# *Environmental Planning GIS Tools for Transportation Planning and Design*

AASHTO TIG Project | Texas Department of Transportation | Maryland State Highway Administration

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**Environmental Affairs Division**
**Texas Department of Transportation**

**July 14, 2010**

# The Rules Have Changed…

**April 2008 –Final Compensatory Mitigation Rule**

- Increased transparency and improved performance
- Set clear science-based and results-oriented standards nationwide
- Encourage watershed-based decisions
- Continued emphasis on avoidance and minimization

# Overview

AASHTO TIG – Environmental Planning GIS Tools Lead States Team – Texas and Maryland

Texas DOT GIS Screening Tool

Maryland SHA's Green Infrastructure Assessment and Approach

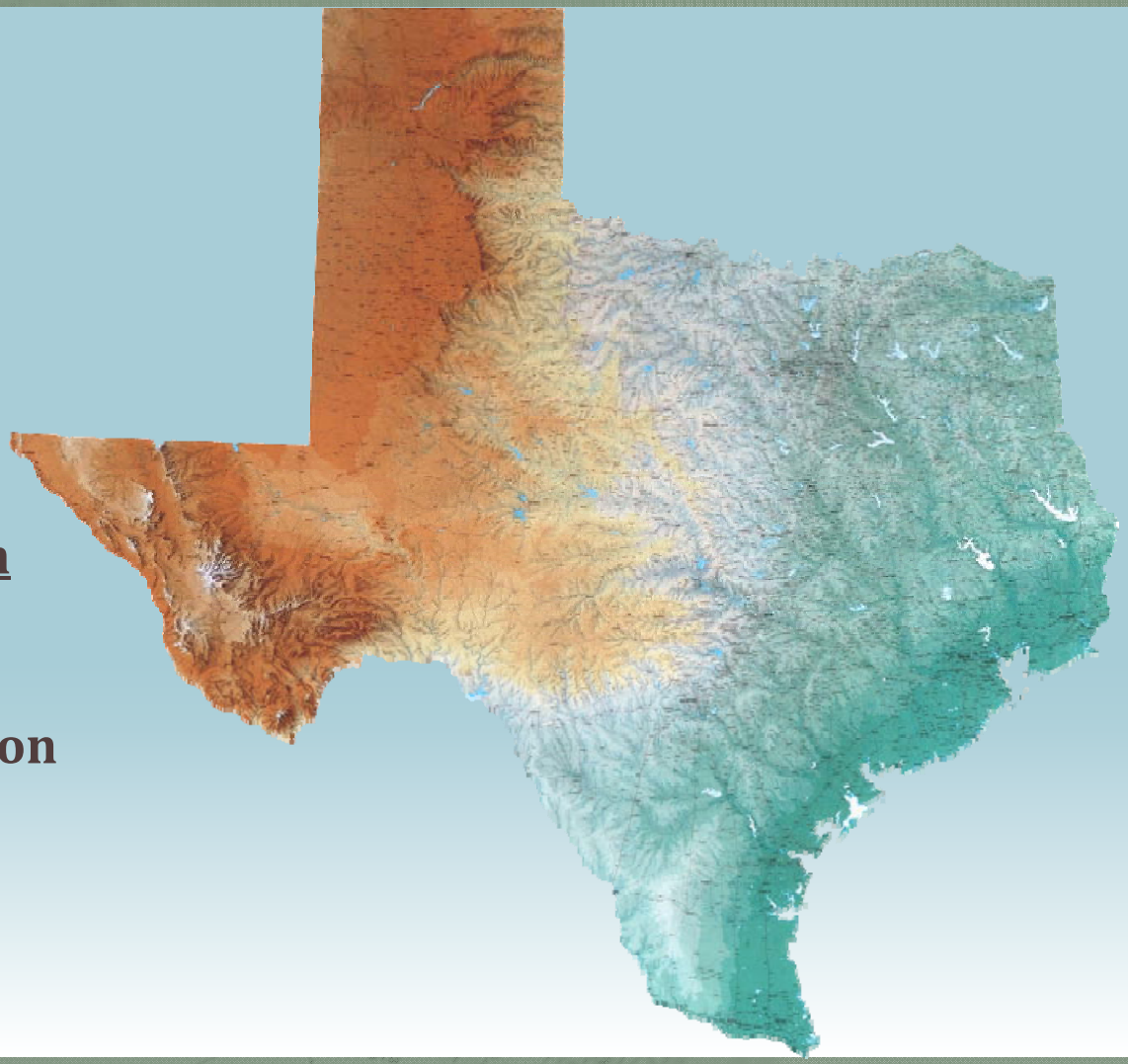
# Texas: A big state with both rural and urban populations

**Land Area**

- **171.1 Million Acres**
- **Ranks 2nd**
- **84% Private Land**

**Estimated Population**

- **25.4 Million**
- **Ranks 2nd**
- **By 2030 – 33.3 Million**

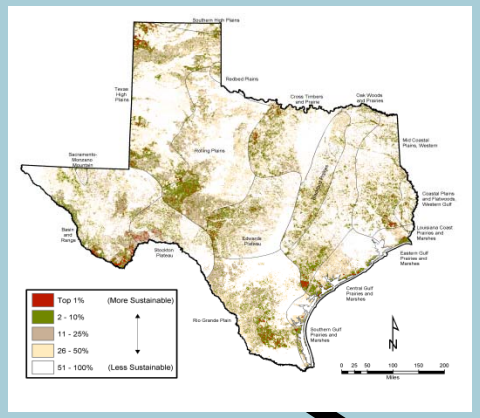


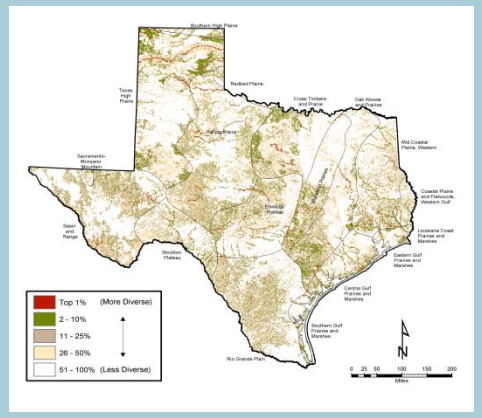
# Environmental Planning Tools

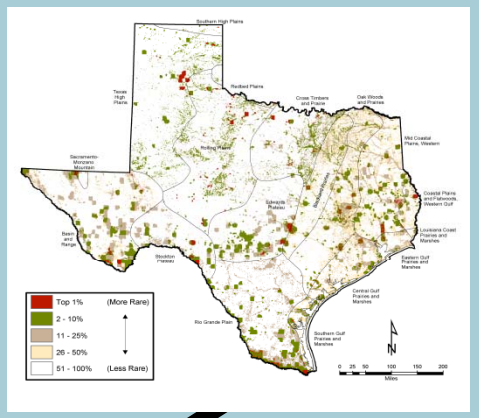
TxDOT has acquired GIS tools from U.S. EPA:

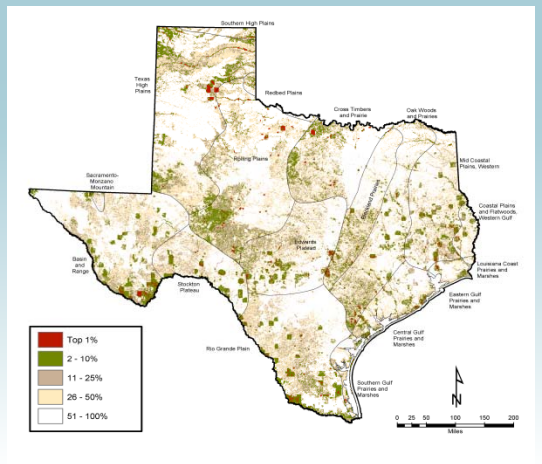
- Texas Ecological Assessment Protocol (TEAP)
- GIS Screening Tool

