

From Shapefiles to Megawatts: Modeling Land Use Suitability for Renewable Energy Alternatives

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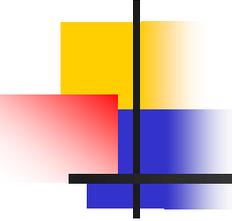
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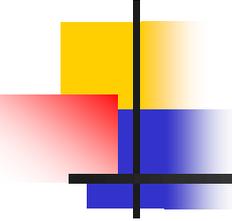
GIS Cooperative Presentation

September 14, 2012



Presentation Outline

- Context
- Research Problem & Objectives
- Modeling Approach
 - Renewable Energy Opportunity Analysis (REOA)
- Results
- Applications & Limitations
- Conclusions & Future Work



Research Context



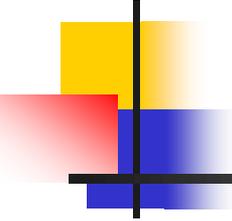
- Land Grant University
- Cooperative Extension
- Economic Development Administration (EDA) Grant
- Regional Center for Sustainable Economic Development
 - Focus on Arizona's strengths & weaknesses
 - Strong, resilient economies
 - Sustainable and just economic system
 - Harness community strengths



Renewable Energy Program

- Provide jurisdictions with best information for renewable energy development
- Sustainable & economic development
- Renewable energy land use suitability analyses
 - Solar, wind, geothermal, and bioenergy





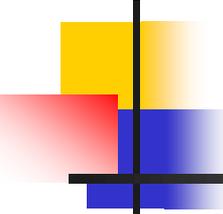
Research Problem & Objectives

■ PROBLEM

- Find the most capable and suitable locations for renewable energy facilities at the county level for Arizona.
- Currently focusing on solar energy (CSP & Solar Arrays)

■ OBJECTIVES

- Produce ranked suitability maps for different project sizes that identify locations of low, moderate, and high suitability.
- Disseminate results to stakeholders.



Solar Energy Considerations

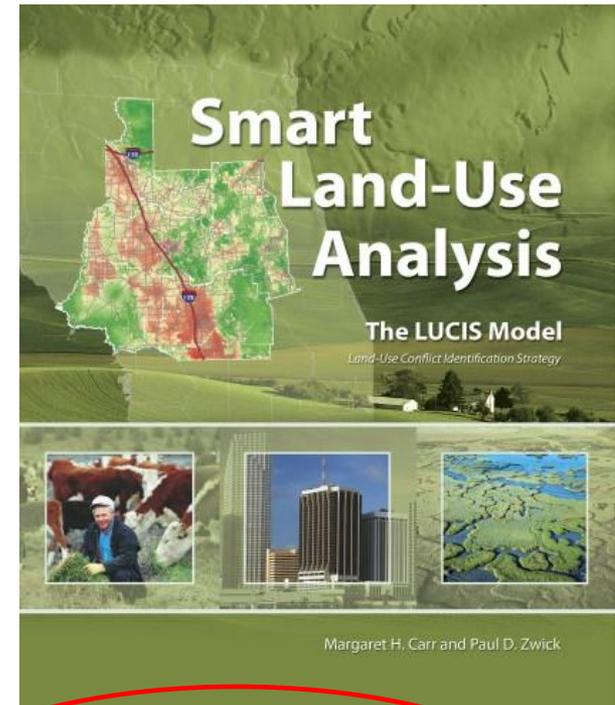
- High estimates of solar radiation in AZ
- AZ mandate: 15% power from renewables by 2025
- Project Scale
 - Small Scale: 5 megawatts or less
 - Large Scale: Greater than 5 megawatts
- 5 Megawatt Solar Array
 - 10 acres per megawatt w/ ~ 79,000 panels
 - 2-3 months construction w/ 60 -75 construction jobs
 - Cost ~ \$23 millions
 - Can power 3,000 – 4,000 homes

Solar Energy



Modeling Approach

- LUCIS: Land-Use Conflict Identification Strategy
- Spatial representation of current & probable future land-use & conflict
- Preference & conflict
- Customized to regions
- LUCIS adapted to fit theme of renewable energy →
- RECIS: Renewable Energy Conflict Identification Strategy →

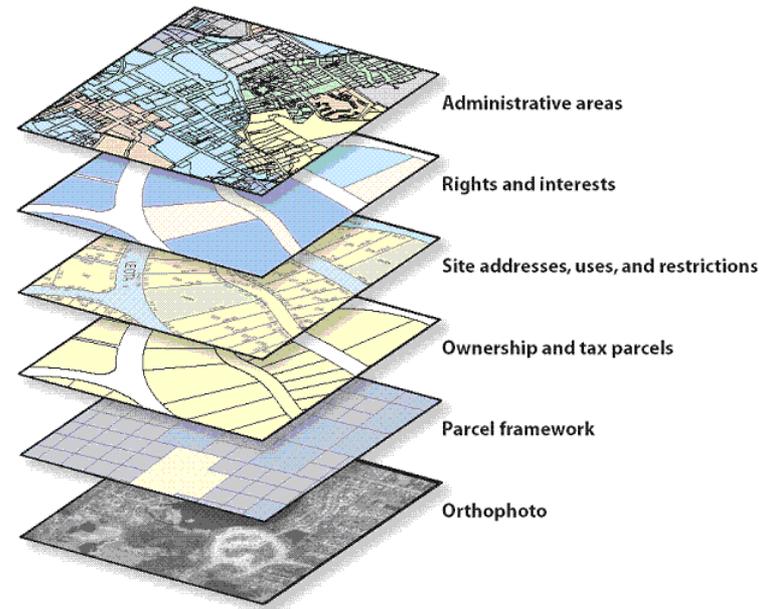


(Carr & Zwick, 2007)

REOA: Renewable Energy Opportunity Analysis

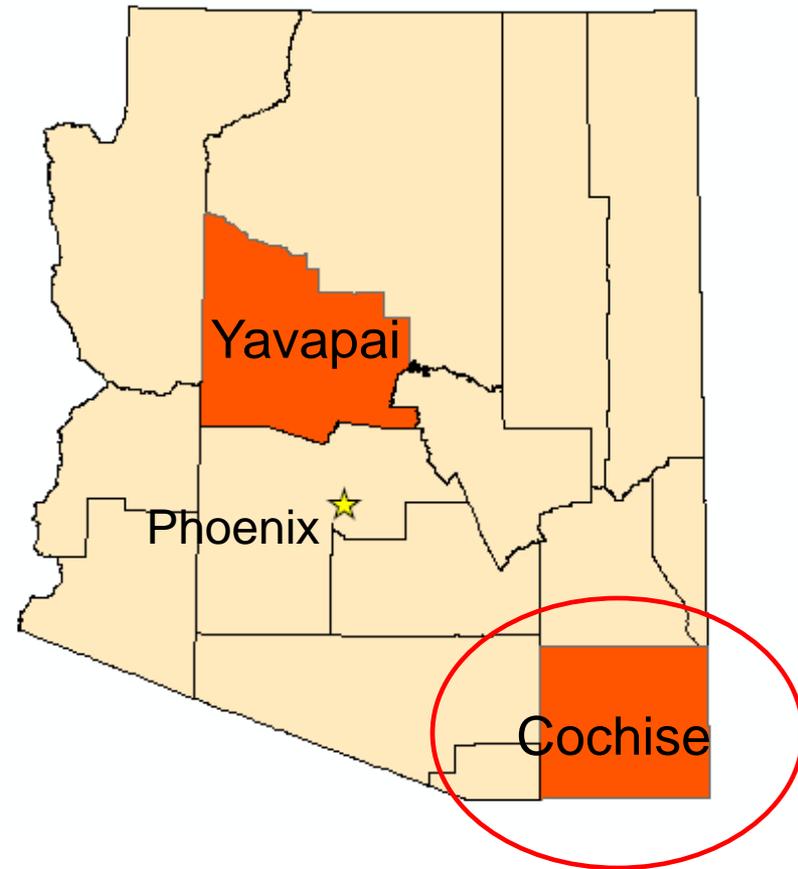
Renewable Energy Opportunity Analysis (REOA)

