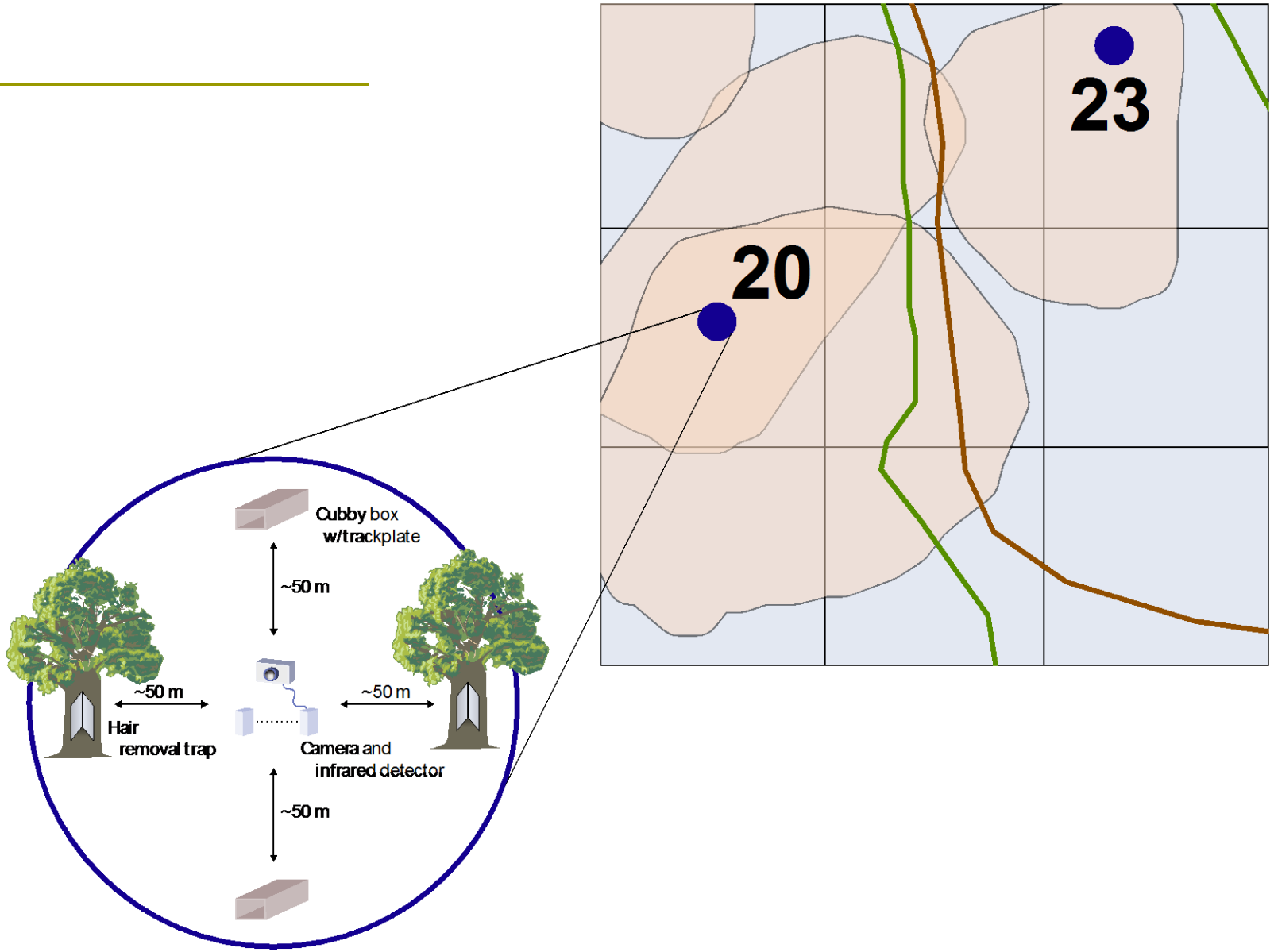
Multiple Detection Methods: Single-season Models

Multiple Detection Devices

- Multiple devices (or methods of detection or types of sign) at each sample unit
- Species may be detected by 1 or more devices
- Common for multispecies surveys (U.S. Forest Service, National Park Service)

Multiple Detection Devices

- Desire inference about device-specific detection probabilities
  - Want to account for possible dependence of detection probability of 1 device on detection by another device
- For animals with ranges that partially overlap sample unit (not complete overlap of range and sample unit); possible to estimate occupancy at 2 different scales


