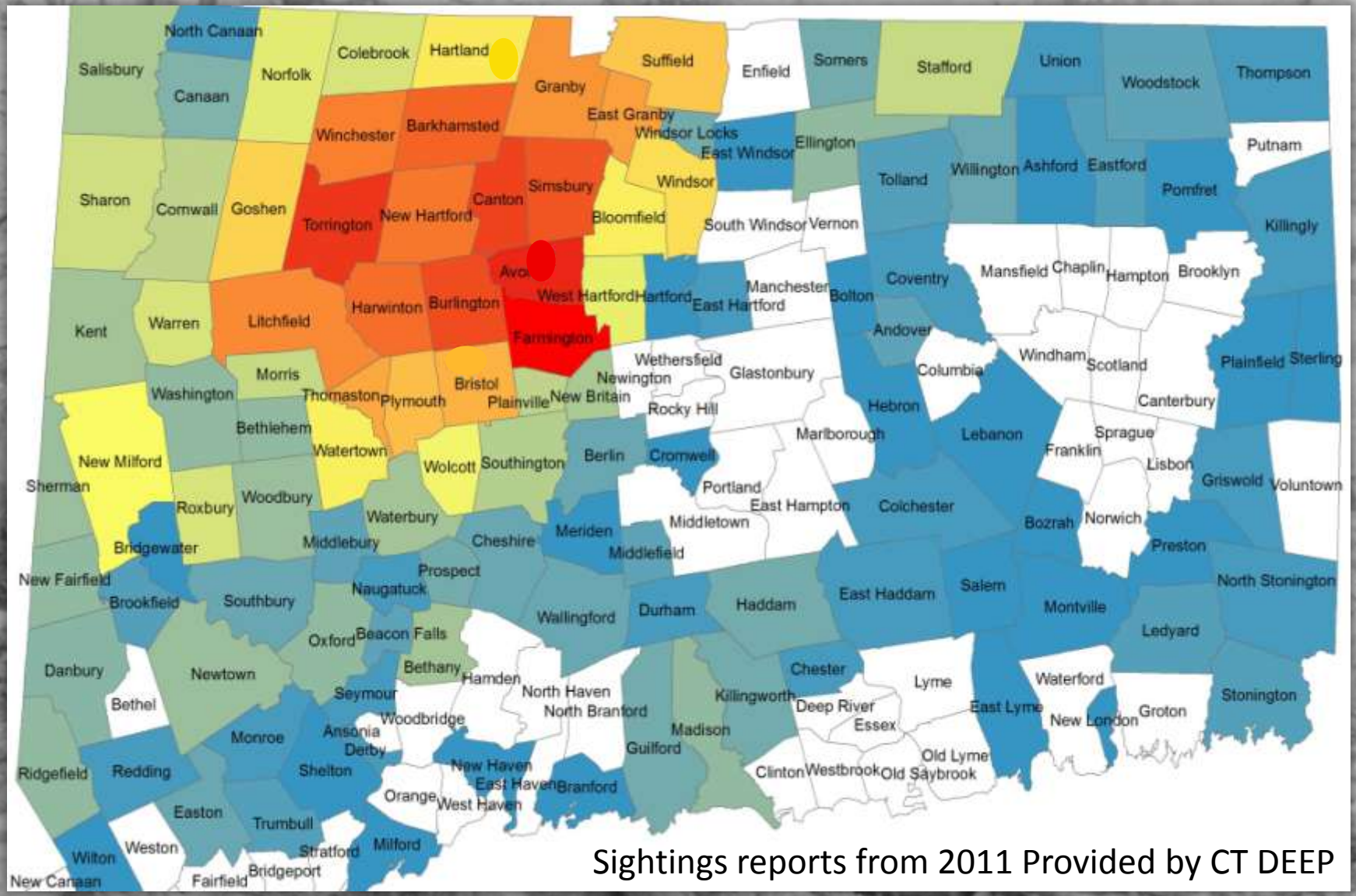
Understanding Connecticut's Black Bears through Non-Invasive Hair Sampling

Michael Evans

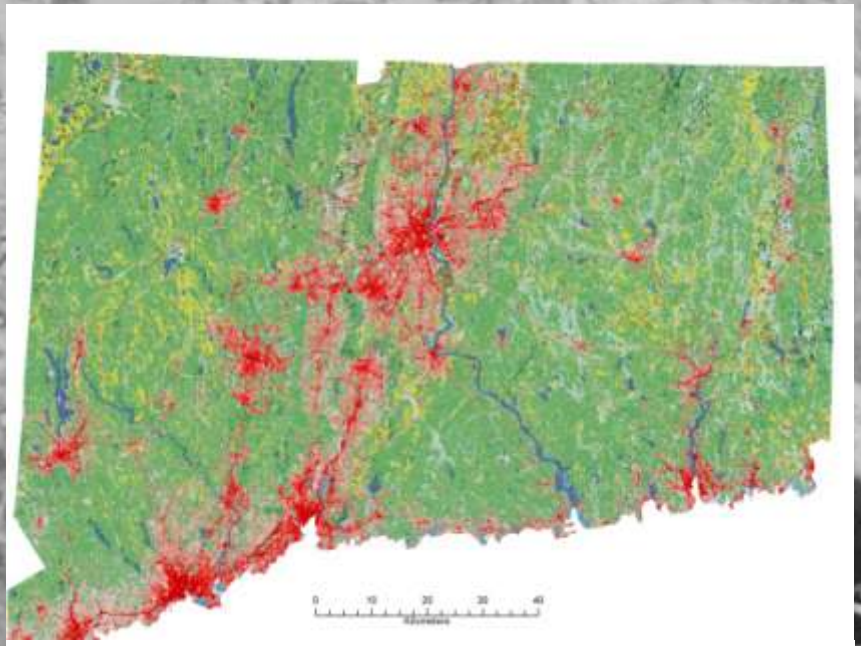
University of Connecticut
College of Agriculture and Natural Resources

Black Bear in Connecticut

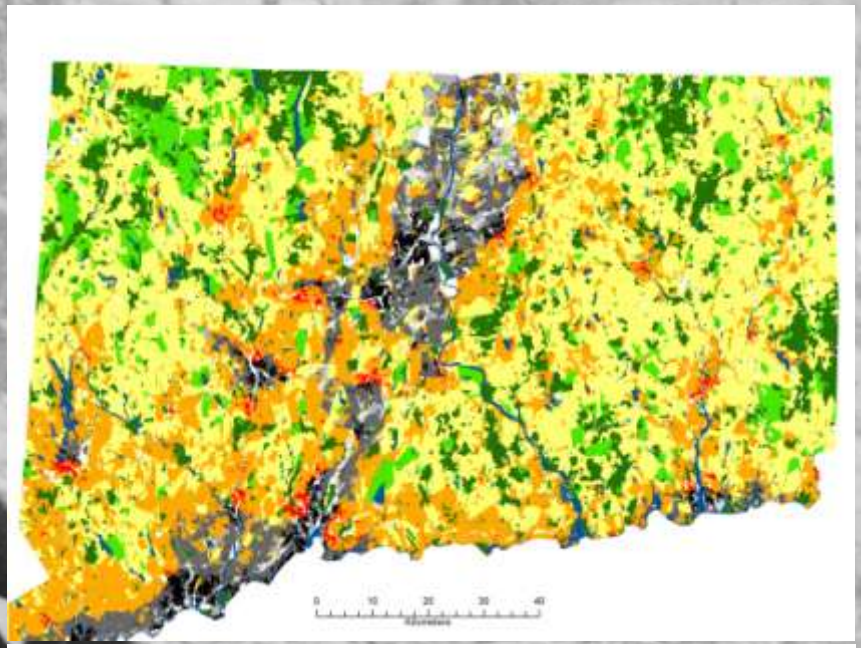


Sightings reports from 2011 Provided by CT DEEP

Connecticut's "Exurban" Landscape



~ 60% Forested Land Cover

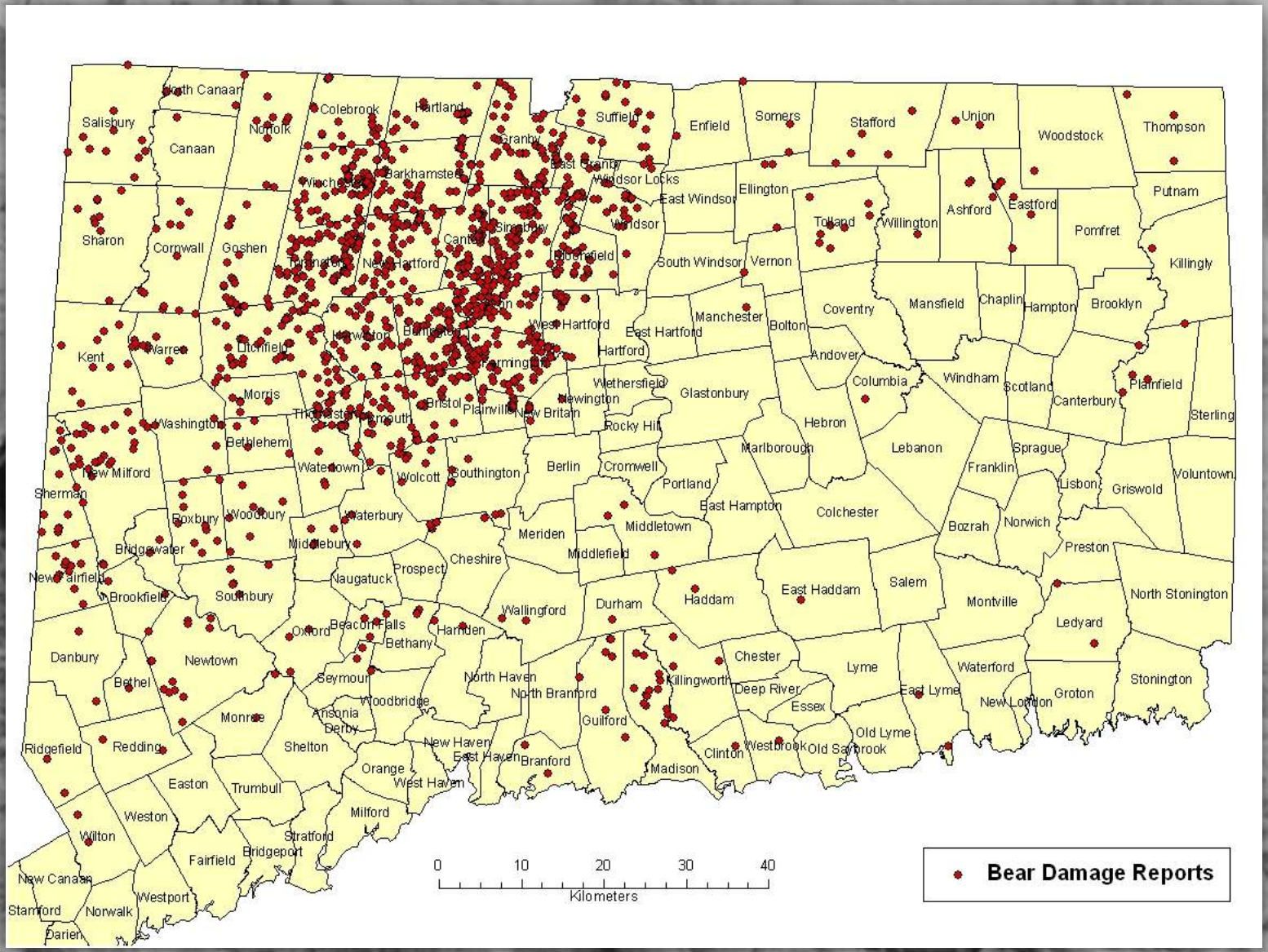


> 50% 'Intermixed' Land Use

Intermixed housing and forest

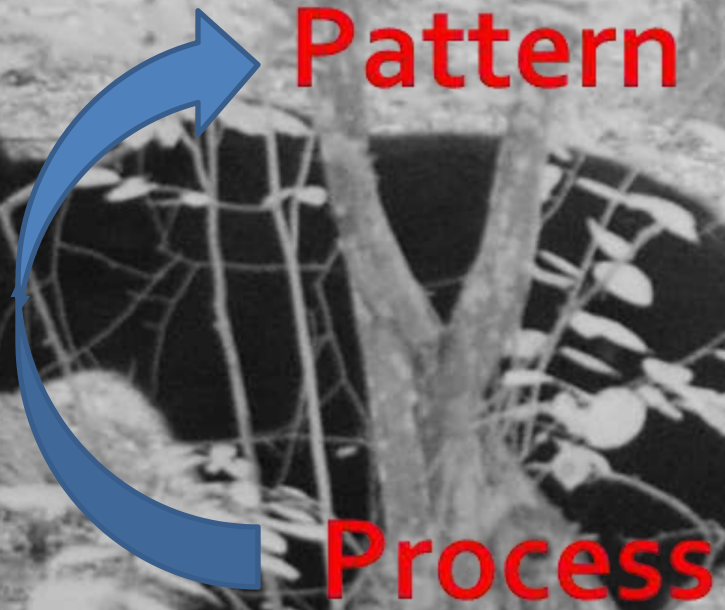
1. Promotes human-bear interactions
2. May affect bear biology and behavior

Bear Damage Reports (2008 – 2012)