- Assess physical & economic constraints
- GIS-based process
 - Spatial location & attributes
 - Systematic, multi-factor analysis
- Where is the best location for x?
 - Intrinsic characteristics of landscape
 - Capability vs. suitability



Current Study Sites

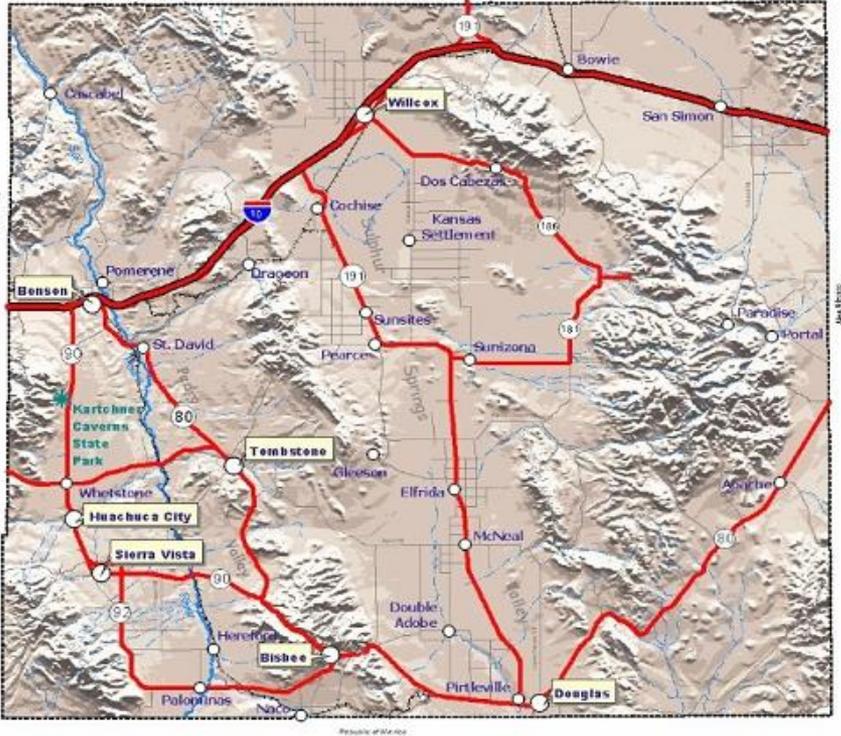
- Cochise County, Arizona
- Yavapai County, Arizona



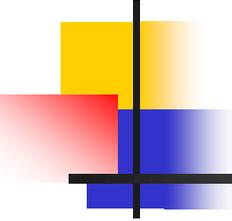
Cochise County

Incorporated Communities:

- Bisbee
- Willcox
- Sierra Vista
- Tombstone
- Douglas
- Benson
- Huachuca City

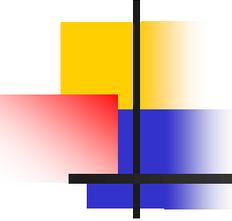


6200 sq. miles
 40% Private
 35% State Trust Land
 25% Federal



Renewable Energy Opportunity Analysis (REOA)

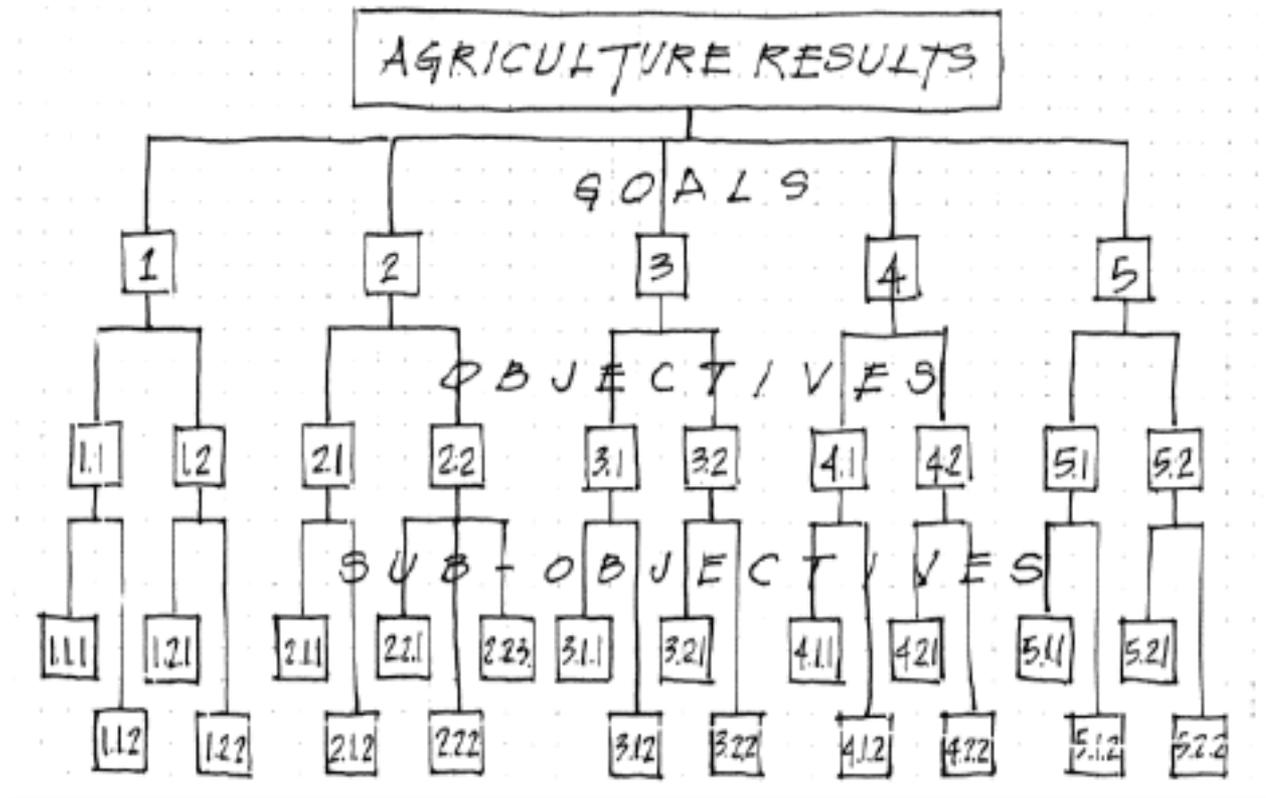
- Step 1: Goals & Objectives
- Step 2: Data Inventory
- Step 3: Capable Areas
- Step 4: Suitable Areas

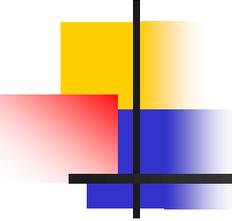


Renewable Energy Opportunity Analysis (REOA)