23
20
Cubby box
w/trackplate
~50 m
~50 m
~50 m
Hair
removal trap
Camera and
infrared detector
~50 m

$p_t^s =$

Model Parameters

- $p_t^{[s]}$ = Pr (detection at occasion t by device s | sample unit occupied and species present at immediate sample station site);
- Ψ = Pr (sample unit occupied);
- θ_t = Pr (species present at immediate sample site at occasion t | sample unit occupied).
- θ_t represents a local scale that may reflect a smaller spatial scale than Ψ
- $\theta_t\psi$ = Pr (species present at local scale at occasion t)

Detection History Data

- *L* = number of devices
- *K* = number of sample occasions
- Example *(L*=3, *K*=2)*:* 010 000

  Occasion 1:

  detection by device 2, nondetection by devices 1 and 3

  Occasion 2:

  no detections by any device

Detection History Modeling: Example

- Pr (010 000) =

$$\psi\left[\theta_1\left(1-p_1^{[1]}\right)p_1^{[2]}\left(1-p_1^{[3]}\right)\left[\left(1-\theta_2\right)+\theta_2\prod_{s=1}^{3}\left(1-p_2^{[s]}\right)\right]\right]$$

- Verbal description:
  - species present at larger scale (species use of area); species present at local scale at period 1; species detected by device 2, but not by devices 1 and 3, at period 1; species either not present at local scale *or* present at local scale but not detected by any device at period 2.

Detection History Modeling: Example

- Pr (000 000) =

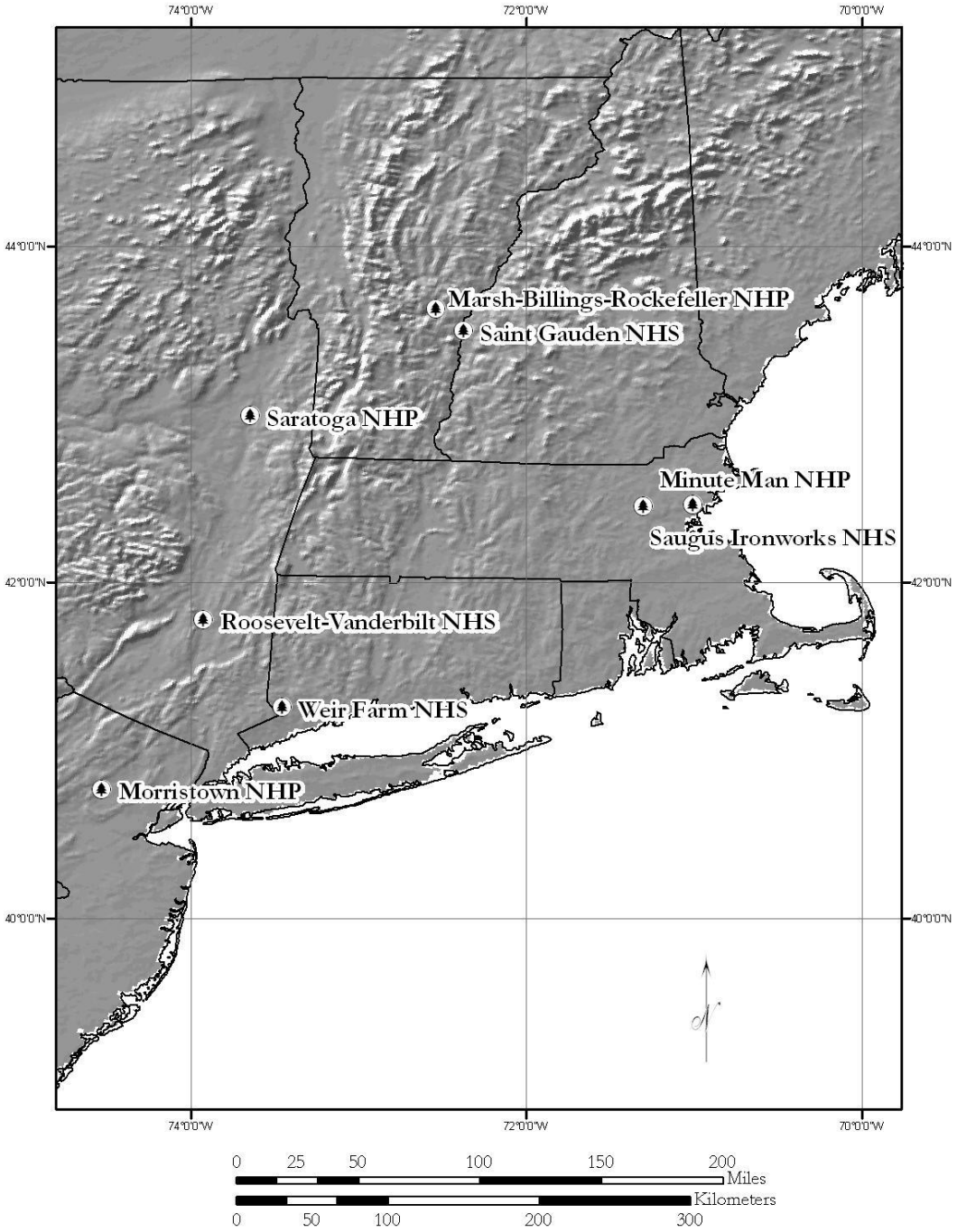
$$
\begin{aligned}
&(1-\psi)\\
&+\psi(1-\theta_1)(1-\theta_2)\\
&+\psi\left[\theta_1\prod_{s=1}^{3}\left(1-p_1^{[s]}\right)\right](1-\theta_2)\\
&+\psi(1-\theta_1)\left[\theta_2\prod_{s=1}^{3}\left(1-p_2^{[s]}\right)\right]\\
&+\psi\left[\theta_1\prod_{s=1}^{3}\left(1-p_1^{[s]}\right)\right]\left[\theta_2\prod_{s=1}^{3}\left(1-p_2^{s}\right)\right]
\end{aligned}
$$

