

# **INTEGRATED LAND-SEA PLANNING**

## **A TECHNICAL GUIDE TO THE INTEGRATED LAND-SEA PLANNING TOOLKIT**

Final Draft - August 14, 2009

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***This document should be cited as:***

Crist, P., K. Madden, I. Varley, D. Eslinger, D. Walker, A. Anderson, S. Morehead, K. Dunton. Integrated Land-Sea Planning: Technical Guide to the Integrated Land-Sea Planning Toolkit. EBM Tools Network. [www.ebmtools.org](http://www.ebmtools.org)

***Acknowledgements:***

We gratefully acknowledge the following institutions and individuals for important contributions to this work:

The David & Lucile Packard Foundation for funding.

Aransas County and the City of Rockport for assistance with data collection, meeting support, and a continued commitment to improving land use and conservation planning in the Texas Coastal Bend.

Employees of the Texas Parks and Wildlife Department, Texas A&M University – Corpus Christi, Texas Coastal Watershed Program, University of Texas at Austin, and Aransas County for participating in the pilot training of the land-sea toolkit and providing valuable feedback which helped guide the development of this document.

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## **Introduction**

Coastal ecosystems contain a rich diversity of species and habitat types that provide an abundance of the world's natural resources (WRI, 2000). These coastal ecosystems also maintain a wealth of economic activity associated with recreation and tourism, waterborne commerce, and energy and mineral production. This economic activity has been one of the driving forces behind increased population growth in coastal communities. However, the activities that make coastal communities so desirable are the same activities that threaten many of our coastal natural resources. As a result, resource managers face the difficult challenge of balancing increasing human uses of coastal ecosystems with environmental protection.

Several estimates suggest that populations along the coast have doubled over the past twenty years and that approximately half of the world's population, or three billion people, currently live within 200 kilometers of the coast. As a result of this population growth, many coastal ecosystems are threatened by pollution, habitat degradation and loss, overfishing, invasive species, and increased coastal hazards such as sea-level rise (WRI, 2000; Hinrichsen, 1998; National Safety Council, 1998). The increasing population density of coastal areas, combined with a fast-growing economy (Colgan, 2004), makes the task of managing coastal resources more difficult. With the world's coastal population expected to continue increasing, the ability to minimize impacts from population growth is essential.

An integrated land-sea planning approach can help mitigate many of the potential problems associated with increased human activity in coastal communities by addressing the human use of land, freshwater, and marine resources while also working to maintain the integrity of terrestrial, aquatic, and marine/estuarine ecosystems. This planning approach, however, requires a significant commitment from planners and resource managers to conduct collaborative planning, while also requiring the participation of scientists and technologists (e.g., GIS analysts and database managers).

To assist in the integrated planning process, a technological toolkit has been developed to guide ecosystem assessment and planning within and across disciplines and ecosystems. This publication is intended to guide users in the application of the integrated land-sea toolkit and facilitate this type of planning approach.

There is a large body of published work on the science and planning process for each aspect of the toolkit and each tool is accompanied by documentation and publications. Therefore, this guide does not attempt to replicate the contents of those publications nor exhaustively reference them. It is strictly designed to explain the process for implementing an integrated land-sea planning approach through the interoperation of three decision support tools. Users of the toolkit are expected to

obtain the appropriate references, training, and support as needed for their particular applications, experience, and capacity.

While this toolkit is described as an integrated land-sea planning toolkit it is also fully suited to inland watershed applications where the effect of land use/management on aquatic ecosystems is of interest.

### ***Background***

The integrated land-sea toolkit is the result of a Tool Demonstration Grant provided by the David & Lucile Packard Foundation under the Coastal and Marine Ecosystem Based Management Tools Program (EBM Tools). The project was lead by the University of Texas Marine Science Institute with Co-Principal Investigators from NatureServe, NOAA Coastal Services Center, Placeways LLC, and Texas SeaGrant.

The objectives of the grant were as follows:

- Develop a toolkit that supports integrated land-sea planning and test it in a real world situation.
- Create a documented methodology for the application of the toolkit.
- Support the pilot location (Aransas County, Texas, USA) in utilizing the tools to create analyses supporting their request for greater planning authority from the state.

Aransas County, Texas was an ideal study location for the development of an integrated land-sea planning toolkit. The watershed of Aransas County supports a healthy estuary with highly diverse habitats that sustain the area's growing recreation and tourism industry, as well as estuarine-dependent commercial and recreational fisheries. However, the county is currently experiencing rapid population growth, and there is strong community interest and involvement in maintaining the resource-dependent quality of life in this region as the population grows. Therefore, Aransas County represented an ideal opportunity for implementing an integrated land-sea planning that would enable better land use and resource management decisions.

## Toolkit Resources

This guide is accompanied by several web resources that are necessary and/or useful for implementing the toolkit. These include:

- Link to the toolkit website (contains all tool links, this technical guide, and the GIS project database for Mission-Aransas NERR that can be used as a practice/tutorial data set): [www.utmsi.utexas.edu/nerr](http://www.utmsi.utexas.edu/nerr)
- Links to the requisite tools. Each tool must be downloaded and installed separately and used on ESRI's ArcView 9.x platform (please check current and available platforms for each tool at time of acquisition). Links for tool acquisition, support, and training on individual tools are also available at these sites:

ESRI: [www.esri.com](http://www.esri.com)

CommunityViz: [www.placeways.com/communityviz](http://www.placeways.com/communityviz)

NatureServe Vista: [www.natureserve.org/vista](http://www.natureserve.org/vista)

NOAA N-SPECT: [www.csc.noaa.gov/digitalcoast/tools/nspect/](http://www.csc.noaa.gov/digitalcoast/tools/nspect/)

## Introduction to the Toolkit

### ***Toolkit components***

Here we briefly characterize each tool and its role in the toolkit.

#### **ArcGIS: The Common Platform**

The three core tools of the land-sea toolkit are extensions to ESRI's ArcGIS® ArcView platform and thus gain the interoperability benefits from using this common platform.

#### **CommunityViz ([www.communityviz.org](http://www.communityviz.org))**

CommunityViz® is an advanced yet easy-to-use GIS software extension that is designed to help people visualize, analyze, and communicate about important planning decisions. Widely adopted by land-use planners, it supports informed, collaborative decision-making by illustrating and analyzing alternative planning scenarios. It features flexible and interactive analysis tools, a rich set of presentation tools, and several options for 3D visualization of future places.

In the land-sea toolkit, CommunityViz (sometimes referred to as "CViz") serves as the platform for creating land use scenarios. It models how urban growth could occur over time as the result of present-day decisions regarding land use and regulation. The resulting future growth conditions are passed to NatureServe Vista (Vista) and N-SPECT for impact assessment, and those results can be returned to CommunityViz for display and for guidance in development of revisions to planning scenarios. Throughout the integration process, CommunityViz provides the ability to assess a variety of socio-economic indicators attached to the land-use scenarios.

#### **NatureServe Vista ([www.natureserve.org/Vista](http://www.natureserve.org/Vista))**

NatureServe Vista is a broad assessment and planning decision support tool focused on conservation of specific mapped features or "conservation elements." It facilitates capturing spatial and non-spatial information and conservation requirements for elements, defining scenarios of land use, management, conservation, disturbance, etc., and evaluating the impacts of scenarios on the elements. Vista also contains powerful internal tools and interoperability with outside tools to facilitate mitigating site-level conflicts, offsite mitigation, and development of alternative scenarios. The primary objective (though not exclusive application) of the tool is to develop/mitigate alternative scenarios such that they meet explicit conservation goals for the elements. Vista can also support goal seeking for competing land uses while preventing development of scenarios that attempt to meet goals for conflicting things in the same place.

The primary role of NatureServe Vista in this toolkit is to evaluate the impacts of land use scenarios on conservation elements in terrestrial, freshwater, and marine ecosystems. It does this through direct evaluation of land use scenarios from CommunityViz (augmented with other use, management, disturbance data) and interoperating with N-SPECT to evaluate water quality impacts on aquatic/marine elements.

### **N-SPECT ([www.csc.noaa.gov/digitalcoast/tools/nspect/](http://www.csc.noaa.gov/digitalcoast/tools/nspect/))**

The Nonpoint-Source Pollution and Erosion Comparison Tool (N-SPECT) is a screening tool developed to help land use planners and managers understand the potential impacts of land use change decisions on erosion and water quality. The tool runs as an extension within the ESRI ArcGIS software package. It utilizes digital elevation maps, soils and precipitation information from data sets that are available nationally. However, it also lets users take advantage of local higher resolution and/or more accurate data sets when available. For example, the N-SPECT pollution coefficients used are similar to those in the EPA's BASINS suite of tools and provide a good starting point for quick comparisons between management scenarios, but the coefficients can still be easily customized as users develop more localized data. The real utility of N-SPECT does not lie in the user's ability to examine the accuracy of any particular run's results, but in the comparison of runs between different development (or restoration) scenarios. By allowing users to modify multiple land uses and providing the results of those changes in a GIS environment, N-SPECT enables managers to quickly understand the overall consequences of different land use scenarios.

The primary role of N-SPECT in this toolkit is to predict sedimentation and pollution changes from different land use scenarios and identify areas that are key contributors of these inputs.

### **Additional Tools**

#### **Marine Plume Model**

To make this toolkit a true integrated land-sea planning toolkit it is necessary to model the input of terrestrial-originated pollution into the marine environment. The physical, geological, chemical, and biological characteristics of coastal/near shore ecosystems greatly affect how pollutants from terrestrial runoff are distributed and deposited within the marine environment. Therefore, it was not practical or advisable to select a single tool that could model these processes for all potential planning locations and applications. We advise that users select a regionally appropriate/calibrated tool or spatial modeling process to model the location and concentration of pollutants. Ideally, this tool should be able to directly use the N-SPECT outputs to facilitate its integration in the toolkit.

The role of a marine plume model in the land-sea toolkit is to model the location and concentration of pollutants in the marine ecosystem coming from runoff (as modeled by N-SPECT).

**Marxan (<http://www.uq.edu.au/marxan/>)**

Marxan, created and maintained by the University of Queensland, assists in creating efficient spatial solutions to planning problems. Though it is not a required component of this toolkit or workflow, it can be extremely useful for quickly generating alternative scenarios and identifying sites that could help achieve conservation goals while reducing cost and/or conflict with other land uses. It can be used independently or through automated interoperability with NatureServe Vista.

The role of Marxan in this toolkit is to utilize conservation element distribution and goals identified in NatureServe Vista to find a set of sites that will be most efficient at meeting conservation goals. Marxan results are then imported back to Vista for additional spatial design and specification of compatible land uses and implementation policies.

**Habitat Priority Planner ([www.csc.noaa.gov/hpp/](http://www.csc.noaa.gov/hpp/))**

Habitat Priority Planner offers a number of useful functions that can complement the use of NatureServe Vista. It is particularly recommended for providing additional fragmentation analysis of Vista results and may be useful for creating initial land cover maps and conservation element inputs for Vista.

**Substituting toolkit components**

This guide is tightly coupled to the specific tools mentioned above. However, other tools may be found that can substitute for any particular part or sub-part of the workflow. For individuals that desire to substitute a different tool, the authors suggest that the toolkit users thoroughly investigate the inputs and outputs needed to integrate that tool with other parts of the toolkit before making this decision.

## **What You Need to Implement This Toolkit**

Planning projects are often highly scalable depending on available time, resources, expertise, and partnerships. Here we describe a moderate level of technology, data and expertise required for an application.

### ***Technology Platform***

This toolkit operates on a desktop computing platform but a high level of internet connectivity is desirable for obtaining data sets, support, and training. We recommend a contemporary desktop or laptop computer with:

- 100GB of hard drive space
- 1.6 GHz or higher CPU speed
- 2GB of RAM
- Dual processor

### **Supporting software**

- Microsoft Windows XP or Vista
- Microsoft Access 2003 or 2007
- ESRI ArcGIS 9.x with Spatial Analyst (check with individual tool providers to confirm which platforms are currently supported)
- Microsoft .NET framework (check individual tool requirements for versions)
- Toolkit software: CommunityViz (3.3. or later), NatureServe Vista (2.x), N-SPECT (1.5.0 or later)

## ***Data***

### **Common Data**

- Land-use classification list for the study area that will be used by all three tools and will specify building densities when applicable. Suggested data layers include current/future land use designations, management practices, disturbance types, etc. It is recommended to begin with the default land use classification in NatureServe Vista or the NOAA Coastal-Change Analysis Program (C-CAP) land classification scheme used by N-SPECT and modify accordingly for use by all three tools.
- Project area boundary
- Reference/context data such as roads, place names, topography, etc.

### **Land Use Planning Data**

The land-use planning analysis component of the toolkit is conducted in CommunityViz. CommunityViz needs GIS layers (shapefiles or geodatabase) that are:

- In a projected (not geometric) coordinate system
- Use the same projection for all layers
- Clipped to a reasonable size and extent (see CommunityViz documentation for advice on size and extent of project area)

**Required Data:**

- Existing land-use data with zoning or other similar local land-use regulations or guidelines in the form of attributed polygons
- Guidelines for future land use and development densities (units/acre, Floor to Area Ratio, or similar) for each land-use type (electronic format is preferred for this but is not required)

**Desirable Data:**

- Development constraints specified in current regulations (such as hazards, steep slopes, floodplains, riparian setbacks, wetlands, existing conservation, etc.); vector or raster format, but Spatial Analyst will be required if any analysis is done on raster layers
- Existing development, either as building points (preferred) or attributed polygons
- Roads
- Sewer and water infrastructure
- Population projections

**Optional Data:**

- More detailed demographics, such as location of vulnerable populations
- Special places (historic, sacred, commercial, cultural, etc.) that may affect or be affected by growth

**Ecological/Conservation Planning Data**

The ecological/conservation planning analysis component of the toolkit is conducted in NatureServe Vista. To ensure consistency throughout implementation of the toolkit, NatureServe Vista needs GIS layers (shapefiles and/or raster data) that are:

- In a projected (not geometric) coordinate system
- Use the same projection for all layers
- Clipped to a reasonable size and extent (see NatureServe Vista documentation for advice on size and extent of project area)

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**Required Data:**

- Land use classification list (see common data section above)
- Land use trend maps created in CommunityViz
- Additional physical features and activities that affect conservation element viability (e.g., surface water uses, resource management practices, storm surge disturbances, etc.)
- Site layer (i.e., map of planning/management units that are used to specify alternative land uses for creating new scenarios) in vector format
- Polygon shapefiles of conservation element distribution
- Condition values for conservation elements - these can be attributes of the polygon shapefile, derived from condition models developed in Vista, or imported as raster layers from other tools (condition of aquatic conservation elements can be developed using an aquatic condition model that makes use of the spatial inputs from N-SPECT)
- Confidence values for conservation elements - these can be attributes of the polygon shapefile, imported as probability rasters from other models, or input as a single confidence score for the entire distribution
- Viability requirements of conservation elements (i.e., non-spatial inputs from element experts that include: minimum required size for occurrence, response of conservation elements to all land use and disturbance types)
- Conservation element goals (i.e., the percentage or the number of spatial units of the element's distribution that must be compatible in order to be counted toward goal achievement)

**Optional Data**

- Several additional attributes are available when inputting conservation elements in Vista and are often useful when running analyses (e.g., categories, weightings)
- Condition of terrestrial conservation elements can be modeled to assess how these elements respond to different land use scenarios, including responses to offsite impacts
- Inputs from the Marxan tool (refer to Marxan documentation and/or the Vista Marxan input wizard for more information)

**Hydrological Modeling Data**

Runoff, sedimentation and pollution changes from different land use scenarios will be modeled using N-SPECT. N-SPECT needs GIS data layers that are:

- In a projected (not geometric) coordinate system
- Use the same projection for all layers

- Clipped to a reasonable size and extent – large areas can be used, but processing speed is a function of number of grid elements, so very large grids take a relatively long time to run

**Required Data:**

- Topography data in the form of a digital elevation model - the resolution of this should be approximately the same as that of the land cover (see below)
- Land cover/land use data in a gridded format created as scenarios in NatureServe Vista - ESRI grid or Imagine (.img) format are acceptable
- Land cover and pollutant coefficients in tabular format - specifies the concentration of pollutant that runs off a given land cover class (default coefficients are given for common pollutants and the C-CAP land cover classes, but users have the ability to add their own pollutants and/or coefficients if the necessary information is available)
- Rainfall data in gridded format - this can vary spatially or be constant throughout the area of interest (annual averages are most often used but individual rainfall events can also be modeled; the average number of raining days in a year is also needed if the annual average is used)
- Soils data are required for runoff and erosion calculations – this can be downloaded from the Soil Survey Geographic (SSURGO) Database maintained by the Natural Resources Conservation Service (NRCS) and transformed within N-SPECT from vector data to raster format

**Marine Water Quality Modeling Data**

As described earlier, we do not recommend any specific marine modeling tool. Therefore, data input recommendations provided below are necessarily general and describe the minimum type of information needed:

- Water body boundary
- N-SPECT outputs
- Bathymetry (optional in some models)
- Water temperature (optional in some models)
- Wind direction and speed (optional in some models)
- Water current direction and speed (optional in some models)

***Expertise***

The type and amount of expertise required to implement the land-sea toolkit can vary depending on the specific issues, ecosystems, and decision-making processes being considered. The amount of expert time required will also vary considerably based on these same factors.

