Integrating Transportation Planning with Land Use and Conservation
Through Decision Support Tools

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NatureServe

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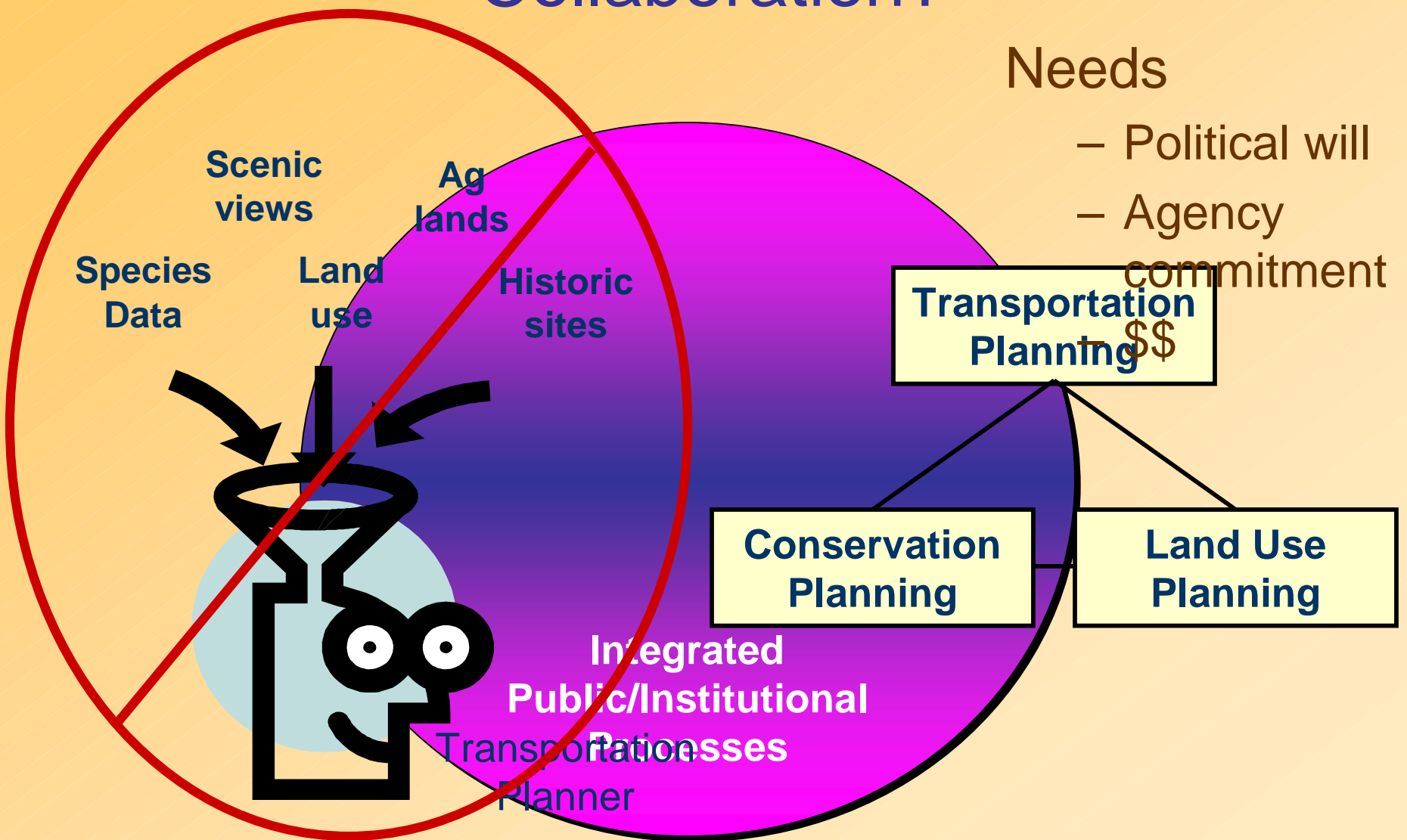A Network Connecting Science With Conservation

A conceptual framework to integrate conservation planning

- Conservation *is* a land use supporting public values like any other land use
- They key to rectifying conflicts among uses is to reveal where uses ***must*** occur and what is the ***envelope of options*** where they can occur
- Collaborative land use planning will allow testing of options that identify where the objectives of each use can be met without foreclosing the ability of any one to be met

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Envelope of options

Regional habitat connection

Forest of sufficient size for interior bird species

Regional hwy corridor

Infrastructure served

Economic devpmt area

Prime ag soils

Rare plant population
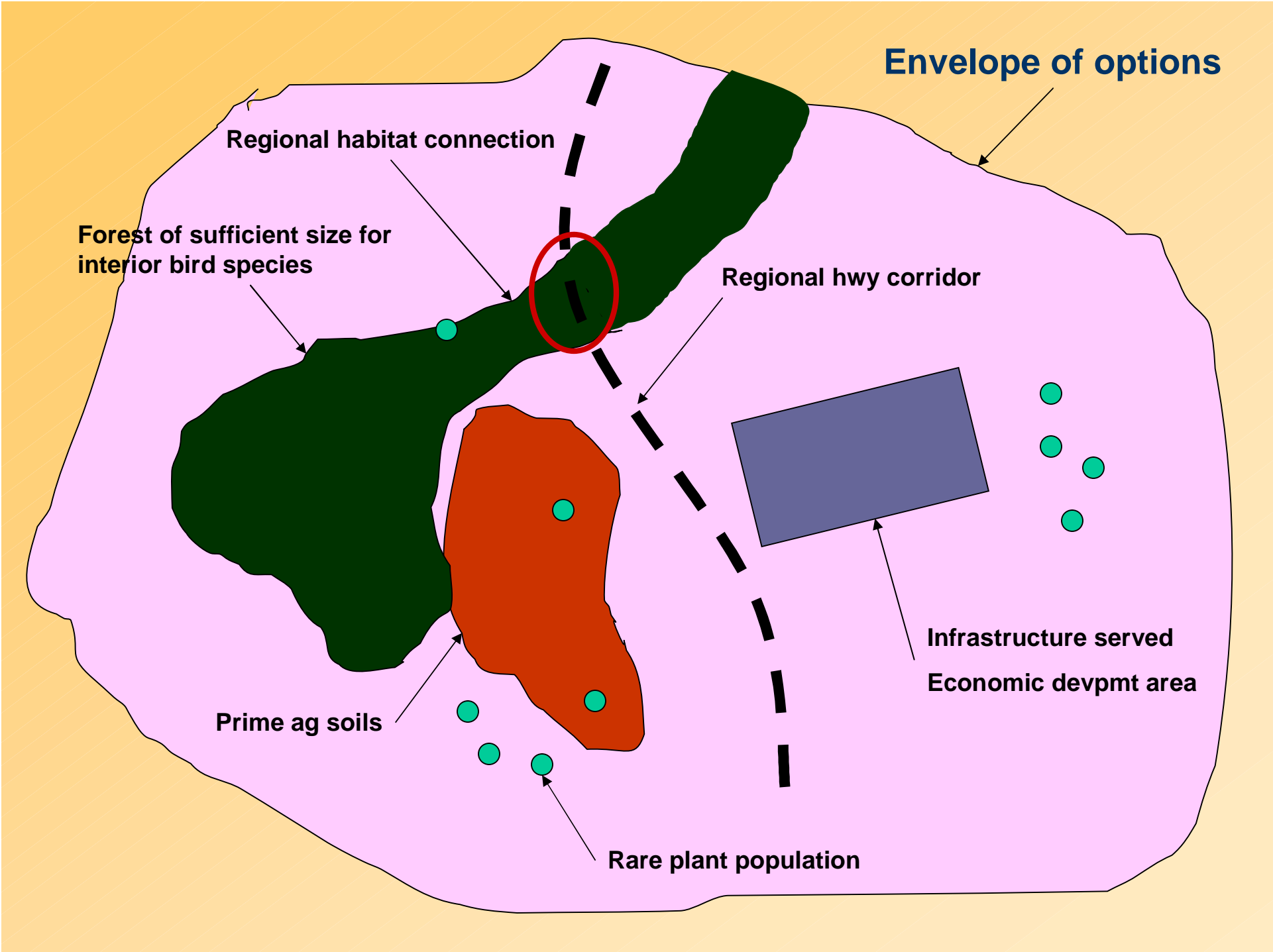
Planning Phase: The Funnel vs Collaboration?

Needs
- Political will
- Agency commitment
- $$

Scenic views

Ag lands

Species Data

Land use

Historic sites

Transportation Planner

Integrated Public/Institutional Processes

Transportation Planning

Conservation Planning

Land Use Planning

Project Phase: Integration via Decision Support

Land use DSS

Conservation DSS

Project Planner
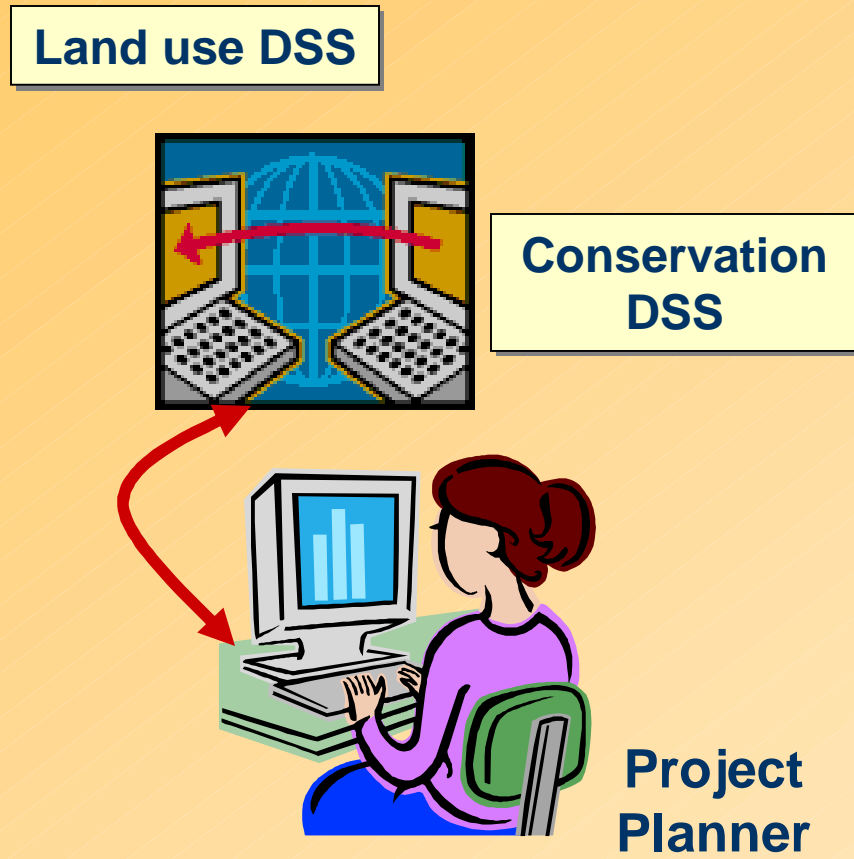
Efficient integration of results of sector planning, data, expert knowledge

Minimum necessary and targeted expert engagement

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What is a Decision Support System?

- Helps you do specific activities vs general tools

- Guides you through a process

- Incorporates expert knowledge/models AND user values

- Provides automation and documentation of the process

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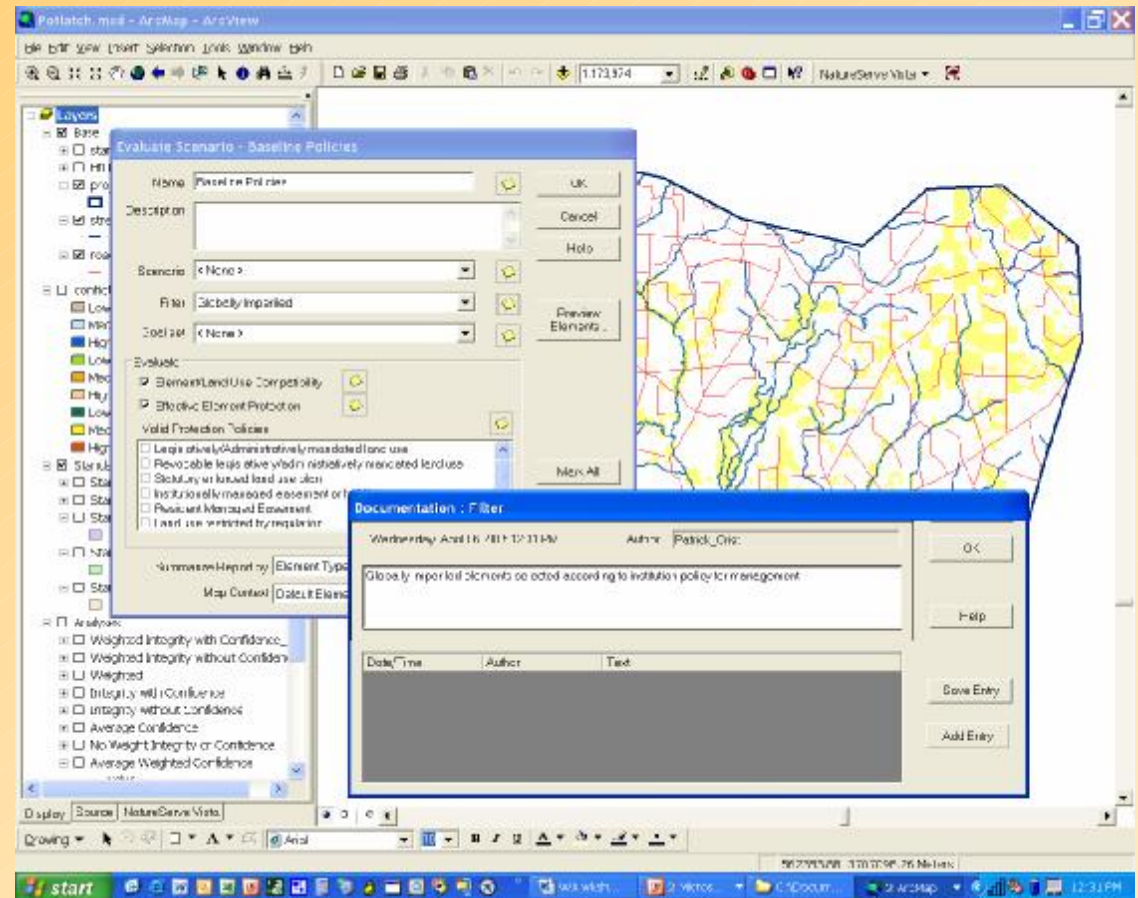
Issues from a Tools Perspective

- Tools are developed for particular sectors and their processes, data, assumptions

- Spatial place-based tools have data commonalities that may support process integration

