The effects of open-space conservation on ecosystems: An application of a joint ecological-economic model

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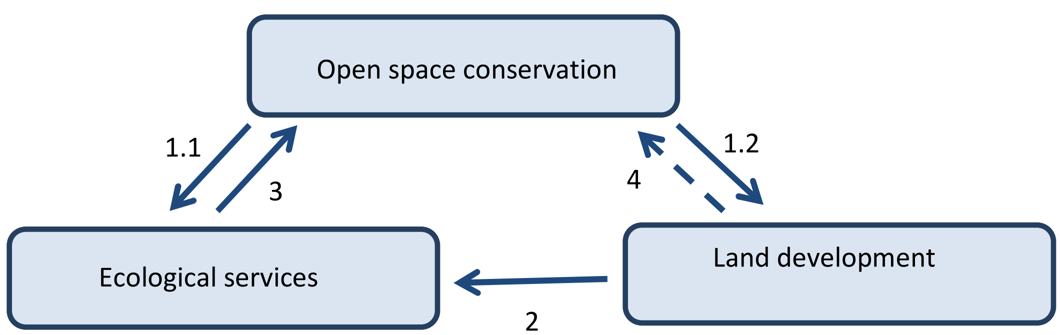
2. Introduction

The location of land development is widely viewed as a major driver of changes in aquatic and terrestrial ecosystems (Naiman and Turner 2000, Jennings et al. 2003), while proximity to attractive ecosystems has an important impact on land development. Recognizing this reciprocal relationship, joint ecological-economic models are increasingly being used to understand the feedbacks of land-use change and ecosystem services (Lewis and Plantinga 2007, Polasky et al. 2008, Lewis 2010, and Butsic et al 2010).

The purpose of this paper is to investigate these feedbacks between open space conservation, ecology and land development in Door County, Wisconsin. See Figure 1 for a diagram of the feedbacks considered in this paper. First, open space impacts ecosystems directly by preserving valuable land, and indirectly by affecting the surrounding probability of development (Bockstael 1996, Irwin and Bosckstael 2004, Walsh 2007; Towe et al. 2008, Lewis et al 2009, Zipp et al working paper). Second, many ecosystems are sensitive to development pressures. Third, the optimal provision and location of open space will depend on the health and stability of ecosystems which depends on land development which, in turn, depends on the location of open space. Finally, it is possible that policy makers choose the location of open space based on land development pressures, which would lead to a fourth part of the feedback loop.

Figure 1: Diagram of the feedbacks between open space, development and ecology



The overarching question that this paper attempts to answer is: if open space affects land development then how does this feedback affect the optimal location of open space? In other words, what are the policy implications of open space location if the effect of open space on nearby development is considered? To answer this larger question requires measurement of the feedback effect and a rule for the optimal allocation of open space. Thus this paper quantifies the effects of open space conservation on land development with an economic land-use model (1.1). The effects of open space and land development on ecological services (1.2 and 2) are measured with an ecological model developed by collaborations with the Trust for Public Lands, the Department of Natural Resources (DNR) and various local planning departments. Future research will involve specifying a model for the optimal provision and location of open space to complete the feedback loop (3 and 4). The optimal location of open space can be determined with and without consideration of the effects of open space on development to determine how importance this feedback is. Discussions and surveys of policy makers will be used to see if policy makers consider these effects and the modeling can be used to see if they should consider these feedback effects.

3. Data

Door County's plentiful open-space, scenic beauty and unique physiographic features such as ridges, embayment lakes, dunes and Niagara escarpment make it a popular tourist destination. The dolomite Niagara Escarpment is exposed as cliffs and ledges on the west side where some of Wisconsin's oldest trees grow. Along Lake Michigan to the east, the same Escarpment forms extensive horizontal rock beaches. This fractured dolomite bedrock has facilitated groundwater contamination from agricultural pesticides and manure.

Door County has more than 300 miles of coastal shoreline, making it one of the counties with the most shoreline in the United States. The shorelines and related habitats are home to one of Wisconsin's greatest concentrations of rare species such as the Hines Emerald dragonfly, dwarf lake iris and the whooping crane, some of which are unique to the Great Lakes. While Lake Michigan is relatively clean in this area, Green Bay has been heavily polluted due to industrial waste from Fox River.

