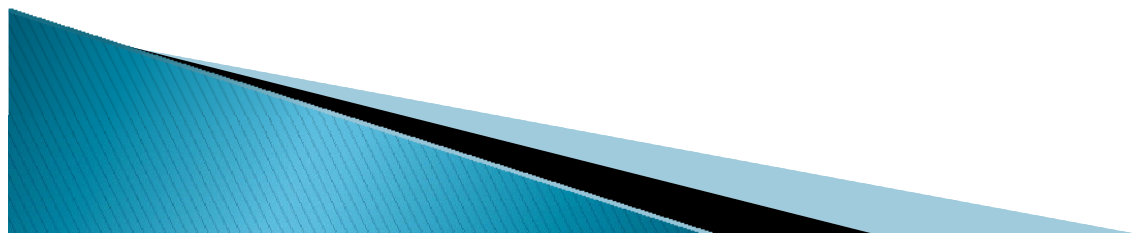


Disease spread in feral swine populations: addressing gaps in knowledge and modeling approaches

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September 28, 2010



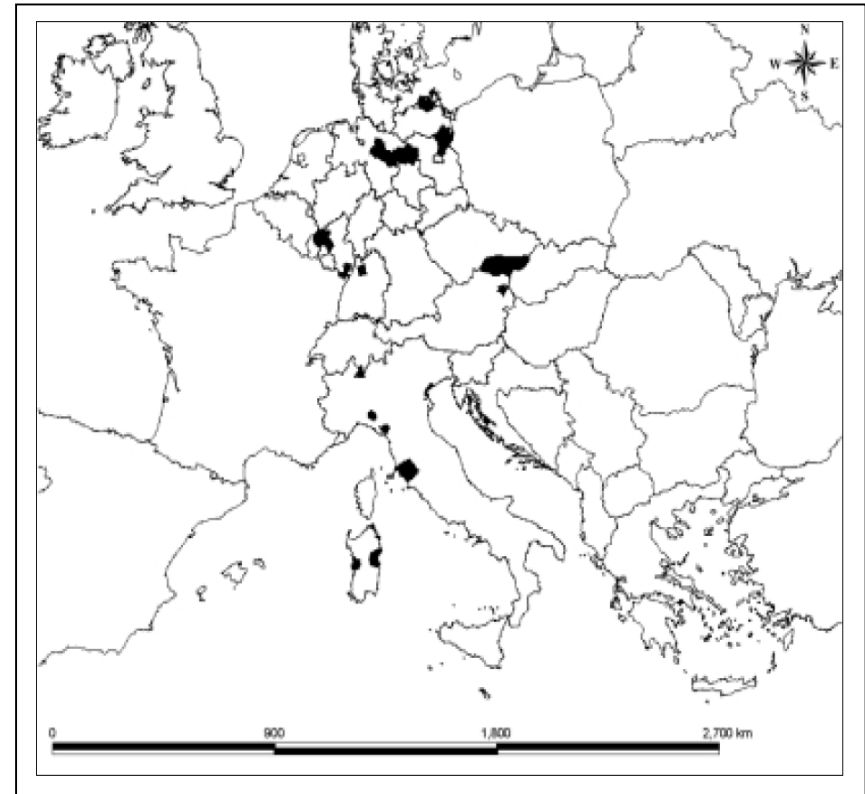
U.S. Experience

- ▶ Foot-and-mouth disease
 - Origin: infected meat fed to pigs
 - 22,214 deer killed in CA, 1925
 - Last outbreak in 1929
- ▶ Classical swine fever
 - US declared free in 1978
 - 16 yrs to eradicate, \$140 million
 - Feral swine involvement?



European Experience

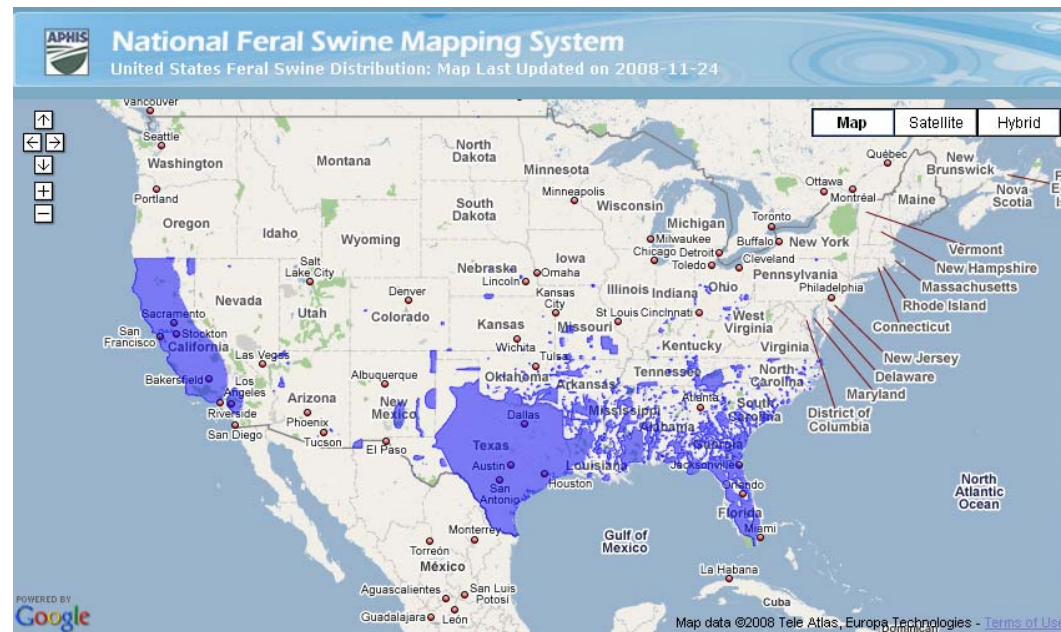
- ▶ Europe:
 - Wild boar play an important epidemiological role
 - Germany: 1990–98, ~59% of outbreaks due to direct/indirect contact with infected wild boars
 - Italy – Illegal to hunt with dogs
 - UK 2000: ham sandwich?



CSF outbreaks in wild boar, 1990 – 2001
Source: Artois et al. 2002

Feral Swine: U.S. Population

- ▶ Widespread distribution, populations continue to increase
 - Recent migrations/introductions in northern states
 - Eurasian boar importation from Canada
- ▶ Population estimates range from 3 to 4 million
- ▶ Disease spread in feral swine:
 - Fade-out or become endemic?
 - Time to detection?
 - Potential domestic/wild pig interaction?
 - Control and mitigation strategies?