- Using a collection of tools and processes may grease the skids for human collaboration across sectors by revealing connections and lowering the bar for mutual understanding
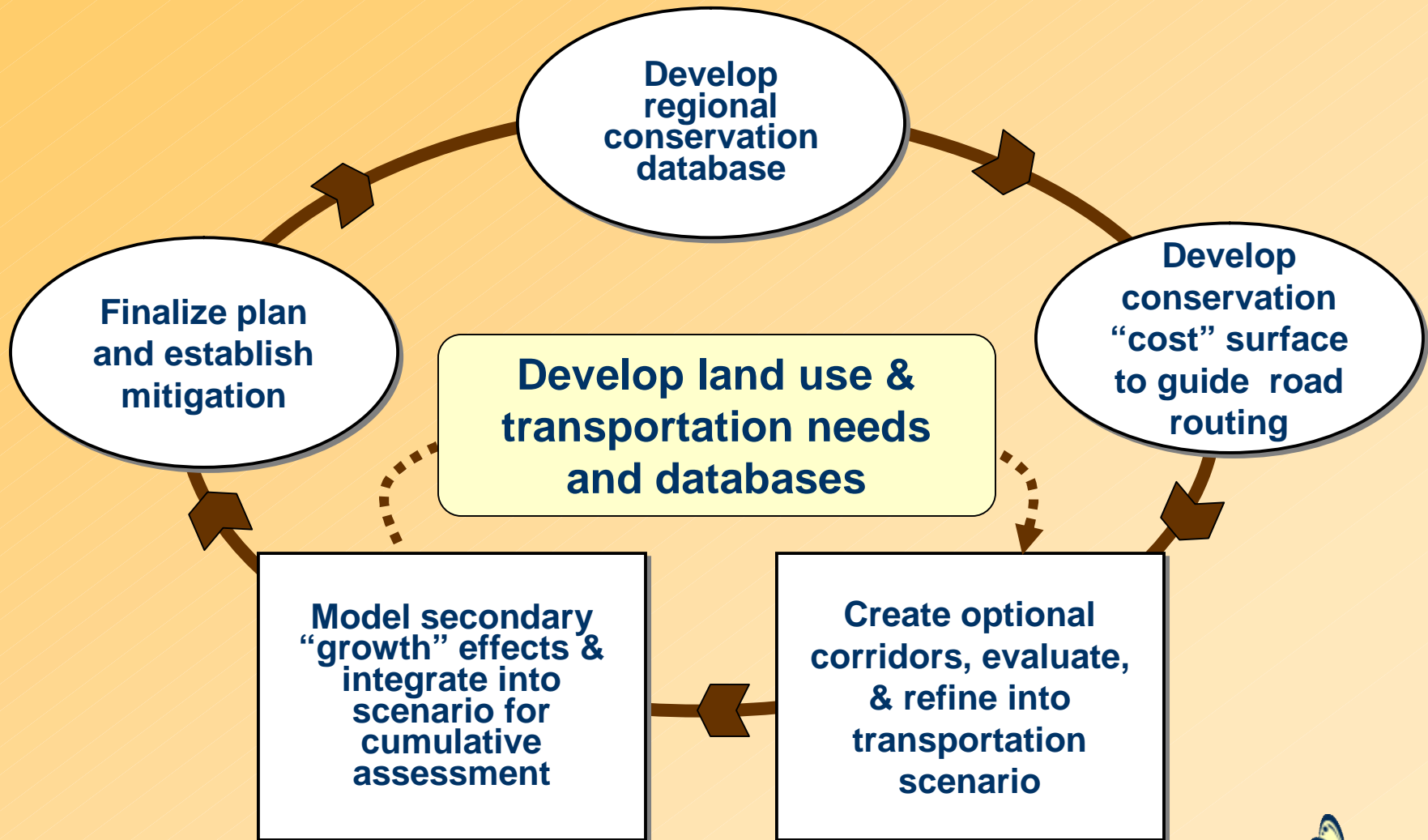
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Some Uses of DSS for Integration Conservation & Transportation

- Guiding least-conflict routing of transportation (macro scale at planning phase, site scale at project phase)
- Rapid evaluation of multiple route options
- Integrating multiple objectives (e.g., transportation, development, conservation) for long-term plans or short-term projects
  - Predicting and evaluating long-term cumulative effects
  - Revealing areas needed (irreplaceable) for any particular objectives
  - Revealing options for achieving objectives to mitigate conflicts

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Example Process of Cumulative Regional Assessment & Planning

Develop regional conservation database

Develop conservation "cost" surface to guide road routing

Finalize plan and establish mitigation

Develop land use & transportation needs and databases

Model secondary "growth" effects & integrate into scenario for cumulative assessment

Create optional corridors, evaluate, & refine into transportation scenario

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About the Tools

- Quantm: transportation route optimization tool applied through a service contract
- CommunityViz: land use planning framework tool applied as desktop software
- NatureServe Vista: conservation framework tool applied as desktop software

None of these tools are required to do this analysis or any can be used in any combination with other tools. NatureServe Vista has no formal relationship or linkage to any of these tools.

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What is Quantm?

- Worlds first advanced planning system for corridor and route optimization developed over 15 years by Australian Government and Quantm.

- Addresses complex route planning issues, investigating millions of alignment options.

- A tool that empowers Planning Engineers with the ability to consider "all reasonable alternatives", upfront and equally.

- Quantm provides training, support and system access – the system is applied by the agency or appointed consultant

Facilitating integration of *all* planning aspects in a single analysis
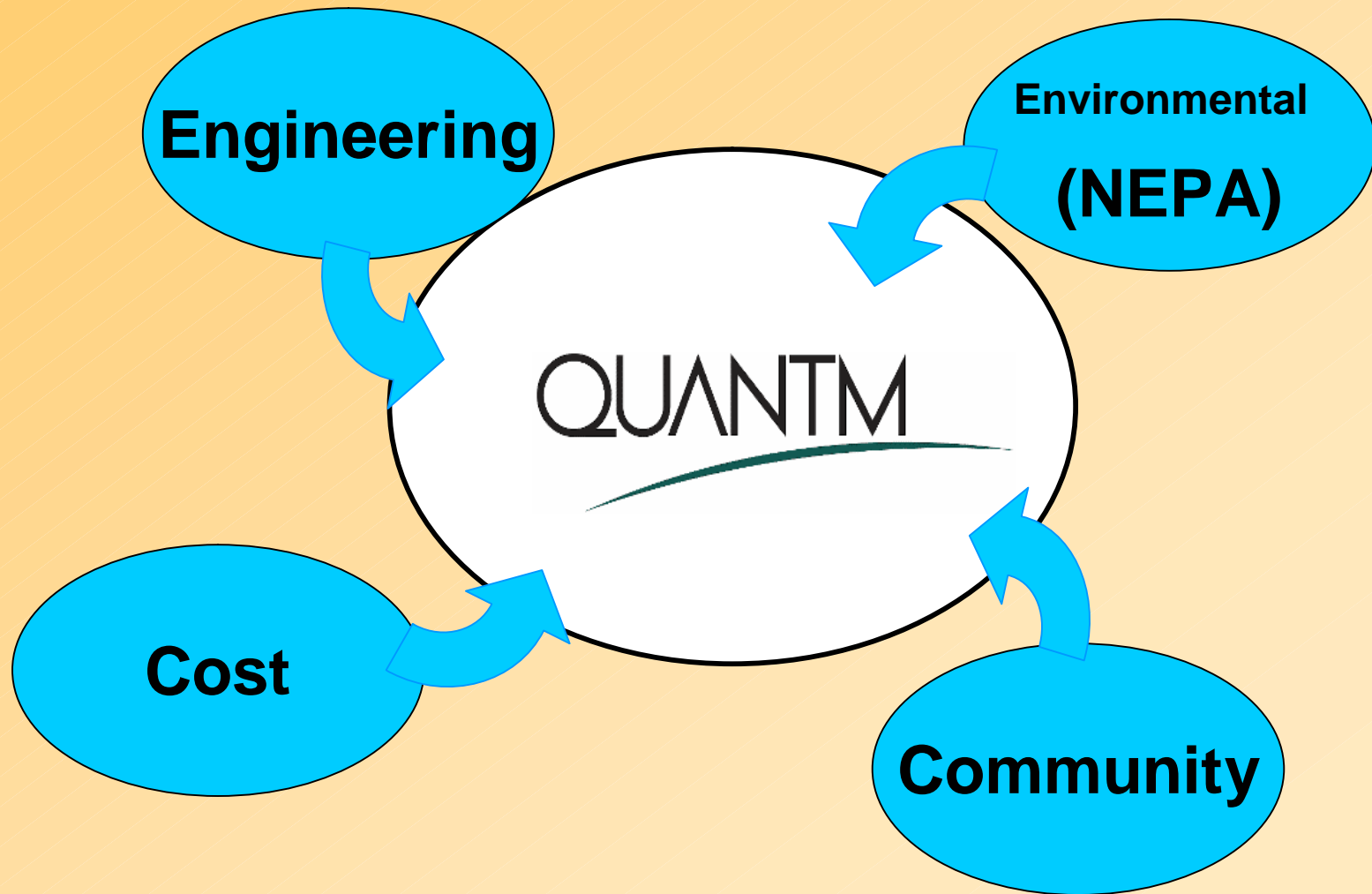
Inputs to QUANTM

Ø **Terrain model** (DEM and/or DTM)

Ø **Geology and Earthworks costs**

Ø **Geometry**

Ø **Structure Costs**

Ø **Constraints**

- Linear – engineering criteria
- Zone – **environmental, biological, cultural, resource, mitigation,** ROW, etc.

QUANTM

3-Dimensional analysis throughout
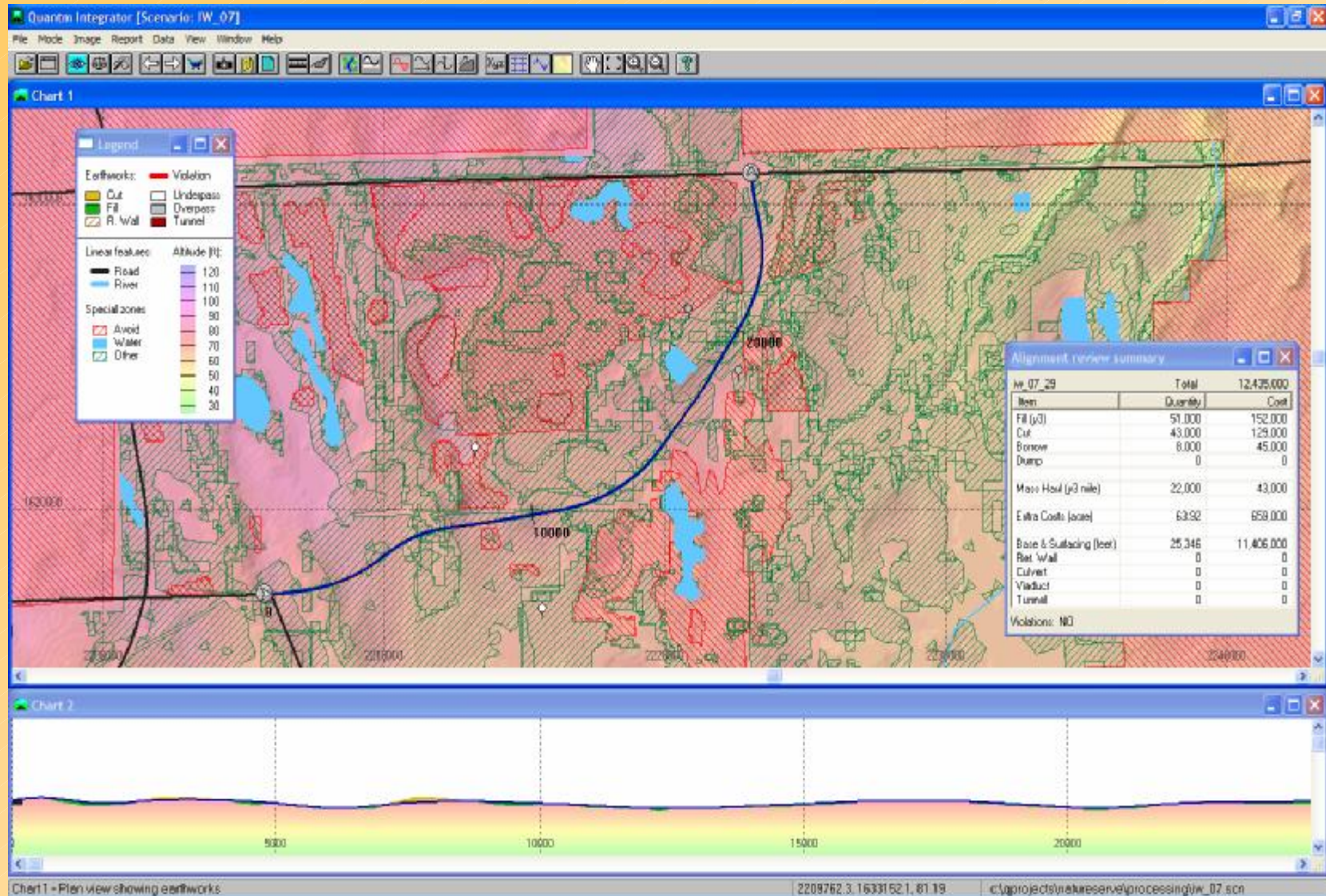
Alternative showing earthworks and constraints

About CommunityViz®

- GIS-based tool for geographic decisions

- Real-world 3D models

- Interactive scenario analysis

- Intuitive, powerful, and flexible

- Made available to the public at very low cost by the Orton Family Foundation

Uses ArcGIS technology

Formula-driven indicator charts update dynamically

Ready-made or custom analyses
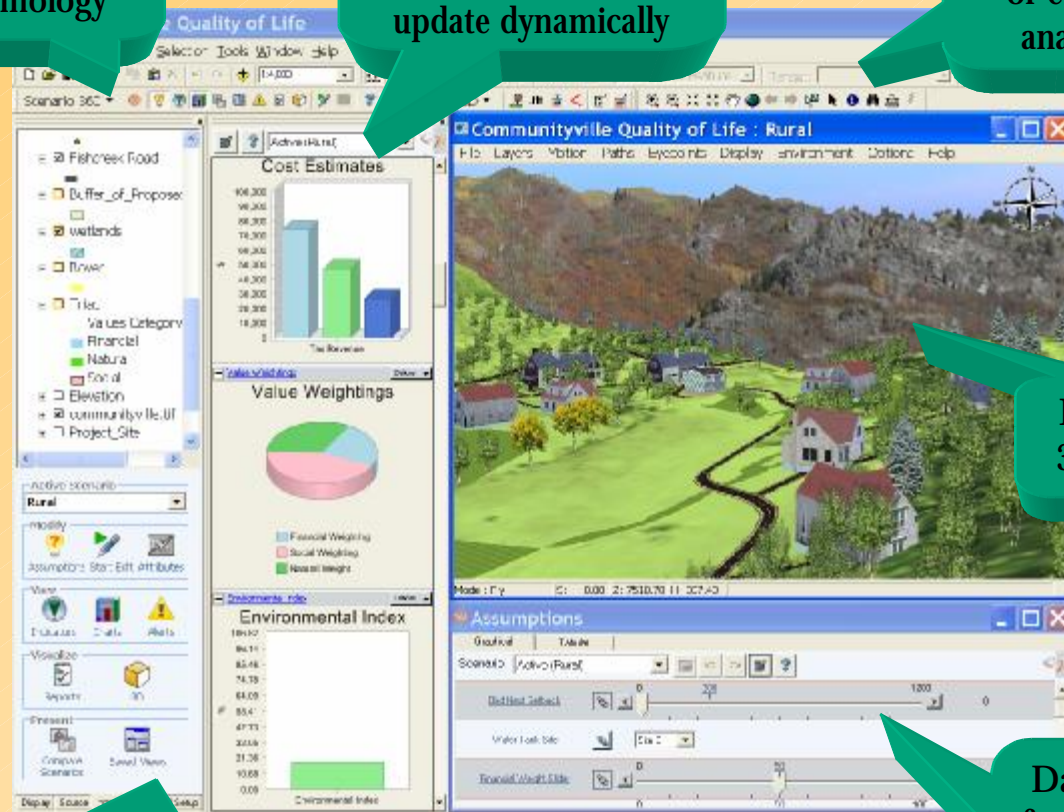
Interactive 3D models

Multiple scenarios can be studied side by side

Dashboard for changing assumptions and settings

CommunityViz Growth Modeling
Hypothetical "build-out" capacity for each scenario:
Road Proposal 11 shown here. Note that "Avoidance" areas are constrained from building.

