Application of distance sampling for assessing abundance and habitat relationships of a rare Sonoran Desert cactus

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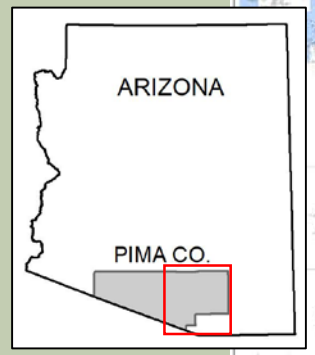
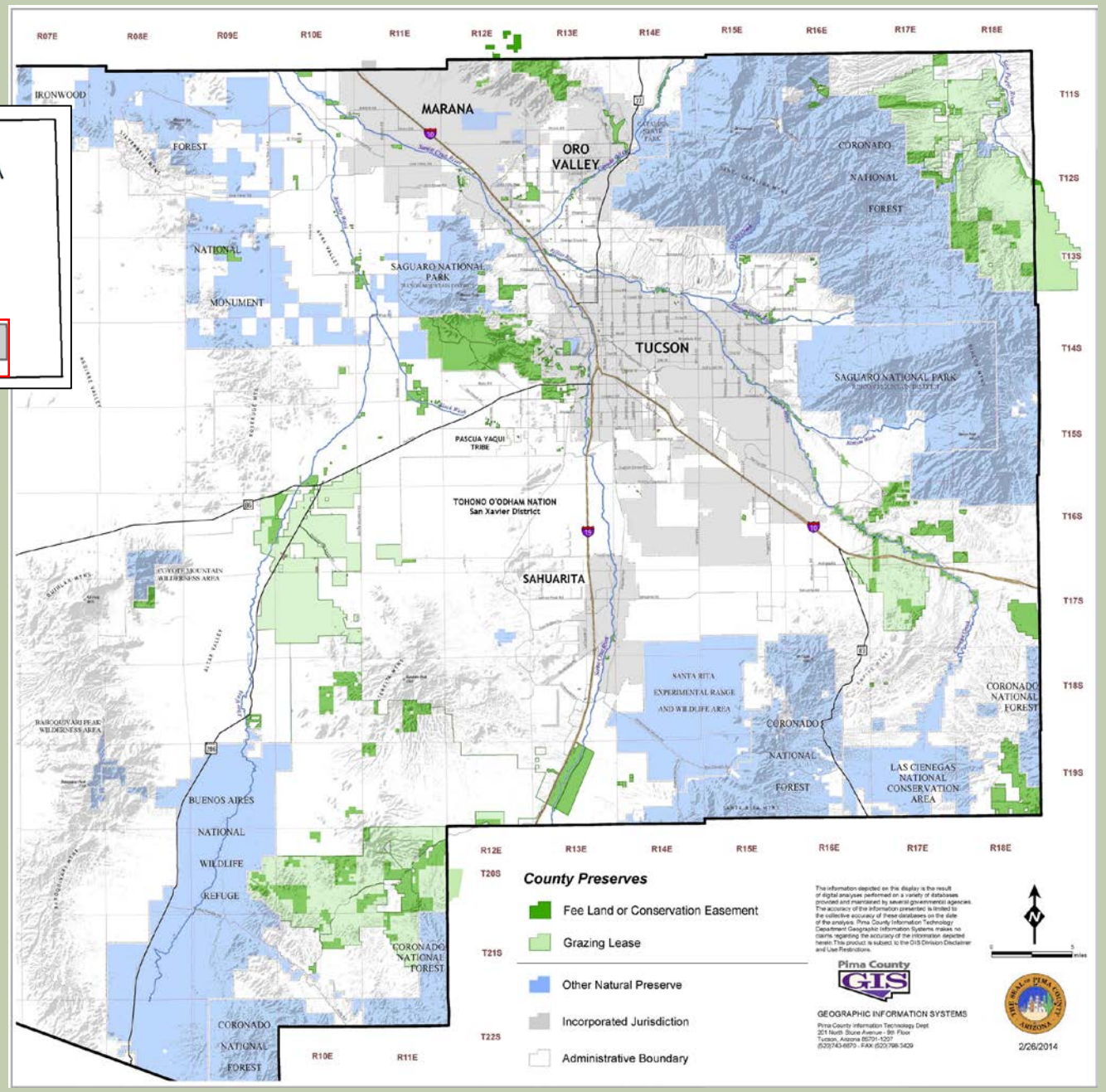
Overview

