A spatially explicit model of the presence of English Holly (*Ilex Aquifolium*): Spatial relationships and implications for management

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Meeting the Challenge:
Preventing, Detecting, and Controlling Invasive Plants

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Background

- Research on invasive alien species has been motivated by the need to mitigate their ***negative influence*** on natural systems (management)

- From a theoretical perspective, invasions provide natural experiments that offer insights into issues that are fundamental to ***ecological*** and ***spatial theory***.

- A big part of the literature on invasive species has concentrated on the analysis of:
  - Types of environments and environmental conditions that allow a successful establishment of a particular species (***Suitability analysis***)
  - Life histories attributes of invasive species in particular environments (***Demographic analysis***)

Background

- When modeling invasive species dispersion, it is useful to consider the environment as a series of filters which prevent unsuited plants from establishing, maturing, reproducing, and dispersing (Keddy, 1992).
- The selection of the appropriate environmental and spatial filters requires an *a-priori* understanding of how the system functions.
- In this study, we focus on the environmental factors that contribute to the successful establishment of holly.
- We hypothesize that the occurrence of holly is related to the spatial and ecological conditions of the area: terrain conditions, proximity to water and vegetation edge, proximity to evergreen vegetation, and forest maturity.

Study Site


Kirkland
Seattle
Lake Washington
Bellevue
Study Area
9 ha
Saint Edward State Park
185 ha
LAKE WASHINGTON
0 0.5 1 2 Kilometers
0 5 10 20 Kilometers

Methods and Data

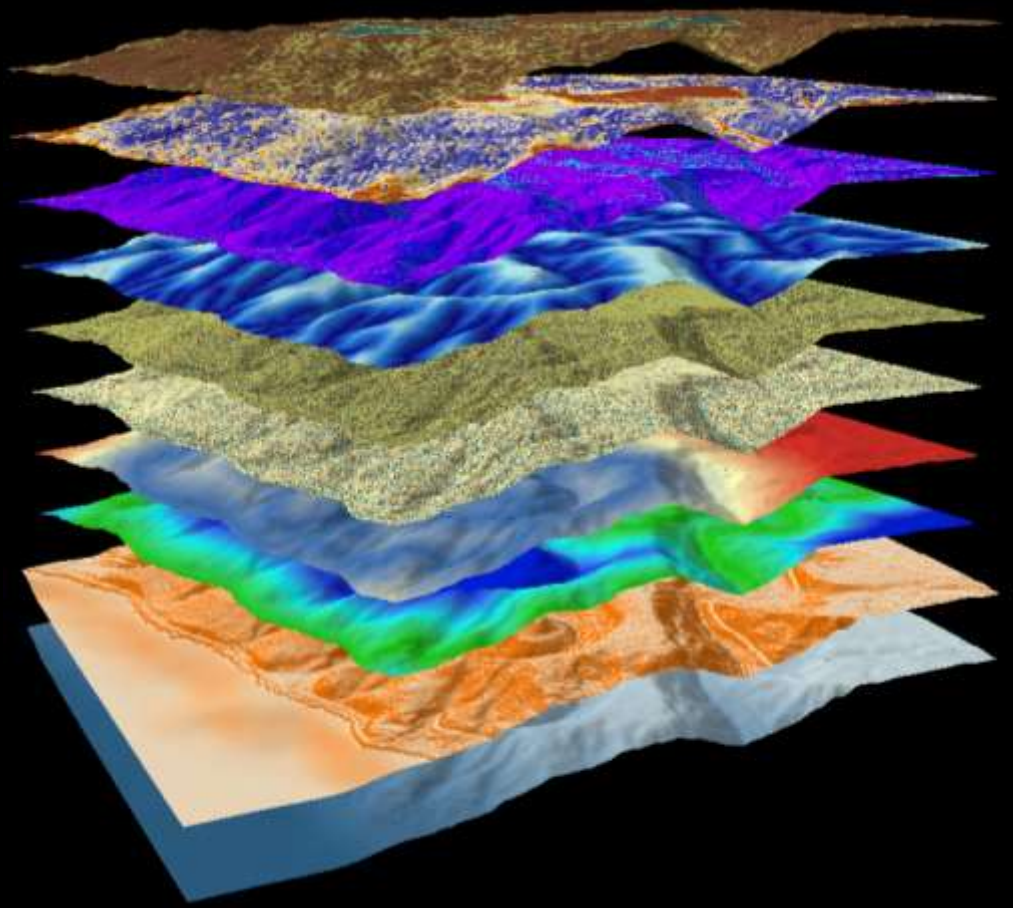
- Data (2011 and 2013) (Stokes et al. 2014; 2013; 2012)