Scenario A:
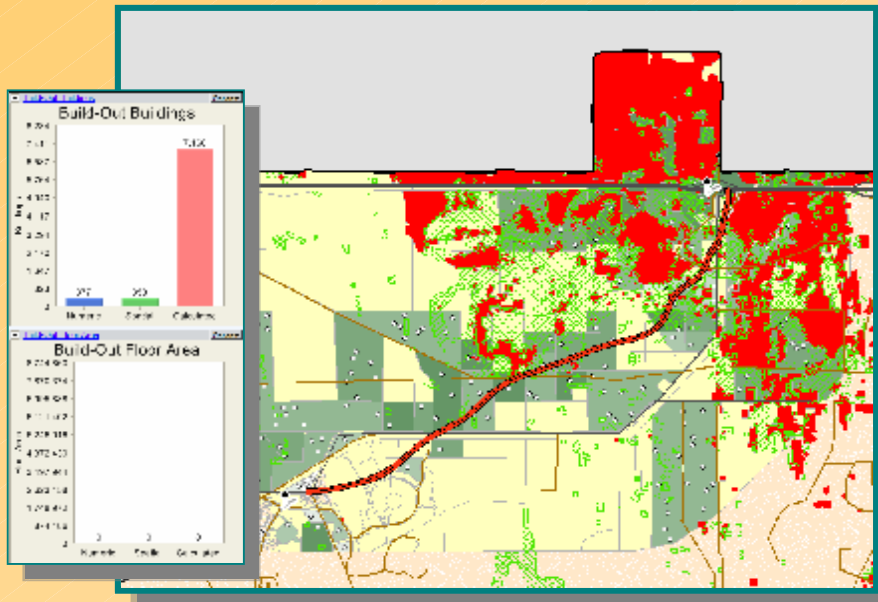Large-lot residential development

Scenario B:
Commercial and mixed-use zones
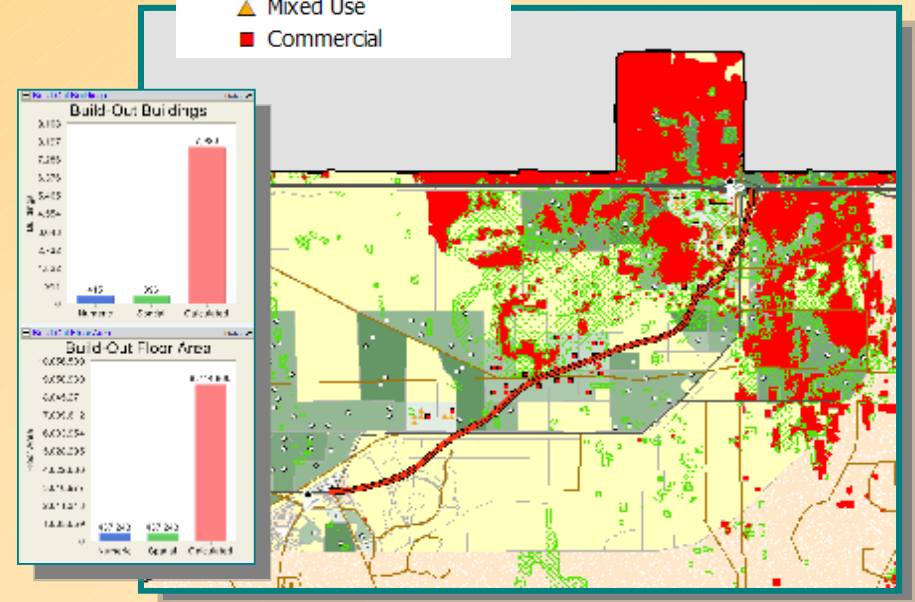
Land Use
Scenario A

Land Use
Scenario B

CommunityViz Growth Modeling

Results are available for all 4 scenarios.

Potential changes to policies and assumptions can still be tested and explored.
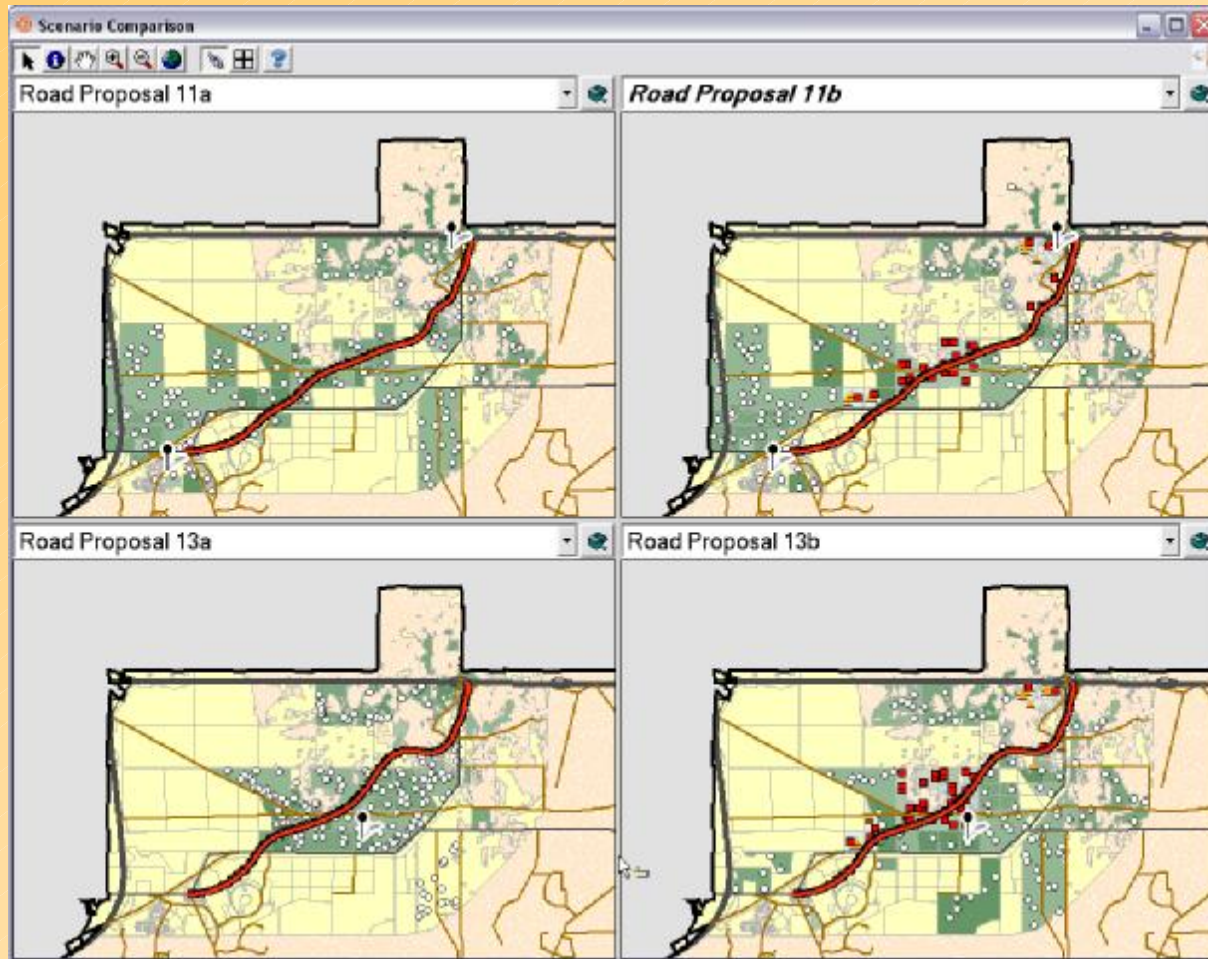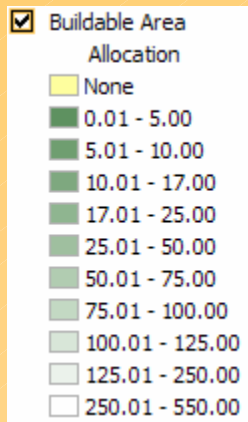
CommunityViz Growth Modeling

CommunityViz also estimates a wide variety of economic, environmental, and social impacts for each of the 4 scenarios:

Just a sample of the many impacts available, all variable by year and other assumptions, are shown here.

NatureServe VISTA
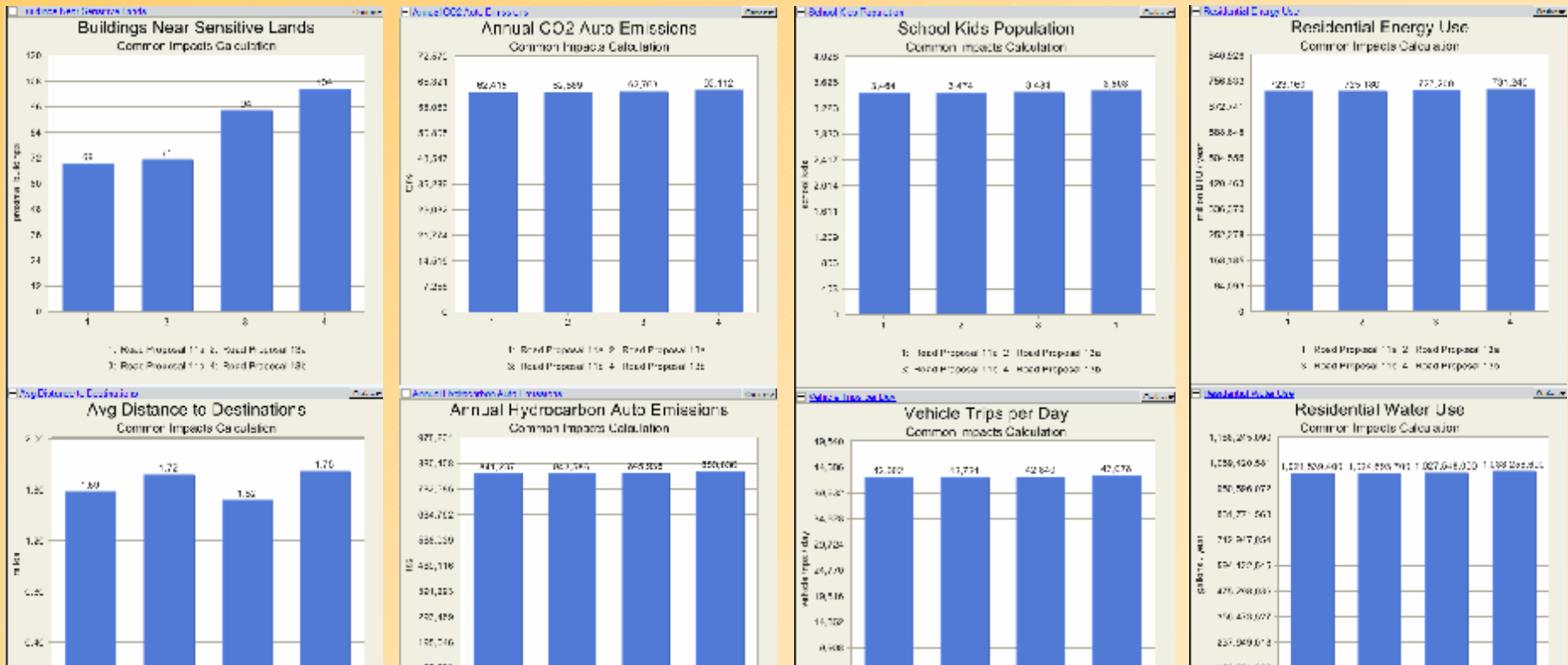
A framework tool for cumulative assessment and conservation planning

About Vista

- Custom GIS application based as an extension of ESRI's ArcMap 9 with spatial analyst

- Licensed software with full integrated help manual, live technical support, available training

- Supports both conservation experts & planners/managers

- Incorporates expert knowledge/models AND user values

- Commercial grade design and engineering

- Provides automation, documentation, & repeatability of the process

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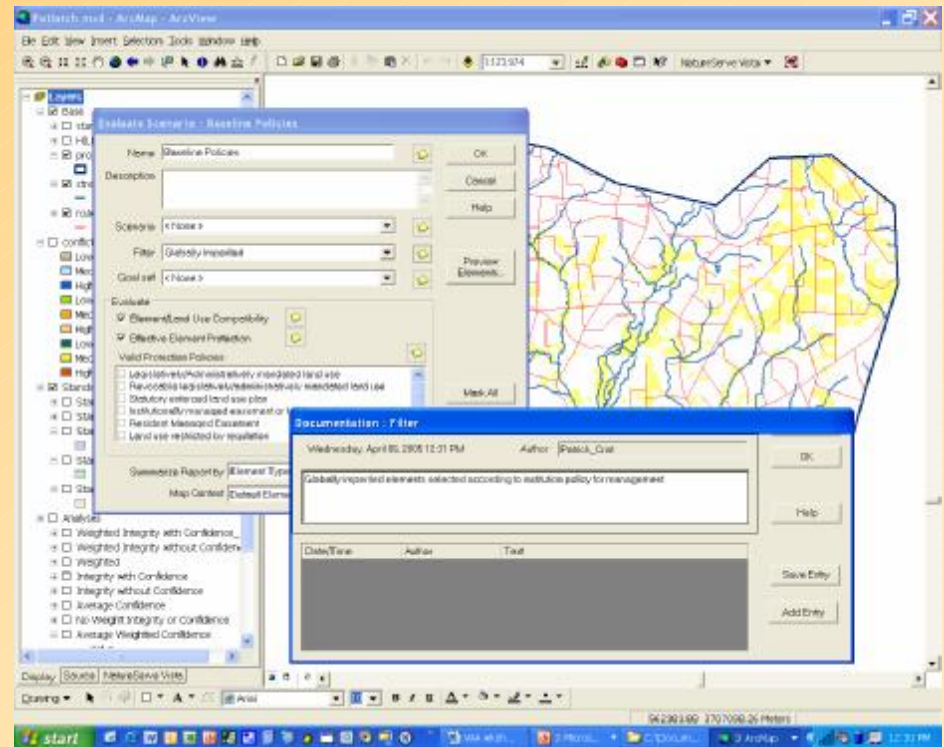
Basic Vista Extension Components

Input to User Decision Process

Custom Interface

Desktop and web

Analytical models

Output

Visualization and Reporting

User

Planners
Managers
GIS analysts
Ecologists
NGOs

Framework

Data handling, metadata, project tracking, etc.

Data

Spatial Extent
Spatial Attributes
Non-spatial data
Expert Knowledge
Social Values

Technology Platform

ESRI ArcMap 9.0, MS Access, Windows .NET

DSS Components

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Vista Status & Support

Software Versions

- Released Version 1.0 on March 1, 2005
- Version 1.3 released Mar 1 2006, 2.0 under development with possible release Mar 1 2007

Development Sponsors: ~$3.4M versions 1-2.0
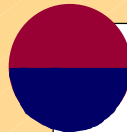
Development Partners

- Environmental Systems Research Institute (ESRI)
- University of California –Santa Barbara
- US Geological Survey
  Florida and Wyoming Heritage Programs

Endowment ~$1.6M permanent maintenance and support

- Doris Duke Charitable Foundation
- The Nature Conservancy
- Centex

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Applications So Far

- 20+ permanent licenses
- 100+ trial downloads
- 10+ direct NatureServe projects spanning:
  - Industry, government, NGOs
  - 30 k acres—12M acres
  - Forestry, Conservation, Land Use Planning, Public Land Management
- Pikes Peak COG has adopted Vista

Heritage Programs 4%
Industry 4%
University 25%
County Government 4%
Other 7%
Environmental NGO 7%
Federal Agency 8%
Environmental Consultant 10%
Land Trust 13%
Unknown 18%
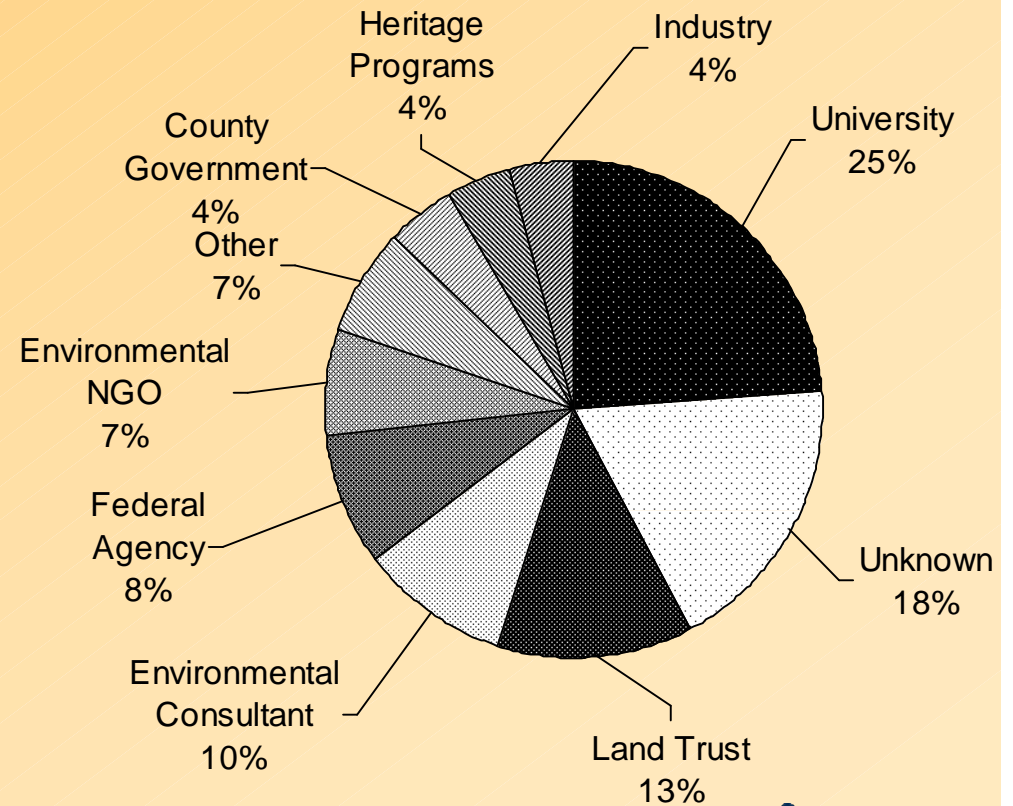
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Some Jargon

- **Conservation Elements:** the features you wish to conserve representing biodiversity & other conservation values

- **Element viability/integrity requirements:** representing the site or population needs for proper condition and minimum size

- **Element conservation goals:** representing the requirements for metapopulation persistence or ecosystem functioning in the planning region

- **Compatibility:** representing analysis of current or alternative futures to meet element requirements while maximizing options to meet other land use objectives

- **Scenario:** any mapped features representing land use or management practices, infrastructure, natural or human-caused disturbance, invasive species, pests, disease, etc.

