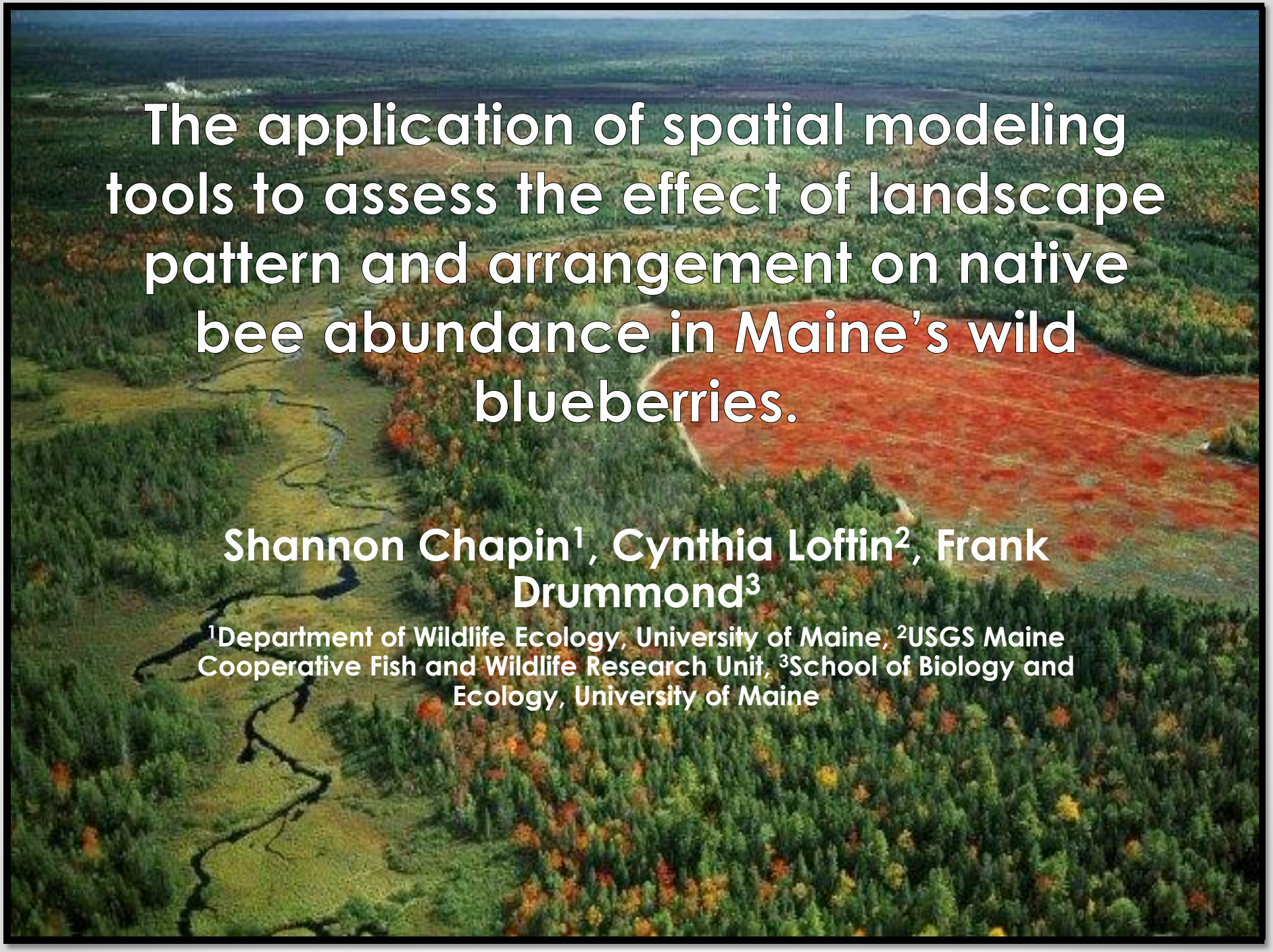


The application of spatial modeling tools to assess the effect of landscape pattern and arrangement on native bee abundance in Maine's wild blueberries.

Shannon Chapin[1], Cynthia Loftin[2], Frank Drummond[3]

[1]Department of Wildlife Ecology, University of Maine, [2]USGS Maine Cooperative Fish and Wildlife Research Unit, [3]School of Biology and Ecology, University of Maine

Maine, blueberries and bees

- Country's largest producer of wild lowbush blueberries
- Wild blueberries, like 75% of the world's crops (Klein et al. 2007), benefit from animal pollination
- Country's second largest importer of non-native honeybees
- Decline in honeybees has increased the cost of hive rentals