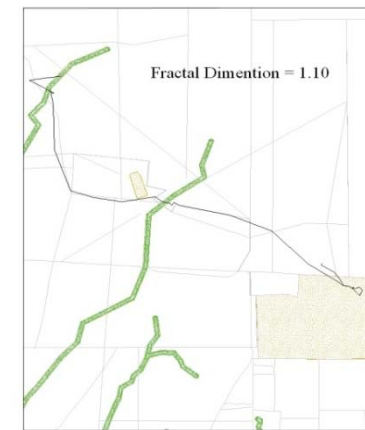
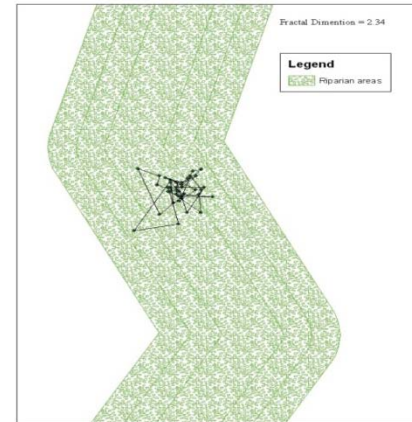


SCWDS <http://128.192.20.53/nfsm>

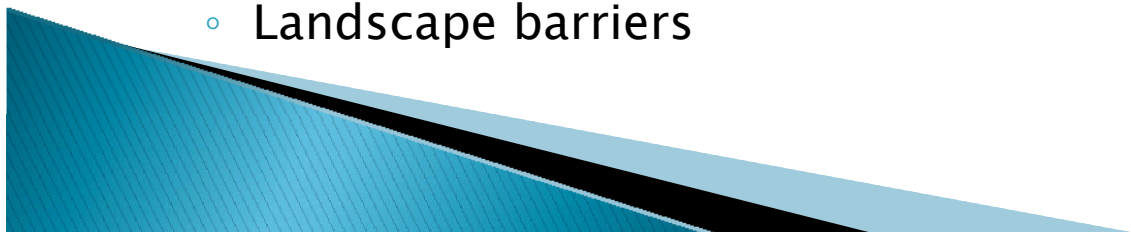
Disease Spread in Feral Swine: Factors to Consider for Models

- ▶ Population Distribution/Density
 - Discontinuous over landscape
 - Landscape changes over time/season, encroachment, hunting pressure

- ▶ Movements
 - Spatial extent, velocity of spread
 - Seasonal/climatic/anthropogenic influences

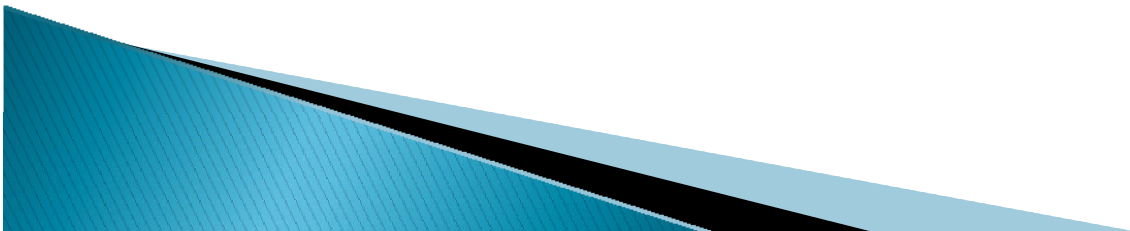


- ▶ Connectivity of populations across fragmented landscapes
 - Interaction between social groups and population structure
 - Overlapping home range – where?
 - Landscape barriers



The Approach

- ▶ Collect empirical data on California wild pigs
 - Global positioning systems (GPS)
 - Landscape genetics
 - Geographic information systems (GIS)
- ▶ Data collection and analyses based on factors important to FAD spread:
 - Distribution, movements/contacts, population connectivity
 - (Doran & Laffan 2005; Cowled & Garner 2009)



Overview

- ▶ Wild pigs in California
- ▶ Data Collection

1. **Factors associated with habitat selection**

- Where do pigs spend their time?

2. **Movement patterns**

- How do pigs move through different habitat types?

3. **Habitat connectivity**

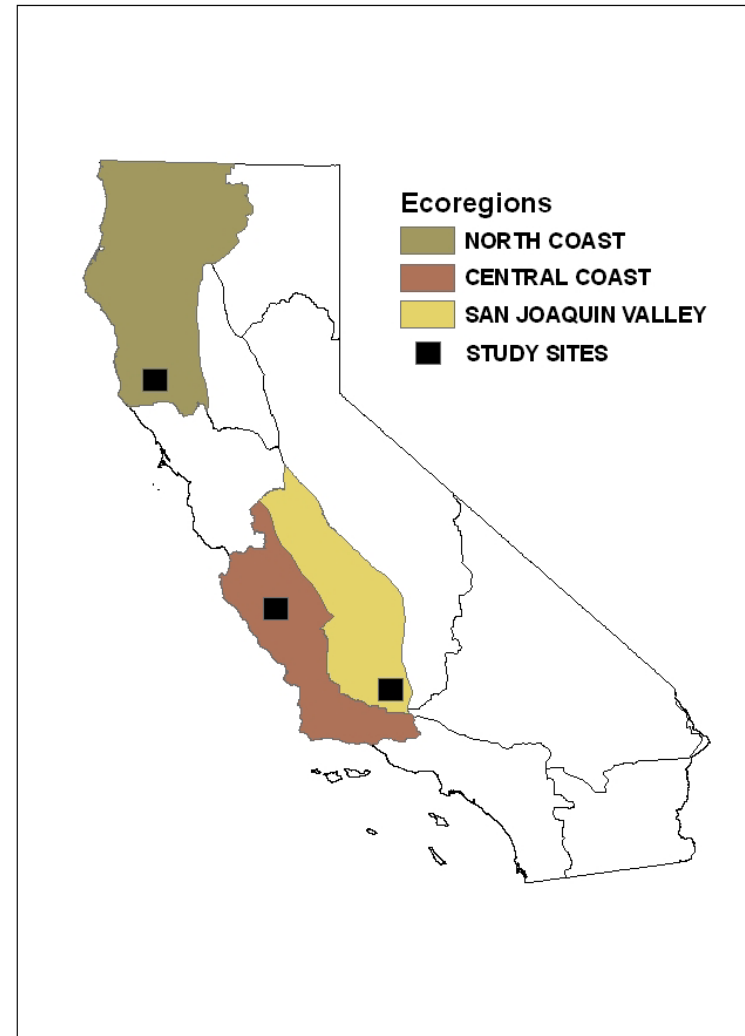
- Where do pigs come into contact?