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Core Conservation Concepts

Conservation planning and implementation need to happen at **multiple scales** to account for such things as

- wide ranging species

- natural disturbance regimes

- patchily distributed species, and

- ecosystem processes and succession.

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But Scales Must Be Linked!

How to get from here…   to here
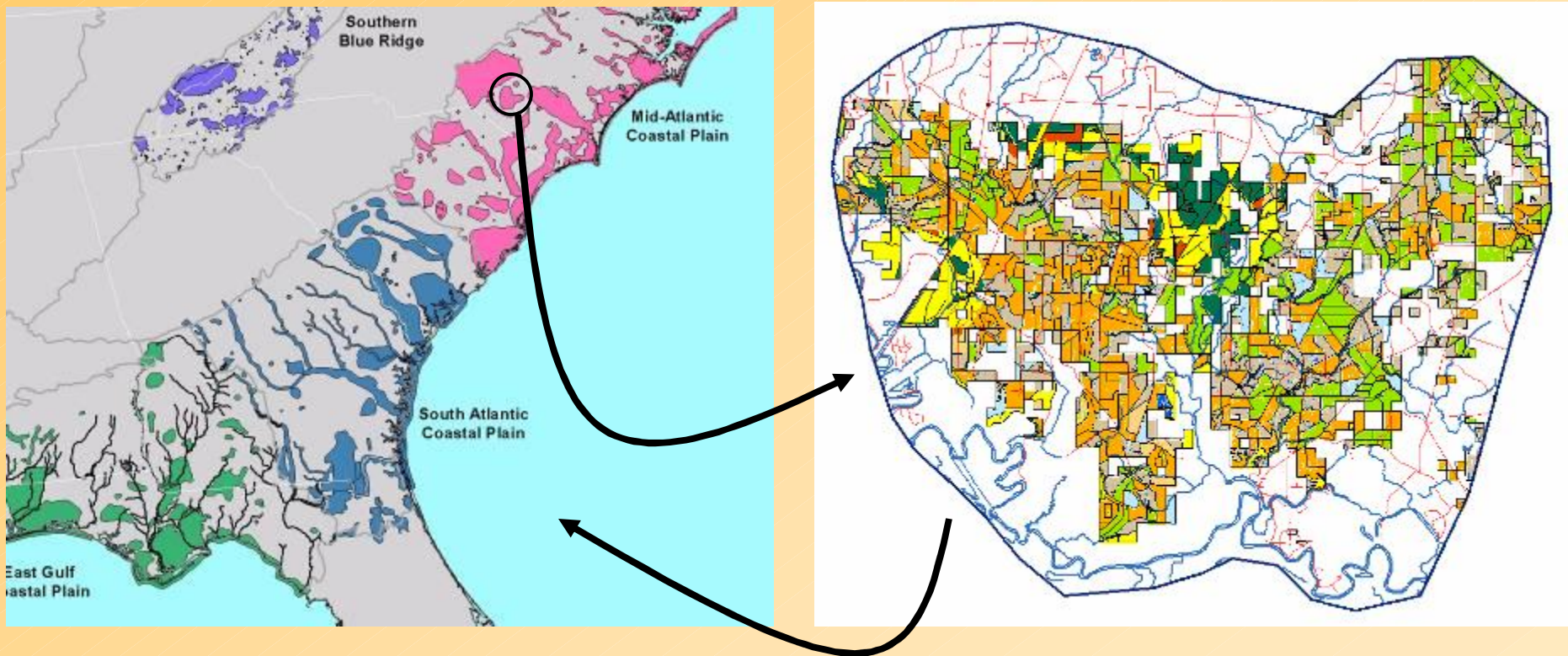
And from site decisions to roll-up of progress toward regional goals

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Core Conservation Concepts

Conservation planning must be dynamic to account for:

- Changing threats and opportunities
- Improved knowledge about biodiversity and response to threats
- Changing policies and economics
- New discoveries, surveys, mapping, etc

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Dynamic Ranking of
Conservation Value

Conservation Planning

Vision vs Process?

Courtesy UCSB
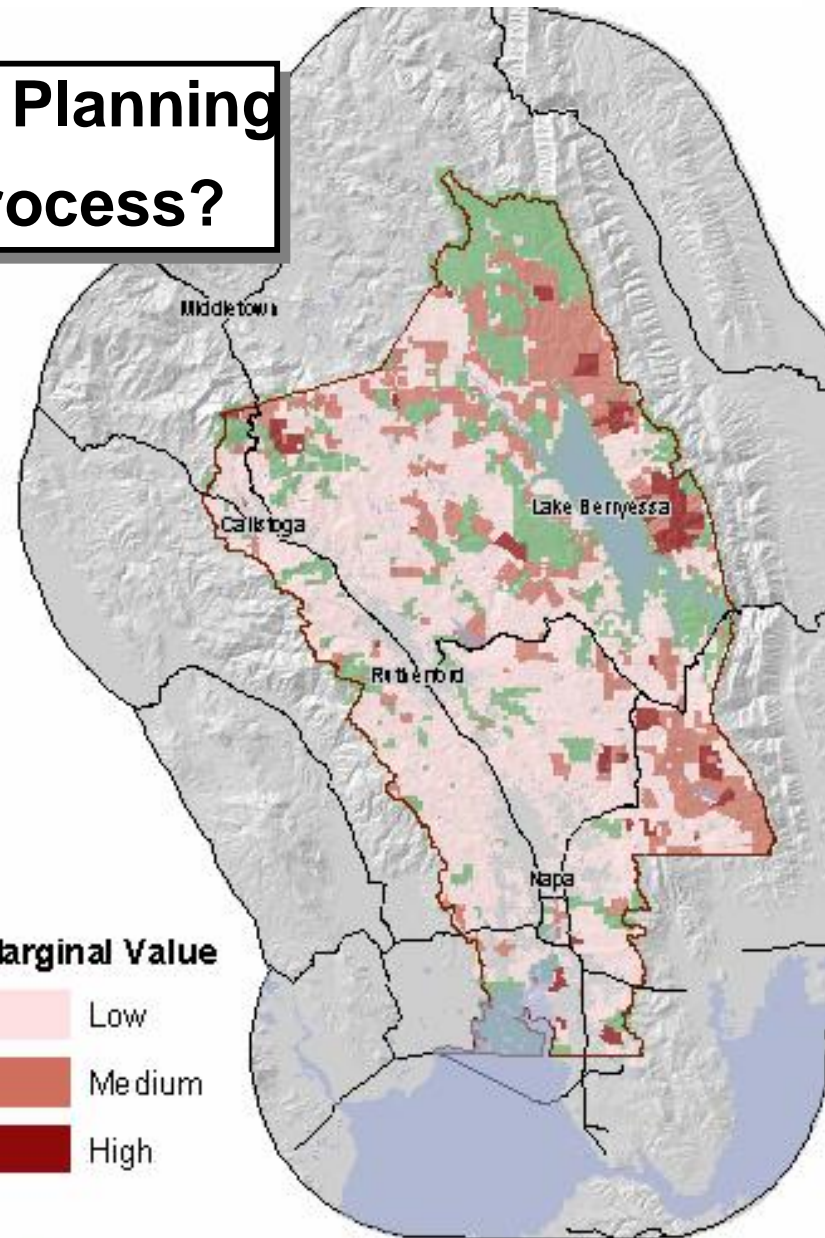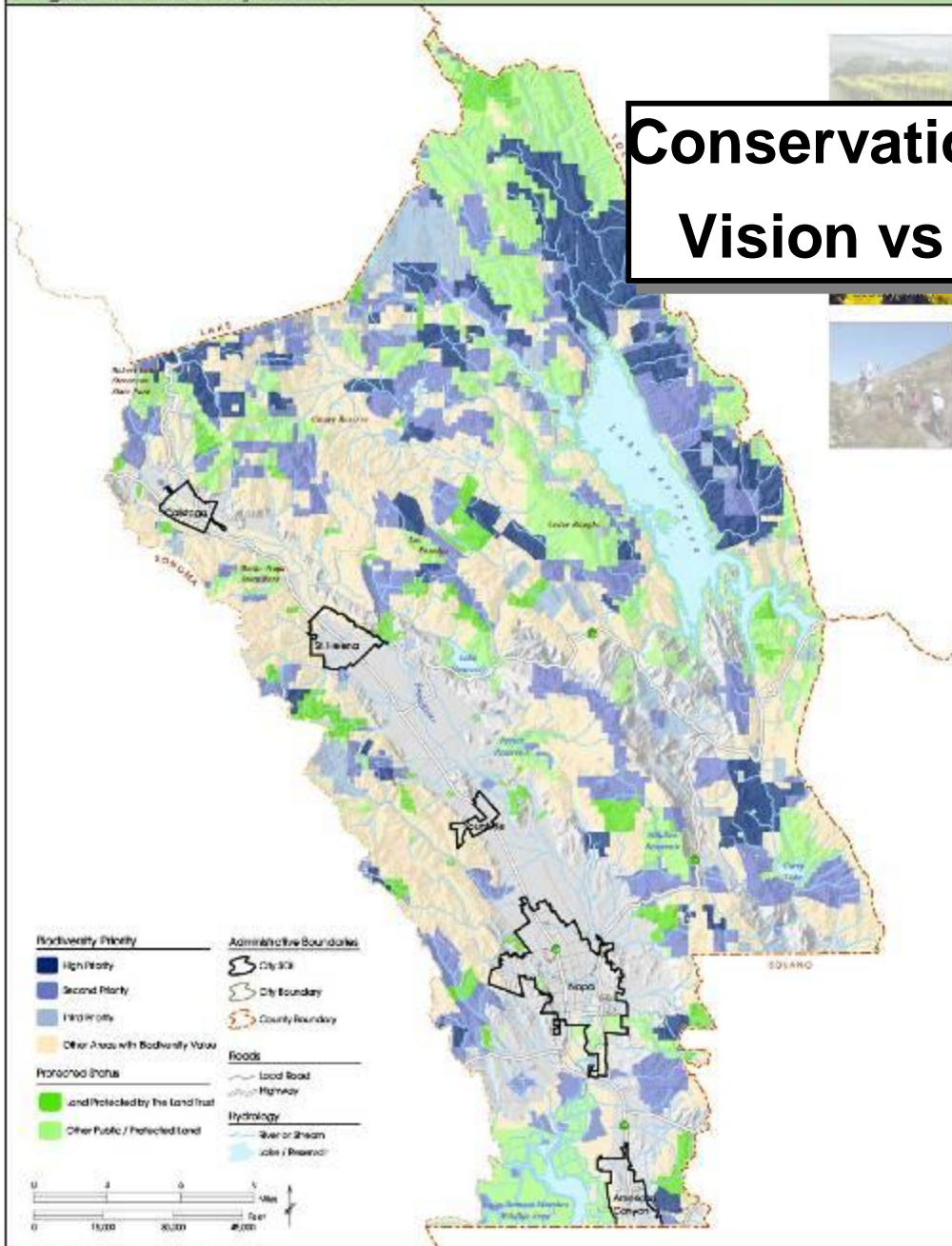
Vista Supported Process

Institutional Process

Identify values to be conserved

Expert Knowledge

ID/develop data
Incorporate knowledge

Monitor Goals

Reprioritize according to goal achievement

Implementation

Develop compatible land use scenario

Database Construction

GIS, Data Entry, Documentation

Analyses

ID Gaps
ID conflicts & priority areas

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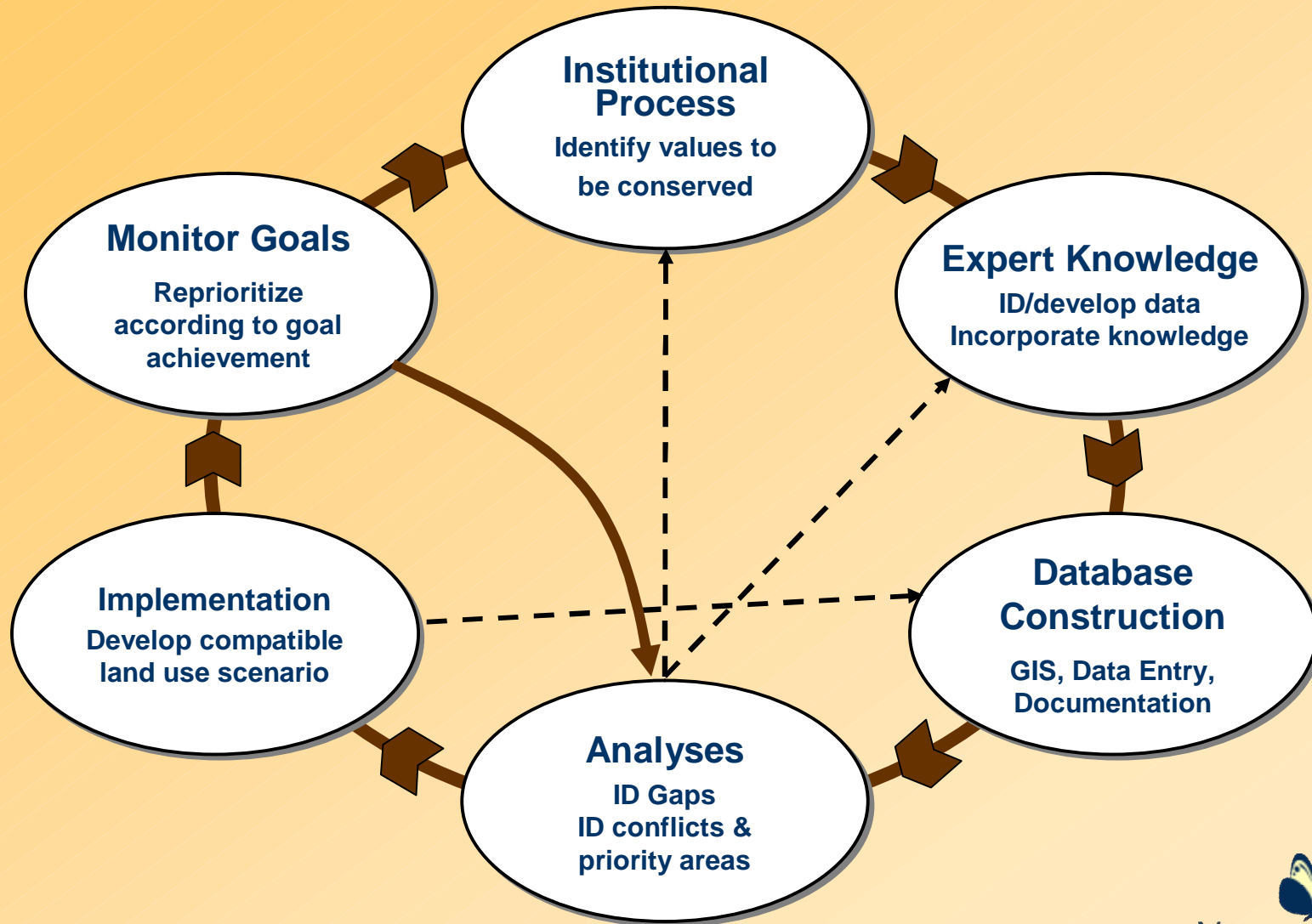
Three Analytical Approaches

Increasing data requirements, complexity, integration

Define High Value Areas

- Select important values (elements & characteristics)
- Overlay maps of elements
- Identify general places to conserve or avoid development