Thus, local planners are concerned about the effects of development on the quality of riparian habitat, ground and surface water contamination and the interconnectivity of conserved land. Door County is the only county in the United States to have a publicly available GIS Greenprint map that quantitatively rates (from a low of zero to a high of five) each 30 meter by 30 meter pixel of land according to the aforementioned ecological goals.

"The Greenprint process is organized based on a set of targeted land use management and planning goals, specific to Door County. These goals, identified by local and regional advisors, provide a thematic framework for the Greenprint analysis. Each goal has been characterized using best available data, scientific review, and advanced analysis." (http://tplgis.org/DoorCounty_Greenprint/)

Unfortunately while the Greenprint map is available the model used to create the map is not. The Greenprint model was developed by the Trust for Public Land, the Wisconsin DNR, and local Door County government agencies and nonprofit organizations to use various attributes of an area such as land-use and development to measure the ecological value of that area of land. I attempt to back-out the Greenprint model from model criteria provided by the Trust for Public Land. Refer to Appendix B for more information about the Greenprint model.

Estimation of the effect of open space conservation on neighboring development requires a parcel-level, spatial data set of legally subdividable parcels in Door County for multiple points in time. However, 2000 was the earliest digital tax parcel map available. Therefore, I develop an extensive panel data set by constructing historical GIS data from paper plat maps and historical zoning maps provided by the Door County Planning Department. This approach gives us a unique spatial and temporal data set following the development and zoning regulation of legally subdividable parcels from 1978-2009 in three-year intervals. In 1978, there were 10,033 legally subdividable parcels; by 2005, this number fell to 6,237 subdividable parcels. Thus, our dataset is an unbalanced panel with parcels dropping from the sample as soon as they are less than twice the size of the minimum lot size permitted and thus are unable to subdivide any further. If a parcel is subdivided into multiple lots which remain subdividable according to local zoning restrictions, those new parcels enter the dataset during the period after their creation.

Additionally, working with the Door County Planning Department and Land Information Office, and the Nature Conservancy, I have spatial and temporal data on all 1,273 parcels of conserved open space (federal, state and local parks, the Nature Conservancy easements, and the Door County Land Trust lands). Current soil maps from the soil survey geographic (SSURGO) database for Door County, Wisconsin (US Department of Agriculture, Natural Resource Conservation Service) are also included in the analysis. Finally, the data set on land use in 1992 was obtained from a land inventory conducted by the Door County Planning Department.[1] See Table 1 in Appendix A for a summary of these variables.

4. Model

The econometric-simulation framework involves specifying an economic model of land development which is then integrated into the ecological Greenprint model to investigate how these ecological ratings would change given the simulated development patterns. In an earlier paper I develop a land-use model that predicts the probability of subdivision as a function of open space conservation. I begin by extending this model to predict the number of parcels a landowner chooses to create after subdivision. I also use the Greenprint map to assign each parcel an average Greenprint rating and regress this on land development to estimate the marginal effect of development on these ecological measures.

4.1 The economic land-use model

To model the decision of how many parcels a landowner chooses to create after subdivision I use a hurdle Poisson model. The hurdle Poisson model allows the zero outcome of the data generating process (the decision not to subdivide) to be qualitatively different from the positive ones (Greene, p.

[1] Land use was categorized as follows: residential, commercial, industrial/extractive, governmental, communications, landfills, transportation related (not including roads), public recreation, private recreation, public road rights-of-way, cropland active, orchards active, idle croplands and orchards, plantation forests, woodland, other natural lands, vacant lots, and inland bodies of water.

922). So the hurdle model estimates the probability that $y = 0$ as a binomial decision and then once the hurdle is passed a truncated Poisson model is estimated as the $Prob(y = j|y > 0)$

I specify the hurdle model of parcel *i* subdividing in time *t* into *j* number of parcels as:

$$Prob(y_{it} = 0) = logit(x_{it}'\beta + \mu_i + \varepsilon_{it}) \tag{1}$$

$$Prob(y_{it} = j|y_{it} > 0) = Poisson(x_{it}'\alpha + c_i + \nu_{it}) \tag{2}$$