- ▶ Implications for FAD spread & control; future directions

Study Regions

- ▶ 3 study sites representing different ecoregions
- ▶ Estimated population varies from 200,000–1 million
- ▶ Hybrid: feral swine/Eurasian boar
- ▶ Prolific reproductive biology, behaviorally adaptive
- ▶ Sympatric with deer, cattle, other domestic livestock



The Data

- ▶ GPS collars placed on a total of 120 pigs
- ▶ Genetic data collection
- ▶ GIS data
 - Vegetation, land use, hydrology, elevation/slope, temperature, precipitation

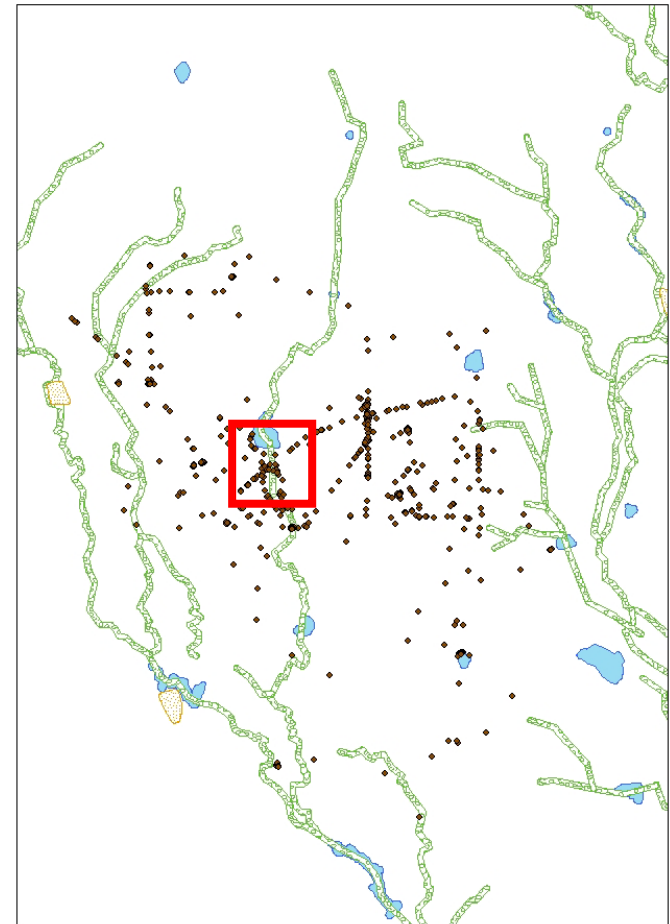


(1) Factors associated with habitat selection

- ▶ Knowledge of general and local distribution needed (i.e. where are pigs?)
 - Currently this is primarily done using expert opinion, hunting or anecdotal information due to resource constraints
- ▶ Relationships between habitat selection and landscape pattern affect distribution
 - Habitat selection as a proxy for distribution
 - Where do pigs spend their time?

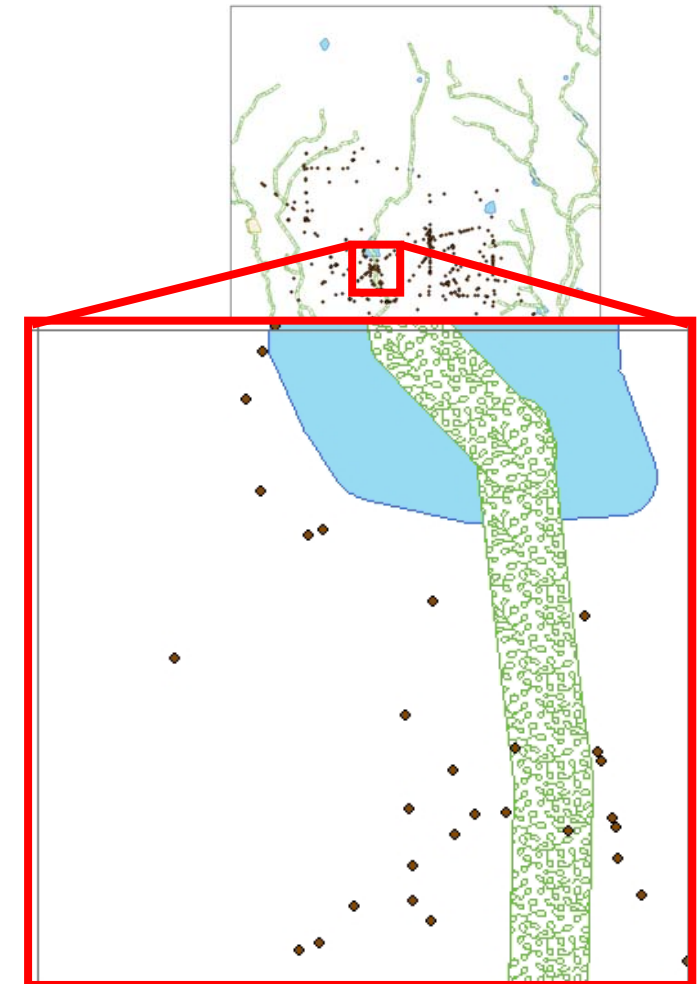
Methods

- ▶ Aim: To assess the association between landscape pattern and habitat selection
- ▶ Multivariate mixed effects model
 - Outcome: time spent in landscape unit