# What is TEAP?



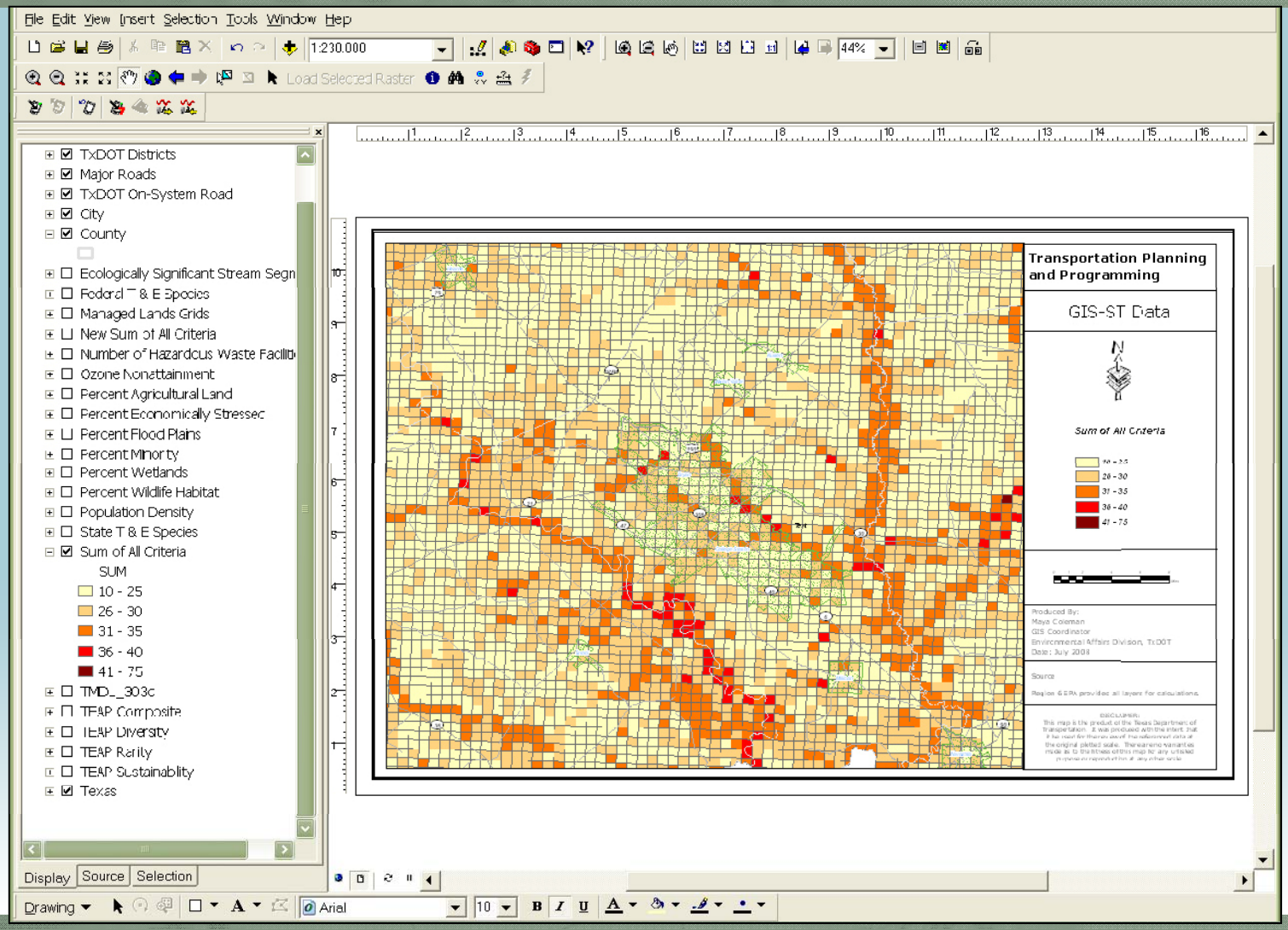




**Composite: identifies important ecological resources in each ecoregion across Texas**

# What is GISST?

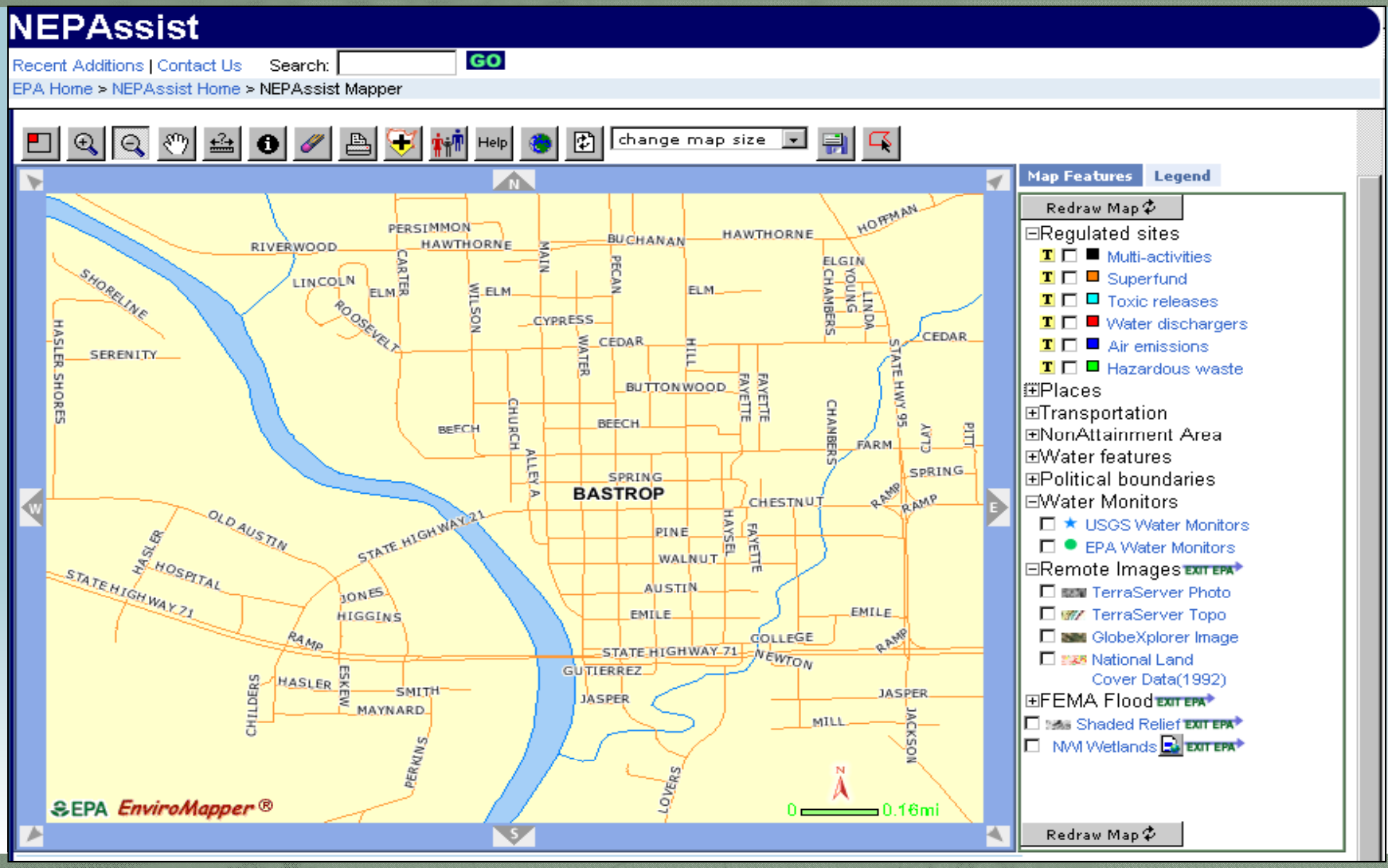


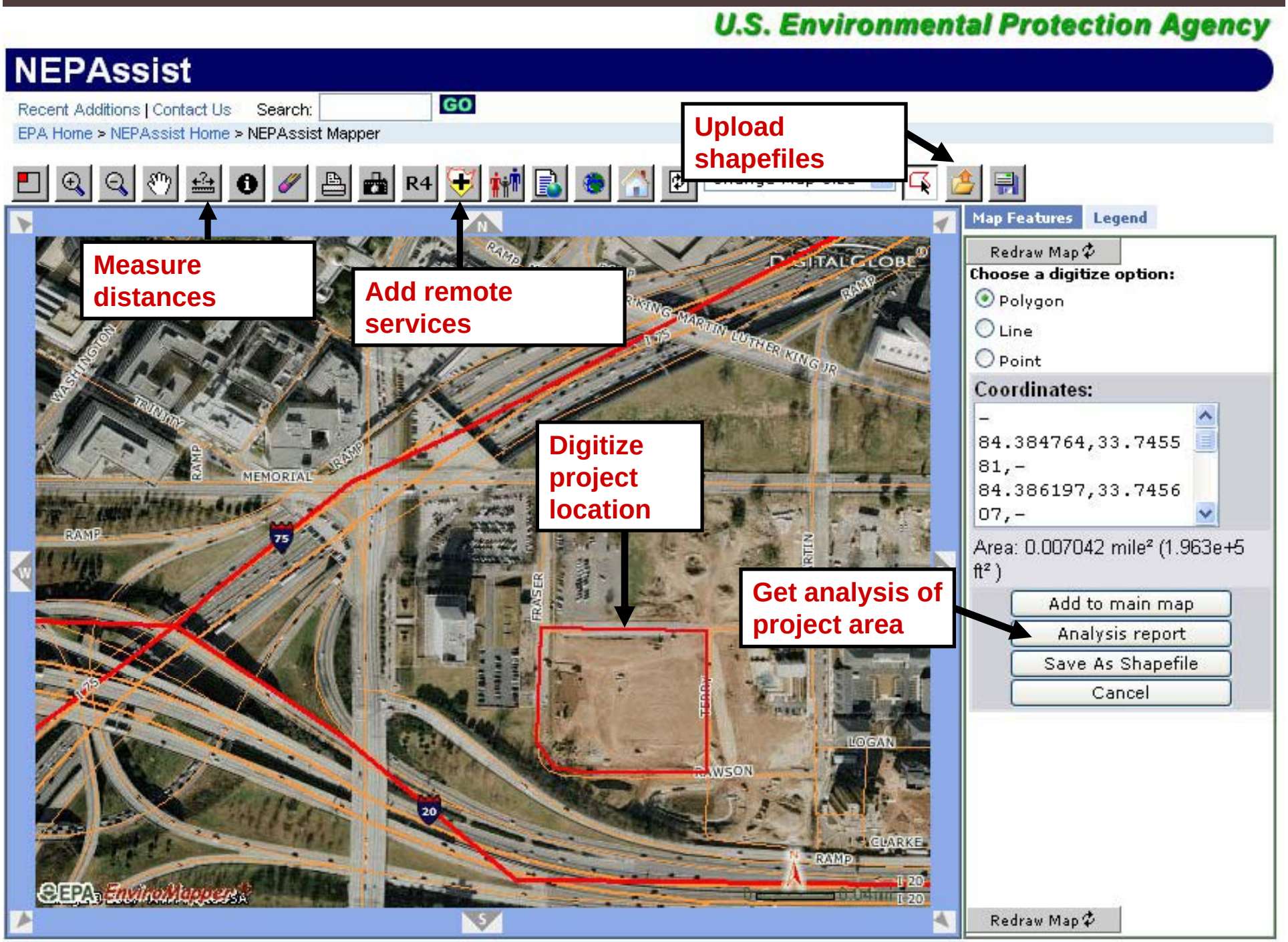
# GIS-ST Calculation Example

| **% Wildlife**<br>**Percentage of cell that is identified as wildlife habitat** | |
|---|---|
| **Rank** | **Value** |
| **1** | **< 20% of the grid cell** |
| **2** | **20-29% of the grid cell** |
| **3** | **30-39% of the grid cell** |
| **4** | **40-49% of the grid cell** |
| **5** | **≥ 50% of the grid cell** |

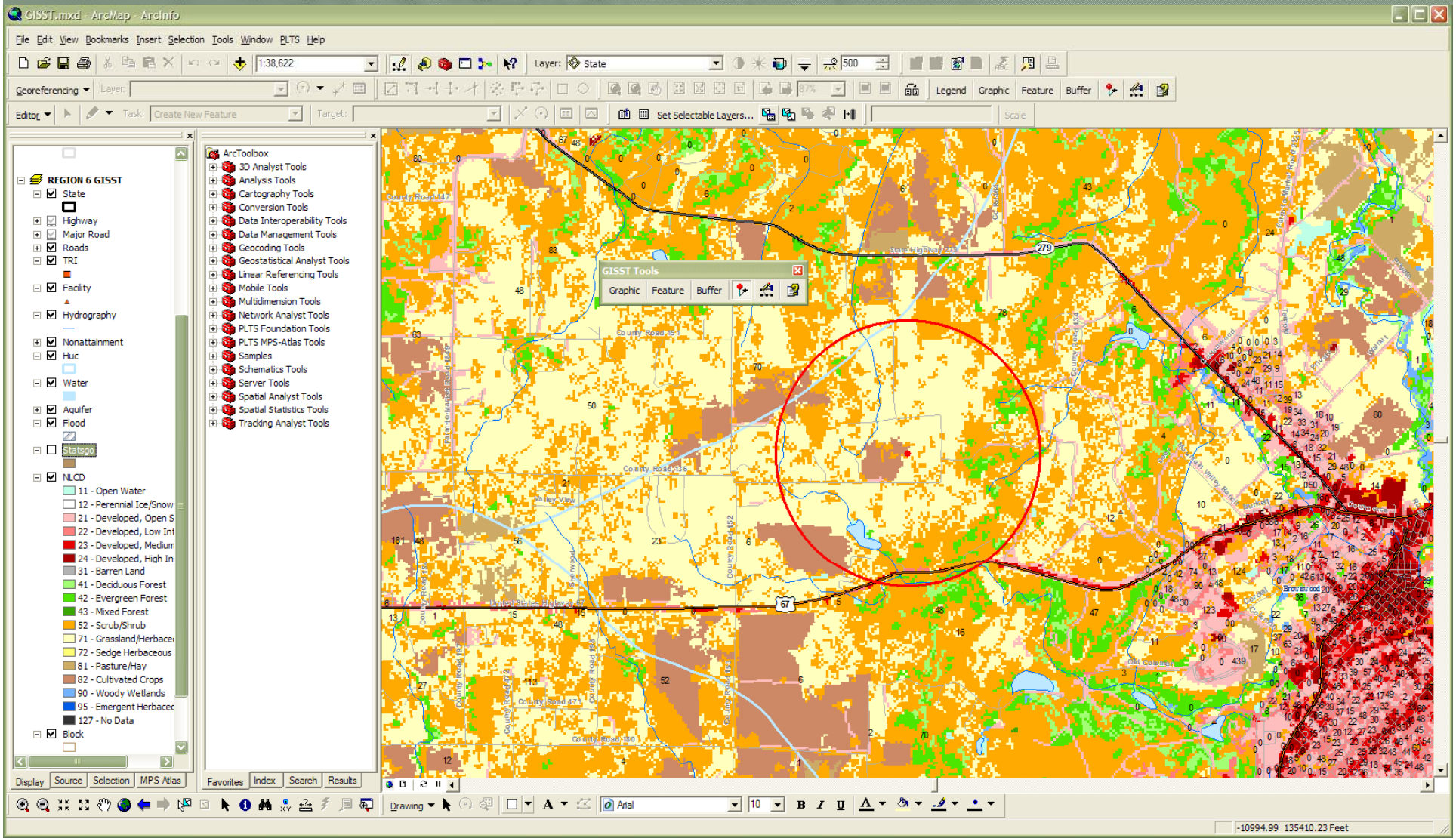
In general, a score of "5" indicates a high degree of concern and a "1" indicates a low degree of concern

# What is NEPAssist?




U.S. Environmental Protection Agency
NEPAssist
Recent Additions | Contact Us
Search:
GO
EPA Home > NEPAssist Home > NEPAssist Mapper
Upload shapefiles
Measure distances
Add remote services
Digitize project location
Get analysis of project area
Map Features
Legend
Redraw Map
Choose a digitize option:
Polygon
Line
Point
Coordinates:
-84.384764,33.745581,-84.386197,33.745607,-
Area: 0.007042 mile² (1.963e+5 ft²)
Add to main map
Analysis report
Save As Shapefile
Cancel
Redraw Map
EPA EnviroMapper
MEMORIAL
RAMP
WASHINGTON
TRINITY
FRASER
RAWSON
LOGAN
CLARKE
I-20
I-75

# GISST


GISST.mxd - ArcMap - ArcInfo
File Edit View Bookmarks Insert Selection Tools Window PLTS Help
Georeferencing
Editor
Legend Graphic Feature Buffer
REGION 6 GISST
State
Highway
Major Road
Roads
TRI
Facility
Hydrography
Nonattainment
Huc
Water
Aquifer
Flood
Statsgo
NLCD
11 - Open Water
12 - Perennial Ice/Snow
21 - Developed, Open S
22 - Developed, Low Int
23 - Developed, Medium
24 - Developed, High In
31 - Barren Land
41 - Deciduous Forest
42 - Evergreen Forest
43 - Mixed Forest
52 - Scrub/Shrub
71 - Grassland/Herbace
72 - Sedge Herbaceous
81 - Pasture/Hay
82 - Cultivated Crops
90 - Woody Wetlands
95 - Emergent Herbace
127 - No Data
Block
ArcToolbox
3D Analyst Tools
Analysis Tools
Cartography Tools
Conversion Tools
Data Interoperability Tools
Data Management Tools
Geocoding Tools
Geostatistical Analyst Tools
Linear Referencing Tools
Mobile Tools
Multidimension Tools
Network Analyst Tools
PLTS Foundation Tools
PLTS MPS-Atlas Tools
Samples
Schematics Tools
Server Tools
Spatial Analyst Tools
Spatial Statistics Tools
Tracking Analyst Tools
GISST Tools
Graphic Feature Buffer
Display Source Selection MPS Atlas
Favorites Index Search Results
Drawing
Arial
-10994.99 135410.23 Feet

# GISST Report

ScoresCumulative : Table

| OBJECTID | Site | RunTime | Surface_Water_Use_Score | STORET_Exceedences_Score | Rainfall_Score | Unified_Watersh | Average_Flow_S | Aquifer_Geology | Distance_to_W | Distance_to_W | Road_Density |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 256 | test | 010 1:45:57 PM | 3 | 1 | 2 | 1 | 4 | 5 | 0 | 5 | 5. |
| 257 | test3 | 10 11:08:07 AM | 1 | 1 | 3 | 1 | 3 | 4 | 0 | 5 | 1. |
| (AutoNumber) | | | | | | | | | | | |

Record: 1 of 2

## GISST Scores

*test3*

| HUC-Related | Score |
|---|---|
| Surface Water Use | 1 |
| Storet Exceedences | 1 |
| Rainfall | 3 |
| Unified Watershed Assessment | 1 |
| Average Flow | 3 |
| Aquifer Geology | 4 |

| Other Water-Related | Value | Score |
|---|---|---|
| Distance to Water (feet) | 0 | 5 |
| Stream Density (miles/ sq mi) | 1.39 | 3 |
| Channel/Canal Density (miles / sq mi) | 0 | 1 |
| % Surface Water | 0.75 | 1 |
| %100 Year Flood | 0 | 1 |
| %500 Year Flood | 0 | 1 |
| Aquifer | 1 | |
| Groundwater Probability | 1 | |
| Soil Permeability | 2 | |