Reduce Conflict

- Import baseline and evaluate scenarios
- Identify conflicts and opportunities
- Reduce conflict/generate mitigation plans

Create Solutions

- Select elements, set conservation goals and design rules
- Integrate data on threats and cost
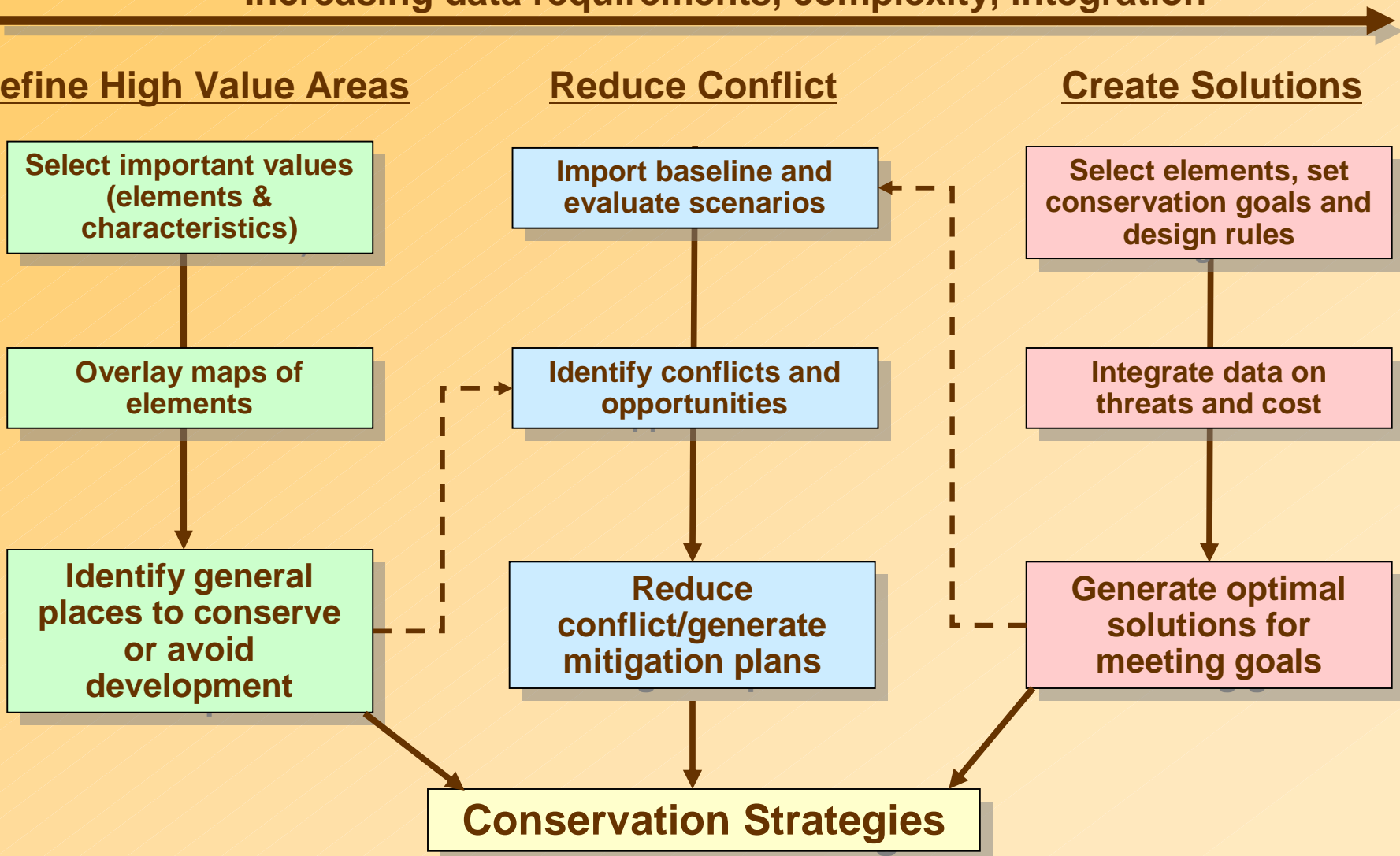- Generate optimal solutions for meeting goals

Conservation Strategies

How Vista Works

Data & Expert Knowledge Inputs
- Element Distribution & Confidence Data
- Current Land use, infrastructure, pollution, etc
- Alternative Land Use/ Activity Scenario
- Element Conservation Goals
- Element Response To Land Use/Activity

Intermediate Processes & Products
- Join and rasterize
- Element Conservation Layer
- Landscape Integrity Index
- Aggregation and Weighting
- Scenario Evaluation
- Scenario Optimization
- Scenario Modification

Outputs
- Aggregated Conservation Value
- Conflict Intensity Indices
- Evaluation Report
- Site Land Use/Mgmt Specification
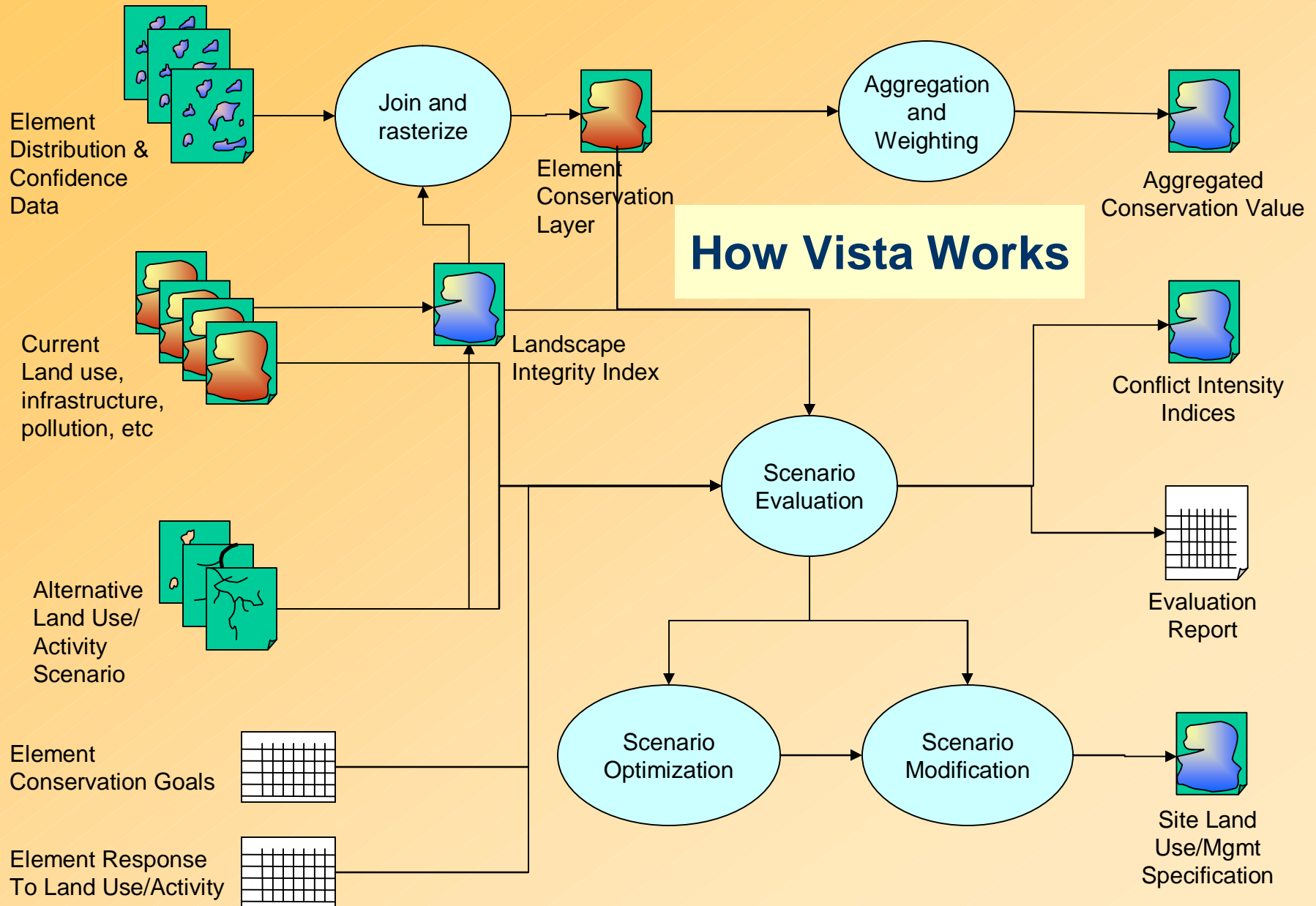
Core Conservation Concepts

Selecting the elements for conservation attention should reflect:

- Laws: what must be protected
- Values: what does the community, stakeholders, decision makers want to protect
- Scientific concepts such as coarse and fine filter assessment, ecosystem function, etc.

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Conservation Elements

Representing Composition, Structure, and Function of Regional Landscapes


- Species
  - Imperiled, Declining, Vulnerable, Endemic
  - Management Indicator Species
- Ecological Communities
  - Rare plant communities
  - Rare aquatic communities
  - Unique environments

Fine Filter Elements
Focus of land trust acquisition and easements

- Ecosystems
  - Groups of communities interconnected on land and waterscapes;
  - Natural pattern and process at local scales useful for management and monitoring

Coarse Filter Elements
Focus of land trust collaboration w/government & industry

- **Already identified priority areas**
- Non-Biological Elements
  - Scenic views
  - Archaeological & cultural sites
  - Valuable agriculture soils
  - Natural hazard zones
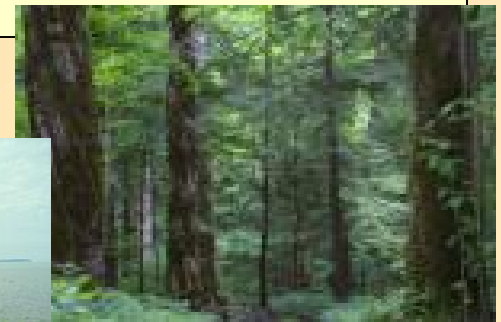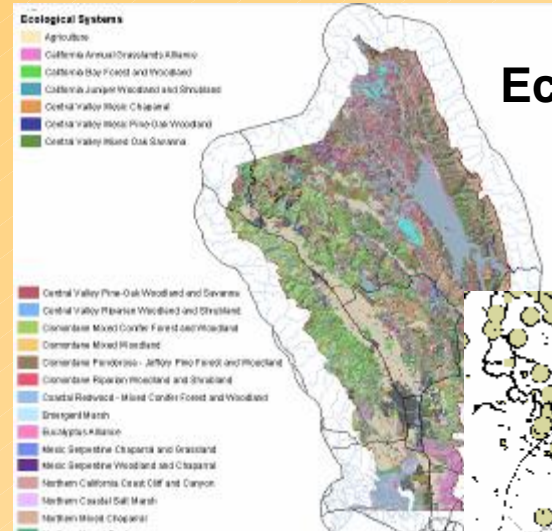
Where Does the Data Come From?

Spatial distribution maps of each element come from:

- Heritage data
- land cover maps
- modeled distributions
- museum collections
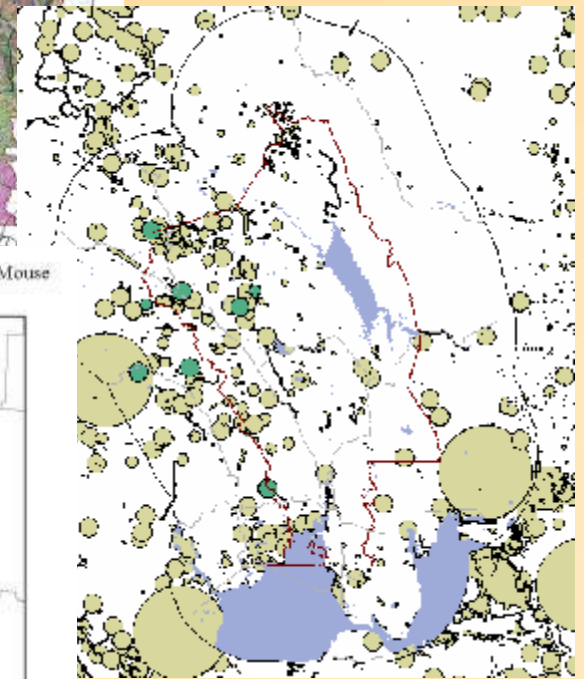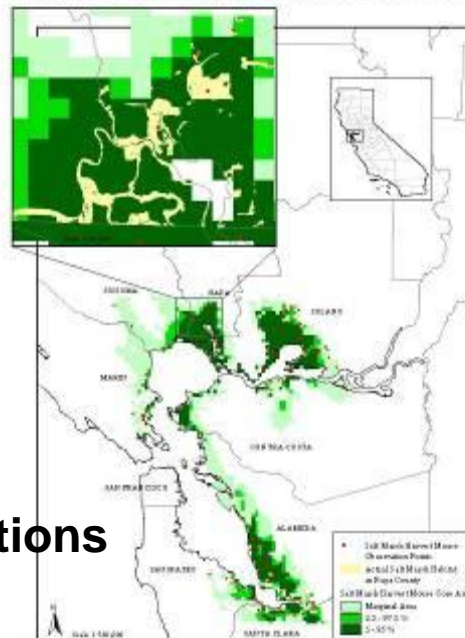- local information sources

Each element occurrence has:

- A viability/integrity score
- A confidence score

Ecological systems

Species and community occurrences

Modeled distributions
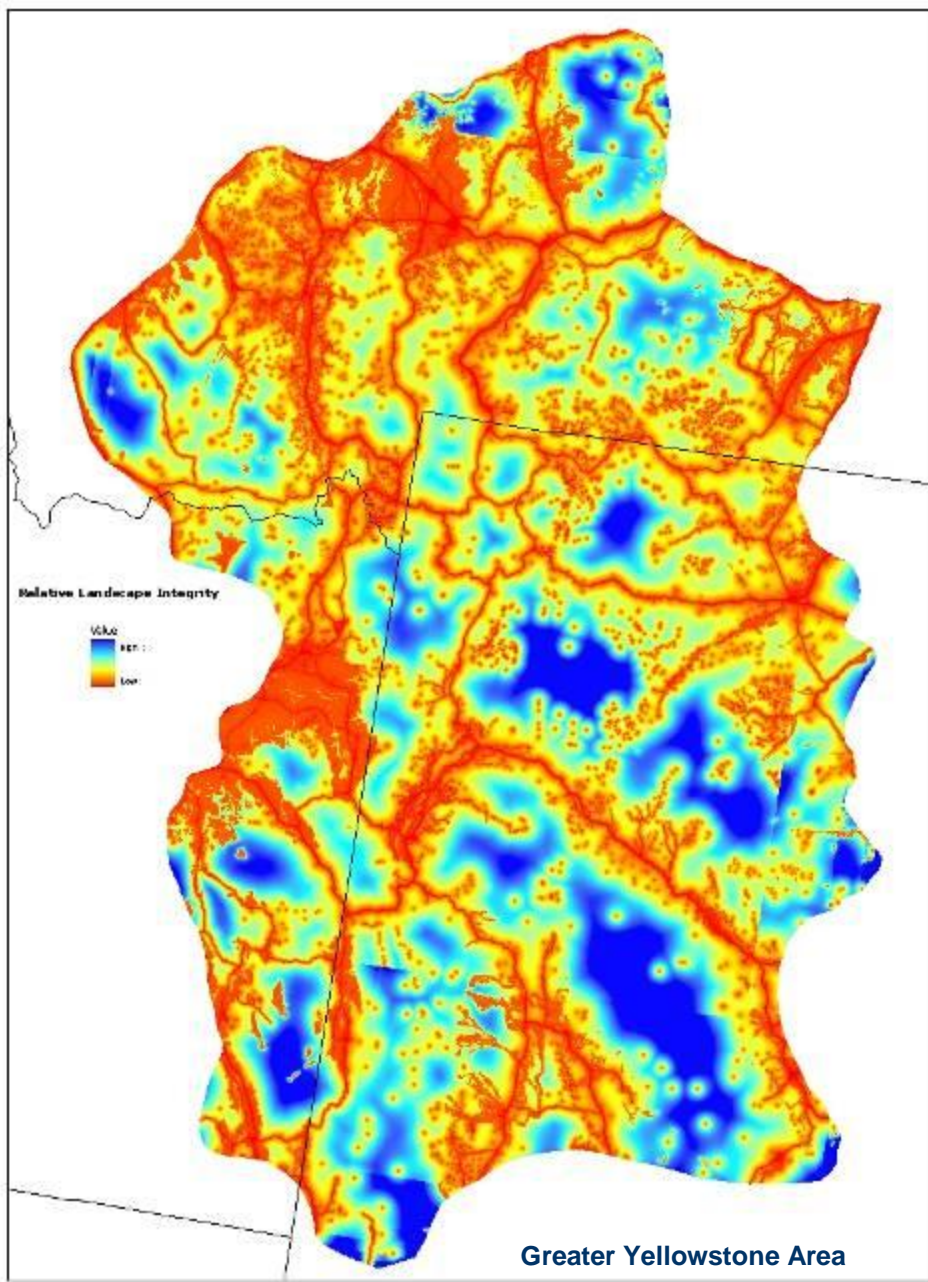
Relative Landscape Integrity

Value
High
Low

Greater Yellowstone Area

Modeling Condition

Landscape Integrity Indices

– Combines land use, roads, infrastructure, pollution, etc.

