natural capital PROJECT

InVEST Crop Pollination

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Crop Pollination

- 75% of important crop plants benefit from animal pollination

- Fruits and vegetables, not staple grains or beans

- Service valued at billions of dollars per year globally

Crop Pollination

Wild bees need:

- Food – pollen, nectar
- Nesting sites - trees, ground

Wild bees provide:

- Increased crop yield and quality
- Food security

Existing models

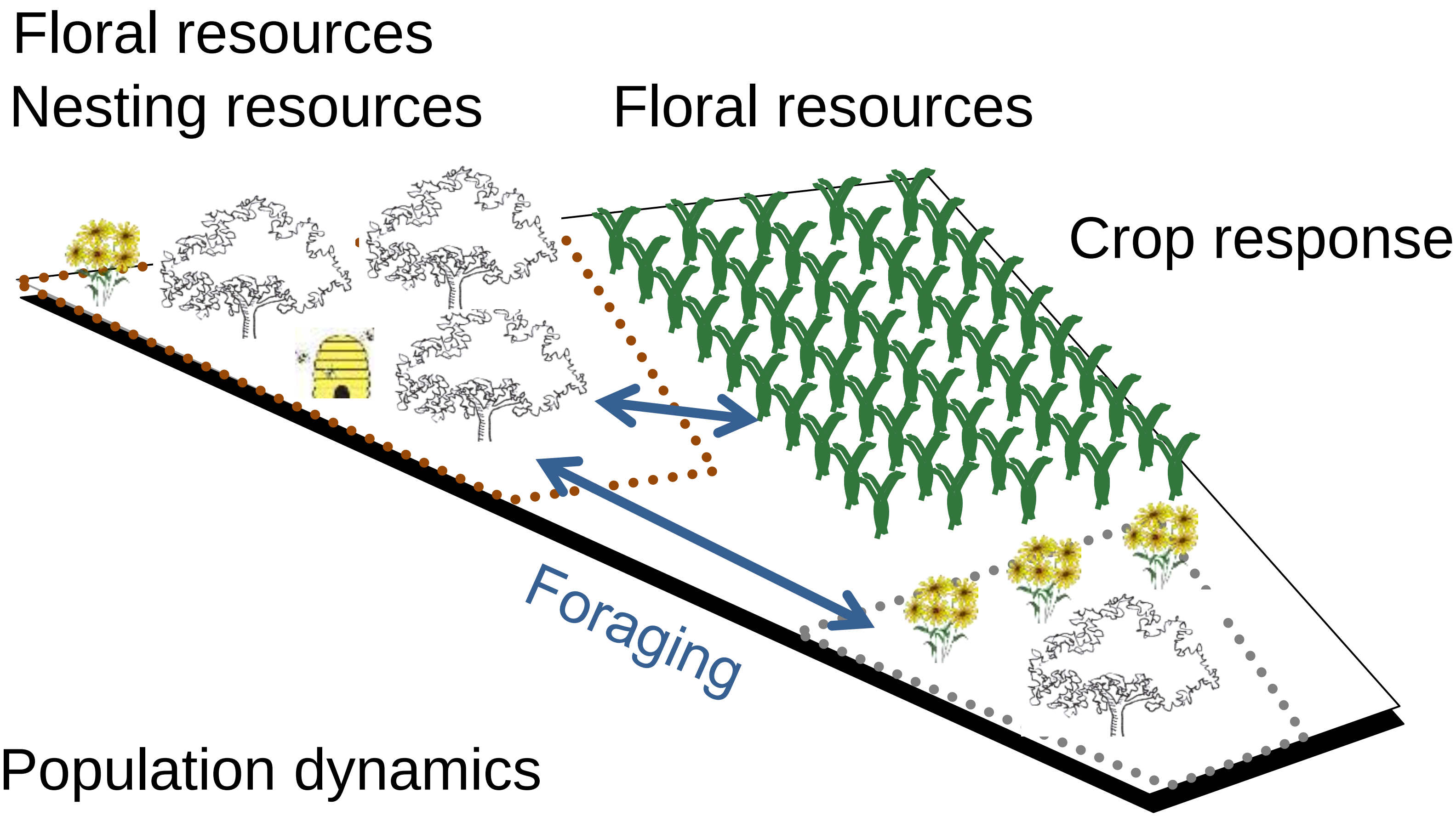
- No other generic pollination models

- Mostly location- or crop-specific

InVEST Pollination Model

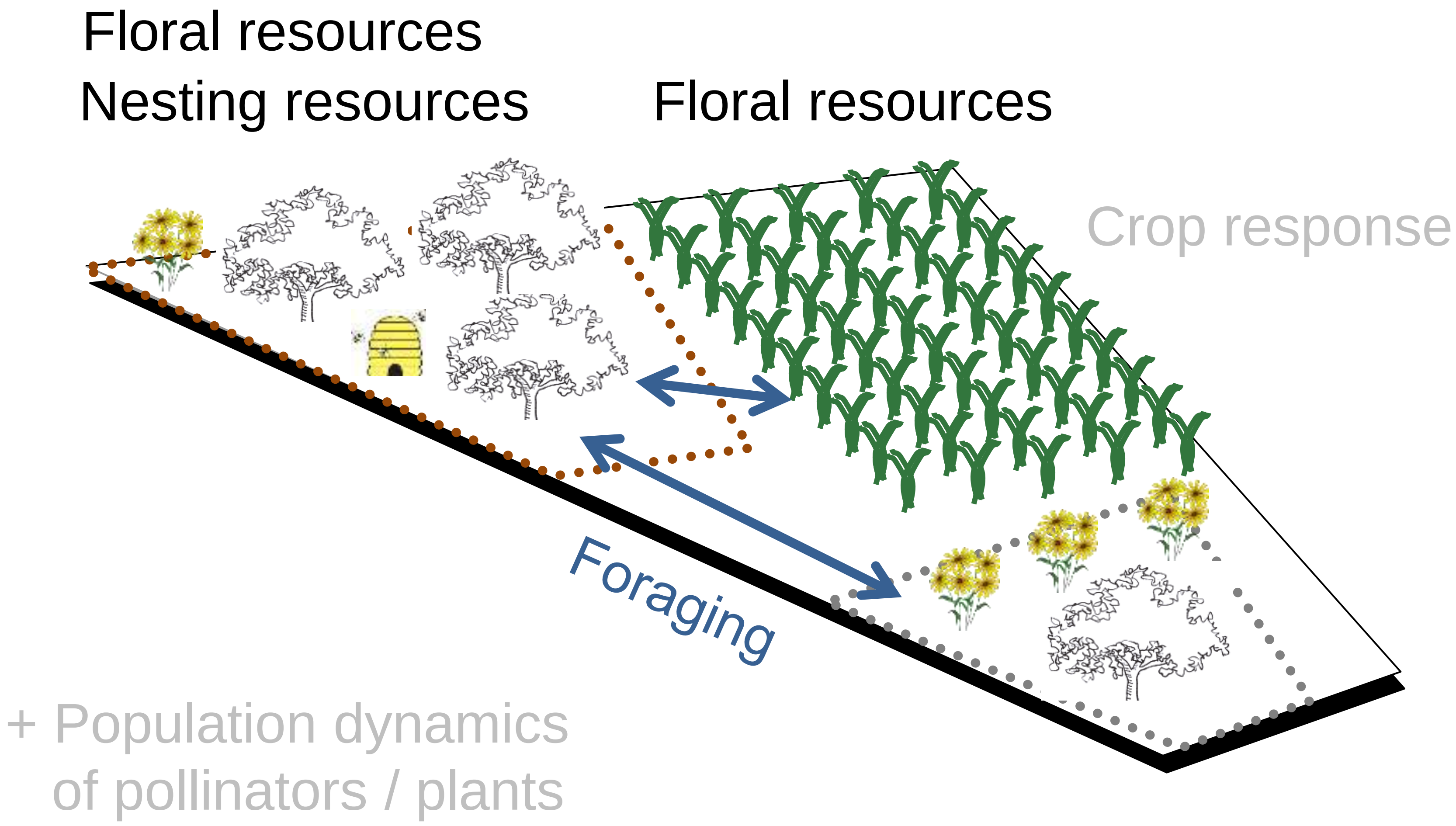
- Focus on wild bees
- *Source abundance* of pollinators across landscape
- *Farm abundance* in agricultural areas
- Pollination value in agricultural areas

