

GIS-based wind farm site selection: Evaluating the case for New York State



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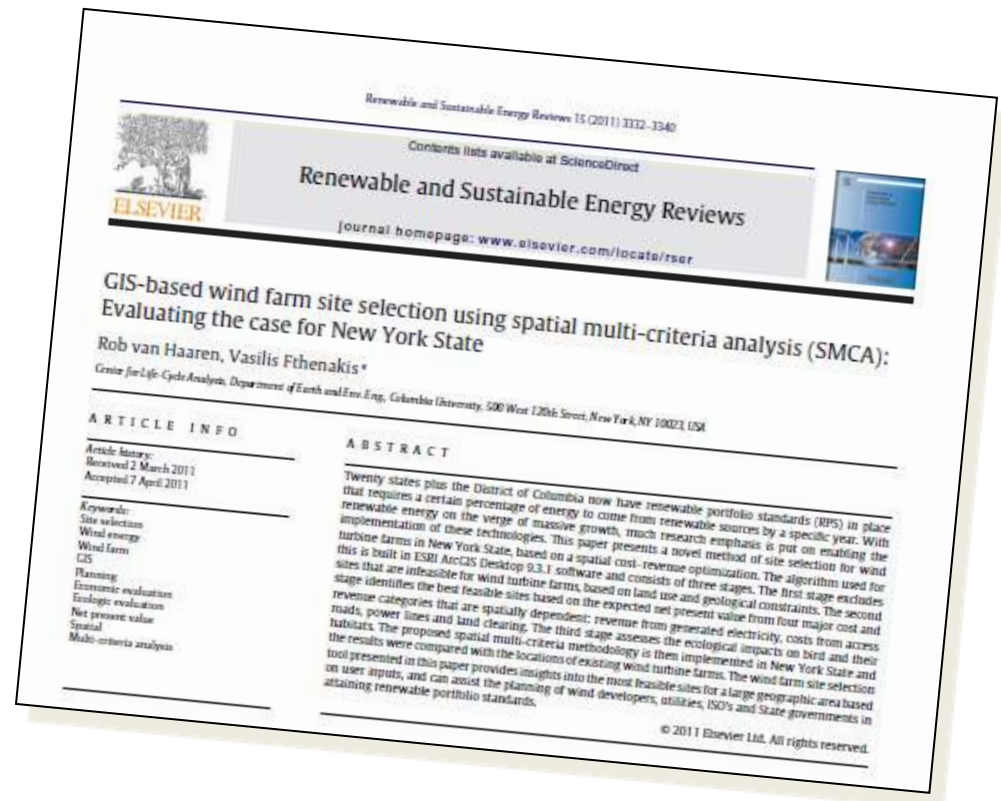
Where to build a 50 MW wind farm?



1. What sites are definitely NOT appropriate or physically impossible?
2. Which sites are most economically feasible?
3. What sites are located in important bird breeding areas?



Outline



Outline

- GIS & Sustainable Energy Research
- Modeling spatial Rate of Return (ROR)
- Architecture of Model
- Results for NYS
- Further Research

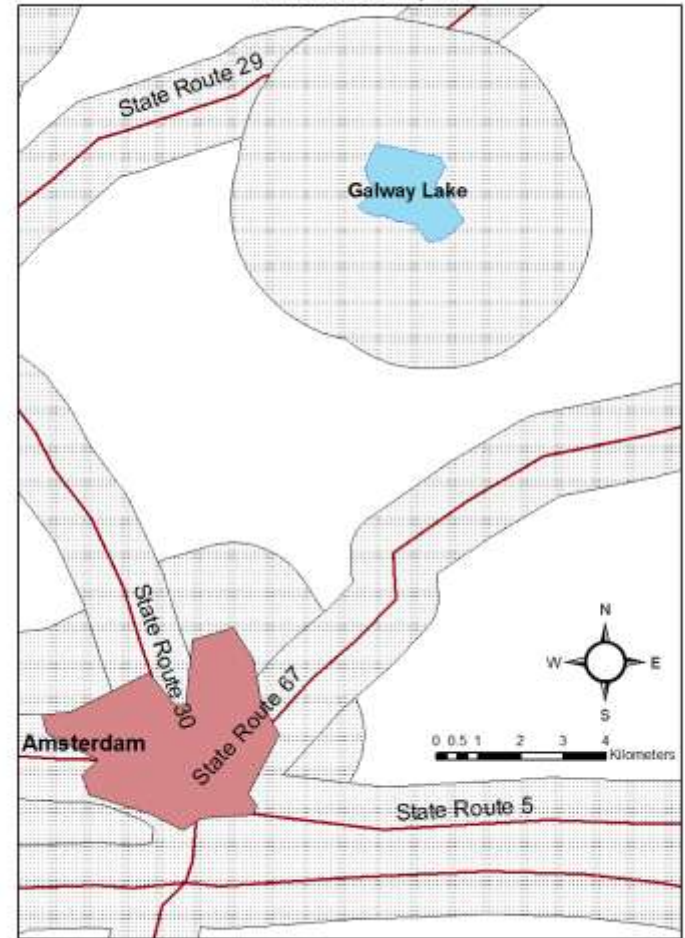
GIS-enabled Site Selection for Wind Turbine Farms

