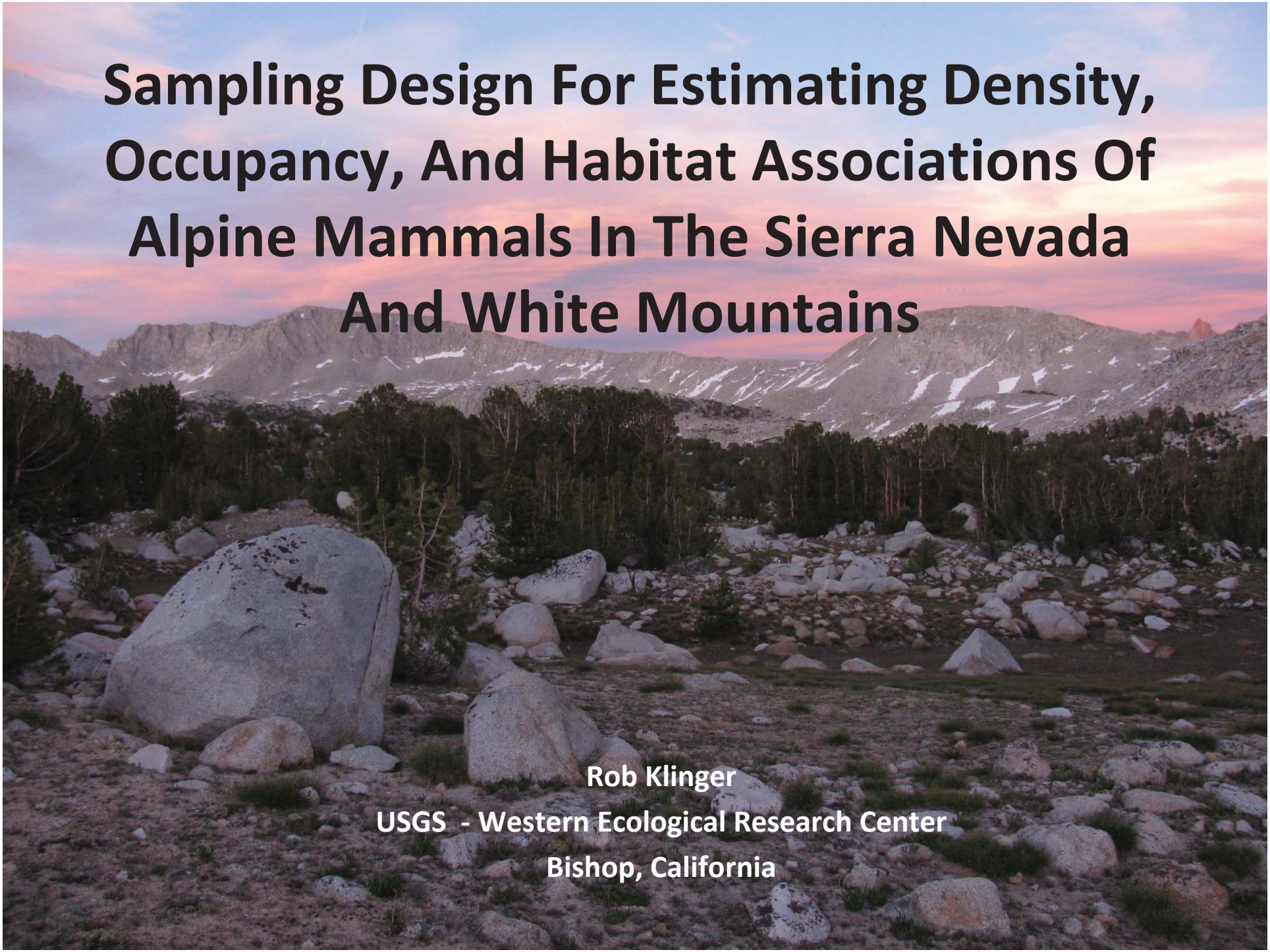
Sampling Design For Estimating Density, Occupancy, And Habitat Associations Of Alpine Mammals In The Sierra Nevada And White Mountains



Rob Klinger
USGS - Western Ecological Research Center
Bishop, California

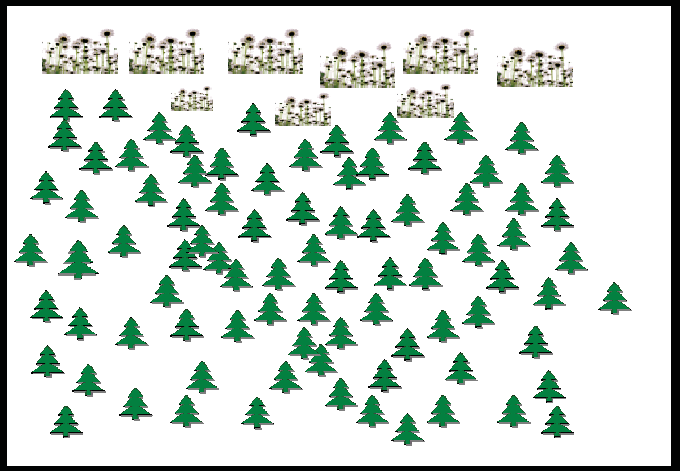
Structure Of Talk

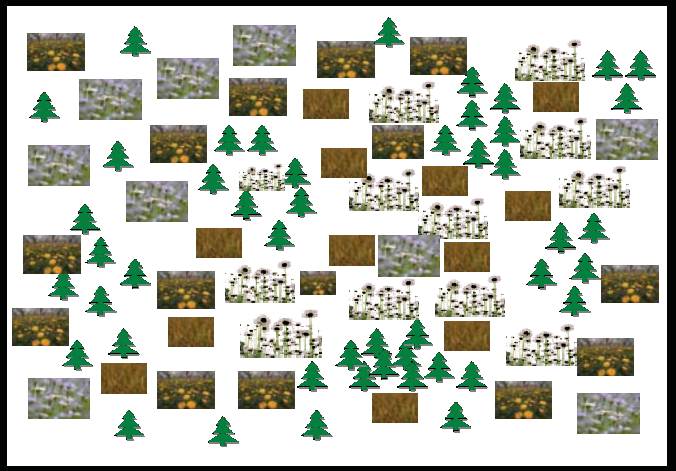
- Background
- Emphasize thinking behind sampling design
- Overview of process of getting to where we are now
  - Focus on abundance and occupancy estimation
- Outline of pilot study
  - 2007 and 2008
- Data from 2009
- Outline refinements and current design (2010)

Central Organizing Question Of Study

What Are Implications Of Potential Range Changes Of Alpine Mammals On Vegetation States?

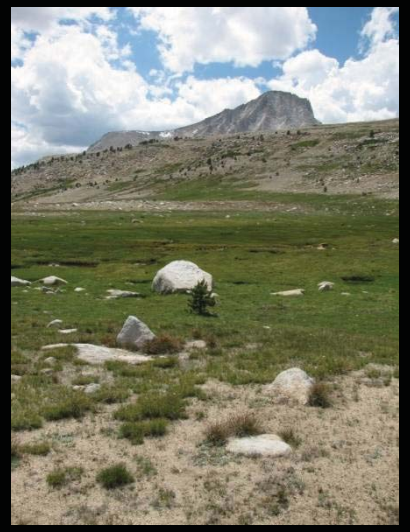
- Can mammals decouple assumed climate-driven vegetation transitions
- Relatively few homogenous states …
  - The climate-driven scenario
- …Or many alternative stable states (high heterogeneity)?
  - **Mammals "manage their own habitat"**





Climate Change & Alpine Ecosystems

- Virtually no data for the Sierra Nevada!
  - Animals or plants

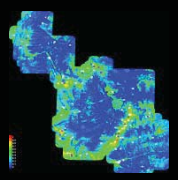


So How Are We Going To Get At This?