Provided by CT DEEP

Effects of Human Development on Black Bear Ecology in Connecticut



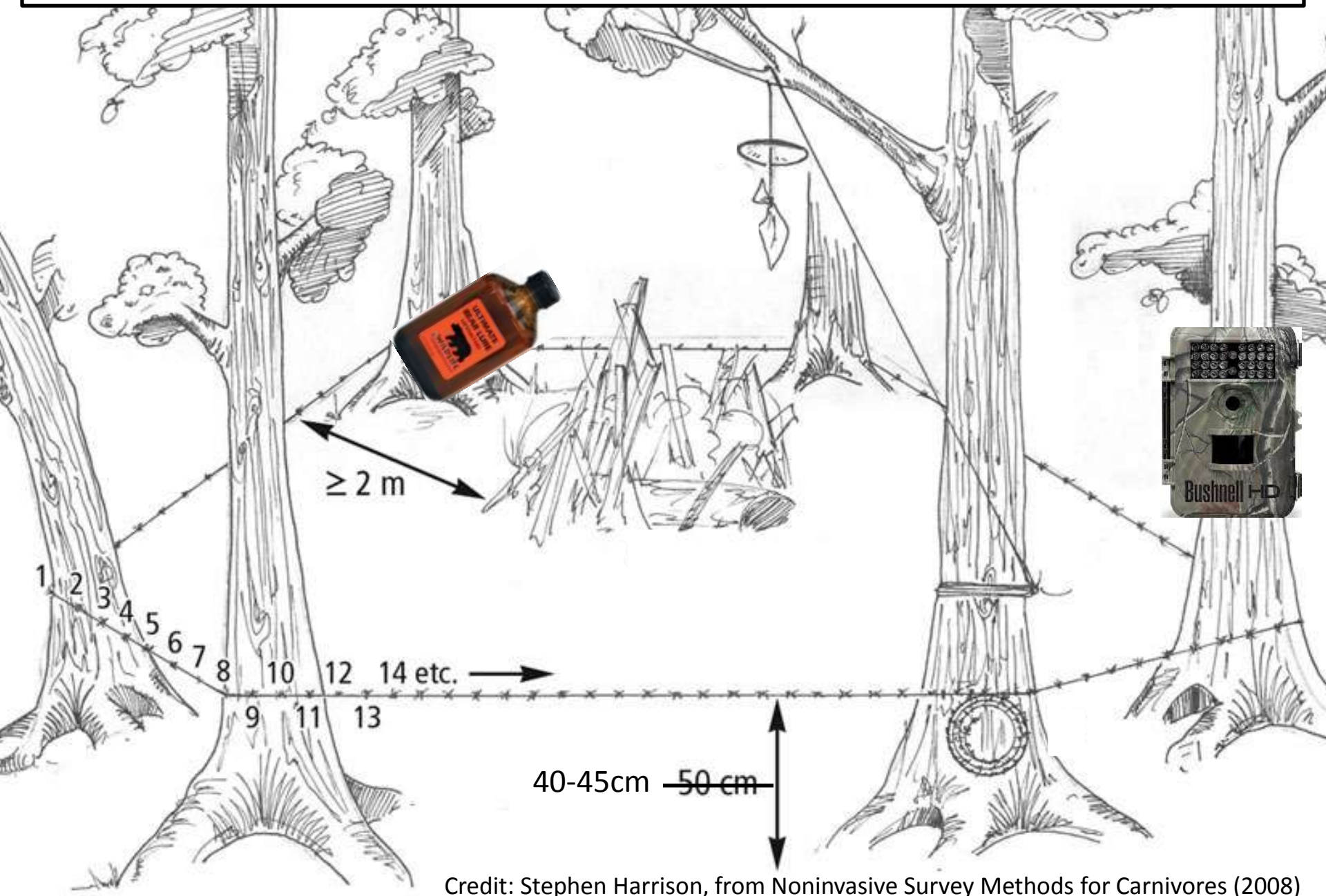
Population Structure

1. Abundance & Density
2. Distribution

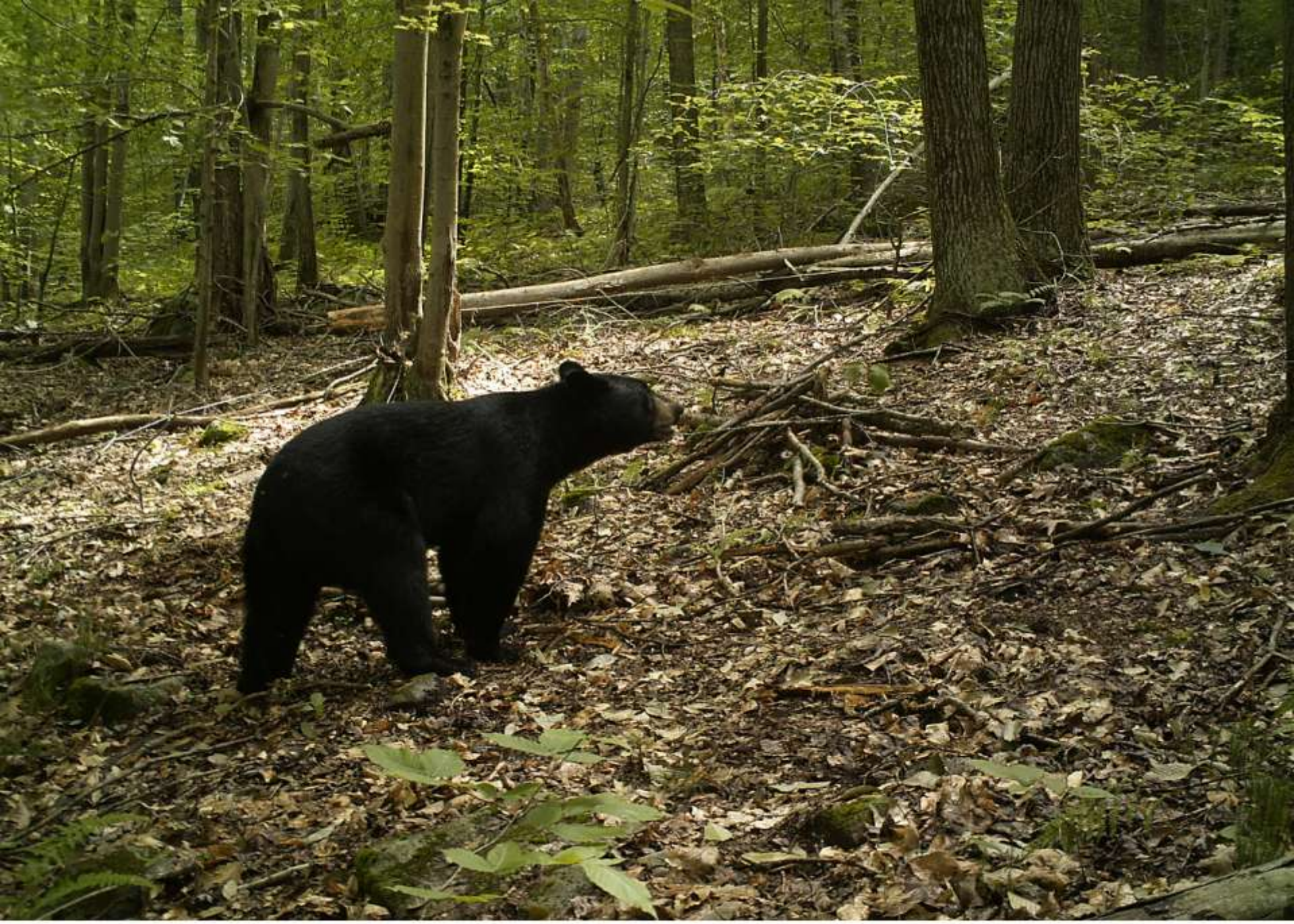
Behavior

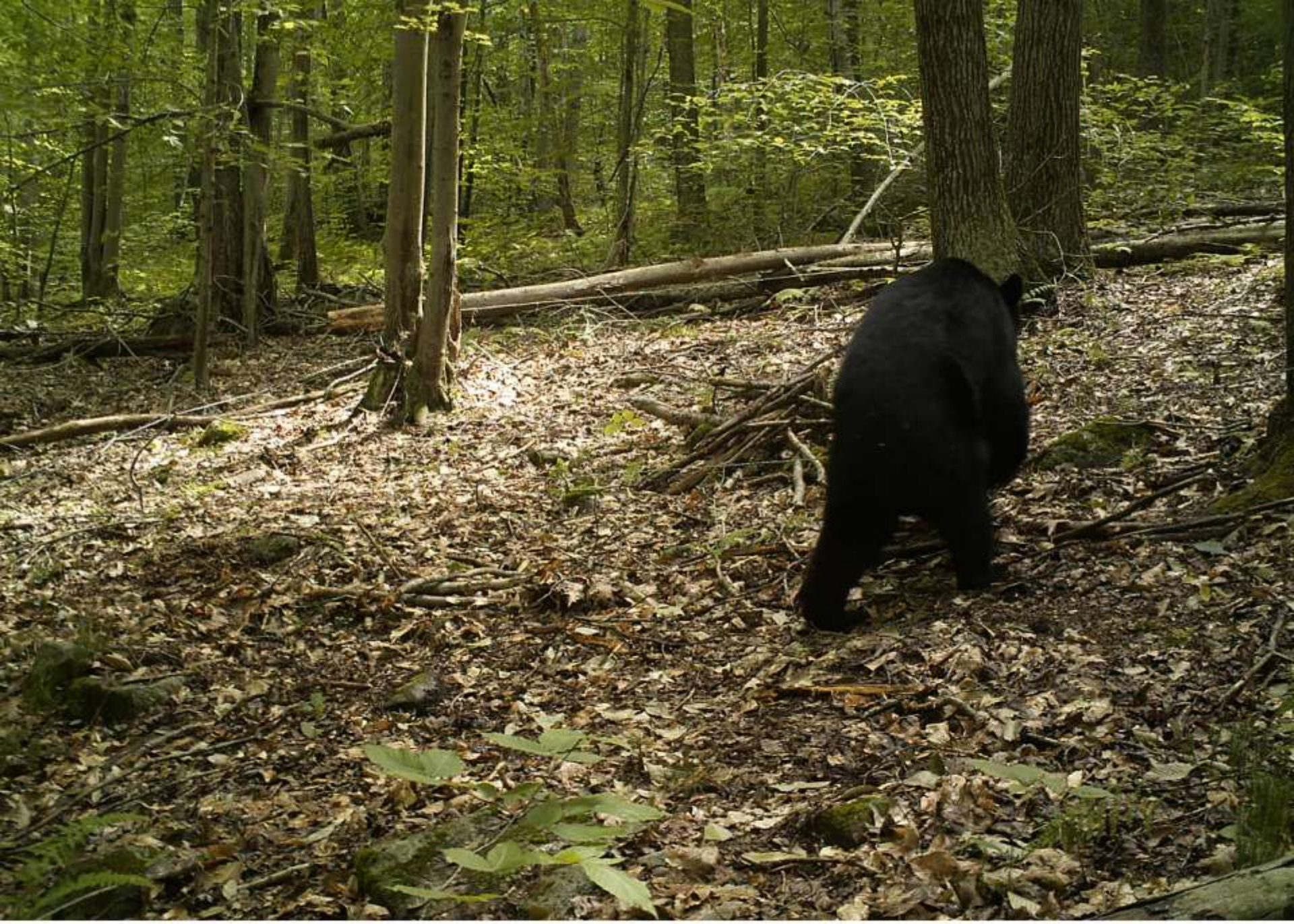
1. Dispersal
2. Resource Selection
3. Home Range Structure

Non-Invasive Hair Sampling



Credit: Stephen Harrison, from Noninvasive Survey Methods for Carnivores (2008)


Bushnell M Camera Name 68°F20°C
07-26-2012 13:59:12


Bushnell
Camera Name
68°F20°C
07-26-2012 13:59:22

Bushnell M 02 86°F30°C
01-06-2012 18:36:05

Bushnell M 02 82°F27°C
01-06-2012 20:29:32

Bushnell Camera Name 71°F21°C
07-22-2013 14:22:26

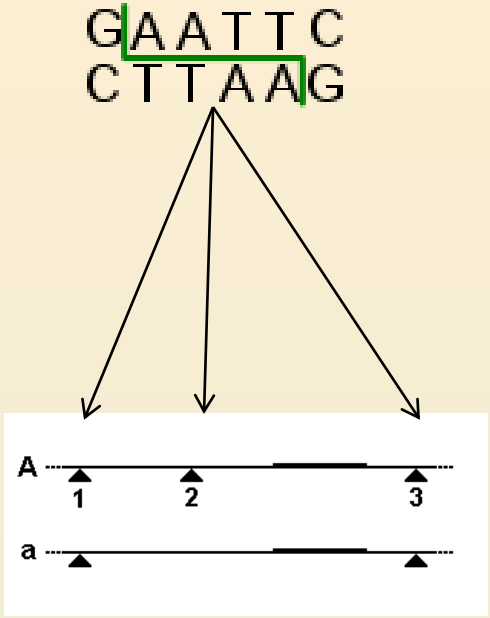
Bushnell
Camera Name
71°F21°C
07-27-2013 12:35:30

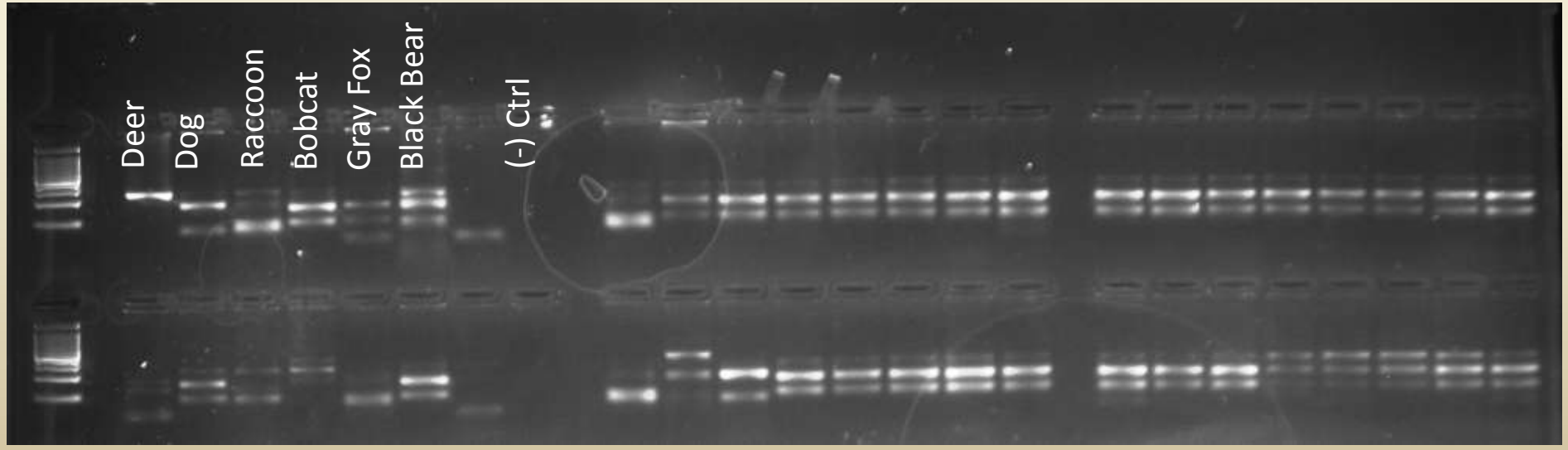
What's In A Hair?

1. Individual identity
2. Relationship to other bears
3. Dietary composition

Species Identification

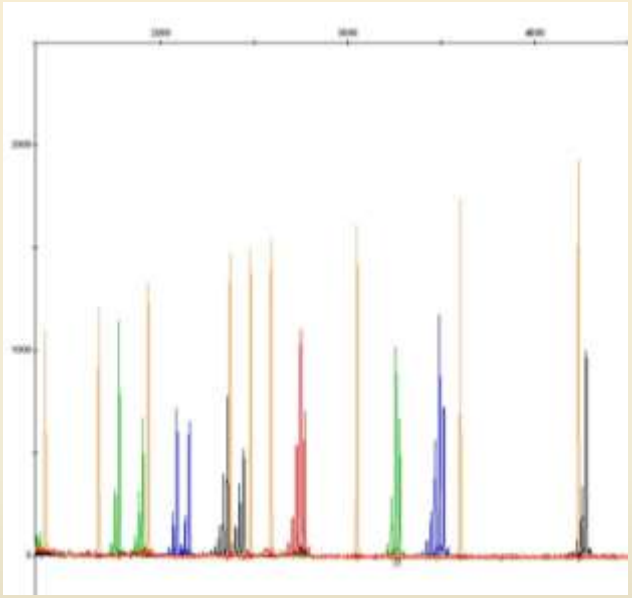
1. **Restriction enzyme digests**
2. Sequence at highly conserved loci

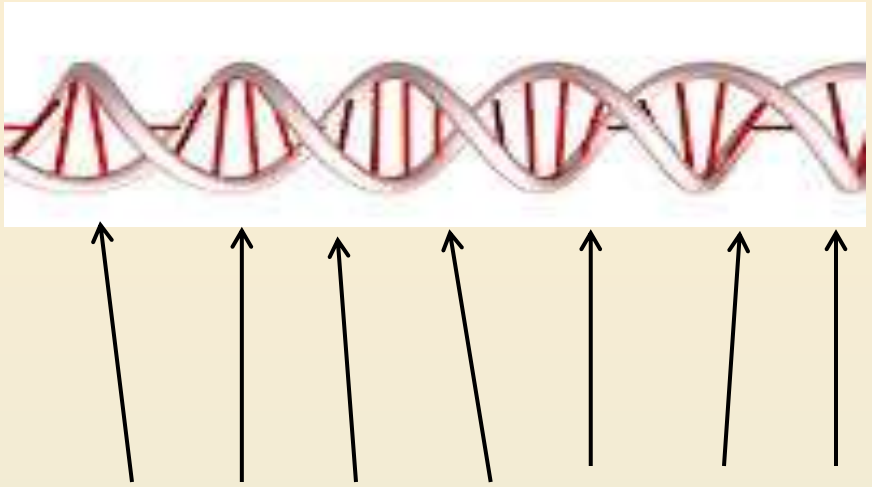




Unique Genotypes – genetic 'fingerprints'

1. Individual ID
2. Relationships



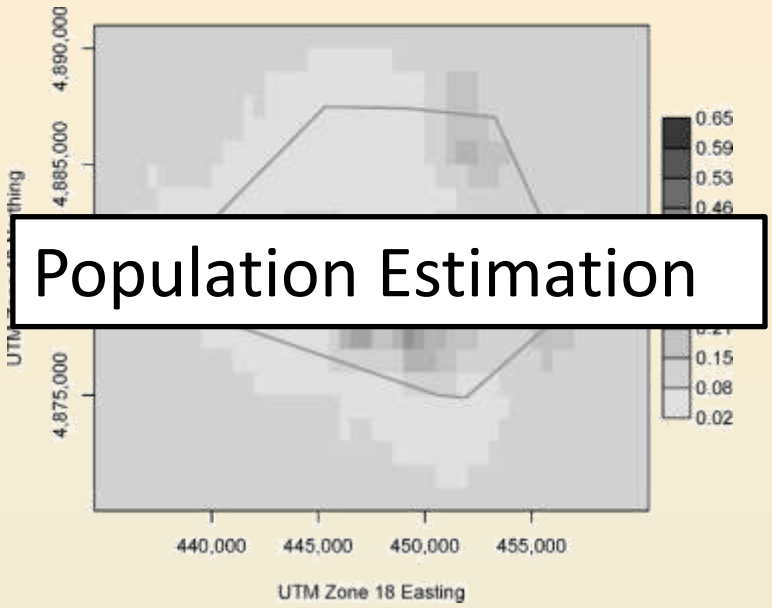


SAMPLE	G10C	G10M	G1A	G10B	G1D	G10L	G10P
BEAR #1	114	200	113	161	130	125	163
	114	200	117	165	130	125	173
BEAR #2	114	200	113	161	130	121	163
	114	202	115	165	130	125	173