- Differentially corrected GPS data (accuracy between 3 – 5 meters) about *presence* of holly trees.

- Surveying methods

- *Absence* data were recorded in a GIS at locations separated a distance of a least 5 m from known holly locations.

Methods and Data



ELEVATION

- LIDAR data (2009) – Puget Sound Consortium – 2 meter resolution

LAND COVER

- National Agriculture Imagery Program (NAIP) Orthoimagery (2011 - 4 Band) – 1 meter resolution and RGB photomosaics (2012 - submeter resolution)

ENVIRONMENTAL FACTORS AND SPATIAL FEATURES

- Geographic information analysis and remote sensing techniques.

Methods and Data

- Methods
  - Statistical technique → Multiple Logistic Regression (MLR)
  - MLR predicts the probability of a cell of being occupied by holly, as explained by a series of independent factors.
  - If the data are spatially explicit (geo-located), MLR generates coefficients that can be used to generate a map depicting the probability of the presence of an event at a given location.

PRELIMINARY RESULTS

RESULTS OF THE MULTIVARIATE LOGISTIC MODEL

	B	S.E.	Wald	df	Sig.	Exp(B)
Distance to Streams	.008	.003	6.509	1	.011	1.008
Distance to Edge	-.020	.005	14.756	1	.000	.981
Average Canopy Height	.028	.010	7.614	1	.006	1.028
Distance to Evergreen Coniferous Vegeation	-.431	.126	11.761	1	.001	.650
Aspect (N/S)	-1.379	.395	12.185	1	.000	.252
Constant	-.972	.869	1.252	1	.263	.378

N = 207 (25% → 1 ; 75% → 0)

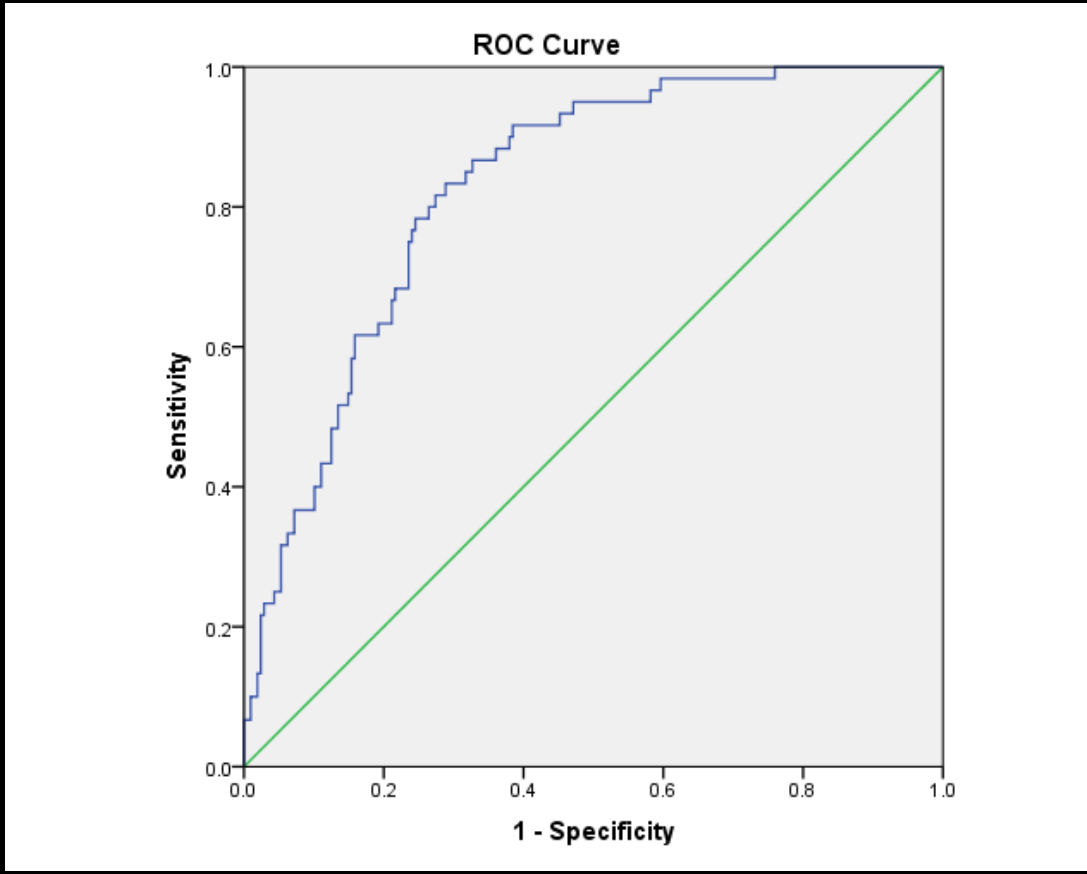
-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
183.651[a]	.285	.413