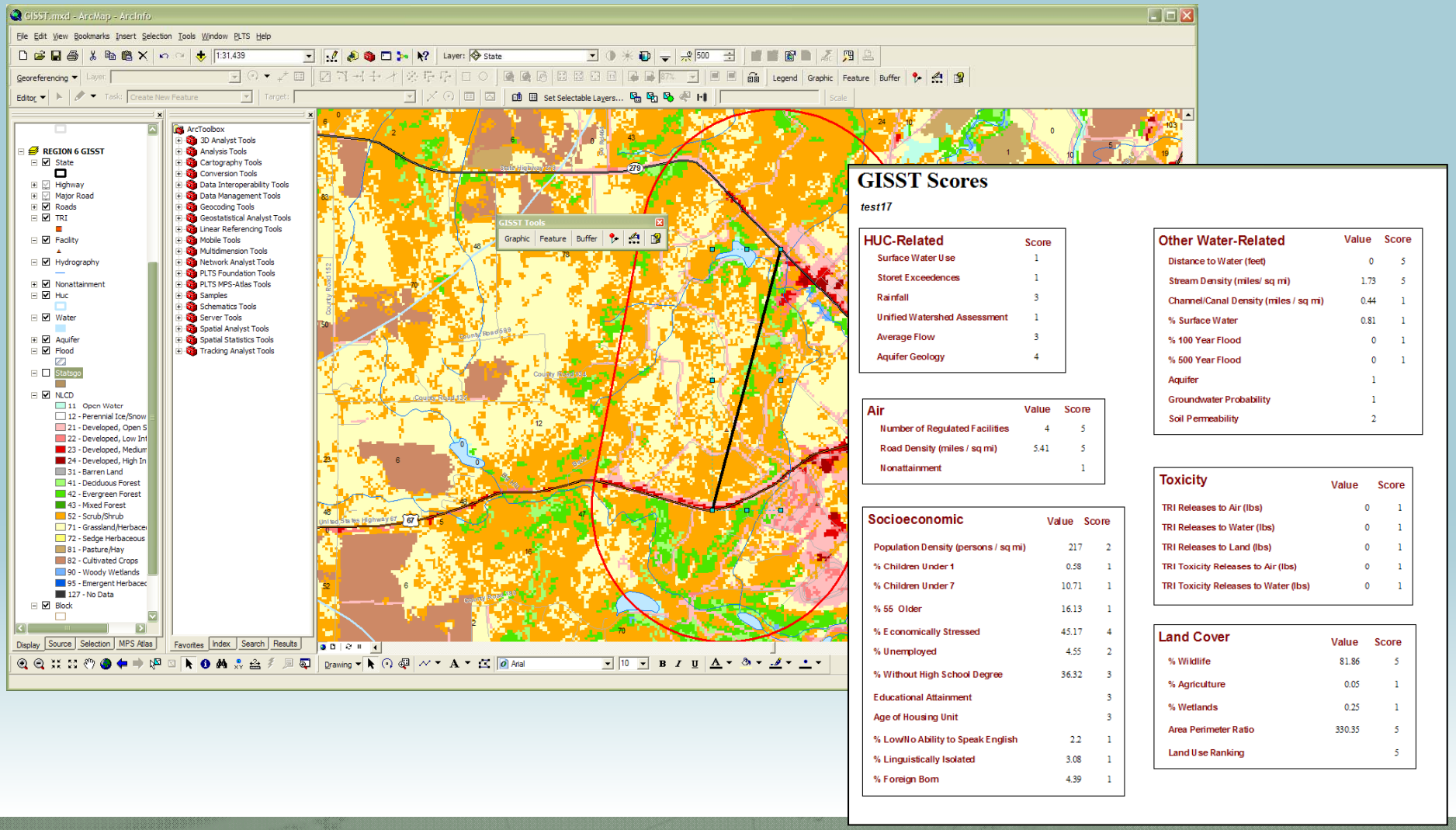
| Air | Value | Score |
|---|---|---|
| Number of Regulated Facilities | 0 | 1 |
| Road Density (miles / sq mi) | 1.94 | 3 |
| Nonattainment | | 1 |

| Toxicity | Value | Score |
|---|---|---|
| TRI Releases to Air (lbs) | 0 | 1 |
| TRI Releases to Water (lbs) | 0 | 1 |
| TRI Releases to Land (lbs) | 0 | 1 |
| TRI Toxicity Releases to Air (lbs) | 0 | 1 |
| TRI Toxicity Releases to Water (lbs) | 0 | 1 |

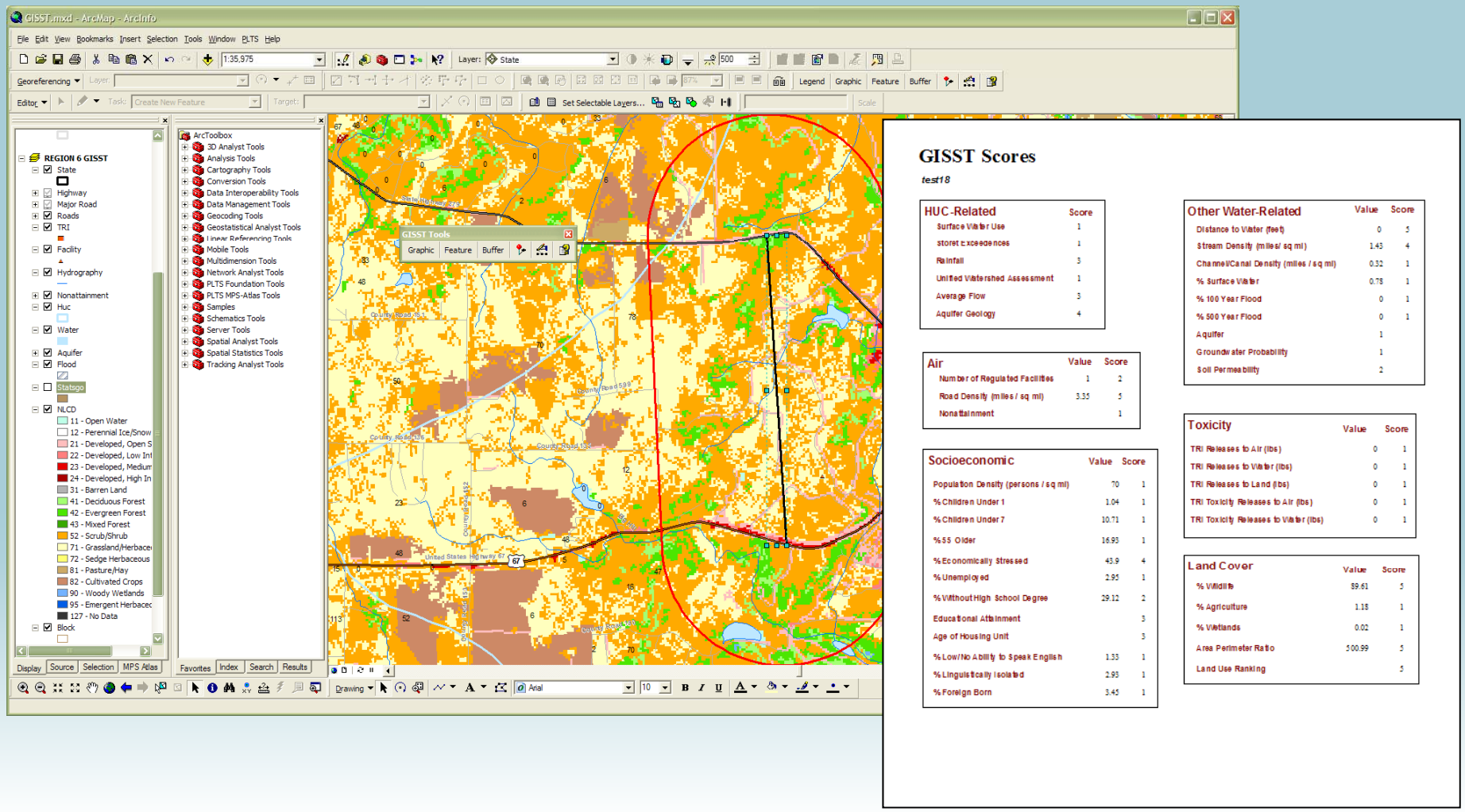
| Socioeconomic | Value | Score |
|---|---|---|
| Population Density (persons / sq mi) | 23 | 1 |
| % Children Under 1 | 1.37 | 1 |
| % Children Under 7 | 6.85 | 1 |
| % 65 Older | 26.03 | 3 |
| % Economically Stressed | 27.39 | 2 |
| % Unemployed | 1.75 | 1 |
| % Without High School Degree | 20.41 | 1 |
| Educational Attainment | | 3 |
| Age of Housing Unit | | 2 |
| % Low/No Ability to Speak English | 1.45 | 1 |
| % Linguistically Isolated | 3.45 | 1 |
| % Foreign Born | 1.37 | 1 |

| Land Cover | Value | Score |
|---|---|---|
| %Wildlife | 93.19 | 5 |
| %Agriculture | 6.25 | 1 |
| %Wetlands | 0 | 1 |
| Area Perimeter Ratio | 1077.2 | 5 |
| Land Use Ranking | | 5 |

# Alternative 1: GISST Report Direct Impacts



# Alternative 2: GISST Report Direct Impacts



# GISST Report

**Facility**

| | |
|---|---|
| Within 100 meters of a hospital? | no |
| Within 1000 meters of a hospital? | no |
| Within 100 meters of a TRI facility? | no |
| Within 1000 meters of a TRI facility? | no |
| Within 100 meters of a regulated facility? | yes |
| Within 1000 meters of a regulated facility? | yes |
| Within 100 meters of an airport? | no |

**Water**

| | |
|---|---|
| Within 100 meters of a Wild and Scenic River? | |
| Within an area over a Sole Source Aquifer? | |
| Within the 100 year flood plain? | |
| Within the 500 year flood plain? | |
| Within 400 meters of an NWI wetland? | |
| Within an NLCD wetland? | |
| Within 1000 meters of an NLCD wetland? | |

**HUC-Related**

| Factor | Value | Score |
|---|---|---|
| Surface Water Use | | 3 |
| Storet Exceedences | | 4 |
| Rainfall | | 5 |
| Unified Watershed Assessment | | 3 |
| Average Flow | | 4 |
| Aquifer Geology | | 4 |

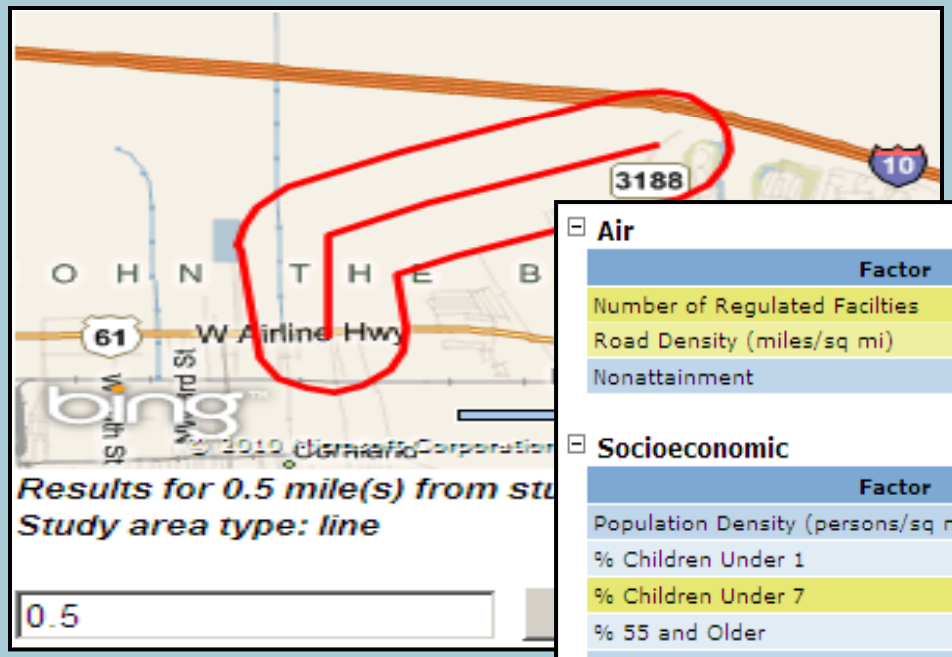
**Air**

| Factor | Value | Score |
|---|---|---|
| Number of Regulated Facilties | 5 | 5 |
| Road Density (miles/sq mi) | 3.03 | 5 |
| Nonattainment | | 1 |

**Socioeconomic**

| Factor | Value | Score |
|---|---|---|
| Population Density (persons/sq mi) | 257 | 2 |
| % Children Under 1 | .87 | 1 |
| % Children Under 7 | 17.12 | 4 |
| % 55 and Older | 15.76 | 1 |
| % Unemployed | 4.76 | 2 |
| % Economically Stressed | 23.68 | 1 |

# Alternative 1: GISST Report Direct Impacts




**Air**

| Factor | Value | Score |
|---|---|---|
| Number of Regulated Facilties | | |
| Road Density (miles/sq mi) | 3.03 | 5 |
| Nonattainment | | 1 |

**Socioeconomic**

| Factor | Value | Score |
|---|---|---|
| Population Density (persons/sq mi) | | |
| % Children Under 1 | .87 | 1 |
| % Children Under 7 | 17.12 | 4 |
| % 55 and Older | 15.76 | 1 |
| % Unemployed | 4.76 | 2 |
| % Economically Stressed | 23.68 | 1 |
| % Without High School Degree | 19.74 | 1 |
| Educational Attainment | | 3 |

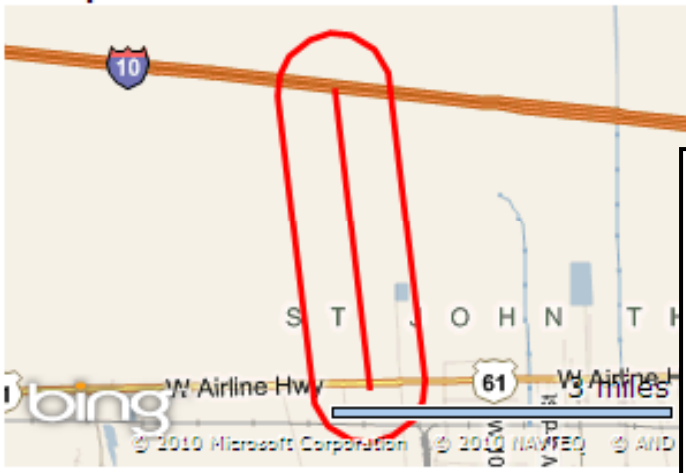
**Land Cover**

| Factor | Value | Score |
|---|---|---|
| % Wildlife | 68.16 | 5 |
| % Agriculture | 14.56 | 1 |
| % Wetlands | 65.0019990549922 | 5 |

# Alternative 2: GISST Report Direct Impacts

**NEPAssist GISST Report**

**Map**




*Results for .5 mile(s) from study area*
*Study area type: line*

.5 Submit Query

**Air**

| Factor | Value | Score |
|---|---|---|
| Number of Regulated Facilties | 2 | 3 |
| Road Density (miles/sq mi) | 2.07 | 3 |
| Nonattainment | | 1 |

**Socioeconomic**

| Factor | Value | Score |
|---|---|---|
| Population Density (persons/sq mi) | 1 | 1 |
| % Children Under 1 | 0 | 1 |
| % Children Under 7 | 0 | 1 |
| % 55 and Older | 25 | 2 |
| % Unemployed | 0 | 1 |
| % Economically Stressed | 100 | 5 |
| % Without High School Degree | 33.33 | 2 |
| Educational Attainment | | 4 |