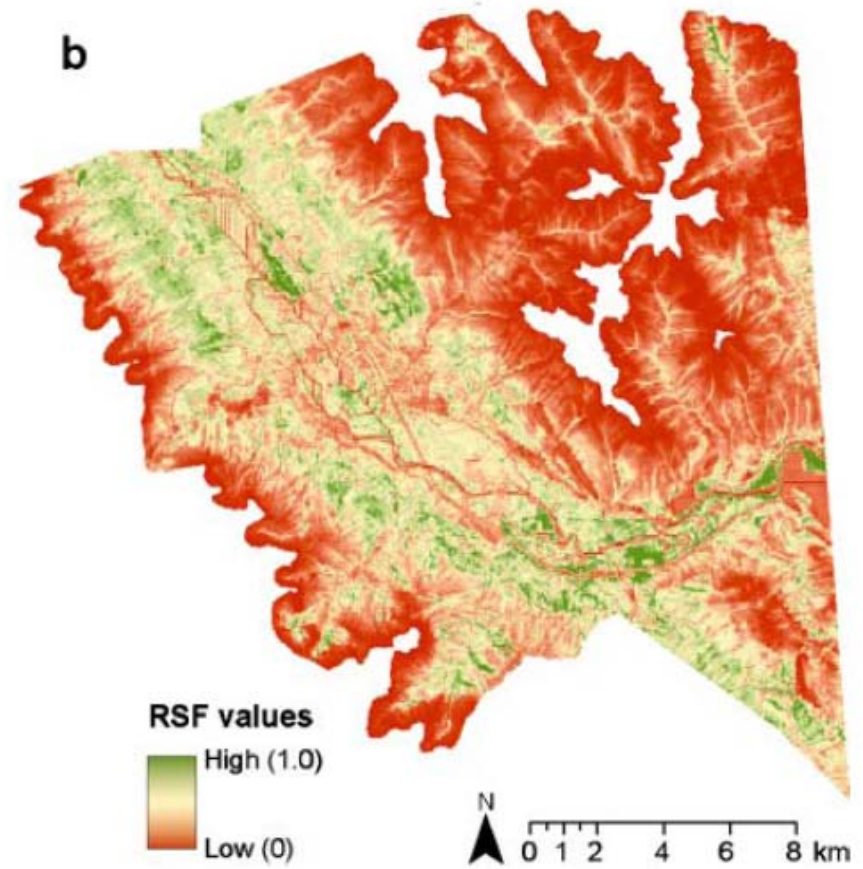
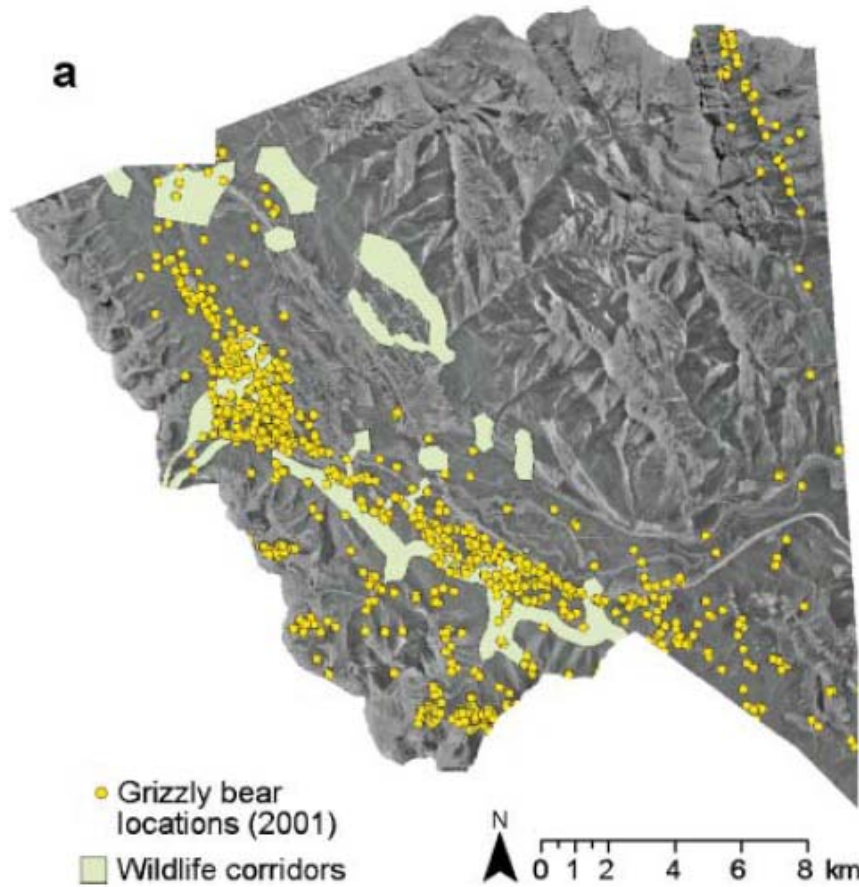


Methods

- ▶ Aim: To assess the association between landscape pattern and habitat selection
- ▶ Multivariate mixed effects model
 - Outcome: time spent in landscape unit
 - Explanatory variables:
 - Environmental/geographic variables
 - Road density
 - Month (season), time of day, study site



Expected outcome



Adapted from Chetkiewicz et al. 2006

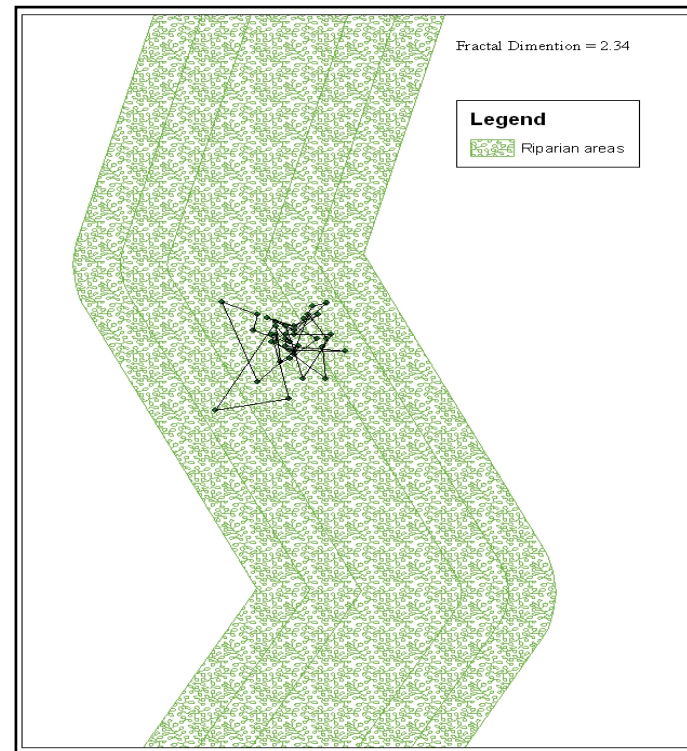
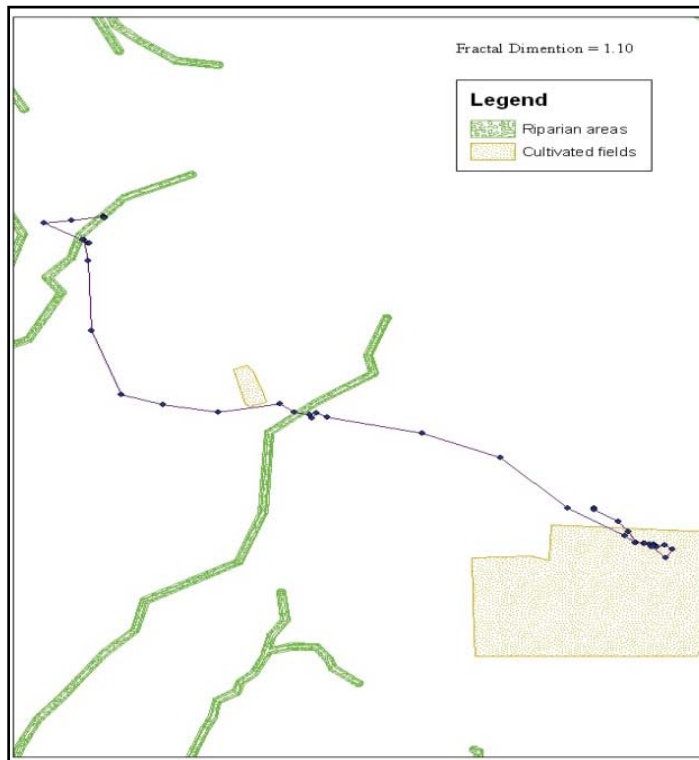
(2) Movement Patterns