Remote Sensing Data
Climate Data

Change In Land Cover Classes
(1972 - Present)

Mammal Distribution Models



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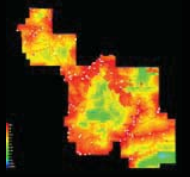


Adjusted by RSF's

Transects
Point Counts
Habitat Sampling

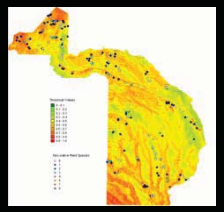
Mammal Density, Occupancy, Habitat Associations

Evaluate interaction strength

Projected Meadow Conversion Models

Exclosures
Seeding

Grazing-Herbivory Experiments
(*Pinus contorta & P. albicaulis*)



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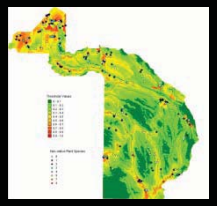


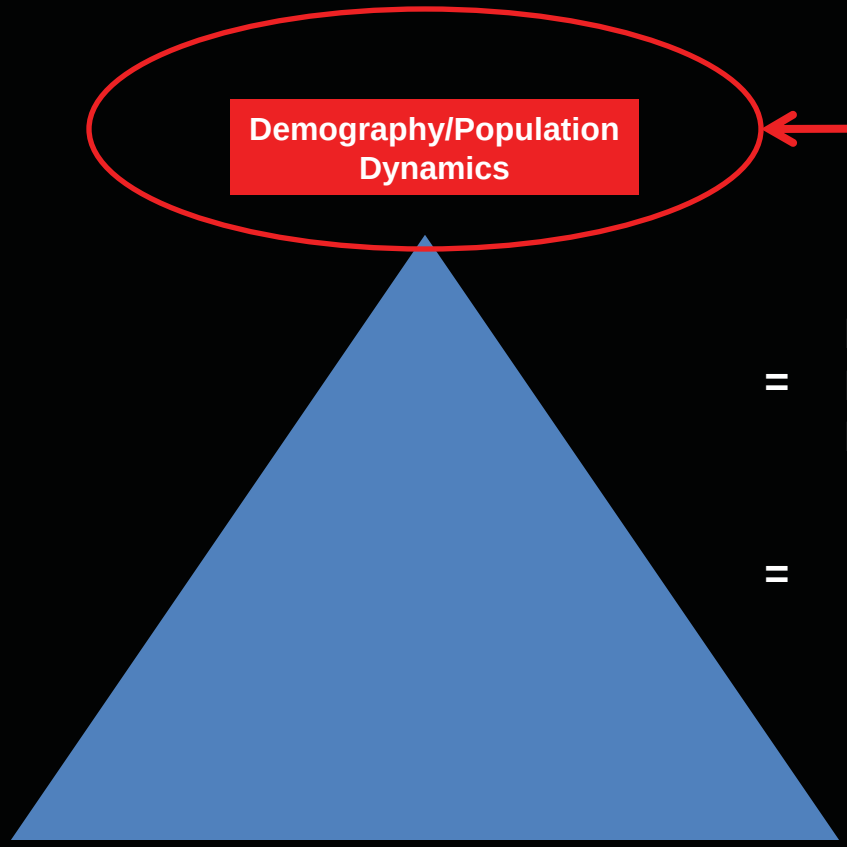
Adjusted for biotic interactions

Sierra Nevada/White Mountain Alpine Mammal Study

- 7-10 year study
- Multi-species study
  - Bighorn sheep
  - Yellow-bellied marmot
  - American pika
  - Belding's ground squirrel
  - Golden-mantled ground squirrel
- Multi-scale
  - Rangewide
  - Regional
  - Local
- Estimate:
  - Density
  - Occupancy
  - Habitat associations
  - Demographic rates

- Model:
  - Species distributions
    - Climate
    - Topography
    - Vegetation
  - Population dynamics
  - Resource selection
  - Persistence
- Compare:
  - Among species
  - Among mountain ranges
  - Temperature gradient

The Legs Of The Triangle



The glaring hole!!

= Pattern (extent) +
Process (direct vs. indirect effects) +
Mechanism (prediction)

= Integrated & comprehensive understanding of factors determining persistence

Data Needs

- Niche modeling
  - *Extensive* data on distribution, abundance, and macrohabitat associations
- Population dynamics
  - *Rangewide* abundance
  - *Local* abundance and demographic rates
- Habitat associations
  - Macrohabitat
  - Microhabitat
  - Occupancy

Primary Considerations

- Sources of variation
  - Process
  - Sampling
- Scale of inference
  - Rangewide
  - Regional
  - Local
  - Patch
- Practical
  - Access
  - Efficiency

Secondary Considerations

- Density
  - What type of density?
- Occupancy
  - Extensive vs. intensive sampling tradeoff
- Habitat associations
  - Between species
  - Density-dependent patterns
  - Habitat heterogeneity

Integrating Needs And Considerations
(Some Basic Reasoning - 2007)

- Extensive surveys will have generality but not practical for collecting demographic data
- Intensive surveys at local scales will lack generality but only practical way to collect detailed demographic data

Integrating Needs And Considerations
(Some Basic Reasoning - 2007)

- Transects appropriate for estimating abundance at rangewide and regional scales but must account for differences in detection (no indices)
- Transects will not provide demographic data

Integrating Needs And Considerations
(Some Basic Reasoning - 2007)

- Point counts appropriate for local-scale abundance but must account for differences in detection (no indices)
- Point counts will not provide demographic data
- Occupancy can be integrated in a point count framework to estimate patch-scale abundance

Integrating Needs And Considerations
(Some Basic Reasoning - 2007)

- Mark-recapture too time consuming and logistically difficult for estimating abundance at all but patch scales




Integrating Needs And Considerations
(Some Basic Reasoning - 2007)

- Mark-resight appropriate for patch-scale abundance and provide demographic data
- Logistically difficult but possible

Integrating Needs And Considerations (Some Practicalities - 2007)

- How random could we be?
- Constraints
  - Terrain
    - Safety
    - Efficiency

Integrating Needs And Considerations (Some Basic Reasoning - 2007)

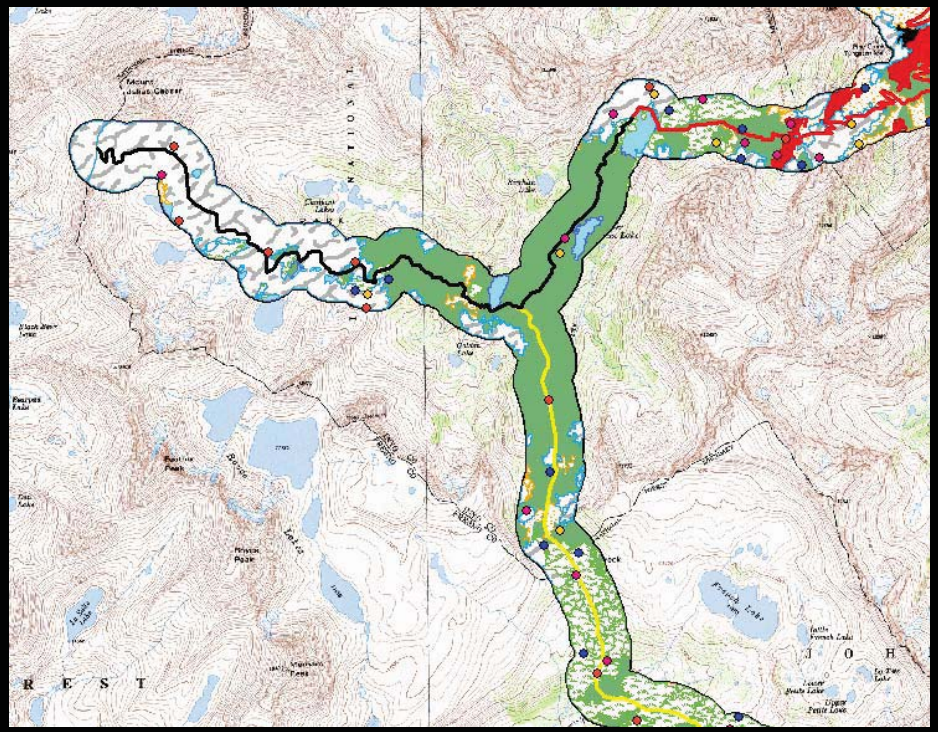
- Decision for pilot study
  - One size would not fit all
    - Need multiple sampling protocols
  - Test transect and point counts at rangewide, regional, and local scales
  - Arrange points randomly along transects
  - Test random transects vs. routes
  - Sample transects and points multiple times each year
    - Reduce within-season variability
    - Allow occupancy estimation