**Land Cover**

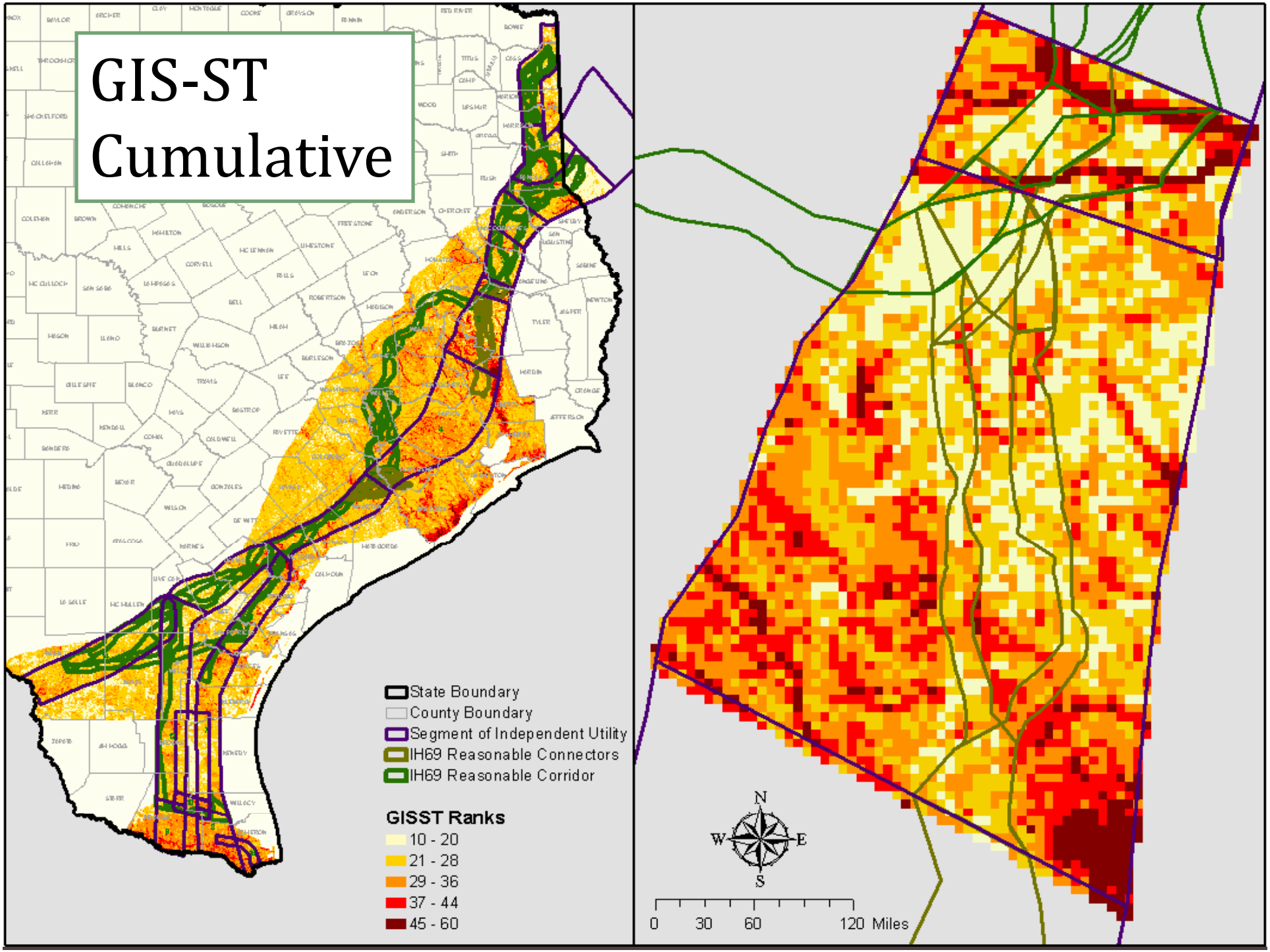
| Factor | Value | Score |
|---|---|---|
| % Wildlife | 60.92 | 5 |
| % Agriculture | 32.16 | 3 |
| % Wetlands | 59.81 | 5 |

# GISST Database Comparison of Alternatives

| **Corridor Alternative** | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Number of facilities | 5 | 2 | 1 | 4 | 0 | 5 |
| score | 5 | 3 | 2 | 5 | 1 | 5 |
| | | | | | | |
| % Wildlife | 79.78 | 60.92 | 89.96 | 86.05 | 68.01 | 75.11 |
| | 5 | 5 | 5 | 5 | 5 | 5 |
| | | | | | | |
| % Agriculture | 10.05 | 32.16 | 3.68 | 2.56 | 25.96 | 15.42 |
| | 1 | 3 | 1 | 1 | 2 | 1 |
| | | | | | | |
| % Wetlands | 75.98 | 59.81 | 87.17 | 80.54 | 67.96 | 74.88 |
| | 5 | 5 | 5 | 5 | 5 | 5 |
| | | | | | | |
| stream density | 2.61 | 2.71 | 1.63 | 3.56 | 1.69 | 2.43 |
| | 5 | 5 | 5 | 5 | 1 | 5 |
| | | | | | | |
| % 100 year floodplain | 84.9 | 70.9 | 88.92 | 87.17 | 75.56 | 84.53 |
| | 5 | 5 | 5 | 5 | 5 | 5 |
| | | | | | | |
| % 500 year floodplain | 100 | 99.99 | 88.92 | 100 | 99.99 | 99.99 |
| | 5 | 5 | 5 | 5 | 5 | 5 |
| | | | | | | |
| Land Use Ranking | 5 | 4 | 5 | 5 | 4 | 4 |

# Texas Case Study – Interstate 69 Project

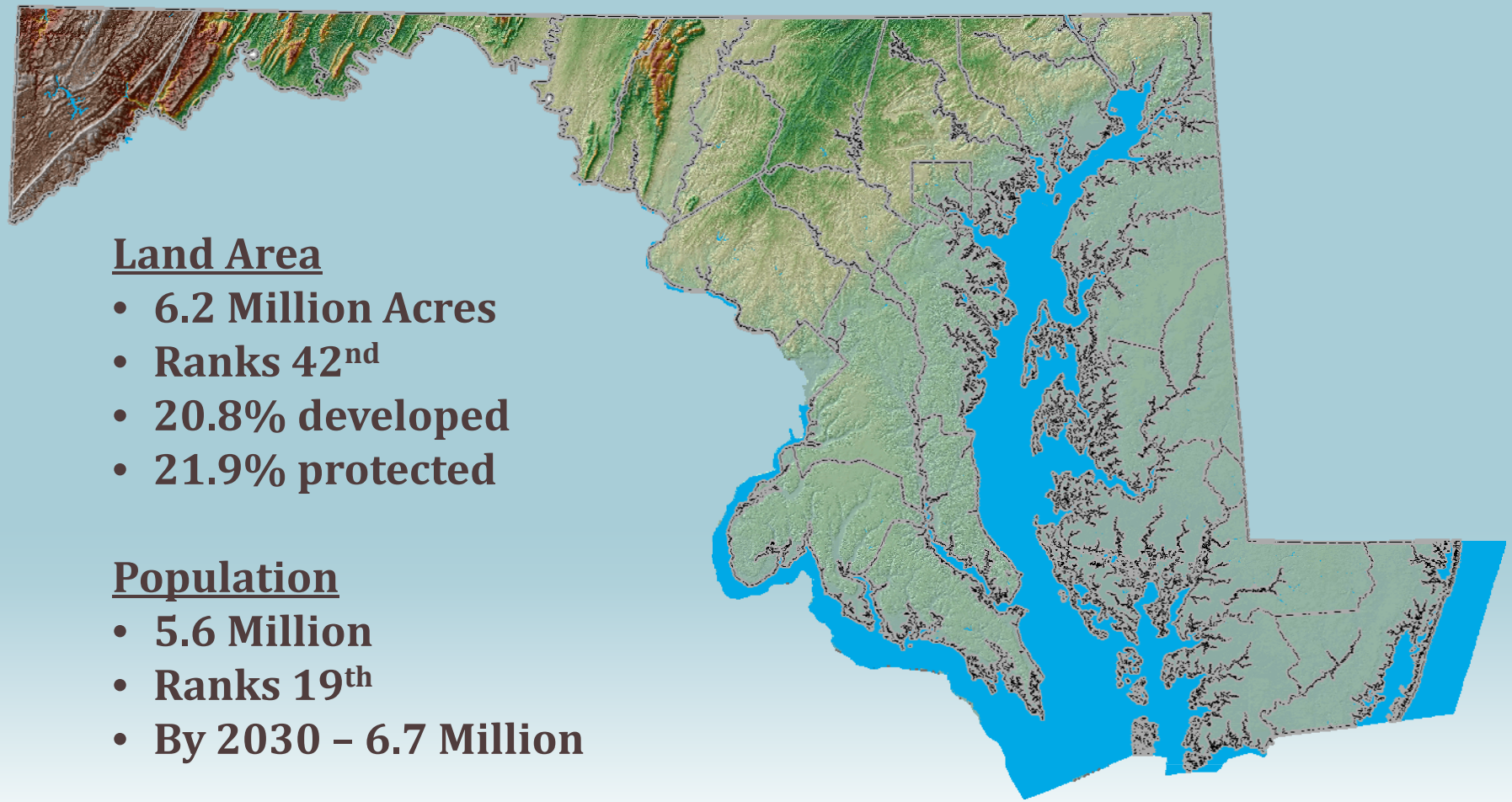
- Planning and Development
- Location
- Environmental Study
- GIS tools used


GIS-ST
Cumulative
State Boundary
County Boundary
Segment of Independent Utility
IH69 Reasonable Connectors
IH69 Reasonable Corridor
GISST Ranks
10 - 20
21 - 28
29 - 36
37 - 44
45 - 60
N
W
E
S
0
30
60
120 Miles

# Current and Future Efforts to Enhance GIS Tools

- Expansion of TEAP to a South Central US Regional Ecological Assessment Protocol (REAP)
- Recalculation to a 0.25 km2 grid—more granular grid for medium size project level analysis
- Recalculations using new land cover data

# Maryland: A small state with many people



**Land Area**

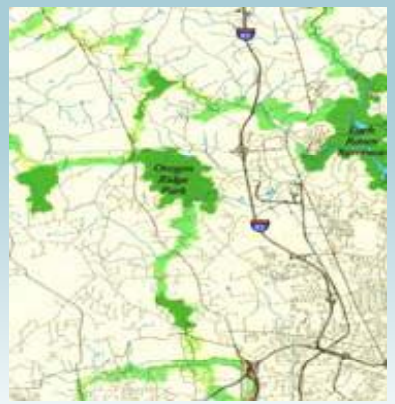
- **6.2 Million Acres**
- **Ranks 42nd**
- **20.8% developed**
- **21.9% protected**

**Population**

- **5.6 Million**
- **Ranks 19th**
- **By 2030 – 6.7 Million**

# Green Infrastructure

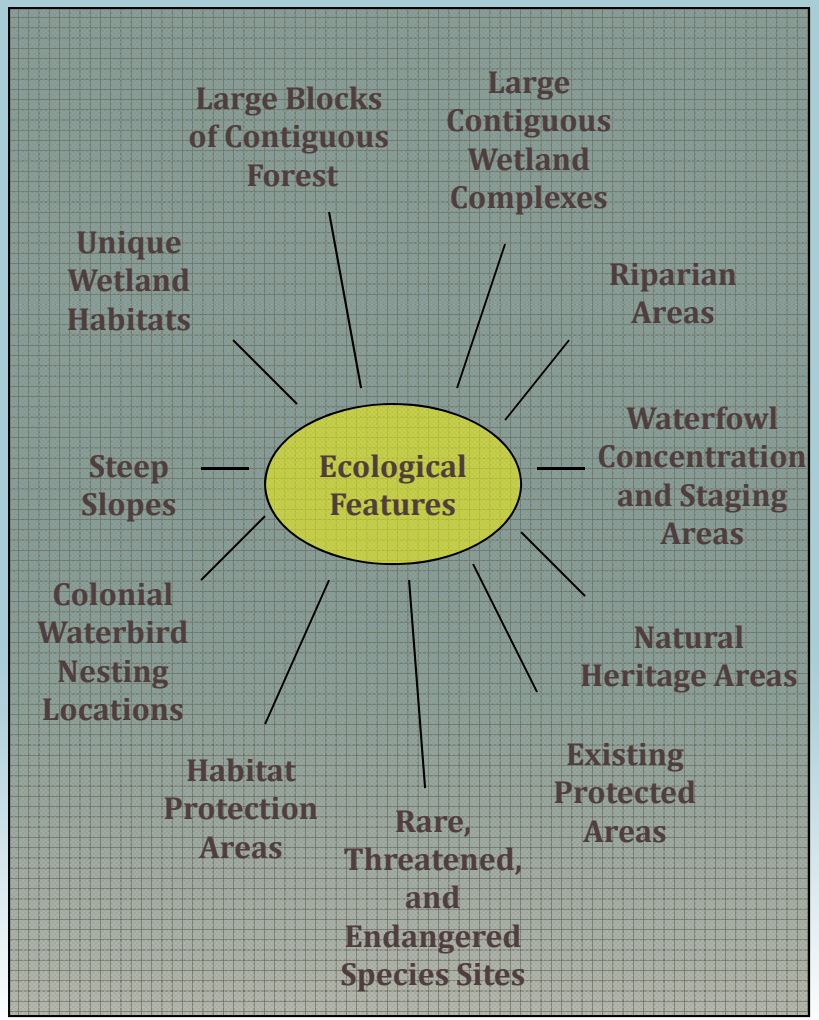
"Strategically planned and managed networks of natural lands, working landscapes and other open spaces that conserve ecosystem functions, and provide associated benefits to human populations"



Jane Hawkey, Jane Thomas, IAN Image Library (www.ian.umces.edu/imagelibrary/)