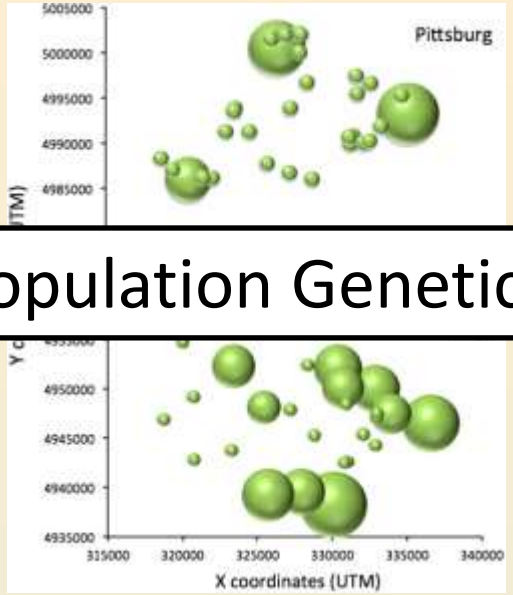
Probability of identity (

$$P_{(ID)} = \Sigma p_i^4 + \Sigma\Sigma\,(2p_i p_j)^2$$

Applications



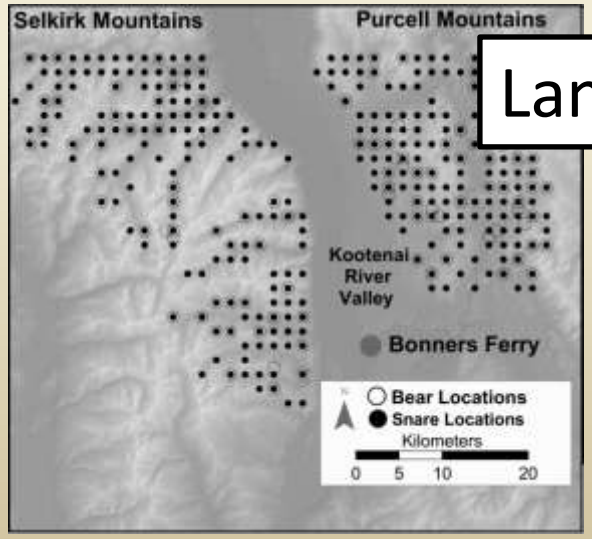
Population Estimation

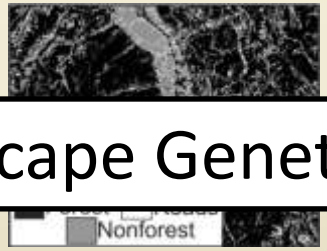


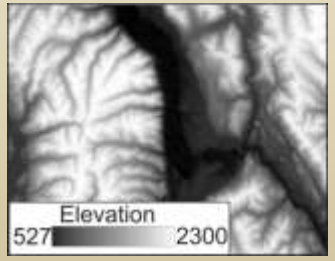
Population Genetics

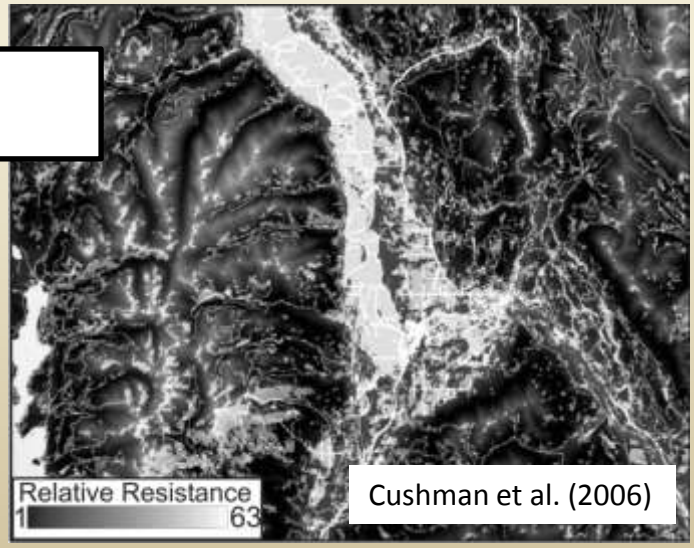
Coster et al. (2010)

Landscape Genetics





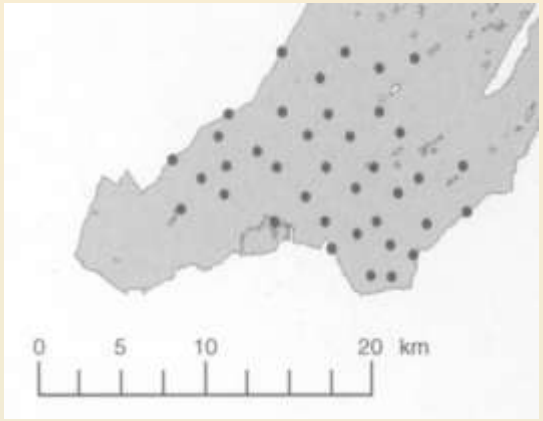


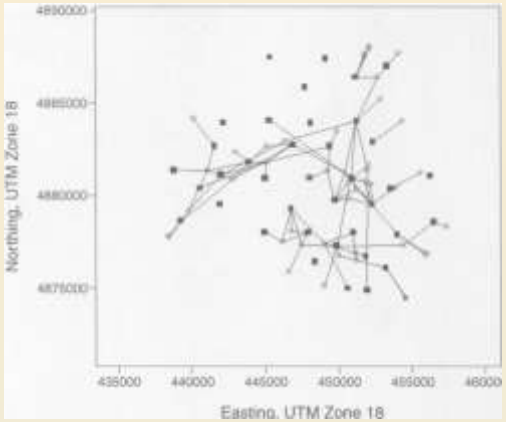


Cushman et al. (2006)

Spatial Mark-Recapture

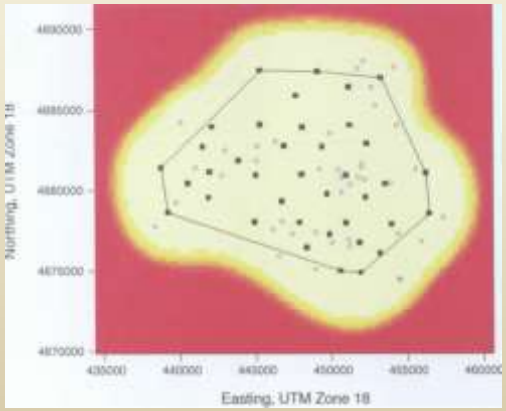
$$\Pr(y_{ijk}=1) = 1 - \exp(-\lambda_0 g_{ij})$$

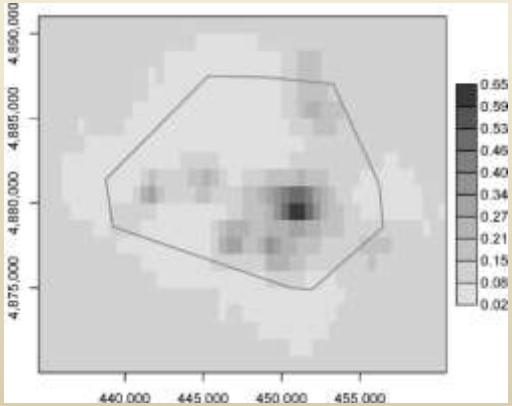




$$g_{ij} = \exp\left(\frac{-d_{ij}^2}{\sigma^2}\right)$$

Incorporates capture heterogeneity as fxn of relative location

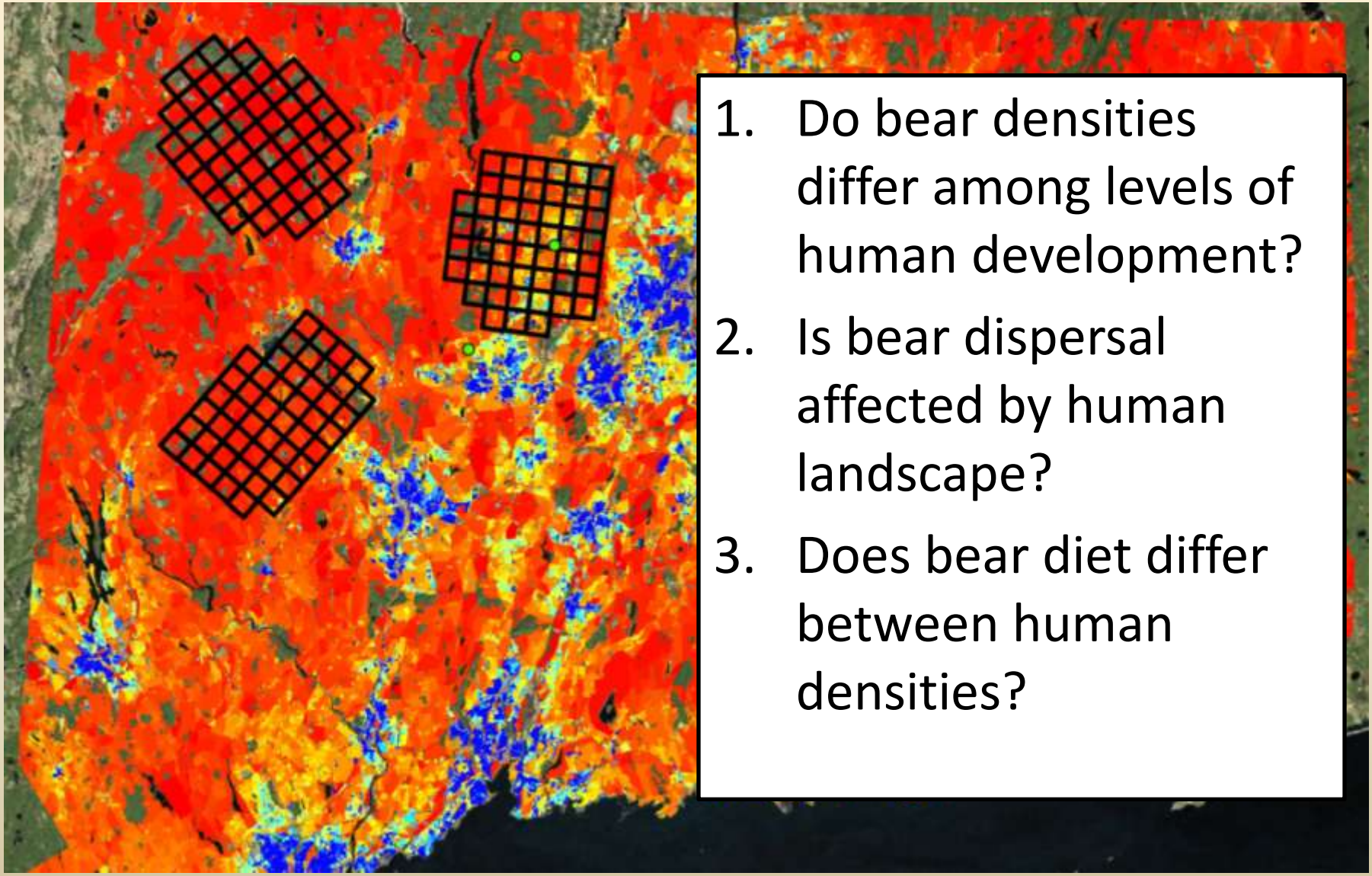




Explicitly defined, inherent estimation of effective sampling area

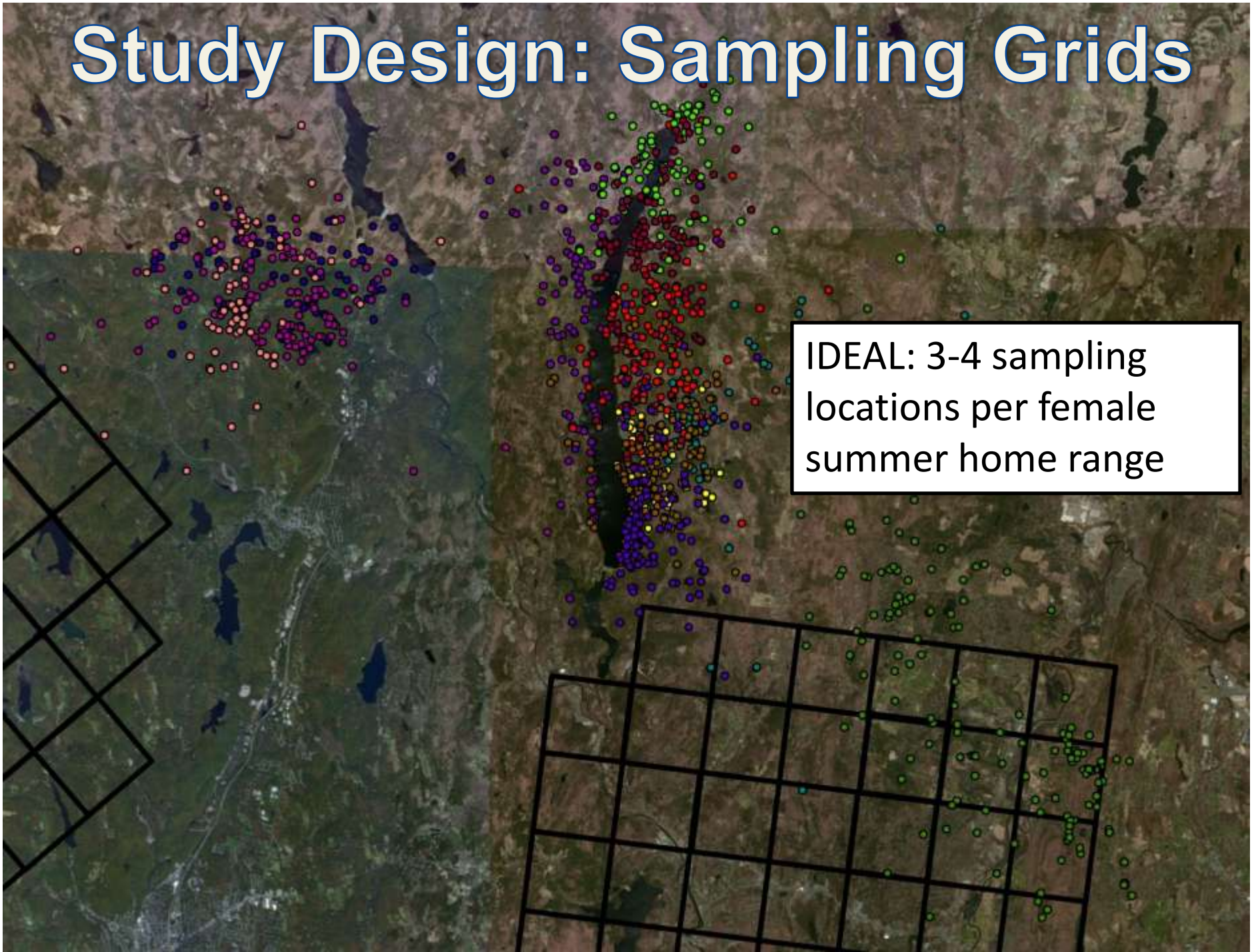
Figures from Gardner et al. (2010)

Additional Research Questions



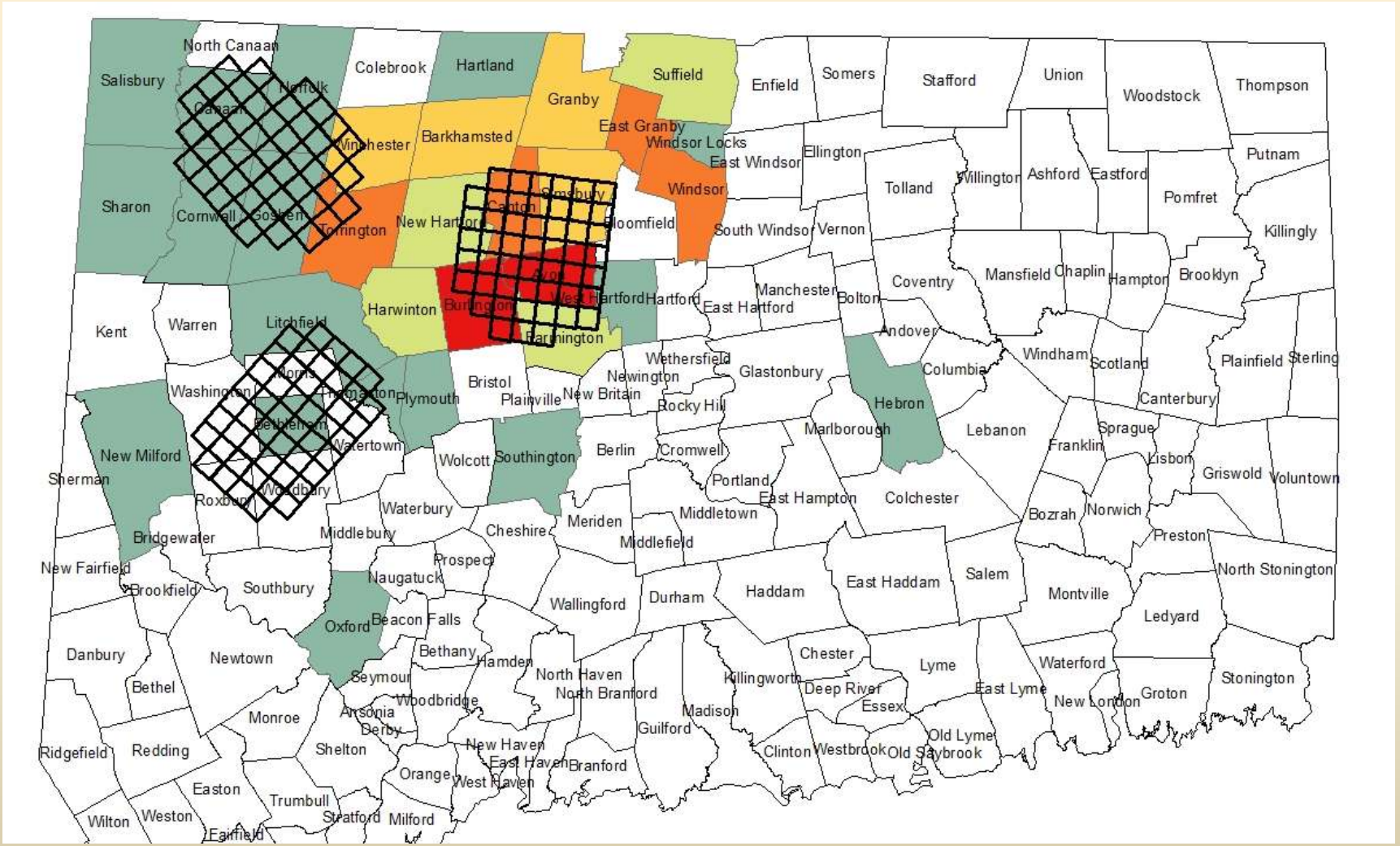
1. Do bear densities differ among levels of human development?
2. Is bear dispersal affected by human landscape?
3. Does bear diet differ between human densities?