Let:

$$B = (\beta, \alpha); u = (\mu_i, c_i); e = (\varepsilon_{it}, \nu_{it})$$

$$\begin{bmatrix} B \\ u \\ e \end{bmatrix} \sim N\left(\begin{bmatrix} B_0 \\ 0 \\ 0 \end{bmatrix}, \begin{bmatrix} B_\sigma & 0 & 0 \\ 0 & G & 0 \\ 0 & 0 & R \end{bmatrix} \right)$$

$$G = \begin{bmatrix} \sigma_{y1}^2 & \sigma_{y1,y2} \\ \sigma_{y2,y1} & \sigma_{y2}^2 \end{bmatrix}$$

where x_{it}' are the variables of interest[2], $u = (\mu_i, c_i)$ are random parcel-specific variables that the landowner observes but the econometrician does not, and $e = (\varepsilon_{it}, \nu_{it})$ are typical independent and identically distributed error components. The structure of the random effects, G, allows correlation between the random effects in the logit and Poisson regressions. The structure of the error terms, R, can be similarly specified to allow correlation between the two decisions.

Including the parcel-specific unobserved component as a random effect makes the implicit assumption that the regressors are not correlated with these unobservables. This assumption might not be applicable in this application. Open space is often located in scenic or beautiful areas which also have higher development pressures. For example, in listing conservation goals on their website, the Door County Land Trust states that their land protection efforts focus on sites "that have been identified for their ecological importance and scenic beauty." If the scenic value is unobserved or observed with measurement error then the distance to open space will be correlated with the error term, leading to endogeneity bias in this estimation. Therefore, I utilize the correlated random effects (CRE) model explored in previous work (Zipp et al. working paper).

The CRE specifies that the correlation between the regressors and the parcel-specific unobserved component can be captured through the time-averages of regressors. This is an intuitive specification stating, for instance, that if the (unobserved) scenic value of an area increases both the probability of subdivision (as reflected in $u = (\mu_i, c_i)$) and the local amount of open space, then the *average* amount of open space over time serves as a good instrument for the effect of scenery on the probability of subdivision; areas with great scenery have more open space early in the study period.

[2] The binomial decision and Poisson decision can be functions of different variables, but in this application I assert that the same variables affect the decision to subdivide and the decision of how many parcels to create upon subdivision.

Therefore the time-averages of the time-varying regressors[3] are included in the hurdle Poisson model along with parcel size (area_ft2) and the minimum lot requirements for the parcel (minlot), distance to the closest shore (Green Bay or Lake Michigan), a dummy variable (bay_dummy) to indicate whether the parcel is closer to Green Bay than Lake Michigan[4]. The distance to the closest city center – the city of Green Bay (GB_dist) – is included to capture potential commuting costs to the region's largest employment base. I also include various parcel soil measures to capture natural development limitations due to steep slopes (pslope), frequent flooding (pflood), or ratings that indicate limited development of basements (pbsmnt). Finally, I include time dummy variables to control for spatially-invariant changes in the general economic environment over the last thirty years, such as housing bubbles and busts, mortgage rates, and interest rates.

The primary regressor of interest is the distance to open space. My database contains GIS layers of open space locations for every year of analysis from 1978-2009, allowing me to create a variable measuring distance to open space (open_dist) that changes over time as new open space is created. I also include a dummy variable (open_dummy) that equals one if a parcel is within 100 feet of open space and zero otherwise, to capture a sharp nonlinearity in the effect of open space associated with a parcel's being adjacent to open space, such as would arise from an unobstructed view of open space.[5]

4.2 The Greenprint ecological model

Given the listed criteria that went into making the Greenprint and the current dataset, I specify the ecological model as a simple censored Tobit regression with a lower bound of zero and upper bound of five. I include an indicator if the parcel is listed as a wetland, the distance to the closest shore (shore_dist), an indicator of which shore the parcel is closest to (bay_dummy), the area of the parcel, and also various neighborhood components such as the number of parcels and land-use types with in a neighborhood and also if there are wetlands in the given neighborhood. Neighborhoods are defined as 150 acres, 500 acres or 1000 acres contiguous area. The two variables of interest will be an indicator if the parcel has subdivided in time period *t* (sub_dummy) and also how many parcels were created upon subdivision (dev_correct).

5. Results

5.1 Economic land-use model results

The economic land-use hurdle Poisson model is estimated with a Markov Chain Monte Carlo (MCMC) Bayesian estimator.

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[3] The time-invariant regressors are already time-averages

[4] Tourism is centered on the coast of Green Bay, which is more developed than the coast of Lake Michigan.