- Geographic Information Systems (GIS) provide:
 - Flexibility in user input
 - Fast processing of spatial data
 - Visual, self-explanatory output (map)
- Useful during general site selection, as well as detailed wind farm planning
 - Optimization of local expected profit
 - Insight in environmental impacts (migratory birds, bats, other species)

Exclusion and O

1. Exclusion of sites using buffer areas
2. Ranking of feasible sites using optimization technique:

Example of Exclusion Stage
Amsterdam, NY



Optimization Stage
Amsterdam



Optimization Stage Land clearing costs
Amsterdam, NY



+ Cost of feeder line
+ Cost of roads



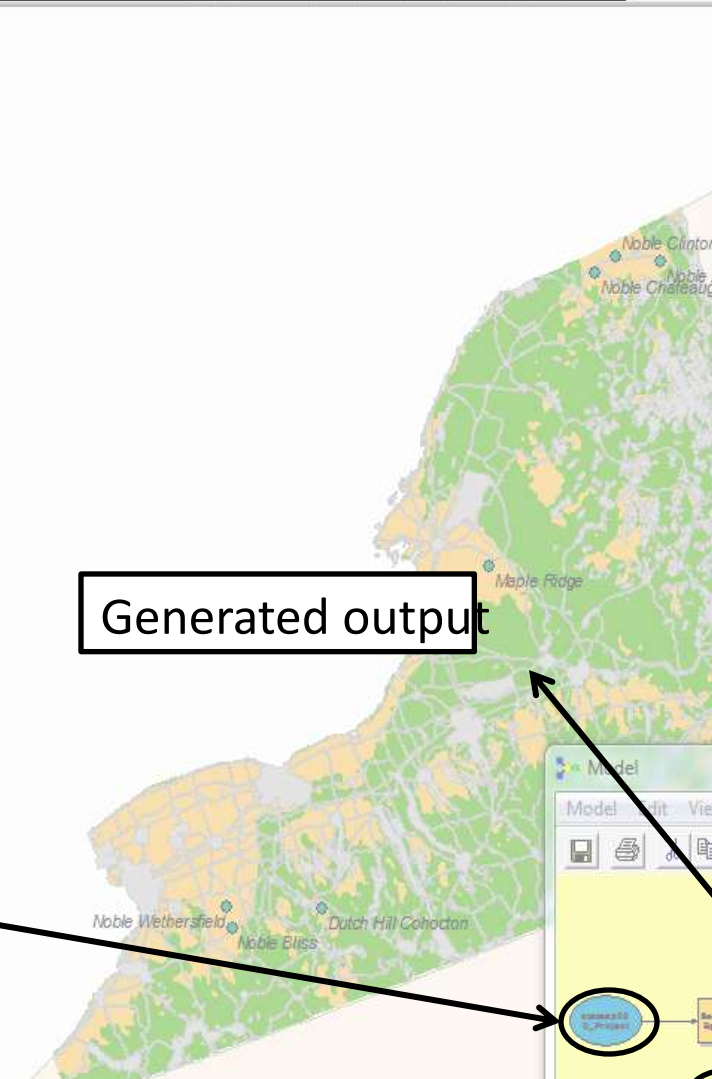
Architecture of GIS

Layers

- Known Wind Farm location
- InfeasibleSites
- RasterT_Reclass1_Erase
- NPVofProject
<VALUE>
 - 8,060,656 - 0
 - 1 - 11,315,137
 - 11,315,138 - 17,070,242
 - 17,070,243 - 22,801,467
 - 22,801,468 - 29,272,974
 - 29,272,975 - 37,511,609
- Input
 - 1statesp020_Map_BG
 - urbanap020cities_Project
 - urbanap020villages_Project
 - countyp020_Project
 - karst0p075_Project
 - fedlanp020_Project
 - hydrogp020_Project
 - Electricity revenue (\$)
 - indlanp020_Project
 - roadtr020_Project
 - Slope_Extract1_CopyRaster.img
 - statesp020_Project
 - Land clearing costs (\$)