Big picture



+ Population dynamics
of pollinators / plants

InVEST Pollination Model



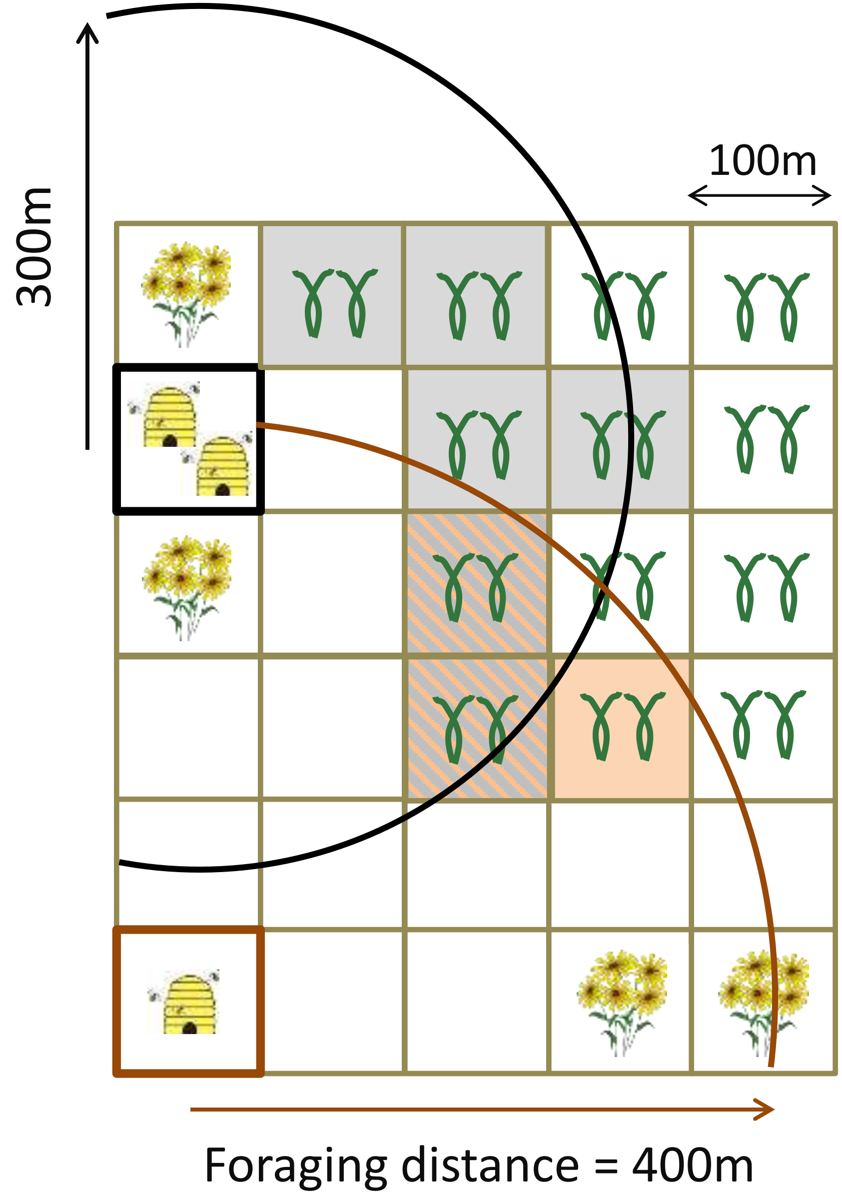
Approach to Abundance

1. Calculate the abundance of bees in each cell of the landscape

   - Nesting sites in that cell
   - Floral resources in surrounding cells

2. Calculate the abundance of bees visiting each farm cell

   - Pollinator supply in surrounding cells