– Model weights effects, adds distance effect

– Can be element-specific

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Defining Goal Achievement

Version 1:

- Adequate number of element occurrences or area in project region (metapopulation viability, ecosystem processes)
- Adequate size of occurrences (population potential, ecological functioning)
- Occurring in areas of compatible land use supported by reliable policies

Version 2:

- Same as version 1 plus:
- Adequate "condition" of occurrences (habitat quality)

Can set minimum and preferred goals to express levels of risk of loss

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Core Conservation Concepts

Elements have individual conservation requirements and responses to development, management, disturbance, disease, etc. The process of evaluating current condition, threats from anticipated future uses and disturbances, and options for achieving conservation should be sensitive to these **individual element needs and sensitivities**.
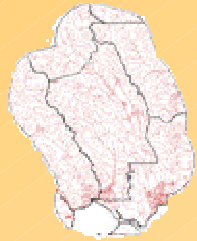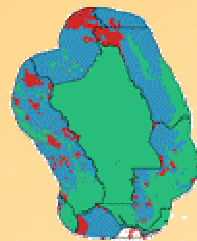
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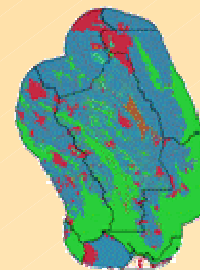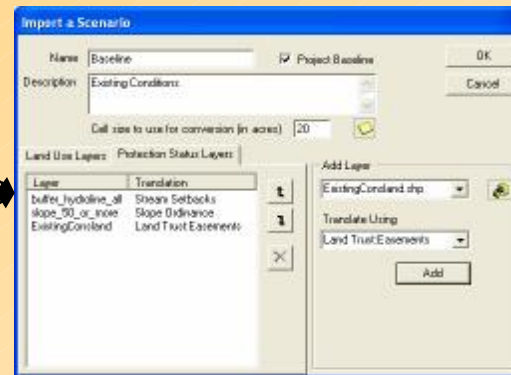# Scenario Integration
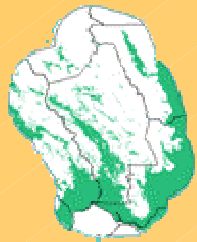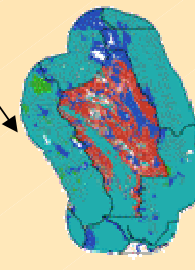

1) Conservation lands
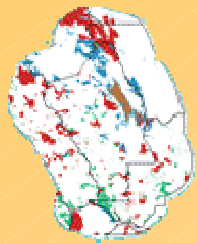
2) SWAP/CWCS

3) Infrastructure

4) Land use and management policies

- **Scenarios describe land-use policy of the planning area.**
- **Vista automates input from raw data sources**
- **Facilitates maintaining current baseline map and experimentation with alternatives**

Land-use Type

Policy Type

Scenario Evaluation

What components can be in a scenario?

- Current, proposed, predicted land use
- Current and planning land management
- Current and predicted spread of invasive species, disease, pests
- Predicted disturbance (wildfire, windthrow)
- Mitigation/restoration practices
- Policies, regulations, and funding mechanisms
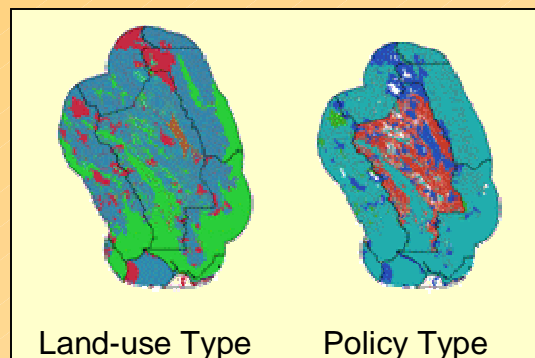
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Scenario Evaluation

Elements

Scenario Ouputs

Land-use Type   Policy Type

**Element
Conservation Goals**

**Evaluation
Report**

GIS
Intersect &
Table
Lookup

**Element Response
To Land Use/Activity**

Creating Solutions

- Mitigate conflicts using Site Explorer until all goals are achieved using information about element distribution and compatibilities

- Generate an optimal solution with MARXAN then bring back in to Vista for more precise evaluation and assignment of land use and implementation mechanism

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Greater Yellowstone Area

Modeling Condition

Landscape Integrity Indices

- Combines land use, roads, infrastructure, pollution, etc.
- Model weights effects, adds distance effect
- Can be element-specific

NatureServe
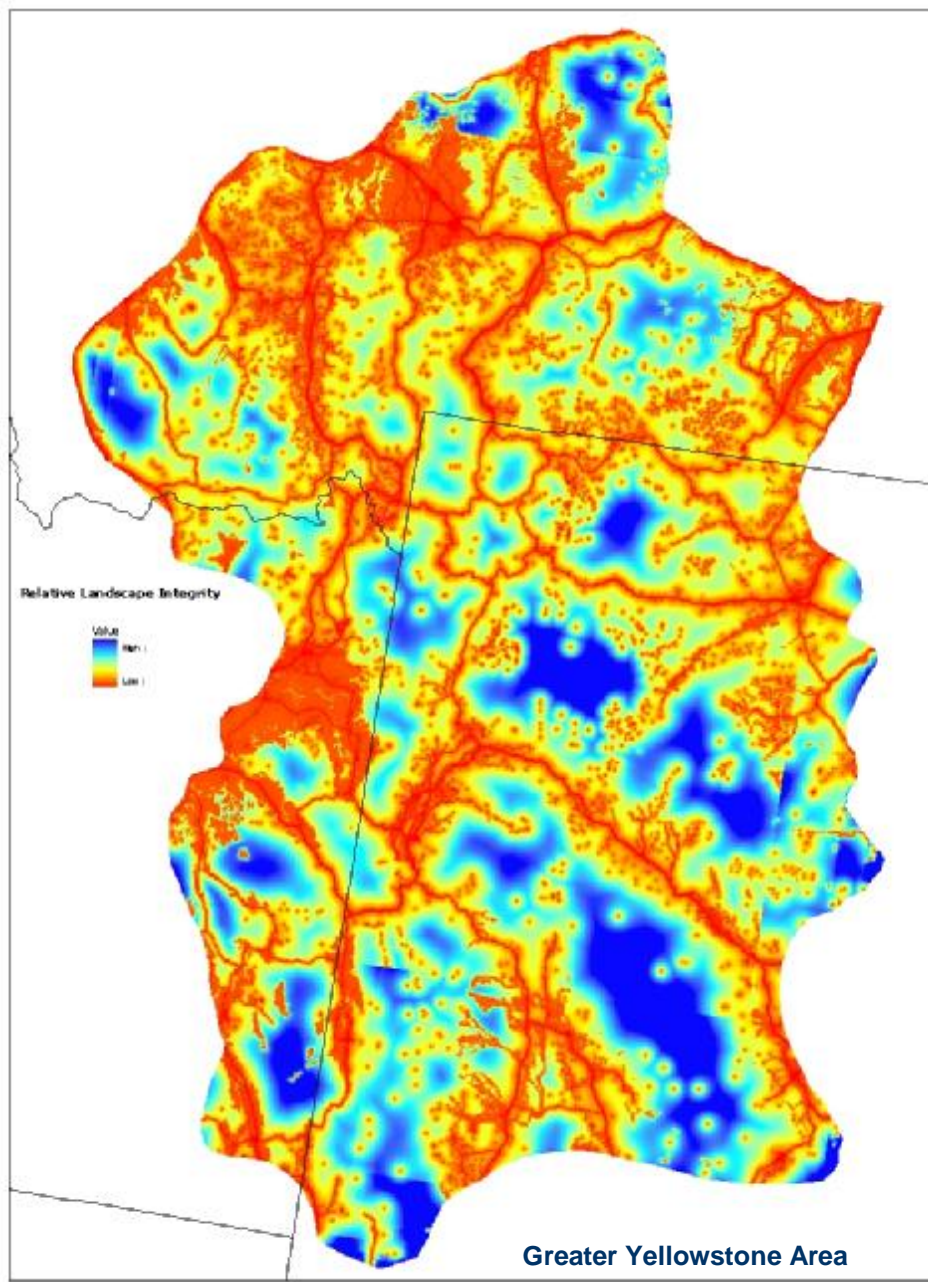
Vista in a DSS Toolkit Transportation Example

Current Tool Suite

Planned Tool Additions

Future Planned Tool interoperability

Other Sector Tools
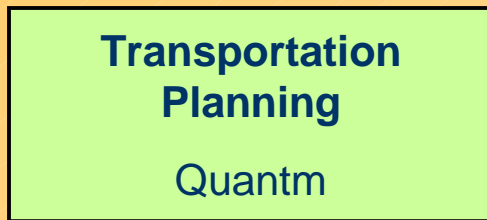
Tools for Conservation Experts

Transportation Planning

Quantm

Conservation Optimization Tools:

MARXAN, SPOT

Vista

Framework Tool

Ecological Process Tools:

Connectivity, restoration modeling

Biodiversity Tools

Element Distribution Modeling Tools:

Land Use Planning

CommunityViz

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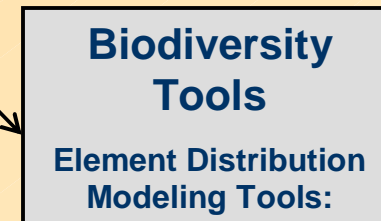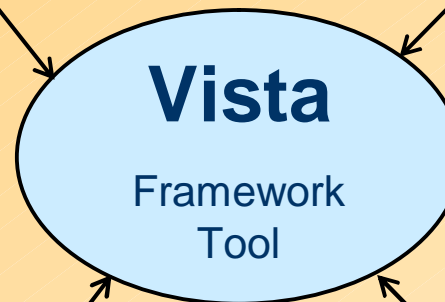
Tool Interoperability Model

Diagram indicates interactions among Vista, Quantm, and CommunityViz. Bold lined boxes and arrows indicate primary path of information to be demonstrated.
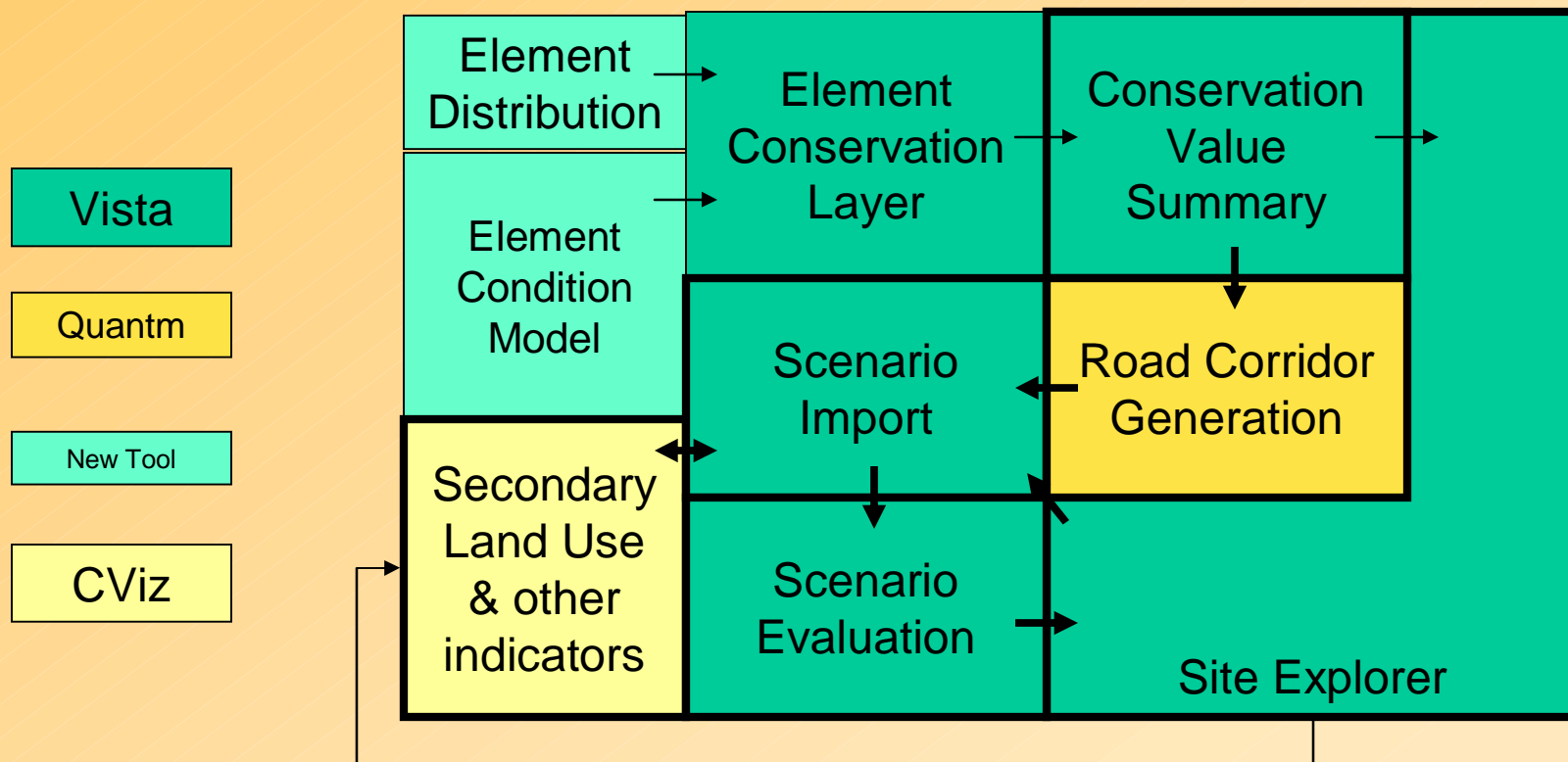
Demonstration
Live Vista w/existing inputs
from Quantm & CommunityViz

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Closing the Loop

- Vista-generated mitigation scenario should be re-evaluated in CommunityViz for impacts on socioeconomic objectives

- Continued fine-tuning iterations between Vista and CommunityViz could help reach an acceptable solution to maximizing achievement of multiple objectives

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Conclusions & Recommendations

- Goals are more appropriately set and are more flexibly met over large regions

- Optimization of conservation solutions saves time and facilitates focus on implementation but must be done iteratively with transportation and land use tools

- Getting started:

  - Can start basic and build detail over time

  - Include the institutions that have the data and expertise needed

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FL Demo Level of Effort

Activity	Source	Approx. Time
Input conservation data into NatureServe Vista	Florida Natural Areas Inventory	2 weeks
Identify high conservation value areas	NatureServe Vista	<2 hours
Generate proposed highway routes	Quantm	1 week
Generate secondary growth effects	Community Viz	1.5 weeks
Identify areas of conflict between proposed transportation routes and conservation values	NatureServe Vista	1 day
Create optimal plan via alternative land use decisions and mitigation efforts	NatureServe Vista	4 hours
TOTAL		~4 weeks

Planned Features for Vista 2.0

- Multiple uses per land unit (for compatibility/conflict mapping)
- User-defined element response to land use
- Assisted import from heritage Biotics system
- Tools for modeling landscape condition
- Calculating sub-region goals

- Aquatic analysis support?
- N-SPECT integration under evaluation

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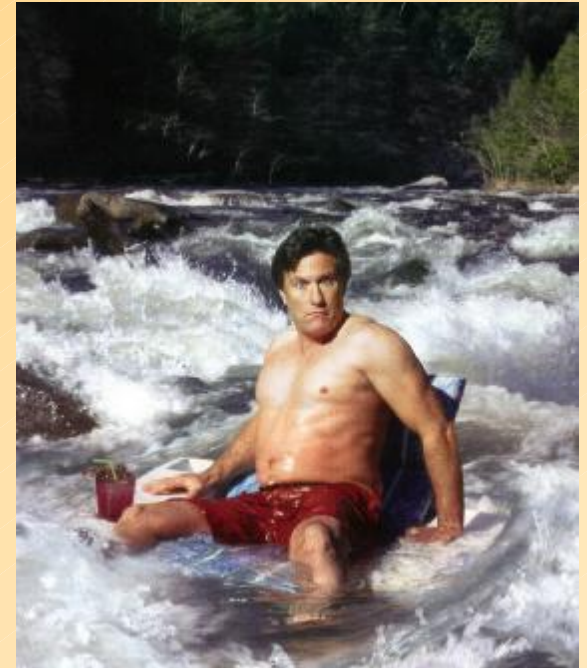
Getting Started

- Start analysis early enough to make a difference
- Appropriate definition of the regional context
- Public process for establishing values
- Investigation of existing studies, plans, priorities for conservation
- Discipline experts required
  - Ecological scientists
  - Conservation planners
  - GIS specialists

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EBM Tools Program

Program Objectives

- Identify available tools that may be useful for performing ecosystem-based management.