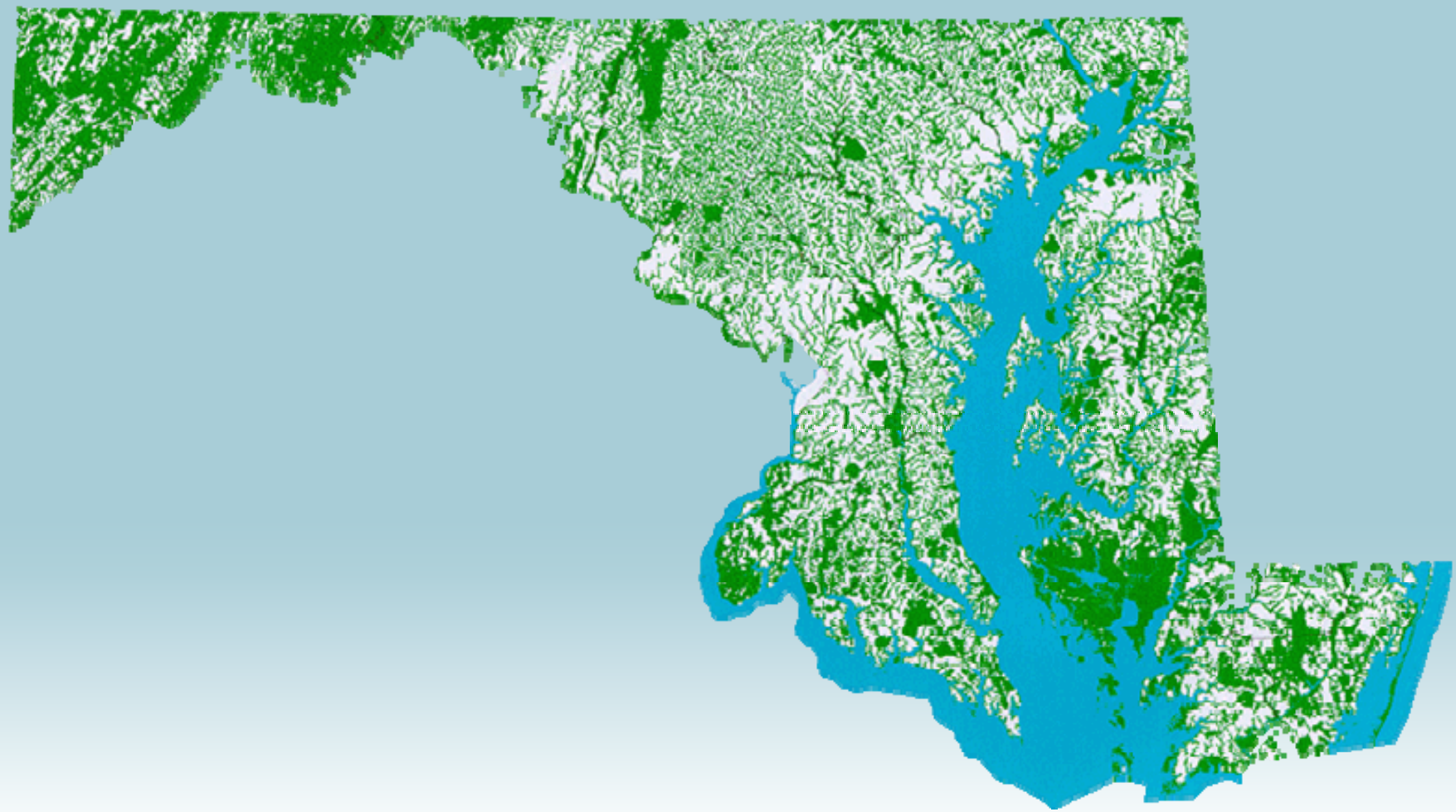
# Maryland's Green Infrastructure Assessment
# Selection of Ecological Components

- Strive to include full range of ecosystem elements vs. single species focus
- Multidisciplinary Effort
  - DNR biologists – Aquatics, Forests, Wildlife and Heritage
  - Scientific Community
- Limited to features with GIS data available statewide

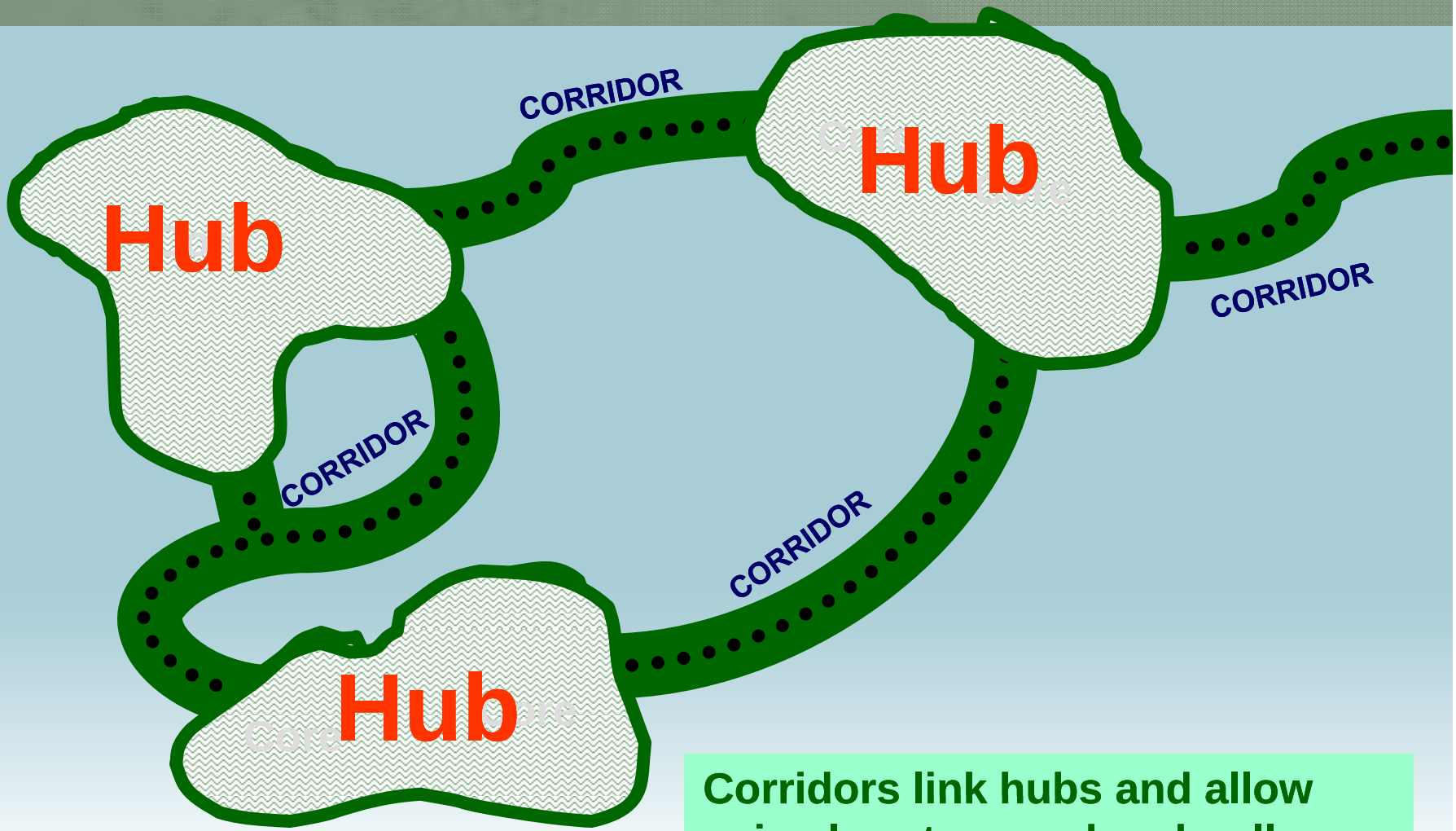


# Maryland's Green Infrastructure Assessment

## Composite of Ecological Features



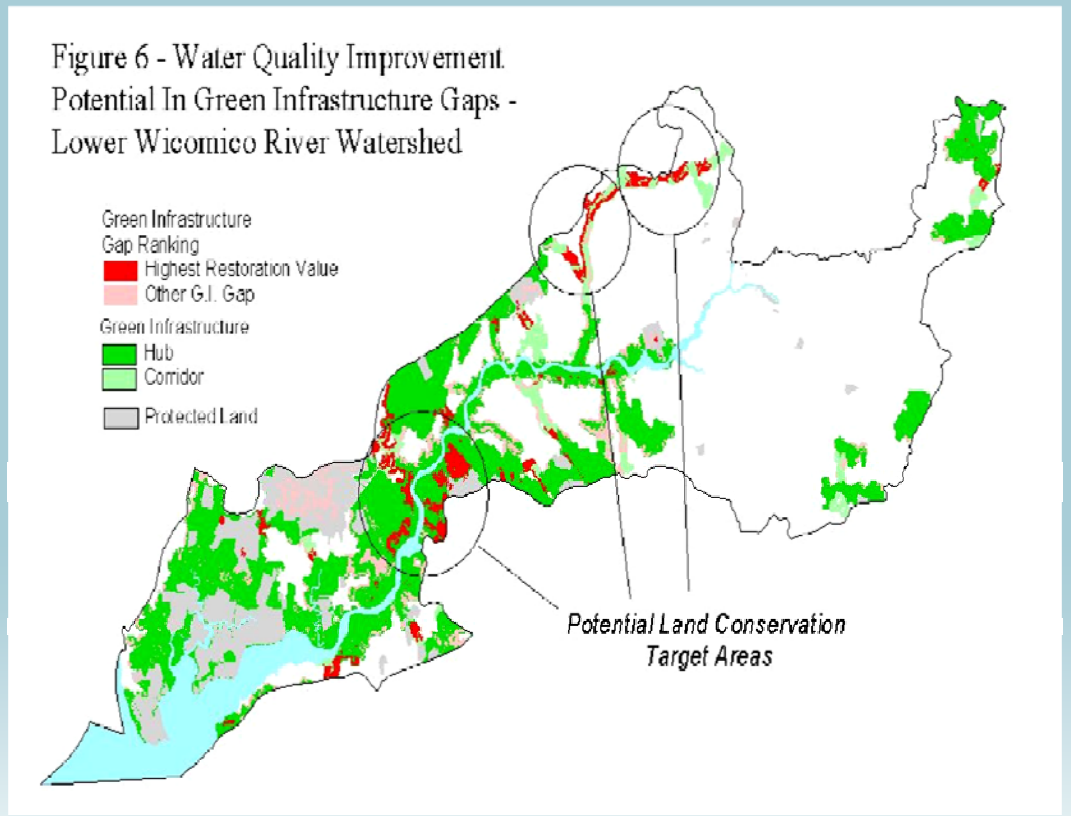
# The Green Network




**Corridors link hubs and allow animal, water, seed and pollen movement between hubs**

# GI Gaps – Repairing the Network and Restoring the Chesapeake Bay

- Undeveloped Gaps may be suitable for restoration activities
- Restoration benefits achieved at local and regional scales
- Hub and Corridor rankings can be used to prioritize restoration sites



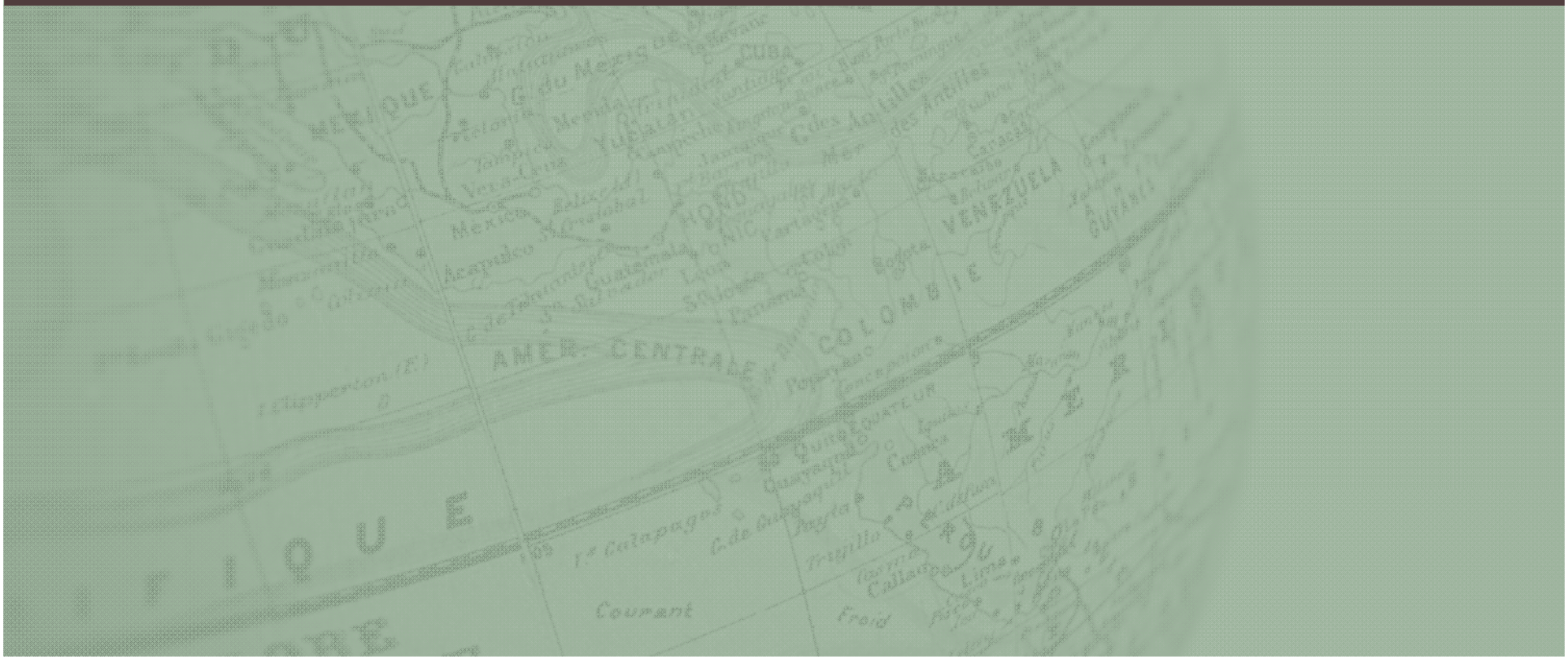
# Green Infrastructure Approach

"… a process that promotes a systematic and strategic approach to land conservation at the national, state, regional, and local scales encouraging land use planning and practices that are good for nature and people."