   - Foraging distance

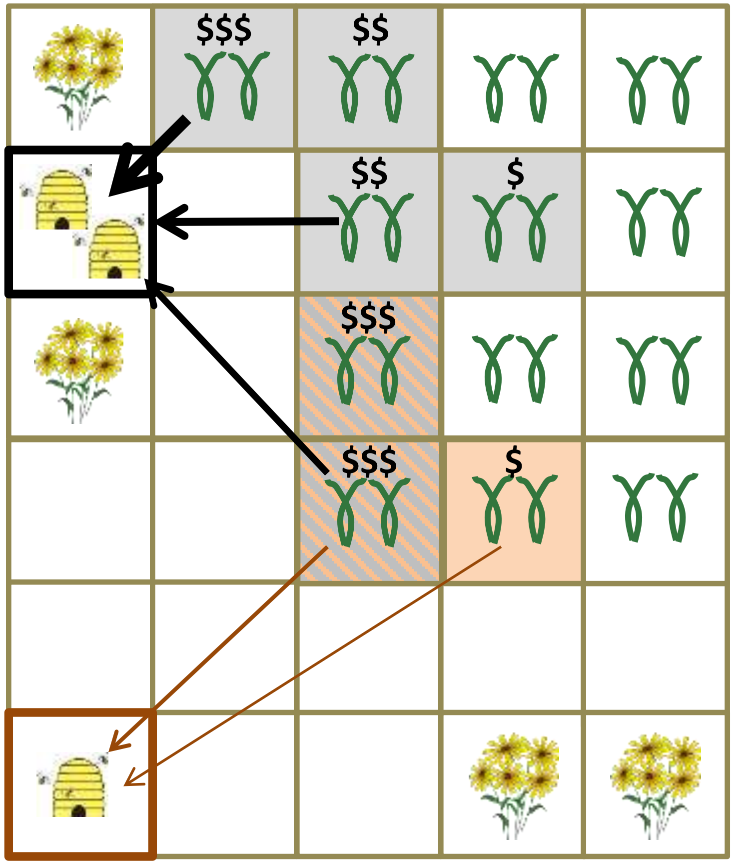


Approach to Valuation

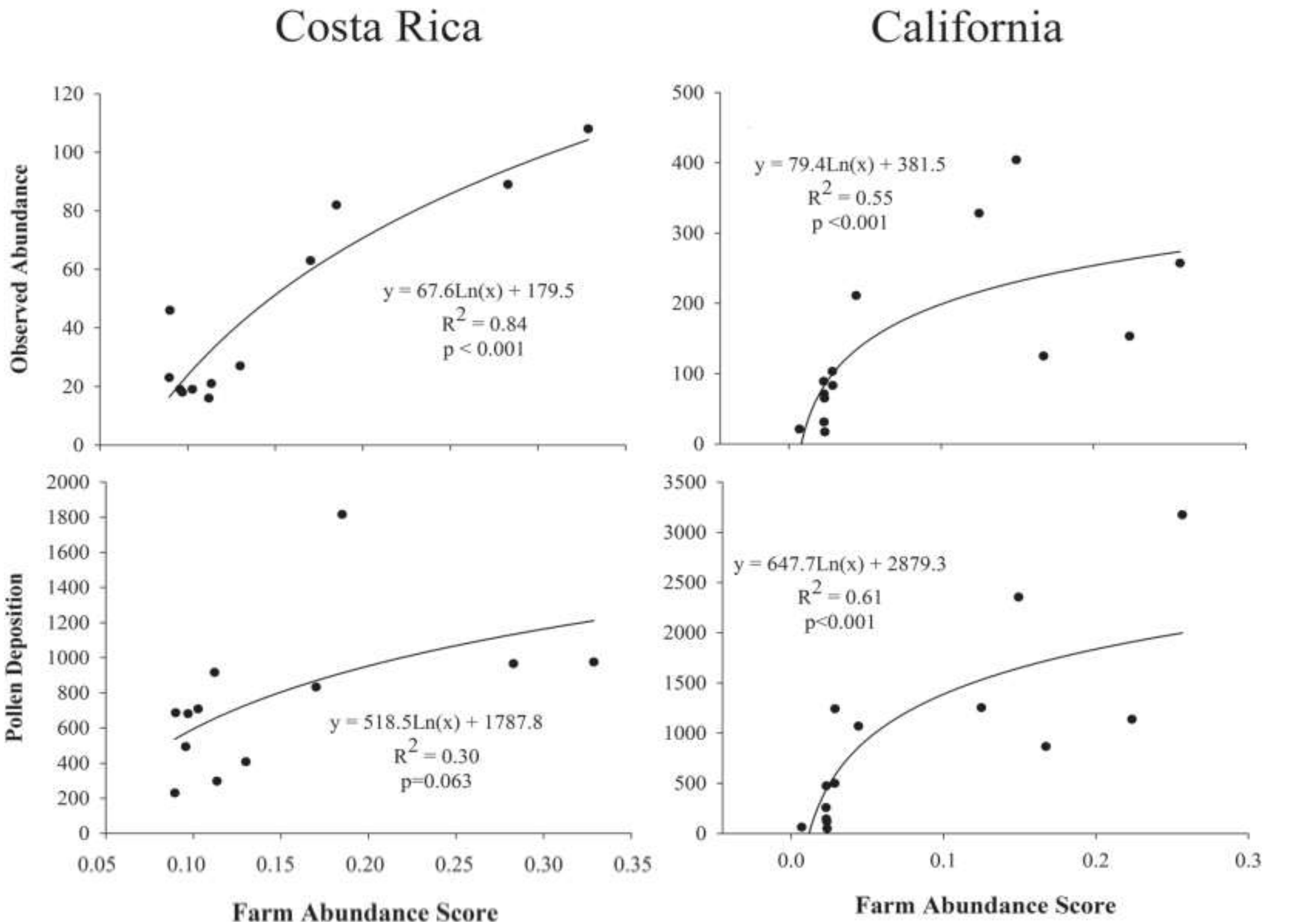
Assumption: Crop yields increase as pollinator visitation increases, with diminishing returns

1. Calculate crop yield (value)
   - Farm abundance
   - Half-saturation constant
   - Wild pollinator proportion
2. Distribute value back to supply cells
   - Fraction for each bee species
   - Distribute fraction among source cells

Relative index, not dollar value

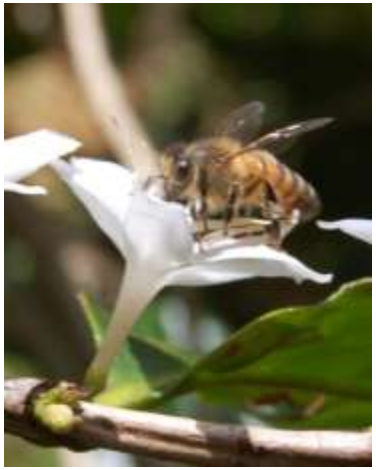


Validation



Costa Rica
California
Observed Abundance
y = 67.6Ln(x) + 179.5
R2 = 0.84
p < 0.001
y = 79.4Ln(x) + 381.5
R2 = 0.55
p <0.001
Pollen Deposition
y = 518.5Ln(x) + 1787.8
R2 = 0.30
p=0.063
y = 647.7Ln(x) + 2879.3
R2 = 0.61
p<0.001
Farm Abundance Score
Farm Abundance Score