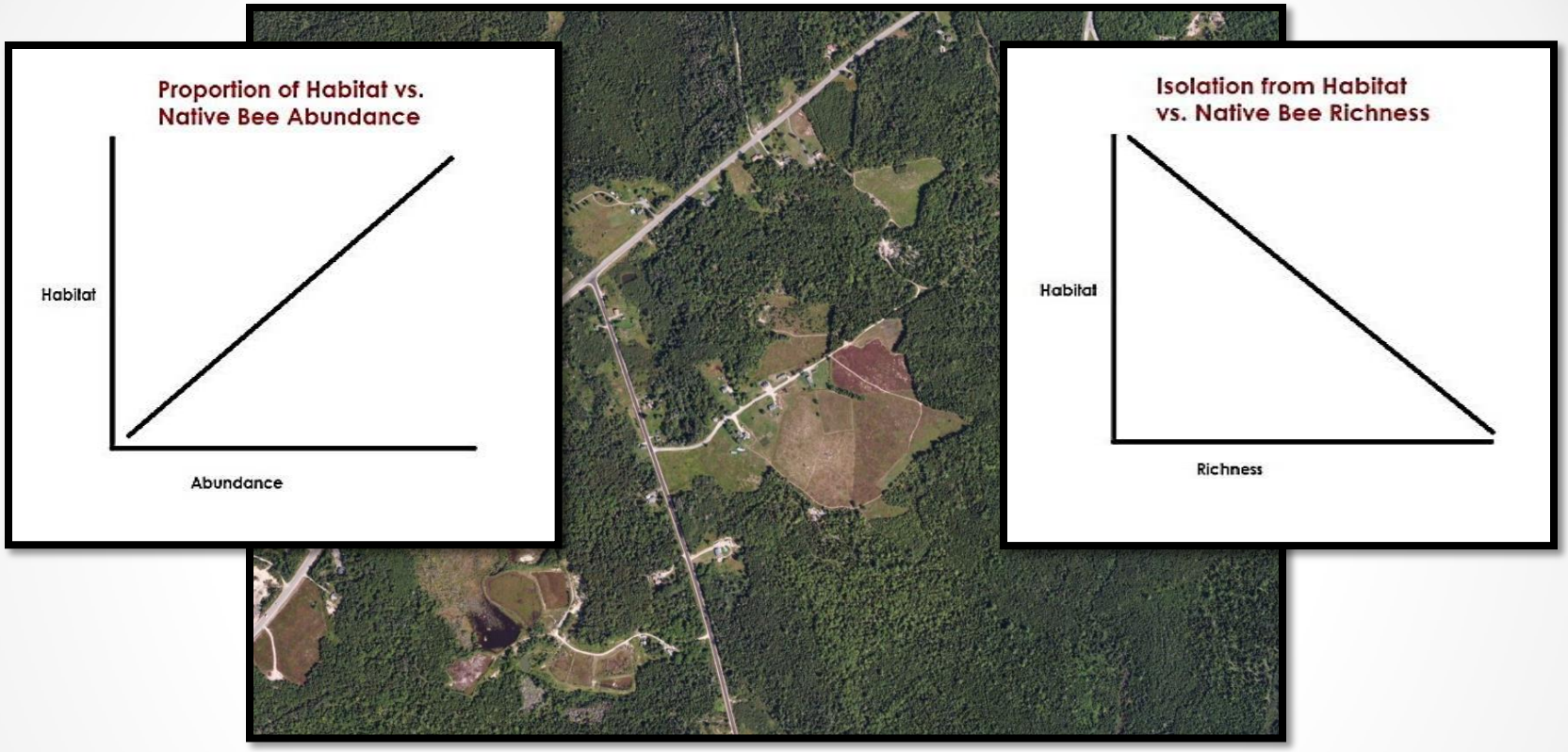
Maine, blueberries and bees

- Native bees are more productive blueberry pollinators than honeybees
- Native bees have adapted to forage in low light levels and cool temperatures
- Of the 270 native bee species in Maine, more than 40 species pollinate blueberries
- Most native bees are solitary species

USDA - pollination security for fruit and vegetable crops in the northeast

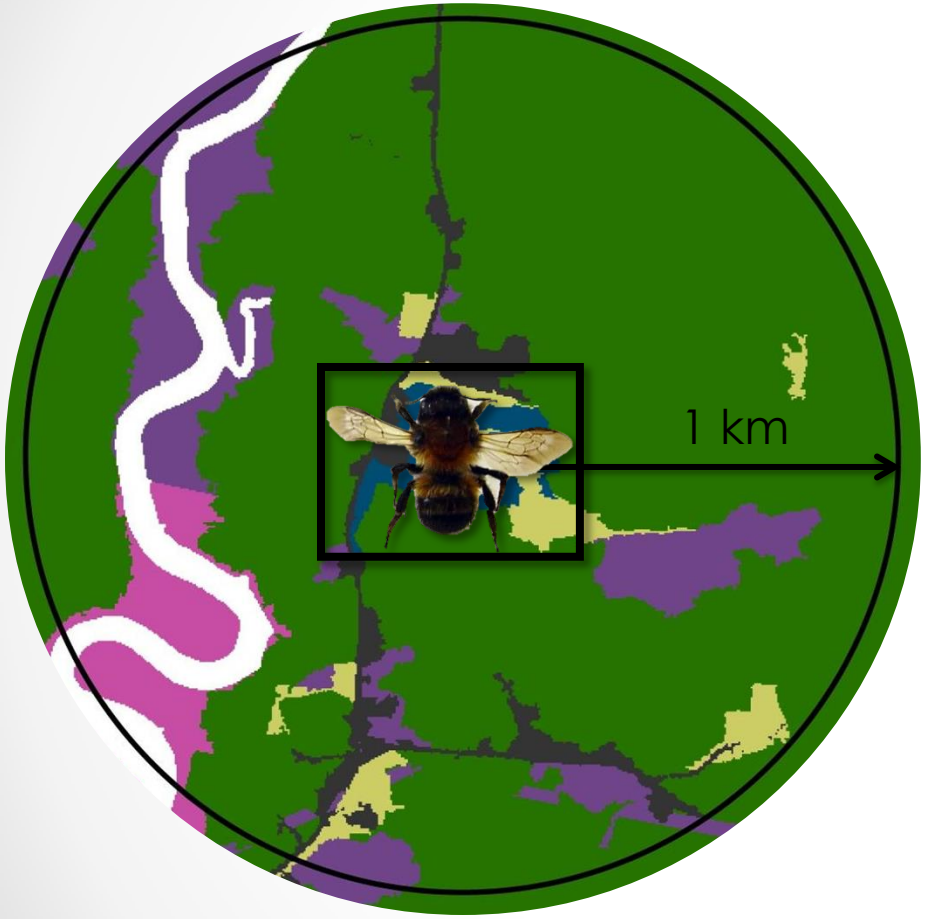
- Collaborative work between economists, anthropologists, biologists, **spatial ecologists**, and growers
- 5 institutions
- NY – apples, CT – squash and pumpkin,
  MA – cranberries, ME – wild blueberries
- Develop recommendations for growers to sustainably manage and protect native pollinator diversity in and around their farms

Native bees and the landscape



Suggested as the next step: Does the pattern and arrangement of the habitat influence pollinator abundance?

InVEST Crop Pollination Model



- Relationship between habitat and bee abundance has been incorporated into the InVEST Crop Pollination Model

- Aim of InVEST: remotely map the relative abundance of pollinators across a landscape using only a landcover layer and user-provided parameters

Research Questions

1. Does the InVEST Crop Pollination Model provide a good fit for predicting native bee abundance in Maine's blueberry fields?