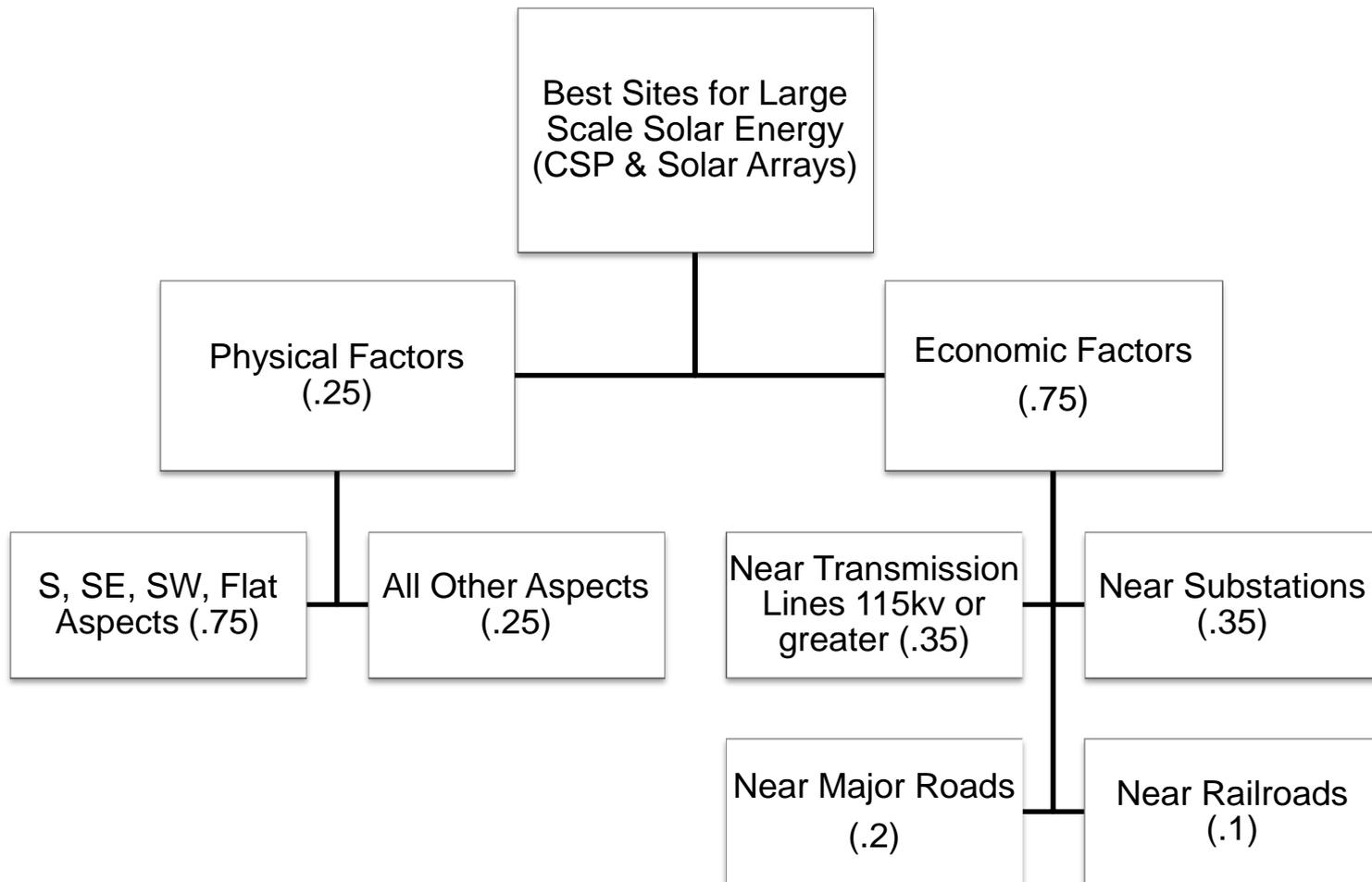
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Goals & Objectives

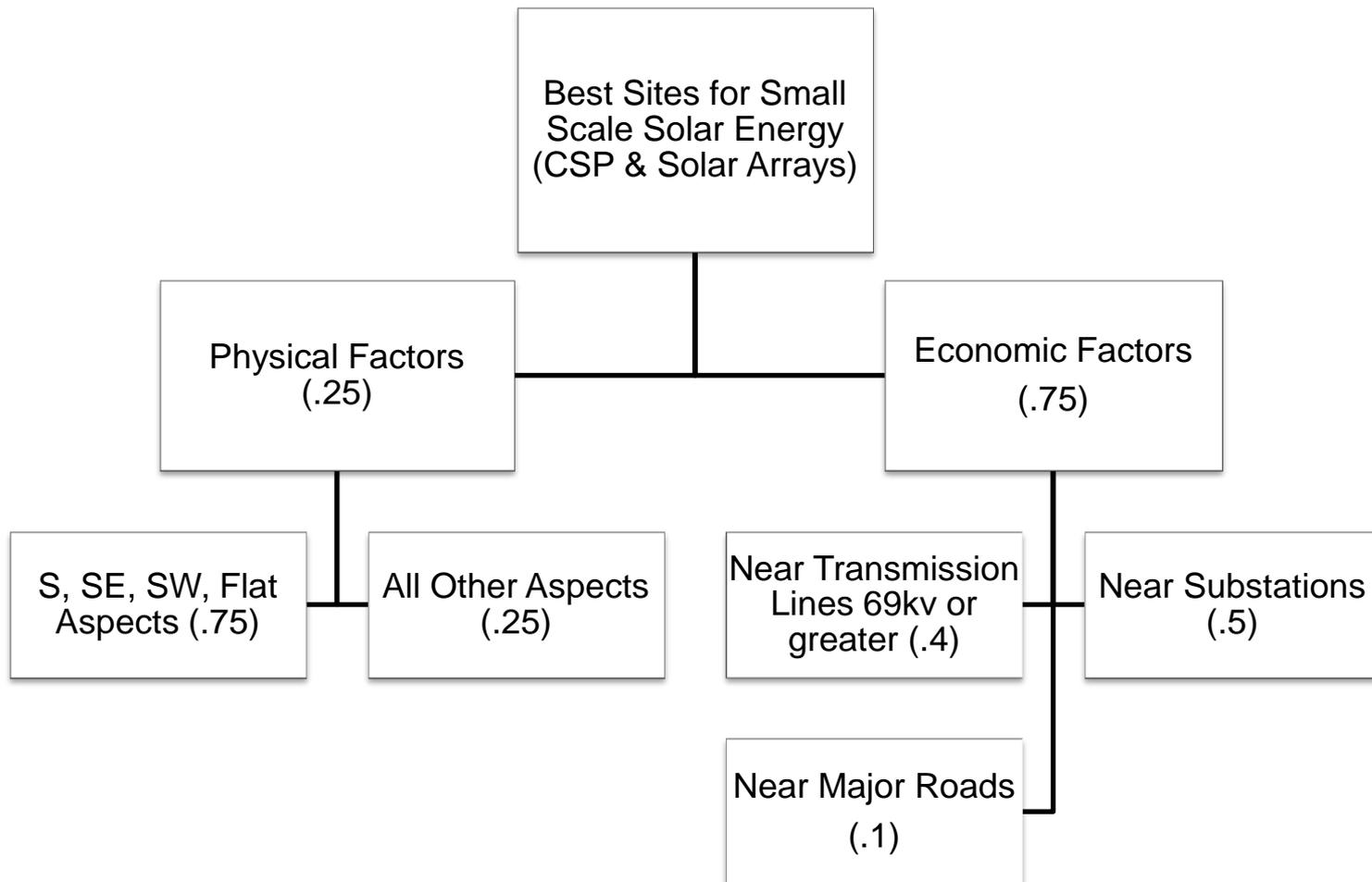


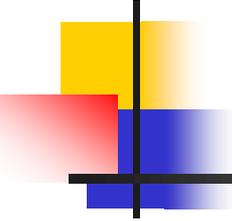


Large Scale Solar Suitability



Small Scale Solar Suitability





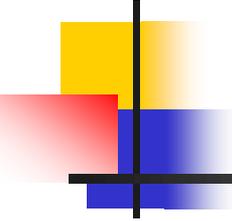
Renewable Energy Opportunity Analysis (REOA)