[5] Instead of 100 feet from open space, I also tried using 1000 feet from open space to define parcels that are adjacent to open space; the results for analyses were similar so that I present the only results using 100 feet to open space

[Fill in more details about this estimator later]

The results of the MCMC Bayesian estimator are presented in Table 2 for residential parcels and Table 3 for agricultural parcels. Open space does not appear to affect the development decisions for agricultural parcels in Door County. On the other hand, the results indicate that open space decreases the probability of subdividing but increases the number of parcels created upon subdivision.

The first set of results is the truncated Poisson results. This regression models the expected number of new parcels created per period given the parcel subdivides. Therefore the negative coefficient on the distance to open space means that residential parcels closer to open space subdivide into more parcels given that they subdivide. The second set of results is the logit results for the decision to subdivide or not. The positive coefficient on the distance to open space means that the closer a residential parcel is to open space the more zero-inflation, meaning that the probability of subdivision decreases near open space.

Table 2: Poisson hurdle model with correlated random effects for residential parcels with year fixed effects not shown

	coef	l-95% CI	u-95% CI	Pr(>|t|)	
dev_count: POISSON					
dev_count	1.55E+00	-1.78E-01	3.58E+00	0.036	*
area_ft2	-9.60E-03	-3.54E-02	1.51E-02	0.476	
Open_dist	-1.06E+01	-1.87E+01	-3.32E+00	<0.001	***
open_dummy1	-3.00E+00	-6.53E+00	-6.57E-02	0.04	*
pbsmnt_3	-5.02E-01	-1.20E+00	8.30E-02	0.08	.
pslope_3	5.00E-01	-7.63E-01	1.54E+00	0.454	
pflood_3	4.29E-01	-5.53E-01	1.32E+00	0.392	
minlot	1.94E-06	5.04E-07	3.32E-06	0.01	*
gb_dist	4.67E-03	-5.42E-03	1.64E-02	0.344	
bay_dist	-1.49E-05	-3.78E-05	7.12E-06	0.18	
openmean	1.37E-04	2.76E-05	2.56E-04	0.01	*
mean_minlot2	-1.89E-06	-3.61E-06	-2.49E-07	0.008	**
subdivide: LOGIT					
const	5.23E+00	3.50E+00	7.44E+00	<0.001	***
area_ft2	-1.25E-01	-1.54E-01	-1.03E-01	<0.001	***
open_dist	8.00E+00	2.81E-01	1.54E+01	0.038	*
open_dummy1	3.70E+00	8.65E-01	6.79E+00	<0.001	***
pbsmnt_3	1.34E-01	-3.69E-01	8.14E-01	0.728	
pslope_3	-4.41E-01	-1.44E+00	8.31E-01	0.534	
pflood_3	-1.28E+00	-2.17E+00	-2.08E-01	<0.001	***
minlot	1.41E-06	-3.77E-07	2.99E-06	0.138	
gb_dist	3.91E-03	-1.42E-03	1.03E-02	0.182	

bay_dist	-1.33E-05	-3.90E-05	5.55E-06	0.248	
openmean	-1.58E-04	-2.55E-04	-3.68E-05	<0.001	***
minlotmeean	-5.80E-07	-1.94E-06	7.00E-07	0.498	

Table 3: Poisson hurdle model with correlated random effects for agricultural parcels with year fixed effects not shown

	post.mean	l-95% CI	u-95% CI	pMCMC	
dev_count:POISSON					
const	1.20E+01	-1.37E+01	5.40E+01	0.606	
area_100000	-4.45E-01	-7.00E-01	-3.07E-01	<0.001	***
open_100000	-1.99E+01	-6.28E+01	1.77E+01	0.286	
pbsmnt_3	2.23E+00	-2.59E+00	7.56E+00	0.286	
pslope_3	5.14E+00	-5.23E+00	1.77E+01	0.306	
pflood_3	-5.94E+00	-1.19E+01	-1.20E+00	0.006	**
minlot	5.28E-06	-1.24E-06	1.27E-05	0.088	.
gb_dist	1.29E-01	1.69E-02	2.63E-01	0.024	*
bay_dist	3.73E-05	-4.69E-05	1.33E-04	0.332	
openmean	2.85E-04	-2.83E-04	7.34E-04	0.21	
mean_minlot2	8.30E-07	-6.84E-06	1.05E-05	0.8	
subdivide: LOGIT					
const	9.27E+01	4.51E+01	1.43E+02	0.004	**
area_100000	-7.07E-01	-8.82E-01	-3.95E-01	<0.001	***
open_100000	-3.19E+01	-8.55E+01	2.46E+01	0.248	
pbsmnt_3	3.74E+00	-3.47E+00	9.69E+00	0.198	
pslope_3	9.24E+00	-5.38E+00	2.36E+01	0.148	
pflood_3	-1.14E+01	-1.84E+01	-5.22E+00	<0.001	***
minlot	9.14E-06	-4.86E-07	1.94E-05	0.048	*
gb_dist	1.95E-01	3.38E-02	3.59E-01	0.028	*
bay_dist	7.98E-05	-2.86E-05	2.09E-04	0.168	
openmean	2.50E-04	-4.31E-04	9.40E-04	0.464	
mean_minlot2	3.32E-06	-8.90E-06	9.40E-04	0.508	