2. Is the InVEST model sensitive to the user provided parameters?

3. What are the optimal parameters needed to predict field collected bee abundance data in our area?

4. Is there a relationship between landscape pattern and arrangement, and pollination services?

Research Question 1:

Does the InVEST Crop Pollination Model provide a good fit for predicting native bee abundance in Maine's blueberry fields?

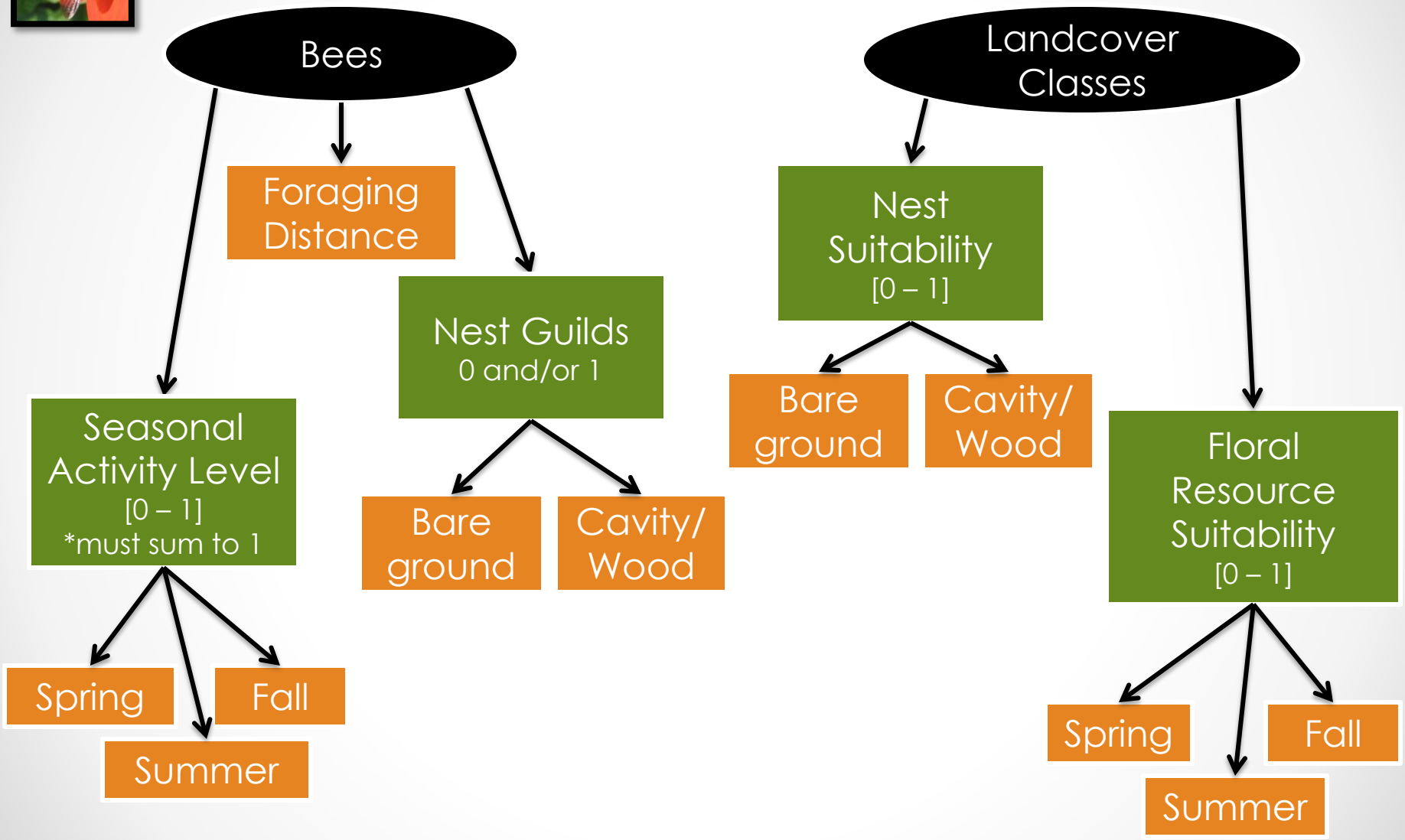
InVEST Crop Pollination Model

- Aim of InVEST: remotely map the relative abundance of pollinators across a landscape using only a landcover layer and user-provided parameters

Landscape	Crop	Predicted Variance (%)
California	Sunflower, Watermelon	55
Costa Rica	Coffee	80
New Jersey, Pennsylvania	Watermelon	4