- Step 1: Goals & Objectives
- **Step 2: Data Inventory**
- Step 3: Capable Areas
- Step 4: Suitable Areas

Data Inventory & Management

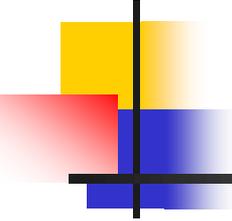
- Data Sources:
 - Cochise County GIS, AZ State Cartographer, NREL, Southern AZ Data Services Program, Arizona Land Resource Information System
- Storage: ArcCatalog Geodatabase
- Cell Size: ~0.003 acre (10 x 10m)
- Model Extent: Cochise County
- Modeling: ArcGIS ModelBuilder

- [-] [Globe] CochiseREOA120511
 - [+] [Folder] BaseLayers
 - [+] [Folder] EconomicFactors
 - [+] [Folder] PhysicalFactors
 - [+] [Grid] aspect
 - [+] [Grid] aspect_sun
 - [+] [Grid] aspectNS
 - [+] [Grid] focal_1442
 - [+] [Grid] focal_range
 - [+] [Grid] hillshade
 - [+] [Grid] hillshade10
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 - [+] [Mask] mask_final_military
 - [+] [Mask] mask_working
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 - [+] [Mask] slope_capable
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 - [+] [Table] Sol_suit_sml
 - [+] [Table] solar_suit_lrg
 - [+] [Table] solar_suit_sml



Renewable Energy Opportunity Analysis (REOA)

- Step 1: Goals & Objectives
- Step 2: Data Inventory
- **Step 3: Capable Areas**
- Step 4: Suitable Areas



Capable Areas

- **Capability (Musts)**

- Absolute Constraints
- Must meet certain criteria
- Incapable areas create model mask
 - Solar Insolation (7 kWh / meter² / day)
 - Land Owners, Streams/ Rivers, Slope, Soils, etc

- **Suitability (Shoulds)**

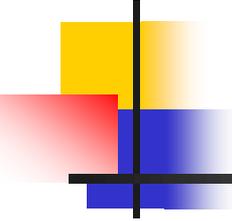
- Relative constraints/ weights
- Weighted based on stakeholder/ expert knowledge/ G&O
 - Aspect, proximity to transmission lines, substations, roads, railroads

Capable Areas → Model Mask

- Land ownership & use
 - Removed NPS, USFS, State Parks, Conservation/ Wilderness areas
- Major streams
 - 600' total foot buffer from centerline
- Erodible soils
- Slope
 - Removed all > ~ 2%



Areas in tan are capable in Cochise County

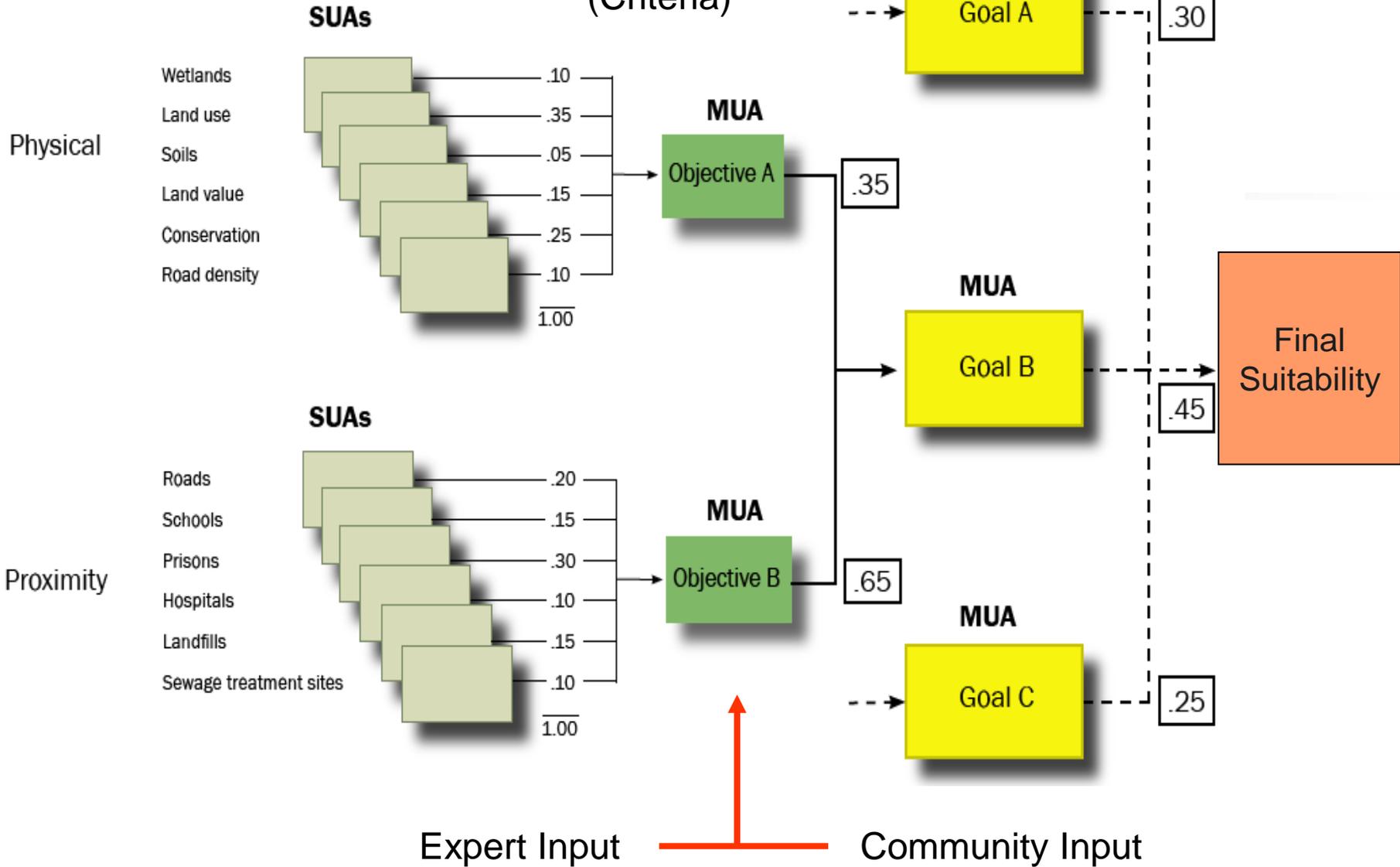


Renewable Energy Opportunity Analysis (REOA)