ArcToolbox

- 3D Analyst Tools
- Analysis Tools
- Cartography Tool
- Conversion Tools
- Data Interoperabil
- Data Managemen
- Geocoding Tools
- Geostatistical Ana
- Linear Referencin
- Mobile Tools
- Model Builder
 - Landcover fix
 - Model
- Multidimension T
- Network Analyst T
- Samples
- Schematics Tools
- Server Tools
- Spatial Analyst To
- Spatial Statistics T
- Tracking Analyst



Model

Minimum distance to Villages
 Linear unit
0.5 Kilometers
 Field

Minimum distance to Cities
 Linear unit
2 Kilometers
 Field

Minimum distance to Indian Lands (Reservations)
 Linear unit
1 Kilometers
 Field

0.4 Kilometers
 Field

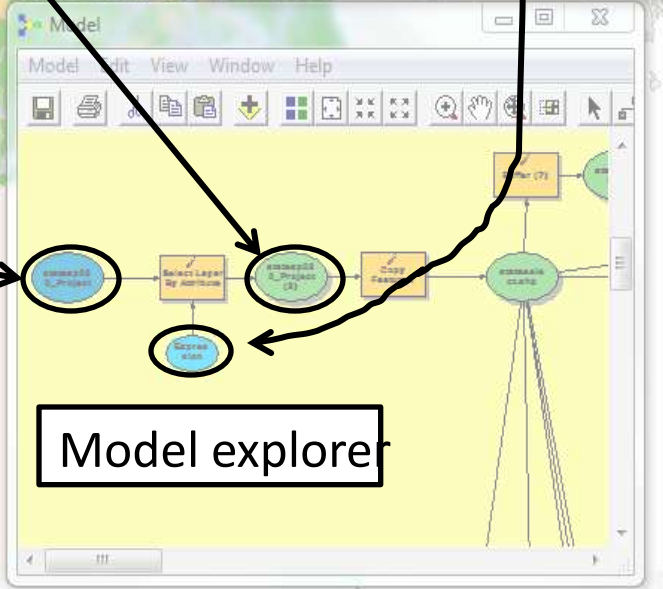
National Parks: Do not allow the Wind Farm to be built in 1

Cancel Environments... Show Help >>

Input datasets

Generated output

Model input interface



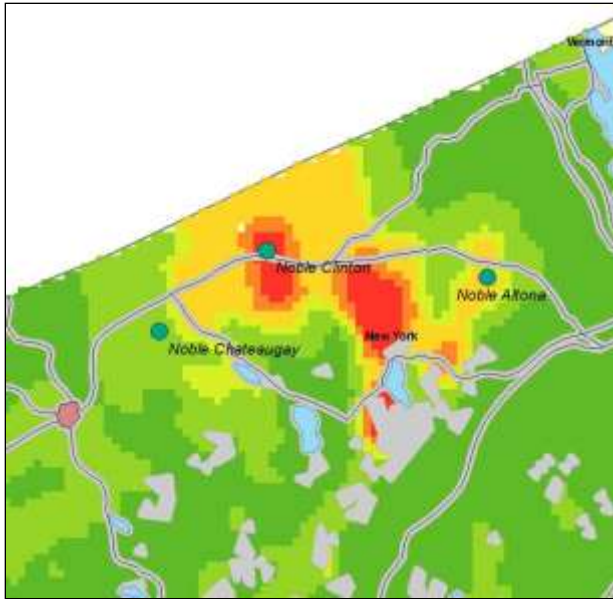
Inputs can be used to interpret results of the exclusion stage.