Mark A. Benedict, Edward T. McMahon, 2006, "Green Infrastructure"

# GREEN INFRASTRUCTURE STRATEGIC APPROACH

## US 301 Case Study



# US 301 Waldorf Area Transportation Improvements Project
# Maryland State Highway Administration

## Partners:

SHA

MARYLAND DEPARTMENT OF NATURAL RESOURCES

U.S. FISH & WILDLIFE SERVICE
DEPARTMENT OF THE INTERIOR

THE CONSERVATION FUND

# Conceptual Environmental Stewardship Process

**1. Stewardship Team Meeting Workshop**
Establish and confirm
- Process
- Roles
- Responsibilities
- Schedule

**2. IAWG ES Kick-off Workshop**
Establish and confirm
- Process
- Roles
- Responsibilities
- Schedule

**3. Identify ES Needs (ES Team and IAWG)**
Identify ES needs based on county policies and objectives and resource agency priorities

**4. Develop ES Process (ES Team and IAWG)**
a. Reevaluate green infrastructure parameters
   i. reassess applicable target species/ habitat
   ii. identify, define and incorporate additional parameters, as needed
   iii. finalize parameter ecological weighting factor
b. Identify process for identifying community opportunities with Community Resource Work Group
c. Assess existing data and identify data gaps and process for filling gaps
d. Update data gaps and baseline mapping
e. Define technical assessment protocols to rank opportunities by broad groups

**5. Perform ES Opportunity Identification**

**Natural Resources (Natural Resource Work Group with SHA oversight)**
a. Perform green infrastructure evaluation for US 301 Waldorf Area
b. Identify strategic opportunities based on gaps, important corridors, etc.
c. Categorize opportunities into broad groups tied to technical assessment protocols

**Community Resources (Community Resource Work Group with SHA oversight)**
a. Identify potential community opportunities for US 301 Waldorf Area
b. Categorize opportunities into broad groups tied to established protocols

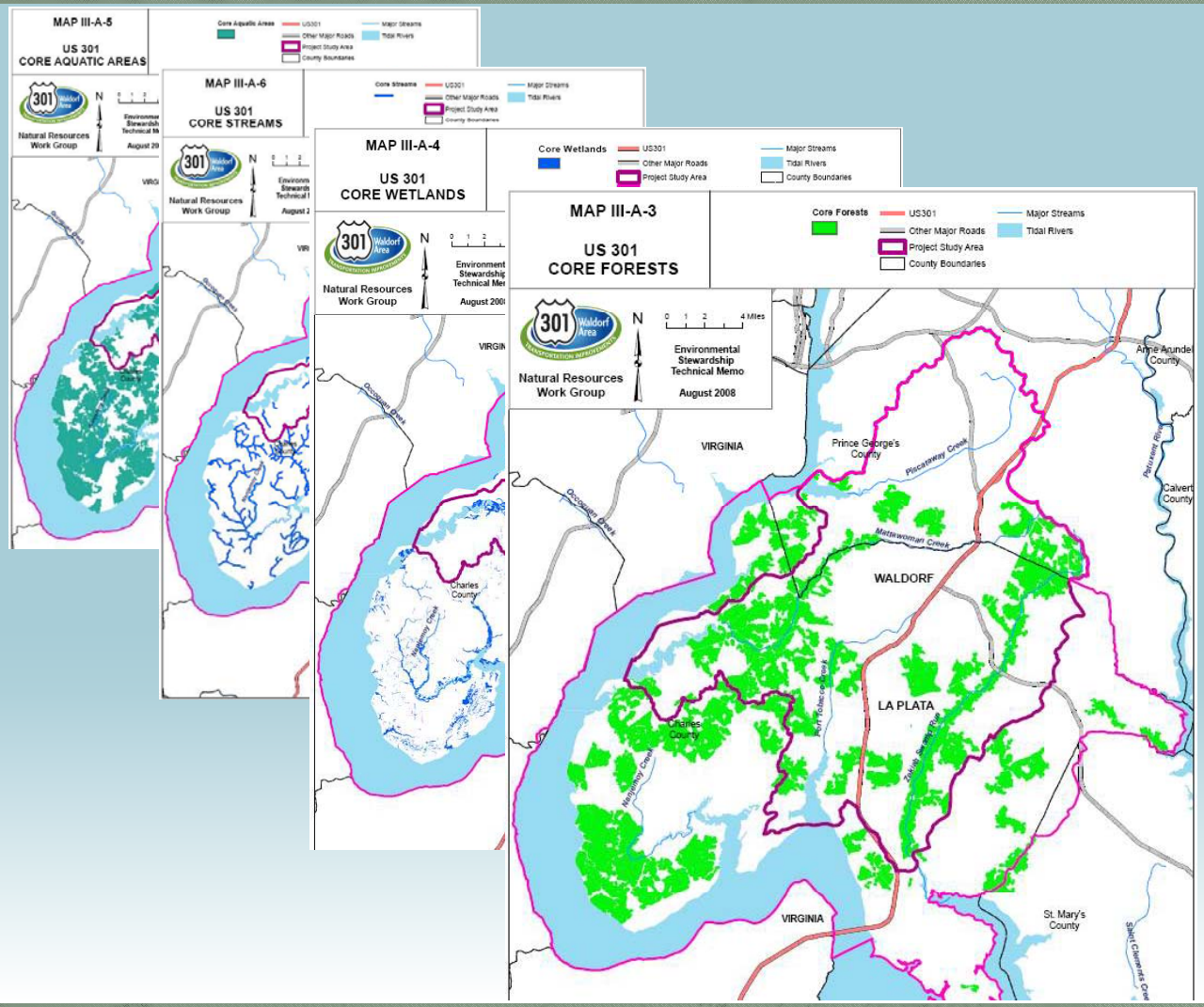
**6. Technical Assessment of ES Opportunities (ES Team with SHA oversight/assistance)**
a. Perform field assessment of opportunities based on established protocols
b. Rank opportunities based on scoring criteria

**7. Feasibility and Benefit/Cost Comparison of ES opportunities (SHA with IAWG oversight)**
a. Develop conceptual approach for implementation (construction, management, preservation, technical assistance, etc.)
b. Develop conceptual cost
c. Compare costs with ranking score to determine overall benefit effectiveness

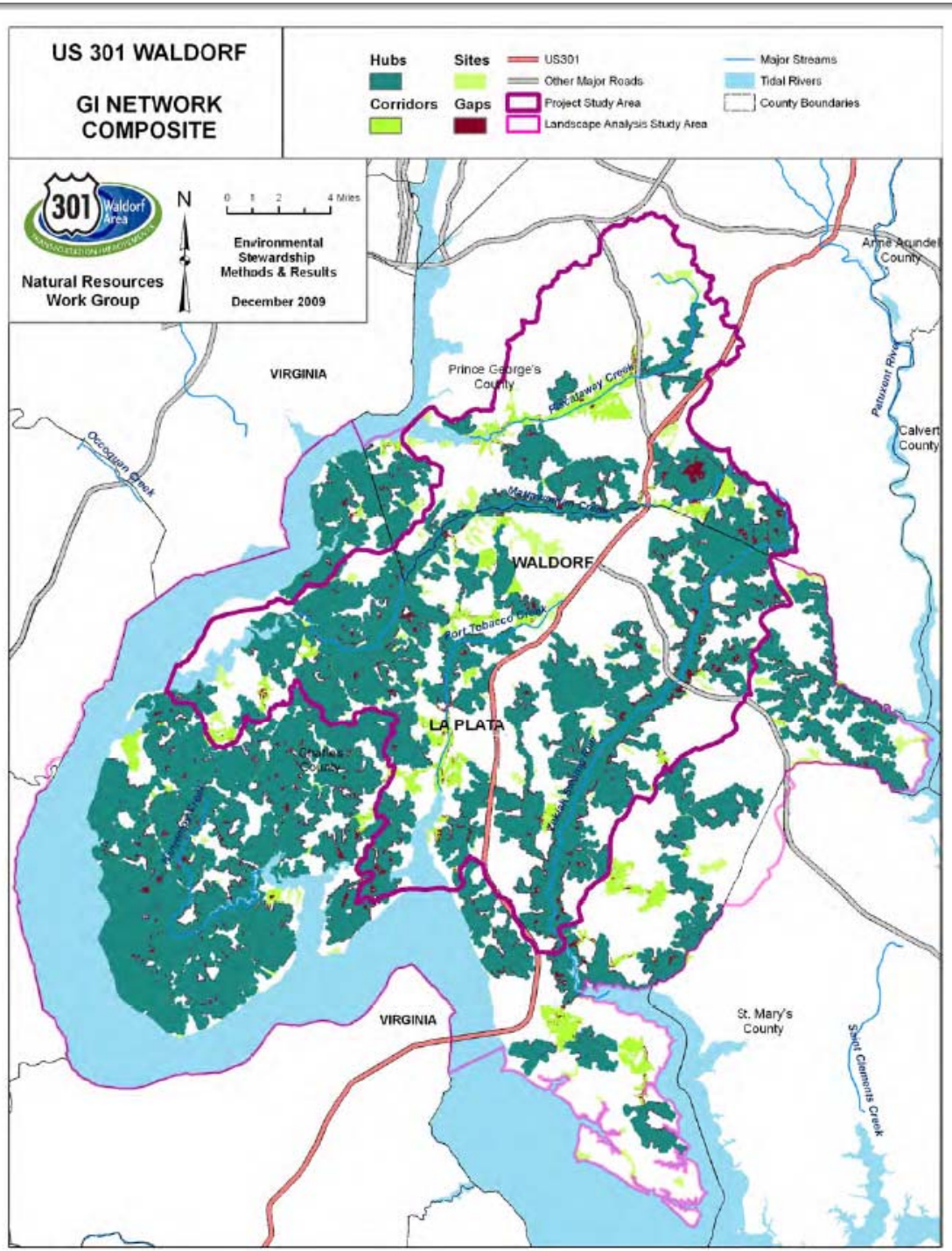
**8. Field View of ES Opportunities with IAWG**

**9. Prioritization of ES Opportunities (IAWG with SHA oversight)**
a. Compare ES opportunities with ES needs
b. Develop Prioritized list of recommended ES opportunities based on ES needs and benefit effectiveness

# US 301 Core Areas



# US 301 Study Green Infrastructure Network Composite



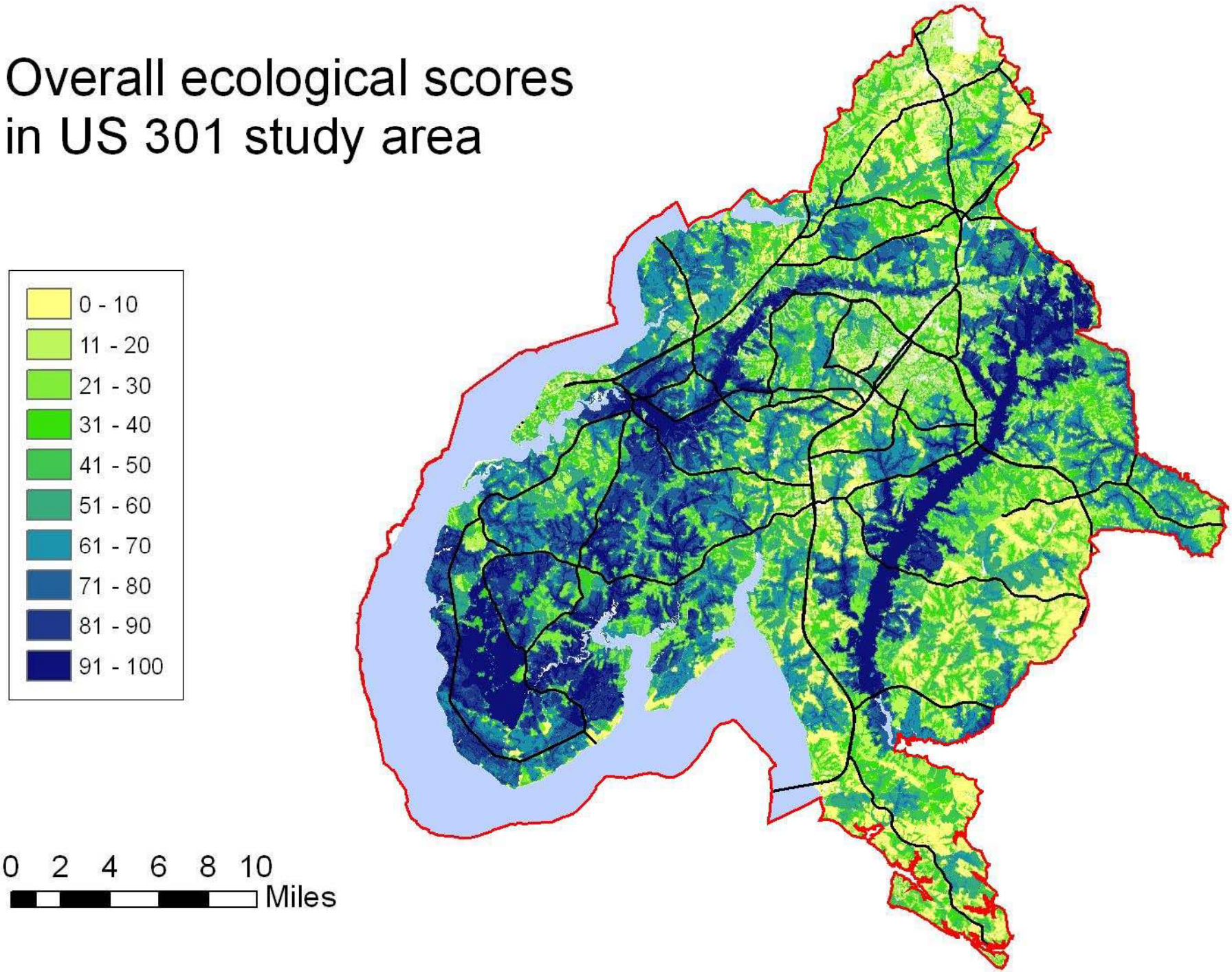
# Example of Ecological Scoring

- Ecological ranking factors and weights. Corridors and hubs do not overlap spatially;
- therefore variables and weights do not combine for these scales.
- Scale Variable Weight
- Core area/site Size of hub the core area is within (not
- in a hub: value of 0)
- 2.0
- Area of Ecologically Significant Areas 2.0
- Area of mature interior forest 2.0
- Area of minimally impacted wetlands 2.0
- Length of core streams 2.0