1. Briefly review Pima County Multi-Species Conservation Plan (MSCP)
2. Pima Pineapple Cactus Distance Sampling evaluation project
   - General overview of distance sampling theory / methodology
3. Recommendations / lessons learned

Pima County MSCP



- HCP under ESA
- Signed July, 2016
- 44 covered species
- 36,000ac development in 30 yrs
- Permit area covers much of eastern Pima County
- Mitigation land portfolio:
  1. County fee – 108,000 ac
  2. AZ/BLM leases – 150,000 ac
- Ecological Monitoring Program



Pima Pineapple Cactus

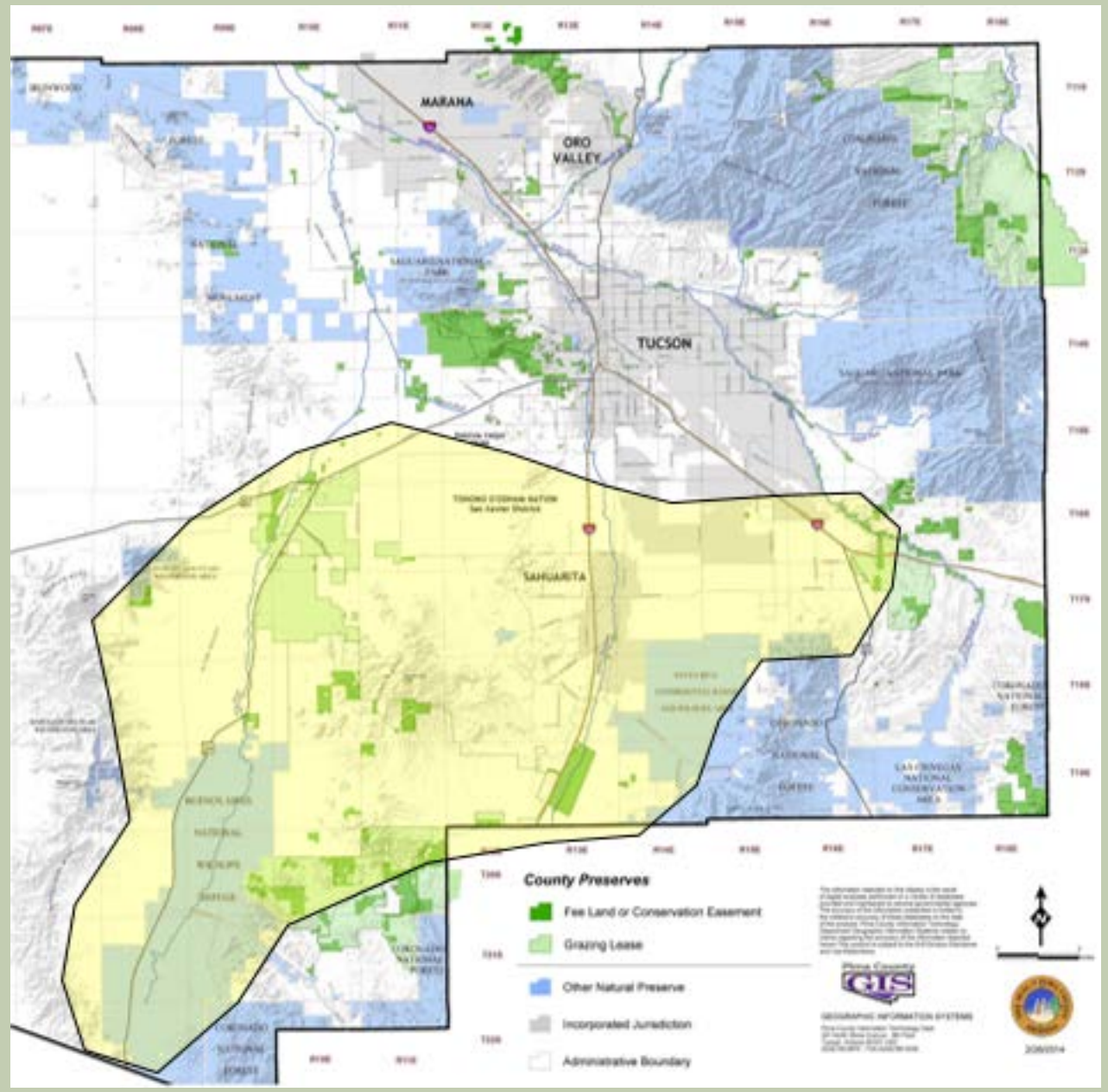
Coryphantha sheeri var. *robustispina*