Study Design: Sampling Grids



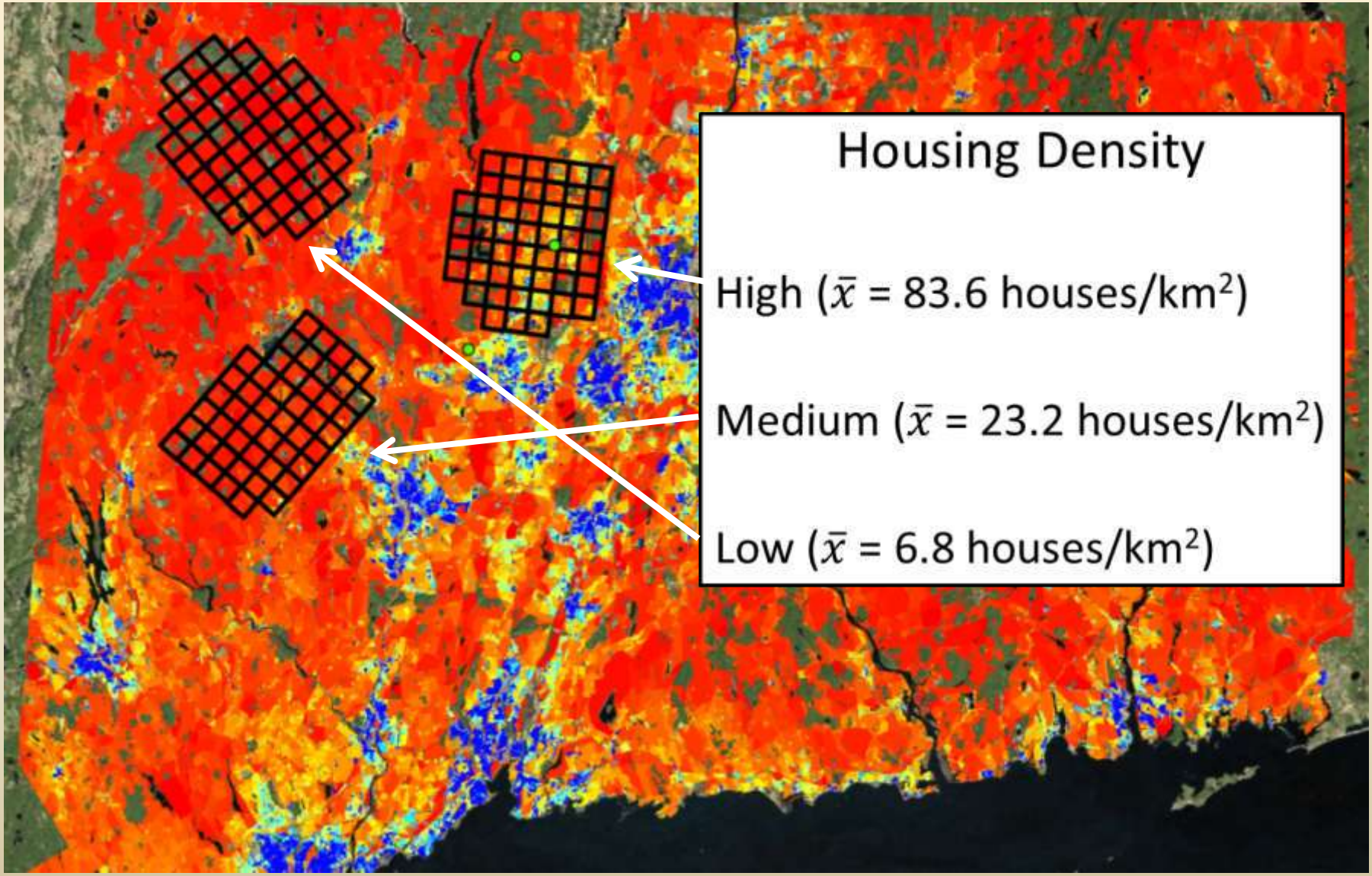
Study Design: Grid Distribution

Cub Sightings (2011)

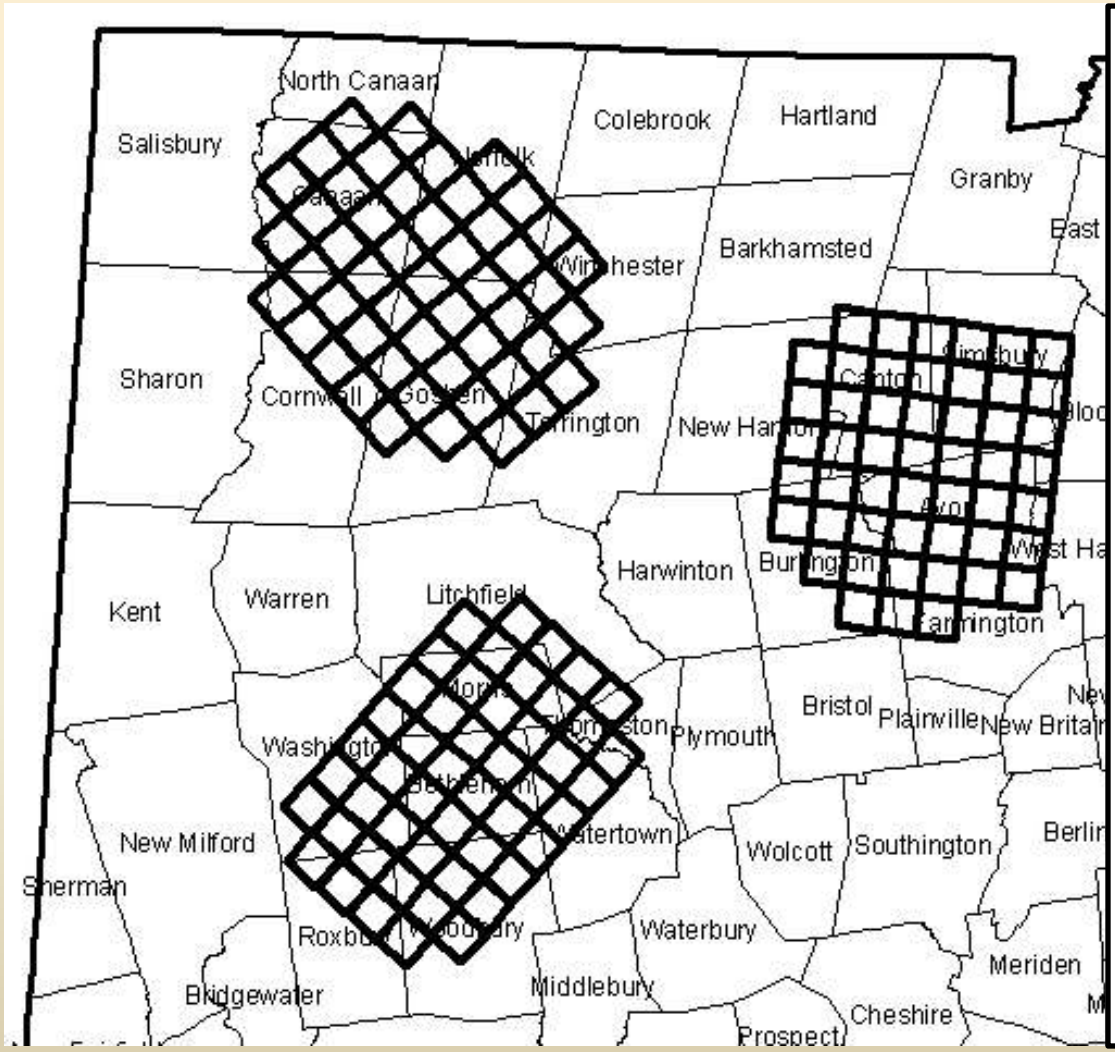


> 25 16-25 11-15 6-10 1-5

Study Design: Grid Distribution



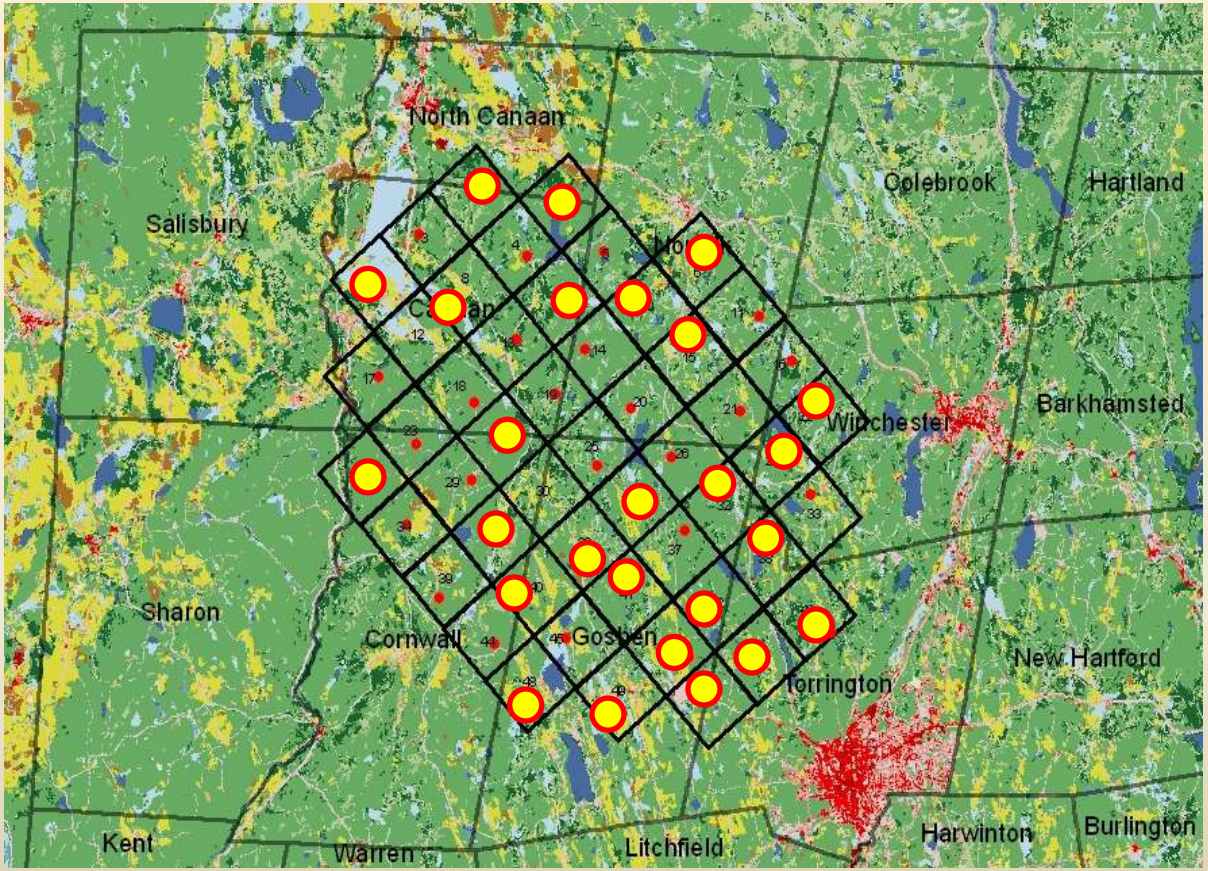
Study Design: Grid Distribution



- 150 ‘Hair Corrals’
- ~2.5km Spacing
- Checked weekly June through August
- 50 wildlife cameras (North grid)