- ▶ Movement through fragmented landscapes
 - How do they move through their home range?
- ▶ Wild pig behavior:
 - Form social groups called sounders
 - Adult boars are usually solitary
 - Interaction during breeding, at common water/food sources
 - Usually nocturnal, seldom move during hot weather



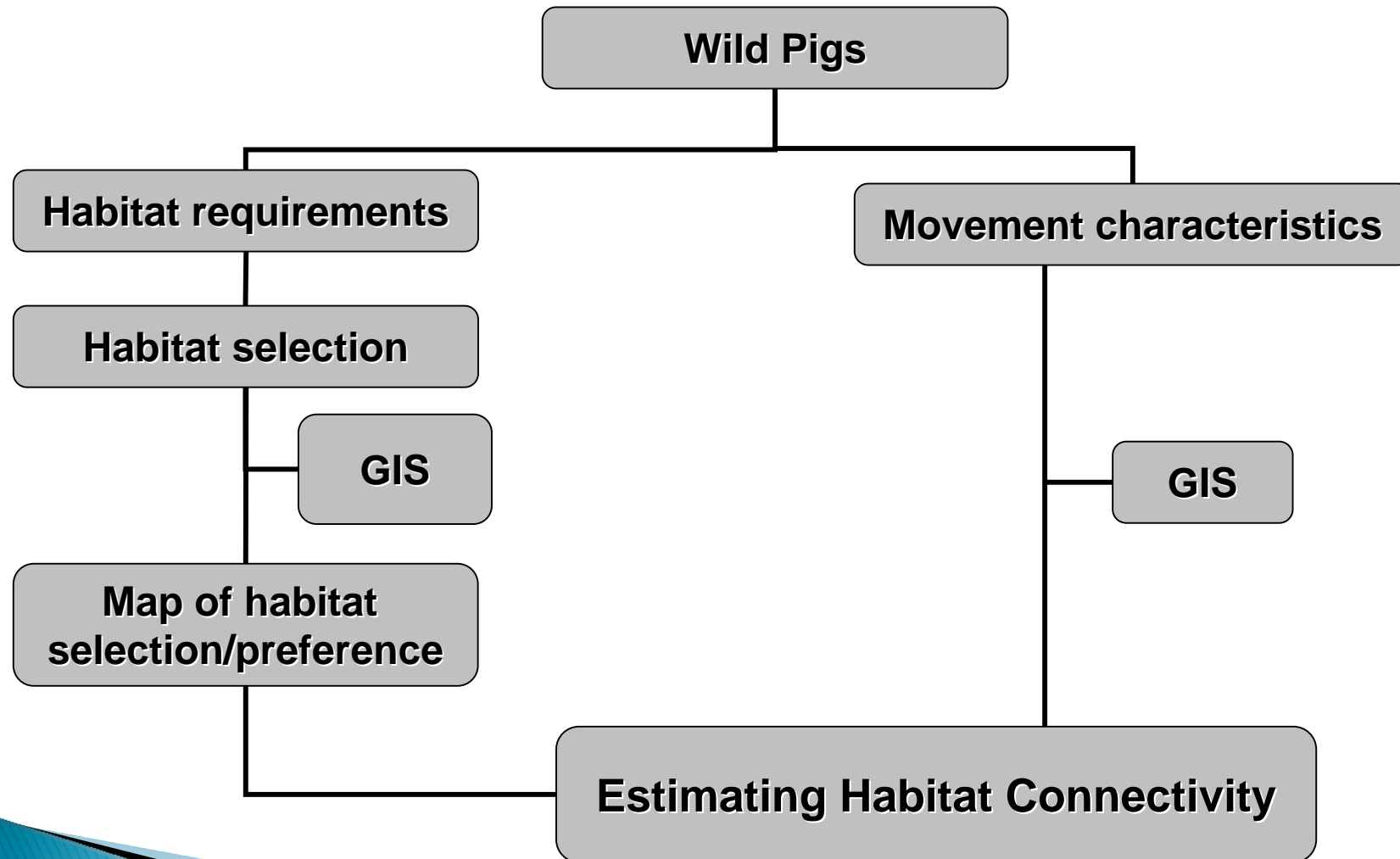
(2) Movement Patterns

- ▶ Aim: To assess the association between movement patterns and landscape features