Statistical Validation: Error matrix

		DEPENDENT BINARY (observed cases)			DEPENDENT BINARY (validation cases)		
OBSERVED		0	1	Percentage Correct	0	1	Percentage Correct
DEPENDENT BINARY	0	138	21	86.8	38	11	77.55
	1	18	30	62.5	7	5	41.67
Overall Percentage				81.2			70.49

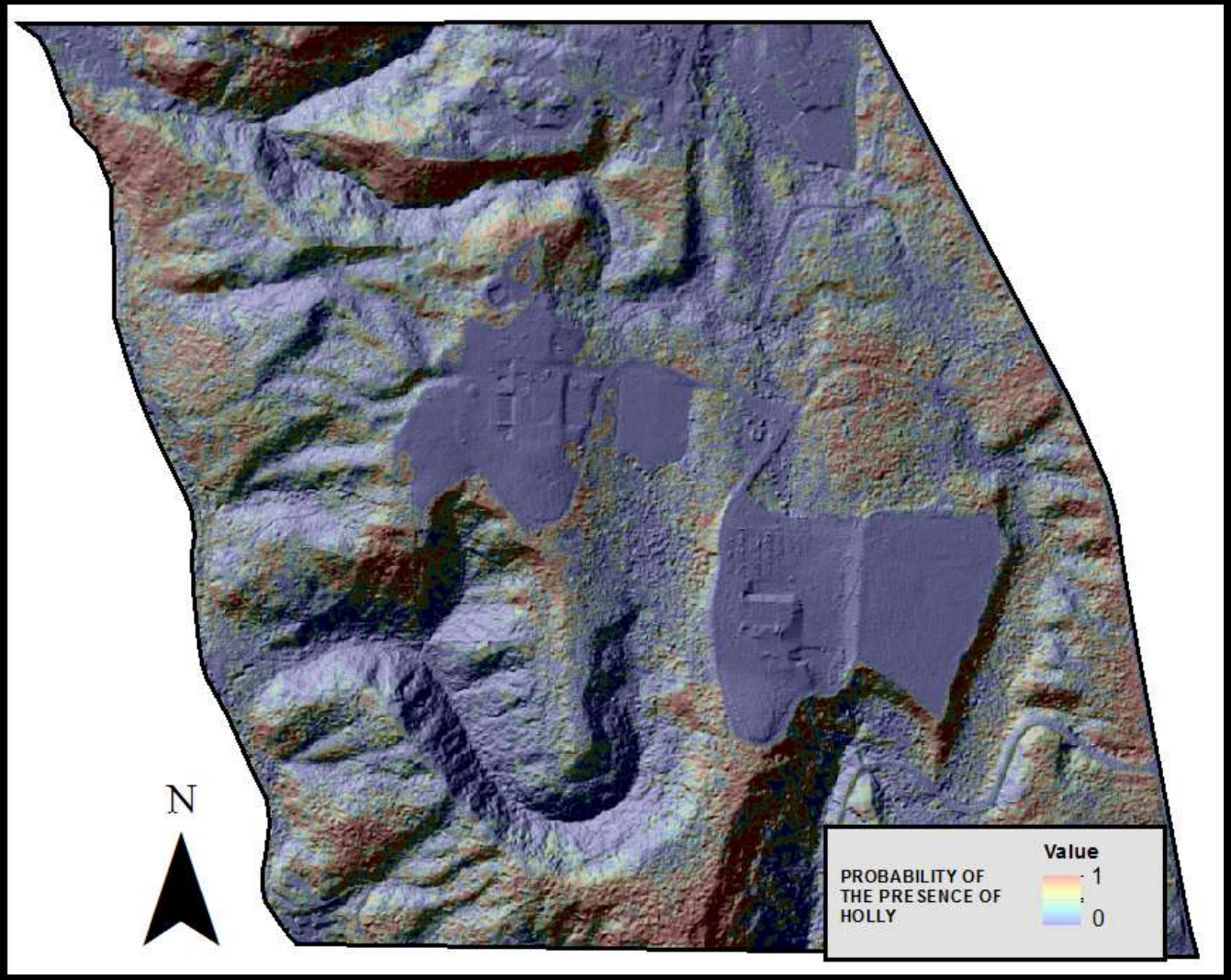
ROC Curve

Positive if Greater Than or Equal To[a]	Sensitivity	1 - Specificity
0.00	1.000	1.000
0.10	.950	.495
0.20	.833	.298
0.30	.683	.231
0.40	.517	.144
0.50	.400	.101
0.60	.267	.053
0.70	.183	.024
0.80	.067	.010
0.90	.033	0.000
1.00	0.000	0.000