5.2 The Greenprint model results

The censored tobit regression results are presented in Table 5 and the marginal effects are presented in Table 6. The negative coefficients and marginal effects for the subdivision indicator (sub_dummy) and the number of parcels created (dev_count) indicate that development decreases the Greenprint habitat measures. Furthermore the negative value of the neighborhood development effects indicate that the Greenprint habitat value decreases if a neighboring parcel subdivides. The marginal effects in Table 6 do not take this into consideration; therefore they are conservative estimations.

[Complete this section later]

Table 5: Censored Tobit regression of the mean parcel-level habitat Greenprint value on development with exogeneous development and neighborhood effects[6]

gp_habitat	Coef.	Std. Error	t	P>|t|	[95% Conf. Interval]	
sub_dummy	-0.09065	0.0249055	-3.64	0	-0.1394694	-0.0418386
dev_count	-0.0169	0.0009496	-17.8	0	-0.0187658	-0.0150434
wetland	0.393452	0.0868116	4.53	0	0.2232994	0.5636052
shore_dist	-1.64E-06	1.17E-07	-13.97	0	-1.87E-06	-1.41E-06
bay_dummy	-0.41548	0.0248684	-16.71	0	-0.4642232	-0.3667377
area_ft2	-7.78E-08	1.77E-08	-4.4	0	-1.12E-07	-4.32E-08
x500_dev_pts	-0.00228	0.0001081	-21.08	0	-0.0024908	-0.002067
x500_landuse_types	-0.00115	0.0000938	-12.3	0	-0.0013376	-0.00097
x500_wetland	0.164388	0.0255379	6.44	0	0.1143326	0.2144423
_cons	2.86628	0.0326224	87.86	0	2.802339	2.930221

Table 6: Marginal effects of censored tobit Greenprint regression

	dy/dx	Std.Error	z	P>|z|	[95% Conf. Interval]	
sub_dummy	-0.0337	0.008893	-3.79	0	-0.0511349	-0.0162749
dev_correct	-0.00596	0.0003392	-17.56	0	-0.0066222	-0.0052927
wetland	0.148152	0.0310024	4.78	0	0.087388	0.2089152
shore_dist	-5.65E-07	4.24E-08	-13.34	0	-6.48E-07	-4.82E-07
bay_dummy	-0.14838	0.0089507	-16.58	0	-0.1659258	-0.1308397
area_ft2	-3.05E-08	6.37E-09	-4.8	0	-4.30E-08	-1.81E-08

6. Conclusion

These preliminary results indicate the open space conservation *decreases* the probability of subdivision for residential parcels but *increases* the number of new parcels created upon subdivision. Thus

[6] The neighborhood effects are defined as 500 contiguous acres but the results do not change significantly for 150 contiguous acres or 1000 acres.

development pattern can be simulated by drawing parameters from the Bayesian distribution and estimating the probabilities of subdivision and number of new parcels created upon subdivision following the hurdle Poisson model developed in this paper. The resulting simulated development landscape can be used to predict the change in ecological value using the Greenprint model for both the direct and indirect ecological effects of open space. The direct ecological effect of open space conservation will be measured by the Greenprint values of the land preserved. The indirect effects of open space will be the effects of open space on development and then the effects of this development on the Greenprint values.

Finally, I would like to eventually specify an optimal location of open space model that maximizes the ecological value of open space given a budget constraint.