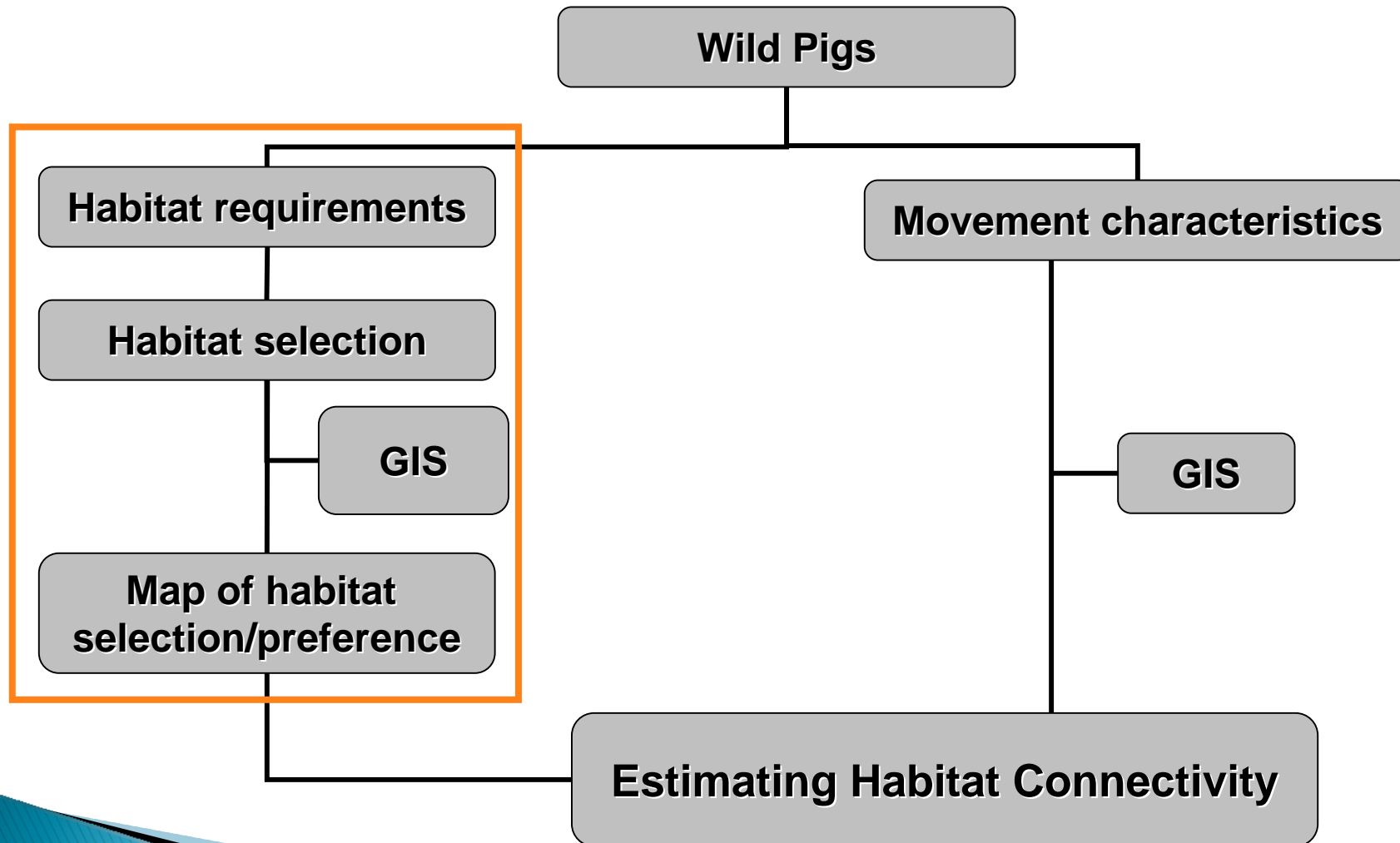


GPS data courtesy of Drs. H. Morgan Scott and Susan Cooper

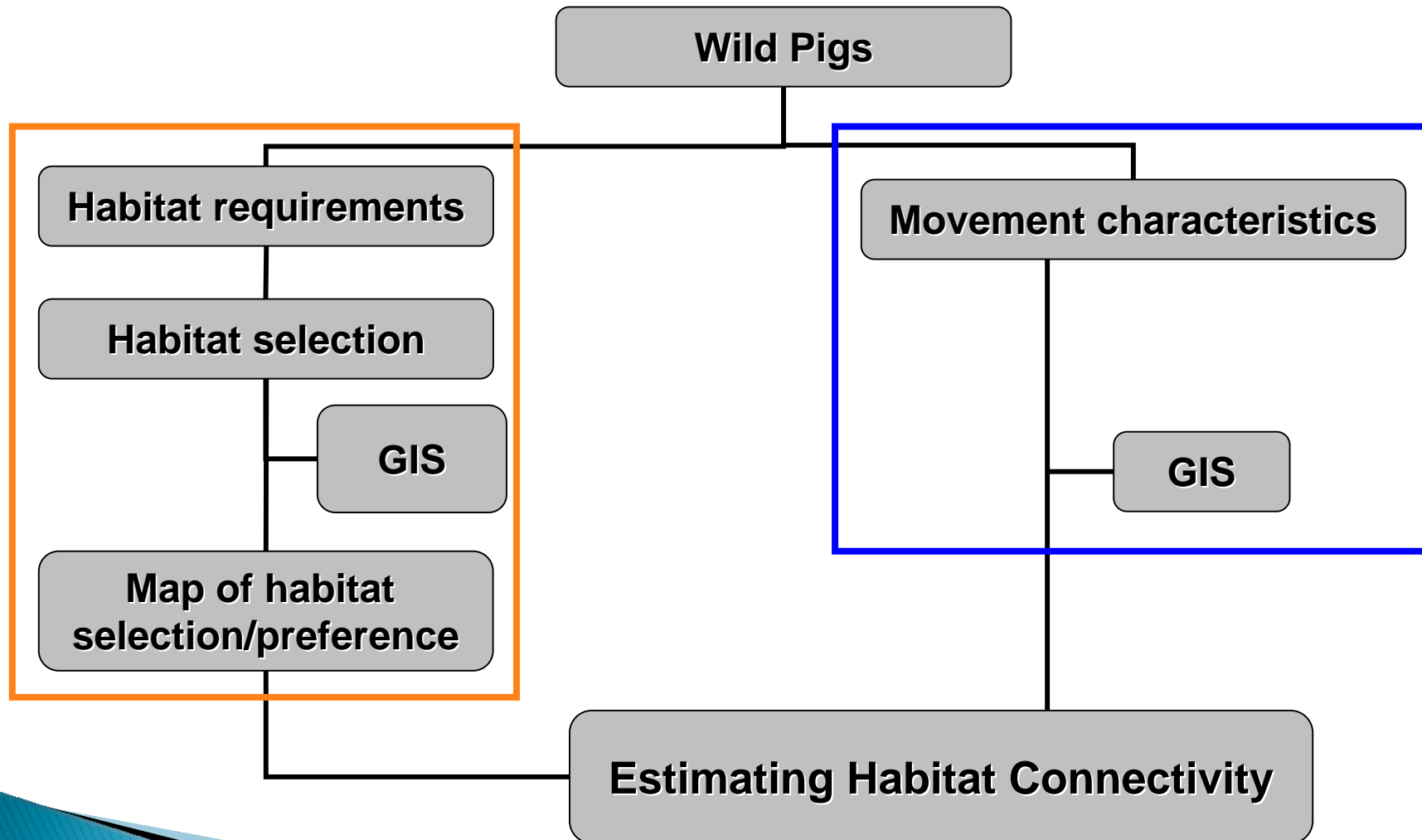
(3) Habitat Connectivity



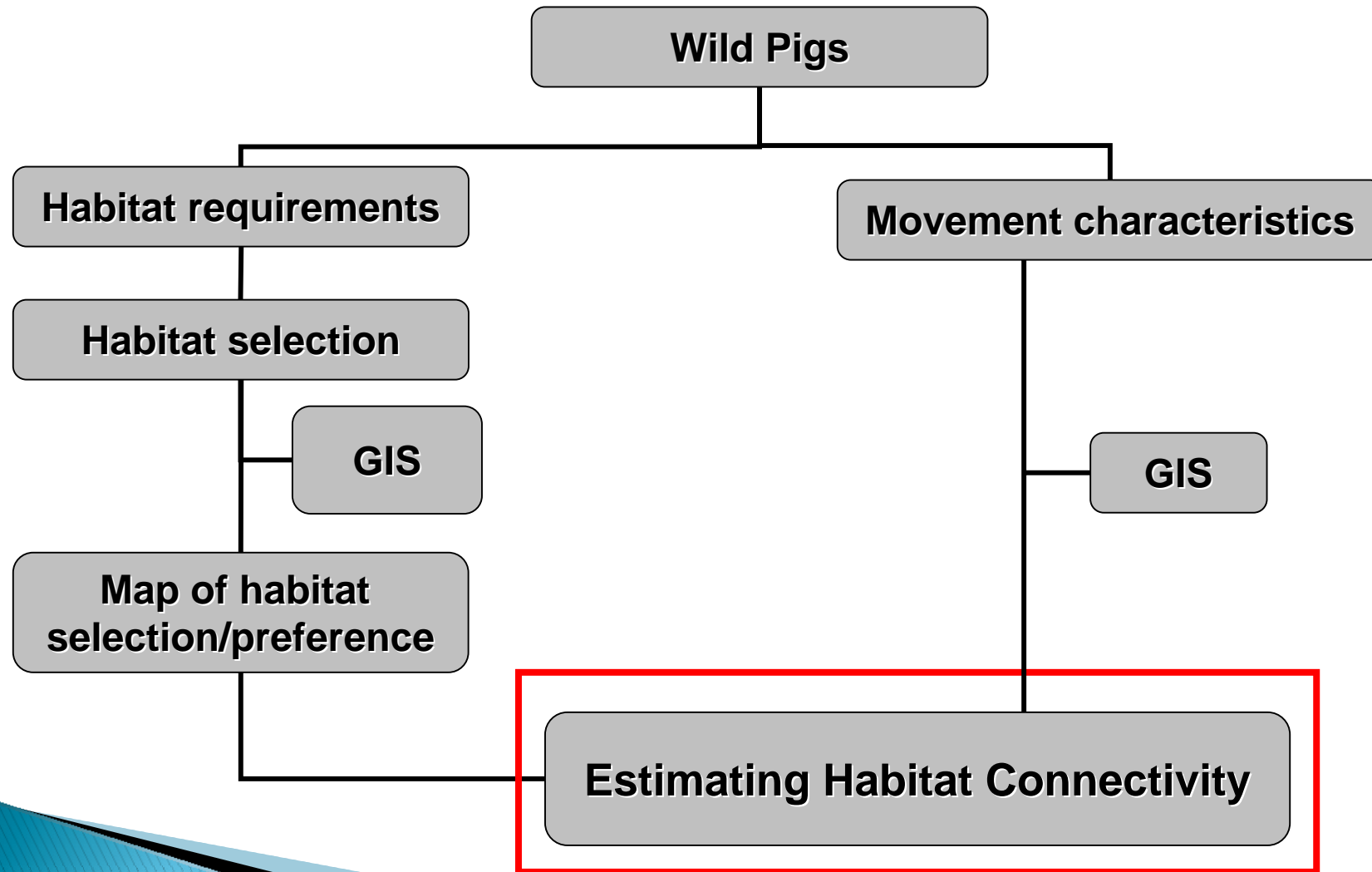
(3) Habitat Connectivity