Hair Sampling: 2012

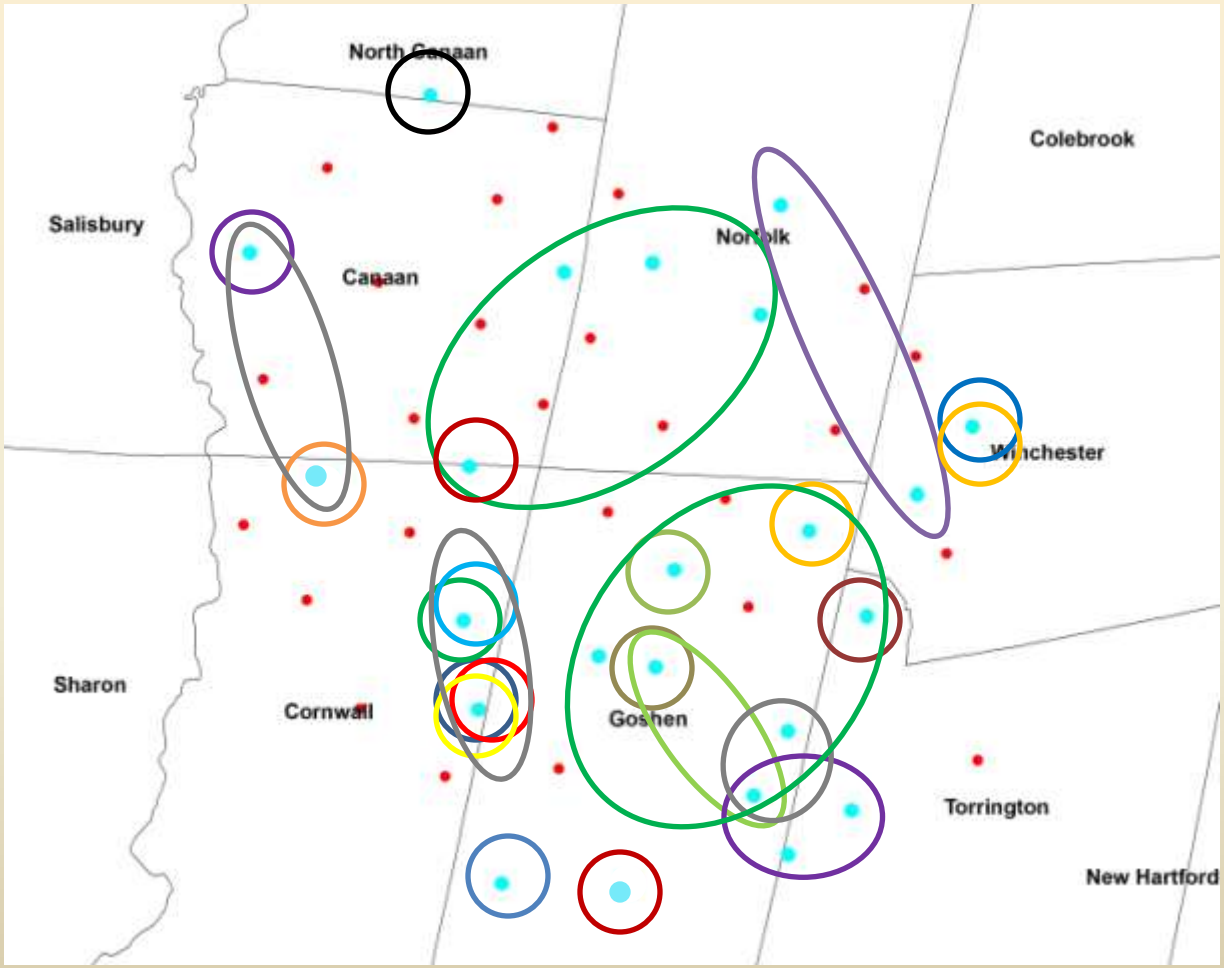
Collected Samples: July to September



72 Bear Samples

26 of 48 Sites

Hair Sampling 2012



26 Unique Individuals Identified

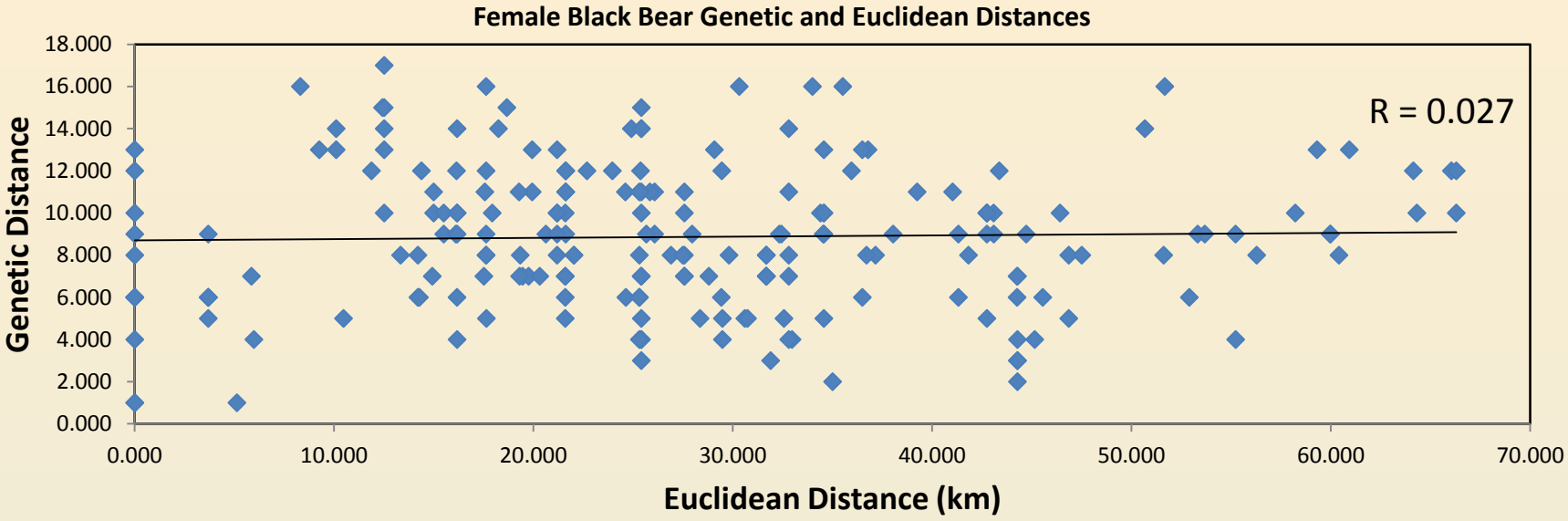
$N = 42 \pm 8.7$

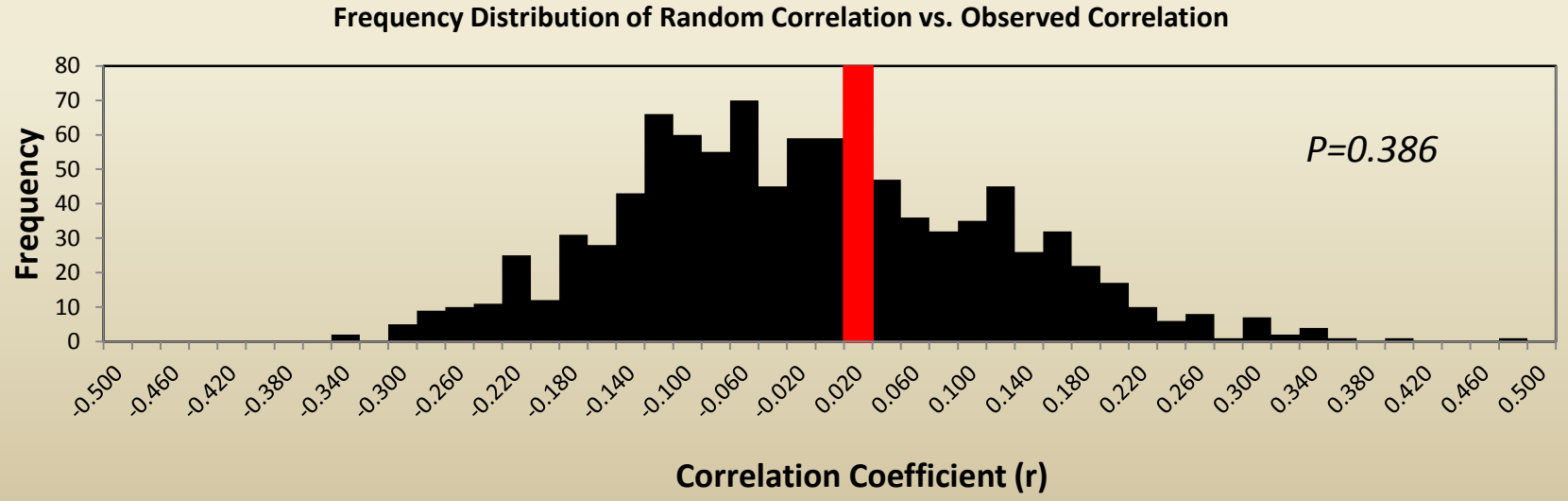
$P_{ID} = 1.9 \times 10^{-4}$

$p = 15.6\%$

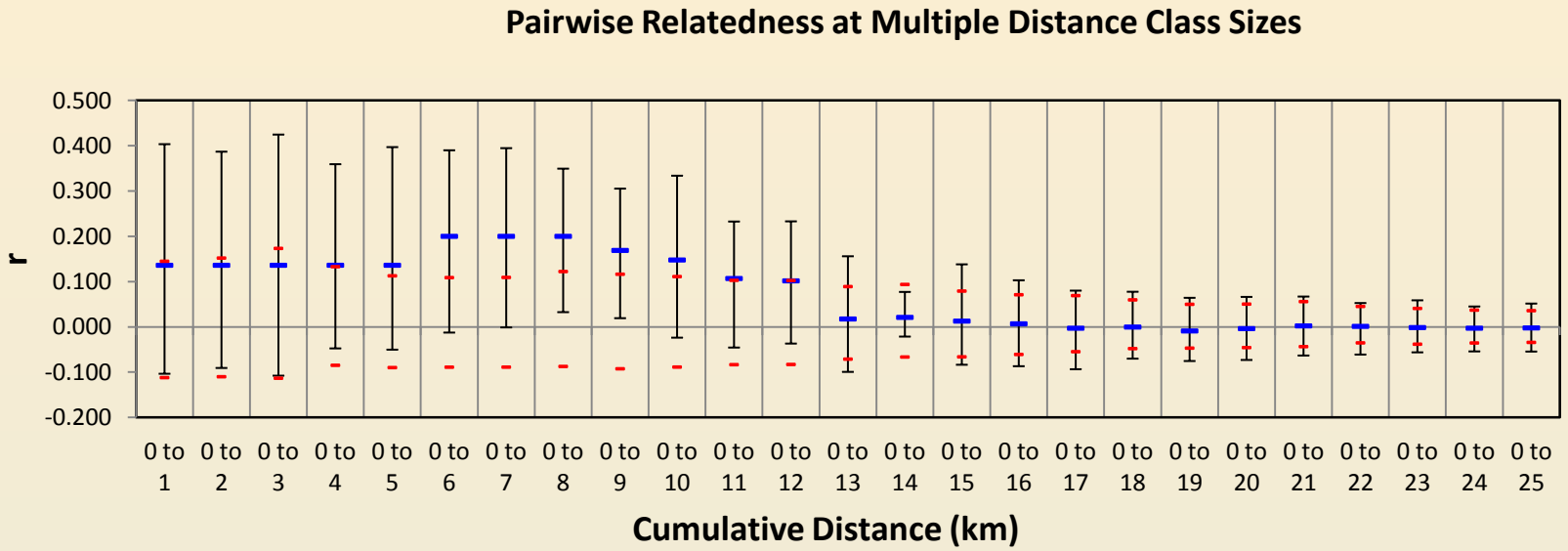
4:1 Female to Male Ratio

Isolation by Distance (Mantel Test)





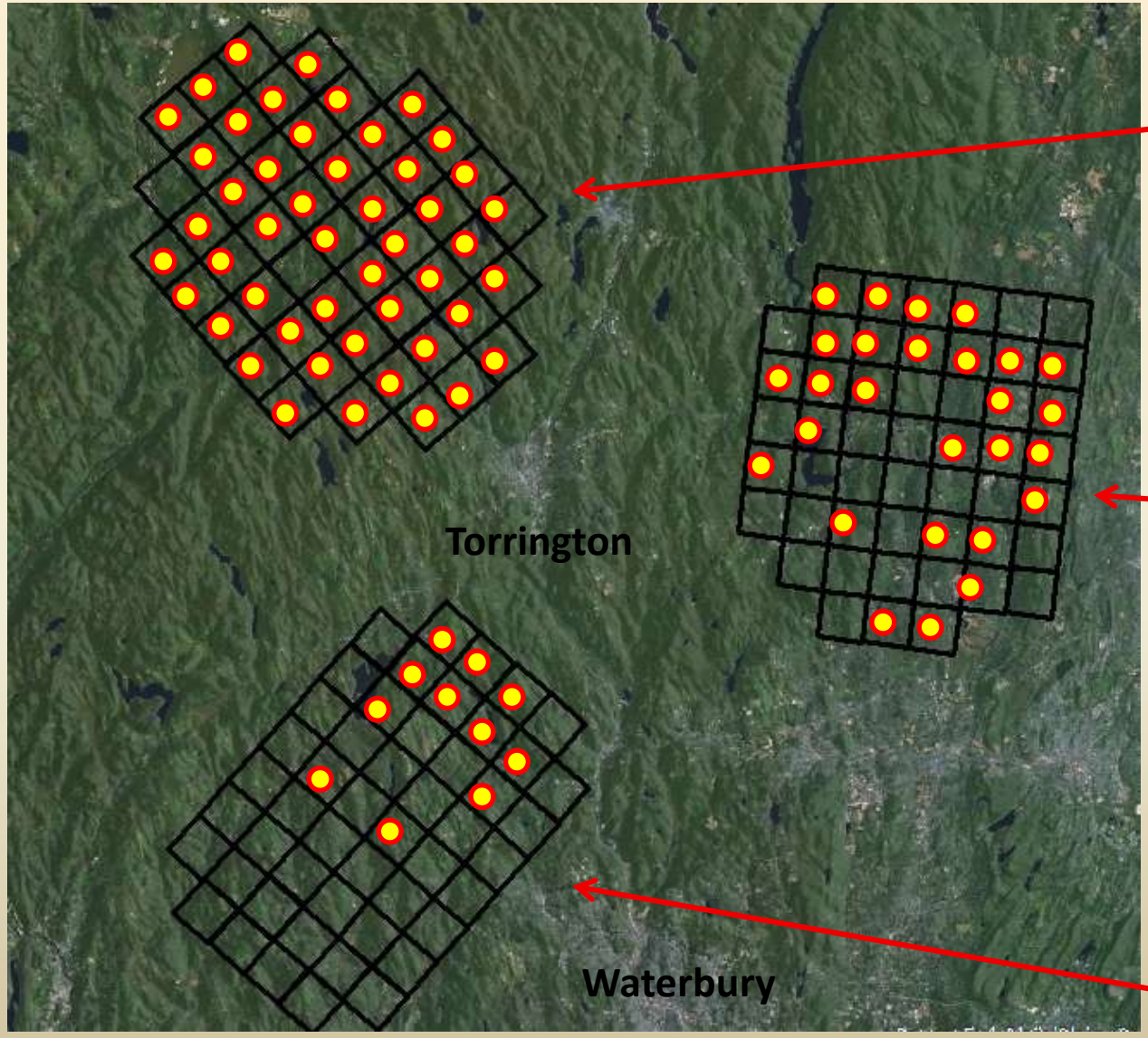
Spatial Genetic Clustering



- Indication of spatial extent at which individuals are more closely related than random
- Individuals within 10 km closely related

Hair Sampling: 2013

June 1st to August 29th



405 Bear Samples

North Grid – 48/49 sites

East Grid – 27/48 sites

South Grid – 11/50 sites

Table I. Identity by descent coefficients (k_0, k_1, k_2) and relatedness, r, for some common relationship categories

Relationship category	k_0	k_1	k_2	r
Monozygotic twins or self	0	0	1	1
Parent-offspring	0	1	0	0.50
Full sibs	0.25	0.50	0.25	0.50
2° (e.g. half sibs, avuncular)	0.50	0.50	0	0.25
3° (e.g. first cousins)	0.75	0.25	0	0.125
Unrelated	1	0	0	0

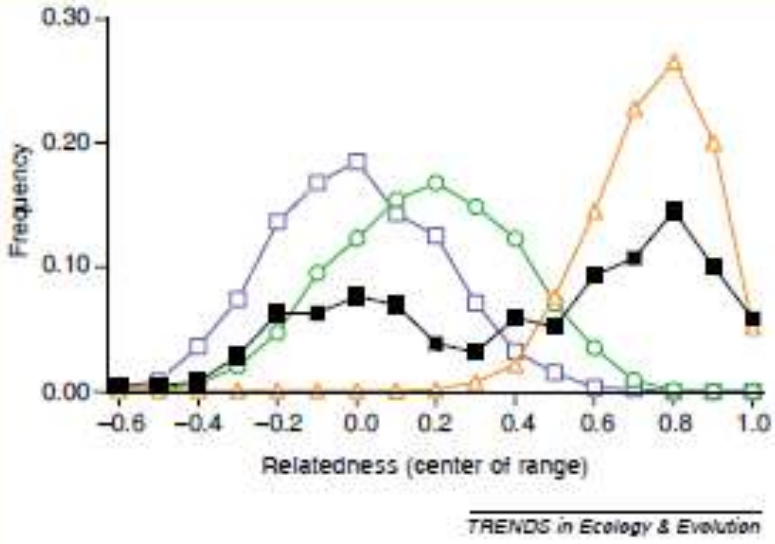
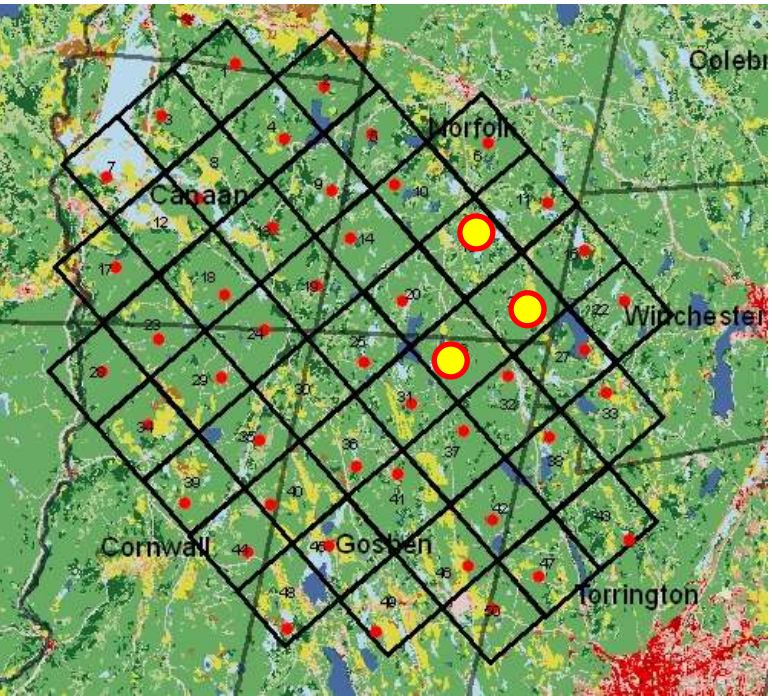


Fig. I. Observed distribution of pairwise r estimates among *Polistes dominulus* foundresses (filled squares) and expected distributions for three other plausible relationship categories (open symbols). Values are grouped into intervals of width 0.1. The expected distributions were obtained via simulation. Open squares = unrelated (true $r = 0$), open circles = cousins (true $r = 3/16$), open triangles = full sisters (true $r = 3/4$). True r values for cousins and sisters are higher than shown in Box 1 because wasps are haplodiploid. Reproduced, with permission, from [34].

Bushnell Ⓜ Camera Name 57°F13°C ● 06-06-2013 17:09:43

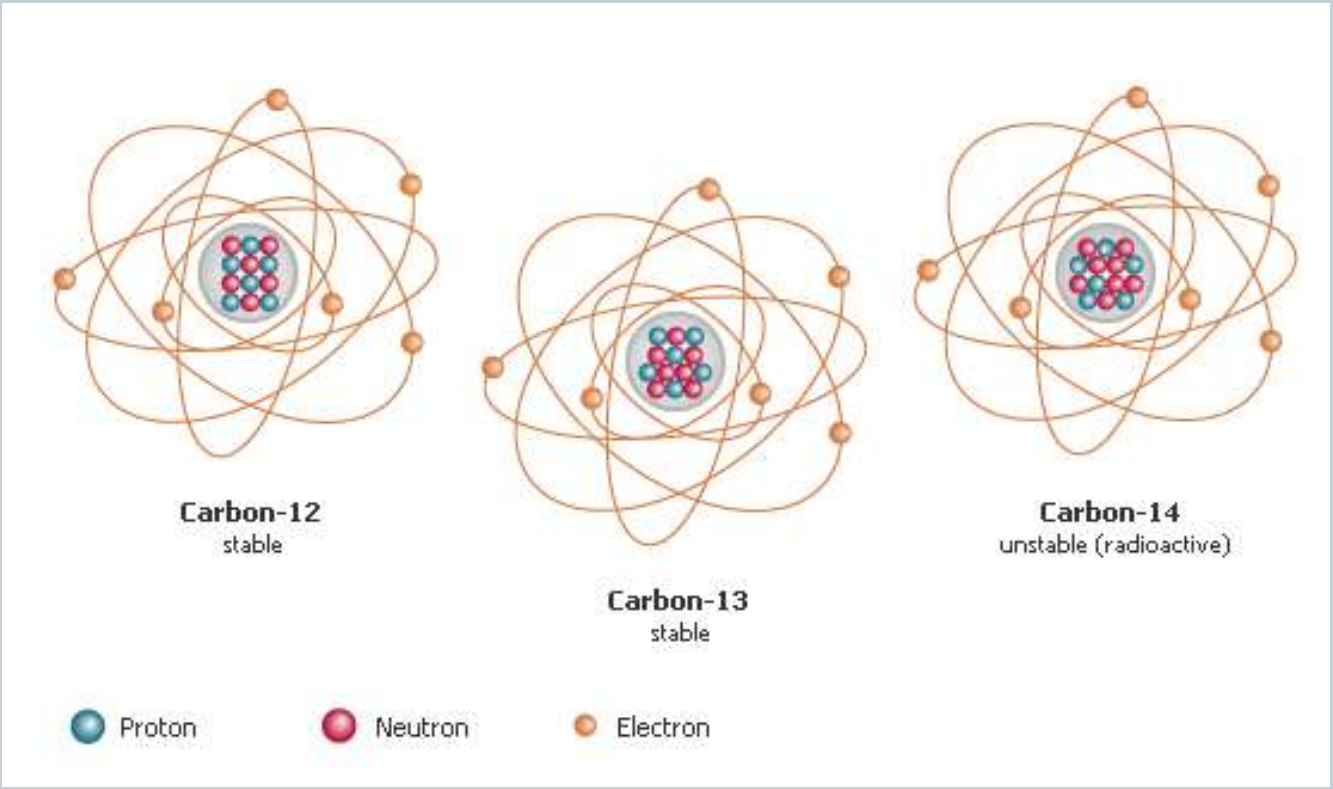
Bushnell M Camera Name 62°F16°C
07-31-2013 10:26:1