Estimation/Inference

- Could be cast into a complete data likelihood framework
- Maximum likelihood-based and Bayesian methods of inference possible

Example: Striped Skunks (*Mephitis mephitis*) in 8 National Parks in NE US

- Random selection of grid cell; random selection of site within cell
- Sample for ~2 weeks during 2 seasons (in winter/spring; summer/fall) in 2004
- Visit detection devices every ~3 days for 5 occasions per season
- 3 devices at each sample station
  - Camera trap
  - Hair removal traps
  - Track plates


74°0'0"W
72°0'0"W
70°0'0"W
44°0'0"N
42°0'0"N
40°0'0"N
Marsh-Billings-Rockefeller NHP
Saint Gauden NHS
Saratoga NHP
Minute Man NHP
Saugus Ironworks NHS
Roosevelt-Vanderbilt NHS
Weir Farm NHS
Morristown NHP
N
0 25 50 100 150 200
Miles
0 50 100 200 300
Kilometers

Models and Inference

- Model each season separately

- 16 models for each season:
  - habitat-specific or constant ψ
  - time-specific or constant θ
  - Time- and/or device-specific p

- Low-AIC model for both seasons:(ψ,θ,p^s)

Results

$$\hat{\psi}^{sf} \approx \hat{\psi}^{ws} = 0.16 \ \ (\hat{SE} = 0.09)$$

$\hat{\theta}^{sf} = 0.67 \ \ (0.31)$ $\hat{\theta}^{ws} = 0.52 \ \ (0.20)$

Predicted greater movement in winter-spring (breeding behavior)

$\hat{p}^{track(sf)} = 0.20 \ \ (0.11)$ $\hat{p}^{track(ws)} = 0.73 \ \ (0.23)$

$\hat{p}^{hair(sf)} = 0.08 \ \ (0.06)$ $\hat{p}^{hair(ws)} = 0.08 \ \ (0.08)$

$\hat{p}^{cam(sf)} = 0.39 \ \ (0.18)$ $\hat{p}^{cam(ws)} = 0.24 \ \ (0.14)$

Advantages of Multiple-device Model

- Deals explicitly with lack of independence of detection induced by animal presence at local site
- Makes efficient use of data for estimating both occupancy and device-specific detection probabilities
- Permits inference about occupancy at 2 spatial scales

Use Similar Modeling for Other Sampling Situations

- Different types of animal sign (tracks, scat, sighting) instead of different devices
- Single device used at 2 temporal scales (Pollock's robust design)
- Multiple spatial scales