A robust expert team is listed below:

- Planning experts (e.g., land use planners, infrastructure planners/engineers, watershed managers, marine planners/managers)
- Experts on Vista ecological, social, and cultural conservation elements (i.e., zoologists, botanists, ecologists, sociologists, and historians)
- Water quality expert (e.g., hydrologist and chemist)
- GIS analysts
- Data managers

In addition to the expert involvement listed above, stakeholder engagement is often desired or required during several phases of implementation of the toolkit. Stakeholder involvement can be used to understand processes such as current and future development and agriculture interests, transportation advocacy, local conservation priorities, current land use policies, etc. The toolkit providers encourage public engagement in the decision-making process, as well as use of the toolkit to support development of maps and other graphics for communication and dialogue.

### ***Getting Help Implementing the Toolkit***

Through the use of this guide and individual tool documentation, it is feasible for individuals with the appropriate type and level of skill to implement this toolkit without direct assistance. However, if additional help is needed or desired the following services may be considered:

#### **Technical Support & Training for Tools**

Each of the tools in the toolkit offers some degree of technical support and training on application of that specific tool. Please see the tool websites for details on obtaining technical support (refer to section titled *Toolkit Resources*).

#### **Land-Sea Toolkit Training**

Currently there are no live training programs available on implementation of the land-sea toolkit, but the toolkit providers hope these will be facilitated by the EBM Tools Program ([www.ebmtools.org](http://www.ebmtools.org)) in the future. Notifications for a variety of EBM training opportunities are available through the EBM Tools newsletter; and any live training opportunities related to this toolkit will be provided through that venue. Otherwise, you may contact any of the tool providers if you wish to try and arrange a custom training for your program on the toolkit.

#### **Consulting Services**

Expert consulting services on the individual tools may be available through consultation with the individual tool providers. You may also inquire with the tool providers if you desire an expert team to consult regarding the entire toolkit. For a list

of individuals that can provide consulting services for the toolkit, please see the website for the EBM Tools Collaborative ([www.ebmtools.org](http://www.ebmtools.org)) and navigate to the Practitioners tab (still in development as of publication of this toolkit).

## Preparing for Application of the Toolkit

In this section we describe the basic steps required to set up the tools and project database. The individual tools' documentation provides considerably more information on setting up each tool, and therefore, this section is meant only to provide an overview to understand the types of activities and level of effort required.

### *Installing the Tools*

After the appropriate ESRI ArcGIS Desktop platform and necessary extensions (i.e., Spatial Analyst) have been installed, users must then follow the links for each tool and install them separately according to their installation guidelines. Each tool will have different registration requirements and some may require payment for licenses. You will also be able to view and make choices about obtaining technical support and training on the individual tools.

### *Setting Up the Common Data Set*

Following tool installation, a land use list indicating current and/or future land use designations (and housing density when applicable) must be developed for the study area for use by all three tools (Table 1). Information gathered from local experts can be used during the development of this table and should include both current and/or potential future land uses, management practices, disturbance types, etc.

**Table 1. Land use classification list for Mission-Aransas NERR demonstration project.**

<b>Land Use</b>
Developed, High Intensity
Developed, Medium Intensity
Developed, Low Intensity
Developed, Open Space
Cultivated Cropland
Pasture and Hay
Grassland/Herbaceous
Forestland
Scrub/Shrub
Palustrine Wetland
Estuarine Wetland
Unconsolidated Shoreline
Bareland
Aquatic Bed
Lakes, Ponds, and Streams

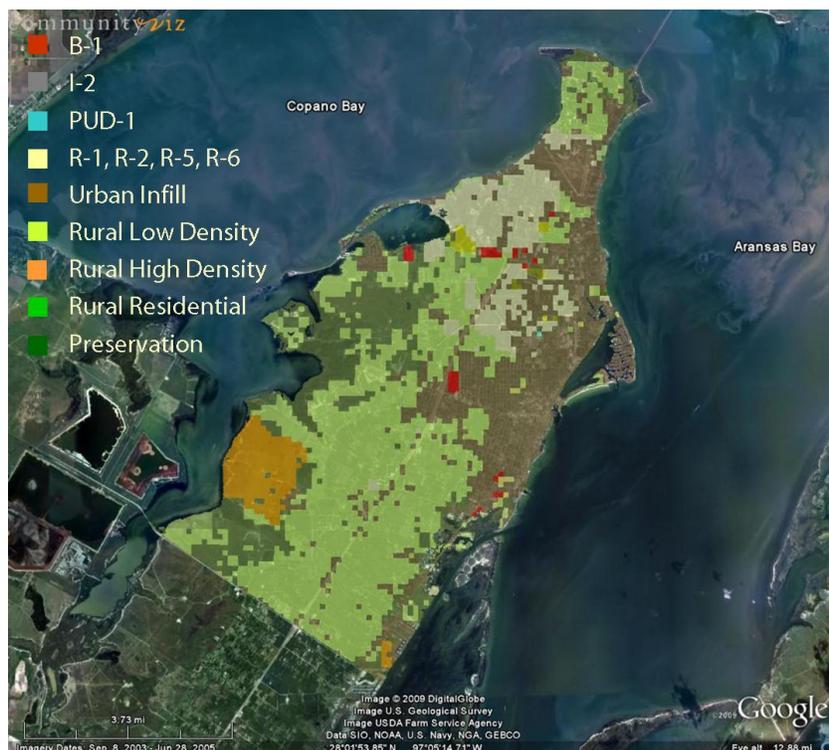
### ***Setting Up the Individual Tools Databases***

To facilitate the planning process we recommend that users develop each tool database prior to conducting the integrated planning process. As mentioned previously, each tool provides considerable documentation and training programs available to assist in the successful application of the tools. This section is intended to provide a high level picture of the steps necessary to prepare the individual tool data sets.

### **Developing the CommunityViz Data Set**

A CommunityViz analysis is designed to look at potential land use and development patterns that might occur within the study area during a specified future timeframe. Within the analysis component of CommunityViz, Scenario 360, there are a number of specific tools which guide this type of high-level planning analysis. The tools are designed to work with “best-available” data, so they tolerate a high degree of variability in inputs. At a minimum, you need a polygon layer (Figure 1) which covers the study area with a meaningful feature distribution (e.g., legal ownership parcel boundaries, future land use and/or zoning district boundaries, census block groups, or a vector grid with a useful cell feature size). Depending on the size of the study area and local jurisdictional boundaries, assembling this layer may involve merging and/or unioning several datasets to provide complete coverage.

**Figure 1. Map showing land use designations used in Mission-Aransas NERR CommunityViz analysis.**



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The first step is to prepare your polygon analysis layer for use as a current or future land use layer (Figure 1). If the local jurisdictions have zoning and/or future land use designations already defined in the polygon layers, this might be all that is required. If the data is not available electronically, or if the local jurisdiction does not have formal growth management procedures utilizing regulated zoning or future land use, this will involve more research and discussion with local experts (i.e., planners, engineers, developers) on:

- What are the recent development trends?
- What are the likely future development locations and densities?
- What, if any, spatially based regulations might dictate the allowance of future development (e.g., access to water and sewer infrastructure, avoidance of steep slopes or other drainage/erosion regulations, direct access to the road network, annexation into municipal boundaries, etc.)?

It is important in this process to determine the difference between “loose” standards and strictly enforced regulations. A brief review of recent development should provide some guidance on how firmly a policy or regulation is enforced. For example, it is not uncommon in many areas for policies on wetland protection to be sidestepped in consideration of off-site mitigation done in lieu of on-site practices. In this case, it might be unrealistic to prepare an analysis which strictly enforces a “no build” policy on wetlands. Policy strictness and/or reliability can also be incorporated at later stages of the project using Vista, and therefore, this type of information should be well-documented during the early stages of project implementation.

After gathering information from local experts, a list of land use designations should be developed to encompass the main types of current and/or future land use. These designations will influence the development of the common land use classification list to be used by all three tools and we suggest that toolkit users devote adequate time at this stage of the project to developing this list. Specific to CommunityViz, these designations typically include, but are not limited to, the following designations:

- Agriculture
- Low Density Residential
- Medium Density Residential
- High Density Residential
- Commercial
- Industrial
- Preservation and/or Parks

The list of appropriate land use designations will vary by region/area and the user should develop a list that meets their study’s needs (Table 2). For example, if your study area is rural, you may not have any need for “high density residential”

designation, and conversely, if your study area is urban you may decide to omit the “agriculture” designation.

**Table 2. CommunityViz land use designations and density rules (i.e., number of dwelling units, floor area measurement (FAR), lot size) applied to Mission-Aransas NERR project area. The table also shows the relationship between the CommunityViz land use designations and the common land use classification list.**

<b>CViz Land Use Designation</b>	<b>Density Rules</b>	<b>Common Land Use Classification List</b>
Business-1	0.6 FAR	Developed, High Intensity
Industrial-2	0.6 FAR	Developed, High Intensity
Planned Urban Development-1	30 dwelling units	Developed, High Intensity
Residential-1	0.16 minimum lot size	Developed, Medium Intensity
Residential-2	0.12 minimum lot size	Developed, Medium Intensity
Residential-5	0.12 minimum lot size	Developed, Medium Intensity
Residential-6	0.12 minimum lot size	Developed, Medium Intensity
Urban Infill	N/A	N/A
Rural Low Density	1 dwelling unit/acre	Developed, Low Intensity
Rural High Density	1.5 dwelling unit/acre	Developed, Medium Intensity
Rural Residential	0.05 dwelling unit/acre	Developed, Low Intensity
Preservation	1 dwelling unit/acre	Developed, Low Intensity

Some planning regulations provide for more complicated land-use rules, such as mixed-use areas or urban center overlay districts (i.e., increased densities and uses are allowed within lower level designations). If these are important designations in your study area, you should use them. However, for the purposes of this analysis, keeping things as simple as possible is advisable. Having too many designations or site-specific zoning regulations might be more detailed than necessary, and the added refinement can make your initial data preparation over-complicated. The improved accuracy of fine-grain details should be weighed against the increased time required and the increased likelihood of processing problems. In most cases, you can get meaningful results using the most basic land use designations available. However, these same land use designations will be used by the other tools and must be appropriate for detecting differences in how water quality and conservation elements respond to such land uses. For example, specifying different residential densities is useful for experts to determine element responses rather than lumping all residential areas into one land use category.

### **Developing the NatureServe Vista database**

Vista provides a broad range of functions and thus uses a broad range of data and user inputs. It has numerous tools for importing, transforming, and analyzing information. Vista has an extensive user manual to guide and assist in identifying necessary data

and using the tool functions. Vista is also designed to allow the user to start with basic data and analyses and build more complex analyses over time.

### Conservation Element Database

Developing the conservation element database is the first step towards developing a Vista project. Conservation elements include any spatial feature that the tool users wish to assess and/or conserve throughout the decision-making process (Table 3). Conservation elements can be determined using policies and laws, stakeholder/public values, and/or expert input. Elements are entered into the NatureServe Vista database as polygon shapefiles that express the spatial distribution and attributes (i.e., condition and confidence) of each element. Several non-spatial data inputs are also required for each element, including conservation requirements (i.e., minimum required size for occurrence) and compatibility with land use types.

**Table 3. Thirty-eight conservation elements incorporated in NatureServe Vista for Mission-Aransas NERR demonstration project.**

Name	Alternate name and/or additional information
Aquatic Bed	Based on NOAA C-CAP data
Atlantic Hawksbill Turtle	<i>Eretmochelys imbricate</i>
Bareland	Based on NOAA C-CAP data
Beach Access Points	Cultural/recreational/socio-economic resource
Bivalve Reef	Oyster Reef
Black-spotted Newt	<i>Notophthalmus meridionalis</i>
Boat Ramps	Cultural/recreational/socio-economic resource
Cultivated Cropland	Based on NOAA C-CAP data; cultural/socio-economic resource
Forestland	Based on NOAA C-CAP data
Freshwater Wetland	Palustrine wetland; based on NOAA C-CAP data
Grasslands	Based on NOAA C-CAP data
Gulf Saltmarsh Snake	<i>Nerodia clarkia</i>
Jaguarundi	<i>Herpailurus yaguarondi</i>
Lakes and Ponds	Based on NOAA C-CAP data (open water)
Live Oak	<i>Quercus</i> spp.
Mangroves	Based on NOAA benthic mapping data
Marinas	Cultural/socio-economic resource
Marsh	Based on NOAA benthic mapping data
Mud and Tidal Flats	Based on NOAA benthic mapping data
National Register of Historic Places	Historic structures
Pasture and Hay	Based on NOAA C-CAP data; cultural/socio-economic resource

Peregrine Falcon	<i>Falco peregrinus</i>
Preserves	GLO/TPWD coastal preserve areas
Rookeries	Rookeries based on Texas Natural Diversity Database
Saltwater Wetland	Estuarine Wetland; based on NOAA C-CAP data
Sanctuaries	National Audubon Society waterbird sanctuaries
Scrub/Shrub	Based on NOAA C-CAP data
Seacoast Bluestem Gulf-dune Paspalum series	<i>Schizachyrium scoparium var. littoralis-paspalum</i>
Seagrass	Based on NOAA benthic mapping data
Shoreline	Based on NOAA C-CAP data
Streams	Stream Network
Tall Dodder	<i>Cuscuta exaltata</i>
Texas diamondback terrapin	<i>Malaclemys terrapin littoralis</i>
Texas scarlet snake	<i>Cemophora coccinea lineri</i>
Tharps rhododon	<i>Rhododon angulatus</i>
Texas Parks and Wildlife Department Boat ramps	Cultural/recreational/socio-economic resource
Velvet Spurge	<i>Euphorbia innocua</i>
Whooping Crane	<i>Grus americana</i>

The fundamental outcome of this spatial and non-spatial data entry is a raster layer for each element that describes the variation in viability and confidence across the extent of that element's distribution. Information for each element is entered via four tabs of the "Element List" dialogue window: General, Spatial, Categories, and Compatibility.

### *General*

Basic information, such as element name, description, and additional documentation/links to source data, is entered in the general tab. This tab also requires users to define the element's conservation unit as an area or occurrences. Finally, several other check boxes allow users to establish thresholds for elements:

- Has minimum size for viability - These values are usually obtained from scientific literature or through consultation with experts and reflect the minimum size that an element needs in order to remain viable. A simple example from the Mission-Aransas NERR project is the estimated territory size of 117 hectares for whooping cranes (*Grus americana*) on and near the Aransas National Wildlife Refuge (Stehn and Johnson 1987). If whooping crane occurrences decline below this threshold due to a change in land use, these instances are recorded in the Scenario Evaluation reports.
- Has a condition threshold - Landscape condition is an important factor to gauge the quality of the distribution of an element (see *Spatial* section

below). Establishing a threshold sets a limit at which the condition of the element distribution no longer contributes to the viability of the element.