Integrating Needs And Considerations (Reconnaissance - 2007)

- Outcomes
  - Random transects were impractical, inefficient, and potentially dangerous
  - Counts would need to be put on hold from late morning through mid to late afternoon
  - Transect length and number of points per transect could not be determined

2008 Pilot Study

- Abundance estimation
  - 40 variable-distance line transects (454 km)
    - 10 - 25 km
    - 1-3 counts per transect
- Occupancy estimation
  - 25 variable-distance point counts
    - 6 visits each (June-August)
- Habitat associations
  - Line transect and point-count observations
  - Macrohabitat
    - CalVeg vegetation layer (GIS)



2008 Pilot Study
Results

- Transects
  - 1206 independent observations
    - Yellow-bellied marmot (N = 355)
    - American pika (N = 230)
    - Belding's ground squirrel (N = 208)
    - Golden-mantled ground squirrel (N = 413)
- Point counts
  - 319 independent observations
    - Yellow-bellied marmot (N = 99)
    - American pika (N = 56)
    - Belding's ground squirrel (N = 84)
    - Golden-mantled ground squirrel (N = 80)

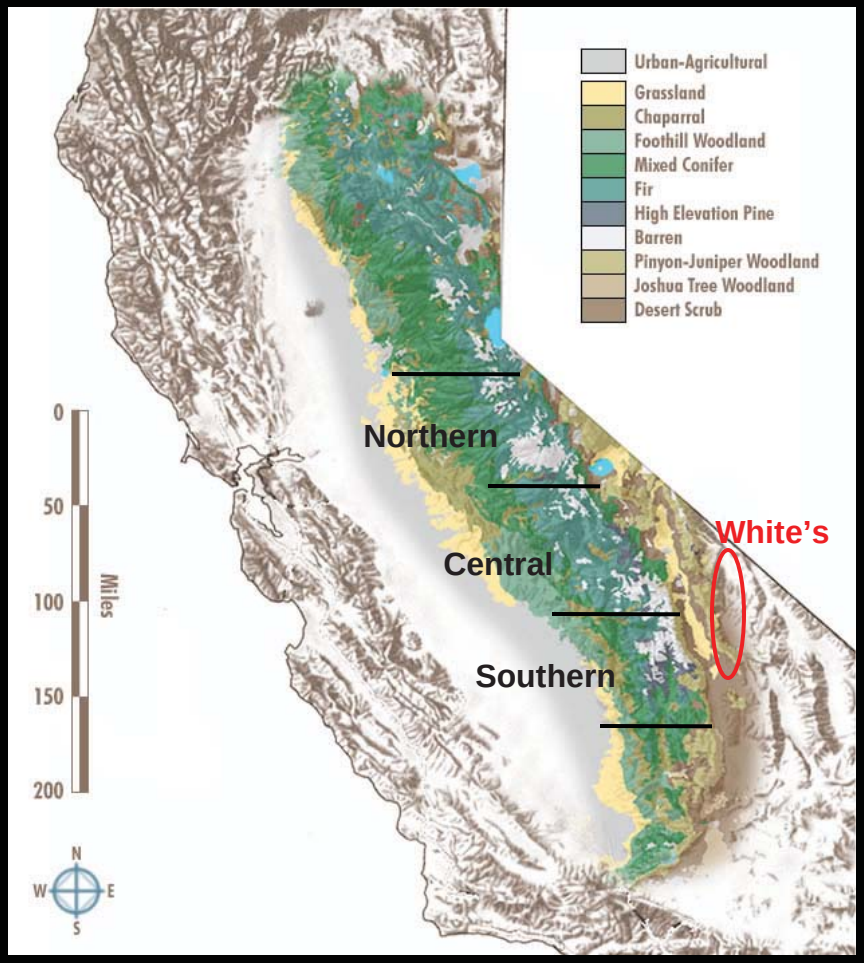
- Occupancy estimation
  - 65% of points occupied
    - Yellow-bellied marmot (N = 19)
    - American pika (n=16)
    - Belding's ground squirrel (N = 14)
    - Golden-mantled ground squirrel (N = 15)

2008 Pilot Study
Interpretation For Pika

- Transects
  - 10-km transects appropriate length
  - Sample-size estimation indicated 148 km transect length adequate for estimating rangewide density with CV = 0.20
- Point counts
  - Sample-size estimation indicated 52 points adequate for estimating local-scale density with CV = 0.20
- Occupancy
  - Six visits per point was overkill
  - Three to four probably adequate

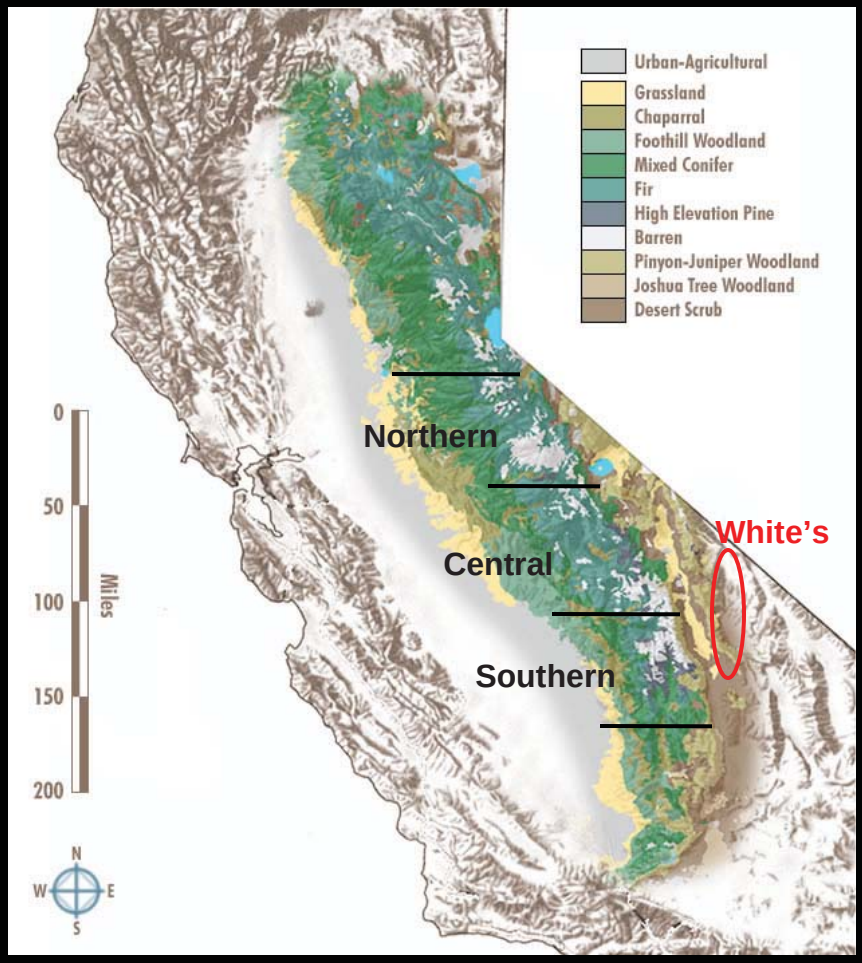
Methods - 2009

- **Rangewide and regional abundance estimates**
  - **18 variable-distance line transects (616 km)**
    - **Sierra Nevada**
      - N = 12 selected randomly from pool of 48 potential routes
      - Four transects in each of three regions
      - 10 km
      - Sampled 4 times June-August
    - **White Mountains**
      - N = 6 selected randomly
      - 1.4 – 7.8 km
      - Sampled 5 times July-September