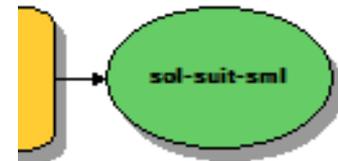
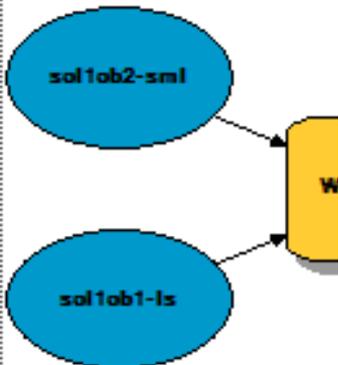
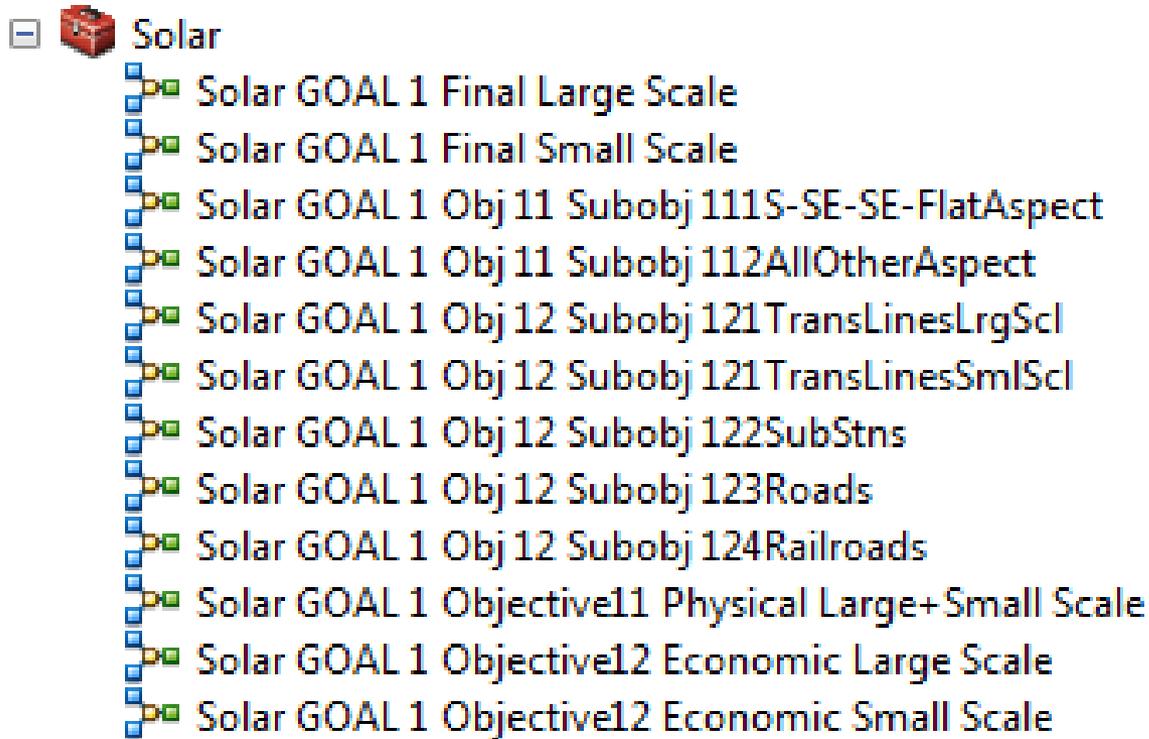
- Step 1: Goals & Objectives
- Step 2: Data Inventory
- Step 3: Capable Areas
- **Step 4: Suitable Areas**

Multiple Utility Assignment II

Goals & Objectives (Criteria)