### *Spatial – Viability/Integrity*

The viability/integrity of an element (also described as landscape condition) influences the desirability of conserving a particular element or the need to restore its condition to meet conservation goals. Using the spatial tab, the viability/integrity of each conservation elements is input as either an attribute or raster layer. Viability and ecological integrity values (ranging from 0.0 to 1.0) are assigned and associated with individual element areas/occurrences and indicate the likelihood that the occurrence will persist based on current size, ecological integrity, and context. There are two methods for assigning viability/integrity values in NatureServe:

- For element shapefiles that contain viability information as attributes (e.g., Element Occurrence ranks assigned to NatureServe Element Occurrences<sup>1</sup>), the most expedient way to assign viability/integrity values is to convert the viability information into appropriate 0.0-1.0 scores and import them directly with Vista. For more information on this data source please see the NatureServe Vista User’s Manual.
- For element shapefiles that lack viability/integrity information as attributes, condition layers can be developed and used to assign viability/integrity values. These raster layers can be created and imported from other tools or developed using the *Landscape Condition Modeler* in Vista. This tool allows users to create and model layers that will reflect the condition of an element across its distribution in both terrestrial and aquatic ecosystems. If aquatic condition is to be included in the condition model, existing N-SPECT outputs are required. These outputs can be based on land use scenarios created for the current project or created from existing land cover/land use information that does not account for future development.

### *Spatial – Confidence*

Confidence values represent the user’s confidence that an element’s “real” spatial distribution is represented by the element’s mapped area/occurrence. They are assigned in the spatial tab and range from 0.0 to 1.0. Confidence values can be assigned as either a statistically-derived assessment of data

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<sup>1</sup> NatureServe member heritage programs track information on Element Occurrences (EOs) and assign EO ranks to indicate the estimated viability/ecological integrity of the occurrences, both according to a standard methodology.

accuracy or a qualitatively-derived/categorical value of data confidence derived from inspection of metadata or familiarity with the data source. Vista offers multiple ways to apply the confidence value to an element, including: 1) attributes of the element shapefile, 2) probability raster developed from other models, or 3) single confidence scores for the entire element distribution.

### *Categories*

The categories tab provides a system for grouping conservation elements based on similar characteristics (i.e., federal status, state status). Categories are useful for organizing reports and creating filters that can be used to subset elements for attribute assignment, model creation, and analyses.

### *Compatibility*

The compatibility tab is used to indicate how conservation elements will respond to the different land uses included in a development scenario (versus the use of a condition threshold which is described above). Compatibility is assigned as a categorical response (e.g., negative, neutral, or beneficial). Compatibility is important when evaluating development scenarios because it enables users to identify areas where land uses support the achievement of element conservation goals. Conversely, compatibility will also identify areas that are incompatible with land use that could potentially be altered in order to achieve conservation goals. Compatibility can be assigned to multiple elements through the "Edit Multiple" function.

## **Conservation Element Goals**

Goals must be defined for each conservation element. They are expressed as either the percentage or the number of spatial units (acres, hectares, occurrences) of the element's distribution that must be compatible in order to be counted toward goal achievement.

## **Scenario Database**

Scenarios define the current (or future, preferred, etc.) land use and policy for a project area. They are used to evaluate the impact of land use/policy on achievement of element conservation goals. The scenario consists of any data layer (or collection of data layers) that represent the land use for a particular scenario. It is optional when creating the scenario to define policies for the project area as well. For the integrated land-sea toolkit, the primary source of data for current (or future, preferred, etc.) land use is the land use data layer created in CommunityViz (i.e., *Current Condition Scenario*, *Future Trend Scenario*, and *Mitigation Scenario*). Once this layer has been imported into Vista, it can be combined with other land use or land policy information to represent a more

complete picture of disturbances and conservation activities that affect achievement of element goals. For more details on creating scenarios, refer to the **Step by Step Instructions for Conducting the Planning Process Workflow** section.

### **Developing the N-SPECT database**

For the land-sea toolkit, the N-SPECT database should be consistent with those used in the other tools. In other words, if topography, precipitation, and soils data is used in the other tools, the same data sets should be used in N-SPECT. For the current workflow, however, the land cover/land use data required by N-SPECT is actually generated as a scenario in NatureServe Vista. This Vista scenario incorporates the results of the CommunityViz development scenario and other physical features and activities that may affect conservation element viability (e.g., surface water uses, resource management practices, storm surge disturbances, etc.). The scenario is produced in a raster format that is required for N-SPECT. Additional detail for Vista scenario development is provided in the step by step instructions below.

If different topography is needed to account for new ditches, diversions, etc., users can create an artificial digital elevation model (DEM) within ArcMap and use this in their N-SPECT analysis. The DEM is only used to determine where the water flows, so it can be manipulated as needed to reflect man-made changes. However, if elevation is important for other parts of the toolkit implementation and will be used in the other tools (e.g., determining building suitability in CommunityViz), users need to be cautious and remember to use the original DEM.

Before an N-SPECT analysis can begin, there is a set of pre-processing tools in the N-SPECT drop-down menu that must be used to generate a new database. Users typically begin at the top of the Advanced Settings pull-down menu (i.e., Land Cover Types) within the N-SPECT Toolbar and work their way down. Complete instructions for generating your N-SPECT database can be found in either the documentation downloaded with N-SPECT or on the tool's website (<http://www.csc.noaa.gov/nspect>).

### **Developing the Marine Pollution Modeling Database**

A specific tool or process is not recommended for this portion of the toolkit, so users will need to consult the database requirements and setup procedures for their selected methodology. However, it is worth noting the increased efficiency that could result from choosing a methodology that is easily integrated with the overall toolkit database. In other words, the chosen tool/model would be able to receive N-SPECT inputs directly, while also providing outputs in the same format as N-SPECT. Example data layers may include: water boundary, N-SPECT outputs, bathymetry, water temperature, wind direction/speed, and water current direction/speed.

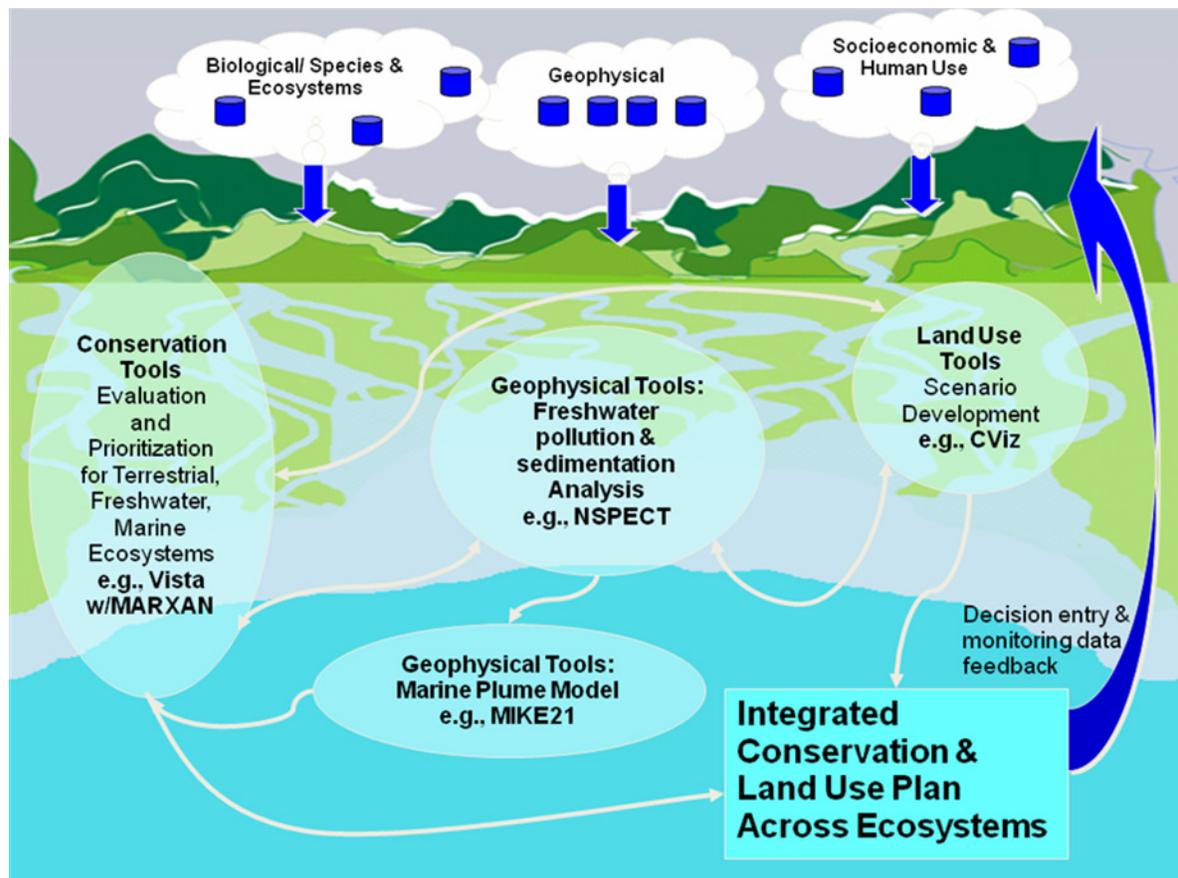
### ***Integrated Land-Sea Planning Workflow***

The sections below depict the toolkit workflow, beginning with raw data inputs and ending with outputs that can be used for decision making. A hierarchy of workflow diagrams are provided to guide the user through the integrated land-sea approach. They begin at the high-level conceptual vision of a land-sea toolkit and proceed down to detailed diagrams of data flow using individual tool functions. This workflow section is followed by a step-by-step description for applying each tool.

### **Conceptual Vision**

Our vision for the toolkit assumes an integrated land-sea planning approach for coastal watersheds that considers conservation and resource planning across terrestrial, freshwater, and marine/estuarine ecosystems (Figure 2). It also assumes that the integrated planning approach will happen via collaborative planning among multiple organizations with expertise in specific areas of the planning process, rather than attempting to conduct all types of planning within a single organization. However, one organization with cross-cutting expertise (GIS, data management, science) may play a lead role and/or provide assistance across organizations.

**Figure 2. Conceptual vision for the integrated land-sea toolkit.**



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## **Operational Workflow**

After completion of the conceptual vision, a formal tool interaction workflow was developed to illustrate the iterative feedback nature of the toolkit. Figure 3 demonstrates how a common GIS database serves all three tools in (1) depicting and assessing scenarios of current conditions and (2) developing the preferred scenario or plan that will be used in both land and water resource management.

### **Tool Roles**

Each tool has a particular role in the toolkit. However, some roles are shared or overlap, giving the user flexibility in how the tools are applied. The roles are as follows:

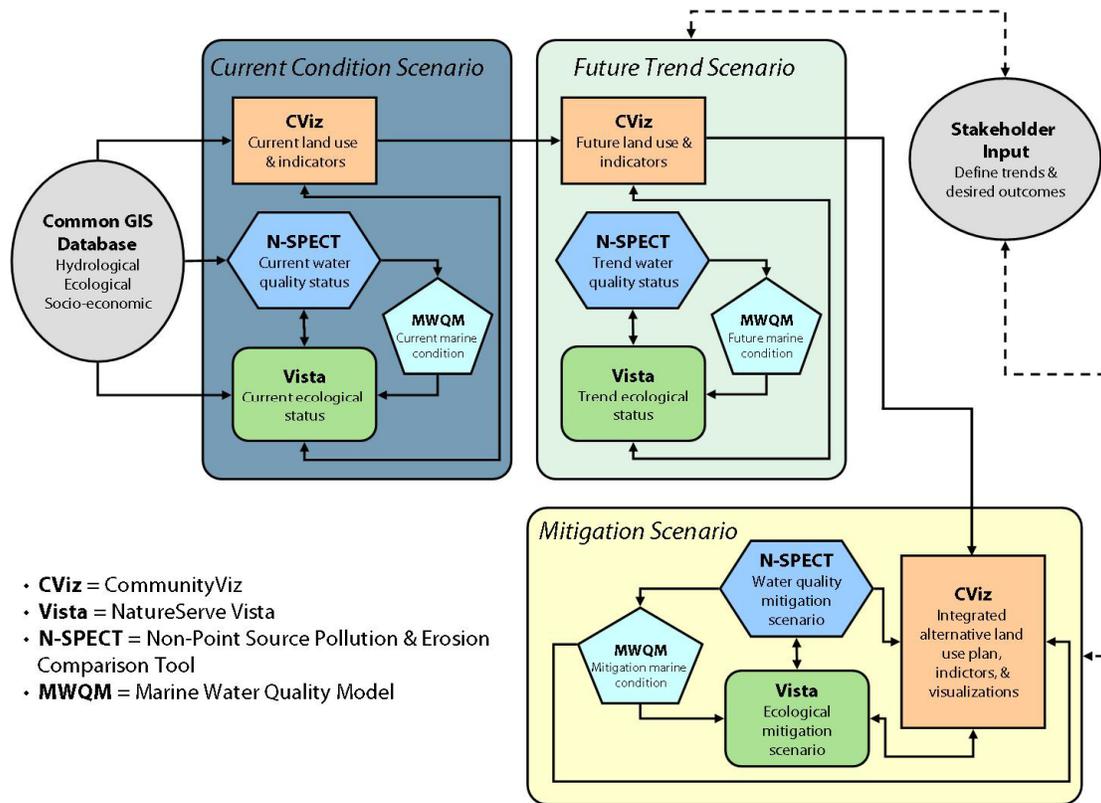
- CommunityViz is the primary tool used to depict land use scenarios and summarize indicators across all tools. It is used to model trends in urban and rural growth and quantify outcomes in terms of numerous socio-economic indicators. It also can incorporate hazard information such as inundation from storm surges and sea level rise.
- NatureServe Vista expands on the land use/hazard scenarios from CommunityViz to depict additional scenario details important for ecological analyses (i.e., water uses, presence of invasive species, and land management activities). Vista then assesses impacts and goal achievement of different land use scenarios for a broad spectrum of “conservation elements,” such as species habitats and cultural features. Vista can also be used to export land use scenarios to N-SPECT in a compatible form. Vista combines N-SPECT outputs and basic scenario information to assess ecological outcomes for elements from terrestrial, freshwater, and marine ecosystems (assessing impacts to marine ecosystems requires output from a tool that models the expected quantity, transport, and deposition of runoff and pollutants). Finally, Vista also supports generation of alternative scenarios or site mitigations for assessment and incorporation in CommunityViz.
- N-SPECT models runoff and pollutant loads based on the “fixed” characteristics of a project region (topography, soils, rainfall) and land cover maps derived from land use scenarios. N-SPECT can then be used to mitigate problem areas by specifying alternative land cover. These alternate scenarios can be returned to Vista and CommunityViz for additional assessment of ecological and socio-economic indicators.

### **Iterative Assessment and Planning**

The tools are interoperated using a series of scenarios (Figure 3), such as (1) current land use and other conditions (referred to as *Current Condition Scenario*); (2) expected land use and other conditions at a future time (referred to as *Future Trend Scenario*), and (3) preferred future land use (referred to as *Mitigation Scenario*). The

toolkit, however, has unlimited ability to analyze scenarios with different trends/proposed future scenarios and develop different options for a preferred scenario.

**Figure 3. Idealized tool workflow and iterations across scenarios.**



During the development of the current conditions scenario, the tools work together to depict and assess outcomes for socio-economic, water quality, and ecological indicators. Following the development of a current condition scenario, trend scenarios based on future development patterns are depicted and assessed. CommunityViz is used to model likely future development over time. Vista can supplement that information with additional ecological and management trend information. Finally, Vista and N-SPECT are used to assess outcomes (i.e., benefits and impacts) from current and trend scenarios and their outputs are rolled up into CommunityViz.

After current and future trend scenarios are assessed, a preferred future scenario can be developed. This process can occur through stakeholder involvement reviewing outcomes and defining parameters for more desirable outcomes. This may include setting or refining goals/objectives or specifying particular sites for

specific uses. In the preferred approach, however, N-SPECT and/or Vista are used to specify alternative land uses for sites that will be more compatible with water quality and ecological objectives. The alternatives identified by N-SPECT and/or Vista are then integrated in CommunityViz and assessed for socio-economic considerations. For most projects, several iterations will be required to develop a preferred scenario that meets all objectives and may still require making tradeoffs in original objectives.