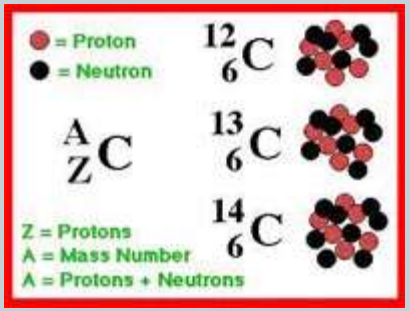
Bushnell M Camera Name 64°F17°C
08-19-2013 13:04:24


Colebr
Norfolk
Canaan
Winchester
Cornwall
Goshen
Torrington

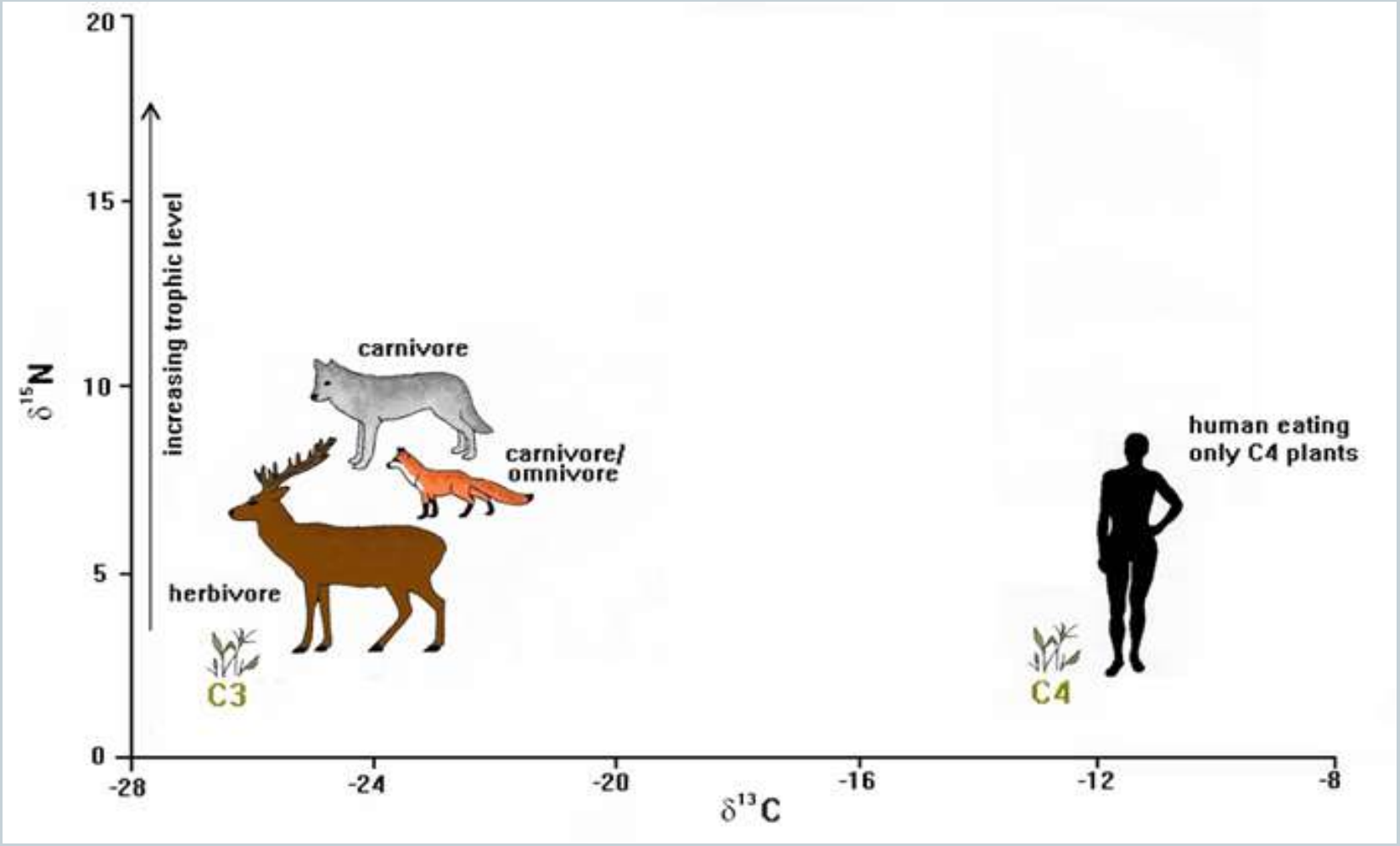
Bushnell M Camera Name 62°F16°C
08-03-2013 19:31:03

Isotopic Diet Analysis

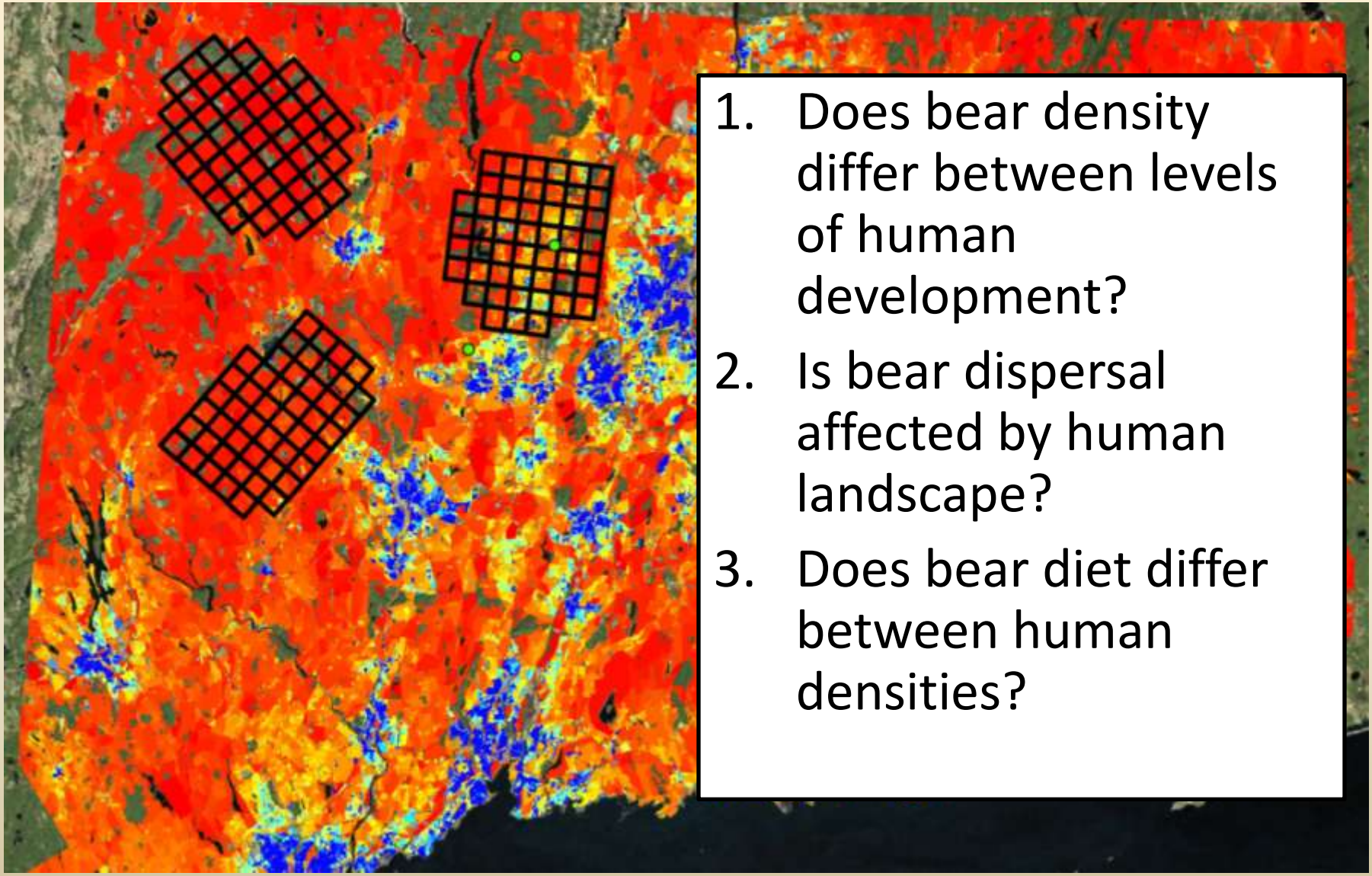




Isotopic Mixing



Research Questions

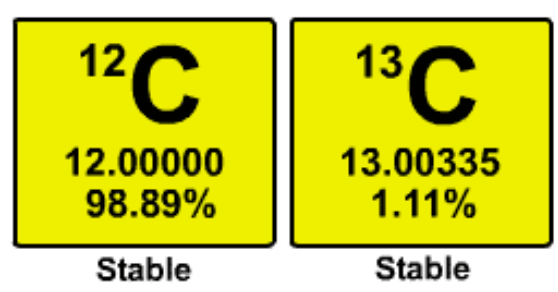


1. Does bear density differ between levels of human development?
2. Is bear dispersal affected by human landscape?
3. Does bear diet differ between human densities?

Questions?
Bushnell
Camera Name
50°F10°C
06-06-2013 06:37:11

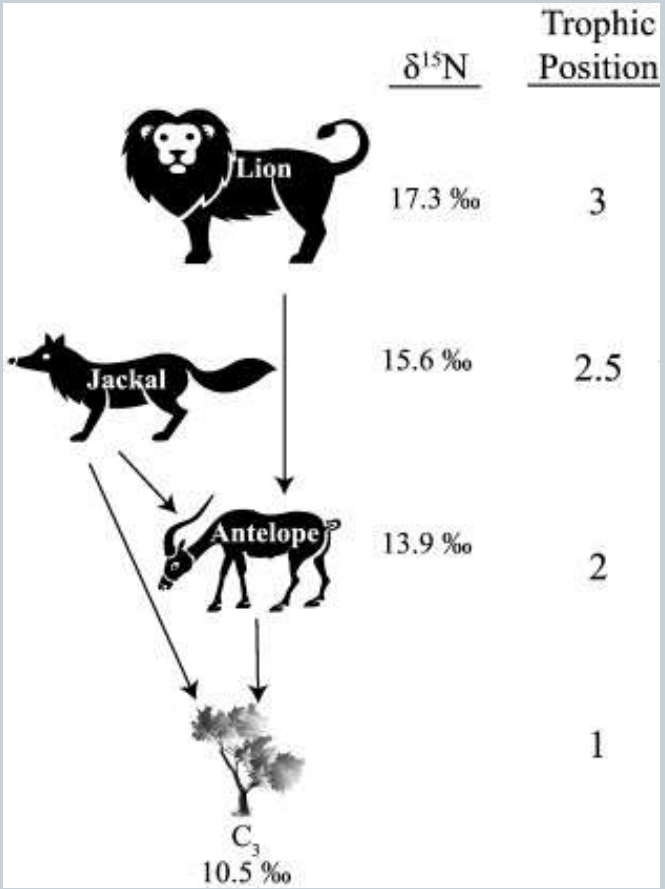
Isotope Ratios

- Atmospheric CO_2 - $\delta^{13}C = -8$
- Atmospheric N2 - $\delta^{15}N = 0$
- Ratios change during chemical bonding
  - Fractionation
  - Mixing



Changes in $\delta^{15}N$

- $\delta^{15}N$ increases with trophic level
- Preferential elimination of ^{14}N in waste during de-aminification



Changes in $\delta^{13}C$

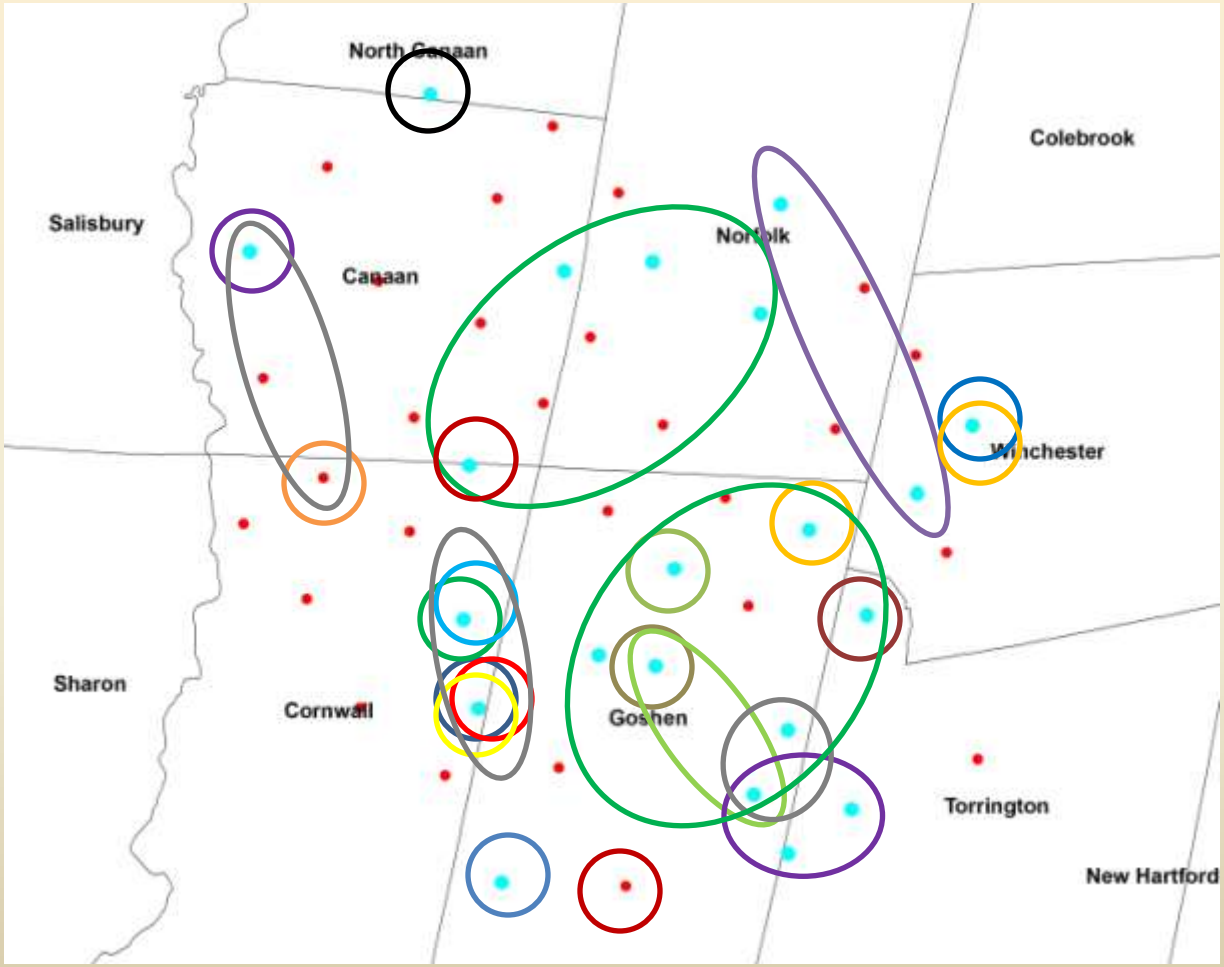
C_3 Plants

- Highly selective against ^{13}C
- $\delta^{13}C \sim -28$
- Predominant plants in temperate climates

C_4 Plants

- More readily incorporate ^{13}C
- $\delta^{13}C \sim -12$
- Tropical plants, CORN &SUGAR CANE

Population Estimation 2012



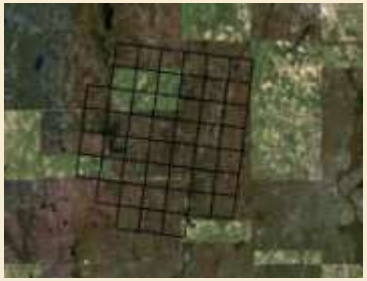
26 Individuals Identified

$N = 42 \pm 8.7$

$P_{ID} = 1.9 \times 10^{-4}$

$p = 15.6\%$

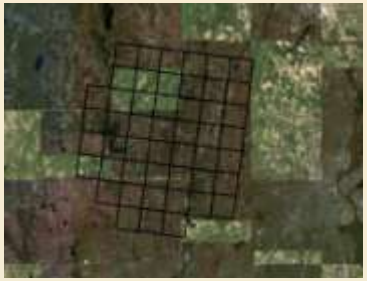
Population Estimation 2013 & 2014



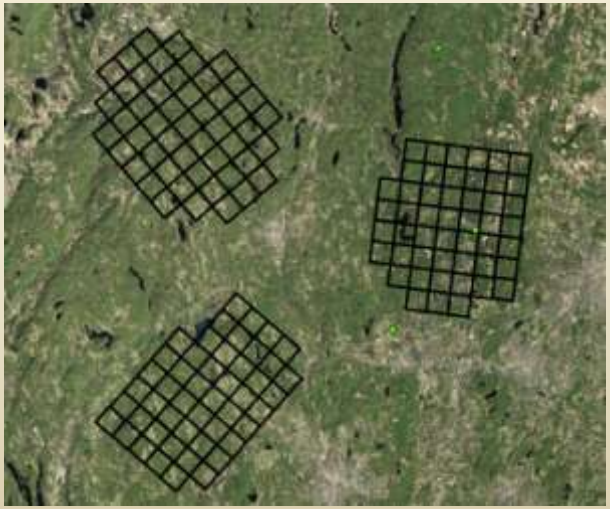
Individual Genotypes → Spatial Mark-Recapture Model → Robust Bear Density Estimate

Question: How Does Human Density Affect Bear Density?