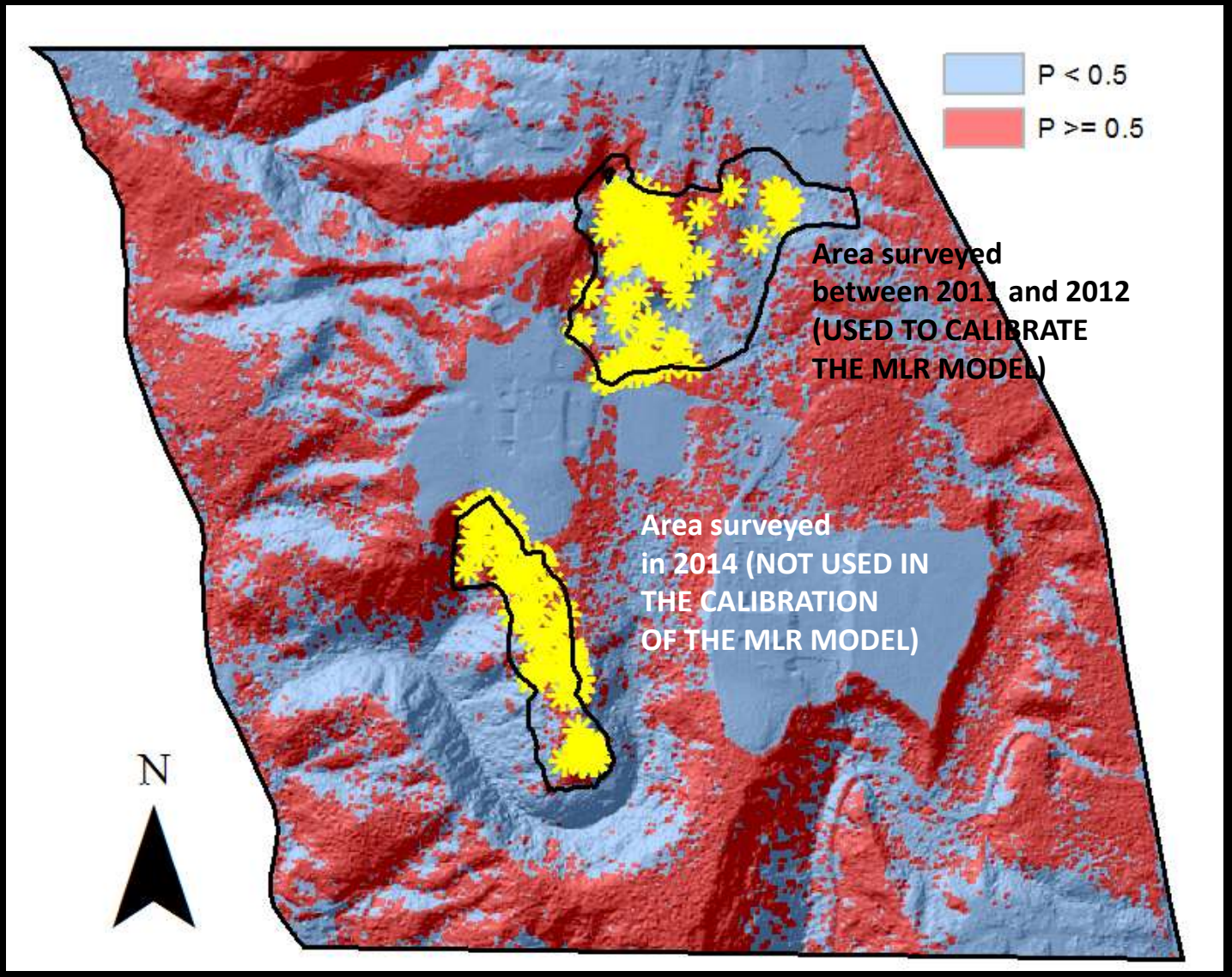


Area	Std. Error[a]	Asymptotic Sig.[b]	Asymptotic 95% Confidence Interval	
			Lower Bound	Upper Bound