- Small, hemispheric cactus
- Desert scrublands and grasslands
- < 45 cm tall, < 18 cm wide
- Endemic to SE Arizona, N Sonora
- Designated Endangered in 1993

- Pima Co. manages ~ 65,000 ac of potential habitat

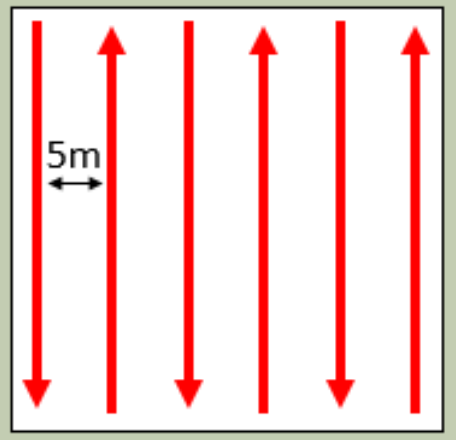
- Very sparse distribution, cryptic

- Monitor abundance at 10 sites, but no USFWS specified method



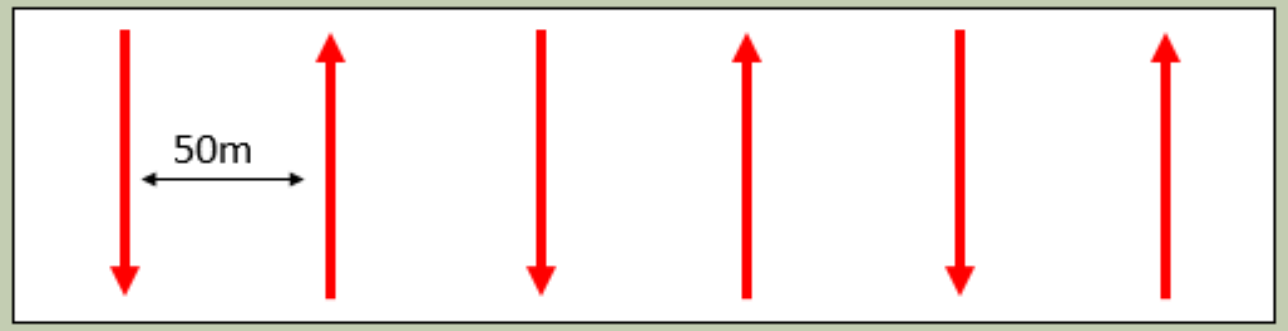
Existing Abundance Estimation Method

- Roller (1996) method = complete census
  1. Observers 4-6m apart, assumes 100% detection
  2. Ideal for construction clearance / salvage
  3. Very time / labor intensive (more than one pass)