- Characterize the tools in a knowledge base

- Prioritize the tools for further description and investigation for investment

- Develop and coordinate a network of tool providers and practitioners

- Conduct outreach and training
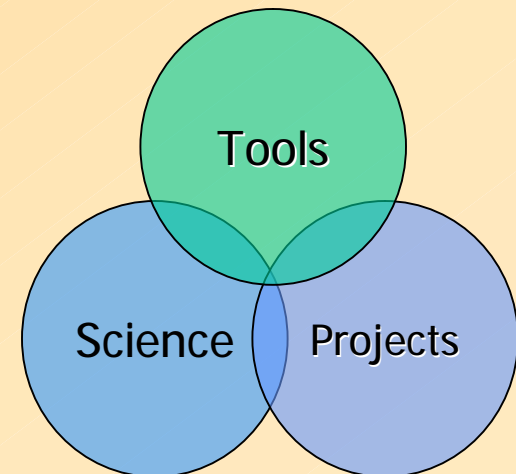
Acknowledgments, resources, & Questions

- FHWA
- Quantm
- Placeways/Orton Family Foundation (CommunityViz)

Resources

- Funding to support pilot implementation of Vista on CWCS implementation
- Other poss cost-share programs

DOT: Dangerous Intersection Causing Some Pretty Cool Accidents

October 13, 2006 | Issue 42•42

SACRAMENTO, CA—The California Department Of Transportation (Caltrans) released a study Monday that focused on a problematic intersection in Livermore, CA estimated to be nine times more likely to have extremely cool, awesome, or just plain unbelievable accidents than anywhere else in the state.

E-MAIL
PRINT
BLOG THIS

ENLARGE IMAGE

The aftermath of a recent totally retarded wreck

"Law enforcement and EMT crews have long been aware of the location's reputation for hosting dozens of the most wicked, twisted, and sick smashups around," said Officer Bill Metz of the Livermore Police Department, which assisted Caltrans in compiling data for the study. "The traffic patterns, poor signage, pavement quality, and sharp changes in gradient combine to make this the single sweetest place to watch a traffic accident."

From "The Onion"

Screenshots in lieu of Demo

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Vista: element data integration

Example: Red Cockaded
Woodpacker

- –A Federal Endangered
  Species with required
  protection
- –Distribution based on potential
  habitat
- –Ground surveys required to
  verify
- –Development restrictions
  and/or HCP may be required

Blue occurrences meet adequate size
requirements, red areas are below minimum
size but still may provide habitat.
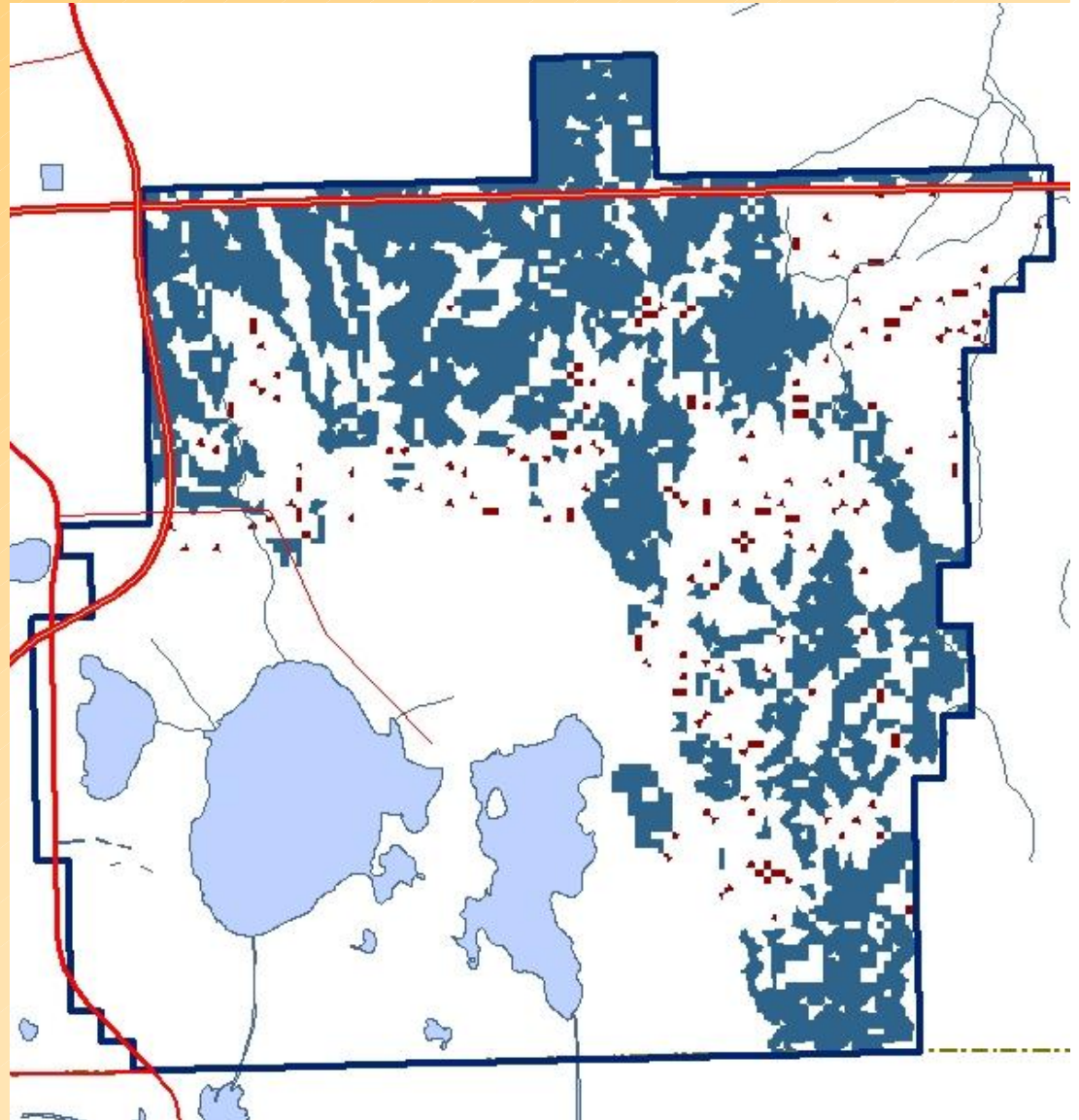
Depicting Conservation Values

Vista conservation value summary. Overlays and combines attributes of conservation elements to provide relative value scores
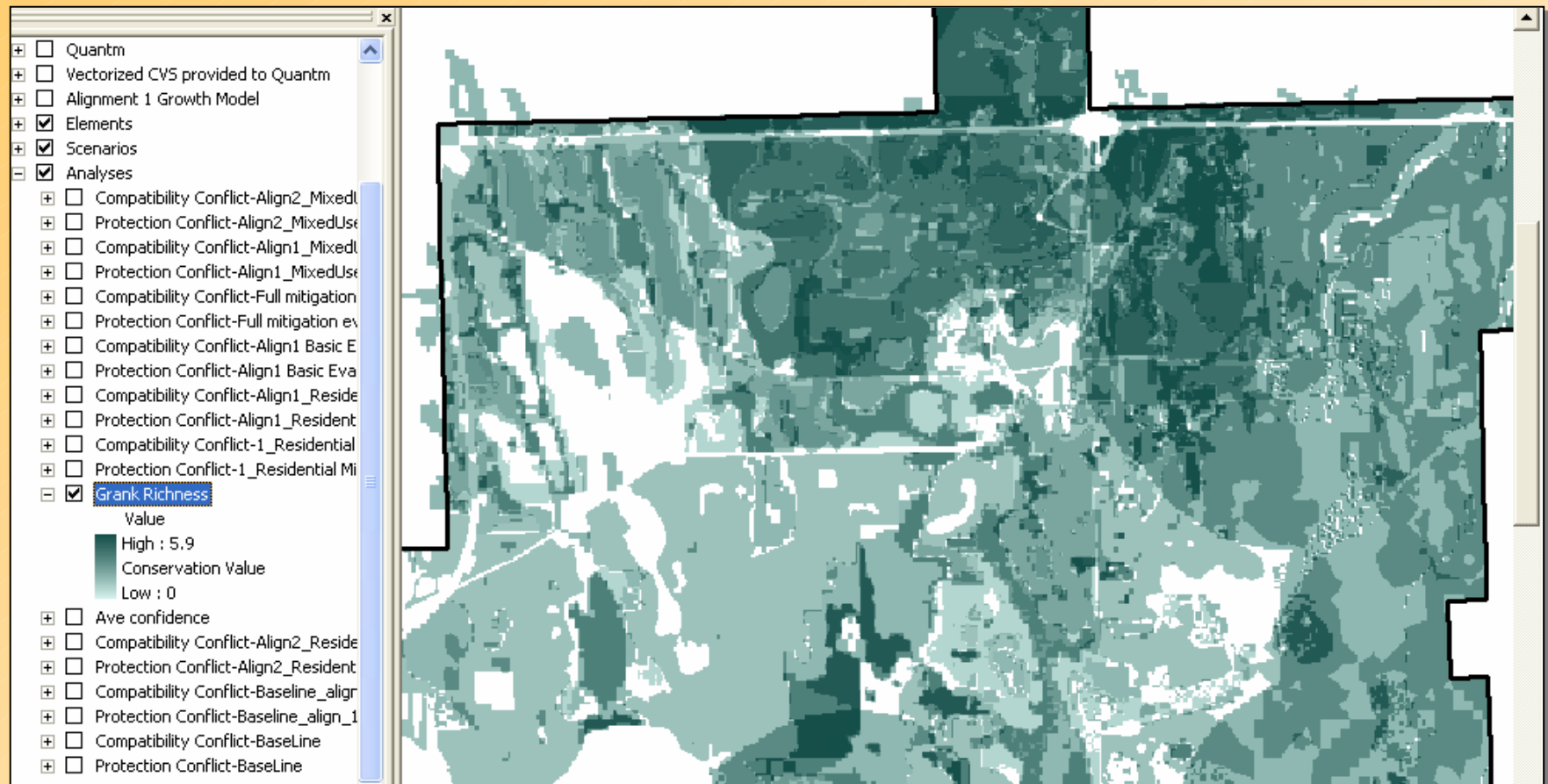
Integrating Transportation Planning

Categorized Vista output used as input to Quantm road routing optimization software (black lines indicate 50 optional alignments and purple indicates best performing option)
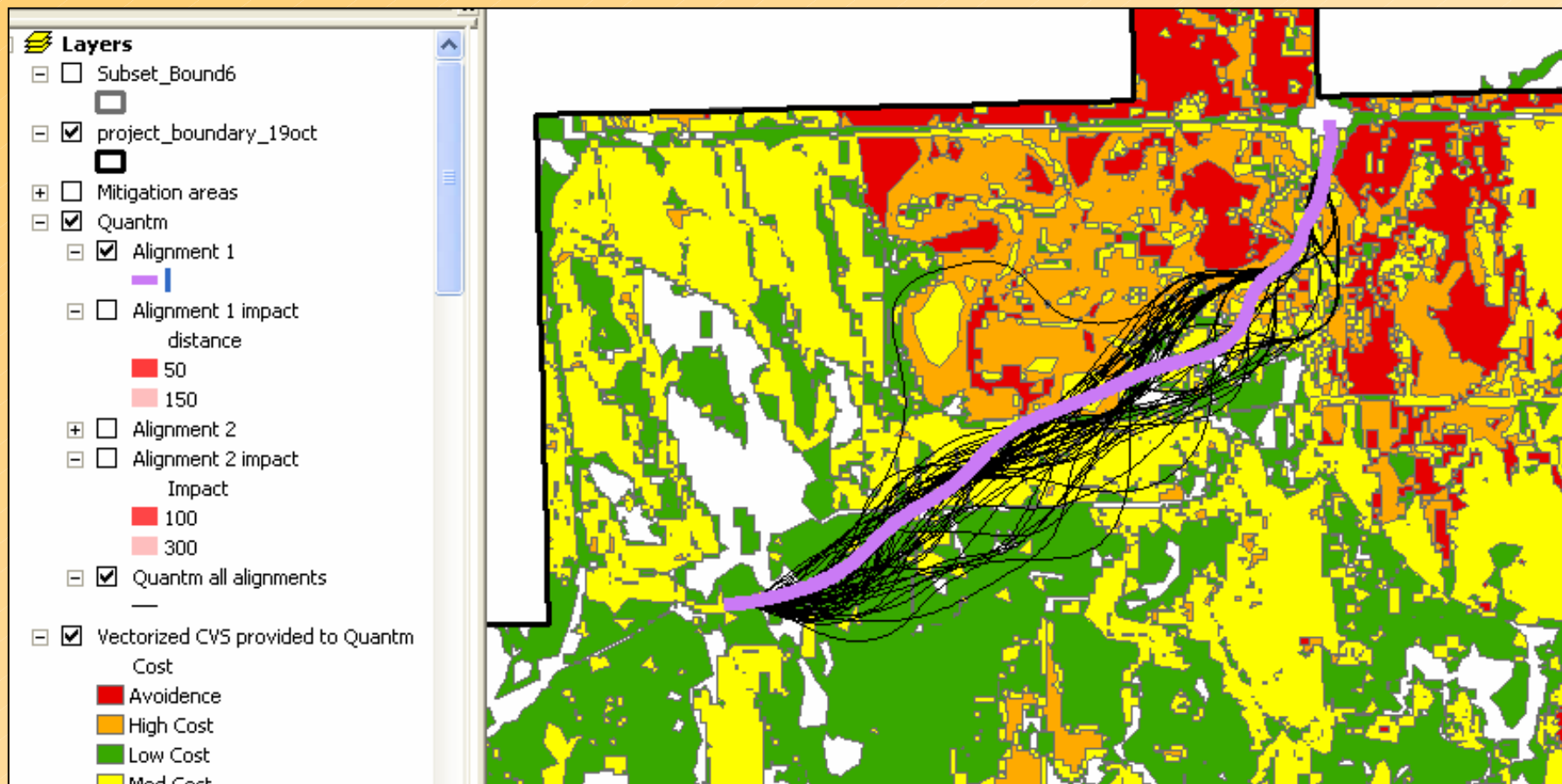
Integrating Land Use Planning

Legend:
- Unknown specific natural use
- Natural area recreation and open space
- Unknown specific working/occupied use
- Low intensity working landscape
- Low-density development
- Minor road
- Unknown specific high intensity use
- High intensity working landscape/recreation parks
- General urbanization: homes, commercial, industrial, etc