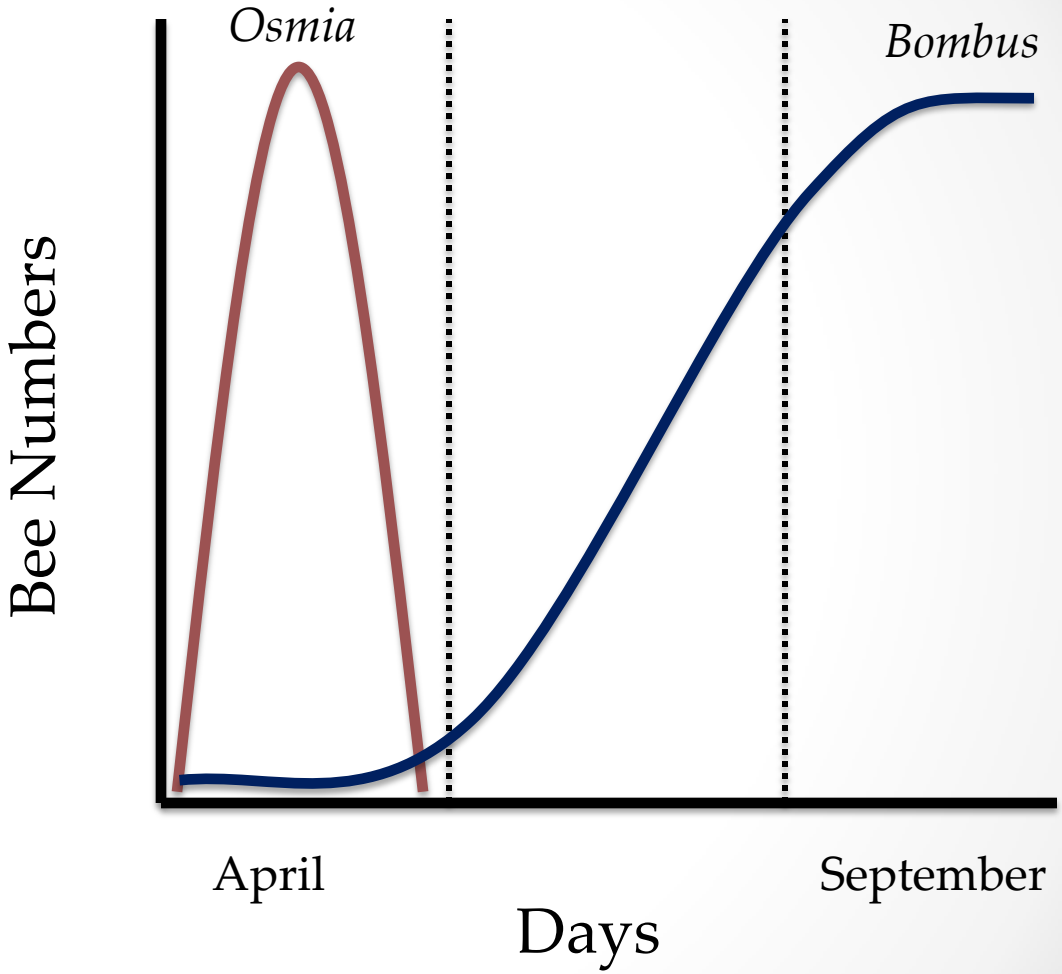
Question 1: Does InVEST provide a good fit for predicting native bee abundance in Maine?

InVEST Crop Pollination Model



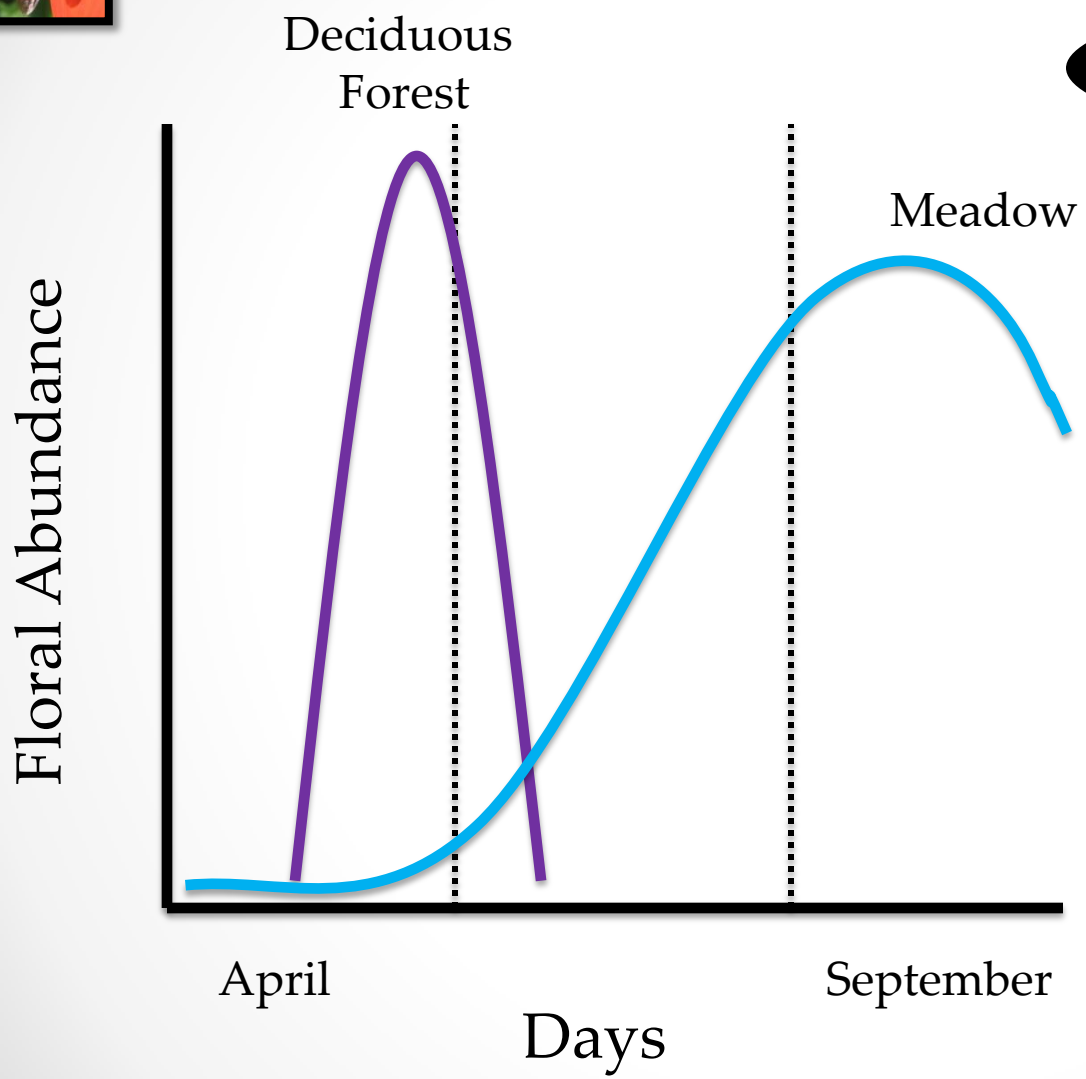
Question 1: Does InVEST provide a good fit for predicting native bee abundance in Maine?

