An Ecological-Economic Model for Sustainable Forest Management:

Modeling Deer Distributions from Local & Landscape Characteristics

J.D.A. Millington[1] (jmil@msu.edu); J.P. LeBouton[2]; M.B. Walters[1,3]; K.R. Hall[1]; M.S. Matonis[1]; E.J. Laurent[4]; F. Lupi[1,5]; S. Chen[5]; J. Liu[1]

[1]Center for Systems Integration and Sustainability, Michigan State University; [2]Sylvania Forestry; [3]Department of Forestry, Michigan State University; [4]American Bird Conservancy; [5]Department of Agricultural, Food and Resource Economics, Michigan State University

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1. Ecological-Economic Forest Model

Forest Disturbance

Timber harvesting and deer browsing are believed to be key disturbance agents altering forest dynamics and habitat for deer, songbirds and other biota in the Northern Hardwood forest landscapes of Michigan's Upper Peninsula.

Project Objectives

We are developing an integrated simulation model to test hypotheses about the spatial interactions among forest dynamics, harvest patterns, deer, and songbird habitat. We will use this model to investigate the mechanistic/quantitative underpinnings of these coupled human-natural processes across multiple scales. The model will serve as a tool to aid management of forested systems for multiple resource objectives.

Integrated Simulation Model Structure

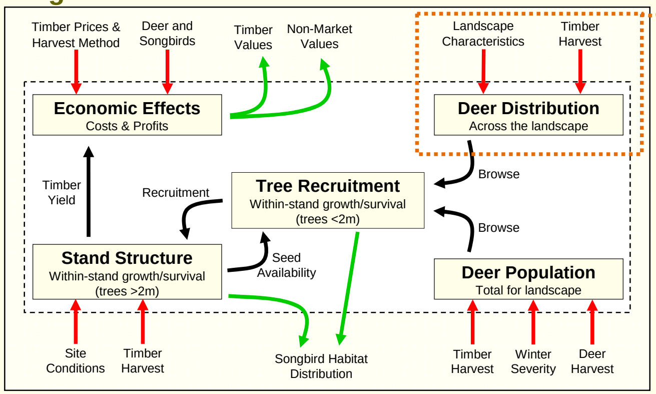


Figure 1. Integrated Simulation Model Structure. Arrows represent model inputs, outputs and influences between components. In this poster we focus on the Deer Distribution component

Study Area

Our study area covers ~4,000 km^2 across parts of five counties in Michigan's Upper Peninsula (Figure 2A) dominated by a mosaic of upland northern hardwood and lowland coniferous forest (Laurent *et al.* 2005).

Data

Within the study region (Figure 2B), randomly selected landscape units (Figure 2C; ~10 km^2) defined areas for the selection of specific plots for vegetation and deer surveys.

Within each 30 m radius plot (Figure 2D) we collected vegetation data to characterize vegetation species composition and vertical structure, estimated deer density and conducted point counts of songbirds.

We have also quantified timber prices and harvesting costs and conducted surveys for non-market valuation of forest ecosystem services and attributes.

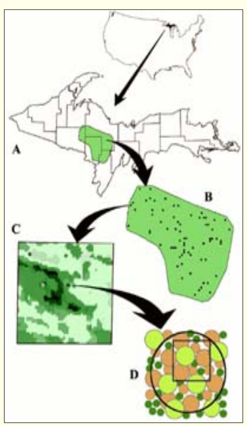
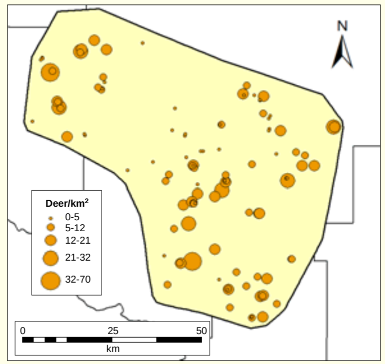


Figure 2. Project study area and levels of ecological data collected

2. Modeling White-Tailed Deer Distribution

a) Regional Patterns

At each plot we counted fecal pellet groups in ten 0.02 ha transects (50x4m) arranged in a bow-tie configuration around the vegetation sample site. These deer pellet survey data serve as a proxy for stand-level wintertime white-tailed deer density.