### **Detailed Operational Workflow**

The operational workflow can be further broken down and additional detail added about information flow and specific functions employed in each tool. Within-tool workflows are not depicted in this toolkit, and are only provided in the “Step-by-Step” instructions when it was deemed useful for illustrating information flow. Workflow diagrams are provided for the following:

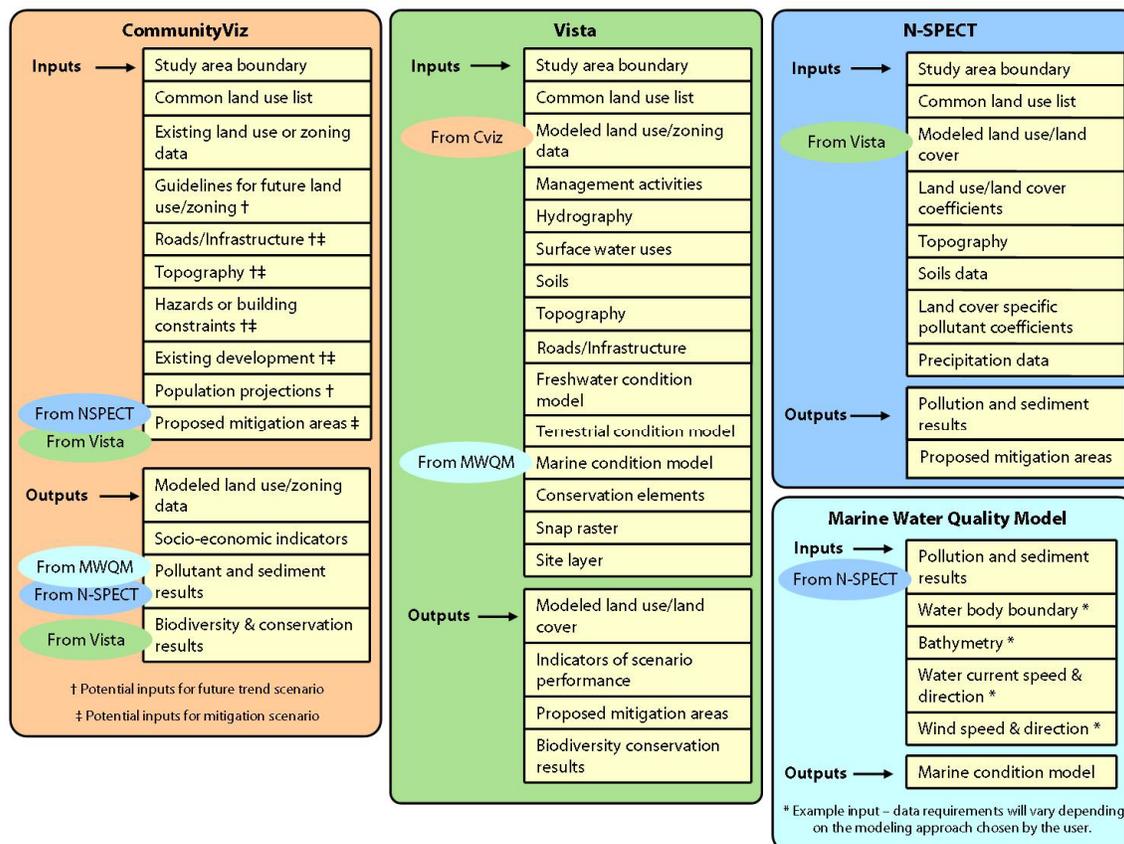
- Operational workflow with detailed data inputs and outputs (Figure 4)
- Assessment of aquatic elements via Vista and N-SPECT interoperation (Figure 5)
- Roll up of water quality and ecological indicators from N-SPECT and Vista, respectively, to CommunityViz (Figure 6)
- Integration of alternative scenarios generated in Vista into CommunityViz (Figure 7)

In order to develop a complete scenario for assessment, the user must begin by mapping land use or zoning in CommunityViz. The land use scenario map can be imported directly into Vista and supplemented with additional “land use” layers that are beneficial for assessing ecological impacts (e.g., recreational uses, infrastructure, sea level rise, exotic species invasion, etc.). In some cases, it may be beneficial to incorporate these additional “land use” layers in CommunityViz prior to using Vista. For example, data regarding hazards caused by inundation can easily be incorporated into the CommunityViz analysis. Users should consider the type and purpose of the additional “land use” layers before choosing which tool to use for incorporation into the toolkit. Vista also provides the option to add the policy mechanisms behind a particular land use scenario. This provides an additional means of depicting current land use threats to conservation. Separate raster maps are produced by Vista for land use and policy type.

The raster maps depicting land use that were produced in Vista can then be imported into N-SPECT for water quality modeling. N-SPECT includes a set of default land cover classifications (with associated coefficients), but if the default N-SPECT land cover classifications do not match the CommunityViz/Vista land use classifications, Vista can be used to translate the scenario into the N-SPECT land cover types. N-SPECT also provides the option, however, of developing user-defined land use classifications that could be used to translate with CommunityViz/Vista land uses. If this option is chosen,

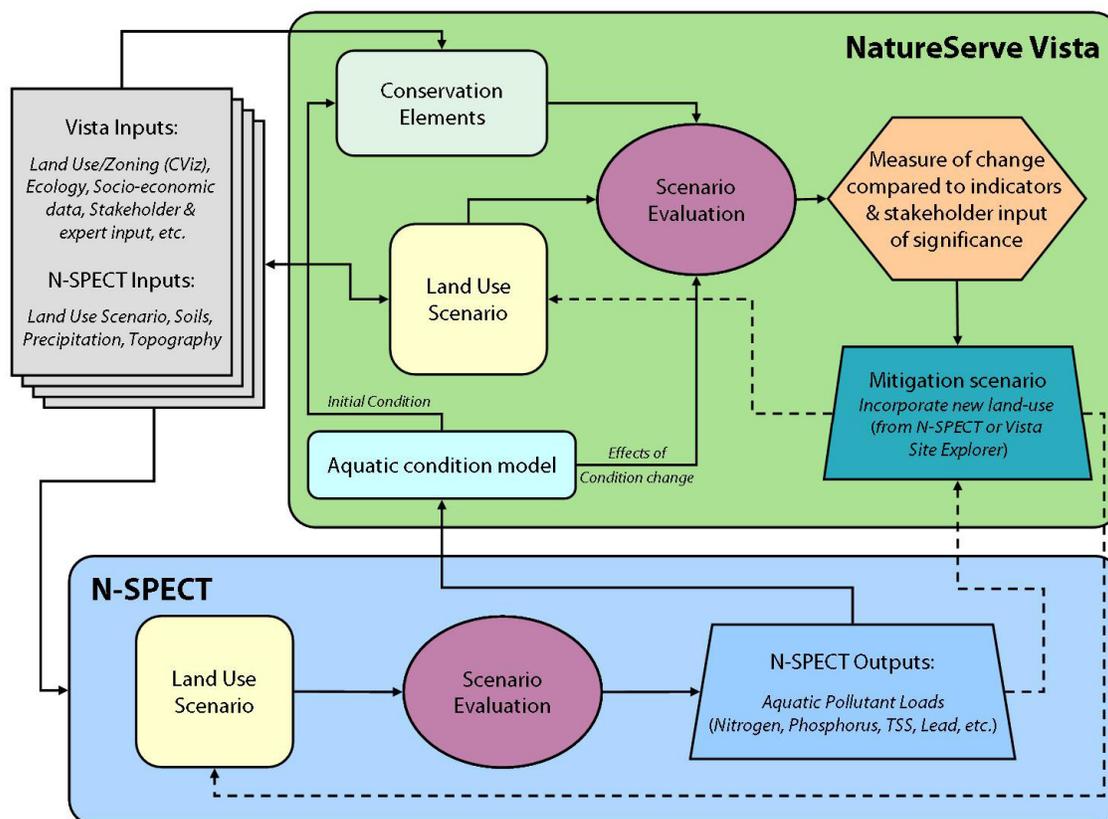
users will need to define land cover and pollutant coefficients that are specific to the CommunityViz/Vista land uses. Figure 4 depicts the interoperation of CommunityViz and Vista to map complete scenarios and export the results into N-SPECT.

Figure 4. Data inputs and outputs for each tool.



Vista has a degree of automated interoperability with N-SPECT. Vista can use N-SPECT results to create rasters that depict aquatic condition through a “Condition System” wizard (Figure 5). This interoperability allows Vista to evaluate the impact of water quality changes on freshwater resources. The N-SPECT results can also be combined in the wizard with additional information (i.e., surface water uses) to more accurately depict the condition of freshwater resources. The “Condition System” wizard can be used when an element is first imported (i.e., creating an initial or baseline condition), and/or it can be used during scenario evaluations. If used for the latter, users are able to model the effects of condition changes between scenarios. In other words, new land use scenarios can be incorporated and used to create new condition systems as the process becomes iterative. This will create multiple water quality/aquatic element metrics which can be compared and used to make better decisions about current priorities and effects of future land uses.

Figure 5. Interoperability flow diagram between NatureServe Vista and N-SPECT

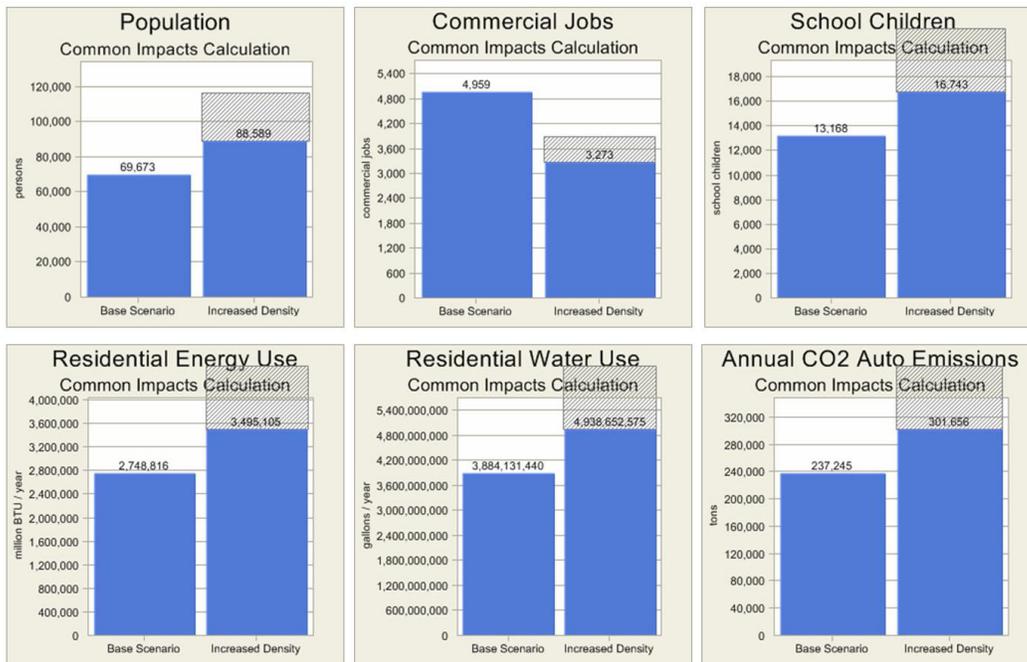


N-SPECT results must also be incorporated into other tools to assess the potential effects of changes in runoff and pollutant loads to marine water resources. The toolkit authors suggest using a locally-appropriate and calibrated marine water quality model (i.e., plume model) to depict the location and concentration of pollutants in the marine ecosystem resulting from runoff (as modeled by N-SPECT). The results of this model can be used as inputs to one or more condition models in Vista. Similarly to the freshwater condition model described above, these condition models can be used with condition thresholds to assess impacts on marine elements. Figures 3 and 4 depict the process for interoperating Vista, N-SPECT, and an unspecified marine water quality modeling tool to utilize N-SPECT outputs for assessment of both freshwater and marine elements.

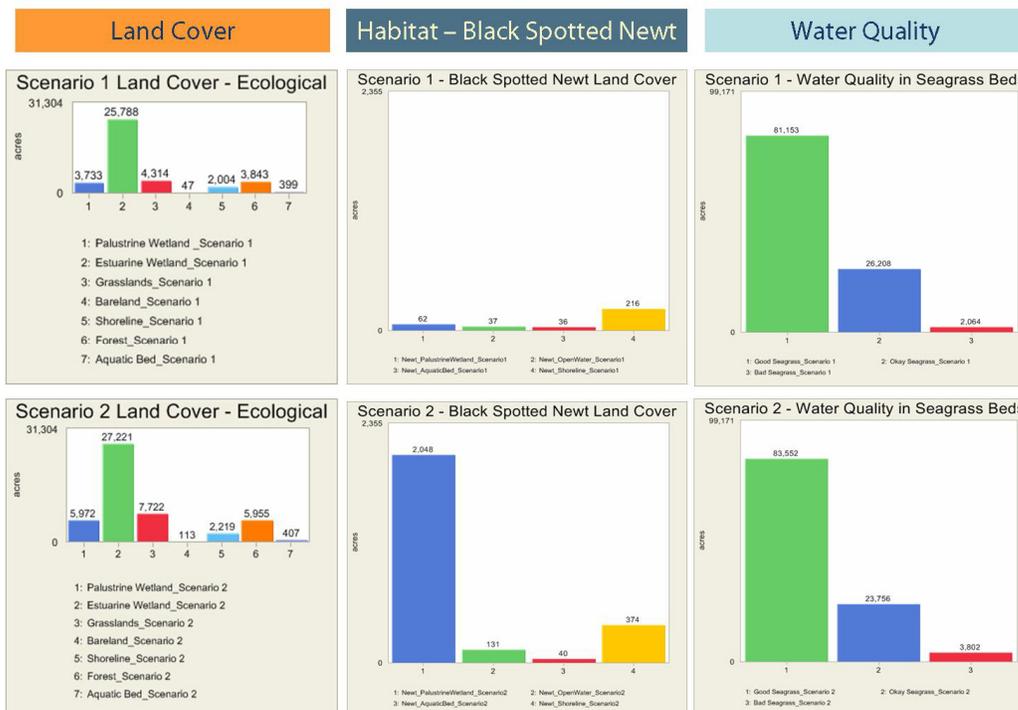
Finally, it is often useful for planners and/or project partners to view a summary assessment (or “roll-up”) of all socio-economic, ecological, and water quality indicators. CommunityViz is specifically designed to display a variety of indicators and thus it may be useful (but optional) to integrate all indicators through CommunityViz. Figure 6 depicts how outputs from Vista and N-SPECT can be displayed with socio-economic indicators in CommunityViz.

Figure 6. Example from Mission-Aransas NERR project showing (A) socio-economic, (B) ecological, and water indicators that have been rolled-up in CommunityViz.