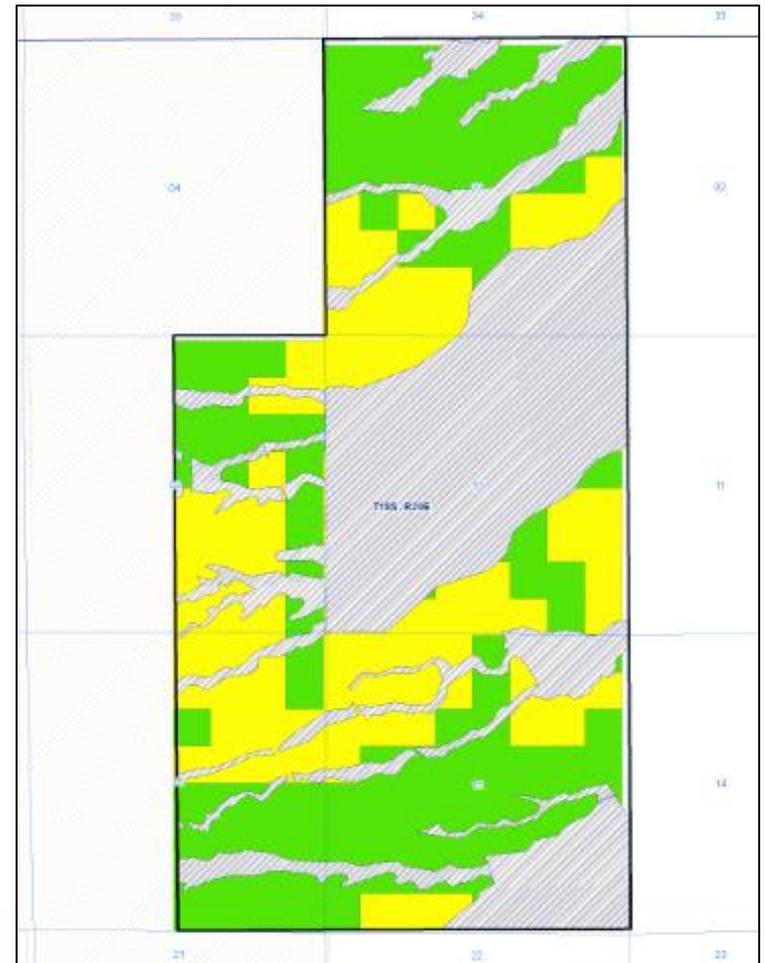


Modeling Suitability



Additional Constraints

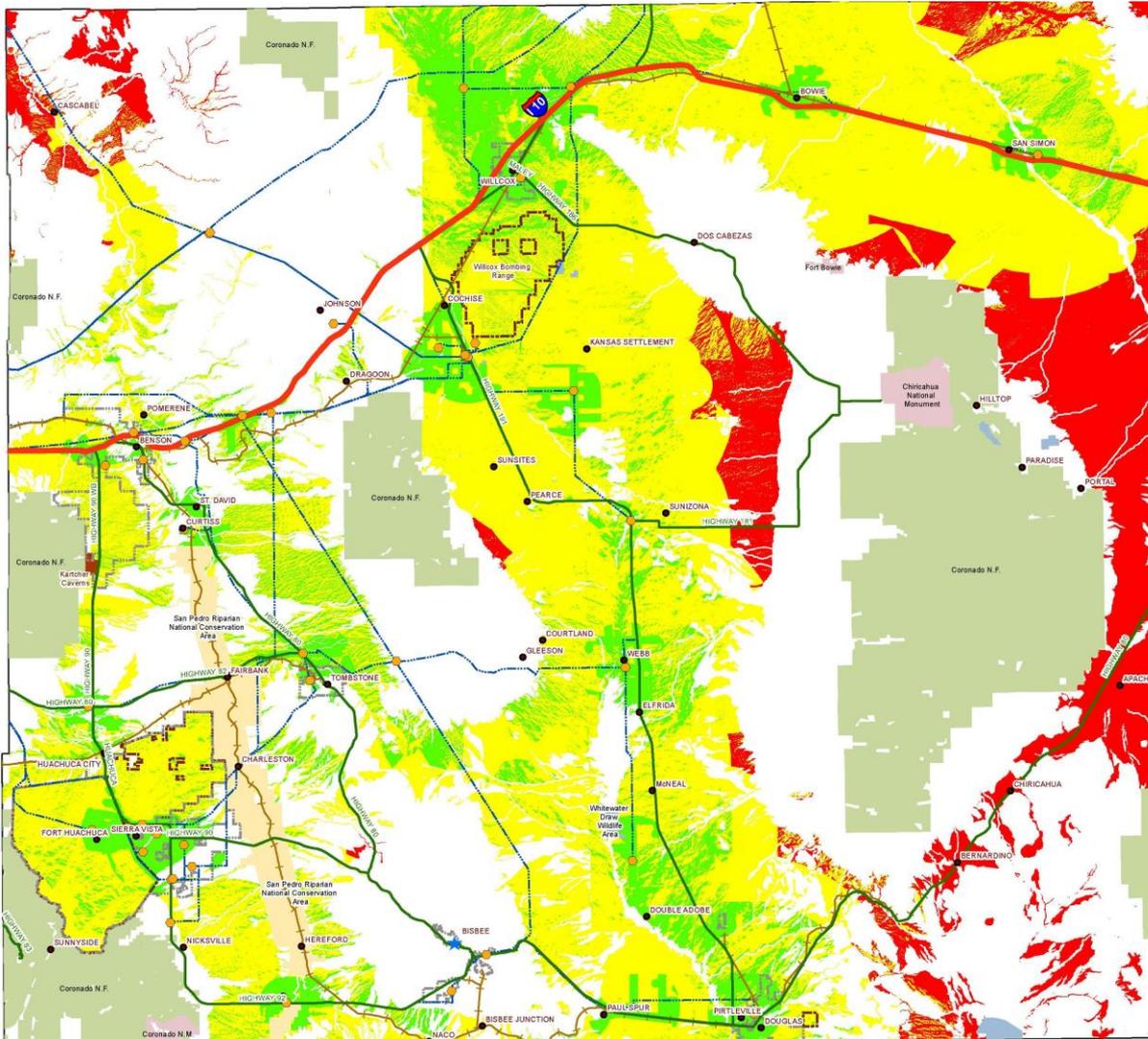
- Limited by data
- Overlaid on final product
 - Floodplains
 - 404 Permits
 - Wildlife Corridors
 - Scenic Corridors
 - Others as available



Results...

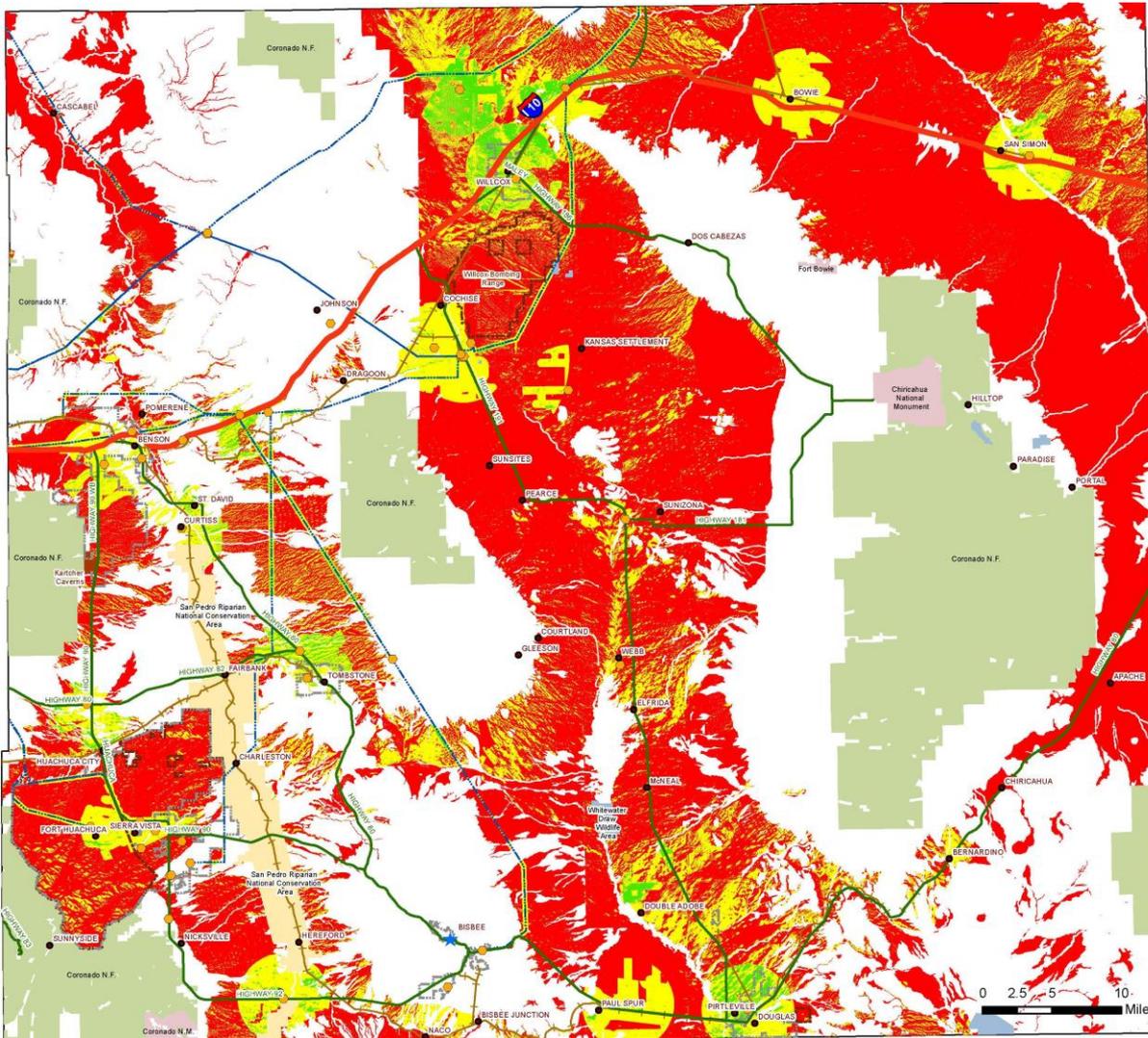


Suitability for projects 5 Megawatts or less



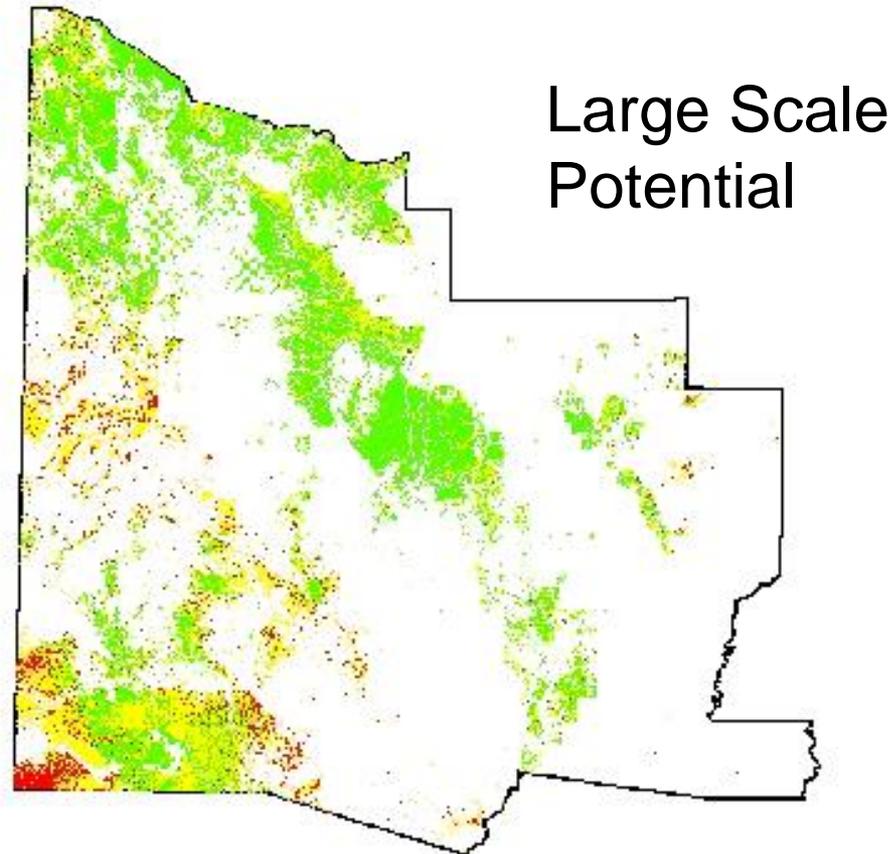
	Acreage
High Potential	343,879
Moderate Potential	1,185,982
Low Potential	281,081