.827	.027	.000	.774	.880

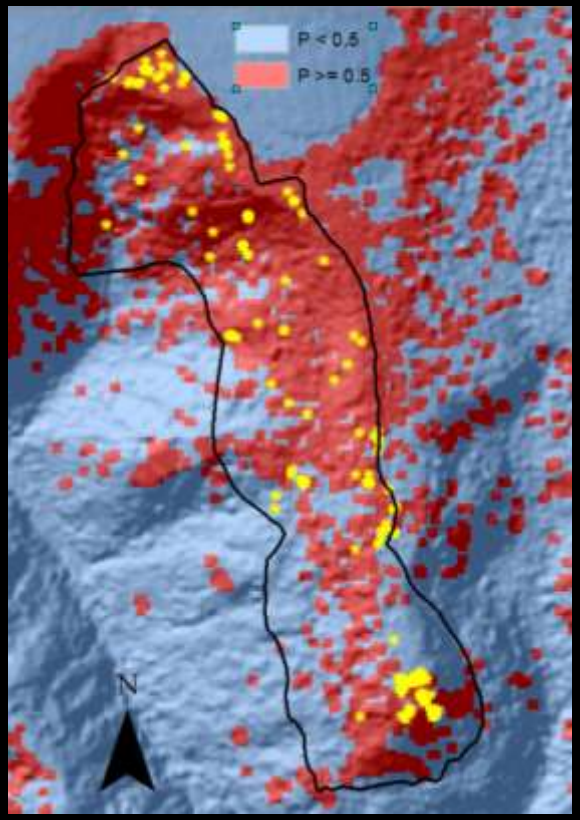
Probability of the Presence of Holly in St. Edward Park