(A) Socio-economic indicators

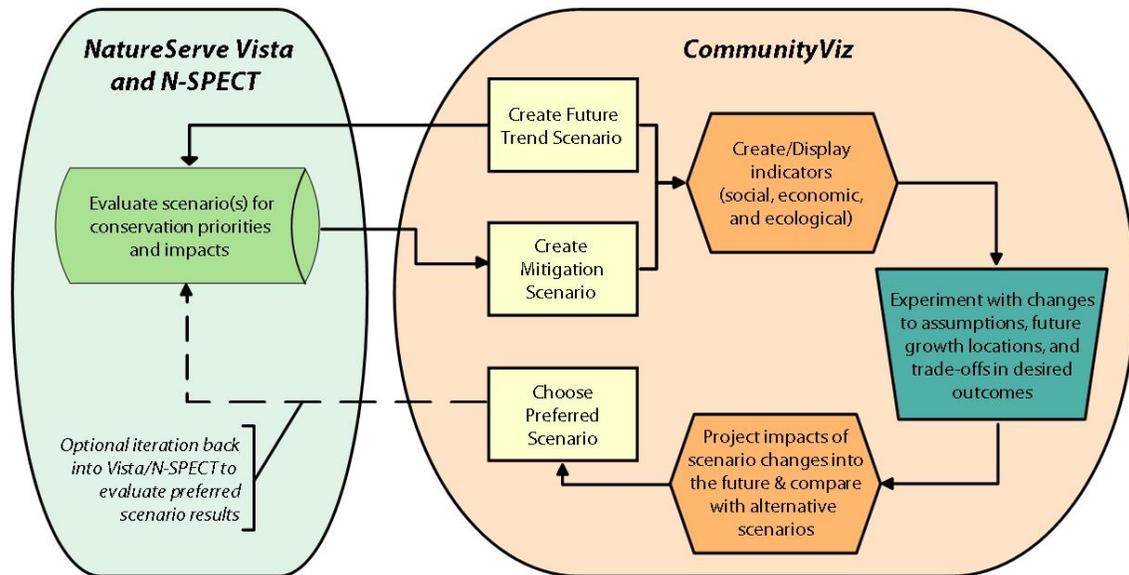


(B) Ecological Indicators



A key part of the toolkit is the ability for sector-specific planners or other experts (land use, watershed, conservation, hazard, etc.) to create site-level mitigations or to complete alternative scenarios in each tool that support iterative collaborative planning. Figure 7 depicts how alternative land use scenarios are integrated in CommunityViz to assist iterative development of a preferred future scenario for land use.

**Figure 7. Flow diagram showing one possible method of using CommunityViz as a platform for comparison of alternative land use scenarios derived through multi-tool iterations.**



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## **Step-by-Step Instructions for Conducting the Planning Process Workflow**

At this stage you will have the full toolkit installed, the common data set accumulated, and the individual tool data sets developed. You will also have an understanding of the conceptual workflow and tool roles. The following section provides step-by-step instructions for conducting the workflow. However, it does not describe every step or function within the individual tools and users must consult the individual tool documentation if more detailed steps are needed.

This section focuses on how scenarios are developed, assessed, and mitigated to understand social, economic, ecological, and water quality impacts. This section will also focus on how to mitigate and develop an acceptable plan that meets all objectives or reveals required trade-offs. For each process of the workflow we provide a description of the purpose, followed by the steps required to conduct the process. This includes identification of which tools and what functions within the tools are to be used. The specific tool inputs and outputs are also consistently identified using the nomenclature of each particular tool to facilitate further investigation within the individual tools' documentation.

### ***Developing the Current Condition Scenario***

The *Current Condition Scenario* begins with existing conditions (i.e., current land use, management, disturbances, etc.) that are used in the toolkit to assess current socioeconomic, water quality, and ecological indicators. The *Current Condition Scenario* then provides the starting point to create future scenarios that depict how the future may unfold under current policies and trends.

### **Development of Current Condition Scenario in CommunityViz**

There are a variety of methods to assess the current existing conditions from a land use perspective. Local tax assessment parcel data often contains existing land use information used for assessment purposes, and a variety of national agencies (e.g., Census, NOAA, USGS, USDA, etc.) and many state/local agencies provide population and/or land cover data which might be current to your study timeframe. In some study areas, the local/regional planning office might maintain a data layer with existing land use information. Finally, aerial interpretation or other methods might be required to translate existing conditions (i.e., building footprints) to the analysis layer. The availability of data and the extent to which any of these potential data sources provide current, accurate land use conditions for your study area should be analyzed to determine the best available method.

Once a data source (or combination of sources) is chosen, the data should be checked for accuracy with multiple sources, if possible. For instance, review of underlying aerials can be used to "spot check" for obvious inaccuracies in the data. Review by

local experts should also be done to check for recent changes in land use and development which might not be included in the available data source(s).

Once users have a reasonable confidence in their existing land use, they must determine which types of land use will allow for future development, either in complete development/redevelopment or in infill development. This determination should be facilitated with discussion with local experts. Redevelopment and infill locations might be very site-specific and not applicable to an entire existing land use classifications, and should therefore be handled as such.

### ***Developing the Future Trend Scenario***

This scenario is often called a “business-as-usual” or “trend” scenario. Developing the basic *Future Trend Scenario* is a natural and important starting point for any planning study, including one that fully anticipates making changes to the current direction.

### **Development of Future Trend Scenario in CommunityViz**

In CommunityViz, the first step in preparing the *Future Trend Scenario* is to determine the maximum theoretical future development that would be allowed under current land use regulations. This type of analysis is called “build-out.”

A build-out analysis requires a map of land-use designations (as developed during data setup, see ***Developing the CommunityViz Data Set***) and a set of simple rules specifying the maximum densities and intensity of development allowed for each land-use type. These rules are usually the density rules commonly found in zoning regulations or growth management plans and are increasingly available in electronic format online from local jurisdictions. If you are working with more general information based on research of trends and local characteristics, you will want to make some assumptions about possible future maximum development.

For purely residential designations, the most common measurement for maximum future development is density (dwelling units per area). Alternatively, you may use a minimum lot size, which gives the minimum area required for each unit. In a very rural area or in a defined subdivision, a third alternative is to simply assign a number of units allowed in a particular feature regardless of its size.

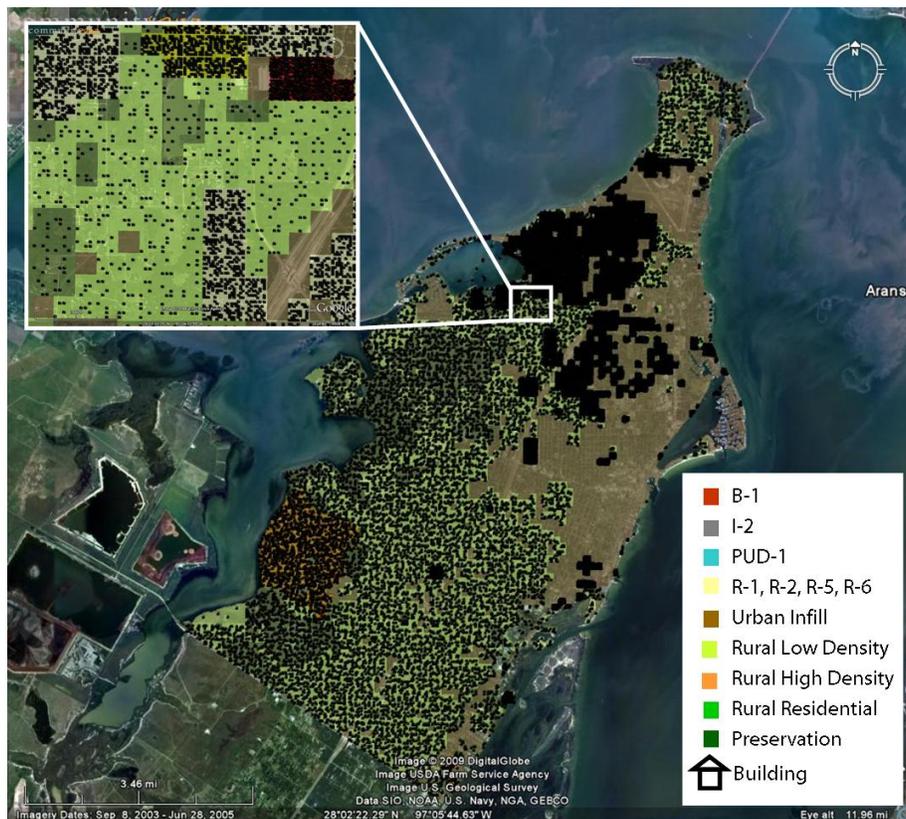
For non-residential designations and areas of mixed-use, maximum future development intensity is most commonly measured with a floor-area-ratio (FAR). This is a percentage of site development based on the overall square footage of buildings divided by the parcel area.

Specifying these rules is an important step in setting up a maximum future build-out for the study area. Scenario 360 has a tool called the “Build-Out Wizard” which is designed to facilitate this build-out analysis with easy-to-follow instructions for

inputting the information mentioned above. The build-out tool will calculate future theoretical maximum development for each feature taking into account the density rules defined by the user, as well as other factors if desired. The other factors could include: no-build constraint layers, existing development points, and building location rules (i.e., required road setbacks and building separation).

The basic build-out analysis can be performed with just a polygon layer and simple density rules (Figure 8). Any additional factors (e.g., constraints, existing development, etc.) can be included where accurate data and information is available. The outputs from the “Build-Out Wizard” in Scenario 360 will be numeric calculations of maximum development by polygon (numeric build-out), and if building location rules are defined, the wizard will also create a point or polygon layer representing potential future building locations (spatial build-out).

**Figure 8. Results of build-out analysis conducted for the Future Trend Scenario of the Mission-Aransas NERR demonstration project.**



### **Development of Time Horizon Analysis in CommunityViz**

Build-out analysis provides maximum theoretical development potential, but it does not determine when this development will occur. In other words, it could take 10 years or 100 years for that much growth to develop. In most cases, it is desirable to think in terms of a planning horizon for development analysis since it is typical to

make decisions for future development that correspond to other local planning horizons (i.e., infrastructure improvements, local facility needs assessments, etc.). Additionally, applying a planning horizon allows the user to see how their decisions, in terms of density and location rules, allow for the best use of land supply over time (e.g., will land supply be exhausted in ten years by developing at a density of one dwelling unit/acre). Time horizon analysis can also be developed to coincide with sea level rise predictions so inundation threats can be calibrated with expected development patterns at certain planning horizons.

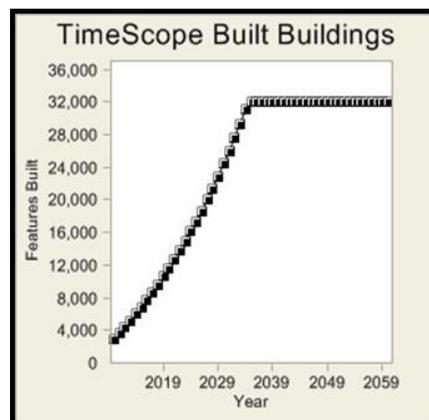
CommunityViz Scenario 360 provides several tools which assist in this type of planning horizon analysis. You need to decide three basic things in order to prepare a time horizon planning analysis:

- What is your time horizon (e.g., 10 years, 30 years, 50 years, etc.)?
- What growth rate will apply to your study area (e.g., 10 buildings per year, 2.5% development increase per year, etc.)?
- What factors will be used to determine the build order (e.g., input from local experts, proximity to existing development, access to services, lowest land cost, etc.)?

The most straightforward method for completing a time horizon analysis is to simply input results from “Build-Out Wizard” into the Scenario 360 “TimeScope Wizard.” The “TimeScope Wizard” will take the total number of future buildings and determine a build date for each building (Figure 9). The build date is based on the rate and build order factors chosen by the user.

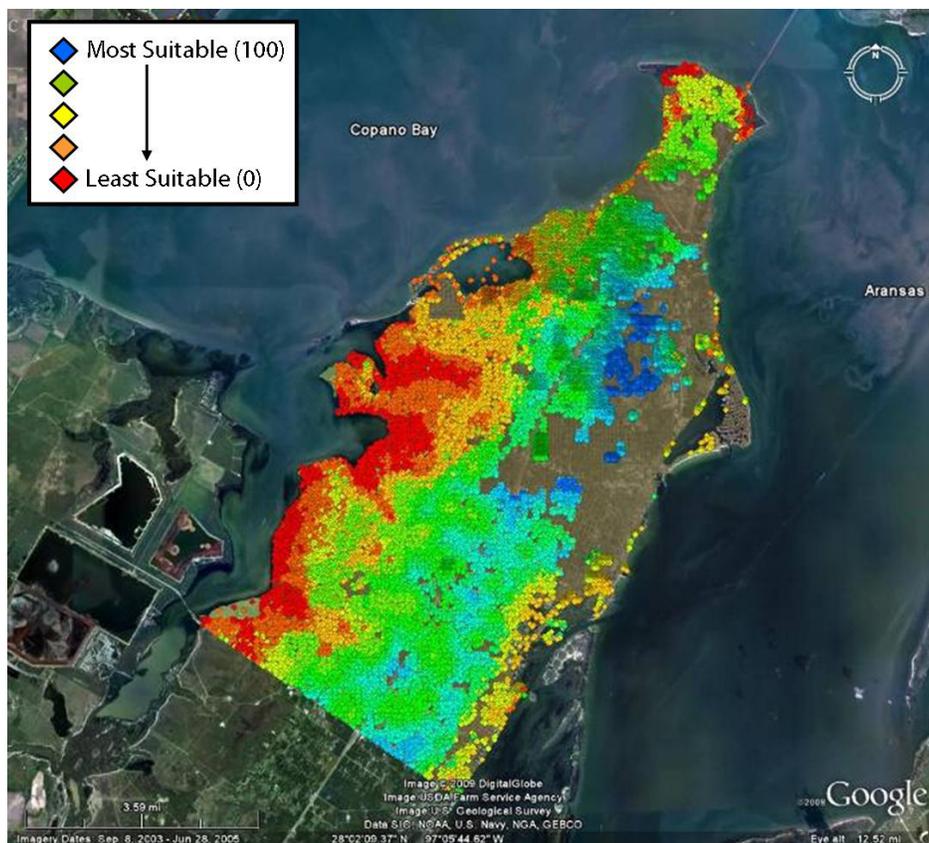
For guidance on the rate determination, users can use census projections, local forecast models, recent development trends, or other comparable methods.

**Figure 9.** Graph showing number of buildings (i.e., features) built per year. Results are based on time horizon analysis for Mission-Aransas NERR demonstration project.



For the future build order (i.e., which buildings are built first, second, third, etc.), it would be acceptable to simply use a random order or a single factor, such as proximity to urban centers. However, when you have more information available or there are multiple factors driving where development occurs, users can prepare a more sophisticated analysis. In the Scenario 360 tool, the “Suitability Wizard” allows users to specify multiple factors (e.g., proximity to roads, overlap with wetlands, access to schools, land cost, potential sea level rise impacts, etc.) that might play a role in promoting or deterring future development (Figure 10). The factors are combined with weighted shares of a total score from 0 to 100 (with 100 meaning a building is most likely to be built first). Initially, each factor gets an equal weight, but you can change the weights to reflect the relative importance of certain factors in the final result. This score is determined for each feature in the analysis layer so that you can use the resulting number to guide the preferred build order in the “TimeScope Wizard.”

**Figure 10.** Suitability of future buildings in the Mission-Aransas NERR demonstration project was calculated based on: proximity to wetlands, proximity to roads, proximity to sewer infrastructure, and overlap with sea level rise inundation areas.



Once you have completed a build-out analysis and a time horizon analysis, you have a *Future Trend Scenario* that depicts how growth and development in your study area will tend to proceed in the future according to current trends, practices, and

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regulations. The next step is to assess the likely effects of this growth using indicator measurements.

### ***Assessing Socio-economic Indicators***

Typical socio-economic indicators used in a planning analysis include: demographics (e.g., population by age, family size, etc.), economics (e.g., jobs, commercial floor space, etc.), social conditions (e.g., housing, incomes, etc.), and services (e.g., schools, traffic, etc.). In the context of the planning process, indicators like these help planners design a built environment that will best serve its human populations. Indicators help to (1) quantify existing conditions and needs/surpluses and (2) compare the relative merits of potential alternative future growth scenarios. The land-sea toolkit primarily uses CommunityViz for the latter type of assessment.

CommunityViz provides a number of tools for measuring socio-economic indicators associated with current and future development trends. The indicators are calculated dynamically using a combination of the data provided by the user, various multipliers and models, the scenario being studied, and the calendar year (if you are including a TimeScope analysis).

CommunityViz analysis tends to treat existing development (current condition) and new development (future trend) separately, although separate indicators for the two can be combined in the end to give a single total.

### **Assessing Current Condition Socio-economic Indicators**

Although CommunityViz can be used to easily calculate socio-economic indicators (see the **Assessing Future Trends Scenario** section below), users may find it helpful to gather actual data when calculating indicators for the *Current Condition Scenario*. This is likely to yield more accurate results and could also serve as a basis for calibrating future-development models.