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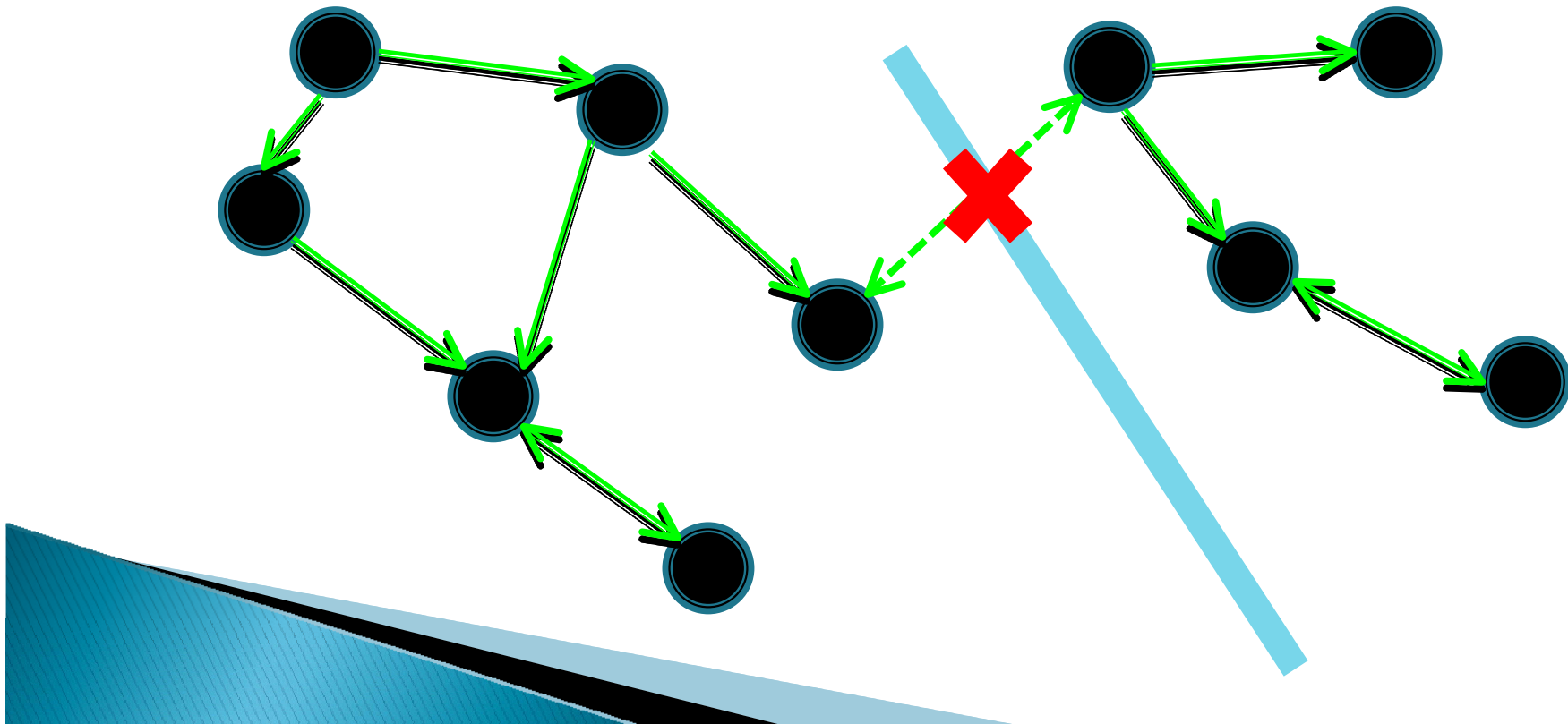


(3) Habitat Connectivity



Habitat Connectivity

- ▶ Aim: To identify habitat connectivity of wild pig populations and assess disease spread control options