Methods - 2009

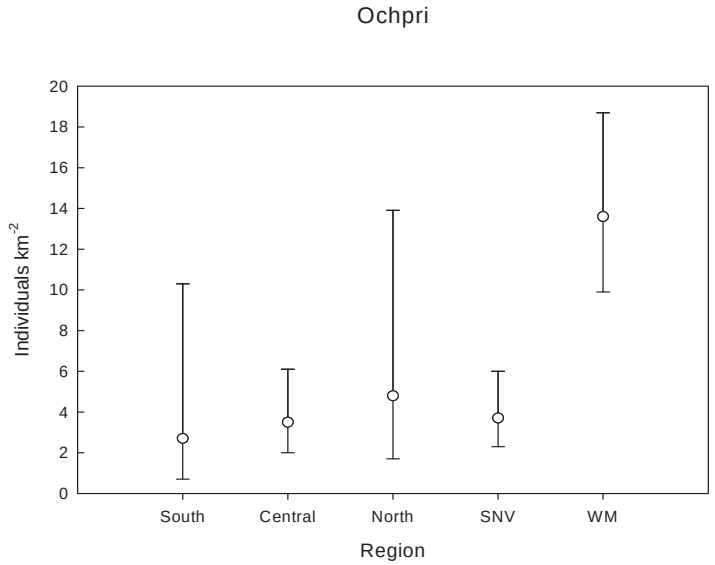
- **Occupancy and local & patch-scale abundance estimates**
  - **Variable-distance point counts**
    - **Sierra Nevada**
      - N = 60
      - 5 randomly located points per transect
      - Sampled 3 times June-August



Sample Sizes -2009

- Rangewide and regional abundance
  - 1916 independent observations
    - Yellow-bellied marmot (N = 522)
    - American pika (N = 289)
    - Belding's ground squirrel (N = 522)
    - Golden-mantled ground squirrel (N = 583)
- Occupancy and local & patch abundance
  - 400 independent observations
    - Yellow-bellied marmot (N = 46)
    - American pika (N = 123)
    - Belding's ground squirrel (N = 161)
    - Golden-mantled ground squirrel (N = 70)
- Habitat associations
  - 2316 independent observations

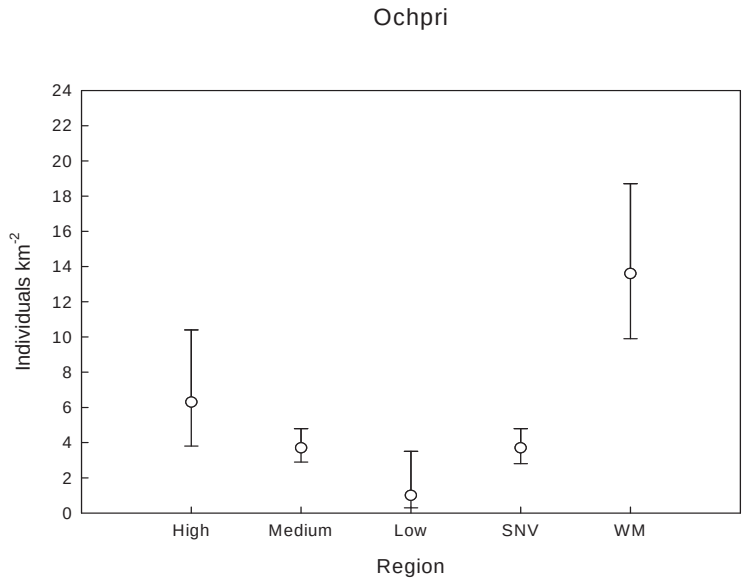
Rangewide And Regional Abundance Estimates
Transects 2009



- No geographic pattern across Sierra Nevada
- Density in White Mountains > 3x greater than Sierra Nevada
- High variability!
  - **Mean regional CV in Sierra Nevada = 34.2%, rangewide = 21.7%**
  - **CV in White Mountains = 14.3%**

Abundance Estimates By Encounter Rate Strata

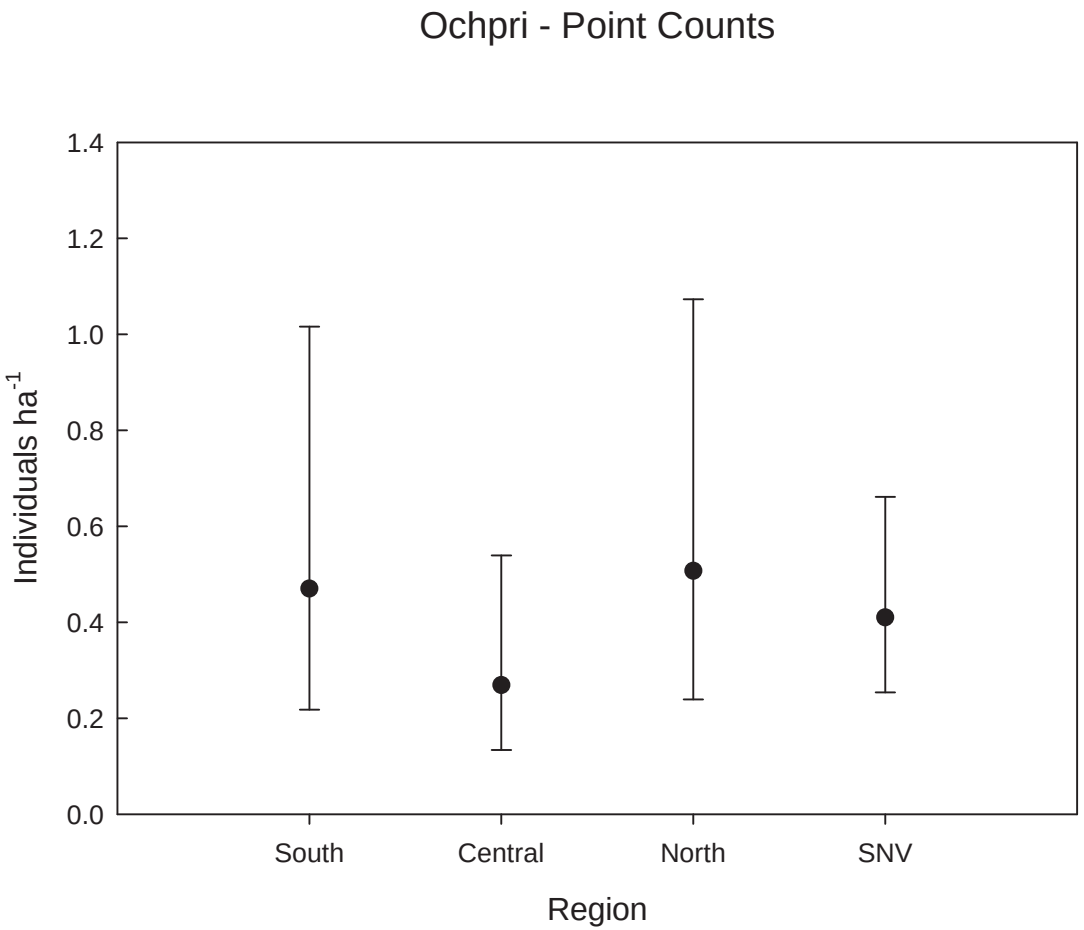
Transects 2009



- **Mean CV by density in Sierra Nevada = 14.5%, rangewide = 12.8%**
- **Mean reduction in CV = 21.1%**