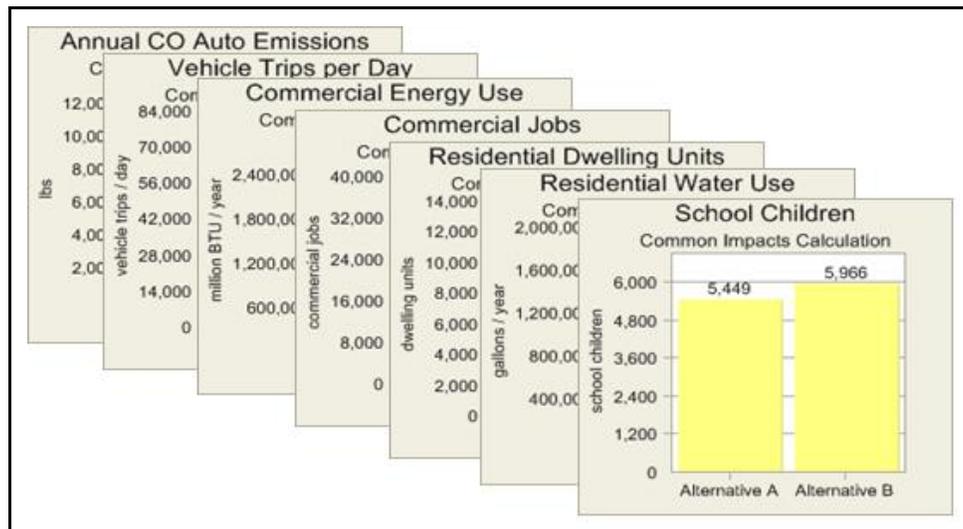
Detailed demographic data is available for most of the US from the US Census Bureau and similar sources (e.g., State Demographers, the American Community Survey, the Bureau of Economic Analysis, the Bureau of Labor Statistics, etc.). Several commercial sources are also available (e.g., ESRI's Business Analyst) and often provide even more detailed demographic data, if desired. Outside of the US, the availability of this type of data varies widely. However, CommunityViz does not require the use of any of this data. Except for credible estimates of current population and housing units, it should all be considered optional supporting information for an integrated land-sea planning project.

### **Assessing Future Trend Socio-economic Indicators**

There are several methods that users can use in the development of socio-economic indicators:

- The “Common Impacts Wizard,” a Scenario 360 tool, quickly creates estimates of commonly used socio-economic indicators (e.g., population, school children, labor force, housing, jobs/housing ratio, and traffic). These estimates are generally based on simple multipliers (e.g., population = number of dwelling units x average number of persons per household) and they provide a good, high-level starting point for comparative decisions (Figure 11).
- The “Custom Impacts Wizard” lets you quickly set up additional, user-defined indicator analyses that adhere to frequently used modeling structures.
- Standard Scenario 360 analysis tools can be used to create indicator measurements of virtually any socio-economic (or other) effect you need to model, assuming you know the modeling logic and parameters to apply.

Figure 11. Metrics developed from the Common Impacts Wizard in CommunityViz.



Similarly to land use assessment and build-out analysis, it is important for users to find the “right” level of detail at which to model socio-economic indicators. While CommunityViz allows you to build very sophisticated and detailed analyses, the time and resources spent must be weighed against the benefits that accrue to the overall land-sea planning process. Often, the simplest calculations are the best, and something similar to the indicators provided by the “Common Impacts Wizard” is a good place to start.

The purpose of indicator measurements is to help guide planning decisions. The decision-making process, whether it involves experts, the public, elected officials, or all of those in combination, will normally include time to set indicator goals. Goals can be directional (e.g., higher is better), targets (e.g., achieve a certain level), or debatable (e.g., “I want this, you want that”). It is not typically expected for a plan to achieve all goals, but the decision-making process involves understanding how to best strike

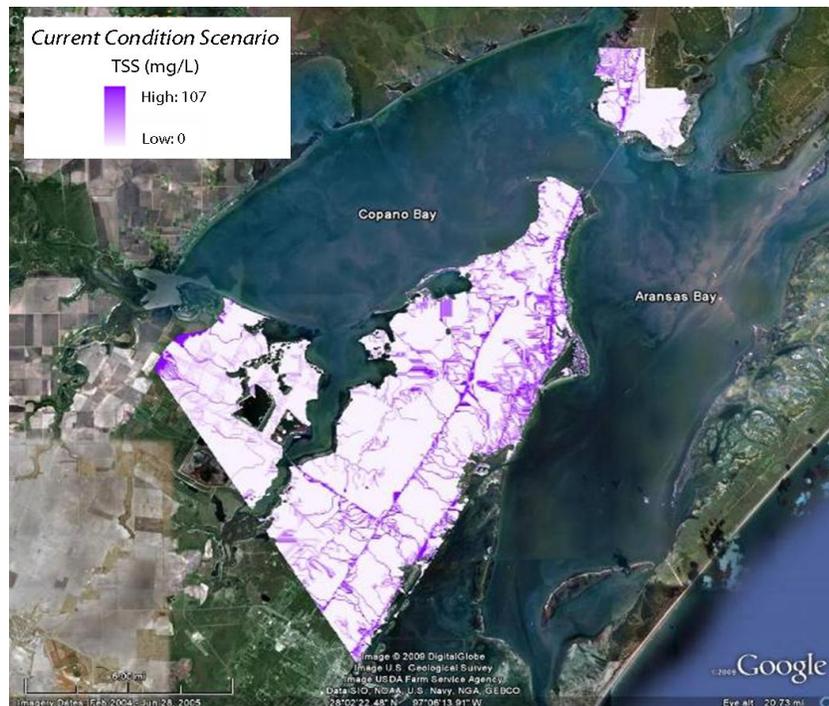
balances and make trade-offs that support the goals. The land-sea toolkit described here assumes goals are set as part of a public and/or expert process. However, software tools may be available that help groups of people explore their collective goals more explicitly.

Users should also keep in mind that many of the same methods used for assessing socio-economic methods in CommunityViz can also be used to calculate indicators of water quality, ecological, biodiversity, etc.

### **Assessing Water Quality**

In this portion of the analysis, you will use N-SPECT to develop estimates of water quality indicators (Figure 12). When deriving these estimates for the land-sea toolkit, you will use the current, future trend, or preferred land cover and elevation data sets, as well as data on soils, rainfall, and pollutants of interest.

**Figure 12. N-SPECT results depicting the concentration of total suspended solids (TSS) based on the *Current Condition Scenario* for the Mission-Aransas NERR demonstration project.**



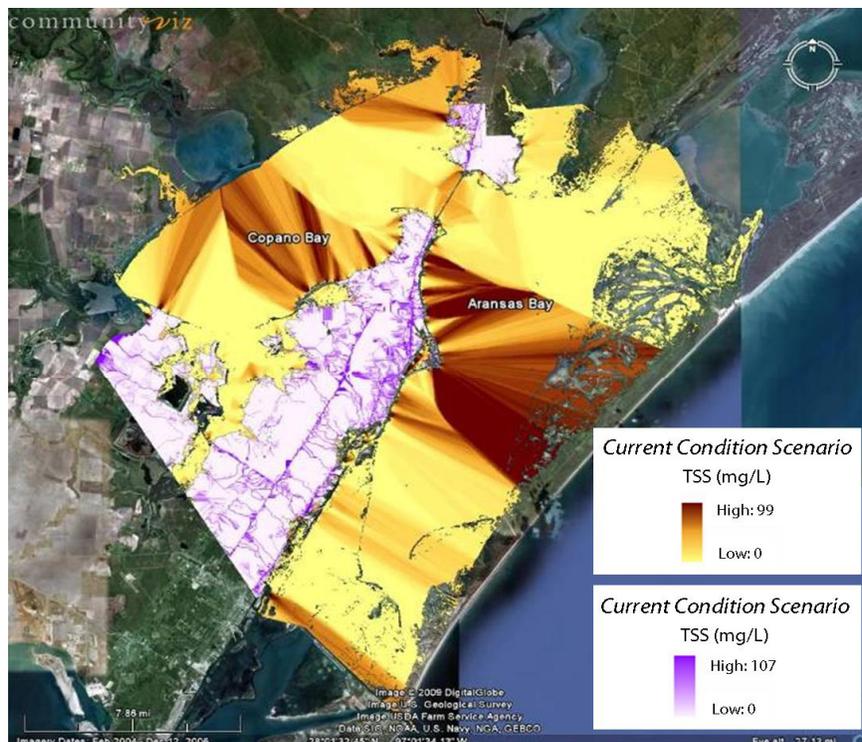
It is important to note that if the user wishes to draw upon the CommunityViz-Vista interoperation to develop the land cover data for the *Current Condition Scenario* (or any other scenarios), then this step will follow the steps described below for Vista land use scenario development (see **Creating a Scenario**).

### Assessing Marine Water Quality

In this section of the toolkit, the N-SPECT values described above (see **Assessing Water Quality**) are input into a process or tool that extends the pollution values into the marine (or lacustrine) environment. As described earlier, the toolkit providers do not identify a specific tool or detailed procedure for this part of the process since the appropriate tool or process will vary depending on the physical environment and available data. There is also considerable variation in the degree of precision that can be modeled and consequent variation in time and cost to develop the model.

The Mission-Aransas NERR demonstration project used a very simple model (available in the ArcGIS Spatial Analyst Extension) to extrapolate the shoreline/river mouth values of the N-SPECT analysis to the marine environment (Figure 13). Although this model's ability to precisely depict concentrations of pollutants within the marine environment is probably low, the repeated use of the same model still allowed a means of comparison between different scenarios (i.e., all parameters for the model remained the same for every scenario except for the pollution values derived from N-SPECT for each scenario).

**Figure 13. Total suspended solids (TSS) concentrations for the Current Condition Scenario of the Mission-Aransas NERR demonstration project. Shoreline/river mouth values of the N-SPECT analysis were selected and then extrapolated to the marine environment using a simple model in ArcGIS.**



The key steps, regardless of the tool or procedure chosen by the user, include:

- Input the N-SPECT results
- Run the marine water quality model/process
- Post-process the results if needed to match the N-SPECT data format (for use in the Vista aquatic condition modeler).

### ***Assessing Conservation Indicators***

At this time you will have already established your NatureServe Vista database with element distributions, conservation requirements, and other attributes described in the **Developing the NatureServe Vista Database** section of this guide. This section below describes how to import the land use scenarios developed in CommunityViz into NatureServe Vista, add additional information to the scenario, and evaluate the scenario. Users will also learn how to import the N-SPECT water quality outputs into Vista scenarios and assess water quality impacts on aquatic conservation elements.

### **Defining a Vista Scenario**

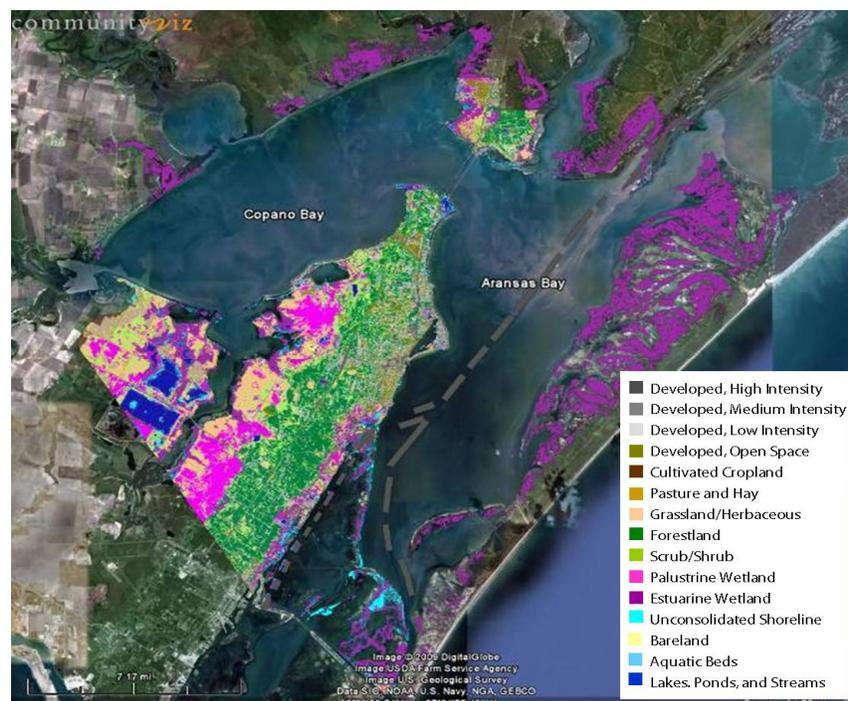
Scenarios are created in Vista and used to evaluate the impact of current (or future, preferred, etc.) land use/policy on achievement of element conservation goals. This can be done directly by defining element compatibility with land use/policy or indirectly through the creation of condition models that have defined condition thresholds. The scenario consists of any data layer (or collection of data layers) that represent the land use for a particular scenario (Figure 14). It is optional when creating the scenario to define policies for the project area as well. For the integrated land-sea toolkit, the primary source of data for current (or future, preferred, etc.) land use is the land use data layer created in CommunityViz (i.e., *Current Condition Scenario*, *Future Trend Scenario*, and *Mitigation Scenario*). Once this layer has been imported into Vista, it can be combined with other land use or land policy information to represent a more complete picture of disturbances and conservation activities that affect achievement of element goals.

A summary of the steps and functions required for creating scenarios in Vista is provided below:

- Open the “Define Scenario” function in Vista.
- Determine if a scenario will contain policy information in addition to land use information. “Land use” is used broadly here to describe what is happening on the ground, in the air, and/or in the water. Policy types are optional and describe the mechanisms that allow those types of “land use” to occur. During the scenario evaluation, users are able to indicate which policy types are considered reliable. This allows for identification of areas where current (or future, preferred, etc.) policy does not support achievement of element goals, even if land use is compatible (e.g., open space that has an unreliable policy to prevent development).

- Create land use (and policy) translators. These translators will be used to crosswalk data layers or features that come from multiple sources with different land use (or policy) coding/names into the same “language.” In the case of this toolkit, the common “language” refers to the common land use classification list. Even if a CommunityViz data layer will use the same classifications as a Vista scenario, you must still build an initial translator that can conduct the crosswalk automatically thereafter.
- Within the “Define Scenario” function, find the layers drop down menu and navigate to the shapefile created in CommunityViz for the *Current Condition Scenario* (or *Future Trend Scenario*, *Preferred Scenario*, etc.). Follow the Vista instructions for translating the shapefile’s land uses (and policies) and choose the “add/combine” or “add/override” option. These options determine how layers are treated when they overlap. Combine means that all overlapping land uses will co-occur, while override means the topmost layer will be the only land use type represented in that location.
- Add additional land use layers that represent uses, disturbances, etc. that are not already included in the CommunityViz shapefile. Follow the same process described in the bullet above to incorporate these layers.
- After all data layers have been added to the scenario, you can choose to run the scenario definition process immediately or delay the processing. The scenario definition will process your inputs into separate raster layers (or stacks if the combine function was used) for land use and policy types (Figure 14).

Figure 14. *Current Condition Scenario* created in Vista for the Mission-Aransas NERR demonstration project.



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### **Create Aquatic Condition Model(s)**

One way to evaluate the effect of water quality on conservation elements is to translate water pollutants into categorical “land uses” (i.e., TSS 0-12 mg/L, TSS 13-26 mg/L, TSS > 26 mg/L) and assess their compatibility with conservation goals. However, it is much more efficient and precise to use condition modeling to assess the impacts of water quality. The steps below apply to assessments of both freshwater and marine elements:

- Open the Vista Condition Modeler and follow instructions for setting aquatic vs. terrestrial condition parameters
- Specify the elements that will be assessed using that condition model
- Point to the pollution input layers and specify the ranges to be used
- Set the 0.0-1.0 scores for how the ranges of pollution types are expected to affect the element condition
- Build additional condition models for different groups of elements if they react differently to the pollutant levels

It is important to note that the condition modeler can perform two different functions within the toolkit. It can be run in conjunction with scenario evaluations (see below) or it can be used to establish starting condition values for elements.