Appendix A: Figures and Tables

Figure 2: Distribution of Subdivisions in Door County, WI, 1978-2009

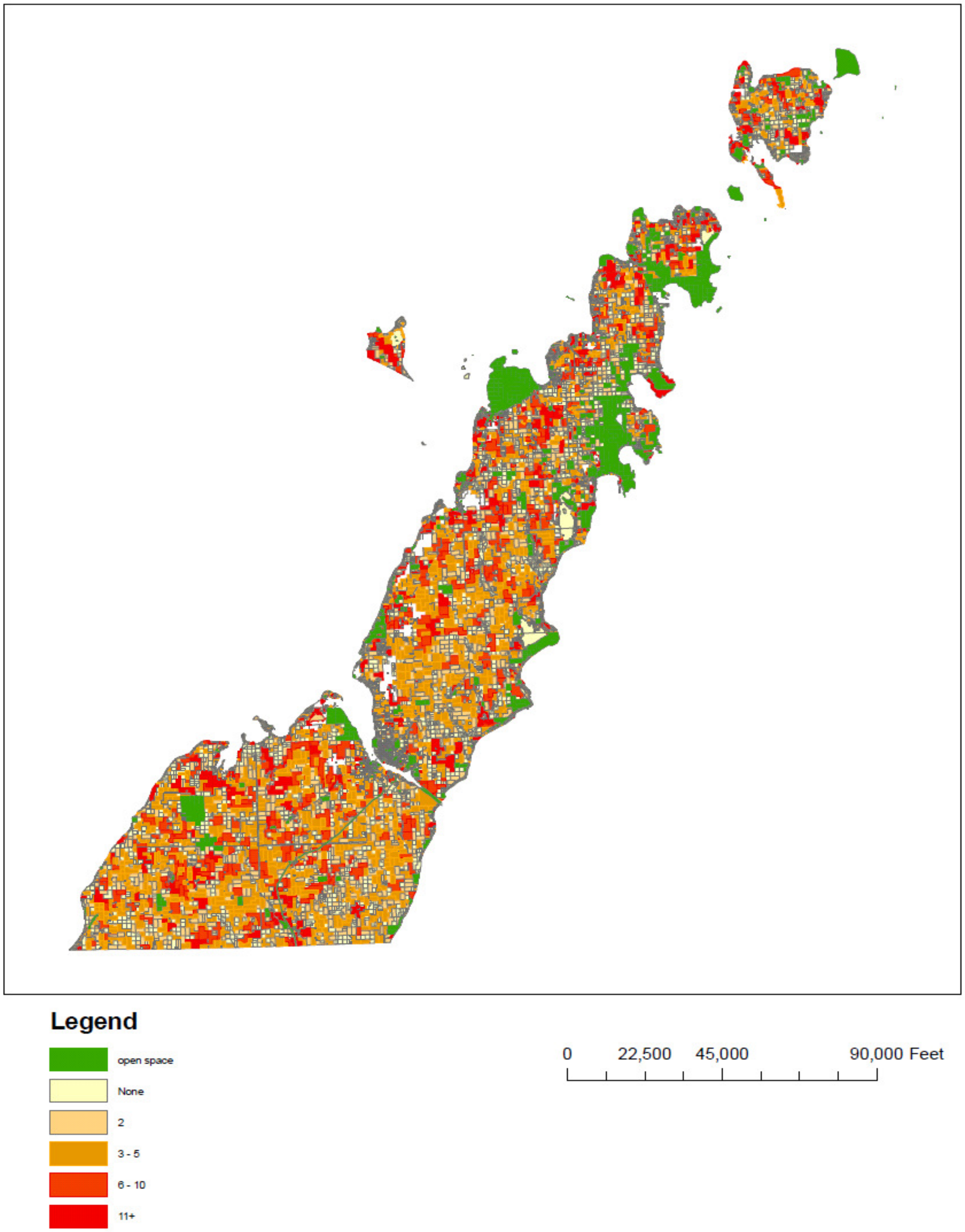

Table 1: Summary of variables used in economic land-use model

Variable	Description	Mean	Std. Dev.	Min	Max
Time-variant Characteristics					
open_dist	Distance to open space (100,000 ft)	0.05	0.04	0.00	0.27
open_dummy	=1 if parcel within 100 ft of open space = 0 otherwise	0.03	0.18	0.00	1.00
minlot	Minimum lot size (zoning) (ft^{2})	98,224.63	202,098.90	4,500.00	1,524,600
Time-invariant Characteristics					
area	Area of parcel (100,000 ft^2)	9.80	16.29	0.17	359.40
shore_dist	min{distance to bay (ft), distance to lake (ft)}	7,574.36	9,540.66	0.00	63,952.29
bay_dummy	=1 if parcel is closer to the bay = 0 if parcel is closer to the lake	0.56	0.50	0.00	1.00
GB_dist	Distance to City of Green Bay (km)	75.76	25.57	20.00	130.00
pbsmnt	Percent of parcel rated limited for dwellings with basements	0.67	0.35	0.00	1.00
pslope	Percent of parcel with a slope of 15-	0.03	0.10	0.00	1.00