# US 301 Project Overall Ecological Score

| Scale | Variable | Scale weight | Variable weight within scale | Total weight |
|---|---|---|---|---|
| Core area/Site | Hub area | 20.0 | 0.100 | 2.0 |
| | ESA area | | 0.100 | 2.0 |
| | Area of mature interior forest | | 0.100 | 2.0 |
| | Area of unimpacted wetlands | | 0.100 | 2.0 |
| | Length of core streams | | 0.100 | 2.0 |
| | Maximum depth of core or site | | 0.100 | 2.0 |
| | Distance to major roads | | 0.100 | 2.0 |
| | Distance to development | | 0.100 | 2.0 |
| | Proximity index | | 0.100 | 2.0 |
| | Connectivity index | | 0.100 | 2.0 |
| Hub | ESA area | 20.0 | 0.182 | 3.6 |
| | Area of mature interior forest | | 0.182 | 3.6 |
| | Area of unimpacted wetlands | | 0.091 | 1.8 |
| | Length of core streams | | 0.091 | 1.8 |
| | Maximum depth of hub | | 0.091 | 1.8 |
| | Distance to major roads | | 0.091 | 1.8 |
| | Distance to development | | 0.091 | 1.8 |
| | Proximity index | | 0.091 | 1.8 |
| | Connectivity index | | 0.091 | 1.8 |
| Corridor | Average rank of linked hubs | 10.0 | 0.333 | 3.3 |
| | Number of hubs linked | | 0.333 | 3.3 |
| | Major road crossings without bridges | | 0.333 | 3.3 |
| 8-digit watershed | Anadromous fish spawning habitat use | 10.0 | 0.500 | 5.0 |
| | Percent core streams in watershed | | 0.500 | 5.0 |
| 12-digit watershed | Stronghold watershed (Tier 1/Tier 2/neither) | 10.0 | 0.500 | 5.0 |
| | Mean combined IBI score | | 0.500 | 5.0 |
| Grid cell (36 $m^2$) | ESA presence and rank | 40.0 | 0.071 | 2.9 |
| | Ecological Community Group rank | | 0.071 | 2.9 |
| | Forest maturity | | 0.286 | 11.4 |
| | Wetland condition and proximity | | 0.143 | 5.7 |
| | Proximity to core streams | | 0.143 | 5.7 |
| | Proximity to water | | 0.143 | 5.7 |
| | Distance to edge of forest, wetland, or water | | 0.143 | 5.7 |
| | Distance to development | | 0.000 | 0.0 |
| **TOTAL** | | **100.0** | | **100.0** |

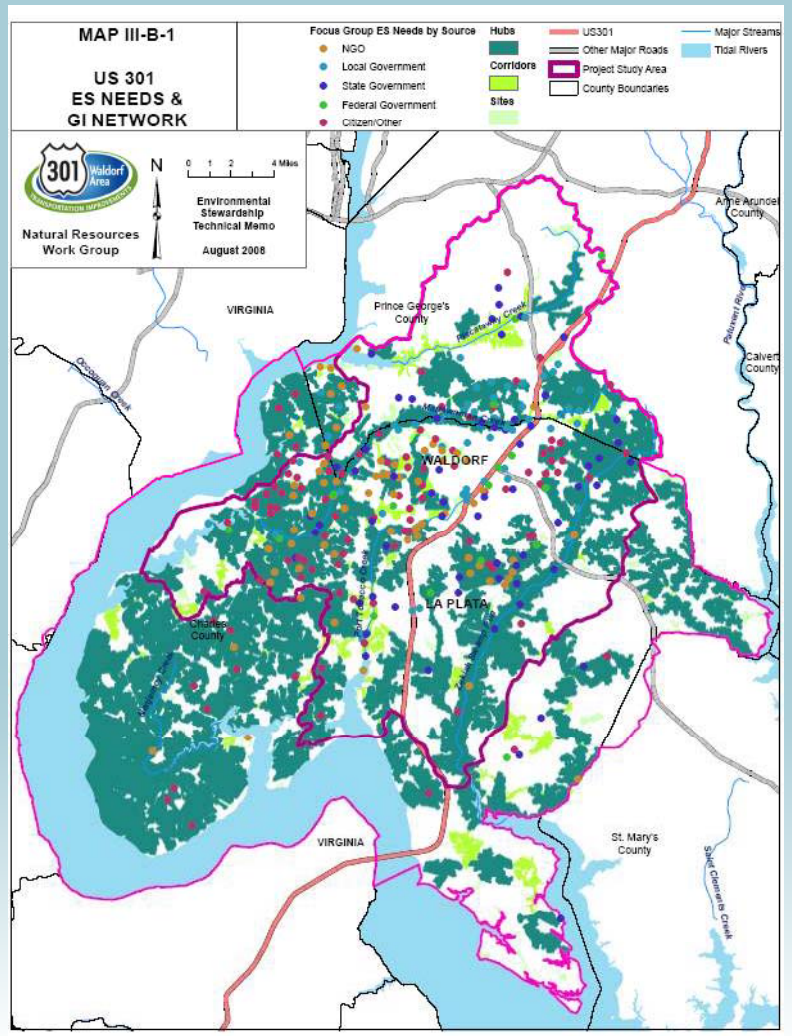
# Overall ecological scores in US 301 study area



# Hub and Corridor Network
# Environmental Stewardship Needs

| Environmental Stewardship Activities | |
|---|---|
| Conservation / Preservation | **60%** |
| Restoration / Creation | 18% |
| Management Actions | 11% |
| Recreation / Public Access to Open Space | 11% |

| Priority Natural Resources | |
|---|---|
| Forests | **22%** |
| Streams and Aquatic Resources | 19% |
| Wetlands | 17% |
| Marine Fisheries | 10% |
| Species Habitat | 11% |
| Passive Recreation Areas | 5% |
| Historic/Archeological | 6% |
| Agriculture | 9% |



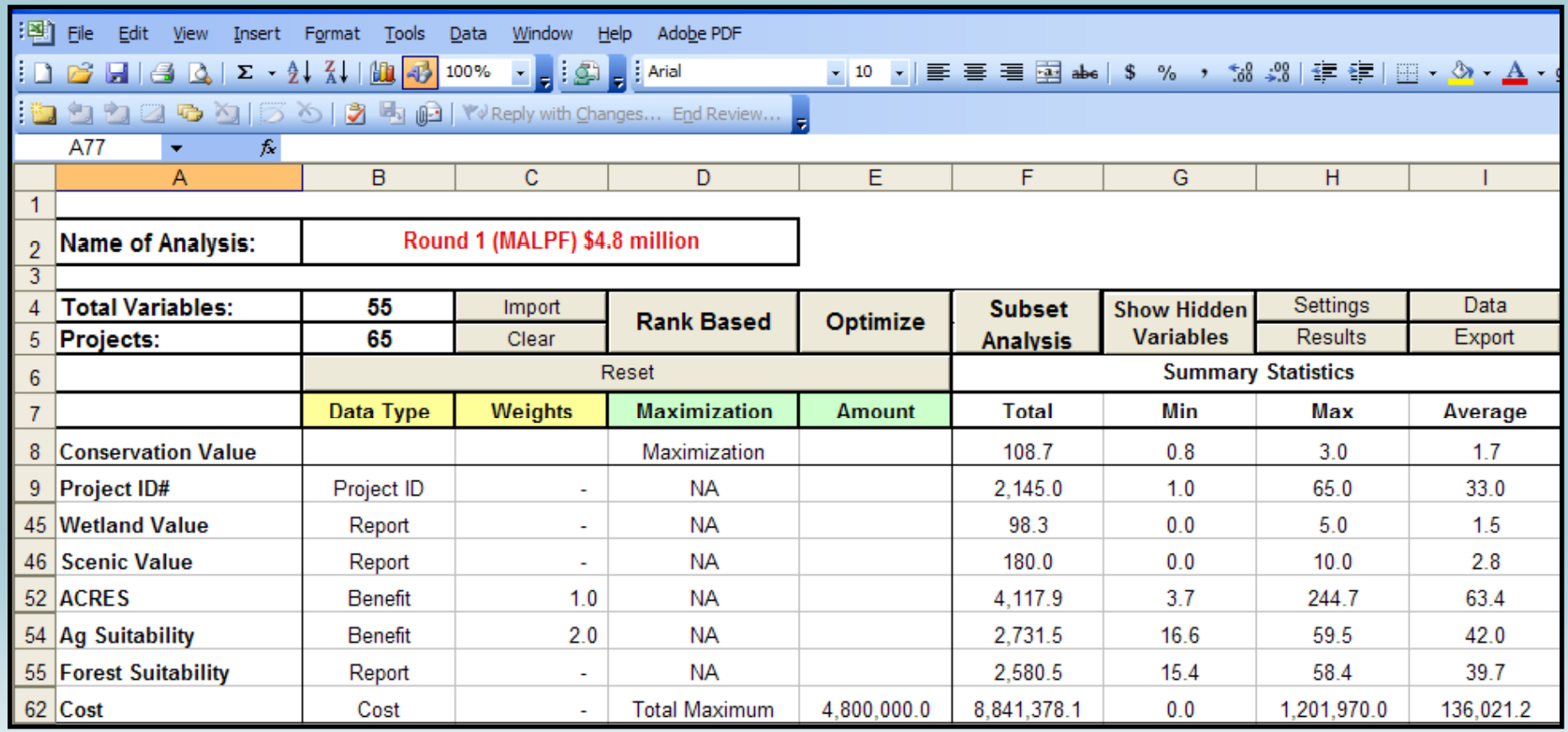
# US 301 NEXT STEPS

- Field truth opportunities
- Select sites
- Establish protocols for future transportation projects

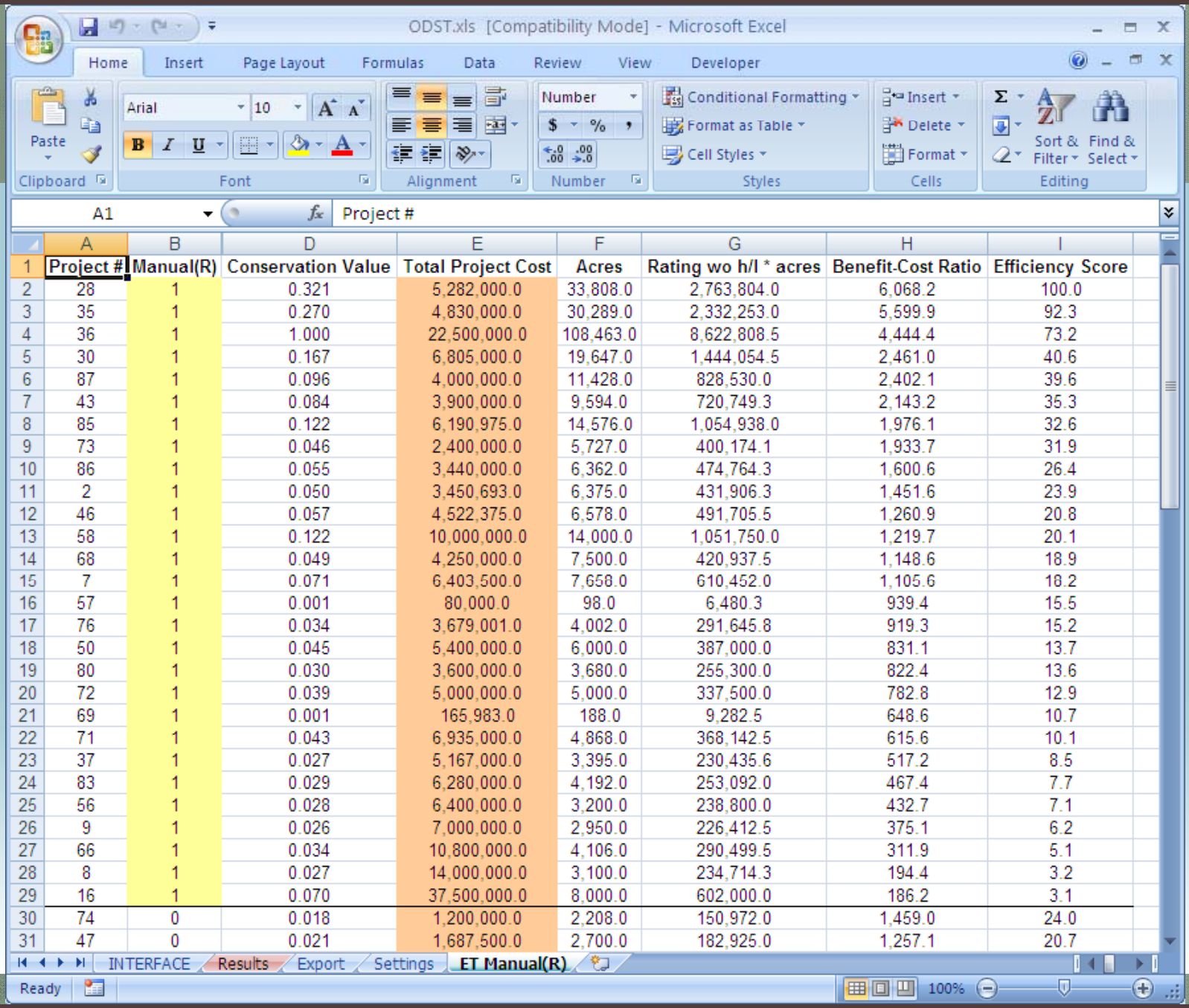
# Project Selection Methods

- Government agencies and NGOs typically use a rank-based approach to select projects for implementation.
- The rank-based approach focuses only on the benefits of a project without considering the project's cost, which can result in highly inefficient investments.
- It ignores potential "good buys" that offer high quality (environmental benefits) at a significantly lower cost.
- The use of optimization in project selection provides a means to extend the reach and effectiveness of environmental efforts.