### **Evaluate Scenario**

Scenario Evaluation is the process of assessing the compatibility of element distributions with land use (and/or policy) scenarios to determine achievement of element goals. Scenario evaluations reveal areas of conflict that could be mitigated to increase overall goal achievement. The following steps are used to evaluate scenarios:

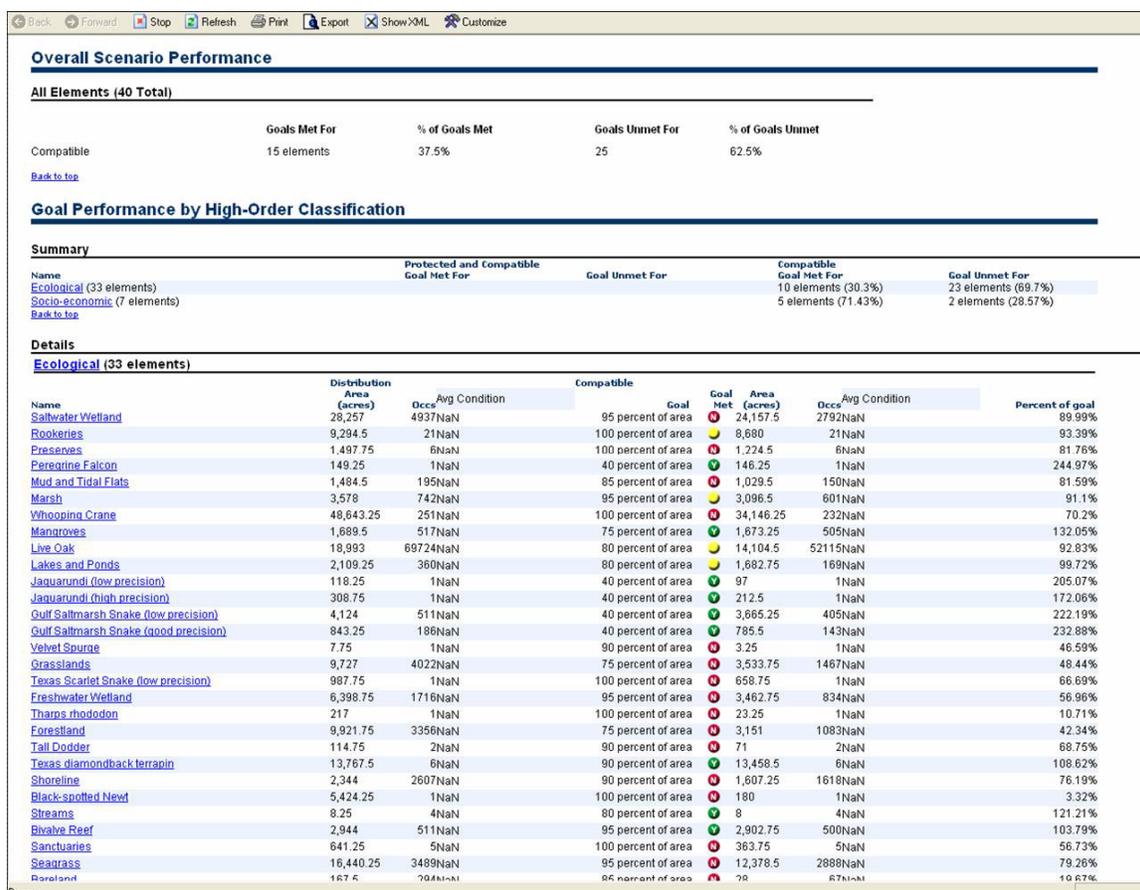
- Open the “Evaluate Scenario” function in Vista and follow the instructions for naming and describing your evaluation.
- Choose any element or spatial filters that you may want to apply and specify your goal set list.
- Select one of the scenarios that you defined above (i.e., *Current Condition Scenario*, *Future Trend Scenario*, or *Mitigation Scenario*) for evaluation.
- Choose the condition systems (see **Create Aquatic Condition Model(s)** section above) that represent your aquatic elements (and other elements, if applicable).
- Choose whether or not to include policy types in the assessment. Policies can only be evaluated if they were originally included when the scenario was defined. If this is the case, check which policy types you consider reliable.
- Select which element responses are considered compatible with element viability.

- If you wish to investigate potential mitigation opportunities (suggested for this toolkit), a site layer must be selected. Site layers are vector layers that can be used to specify alternative land uses for creating new scenarios (i.e., property parcels, management units, basins, etc.). It is recommended that users create a hybrid vector layer by manually combining maps that represent the units of decision making (for further guidance see the Vista User’s Manual).
- After all necessary inputs have been added to the evaluation, you can choose to run the evaluation process immediately or delay the processing. Scenario evaluations can take a considerable time to run, so it is often useful to delay processing and run these overnight (very large complex regions may take multiple days to complete).

### Scenario Evaluation Outputs

Scenario evaluations produce a hierarchy of reports and maps. The overall scenario evaluation report (Figure 15) summarizes (by total and by category) the performance of the scenario in terms of the number and percentage of elements that met their conservation goals.

Figure 15. Scenario evaluation report for Future Trend Scenario of Mission-Aransas NERR project.

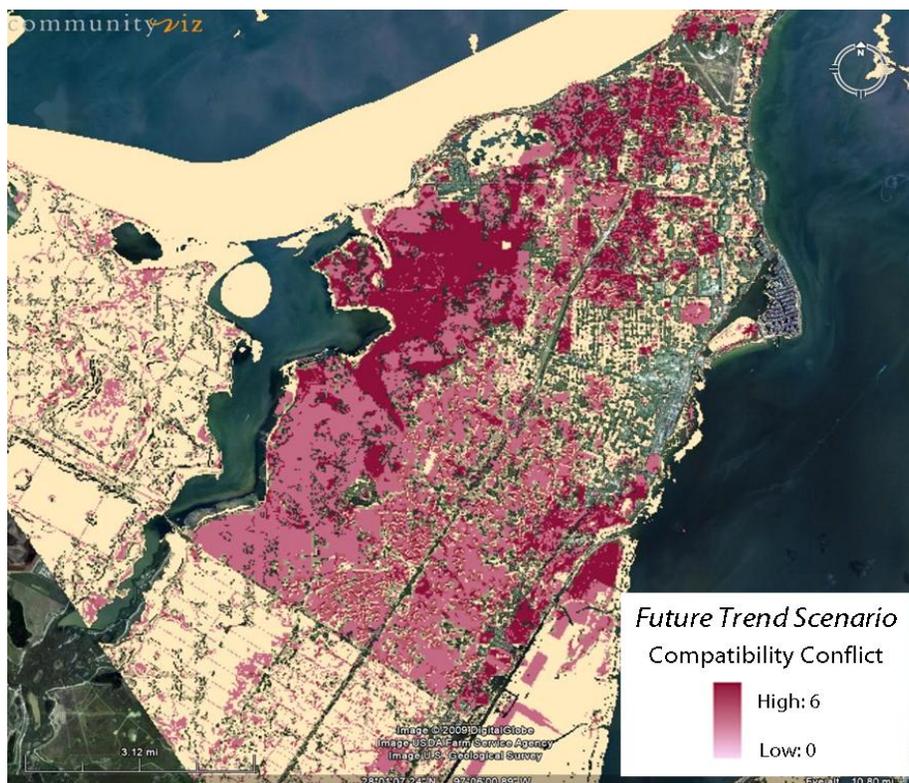


The report also provides detailed performance statistics for both individual and groups of elements, including the original element distribution and the amount/percentage that was retained in areas with compatible land use (both with and without adequate protection). The report also provides links to individual element reports that offer considerably more charts and statistics on element performance under a particular scenario.

The raster layers generated by the Scenario Evaluation (Figure 16) identify areas in the planning region where opportunities exist for improving goal performance. The first layer identifies compatibility conflicts (i.e., concentrated areas where elements are incompatible with land use and do not meet conservation goals). The second raster layer (not shown) identifies areas where elements with unmet goals have compatible land use but unreliable policy. For more information on how layers created by Scenario Evaluations are calculated and how they are interpreted, visit the NatureServe Vista User's Manual.

In Figure 16, the tan color represents areas where (1) there are no conflicts between elements and land use or (2) a given element has met its conservation goal in areas of compatible land use. Red indicates areas where elements are in conflict with land use, and darker red areas indicate that more elements are in conflict.

**Figure 16. Zoom in of a scenario evaluation for the *Future Trend Scenario* of the Mission-Aransas NERR Demonstration project.**



### ***Developing a "Proposed" Scenario***

Informed decision-making calls for fair consideration of alternatives before one particular path is chosen. The land-sea toolkit supports this approach through the use of alternative scenarios and an iterative analysis sequence. While process specifics will vary from project to project, the general flow is as follows: (1) the current and future trend scenarios are assessed, (2) problems are identified, and (3) suggested mitigations are used to construct a preferred scenario.

### **Assess Current and Future Trend Scenarios**

In CommunityViz, alternative scenarios can be created and compared within one analysis (i.e., one ArcMap project). Once the *Current Condition* scenario is created, adding additional scenarios is straightforward and is accomplished by making a "copy" and applying changes to the land use plan, policies, assumptions, or other variables (see **Developing the Future Trend Scenario** section above). Indicators are automatically recalculated for each scenario, so assessing and comparing the relative results of alternatives is easy. Another approach is to create separate but similar analyses (i.e., multiple ArcMap projects). This eliminates the ability to do side-by-side analysis and makes it complicated to synchronize changes, but it may improve processing performance for large studies and simplify data transfers to NatureServe Vista and N-SPECT.

New alternative scenarios, such as the *Future Trend Scenario*, can be brought from CommunityViz into the same Vista project, but the steps described above for scenario definition and evaluation must be repeated for this (and every subsequent) scenario. However, the import process is much quicker for subsequent scenarios since the same translators, categories and goal sets can be used. Condition systems will also need to be updated to reflect new impacts to land and water. In other words, the N-SPECT and marine water quality model must be run for the *Future Trends Scenario* and incorporated into the Vista scenario using the Aquatic Condition Modeler.

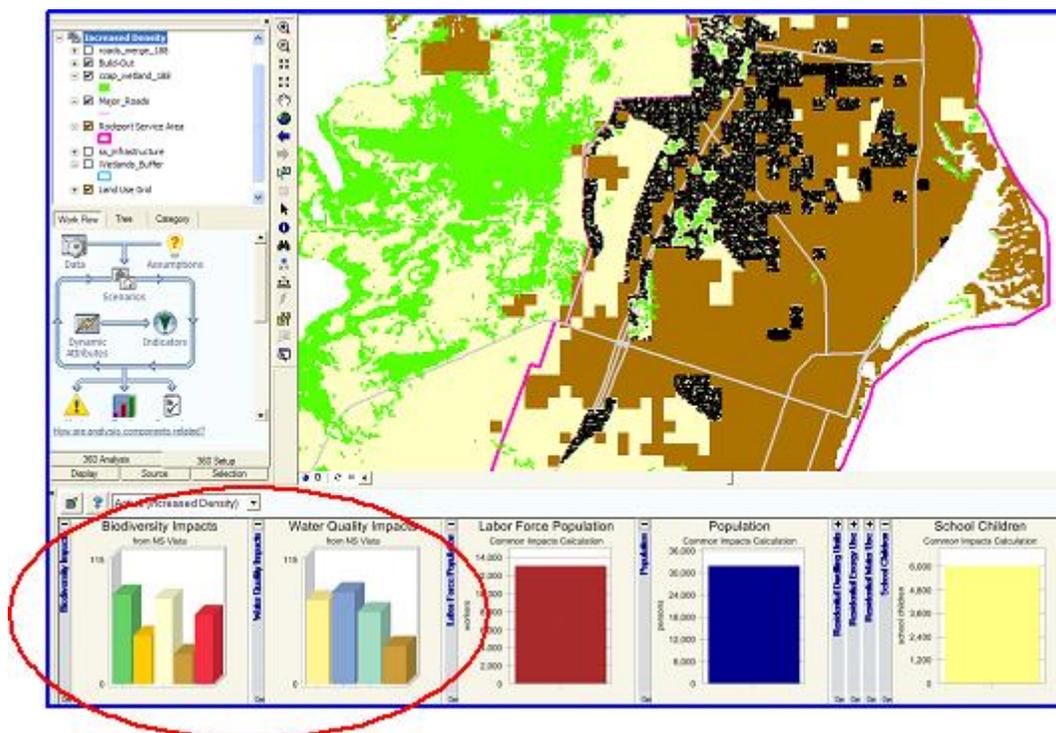
After scenario evaluations have been run for the new scenario, users will have multiple conservation element impact maps and reports to allow for comparison. These results can be shared directly with stakeholders to help them make informed decisions about the impacts of scenarios upon their conservation goals. Another option, however, is for users to draw on these results for the development of new scenarios that mitigate conflicts and improve goal achievement.

### **Summarizing Conservation Indicators**

As described earlier in the **Assessing Future Trend Socio-economic Indicators** section, the purpose of indicator measurements is to help guide planning decisions. In addition to calculating socio-economic indicators, CommunityViz also provides a good platform for summarizing water quality and conservation results

and displaying these types of indicators (Figure 17). The “Custom Impacts Wizard” lets you quickly set up additional, user defined indicator analyses that adhere to frequently used modeling structures. There are also several standard Scenario 360 tools that can be used to create indicators of virtually any effect you need to model (assuming you know the modeling logic and parameters to apply). While CommunityViz allows you to build very sophisticated and detailed analyses, the time and resources spent must be weighed against the benefits that accrue to the overall land-sea planning process. Often, the simplest calculations are the best.

**Figure 17. Ecological and water quality indicators developed for the Mission-Aransas NERR demonstration project using CommunityViz.**



### **Interpreting Results**

Once results are obtained from each tool for both scenarios, the planning team should have an understanding of scenario performance and potential trends in socioeconomic, ecological, and water quality indicators. The planning team must then interpret the results to determine what, if any, changes/mitigations are needed. From our experience, current conditions and trend scenarios rarely demonstrate full goal attainment and a new plan that builds on the previous work must be developed. A few questions that the team may ask when reviewing the results include:

- What types of indicators failed to meet goals? (e.g., if failures are limited to just one type of indicator then the problem and solutions are relatively contained)

- How much of a gap in goal attainment exists? (e.g., large gaps suggest considerable changes may be necessary)
- Could goals be achieved by changing land use plans or are trade-offs (i.e., changes in goal sets) needed? (e.g., if the results suggest that considerable changes to both development *and* conservation are needed in order to meet goals, this may not be feasible)

### **Mitigating Conflicts for Achieving Goals**

Users should consider the following ideas when interpreting results and developing potential mitigation scenarios:

- It is important to configure a mitigation process. The toolkit providers suggest starting the mitigation process in the marine environment and working upstream. Step one of this process would involve mitigating “direct” impacts to the marine environment (e.g., jet ski damage to seagrass beds, dredging of oyster reefs, etc.). Step two would require moving upstream and mitigating the “indirect” marine impacts that are the result of land use change and increased runoff/pollution. The third step involves mitigation of any impacts to freshwater elements that might remain after step two. Finally, the user would consider mitigation strategies for terrestrial conservation elements.
- The land-sea planning approach described throughout this toolkit is embodied in the mitigation sequence described above. This approach can make the process of mitigation and goal achievement easier for the planning group because mitigating marine impacts often results in the mitigation of terrestrial and freshwater impacts as well. These benefits can also extend into the socio-economic realm. For example, establishing building setbacks along an important freshwater tributary will provide: (1) an important buffer zone for filtration of potential pollutants, (2) a biological corridor for wildlife, and (3) protection for residents from flood damage. It is possible, but unlikely, that this approach will create further conflicts (potential conflicts with socioeconomic goals are addressed below – see **Assessing Mitigation Scenarios for Socio-economic Impacts** section). It is also possible that mitigations aimed solely at improving water quality will be insufficient for mitigating terrestrial conflicts, but this problem can easily be addressed through the mitigation sequence proposed above.
- Scenario modifications can be made in any of the tools, but each tool is oriented toward mitigating changes to the indicators covered by that specific tool. Therefore, it is probably more efficient and effective to use the appropriate tool for modifications. For example, conservation mitigation changes should be made in Vista rather than CommunityViz or N-SPECT. However, N-SPECT is ideal for assessing how water quality indicators will

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change with land use mitigations and CommunityViz is ideal for assessing socio-economic changes. Both Vista and N-SPECT have functions for quickly creating “site-level” alternative scenarios (see below for action on **Mitigation Tools for Achieving Goals**).

