minutes
Uinta Hookless Cactus: 2 minutes
All CNHP elements: 38 minutes (67 elements)

Conservation Value Summary:
Richness (Birds): 36 minutes (10 elements)
Richness (mammals): 3 minutes (3 elements)
Richness (reptiles): 15 minutes (3 elements)
Richness (riparian): 1 hour 4 minutes (20 elements)
Richness (CNHP GJFO): cancelled after 2.5 hours. Expected completion time would be 3+ hours (67 elements)
Confidence (Birds): 1 hour 3 minutes

Scenario Definition: (override refers to setting 1 land use as dominant or overriding the attributes of another overlapping land use; combine refers to combining attributes of overlapping land uses; translators refers to creating a crosswalk table that translates the attributes of an input layer to the project land use categorization)
Baseline 0109 4: 3 minutes (3 combines, 10 translators)
Baseline 0109 3: 5 minutes (3 combines, 13 translators)
Baseline 0109 2: 2 minutes (3 combines, 6 translators)
Baseline Jan 09: 2 minutes (1 override, 1 combine, 5 translators)

Scenario Evaluation:
*CNHP 2: 1 hour 40 minutes (Scenario: Baseline 0109 4, Filter: Birds & Mammals, Condition system used, 28 reliable policy types)
*CNHP 3: 2 hours 15 minutes (Scenario: Baseline 0109 4, Filter: Birds & Mammals, altered

Condition system used, 28 reliable policy types)
*CNHP 3 (unfiltered): process failed (too large to process) (same as CNHP 3 above, removed the filter)

Landscape Integrity Raster (stand alone tool):
28 inputs; 2.5 hours
The Condition Model running inside the Vista evaluation required about 10 minutes on each model.

18 APPENDIX 4: LEAP EVALUATION REPORT

The attached report (see LEAP eval report.pdf) from the Lake Erie Alleghany Partnership which has been applying Vista to a watershed project as an evaluation of its suitability for a large regional biodiversity conservation planning process.

Chagrin River Watershed Vista Pilot Project (CRWVPP)

Report to LEAP Planning Committee