	25				
pflood	Percent of parcel with frequent flooding	0.11	0.22	0.00	1.00

Appendix B:The Greenprint model

Here is an example of the general methodology used in the Greenprint model for the goal of protecting habitat for native plants and animals:

Goal	Criteria	Methodology	Data	Data Confidence (High, Med, Low)
Protect Habitat for Native Plants and Animals				
	Rare Species	This model assigns priority to areas with rare species based on Natural Heritage Inventory data provided by Wisconsin Department of Natural Resources. The model ranks the data on a scale of 0-5, as follows: Federally listed species and dragonfly critical habitat =5 (highest concern State Threatened/Endangered (but not Federal Threatened/Endangered) = 4 Species of State Special Concern = 3 Dragonfly Potential Habitat = 3. Important potential habitat data identified by TNC = 2 All Developed Land cover types were removed from the ranked results. Note: Non-listed SGCN are not included (spatial data was not available).	Designated critical habitat for Hine's Emerald Dragonfly Potential Hines Emerald Dragonfly habitat Natural Heritage Inventory Important potential Habitat Landcover	Low

	Natural Communities and Habitats	This model uses Door County 2008 landcover to identify natural communities and habitat. The following landcover types were taken into consideration, and were ranked on a scale of 0-5 as follows: **High Concern (5)** - Beaches, Bluffs, Natural Areas, Nature Study Areas, Other Natural Areas, Other Publicly-Owned Natural Areas, Parks/Parkways/Forest-Related Picnic Areas, Wildlife Refuges, Wetlands, and Woodlands greater than 30 acres. **Moderate Concern (3)** - Other Natural Areas including Wetlands and Other Publicly-Owned Natural Areas (determined via imagery that these types were more disturbed). **Low Concern (1)** - Commercial Forests, Tree Plantations, Open Space, and Grasslands. Developed typeare not a priority Model updated March 2011 due to new zoning data	Significant Wildlife Habitat Door County Zoning (wetlands areas, most of study area) Wisconsin Wetland Inventory (where zoning does not have data) Landcover 2008	High
	Escarpment	This model assigns high concern to escarpment areas. Available escarpment location data was line data. A 200 foot buffer was created around each line.	Escarpment	Medium

	Embayment Complexes	This model ranks embayment complexes. Embayment complexes were dervied as specified in 2009 mapping exercise by Door County and The Nature Conservancy. In this modeling effort, areas with sand deposits were identified using soils data, and then scored using the following approach: Presence of surface water (0 points =no water, 3 points =water present) Percent development (1-5 points based on percentage) Development along shore (1-5 points based development intensity), Total area (1-3 points based on relative overall size), Diversity of NHI Occurences (0 points = no rare species, 3-5 points based on relative diversity of site), Number of NHI Occurrences (0-2 points based on rare species count). Diversity of non disturbed habitat (0 points for distubed habitat, 3-5 points based on relative diversity of site). Scores were added together, and then normalized to be consistent with Greenprint scoring range of 0-5 Model not rerun in March 2011 even though new hydro data and impervious data are available. The new streams data would make no change in the result of this model as points are given simply for presence of surface water. The impervious is not needed as the percent development aspect of this model is derived from the landcover data. Not impervious.	Embayment Complexes Streams Door County Boundary 2008 County Landcover Natural Heritage Species Locations	Medium
	Coastal Wetlands	This model assigns highest concern (5) to all wetlands within 50 feet of shoreline. Moderately high concern (4) was assigned to any wetlands that were within 25 feet from the high priority wetlands above. Model updated March 2011 due to new zoning and hydro data	Shoreline Door County Zoning (wetlands areas) Cities where zoning data does not have wetland Information Wisconsin Wetland Inventory	High
	Bedrock Beaches	This model identifies Gravel Beaches from the Environmental Sensitivity Index Shoreline data. Available data used was	NOAA environmental sensitivity	Low