Population Estimation 2013 & 2014



Individual Genotypes → Spatial Mark-Recapture Model → Robust Bear Density Estimate



Individual Genotypes → Spatial Mark-Recapture Model → Robust Bear Density Estimate

Individual Genotypes → Spatial Mark-Recapture Model → Robust Bear Density Estimate

Individual Genotypes → Spatial Mark-Recapture Model → Robust Bear Density Estimate

Link Pattern to Process

Bear Density

Home Range Structure

Dispersal

Resource Selection

Q: Differences in Bear Diet Composition According to Human Density?

Link Pattern to Process

Bear Density

Home Range Structure

Dispersal

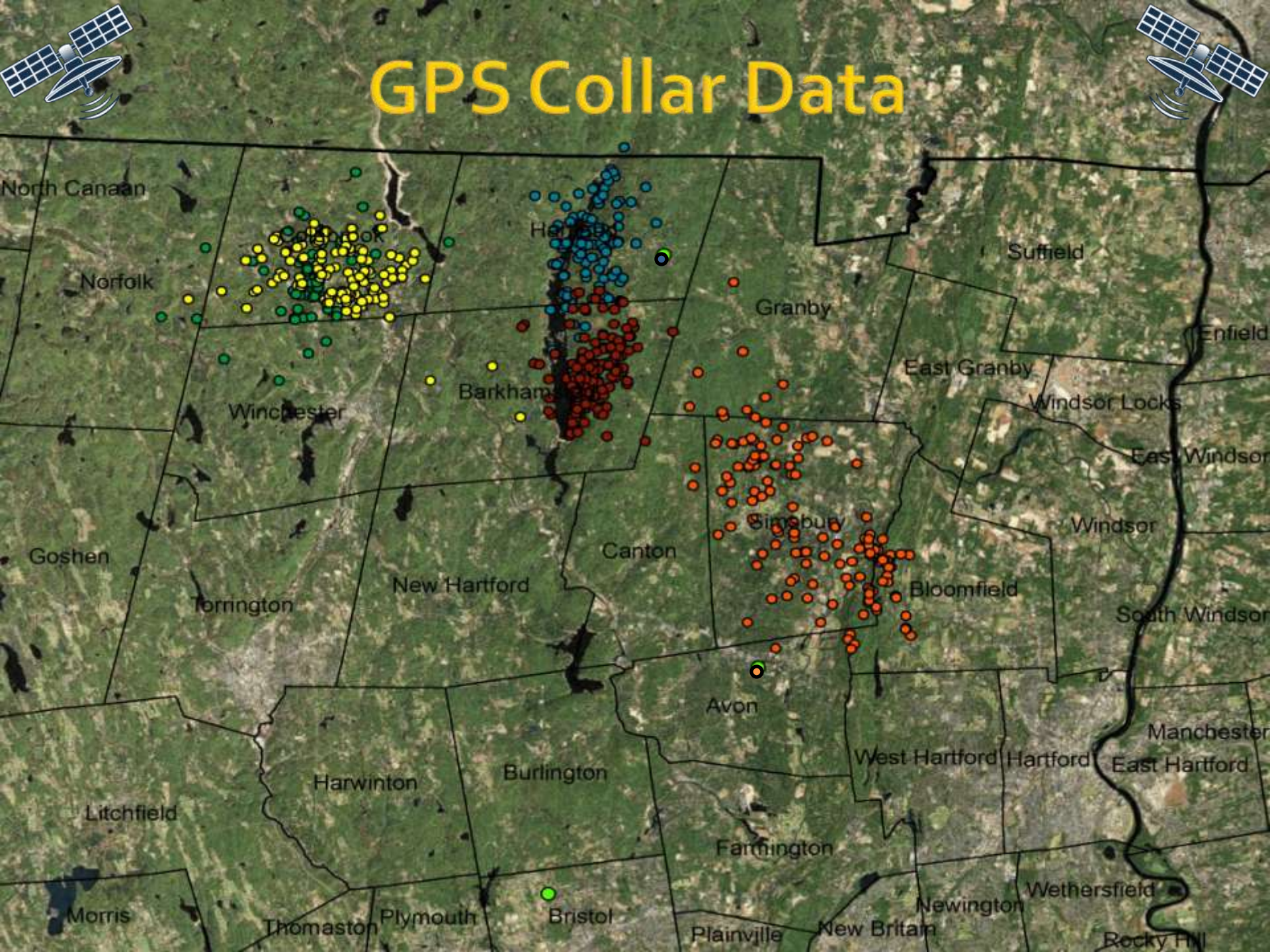
Resource Selection

Q: Do Bears Select Resources/Habitat Differently According to Human Density?

GPS Collars

- ~ 20 collars on female bears in western CT
- Take a position once per hour
- Store information on location and movements from spring to winter

Photo credit: Connecticut Department of Energy and Environmental Conservation


GPS Collar Data
North Canaan
Norfolk
Winchester
Barkhamsted
Granby
Suffield
Enfield
East Granby
Windsor Locks
East Windsor
Windsor
Simsbury
Canton
Goshen
Torrington
New Hartford
Bloomfield
South Windsor
Avon
Manchester
West Hartford
Hartford
East Hartford
Harwinton
Burlington
Litchfield
Farmington
Wethersfield
Newington
Morris
Thomaston
Plymouth
Bristol
Plainville
New Britain
Rocky Hill

Link Pattern to Process

Bear Density

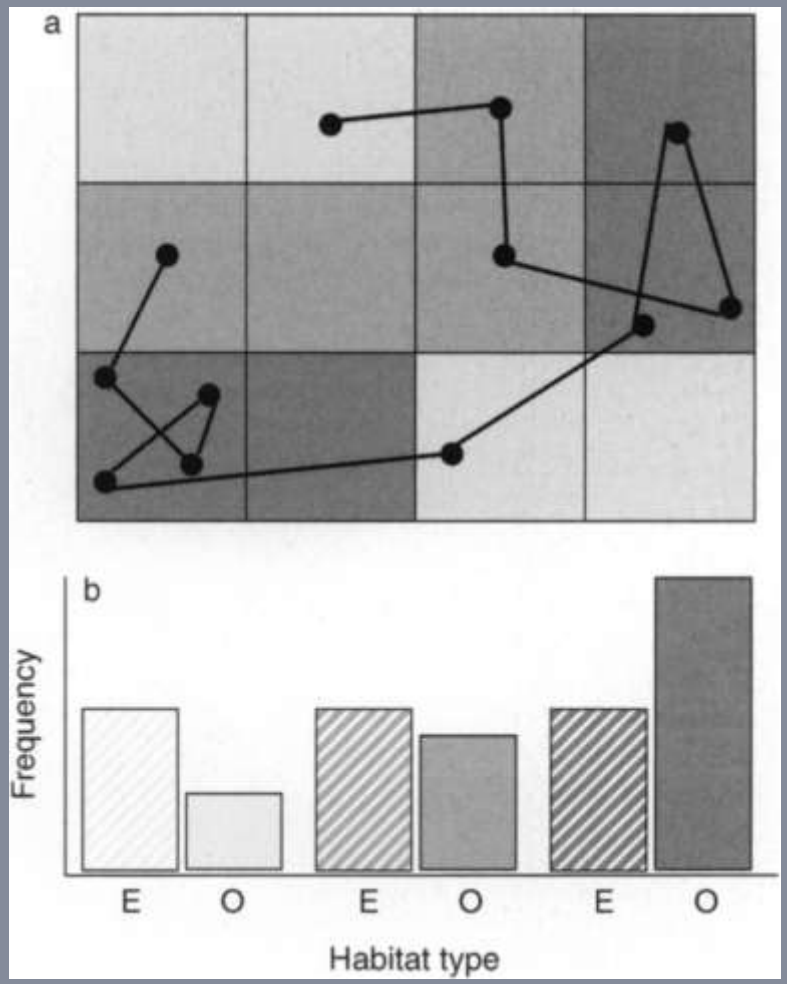
Home Range Structure

Resource Selection

Q: How are bears using human modified landscapes?

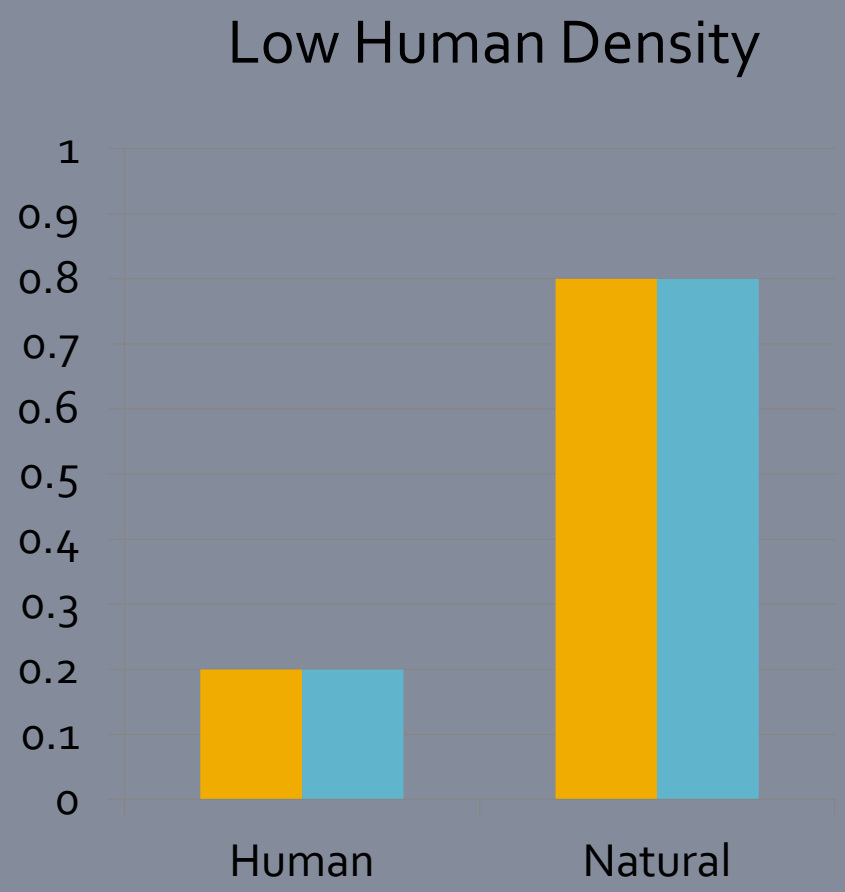
Resource Selection Analysis

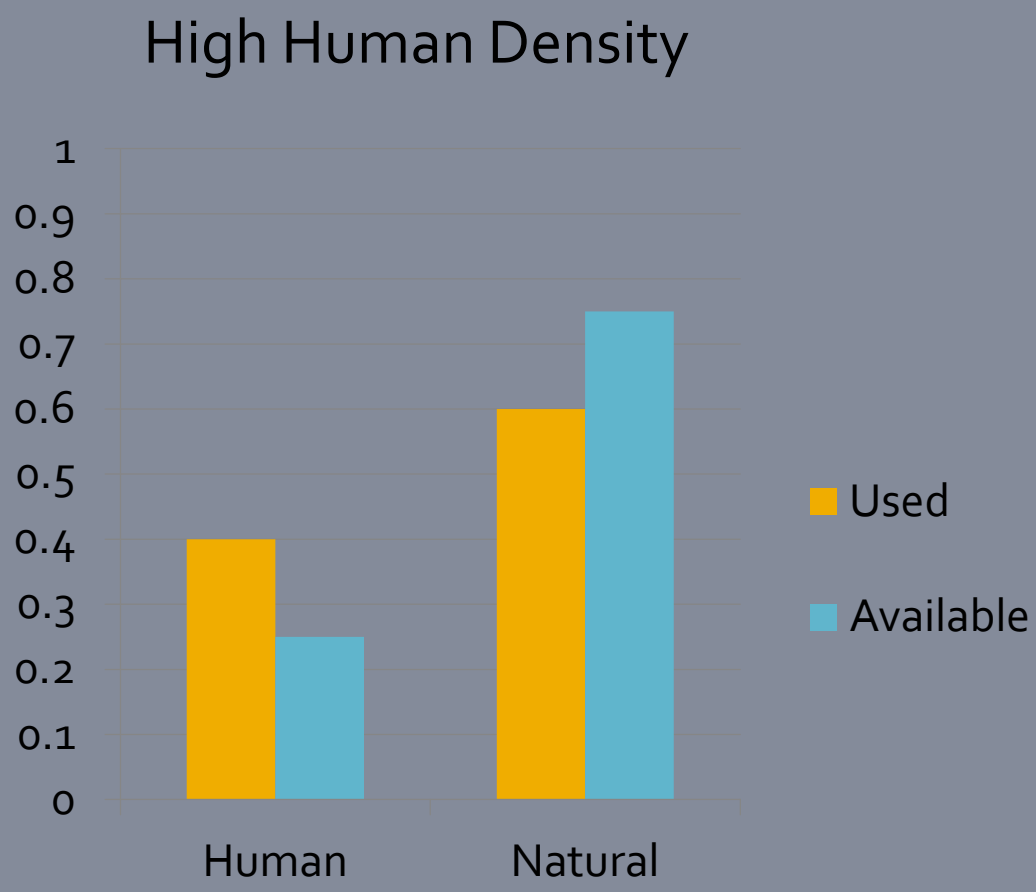
1. Quantify variables of interest at used locations
2. Compare use to availability – Higher or Lower than expected?



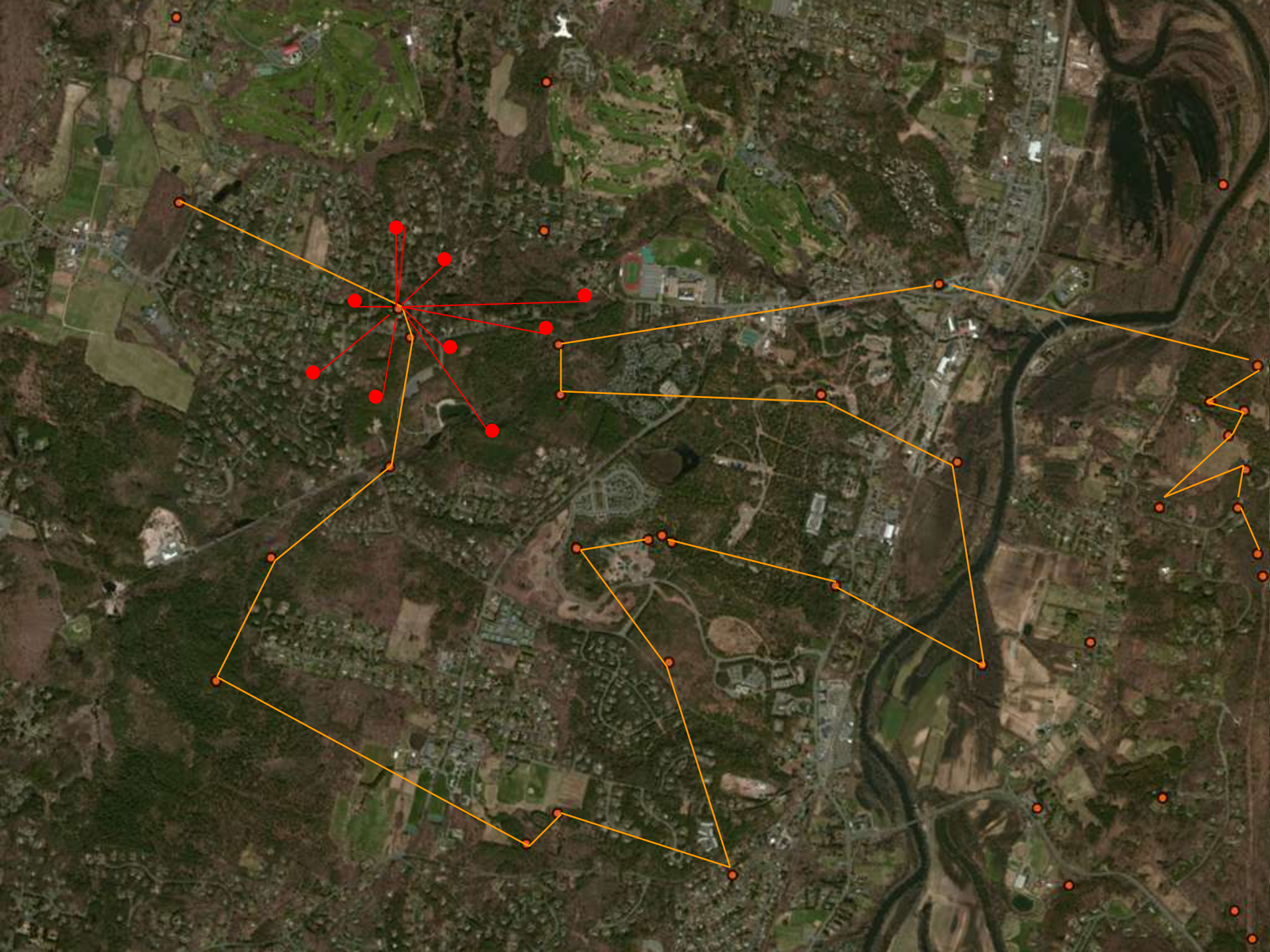
From Moorcroft and Barnett (2008)

Resource Selection Analysis





Q: Does Resource Selection Change in High and Low Human Density Areas?