### **Mitigation Tools for Achieving Goals**

#### **N-SPECT:**

In N-SPECT, land use changes can be made to specified regions of the project area by opening the “Run Analysis” window of N-SPECT and right-clicking on “Land Uses” and then selecting “Add Scenario” from the drop-down list. A new polygon layer that reflects the alternate scenario land use (as well as the soil conservation numbers, cover factor, potential pollutants and their corresponding coefficients) must be provided and chosen from the drop-down list.

Alternatively, the user could also use the “Management Scenarios” tab to create changes to land use management. This option will change the land use within a specified region of the project area to a different land use class that is already defined in the analysis’ land use classification. For example, to estimate the impact of a new housing development, you can create a polygon shapefile of the area to be developed and apply the high- or low-intensity developed land use class to that polygon. The coefficients for the newly designated land use will be used in the designated area in lieu of the coefficients for the original land use data set.

#### **NatureServe Vista – Site Explorer:**

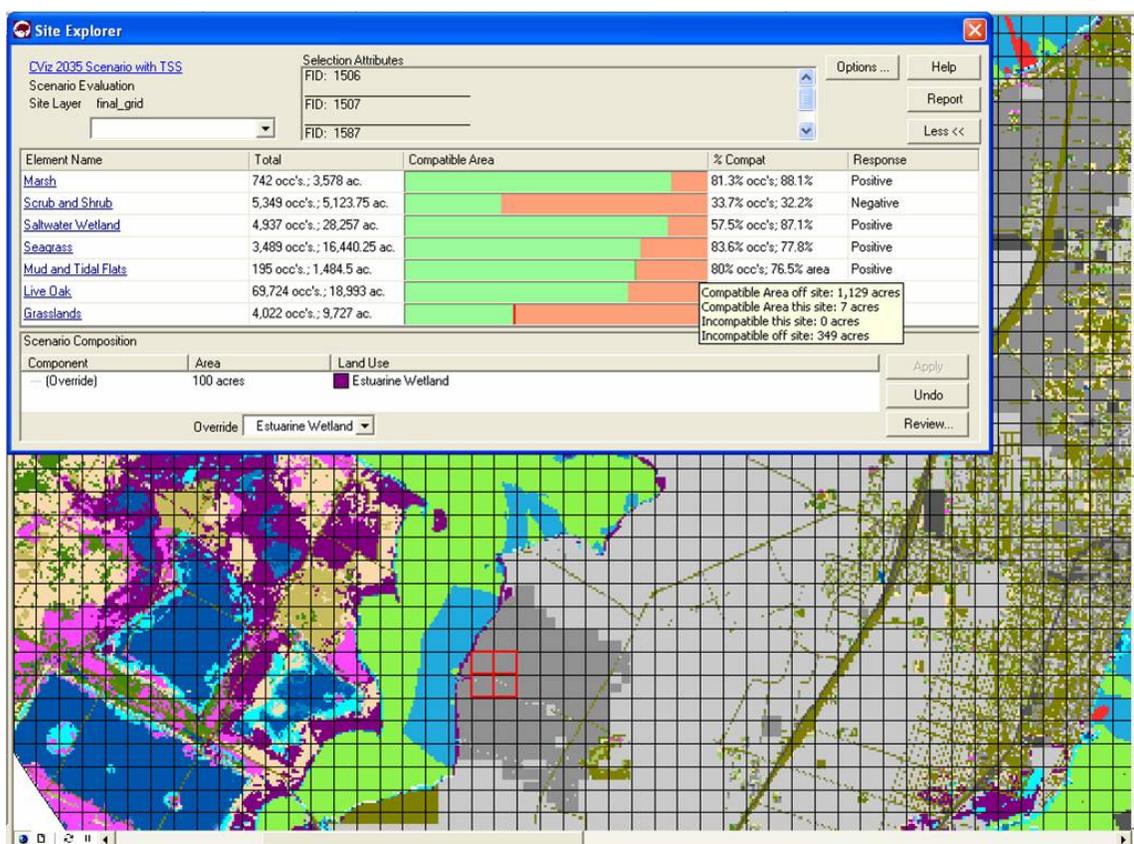
In NatureServe Vista, you are able to propose and evaluate the effect of land use and/or policy changes on conservation goals by using “Site Explorer.” This Vista function allows the user to explore potential changes to land use (and/or policy) before making any “physical” changes to the scenario itself. Once “Site Explorer” is active, the users can select a specific site from the site layer (see **Evaluate Scenario** section above for details on the site layer) where mitigation is desirable and land use changes (or policy) changes may be “proposed.” One option for identify good areas for potential mitigation is to look at “Scenario Evaluation” results and find areas of high compatibility conflict (i.e., dark red areas in Figure 16).

Once sites have been selected, “Site Explorer” provides data on the land use and/or policy types for that particular site. It also provides detailed information on the conservation elements that occur within the selection and their effect on goal achievement. In Figure 16, the chart depicts the proportion of the goal achieved (green) and unachieved (red), as well as the proportion of the area within (dark colors) versus the area outside (light colors) the selected site for each element.

Dragging the mouse over these boxes will provide the actual numbers for each of these parameters.

“Site Explorer” can then be used to mitigate impacts from current land use (and/or policy) and increase goal achievement by changing land use (and/or policy). This is done by using the “Override” option within the “Site Explorer” window. For example, in Figure 18 the land use has been changed from an incompatible land use to a compatible land use. This will improve goal achievement in a priority conservation area. These changes can be saved to a shapefile that contains the new land use (and/or policy) for each site. This shapefile can then be integrated into an existing scenario or added to a new alternative scenario.

**Figure 18.** Site Explorer can be used in NatureServe Vista to identify mitigation areas. The figure below shows the use of Site Explorer in the Mission-Aransas NERR project.



#### *Other useful tools/approaches for mitigation:*

There are other tools and approaches that could potentially interact within the toolkit and be helpful in the mitigation process. While these tools were not used in the Mission-Aransas NERR demonstration project, they could provide additional

functionality and more detailed information on areas that are often important within the context of land-sea planning.

*Impervious Surface Analysis Tool:*

The Impervious Surface Analysis Tool (ISAT) is provided by NOAA CSC and is used to calculate the total impervious area and percent impervious area within specified polygons. Ultimately, the tool was designed to help managers determine the effect of impervious surfaces on the local water quality. Within the land-sea toolkit, the ISAT tool could help the planning team quickly quantify stormwater runoff impacts from scenarios with different levels of development.

*Habitat Priority Planner:*

Habitat Priority Planner (HPP) is also provided by NOAA. Within the land-sea toolkit, this tool provides a means of post-processing Vista results and analyzing habitat fragmentation effects on conservation elements. It may also provide functions for targeting element occurrences that require mitigation attention.

*Marxan/Marxan with Zones:*

Marxan is provided by the University of Queensland and is designed to assist with the generation of optimized conservation solutions. This tool interoperates with NatureServe Vista to produce optimized solutions to planning problems. Marxan uses the spatial distribution of conservation targets (i.e., Vista conservation elements), conservation goals, information on cost (defined a variety of ways), and other spatial configuration parameters to produce at least one site that will efficiently meet conservation element goals. The role of this tool in the toolkit would be to direct the use of "Site Explorer" in Vista for producing efficient mitigation scenarios that meet element goals and implementation mechanisms. This tool is also useful for identifying sites that are "irreplaceable" (i.e., required for meeting element conservation goals).

Marxan with Zones builds on the Marxan functionality and supports spatial planning with multiple zones, multiple costs, and multiple objectives. Using Marxan with Zones allows practitioners in natural resource management to identify configurations of sites that contribute to a range of management objectives. These sites can be clumped into zones to accommodate different types of activities. This makes Marxan with Zones a good tool for local and regional planning, where the objective is to achieve a balance across a range of competing uses (University of Queensland, 2008).

### *Offsite Mitigation Query Tool:*

This tool is a companion to NatureServe Vista and can assist users in resolving problem areas where the development activity (e.g., land use, infrastructure, etc.) must occur in a specific location and the impact on conservation elements cannot be mitigated onsite through avoidance or minimization. If this is the case, the Offsite Mitigation Query tool will assist users in: (1) quantifying the amount of impact that must be mitigated for each conservation element, (2) identifying sites within the region that can provide sufficient quantities of the elements, and (3) allowing users to rank sites based on other characteristics (e.g., cost, buffer and connectivity value for existing protected areas, biodiversity value, and ecological integrity). The role of this tool in the land-sea toolkit is to assist in creating an acceptable land use scenario through identification of offsite locations that must be land use compatible with conservation element goal achievement.

### **Developing and Assessing the Mitigation Scenario(s)**

At this point new shapefiles have been generated in Vista (and/or N-SPECT) that specify land use changes to specific sites. These new shapefiles will help mitigate the conflicts created in the *Future Trend Scenario*, and must be integrated back into CommunityViz to create the *Mitigation Scenario*. This is also the point when additional changes can be made in CommunityViz to address shortfalls in socio-economic goals. This new “hybrid” becomes the initial *Mitigation Scenario*. It is important to note, however, that the land use changes proposed in Vista and/or N-SPECT may not necessarily translate into meaningful land use changes in CommunityViz. For example, a specific natural resource management practice proposed in Vista may still equate to rural land use in CommunityViz. In this case the change will not likely have land use planning implications, but such changes still need to be incorporated into later scenario analyses in Vista and N-SPECT. This is important for assuring that conservation goals are achieved.

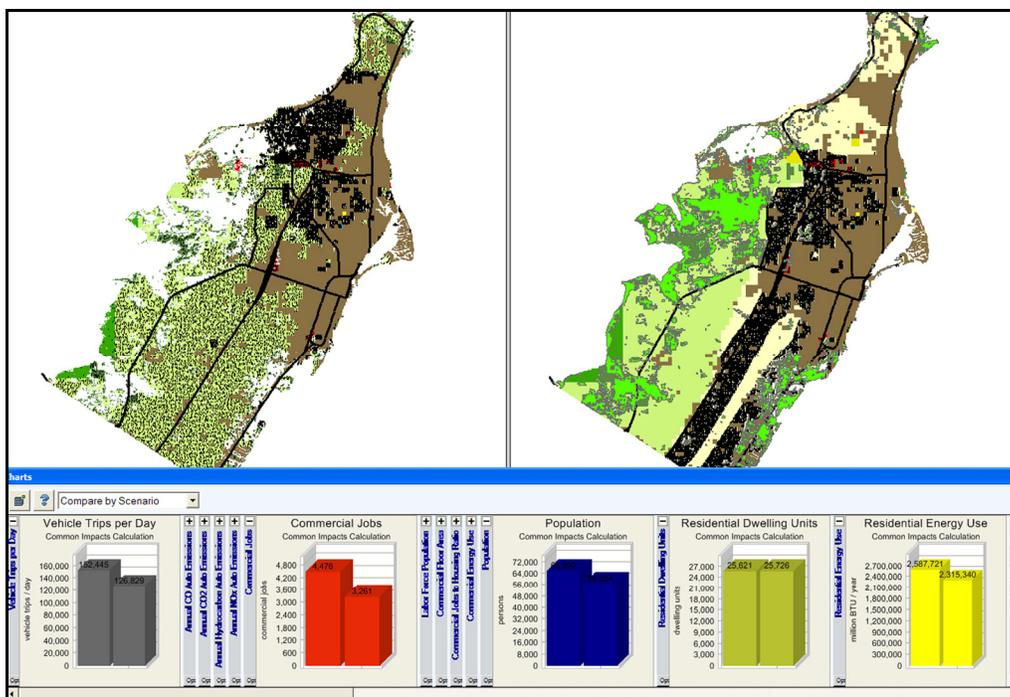
After the initial *Mitigation Scenario* is “assembled” in CommunityViz, it must be run through the remaining tools (i.e., analyzed in Vista, N-SPECT, and the marine water quality modeling tool). Then, the scenario can be evaluated for socio-economic, ecological, and water quality impacts and more mitigation scenarios can be created until a “proposed” scenario is reached. Use of the word “proposed” in this case means that the planning team has developed a scenario that meets their goals (or meets a feasible alternative) and it is ready to be “proposed” to decision-makers.

### **Assessing Mitigation Scenarios for Socio-economic Impacts**

Once a mitigation scenario has been defined, it is important that socio-economic goals (e.g., maintaining adequate housing, sufficient commercial development, efficiency of infrastructure, etc.) are assessed in CommunityViz (Figure 19). For

example, to achieve better water quality and or conservation goal achievement, development may have been replaced or moved using N-SPECT, Vista, or one of the other mitigation tools. These changes may cause conflicts in meeting socio-economic goals (e.g., insufficient housing to meet population projections or increased infrastructure costs) and should be considered before the “proposed scenario” is chosen.

**Figure 19. Assessing alternative scenarios in CommunityViz for changes to socio-economic indicators.**



### Assessing Mitigation Scenarios for Ecological and Water Quality Indicators

In addition to calculating socio-economic indicators, CommunityViz also provides a useful platform for summarizing water quality and conservation results and displaying these types of indicators and comparing scenarios (see Figure 17).

### Developing the Final Plan through Tool Iteration

Once the proposed mitigations/alternative scenarios have been “rolled-up” and assessed in CommunityViz, it is likely that some further refinements will be needed. Using the proposed changes and outputs from NatureServe Vista and N-SPECT, the user can propose a revised plan using CommunityViz. If proper attention is paid to outputs from the other tools (e.g., locations of conflict, areas of high priority for meeting conservation goals, areas with high runoff and pollution, etc.), the user should be able to develop a new plan that is very responsive to the conservation and water quality goals while still meeting socioeconomic goals. Of course, this new plan

will need to be assessed in the other tools and any additional conflicts must be mitigated. At this stage, users may realize that all conflicts cannot be mitigated by simply moving certain land uses (development or conservation) to other locations and that other mitigation approaches must be applied. These approaches include:

- Minimization of onsite impacts through development regulations.
- Offsite mitigation in areas where alternatives exist for meeting conservation goals.
- Modification of goals for any one or a combination of objectives (i.e., reduced development, reduced conservation, or reduced water quality targets) – this approach will require negotiation among stakeholders based on the limits identified through the toolkit analyses.

However, this goal-seeking iteration process is not the only possible decision-making structure. A project may take a broader view of scenarios and begin by studying two or three plausible variations of the *Future Trend Scenario*. For example, permutations of important, but uncertain or uncontrollable, variables (e.g., rate of population growth, development drivers, rate of global sea-level rise, etc.) can be used to understand the plausible limits of these variables. Then,, a process closer to the goal-seeking one can be used to arrive at a preferred direction.

## Utilizing the Toolkit for Adaptive Planning and Management

It is common in many areas for land use decisions (e.g., development permitting, resource management practice, etc.) to diverge over time from an original plan. Changes are often needed in the face of new information, opportunities, and crises/disasters. However, a planning team would be well-served to take an adaptive planning and management approach that uses tools, such as those described in this toolkit, to continually update their information and analyses relative to their goals.

Using this adaptive management approach with the land-sea toolkit will involve:

- Maintaining a *Current Condition Scenario* that reflects actual land use changes.
- Maintaining a *Future Trend Scenario* that represents the accepted plan
- Obtaining new updates for various components of the toolkit as they become available. Examples include: (1) new or improved distribution maps for land cover and conservation elements, (2) new conservation requirements for conservation elements based on new data or expert judgment, and (3) new N-SPECT parameters based on local calibration of models.
- Optionally, maintaining a *Future Trend Scenario* that inputs revisions to socio-economic, ecological, water quality and climatic trends that can reveal “down the road” conflicts between the accepted plan and longer-term trends.
- Identifying possible conflicts with goal achievement by evaluating scenarios periodically – this will trigger the need for new iterations of the toolkit to suggest mitigation opportunities before problems become acute.

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