Model explorer

Example: New York State

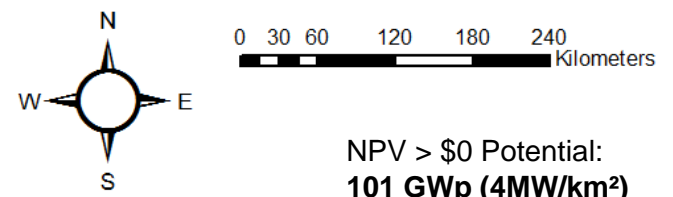
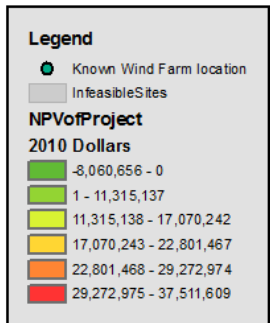
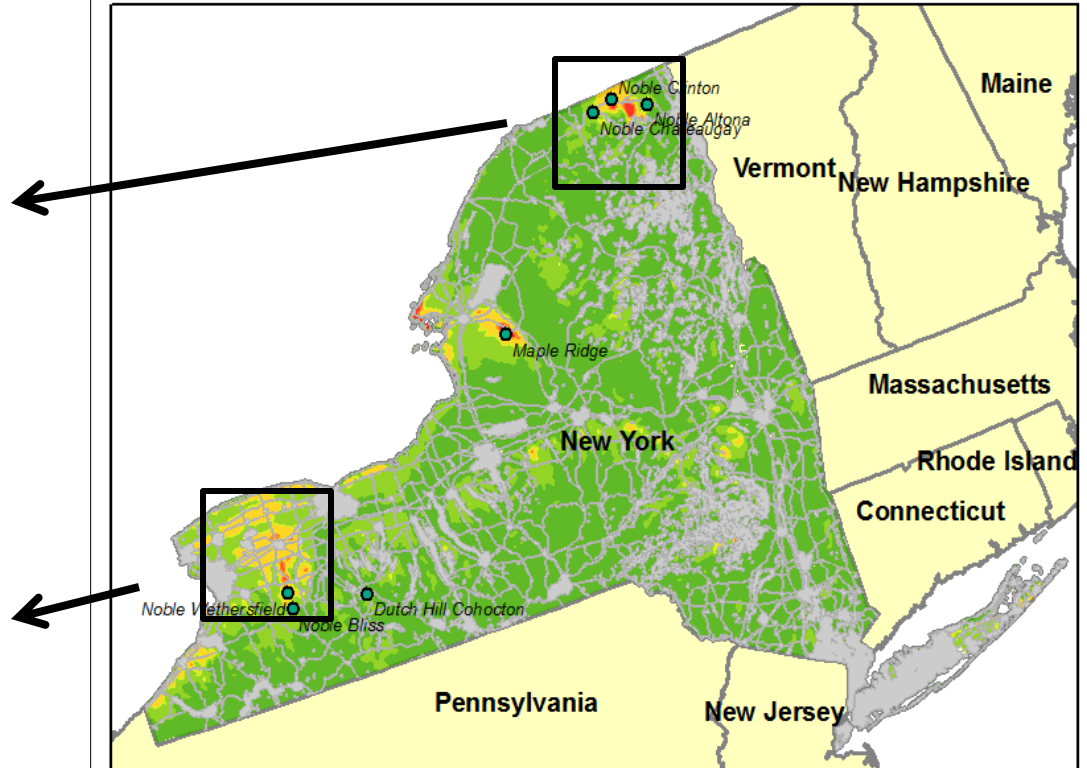
State	New York	
Slope	<10%	Baban, S. et al., 2001
Distance to towns	>0.5km	Baban, S. et al., 2001
Distance to cities	>2km	Baban, S. et al., 2001
Distance to Indian reservations	>1km	Own evaluation
Distance to water bodies	>0.4km	Baban, S. et al., 2001
Distance to roads	>0.5km	Department of Environmental Management, Rhode Island, 2009
Do not allow wind farm in the following federal lands:	For example: 'National Park, 'Air Force Base', etc.	Own evaluation
Forecasted revenue per MWh:	\$40/MWh	Wiser et al., 2009
Capital cost/kW	\$1,580/kW	Wiser et al., 2009

North NYS



Buffalo area

State Wind Energy Site Selection



NPV > \$0 Potential:
101 GWp (4MW/km²)

Map generated in ArcMap with main inputs from USGS, AWS Truewind, GTOPO and FEMA. By: Rob van Haaren, Center for Life-Cycle Analysis, Columbia University. Contact: rv2216@columbia.edu

Model Verification

- Verify model using:
- Existing wind farms in NYS
 - Maple Ridge
 - Noble Bliss
 - Noble Clinton
 - Noble Altona
 - Dutch Hill Cohocton
 - Noble Chateaugay
 - Noble Wethersfield

NPV class	# wind farms
1 (worst)	0
2	0
3	0
4	1
5	0
6	2
7	3
8	1
9 (best)	0 (tiny area)

Conclusions

- General site selection possible based on multiple GIS data sources
- Optimization with economic analysis allows accumulation of multiple criteria
- Model results were verified with existing wind farms in NYS

Further Research

- Grid congestion modeling
- Include pricing as data layer
- Environmental Impact Assessment (bats, birds)



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