Local Abundance Estimates By Region

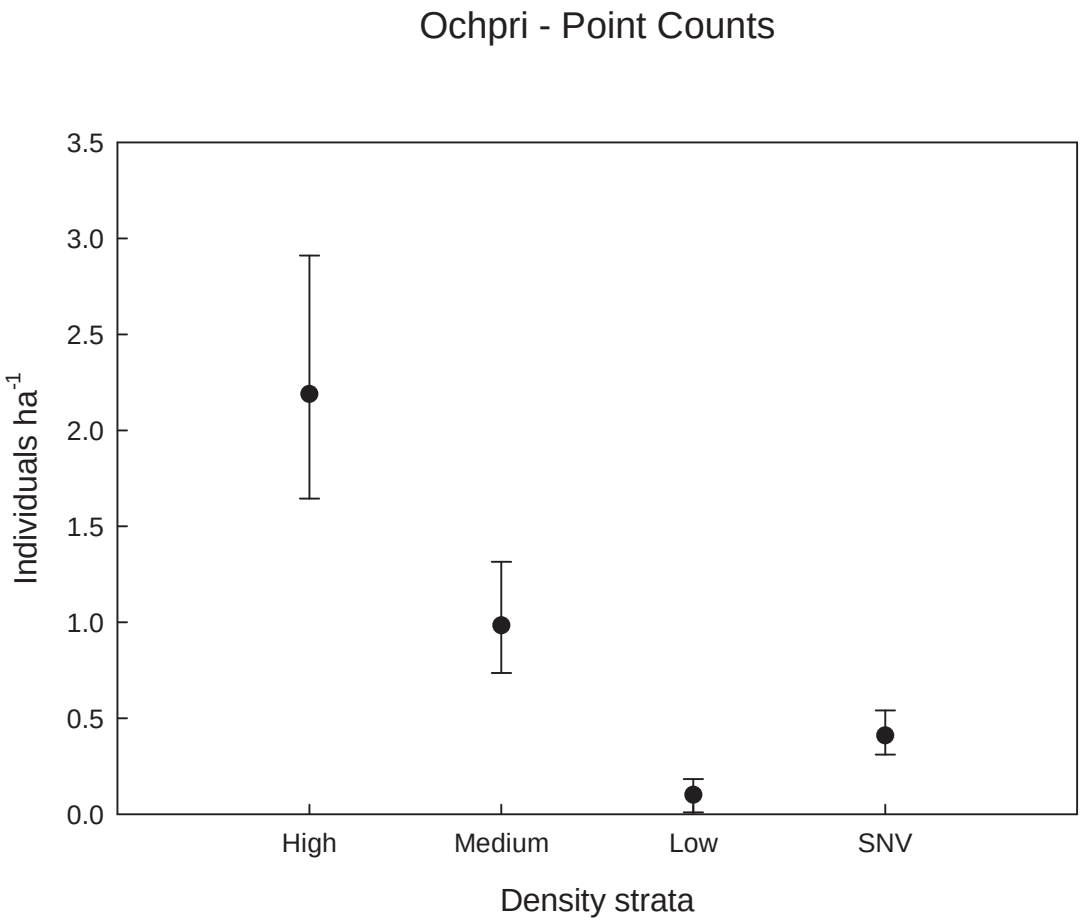
Point Counts 2009



- No geographic pattern across Sierra Nevada
- High variability!
  - **Mean regional CV = 37.1%, rangewide = 24.4%**

Local Abundance By Encounter Rate Strata

Point Counts 2009



- **Mean CV = 19.8% by density strata, rangewide = 14.1%**

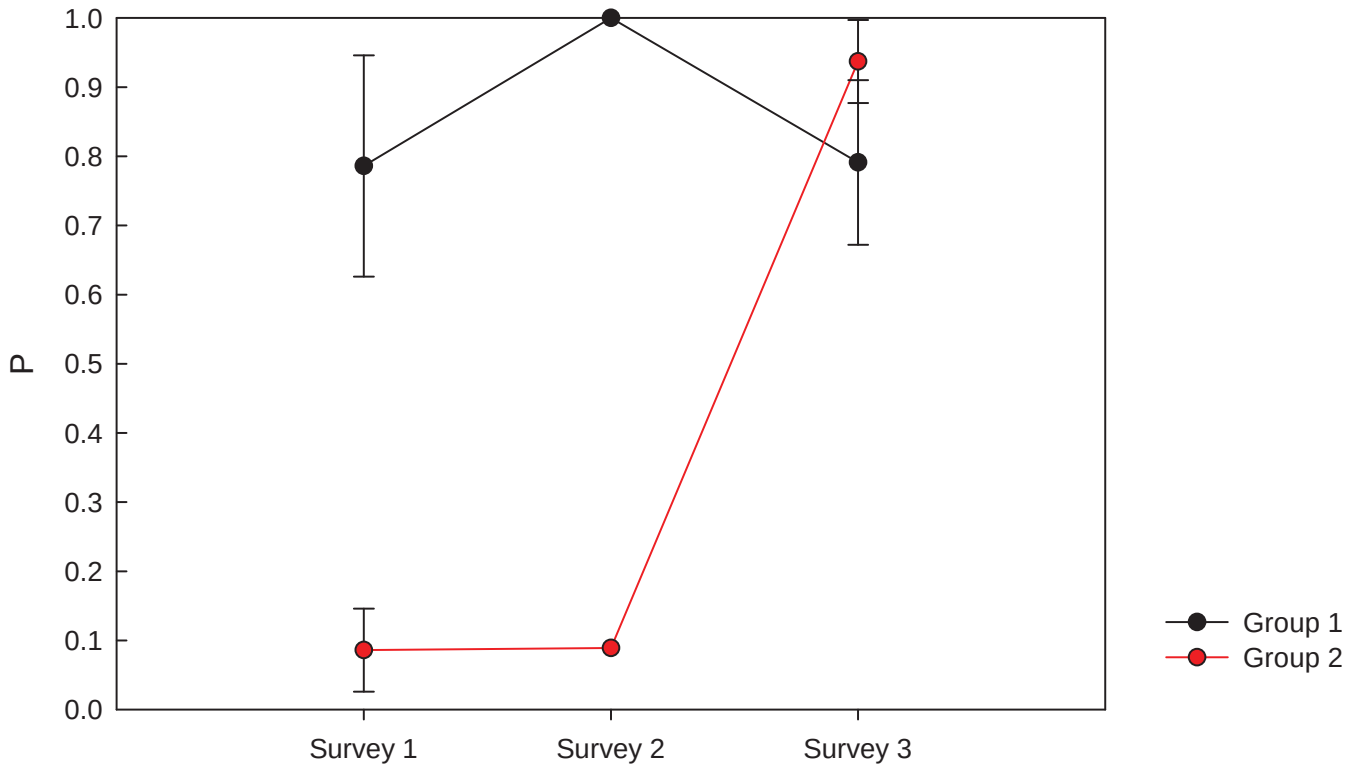
Occupancy And Patch Abundance - 2009

- **55%** of sites unoccupied by any species
- Yellow-bellied marmot
  - 23.3%
- American pika
  - 43.3%
- Belding's ground squirrel
  - 40.0%
- Golden-mantled ground squirrel
  - 33.3%

Process Related Patterns

Detection Probabilities

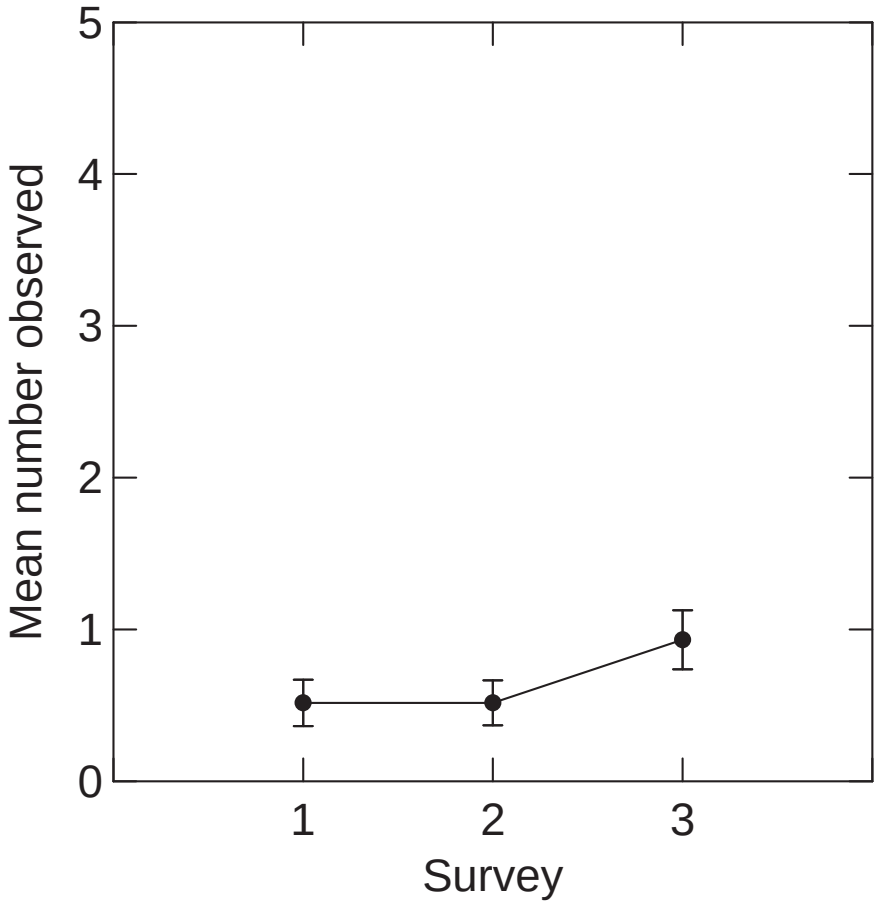
Ochpri



- **Two distinct groups of sites with different detection probabilities (P)**
- **Influx of individuals on third survey**
- **Indicative of dispersal into sink habitats?**