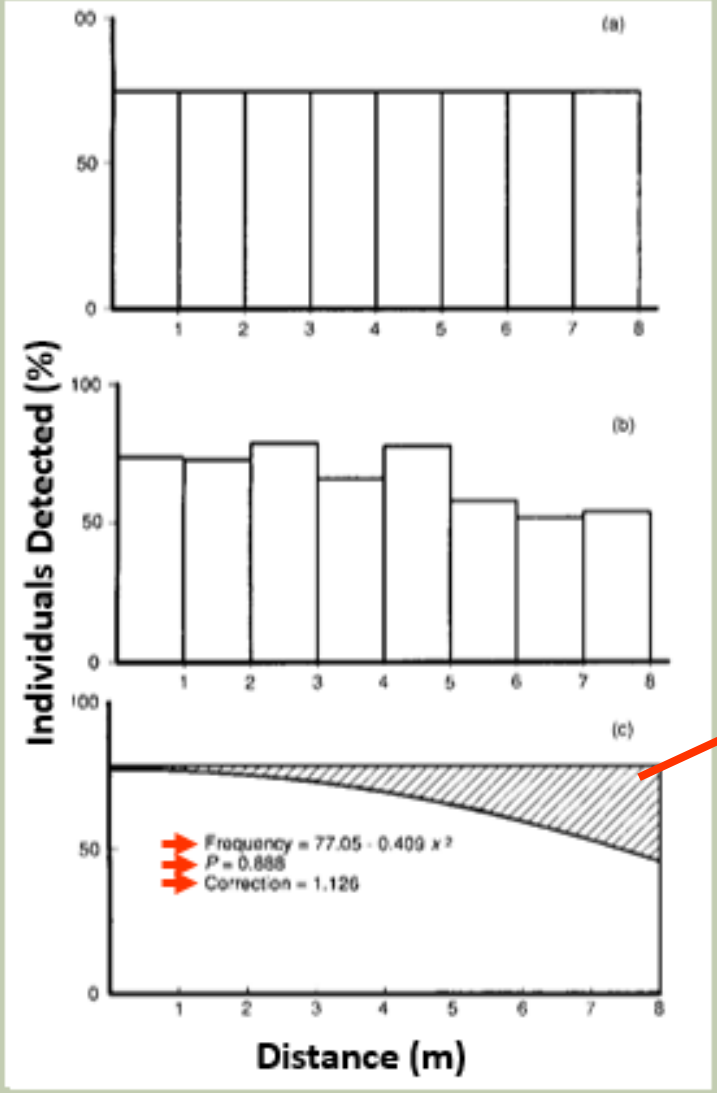
- Need an efficient survey method to:
  1. Estimate population abundance over **large areas**
  2. Track change in abundance over time

➢ Distance sampling



Benefits of Distance Sampling

- < 100% detection required
- Can incorporate predictor covariates
- Can estimate abundance / draw inference across large areas



If all individuals detected

Some individuals undetected

= 67 individuals unseen

Proportion detected vs. undetected.