# Optimization Model

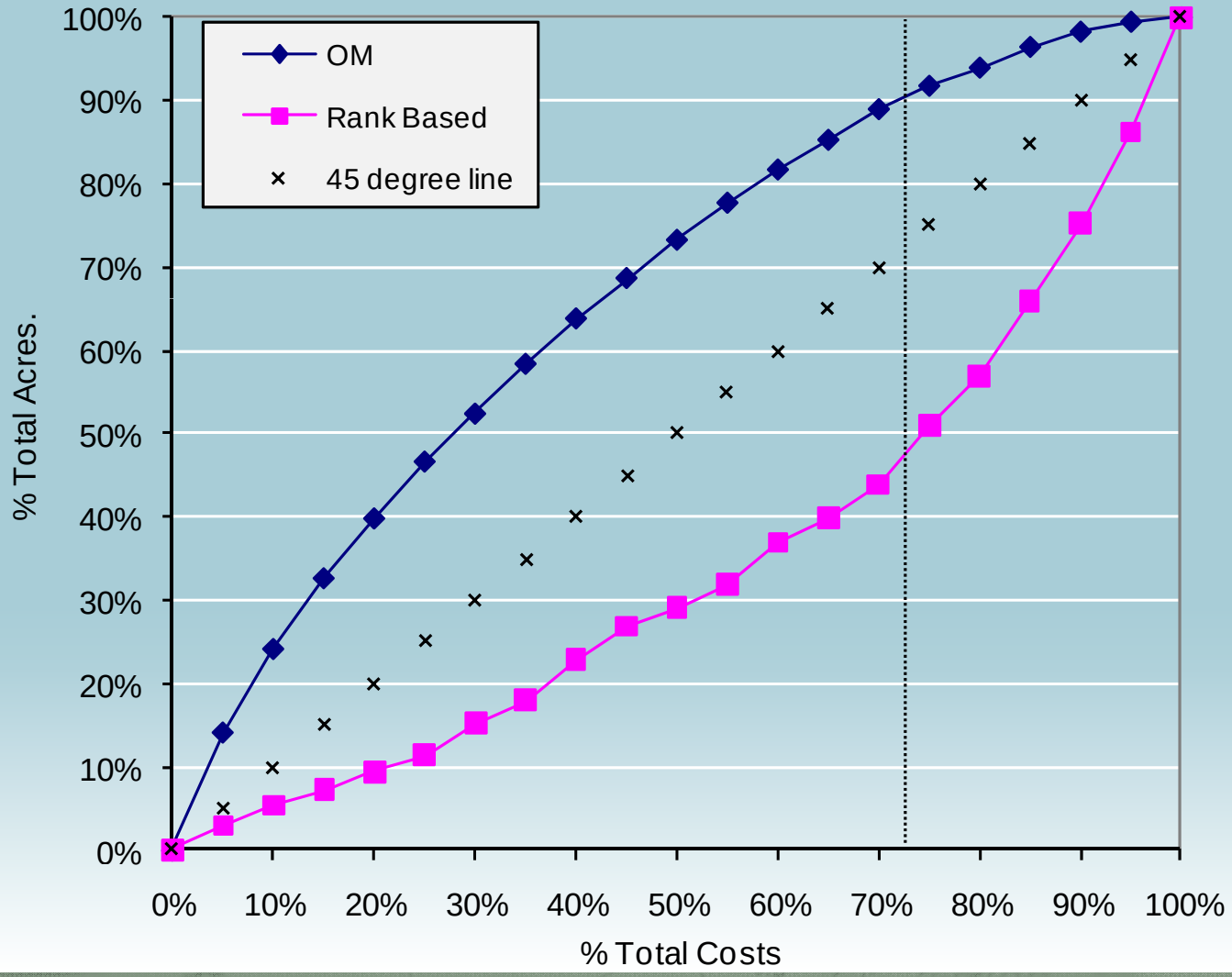


| | A | B | C | D | E | F | G | H | I |
|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | | | | | | |
| 2 | **Name of Analysis:** | Round 1 (MALPF) $4.8 million | | | | | | | |
| 3 | | | | | | | | | |
| 4 | **Total Variables:** | **55** | Import | **Rank Based** | **Optimize** | **Subset Analysis** | **Show Hidden Variables** | Settings | Data |
| 5 | **Projects:** | **65** | Clear | | | | | Results | Export |
| 6 | | Reset | | | | **Summary Statistics** | | | |
| 7 | | **Data Type** | **Weights** | **Maximization** | **Amount** | **Total** | **Min** | **Max** | **Average** |
| 8 | **Conservation Value** | | | Maximization | | 108.7 | 0.8 | 3.0 | 1.7 |
| 9 | **Project ID#** | Project ID | - | NA | | 2,145.0 | 1.0 | 65.0 | 33.0 |
| 45 | **Wetland Value** | Report | - | NA | | 98.3 | 0.0 | 5.0 | 1.5 |
| 46 | **Scenic Value** | Report | - | NA | | 180.0 | 0.0 | 10.0 | 2.8 |
| 52 | **ACRES** | Benefit | 1.0 | NA | | 4,117.9 | 3.7 | 244.7 | 63.4 |
| 54 | **Ag Suitability** | Benefit | 2.0 | NA | | 2,731.5 | 16.6 | 59.5 | 42.0 |
| 55 | **Forest Suitability** | Report | - | NA | | 2,580.5 | 15.4 | 58.4 | 39.7 |
| 62 | **Cost** | Cost | - | Total Maximum | 4,800,000.0 | 8,841,378.1 | 0.0 | 1,201,970.0 | 136,021.2 |




| | A | B | D | E | F | G | H | I |
|---|---|---|---|---|---|---|---|---|
| 1 | Project # | Manual(R) | Conservation Value | Total Project Cost | Acres | Rating wo h/l * acres | Benefit-Cost Ratio | Efficiency Score |
| 2 | 28 | 1 | 0.321 | 5,282,000.0 | 33,808.0 | 2,763,804.0 | 6,068.2 | 100.0 |
| 3 | 35 | 1 | 0.270 | 4,830,000.0 | 30,289.0 | 2,332,253.0 | 5,599.9 | 92.3 |
| 4 | 36 | 1 | 1.000 | 22,500,000.0 | 108,463.0 | 8,622,808.5 | 4,444.4 | 73.2 |
| 5 | 30 | 1 | 0.167 | 6,805,000.0 | 19,647.0 | 1,444,054.5 | 2,461.0 | 40.6 |
| 6 | 87 | 1 | 0.096 | 4,000,000.0 | 11,428.0 | 828,530.0 | 2,402.1 | 39.6 |
| 7 | 43 | 1 | 0.084 | 3,900,000.0 | 9,594.0 | 720,749.3 | 2,143.2 | 35.3 |
| 8 | 85 | 1 | 0.122 | 6,190,975.0 | 14,576.0 | 1,054,938.0 | 1,976.1 | 32.6 |
| 9 | 73 | 1 | 0.046 | 2,400,000.0 | 5,727.0 | 400,174.1 | 1,933.7 | 31.9 |
| 10 | 86 | 1 | 0.055 | 3,440,000.0 | 6,362.0 | 474,764.3 | 1,600.6 | 26.4 |
| 11 | 2 | 1 | 0.050 | 3,450,693.0 | 6,375.0 | 431,906.3 | 1,451.6 | 23.9 |
| 12 | 46 | 1 | 0.057 | 4,522,375.0 | 6,578.0 | 491,705.5 | 1,260.9 | 20.8 |
| 13 | 58 | 1 | 0.122 | 10,000,000.0 | 14,000.0 | 1,051,750.0 | 1,219.7 | 20.1 |
| 14 | 68 | 1 | 0.049 | 4,250,000.0 | 7,500.0 | 420,937.5 | 1,148.6 | 18.9 |
| 15 | 7 | 1 | 0.071 | 6,403,500.0 | 7,658.0 | 610,452.0 | 1,105.6 | 18.2 |
| 16 | 57 | 1 | 0.001 | 80,000.0 | 98.0 | 6,480.3 | 939.4 | 15.5 |
| 17 | 76 | 1 | 0.034 | 3,679,001.0 | 4,002.0 | 291,645.8 | 919.3 | 15.2 |
| 18 | 50 | 1 | 0.045 | 5,400,000.0 | 6,000.0 | 387,000.0 | 831.1 | 13.7 |
| 19 | 80 | 1 | 0.030 | 3,600,000.0 | 3,680.0 | 255,300.0 | 822.4 | 13.6 |
| 20 | 72 | 1 | 0.039 | 5,000,000.0 | 5,000.0 | 337,500.0 | 782.8 | 12.9 |
| 21 | 69 | 1 | 0.001 | 165,983.0 | 188.0 | 9,282.5 | 648.6 | 10.7 |
| 22 | 71 | 1 | 0.043 | 6,935,000.0 | 4,868.0 | 368,142.5 | 615.6 | 10.1 |
| 23 | 37 | 1 | 0.027 | 5,167,000.0 | 3,395.0 | 230,435.6 | 517.2 | 8.5 |
| 24 | 83 | 1 | 0.029 | 6,280,000.0 | 4,192.0 | 253,092.0 | 467.4 | 7.7 |
| 25 | 56 | 1 | 0.028 | 6,400,000.0 | 3,200.0 | 238,800.0 | 432.7 | 7.1 |
| 26 | 9 | 1 | 0.026 | 7,000,000.0 | 2,950.0 | 226,412.5 | 375.1 | 6.2 |
| 27 | 66 | 1 | 0.034 | 10,800,000.0 | 4,106.0 | 290,499.5 | 311.9 | 5.1 |
| 28 | 8 | 1 | 0.027 | 14,000,000.0 | 3,100.0 | 234,714.3 | 194.4 | 3.2 |
| 29 | 16 | 1 | 0.070 | 37,500,000.0 | 8,000.0 | 602,000.0 | 186.2 | 3.1 |
| 30 | 74 | 0 | 0.018 | 1,200,000.0 | 2,208.0 | 150,972.0 | 1,459.0 | 24.0 |
| 31 | 47 | 0 | 0.021 | 1,687,500.0 | 2,700.0 | 182,925.0 | 1,257.1 | 20.7 |

# Differences in Selection Models



# Project Selection Using Optimization

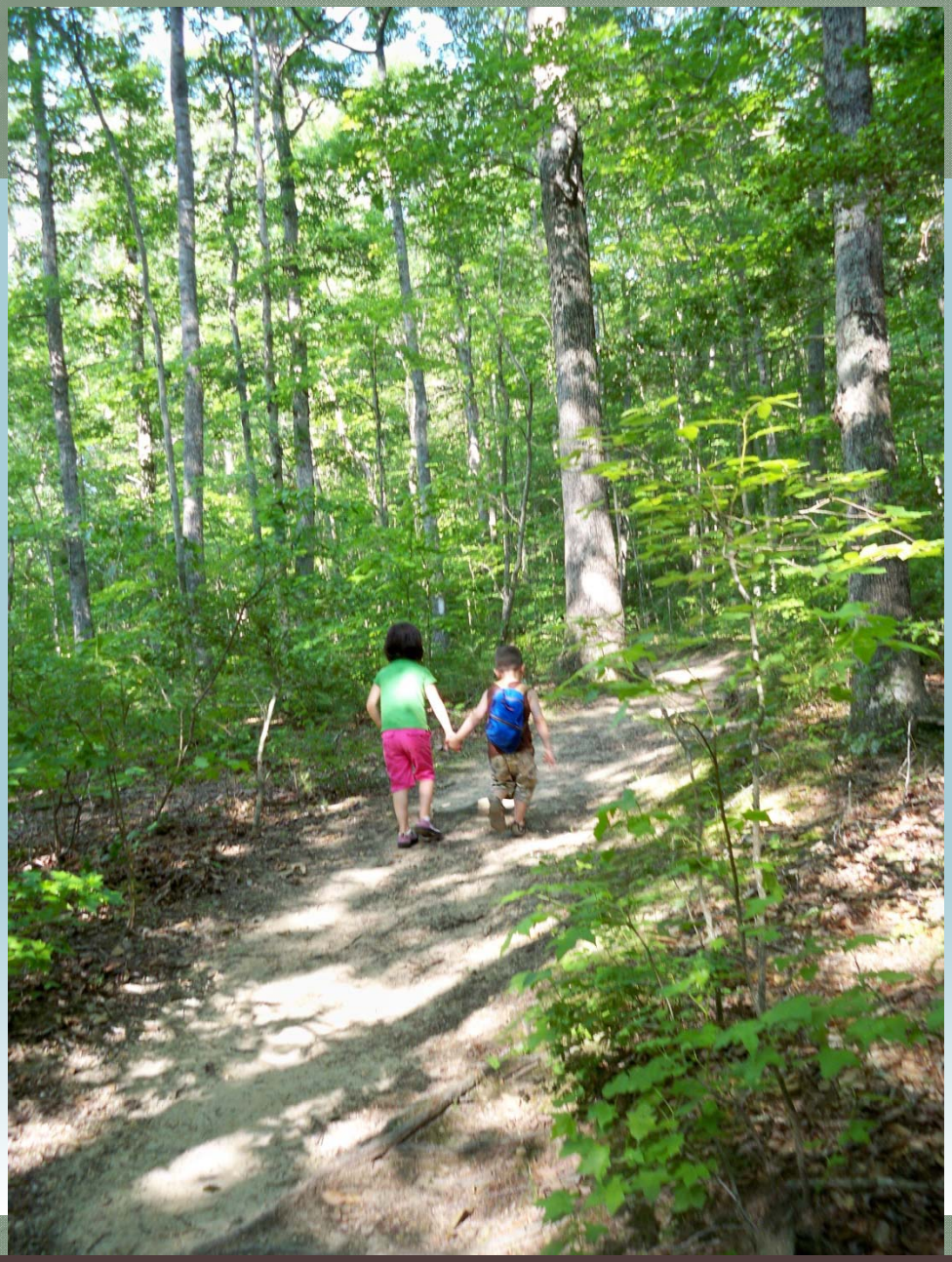
- Optimization Decision Support Tool requirements
  - **Opportunities** (Environmental stewardship projects)
  - **Benefits** (Project benefit scoring/ranking)
  - **Costs** (Financial investment required to achieve benefits)
  - **Constraints** (Budget scenario, other decision constraints)
- Tool benefits
  - Easy to use (Excel interface)
  - Flexible (answer multiple planning questions)
  - Ability to run multiple scenarios (sensitivity analysis)
  - Potential to extend limited funds for compensatory mitigation and environmental stewardship

# Why Use These Tools?

- Compliance with existing regulations
- Defensible decisions
- Accelerated project delivery
- Improved resource protection
- Sustainable planning
- Supports a watershed approach
- Scalable solution
- Can be integrated with existing GIS data

# Why Use These Tools?

Because we can't afford not to.



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