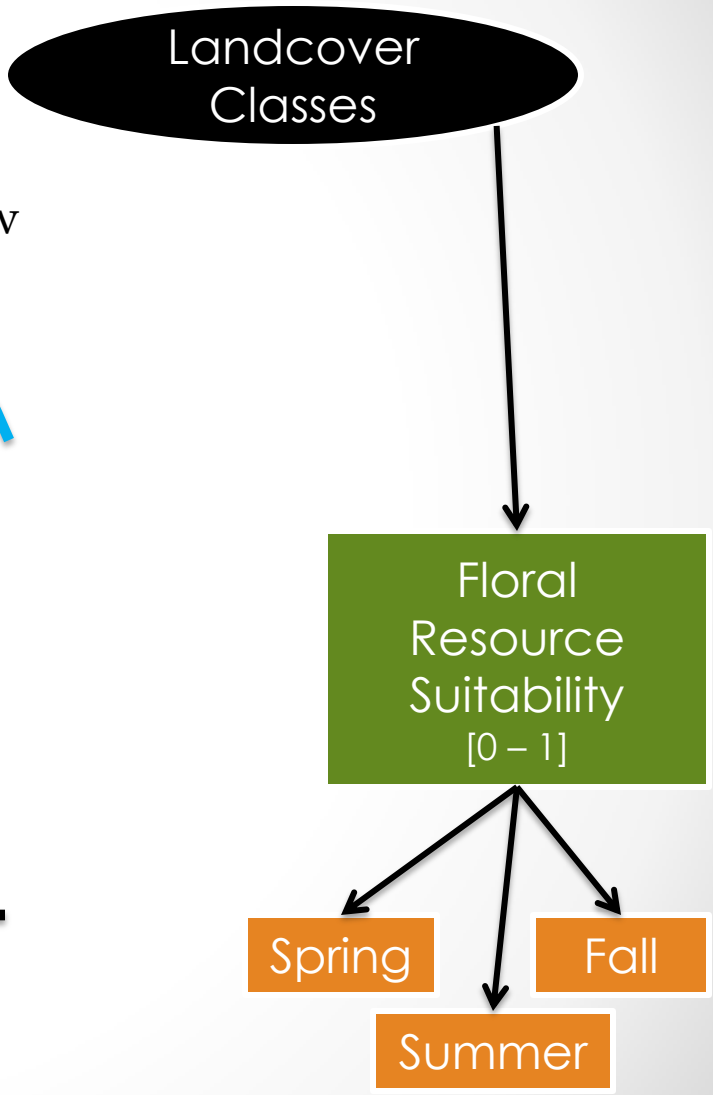
InVEST Crop Pollination Model



Question 1: Does InVEST provide a good fit for predicting native bee abundance in Maine?

InVEST Crop Pollination Model





Question 1: Does InVEST provide a good fit for predicting native bee abundance in Maine?

Input Parameters

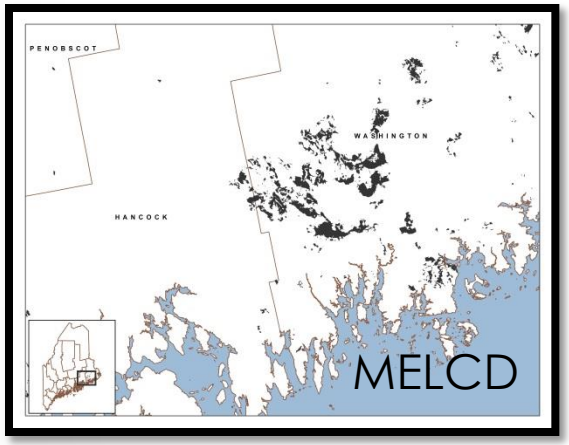
Species	Ground Nester?	Cavity Nester?	Foraging Range
Short Dist. Forager (*Halictus*)	yes	no	100 meters
Long Dist. Forager (*Bombus*)	yes	yes	4000 meters

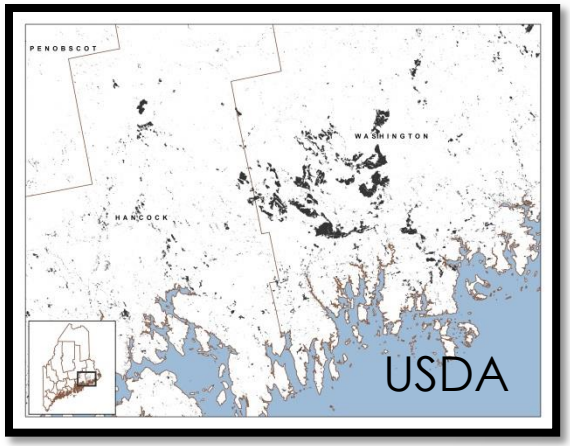
	Nest Suitability (Ground)	Nest Suitability (Cavity)	Floral Resource Suitability
by Landcover Class	0 – 1	0 -1	0 – 1

Question 1: Does InVEST provide a good fit for predicting native bee abundance in Maine?

Data Requirement 1 – Landcover Layer

Spatial Dataset	Date	Resolution (meters)	Blueberry Class?	Accuracy (%)	# of Fields
MELCD	2004	5	Commerical Blueberries	89.7	1,258
USDA Cropland Dataset	2012	30	Blueberries	80.7	55,676





Major differences between the two, so…

- SPOT imagery, 2011 – 10 meter, 3,600 km^2 scene
- Also incorporate ancillary GIS data