Distance Sampling Assumptions

Three Methodological Assumptions

1. All objects along line or at point detected – [*g(0) = 1*]

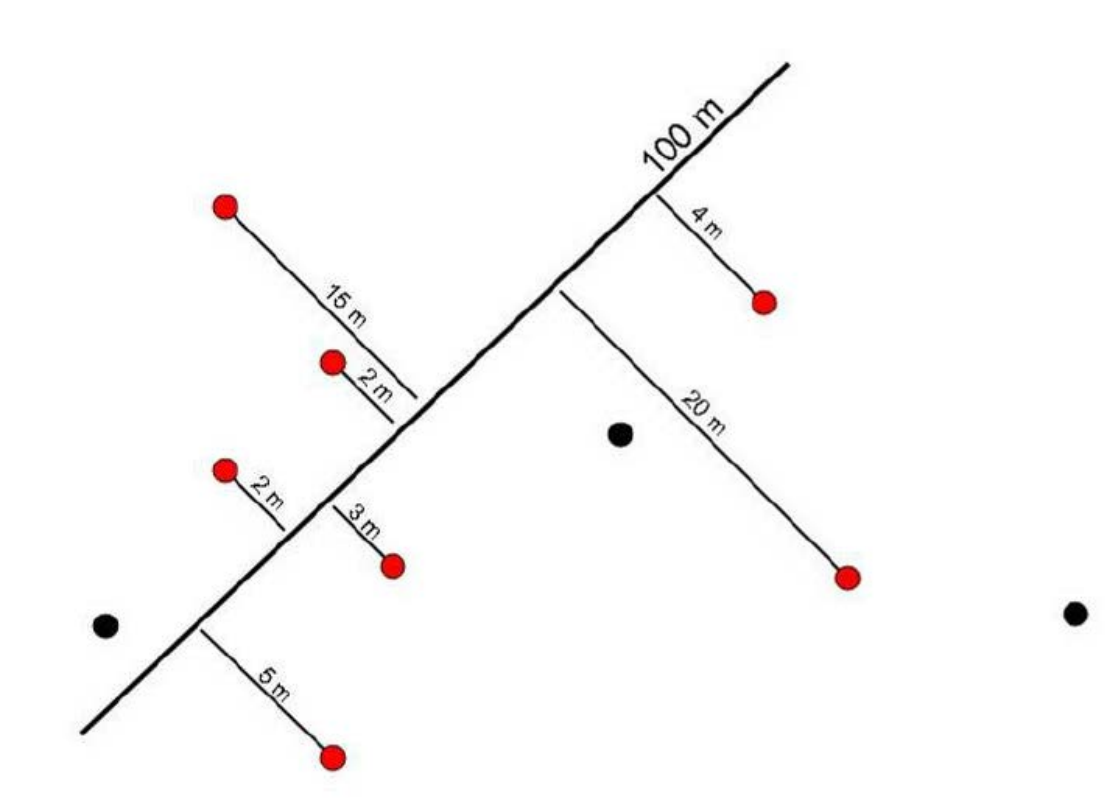
2. Objects detected in their initial locations