Spatial Validation



Overall Accuracy



	NO HOLLY	HOLLY	TOTAL	PERCENTAGE CORRECT
HOLLY	18	93	111	0.84
PROB >= 0.50				

Preliminary Conclusions

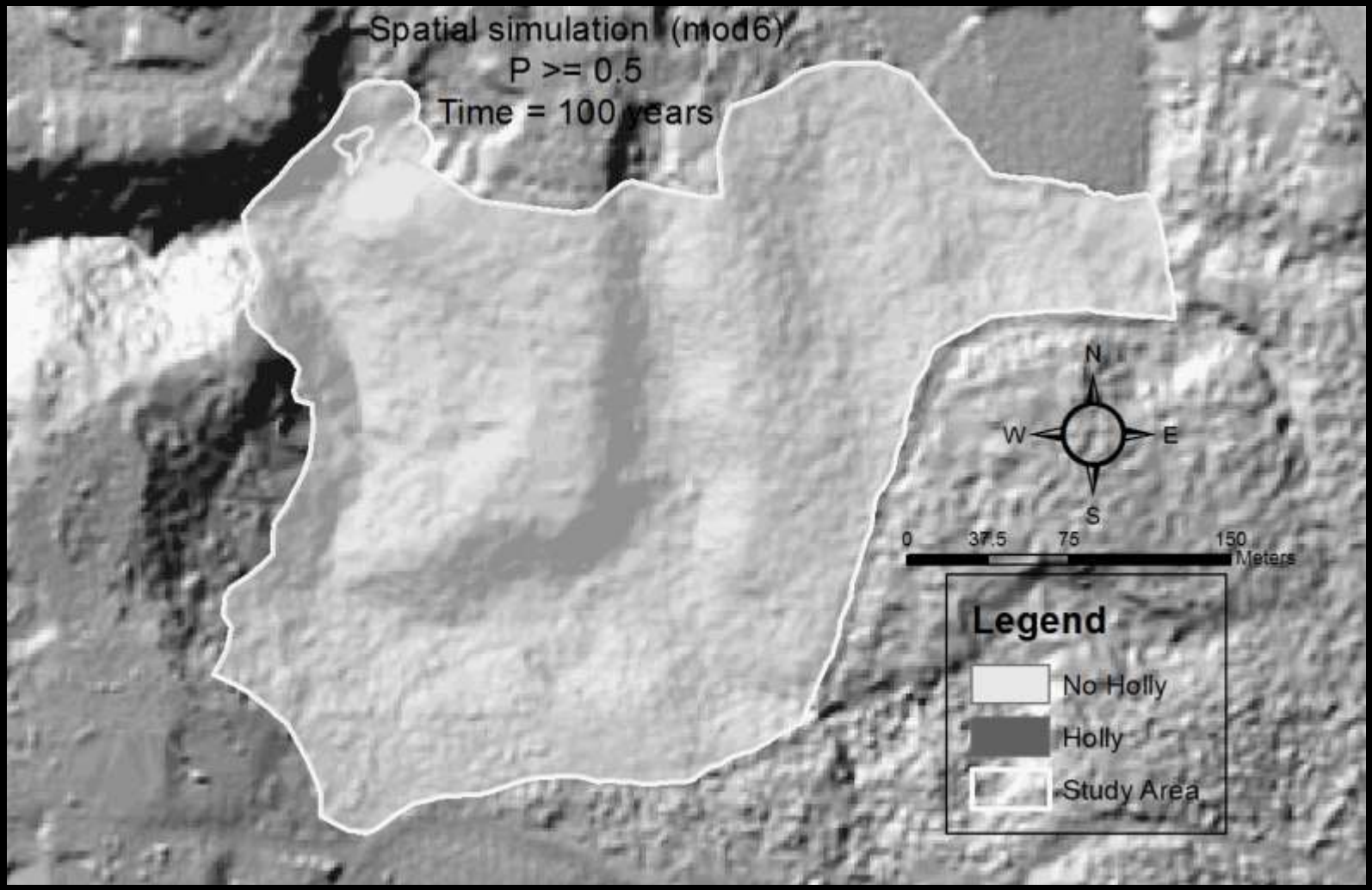
- Physical (slope)and ecological (proximity to specific vegetation communities –evergreen vegetation), and are the most important spatial factors associated with the presence of holly.

- Mature forest areas (higher canopies) seem to be more suitable for holly invasion.

- Actions that could reduce (e.g. modifying edge shapes, re-vegetation, careful monitoring) could also address problems associated with holly invasion.

Future research

- Environmental conditions play an important role in explaining the occurrence of holly. These together with demographic trajectories of individuals may allow obtaining an accurate depiction of the process of invasion.
- Is it possible to extrapolate trends into the future?
- Based on the data collected, the combination of MLR and other techniques such as cellular automata could help understand the process of invasion in the long term



Exploring scenarios