		line format The line was buffered to the high water mark of 584 ft.	2 ft contours Shoreline	
	Riparian Habitat	This model identifies streams designated as trout streams and/or as outstanding and exceptional waters by the Wisconsin DNR Fisheries Program. A 200 ft buffer was created along all identifed streams. Streams were ranked as follows: Critical habitat waters, trout streams, and designated outstanding waters = 5 (highest concern) Designated exceptional waters (may have point source influences) = 4 Other stream segments = 3	Wisconsin Trout Streams layer Outstanding and Exceptional Streams Door County Critical Habitat Designations	Low
	Migratory Bird Stopover Habitat	This model identifies migratory bird habitat along shorelines. Areas are ranked using shorebird, waterbird and landbird priority scores provided by Wisconsin DNR. DNR scoring is based on proximity to shore, covertype, and patch size.	Shorebird, waterbird and landbird data	High
	Undeveloped Off-Shore	The model assigns priority to shoreline with no off-shore man-made structures. Piers and docks were located by reviewing high resolution 2007 imagery. After removing all segments with man made structures from the shoreline data, the remaining undeveloped shoreline was buffered by 200 feet (or the average lot witdth). Undeveloped Shoreline that has sandy beaches was ranked as a 5 (highest concern) other shoreline types were scored as 4. Model updated March 2011 due to new hydro data	Pier, boat ramp and seawall locations 2008 County Landcover Streams and Rivers Environmentally Sensitive Shoreline Inventory	Medium
	Coastal Habitats and Undeveloped On Shore	This model identifies and ranks coastal habitats by incorporating Natural Heritage Inventory sites within 1/2 mile of the shoreline and all woodlands within 1/4 mile of the shoreline. Areas are ranked based on degree of disturbance to the natural landcover: Natural Landcovers = 5 (highest concern) Moderately Disturbed Areas = 3 Disturbed Areas = 1 Developed Landcover not a priority Model updated March 2011 due to new zoning and hydro data	Natural Heritage Inventory Shoreline from Hydrology Woodlands from Landcover 2008 Hines Dragonfly contributing habitat Hines Dragonfly critical habitat 2008 County Landcover Roads Rivers and	High

			Streams	
	Large, Unfragmented Natural Areas	This model uses Door County 2008 landcover to identify natural areas. The following landcover types were considered "natural": Beaches, Bluffs, Natural Area, Nature Study Areas, Other Natural Area, Wetlands, other Publicly-Owned Natural Areas, Parks/Parkways/Forest-Related, Parks/Parkways/Forest-Related Picnic Area, Wildlife Refuges, and Woodlands. Also included are Wetlands from Door County Zoning/Wisconsin Wetland Inventory. Fragmentation of these natural blocks was modeled by removing buffered paved roads. Remaining contiguous blocks were then ranked by size: Unfragmented blocks of 1000 or more acres were ranked as 5 (highest concern). Blocks 500-1000 acres were ranked as 4. Blocks 150-500 acres ranked as 3. Blocks under 150 acres were not considered "large", and therefore were not included. Model updated March 2011 due to new zoning data and adding new impervious data	Door County Zoning (wetlands areas) Cities where zoning data does not have wetland Information Wisconsin Wetland Inventory Landcover 2008 Roads Impervious Surface	High

	Habitat Richness	This model prioritizes unfragmented natural areas based on a "habitat richness" score. Unfragmented blocks of at least 150 acres in size were determined using the methodology described above. Blocks were then assigned points based on the following strategy: Number of NHI species occurances (1-5 points based on occurance count), Number of different landcover types (1-5 points based on landcover type count) Presence of a natural spring (3 points) Presence of surface water/ outstanding/exception waters / trout waters (2-5 points based on types present) Presence of escarpment areas (2 points) Access to shoreline (3 points) Overall size (1-5 points based on size range). Scores were added together, and then normalized to be consistent with Greenprint scoring range of 0-5 Model updated March 2011 due to new zoning data, hydro and adding new impervious data	Door County Zoning (wetlands areas) Cities where zoning data does not have wetland Information Wisconsin Wetland Inventory 2008 County Landcover Roads Natural Heritage Inventory WDNR Landcover data with forest types Springs Streams and Rivers Outstanding and Exceptional Streams Trout Streams Escarpmet Impervious Surface	High
	Conservation Opportunity Areas	This model identifies areas designated as Wisconsin DNR Conservation Opportunities Areas (incorporates WI Wildlife Action Plan priorities).	Conservation Opportunity Areas	High