Process Related Patterns

Intra-annual Patch Abundance

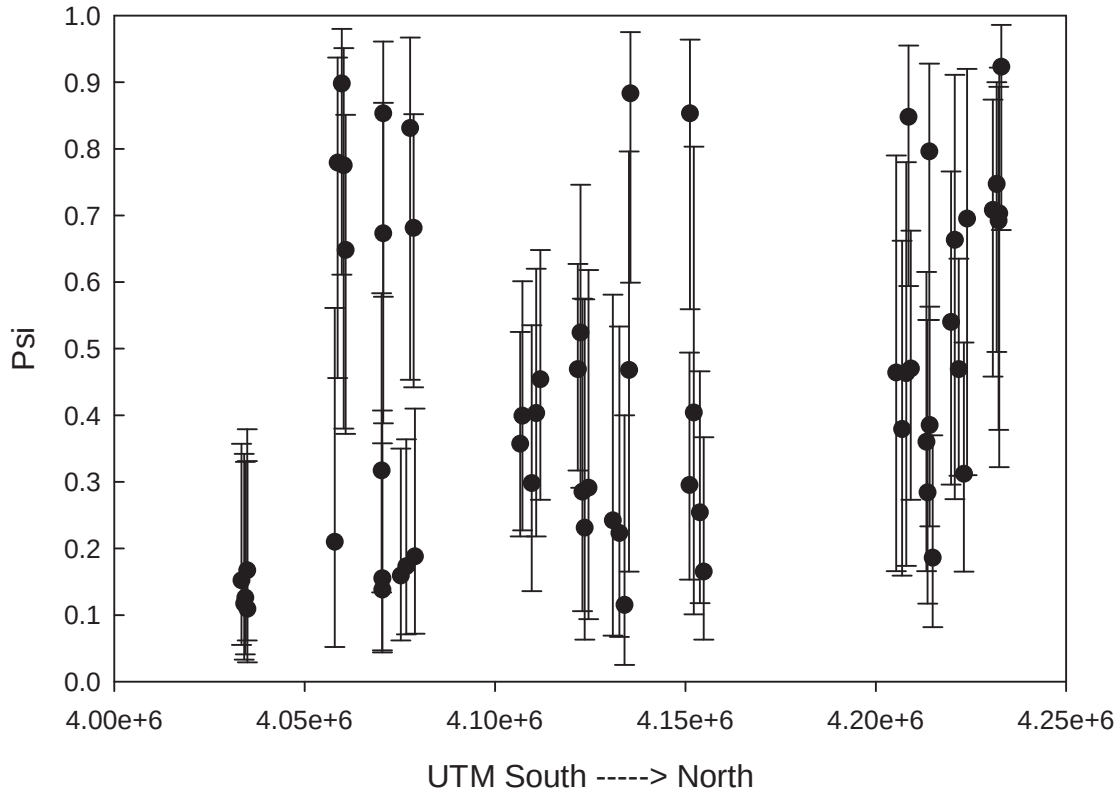


- **Greater mean abundance on third survey**
- **Indicative of dispersal and/or reproduction?**

Process Related Patterns

Occupancy (Psi)

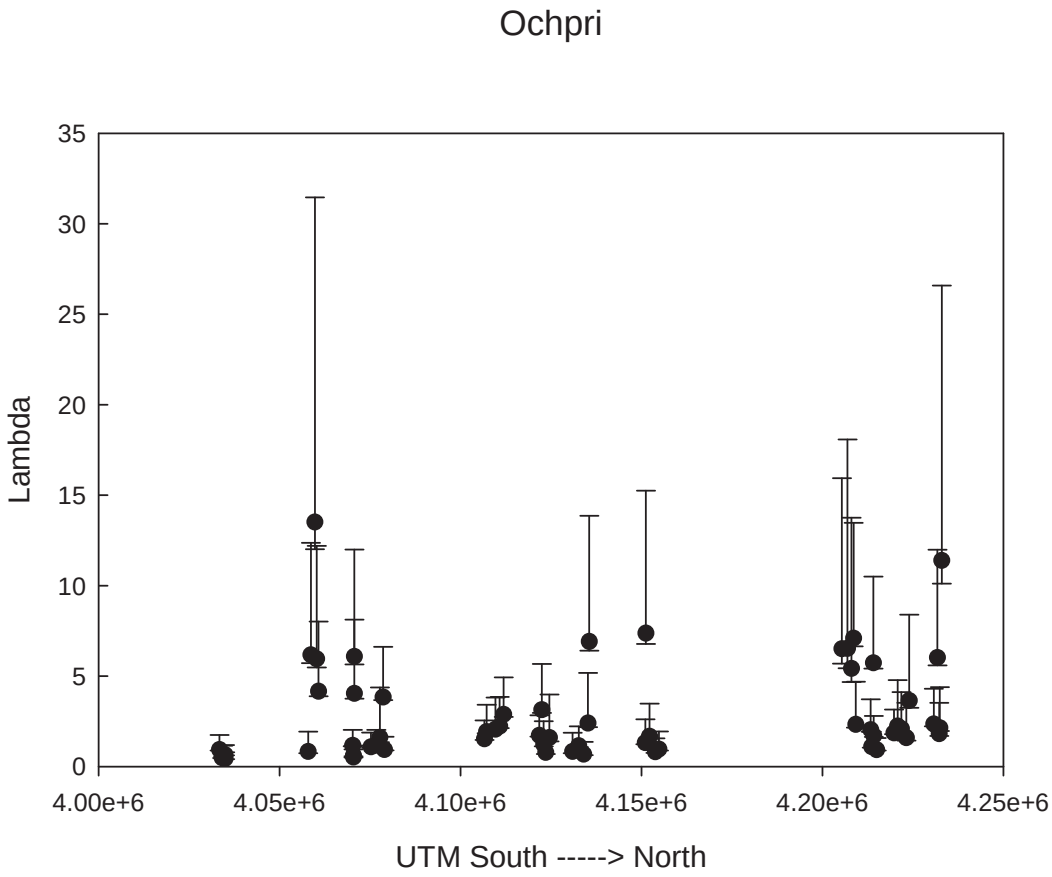
Ochpri



- No latitudinal pattern
- Best model = Barren + Conifer + Shrub (macrohabitat)