Spatial Patterns

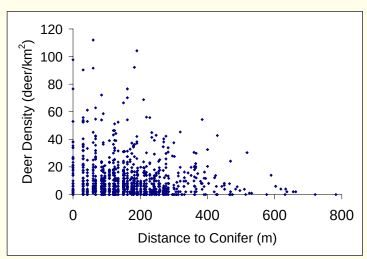
No spatial patterns in deer distribution are self-evident at the regional level despite a general gradient of increasing snow depth from south to north (Figure 3). However, high variance in deer estimates among sample sites could be related to local landscape variation.

Figure 3. White-tailed deer density estimates at plot locations within our study area

b) Sub-Regional Predictors

Using transect-level data we identified an inverse relationship between distance to coniferous forest and maximum transect-level deer density (Figure 4). Deer use (lowland) coniferous forest as thermal cover during winter months, venturing out to surrounding areas to browse.

For each plot-level deer density estimate we then 1) calculated cover composition & configuration metrics for local Landscapes of Influence (LOI) with area 0.125 – 8.0 km^2 based on a Landsat TM derived land cover map, and 2) determined ecoregion designation according to the system of Albert (1995).



Predictive power was limited with these plot-level data

The best significant model of plot-level deer density estimates had significant terms for 2.0 km^2 LOI land cover variables, distance to coniferous forest, and ecoregion class (total 12 variables), but predictive power was weak (r^2 = 0.22).

Figure 4. Deer density against distance to coniferous forest by pellet transect

c) Stand-Attribute Predictors

To improve predictive power we examined stand-attribute data from the Michigan DNR Forest Division Operations Inventory for two LOIs with area 0.125 km^2 and 0.454 km^2 (Figure 5).

These small LOI areas were used because incomplete (at present) spatial stand attribute data increasingly restricted sample size with increasing LOI size (as demonstrated in Figure 5 by the red circle which encompasses 8.0 km^2).

Stand attributes include:

- Canopy cover class (see legend of Figure 5 for example classes)
- Mean stand diameter at breast height
- Stand basal area
- Distance to the nearest lowland conifer stand

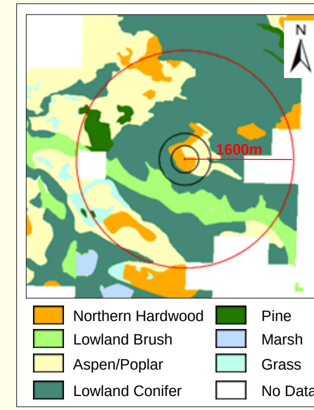


Figure 5. Example LOIs and DNR stand inventory data (canopy cover). LOIs are 0.125 km^2 and 0.454 km^2

Stand-Attribute Data Improve Predictions

The best multiple linear regressions for the 0.125 km^2 (Table 1) and 0.454 km^2 (Table 2) LOIs include stand basal area and minimum distance to lowland conifer stands. These models explain ~42% and ~50% of variation in log10 deer density (deer/km^2) estimates respectively.

Parameter Estimates

The negative parameter estimates for basal area indicate that deer densities are greater in stands that have been selectively cut more recently. Relationships for distance to lowland conifer are provisional given the spatial incompleteness of stand attribute data.

Data to be collected in summer 2008 will focus on increasing sample sizes and decreasing spatial biases for this analysis.

Table 1. Best model from DNR stand inventory data for 0.125 km^2 LOI

	Estimate	*Pr(>|t|)*
(Intercept)	1.109	0.000
Stand Basal Area (sq. ft./acre)	-0.007	0.000
Distance to Lowland Conifer (km)	0.249	0.019

Model r^2 = 0.42, p < 0.001, Residual standard error 0.25 on 36 d.f.

Table 2. Best model from DNR stand inventory data for 0.454 km^2 LOI

	Estimate	*Pr(>|t|)*
(Intercept)	1.042	0.000
Stand Basal Area (sq. ft./acre)	-0.009	0.009
Distance to Lowland Conifer (km)	0.355	0.018

Model r^2 = 0.50, p < 0.001, Residual standard error 0.23 on 21 d.f.

3. Summary

Results indicate that white-tailed deer density is determined by both timber management-influenced stand attributes (stand basal area) and by landscape configuration of forest types (distance to lowland conifer stands). Continuing data collection and further analysis should improve confidence in these findings.

Quantifying the drivers of spatial deer distribution, as we have here, will contribute to the specification and parameterization of interactions and feedbacks in the integrated ecological-economic simulation model we are developing (Figure 1).

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References

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