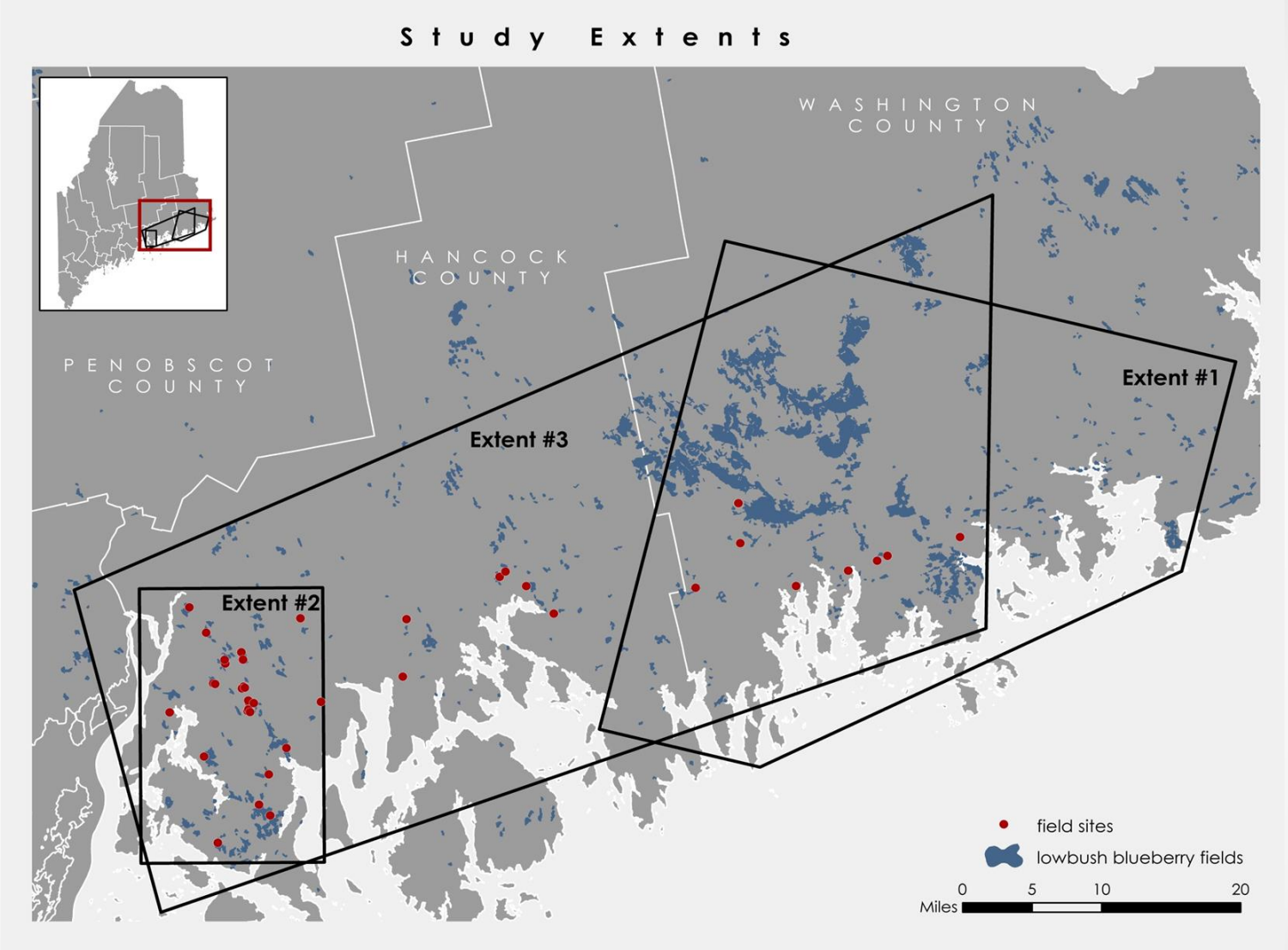
Question 1: Does InVEST provide a good fit for predicting native bee abundance in Maine?

Data Requirements 2 & 3 – Bee Data & Landcover Suitability

- Bee foraging/flight distances (Greenleaf et al. 2007)

$$\log_{\text{foraging distance}} = \log((-1.643 \pm 0.582) + (3.242 \pm 1.218))*(\log_{\text{IT span}})$$

- All other parameter values were developed through an expert opinion survey and available literature



Question 1: Does InVEST provide a good fit for predicting native bee abundance in Maine?

Input Parameters - Bees

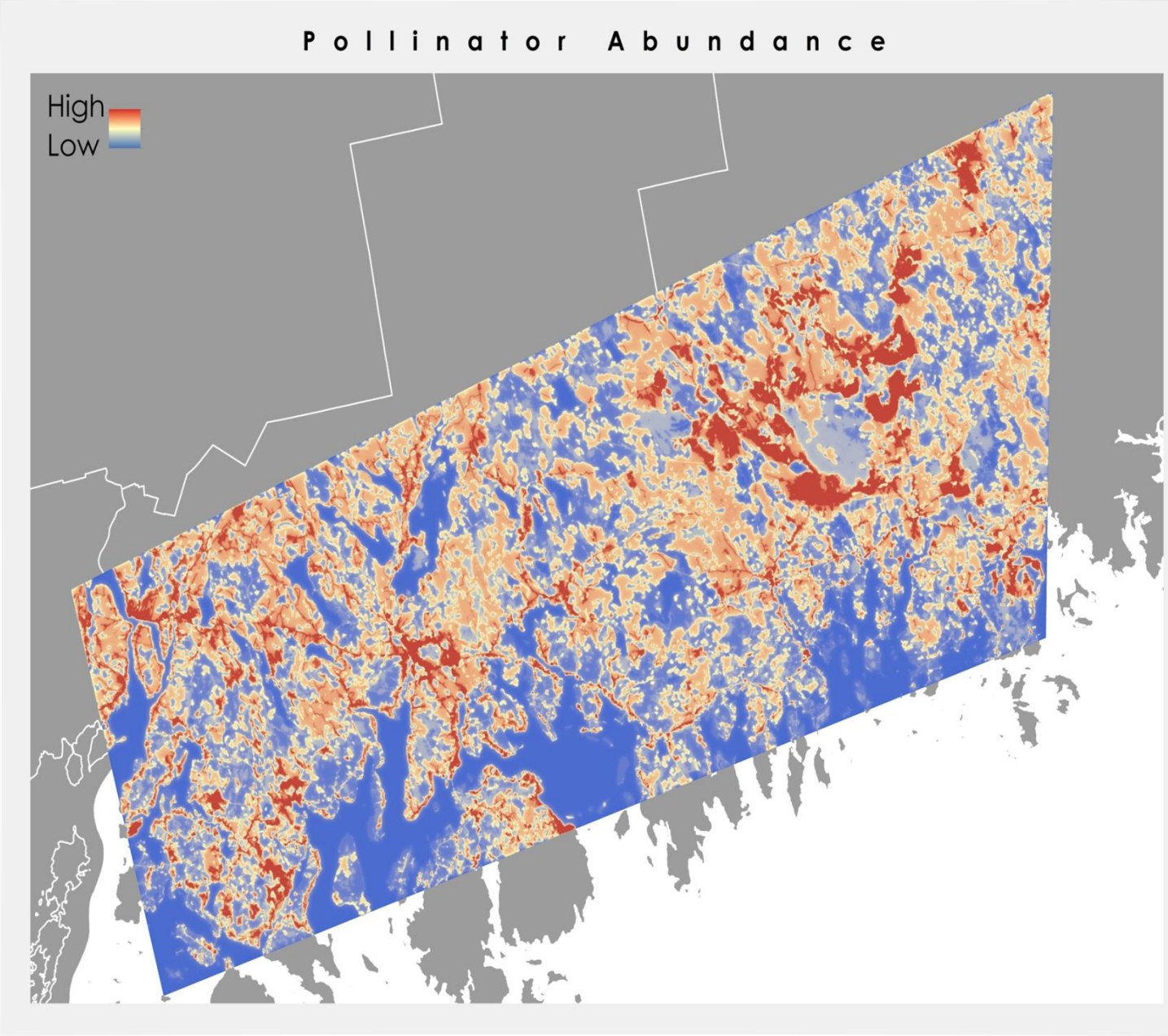
Species	Nest Substrate	Typical Foraging Distance (m)	General Flight Season
Andrena carlini	ground	598	Mar - Aug
Andrena carolina	ground	246	Apr - Jul
Andrena vicina	ground	569	Mar - Aug
Augochlorella aurata	ground	60	Apr - Oct
Colletes inaequalis	ground	1091	Mar – Sept
Halictus ligatus	ground	148	Mar – Nov
Lasioglossum acuminatum	ground	186	Apr – Oct
Lasioglossum cressonii	cavity	63	Mar – Oct
Lasioglossum heterognathum	ground	16	Apr - Sept
Lasioglossum leucocomum	ground	31	Mar – Oct
Lasioglossum pectorale	ground	81	Mar – Nov
Lasioglossum versatum	ground	79	Mar – Oct
Osmia atriventris	cavity	186	Apr – Jul
Osmia inspergens	cavity	495	May – June