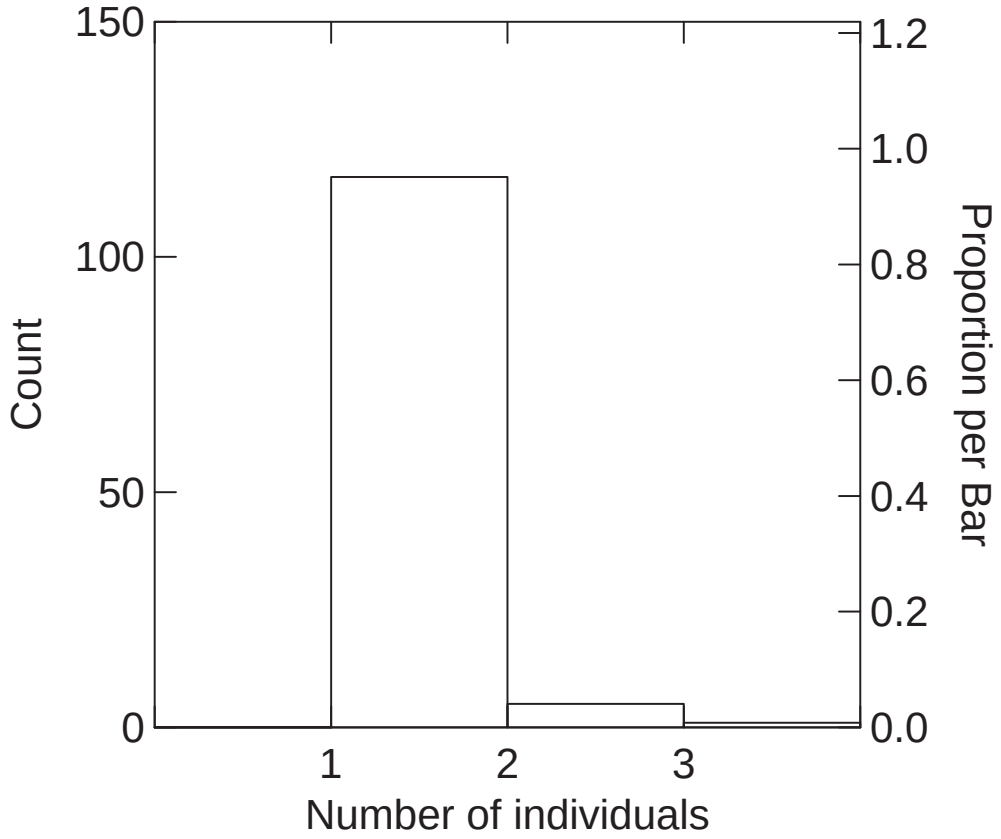
Process Related Patterns

Spatial Variation In Patch Abundance (Lambda)



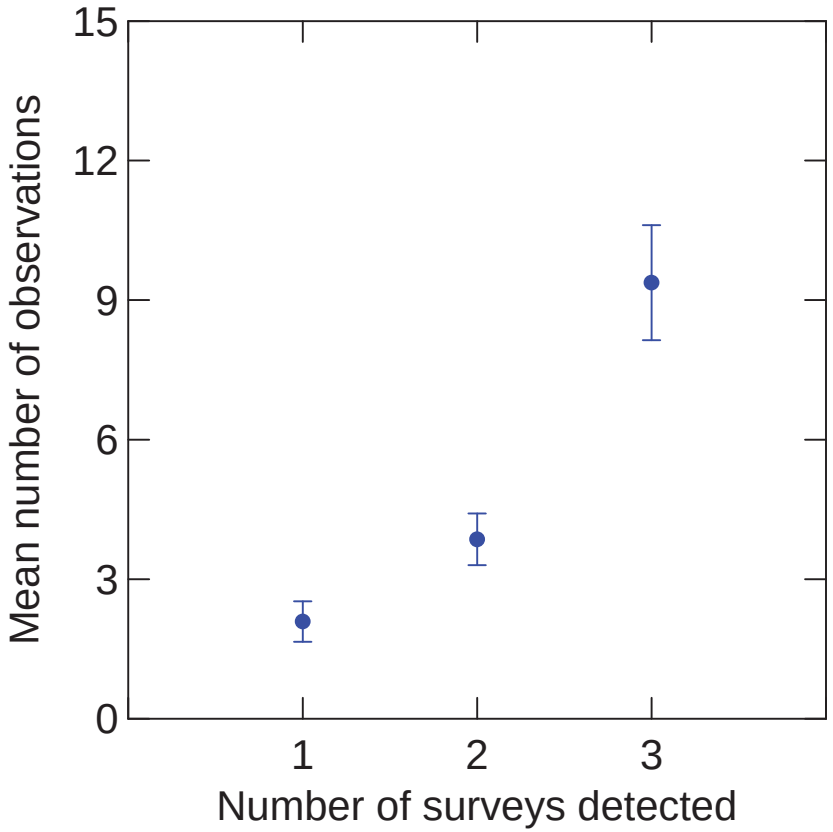
- Abundance (number of individuals) conditional on occupancy
- No latitudinal pattern
- Best model = Elevation + Slope + Aspect + Barren + Conifer + Meadow + Shrub (macrohabitat)

Sampling Related Patterns



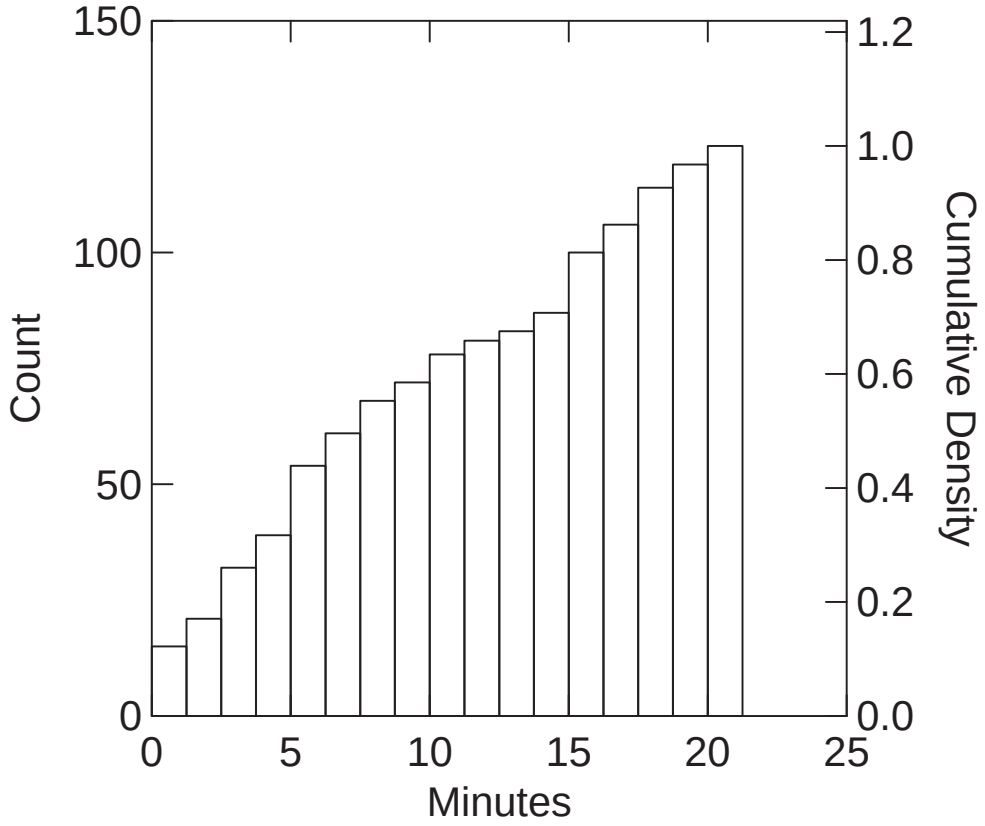
- **> 95% of observations were single individuals**