Sensitivity



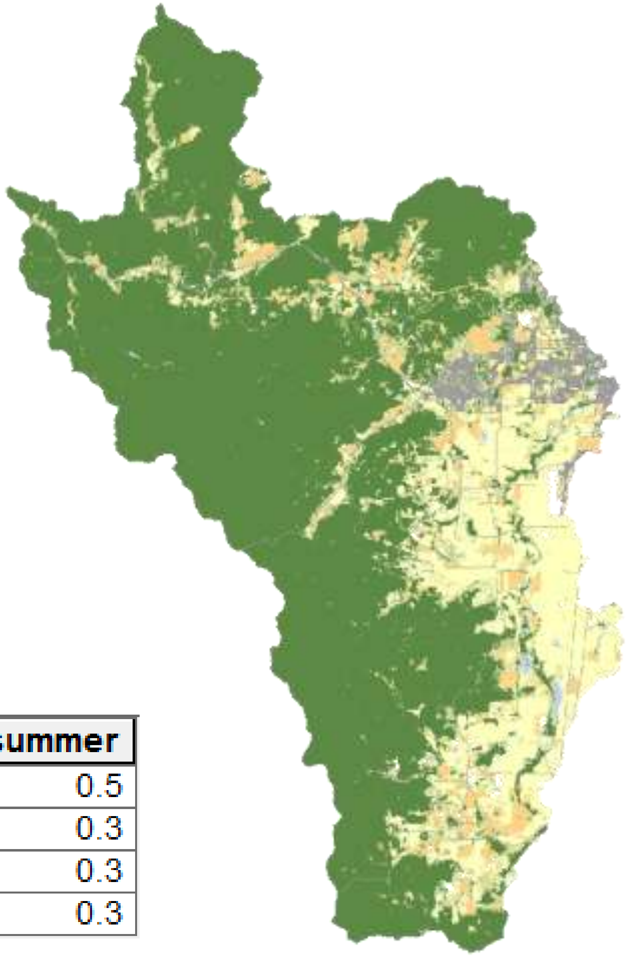
For Costa Rica study:

- Most sensitive to foraging resources in
  - coffee (t-value = 11.643, $p < .05$)
  - and forest (t-value = 3.493, $p < .05$)

- Also species foraging distance 77 – 214m
  - Huge black bee (t-value 2.376, $p < .05$)
  - Trigona fulviventris (t-value 3.158, $p < .05$)

Input Data

- Land use / land cover map



- Land use attributes

LandUse	N_cavity	N_ground	F_spring	F_summer
Residential	0.3	0.2	0.7	0.5
Forest Closed mixed	0.6	0.3	0.3	0.3
Field crop	0.1	0.7	0.5	0.3
Pasture	0.1	0.7	0.5	0.3