3. Distance from line measured accurately

Two Statistical Assumptions

1. Individual sightings are independent

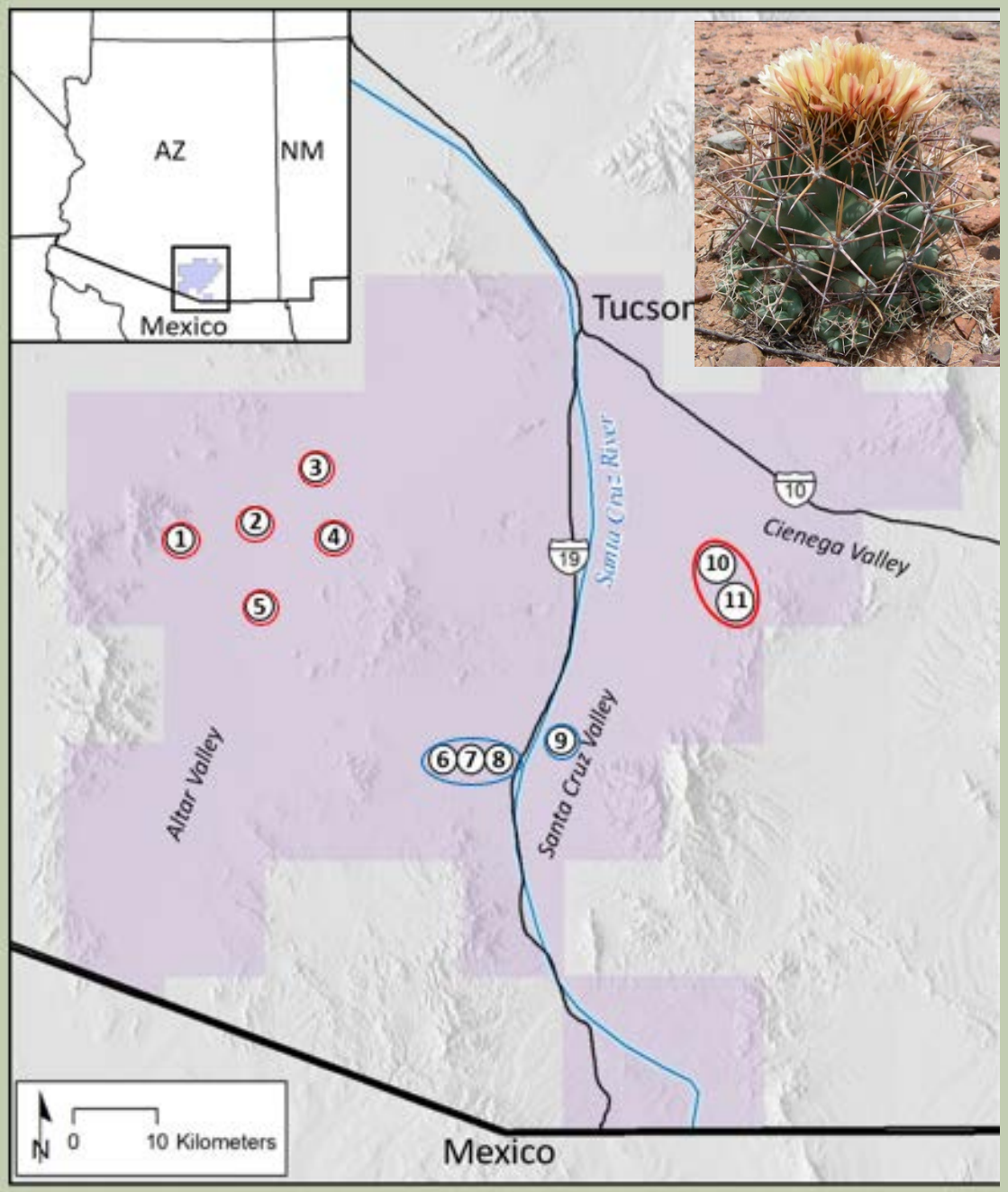
2. Detectability decreases with distance from line



Field Sites

- 11 sites - two major habitat types
  - Desert scrub / semi-desert grassland

- Two criteria:
  - 1. Sites with long-term monitoring, abundance estimates ~ 1 year of DS
    - Distance Sampling only
  - 2. Pima Co. lands with known PPC presence, but unknown abundance
    - Roller method then Distance Sampling