Sampling Related Patterns



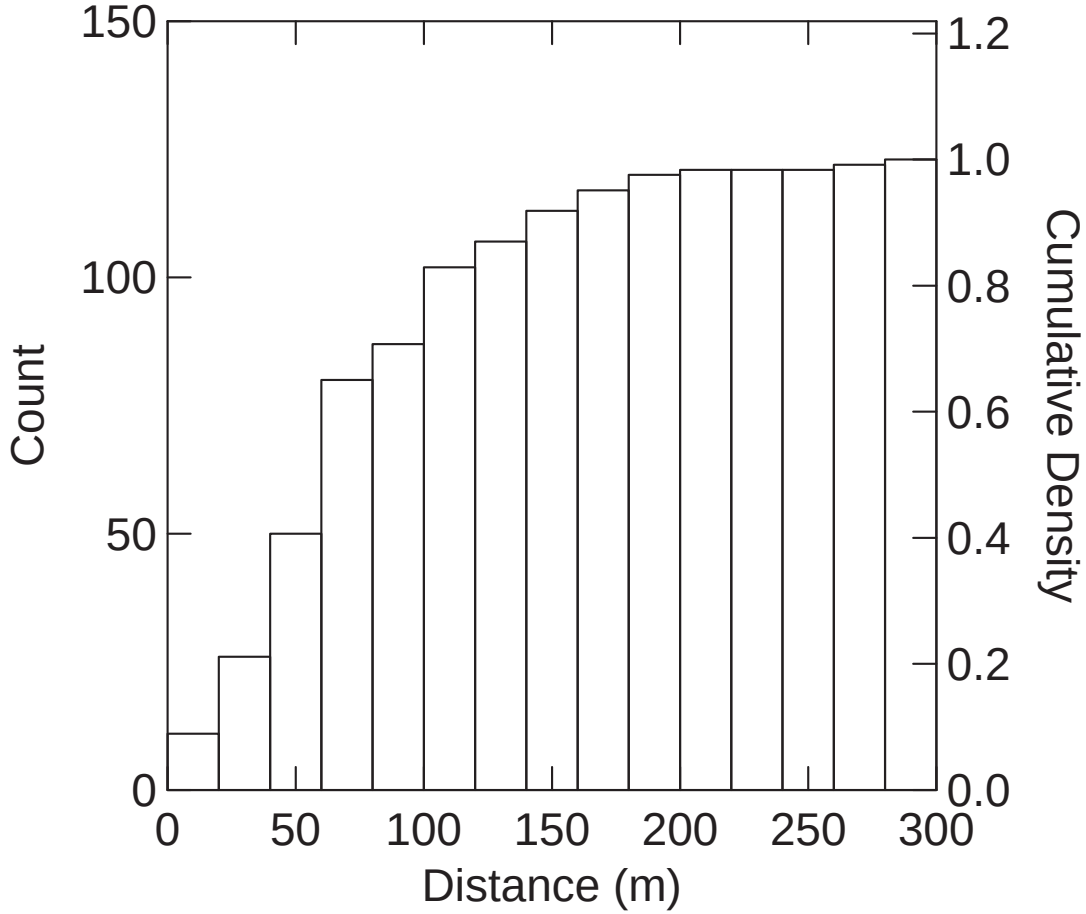
- **Relationship between abundance and detection**
- **Indicative of habitat quality?**

Sampling Related Patterns



- **≈ 90% of observations made within 15 minutes**
- **> 85% of observations on point counts visual**

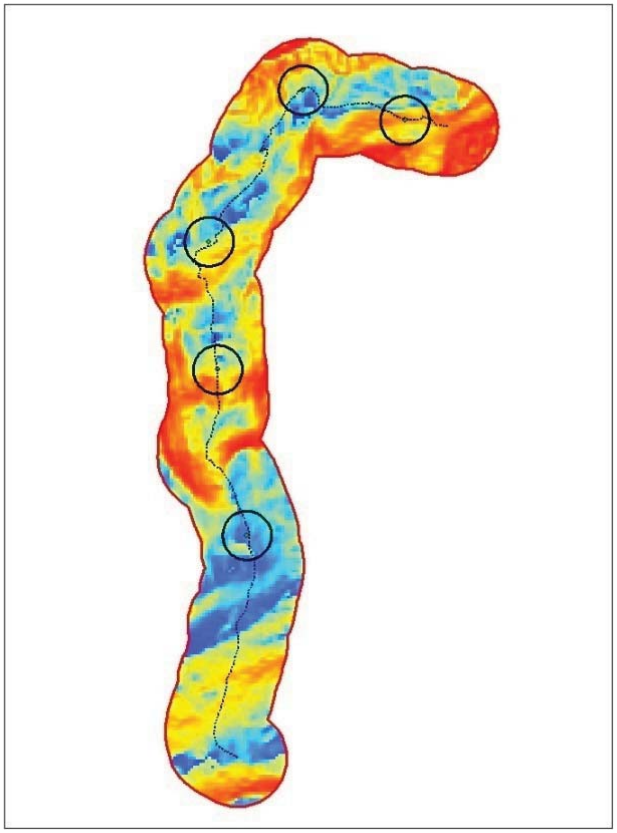
Sampling Related Patterns



- **≈ 75% of observations made within 75 meters of point**
- **≈ 90% of observations made within 125 meters of point**

What Are Process Related Patterns Telling Us?

- **Occupancy and abundance is patchy!**
- **Intra-annual variation in occupancy**
- **Need to think fine grained for sampling rather than coarse-grained**
- **Several years of refining protocols likely needed**



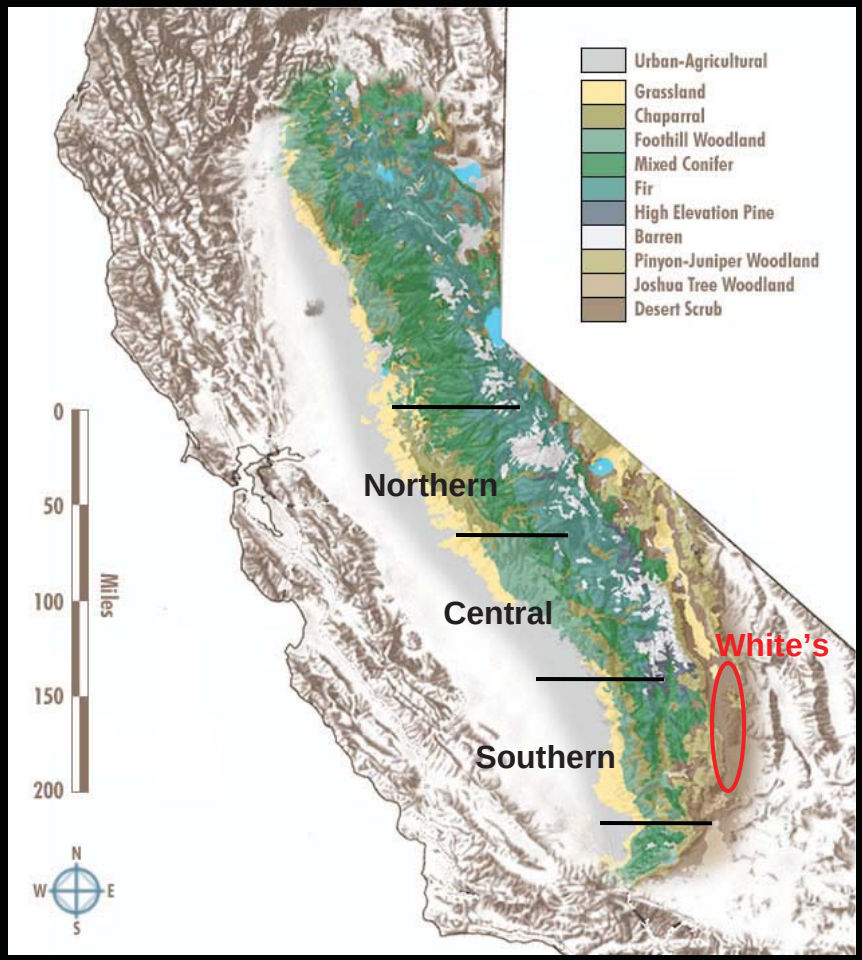
Sampling Issues Still To Be Resolved

- Bias analysis
  - Underway
- Tradeoff between number of point locations and repeat surveys
- Synchrony in spatial variation in abundance?
- Microhabitat sampling
- Have yet to begin collection of demographic data
  - Likely in 2011
- Power analysis
  - Temporal trend
  - Time as random factor
  - 2010 or 2011

Current Methods

2010

- Rangewide and regional density and habitat use
  - 24 variable-distance line transects sampled 4 times per year (776 km)
    - Sierra Nevada
      - N = 18
      - 10 km
    - White Mountains
      - N = 6
      - 1.4 – 7.8 km
- Occupancy, local and patch-scale density, and habitat use
  - 180 variable-distance point count locations
    - 10 per transect in the Sierra Nevada
    - Samples collected within 10-day period



Sampling spans ≈ 3° latitude
and ≈ 1300 m (4500 feet) elevation

Some Suggestions Beyond Just Sampling Issues

- ***CLEAR*** conceptual foundation
  - Technical focus is outstripping conceptual basis
- Organizing hypotheses
  - Source-sink
  - Dispersal limitation
- A hierarchical view of species distributions
  - *Mackey and Lindemayer 2001*
  - *Pearson and Dawson 2003*