Step Selection Analysis

- Model movement likelihoods given available resources at each GPS relocation
- Produce probabilities of resource attraction/avoidance – incorporate into home range models
- Selection is dependent on current location

Q: Do Bears Select or Avoid Anthropogenic Resources (Homes/Roads)? Is Selection Affected By Level of Development/Surrounding Environment?

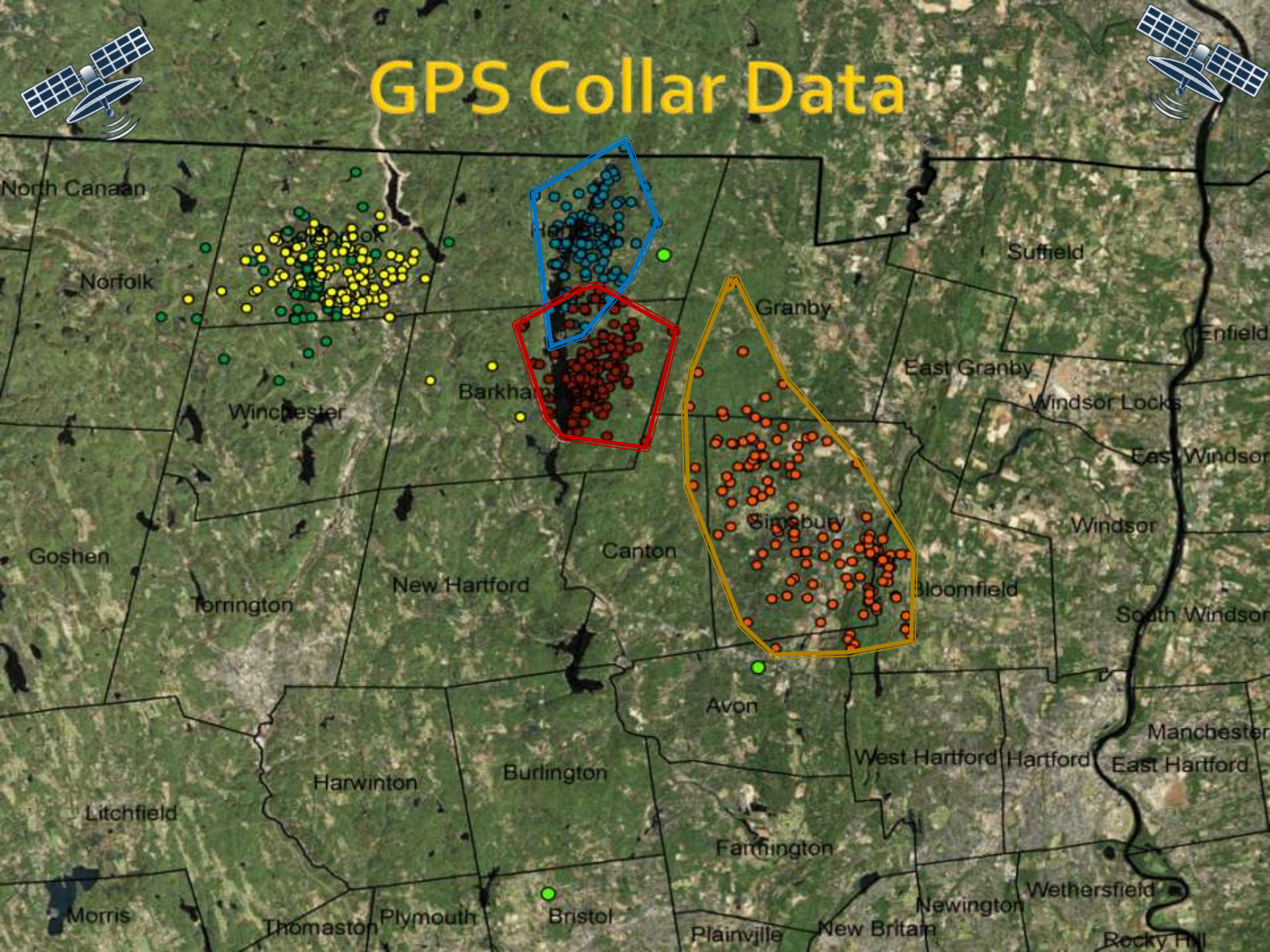
Link Pattern to Process

Bear Density

Home Range Structure

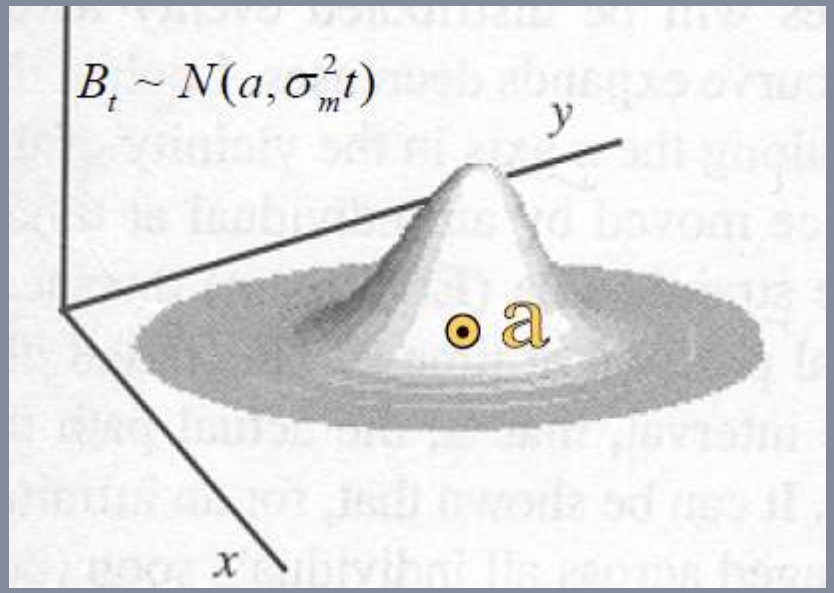
Resource Selection

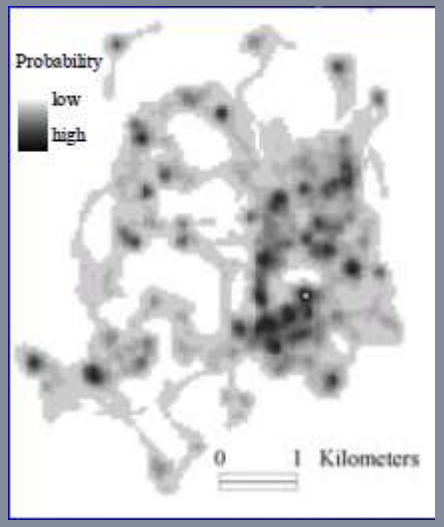
Q: Does Home Range Size/Overlap Differ According to Human Density?


GPS Collar Data
North Canaan
Norfolk
Winchester
Barkhamsted
Granby
Suffield
Enfield
East Granby
Windsor Locks
East Windsor
Windsor
Simsbury
Canton
Goshen
Torrington
New Hartford
Bloomfield
South Windsor
Avon
Manchester
West Hartford
Hartford
East Hartford
Harwinton
Burlington
Litchfield
Farmington
Wethersfield
Newington
Morris
Thomaston
Plymouth
Bristol
Plainville
New Britain
Rocky Hill

Mechanistic Home Range Estimation

- Identify Predictors
- Test ecological hypotheses



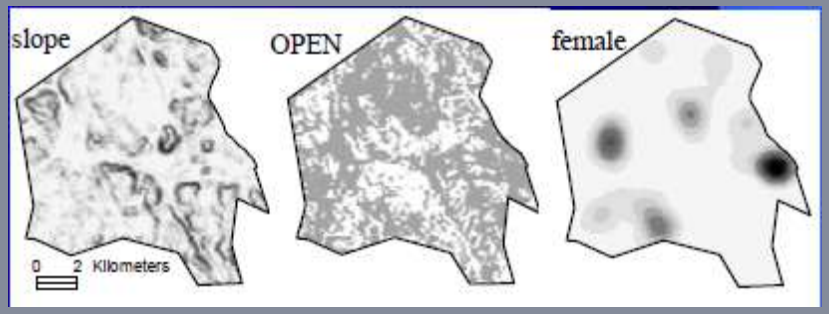


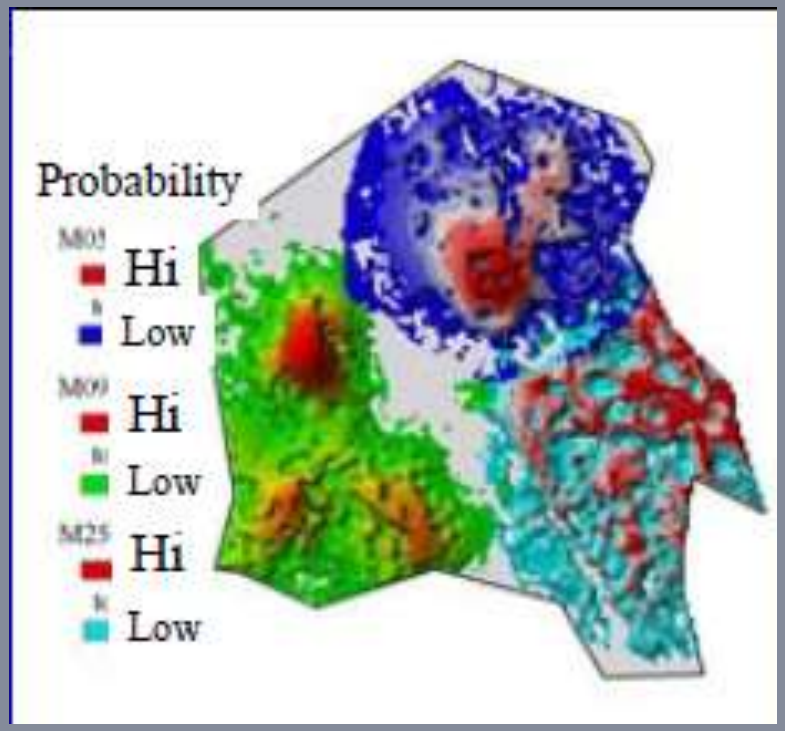
$$f_u(x) = \frac{f_a(x)\exp(\beta' H(x))}{\int_x f_a(x)\exp(\beta' H(x))}$$

From Horne & Garton 2012

Mechanistic Home Range Estimation

	Parameter Estimate (β)		
Male ID	**Female Density**	**Percent Slope**	**OPEN**
M05	8.77	-0.99	2.00
M09	47.58	-0.53	1.36
M25	1.48	-0.98	0.66





From Horne & Garton 2012

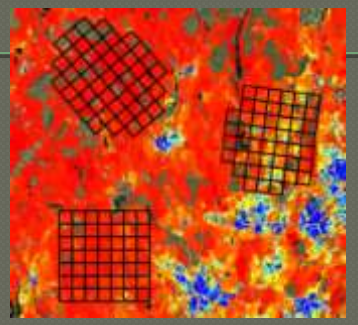
Home Range Estimation

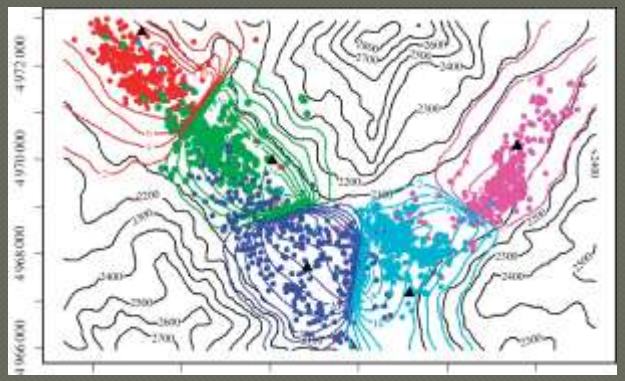
1. Female Bears Structure Home Ranges to Avoid Conspecifics
2. Female Bears Structure Home Ranges to Include Minimum Area of Forest
3. Female Bears Structure Home Ranges to Exclude Human Development
4. Compare btwn 'Suburban' and 'Rural' Bears

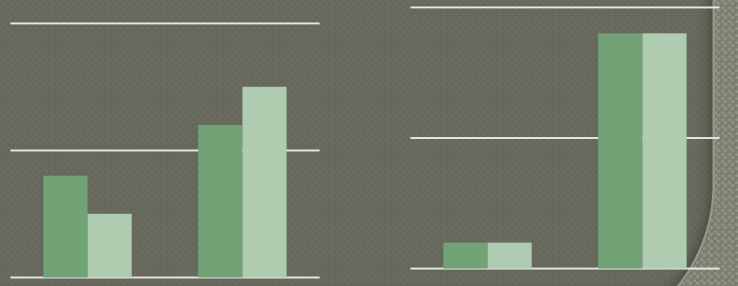
Answers Where and WHY bears are likely to occur

Summary

- Describe relationship between human and bear density
- Associate these patterns with underlying processes using GPS data
- Quantify how human landscape modification affects those processes







Questions?
Bushnell
Camera Name
64°F17°C
08-13-2012 09:29:17

ome Range Model

Q: Does Home Range Size & Overlap Differ According to Human Density?

Q: Does Human Development Affect Home Range Structure?

Q: How Will Home Ranges Be Structured as Bears Expand in CT?

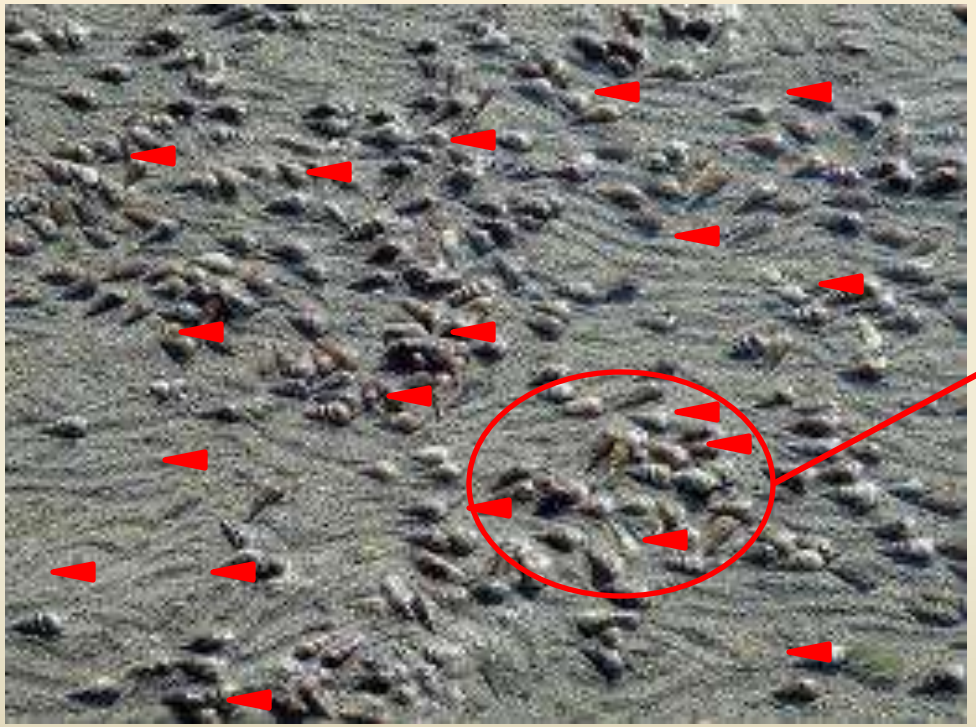
Hair Collection: 2012

Determining Corral Distribution:

1. Areas with bears
2. Low human density
3. Contiguous habitat
4. 2-3 corrals per female home-range

Population Estimation: Genetic Mark Re-Capture

Population Estimation: Genetic Mark Re-Capture



$$\frac{\text{Number marked in second sample}}{\text{Total caught in second sample}} = \frac{\text{Number marked in first sample}}{\text{Size of whole population (N)}}$$

Population Estimation: Genetic Mark Re-Capture

Unique genetic ID replaces physical mark

1. Obtain DNA from multiple ‘sampling’ sessions
2. Genotype individuals
3. Encounter History = ‘Captures’ and ‘Re-captures’

Advantage: Non-Invasive