Input Data

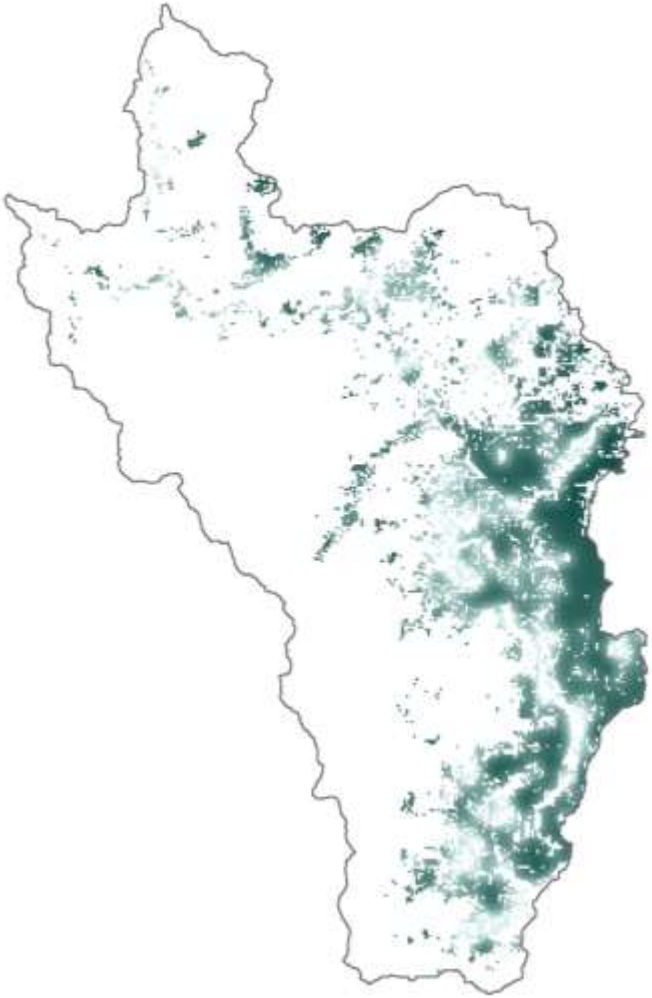
- Species / guild attributes

species	NS_cavity	NS_ground	FS_spring	FS_summer	Alpha
Apis	1	1	0.5	0.5	500
Bombus	1	0	0.4	0.6	1500

- Half-saturation constant
- Wild pollinator proportion
- Future landcover map (optional)

Output Maps

- Pollinator abundance over whole landscape
- Pollinator abundance on farms
- Pollinator service value
- For both current and future scenario, if provided



Application

- Land use planners: Consequences of policies on farmers
- Farmers: Locate crops
- Land trust: Invest in places that benefit both biodiversity and farmers
- Payments for ecosystem services

Install GDAL

1/ Download GDAL from:

http://www.naturalcapitalproject.org/

2/ Open User Guide:

<InVEST install>/InVEST_2.2.1_Documentation.pdf

Post-analysis

- Colony Collapse!!

Bombus

Apis

- Prioritize conservation efforts
- Input to crop production function
- Effects of field buffers

Limitations

- Relative indices of abundance and value only
- No population dynamics over time
- Fine-scale resources not captured
- No effects of land parcel size
- No managed pollinators

Outlook

- Specify half-saturation and wild pollinator constants per land use

Equations

Pollinator abundance on cell *x:*

$$P_x = N_j \frac{\sum_{m=1}^{M} F_j e^{\frac{-D_{mx}}{\alpha}}}{\sum_{m=1}^{M} e^{\frac{-D_{mx}}{\alpha}}}$$

- N_j = suitability of nesting on LULC *j*
- F_j = floral resources on LULC *j*
- D_{mx} = Euclidian distance
- α = foraging distance

Equations

Farm abundance from source cell *x* to ag cell *o*:

$$P_{ox} = \frac{P_x e^{\frac{-D_{ox}}{\alpha}}}{\sum_{x=1}^{M} e^{\frac{-D_{ox}}{\alpha}}}$$

- P_x = supply of pollinators on cell *x*
- D_{ox} = Euclidian distance
- α = foraging distance

Equations - Valuation

Expected yield of crop *c* on farm *o*:

$$Y_o = 1 - \nu_c + \nu_c \frac{P_o}{P_o + \kappa_c}$$

- ν_c = proportion of crop *c*'s yield attributed to wild pollination
- κ_c = Half-saturation constant

Pollinator service value for cell *m*:

$$PS_m = \nu_c \sum_{o=1}^{O} V_o \frac{P_{om}}{P_o}$$

- V_o = crop value in farm cell *o*