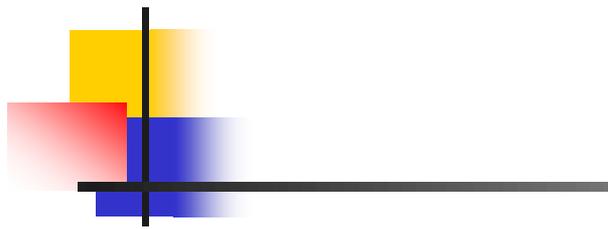
Suitability for projects greater than 5 Megawatts



	Acreage
High Potential	53,461
Moderate Potential	402,002
Low Potential	1,355,454

Preliminary Results in Yavapai County



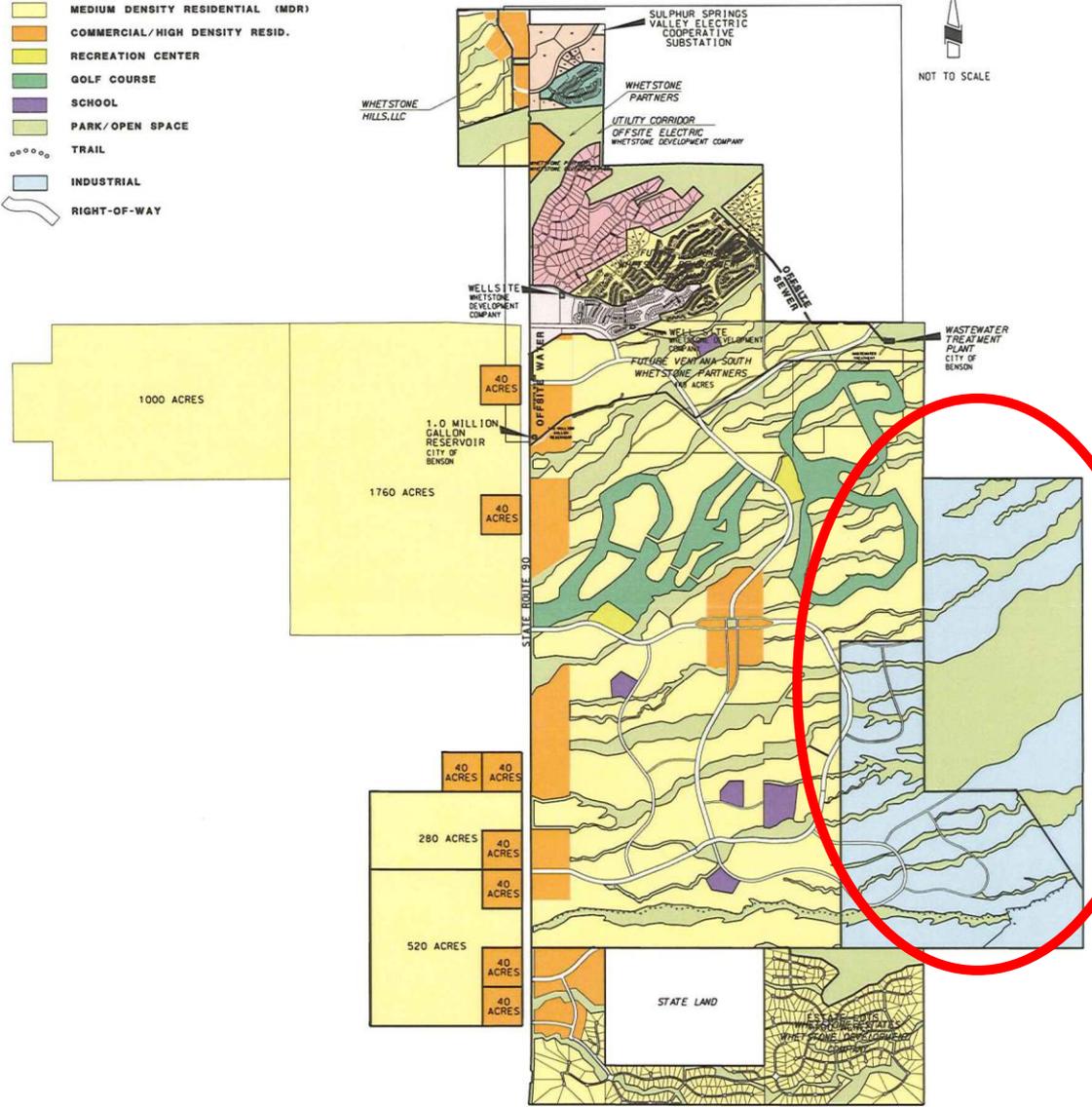


Whetstone Ranch MDP

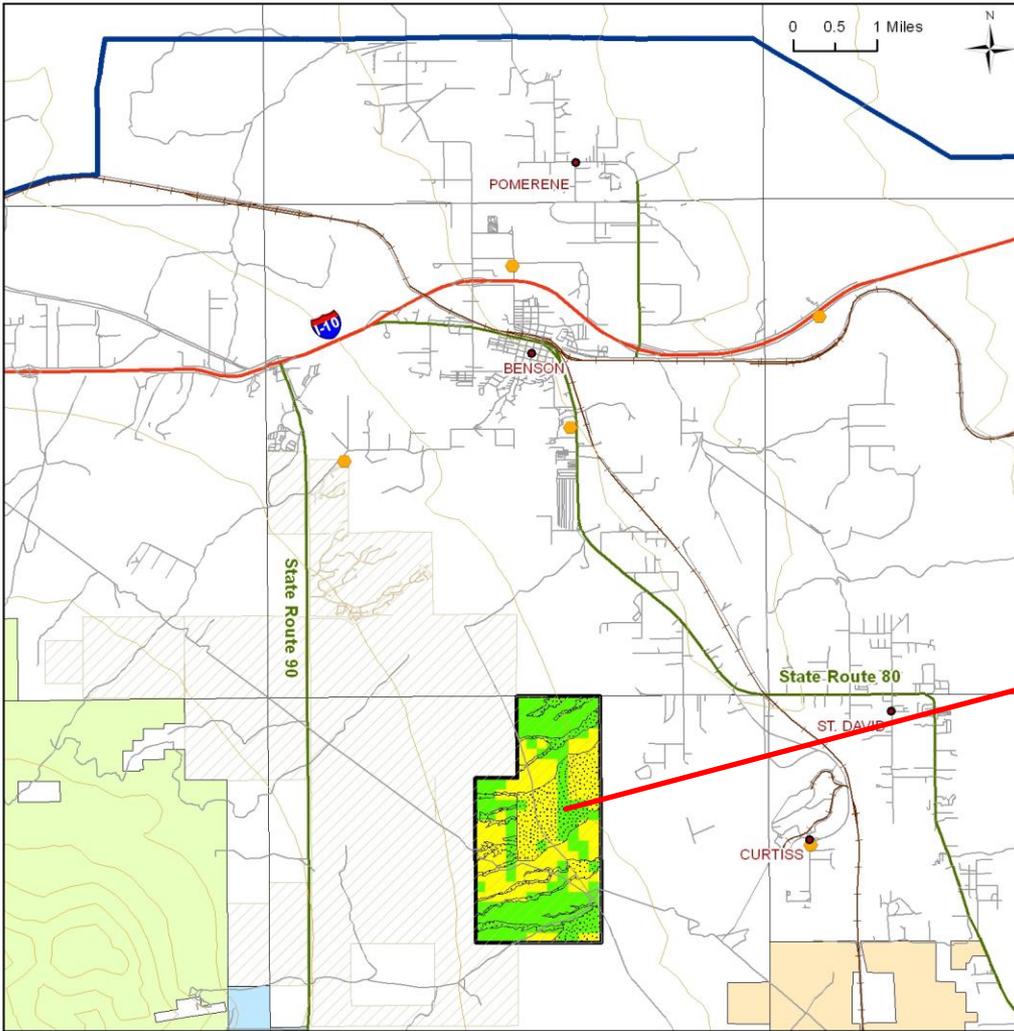
- Approved in 1993
- 7500 Units, 3 golf courses
- Portion rezoned from R1-R3 to Industrial in May, 2011
- Proposed uses include solar arrays, data center, substation and transmission lines