Question 1: Does InVEST provide a good fit for predicting native bee abundance in Maine?

Input Parameters – Landcover

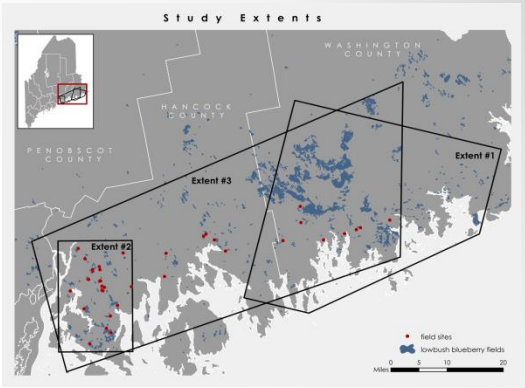
Landcover Type	Nesting – Ground	Nesting – Cavity	Forage – Spring	Forage – Early Summer	Forage – Late Summer
Deciduous/Mixed Forest, edge	0.9	1.0	0.9	0.9	1.0
Developed/Other	0.9	0.6	1.0	0.9	1.0
Coniferous Forest	0.5	0.6	0.1	0.1	0.1
Deciduous/Mixed Forest	0.6	0.9	0.7	0.5	0.4
Emergent Wetlands/ Scrub Shrub	0.2	0.4	0.7	0.6	0.6
Wetlands/Water	0.1	0.1	0.3	0.2	0.5
Agriculture/Field	0.7	0.2	0.9	0.7	0.9
Blueberries	1.0	0.4	0.4	1.0	0.5

Question 1: Does InVEST provide a good fit for predicting native bee abundance in Maine?



Question 1: Does InVEST provide a good fit for predicting native bee abundance in Maine?

Analysis: InVEST validation



Run	Extent	Number of Species Modeled	Landcover Dataset	Validation Dataset	r
1	# 1	9 total	updated landcover, no SPOT, no soils	7 sites	0.77
2	# 1	9 total	updated landcover, no SPOT, with soils	7 sites	0.76
3	# 1	9 total	updated landcover, with SPOT, no soils	7 sites	0.77
4	# 1	6 total	updated landcover, no SPOT, no soils	7 sites	0.86
5	# 3	9 total	updated landcover, no SPOT, no soils	40 sites	0.36
6	# 3	14 total	updated landcover, no SPOT, no soils	40 sites	0.32

Question 1: Does InVEST provide a good fit for predicting native bee abundance in Maine?

Research Question 2 :

Is the InVEST model sensitive to the user-provided parameters?

Sensitivity Analysis

- Study of how the uncertainty in the output of a model can be apportioned to different sources of uncertainty in its inputs.

- Goal is to calculate how variation in each parameter affects estimates of a parcel's pollinator abundance, independent of all other parameters in the model (Lonsdorf et al. 2009)

Parameter	Estimate	Max	Min
Forage Suitability - Spring			
Deciduous/Mixed Forest, edge	0.9	1	0.8
Developed/Other	1	1	0.9
Coniferous Forest	0.1	0.2	0.1
Deciduous/Mixed Forest	0.7	0.8	0.6
Emergent Wetlands/Scrub Shrub	0.7	0.8	0.6
Wetlands/Water	0.3	0.4	0.2
Agriculture/Field	0.9	1	0.8
Blueberries	0.4	0.5	0.3

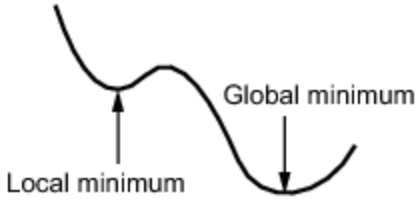
Question 2: Is the InVEST model sensitive to the user-provided parameters?

Research Question 3 :

What are the optimal parameter values needed to predict field collected bee abundance data in our area?

Model Optimization

- Simulated annealing



- Compare results of expert opinion survey to optimized results

Question 3: What are the optimal parameter values needed to predict bee abundance data in our area?

Research Question 4 :

Is there a relationship between landscape pattern and arrangement, and pollination services?