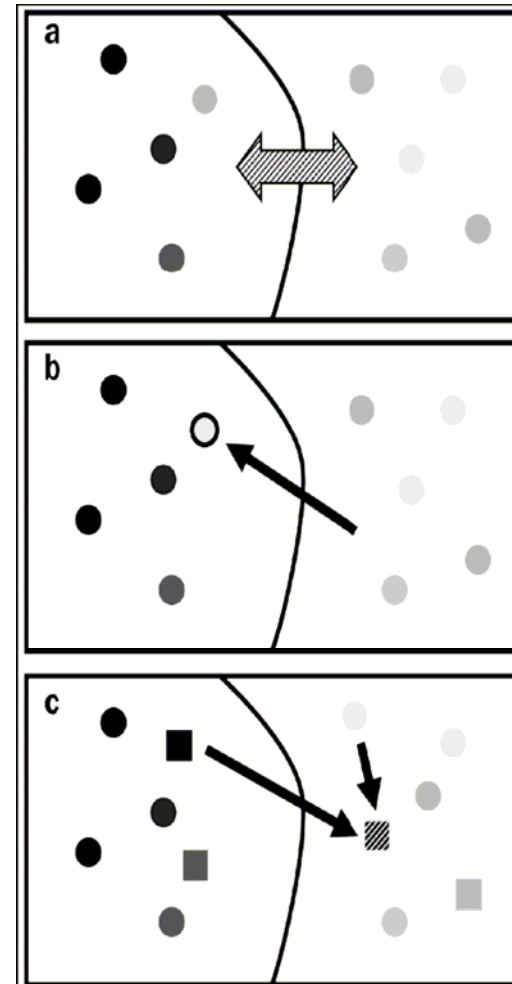
Methods

- ▶ **Graph theory/ social network analysis**
 - Used in ecology for corridor planning
 - Represents a landscape of connected/disconnected habitat patches
 - Identify areas to target for preventing or controlling disease spread

- ▶ **Landscape genetics**
 - population genetics + landscape ecology + spatial statistics

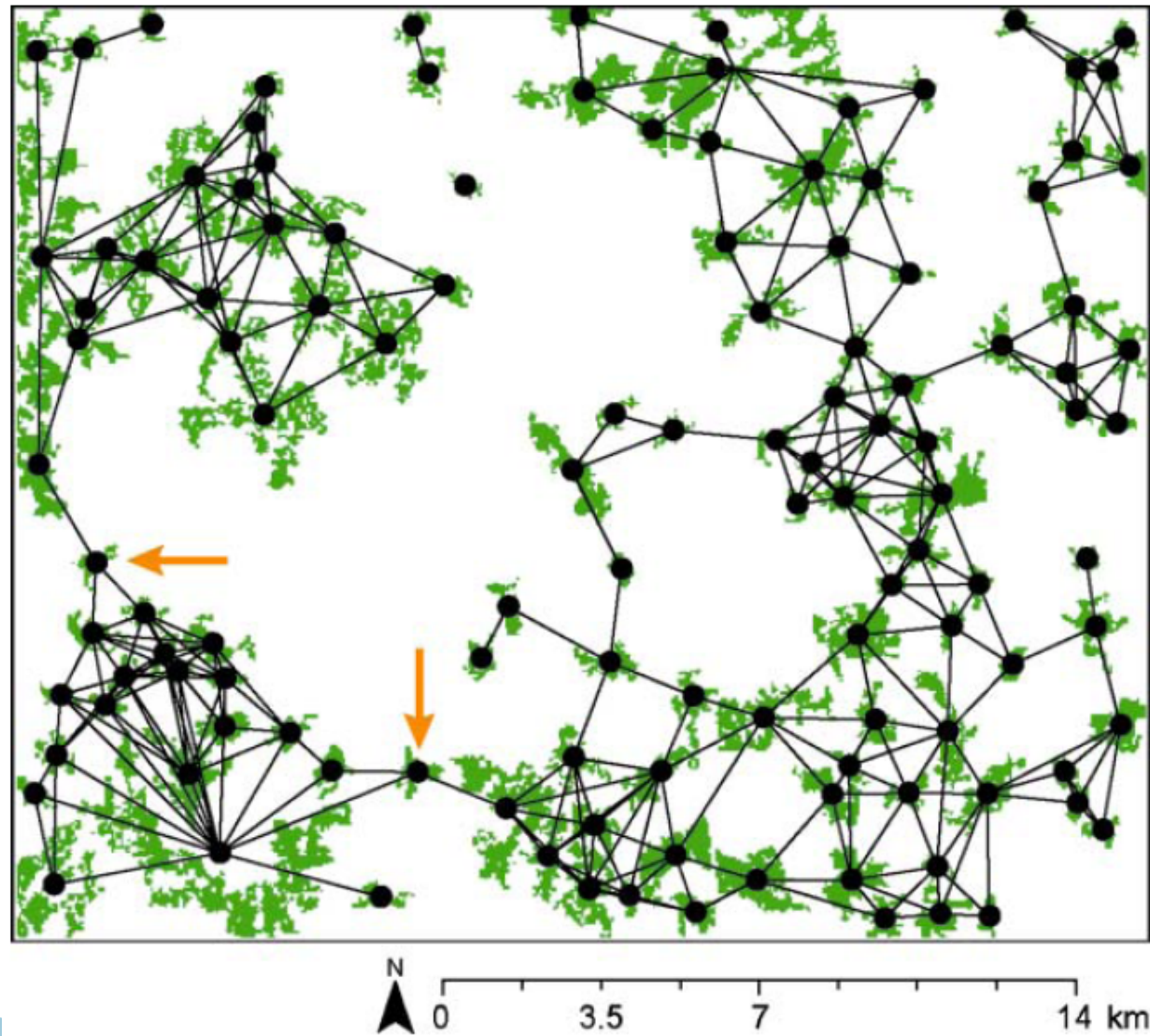
Landscape genetics

- ▶ Characterizes areas between habitats and their influence on biological/ecological processes (connectivity)
 - Landscape metrics
 - Gene flow
- ▶ Use in disease modeling:
 - Animal dispersal
 - Metapopulations
 - Landscape barriers



Holderegger and Wagner, 2008

Expected Outcomes



Adapted from Chetkiewicz et al. 2006

Implications for foreign animal diseases

- ▶ Understanding potential FAD spread requires knowledge of wild pig distribution
 - Habitat selection
- ▶ Understanding movements and potential contact
 - Spatial extent/velocity of disease spread
- ▶ Identifying areas of increased disease spread
 - Where to look?
- ▶ Identifying areas to focus mitigation strategies
 - Disconnect subpopulations of wild pigs?

Future Directions

- ▶ Data generalization
 - ▶ Wildlife epidemic model
 - ▶ Pig/deer interaction
 - ▶ Domestic/wildlife interaction
-
- ▶ Funding source:
 - Department of Homeland Security
 - Long Range Broad Agency Announcement (BAA) 09–05



Questions?