CommunityViz growth model on right

Current land use map indicating mostly green space

Growth model map indicating substantial new urbanization
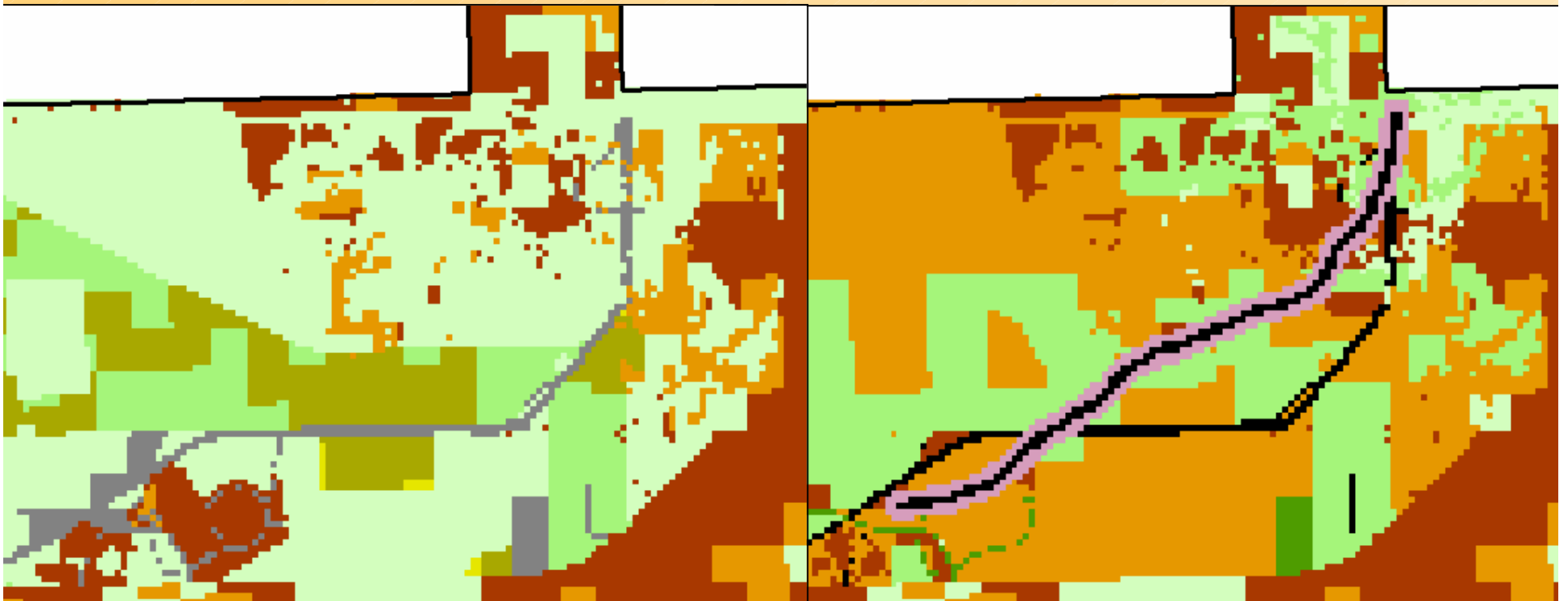
Evaluating Transportation Impacts

Road corridor imported and evaluated in Vista. Compatibility conflict map for current land use with new proposed road. Pink-red colors represent and index of number of conservation elements in conflict with the land use/infrastructure preventing goal achievement
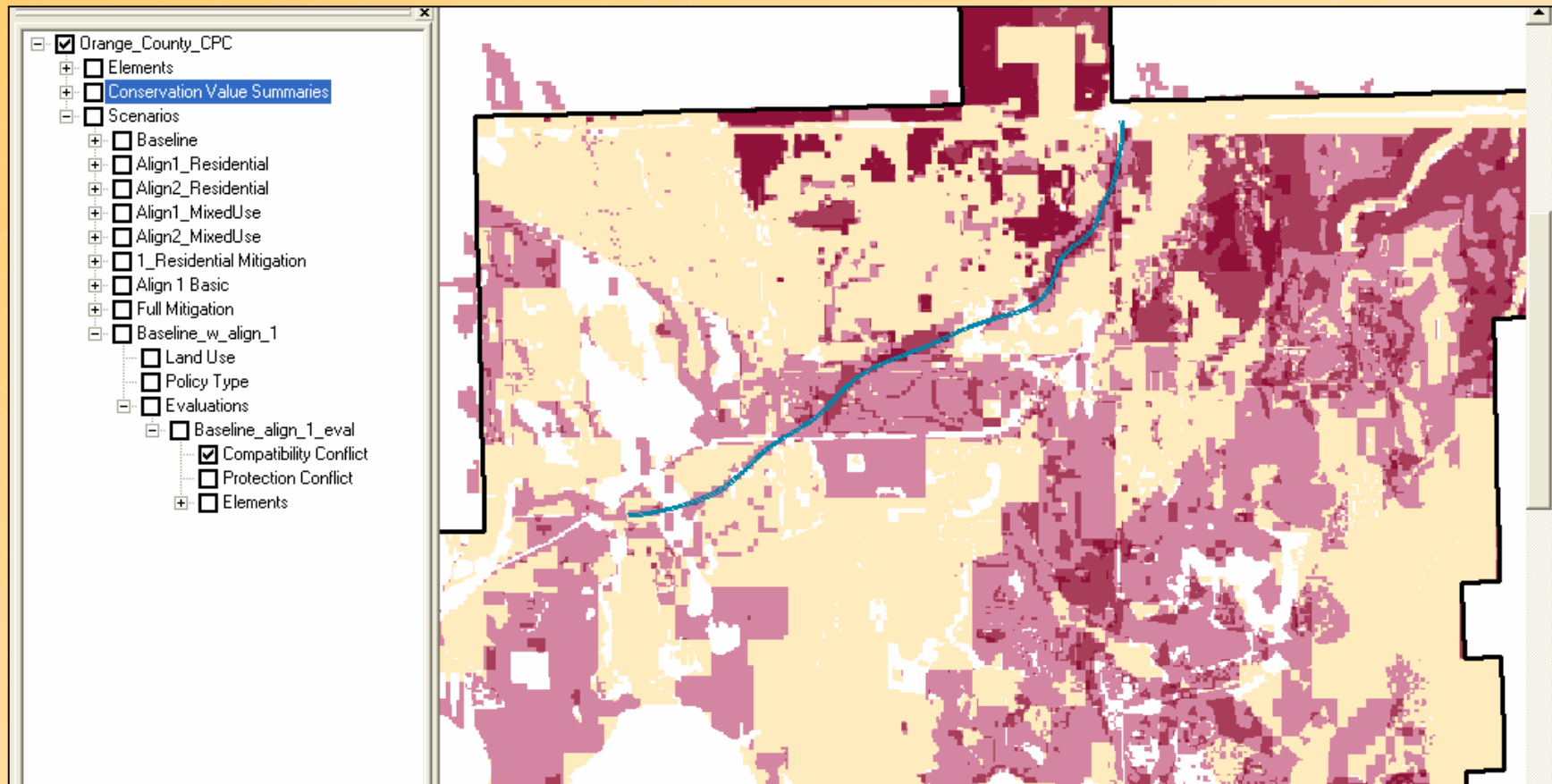
Evaluating Transportation Impacts

All tools provide reports. Example Vista report on quantitative goal achievement for conservation objectives

Goal Performance by Element

Elements (14 elements)

Name	Distribution Area (acres)	Occs	Goal	Goal Met	Protected and Compatible Area (acres)	Occs	Percent of goal	Goal Met	Compatible Area (acres)	Occs	Percent of goal
Wetlands	4,134.7	426	40 percent of area	Y	1,910.6	145	115.52%	Y	2,672.1	267	161.57%
Watersheds Priorities 4-6	7,098.1	167	40 percent of area	Y	3,121.2	58	109.93%	Y	3,397.2	66	119.65%
Watersheds Priority 3	4,832.5	84	60 percent of area	N	1,893.9	24	65.32%	N	2,046.5	33	70.58%
Watersheds Priority 2	224	40	70 percent of area	N	30.3	7	19.32%	N	125.4	16	79.97%
woodstork	4,393.1	297	50 percent of area	N	1,257.9	94	57.27%	(yellow)	2,173.8	166	98.96%
sandhill	1,023.9	27	60 percent of area	N	277.6	6	45.19%	Y	639.7	20	104.13%
gopher frog	16.1	1	80 percent of area	Y	16.1	1	125%	Y	16.1	1	125%
red-cockaded woodpecker	7,573.4	7	60 percent of area	N	927.3	2	20.41%	N	3,190.4	3	70.21%
celestial lily	2,803.4	6	80 percent of area	N	571.3	6	25.47%	N	1,965.5	6	87.64%
scrub	973.3	603	50 percent of area	N	9.6	6	1.97%	N	118.5	112	24.35%
bald eagle	1,915.7	7	40 percent of area	Y	1,324	3	172.78%	Y	1,324	3	172.78%
Florida sandhill crane	9,452.7	123	70 percent of area	N	2,050.7	58	30.99%	N	2,709.9	70	40.95%

Evaluating Cumulative Impacts

Imported & evaluated CommunityViz urban growth model and Quantm road into Vista to evaluate cumulative impacts. Pink-red colors represent and index of number of conservation elements in conflict with the land use/infrastructure
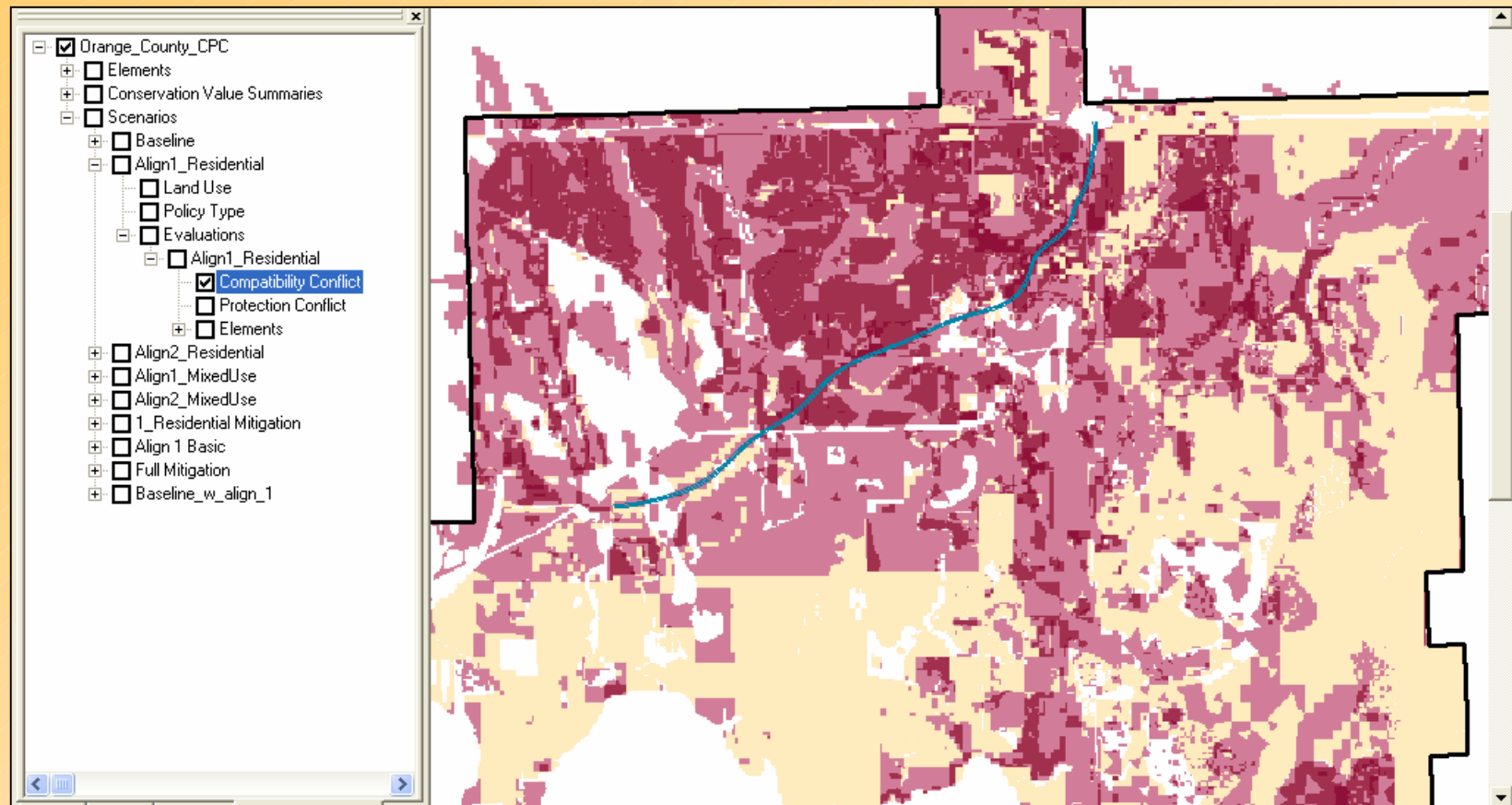
Developing Mitigation Scenarios

Legend:
- Unknown specific natural use
- Natural area recreation and open space
- Unknown specific working/occupied use
- Low intensity working landscape
- Low-density development
- Minor road
- Unknown specific high intensity use
- High intensity working landscape/recreation parks
- General urbanization: homes, commercial, industrial, etc

CommunityViz growth model on right & Vista mitigation scenario

Vista mitigation scenario

Growth model map indicating substantial new urbanization
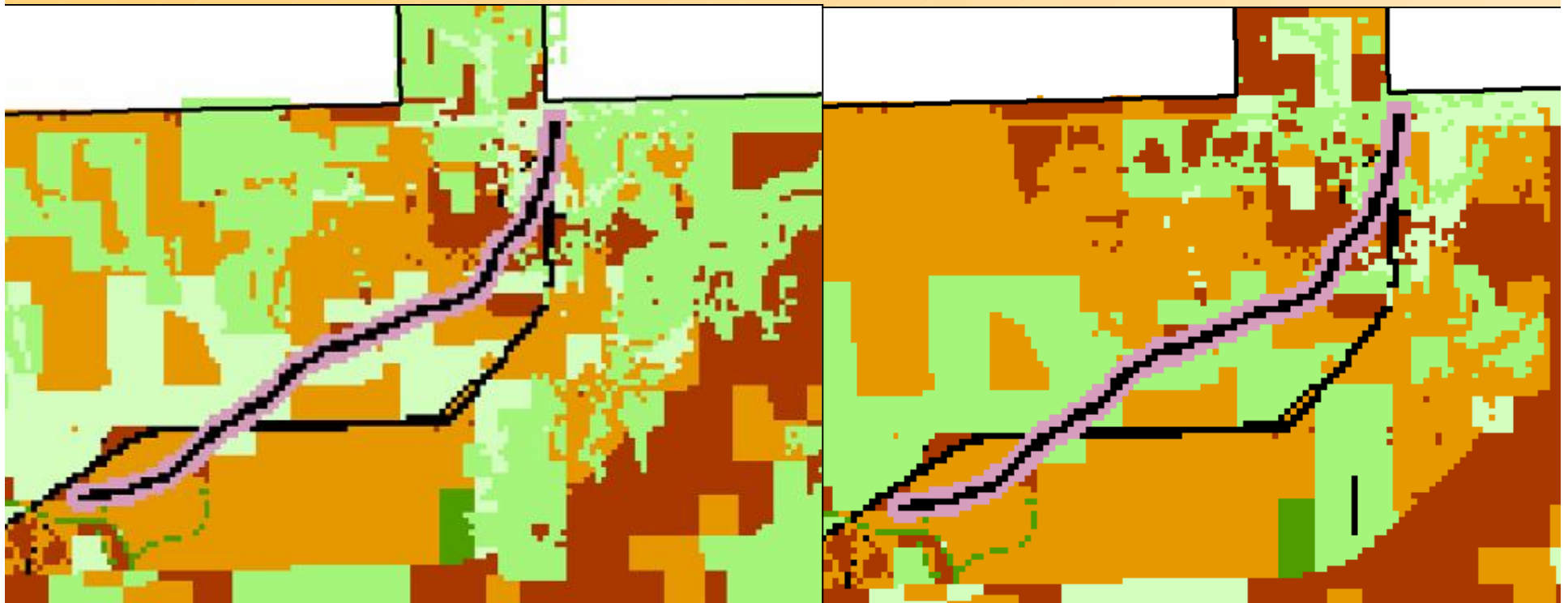
Evaluating Cumulative Impacts

Compatibility conflict map for mitigated scenario.. Remaining conflict (red) indicates a management conflict between a shrubland and forest to support an endangered species. Such remaining conflicts must be resolved over larger spatial extents.