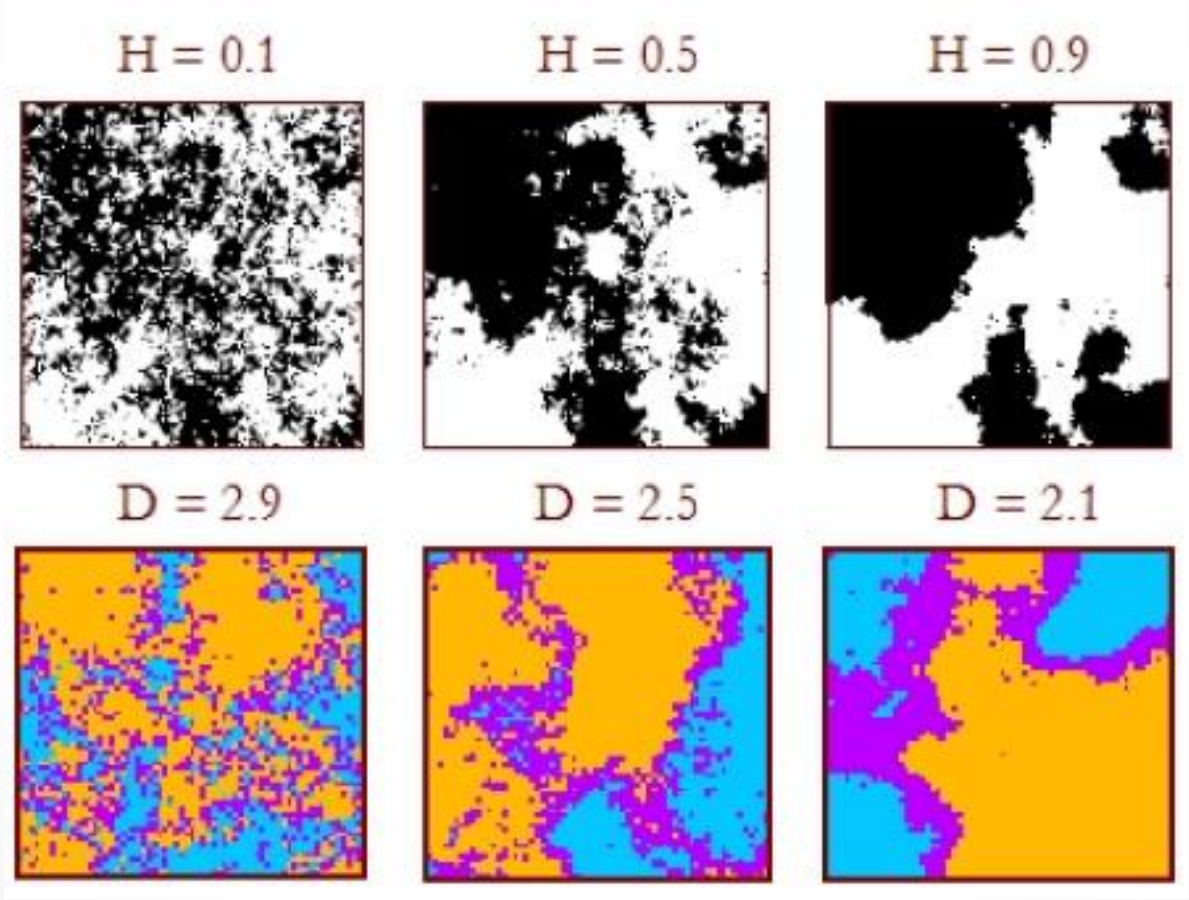
Neutral Landscape Models (NLMs)

1. Determine the extent that some properties of a landscape deviate from random

2. **Predict how ecological processes are affected by the landscape structure**

Neutral Landscape Models (NLMs)

fractal



King and With, 2002

Question 4: Is there a relationship between landscape pattern and pollination services?

InVEST ->Neutral Landscape Models

1. Create fractal NLMs using QRULE

2. Re-run InVEST Crop Pollination Model on simulated NLMs

3. Regress changes in InVEST model output of bee abundance to landscape metrics (i.e. # of patches, average patch size, and patch compactness).

Question 4: Is there a relationship between landscape pattern and pollination services?

Models	Landscape	Research Questions
model bee abundance with InVEST	real landscapes	compare model-predicted vs. field-observed bee abundance (1)
model bee abundance with InVEST		sensitivity analysis on parameters (2)
model bee abundance with InVEST		parameter optimization (3)
develop NLMs with QRULE	simulated landscapes (NLMs)	compare model-predicted bee abundance vs. landscape metrics (4)

Models **Landscape** **Research Questions**

model bee abundance with InVEST

real landscapes

compare model-predicted vs. field-observed bee abundance

1

sensitivity analysis on parameters

2

parameter optimization

3

develop NLMs with QRULE

simulated landscapes (NLMs)

compare model-predicted bee abundance vs. landscape metrics

Models **Landscape** **Research Questions**

model bee abundance with InVEST

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Models **Landscape** **Research Questions**

model bee abundance with InVEST

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parameter optimization **3**

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Models **Landscape** **Research Questions**

model bee abundance with InVEST

develop NLMs with QRULE

real landscapes

simulated landscapes (NLMs)

compare model-predicted vs. field-observed bee abundance 1

sensitivity analysis on parameters 2

parameter optimization 3

compare model-predicted bee abundance vs. landscape metrics 4

My contributions

- **Economists:** Are growers more likely to experience lower profits in areas with lower native bee abundance (as predicted by the InVEST model) ?

- **Anthropologists:** Are growers more likely to adopt practices to enhance native bee habitat it they live in an area with higher native bee abundance (as predicted by the InVEST model)?

- **Growers/Land Managers:** If I provide native bee habitat, does the location and arrangement matter for bees? (as predicted by the NLMs in the InVEST model)

Acknowledgments

Committee: Cyndy Loftin, co-advisor; Frank Drummond, co-advisor; Brian McGill

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Photos: AirPhoto - Jim Wark, Maine ACF, Bangor Daily News, Amy Campbell

Questions, Comments, Suggestions?