LEGEND

	LOW DENSITY RESIDENTIAL (LDR)
	MEDIUM DENSITY RESIDENTIAL (MDR)
	COMMERCIAL/HIGH DENSITY RESID.
	RECREATION CENTER
	GOLF COURSE
	SCHOOL
	PARK/OPEN SPACE
	TRAIL
	INDUSTRIAL
	RIGHT-OF-WAY

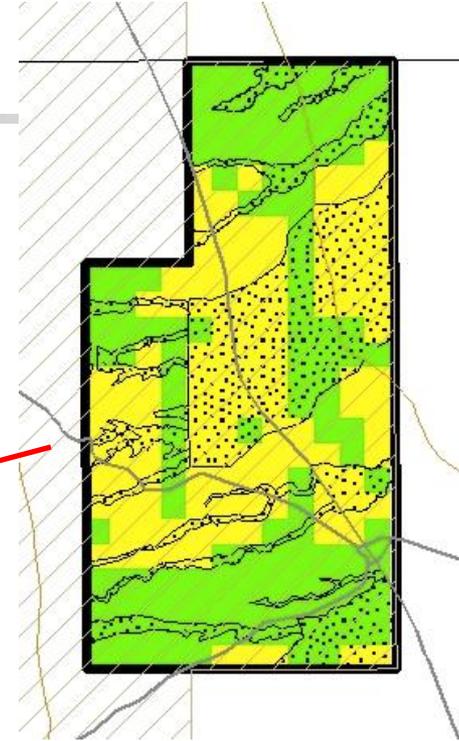


Suitability for Large Scale Solar Projects



- | | | | |
|------------------------------|-----------------------------|--------------------------------|----------------------------------|
| ● Towns | — Interstates | ■ Bureau of Land Management | □ Ernie Graves' Property |
| ● Substations | — Major Arterials | ■ US Forest Service | ■ 2 - Moderate Solar Suitability |
| — Contour Lines | — Streets | ■ Kartchner Caverns State Park | ■ 3 - High Solar Suitability |
| — Railroads | — US, State, County Hwys | ■ Whetstone Ranches | |
| — Transmission Lines > 230KV | □ Township & Range Sections | ■ 404 Permits/ Open Space | |

Suitability for projects 10 MW or greater



- | | |
|---|--------------------------------|
| ■ | 2 - Moderate Solar Suitability |
| ■ | 3 - High Solar Suitability |

Who Can Use The Models?



- Land Use Planning & Sustainable Development Program
 - Latest innovations
 - Targeted information
 - Well-researched outputs
- Provided to planning jurisdictions and elected officials.
- Targeted Stakeholders
 - Elected Officials
 - Planning Commissionaires
 - Land Owners
 - Ranchers
 - Developers/ Real Estate
 - Community Organizations
 - Agricultural Interests

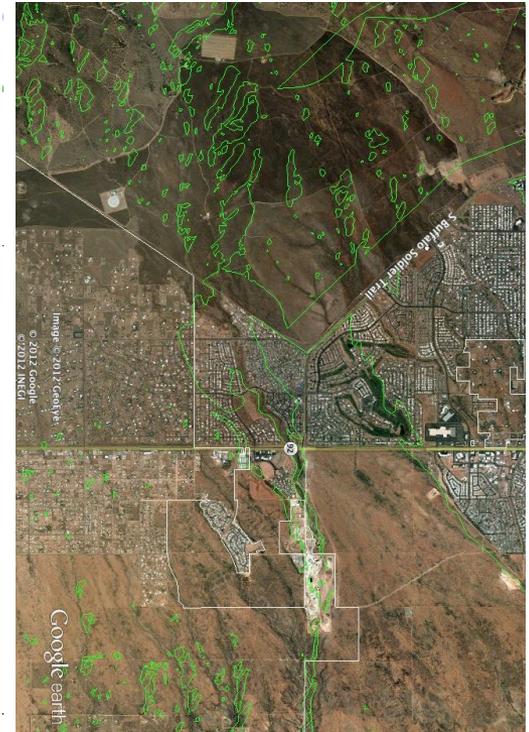
How Can These Models Be Used?

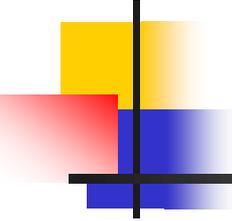
- Sustainable & economic development
- Develop maps for counties & planning agencies
- Comprehensive Plans
 - All counties in Arizona over 125,000 in population are required to have an Energy Element in their plans (ARS 11-804.B.4)
- Reports and recommendations
- Target energy firms



How Can These Models Be Used?

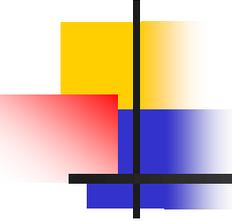
- Suitability maps
- Summary of outputs
- Incorporated into local GIS, Google Earth, web mapping applications
- Overlay with available lands
- Overlay with other layers (urban, wildlife, scenic, water, agriculture, etc.)





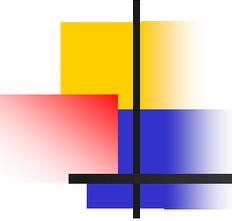
Model Limitations

- BLM & DOE Draft Programmatic Environmental Impact Statement for Solar Energy for 6 SW States
 - Considers land cover, potentially suitable habitat, ecological impact (large scale)
- Water availability
- Rooftop solar



Conclusions & Future Work

- Shows capable and suitable areas
- Other renewable energies
- Groundtruthing
- Modeling not final assessment, but “first cut”
- Policy is key
- Editing goals & objectives with stakeholder input
- Future work throughout Arizona



Feedback/ Questions?

- References:
 - Carr, Margaret H. and Paul D. Zwick (2007). Smart Land-Use Analysis: The LUCIS Model Land-Use Conflict Identification Strategy. Redlands, CA: ESRI Press.
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