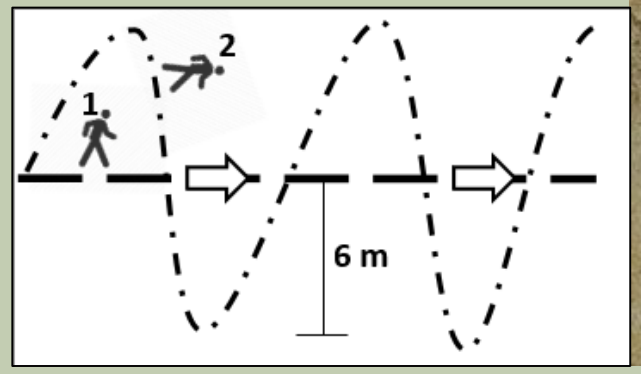


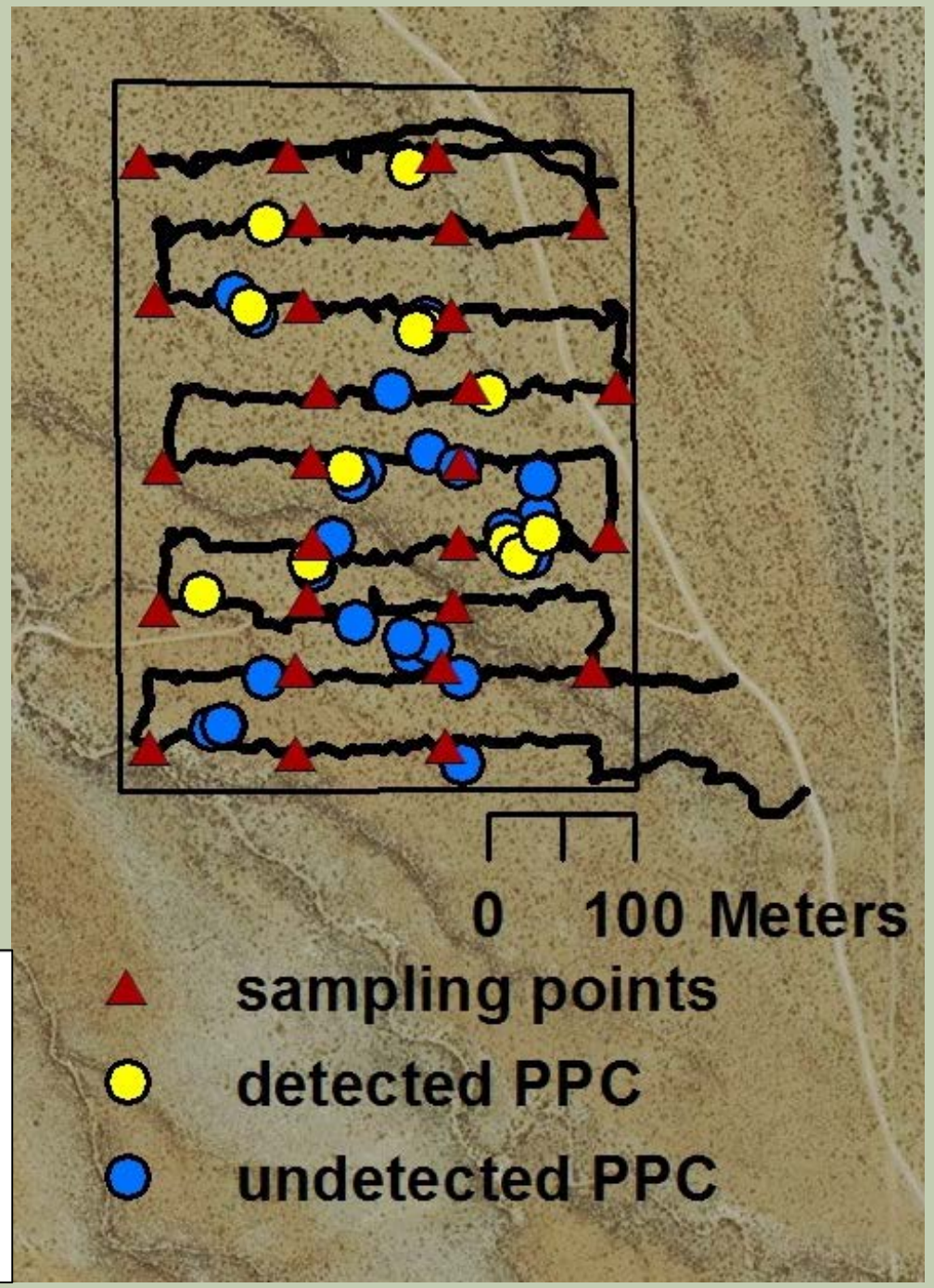
Distance Sampling Transects

- Parallel transects across plot, 50m apart
- 1st observer 0-6m from line
- 2nd observer 6-25m from line

Vegetation sampling plots (10m) every 100 m

1. Volume of vegetation < 1 m
2. Grass foliar cover
3. Understory veg. height
4. Soil substrate size class





Distance Sampling Transects

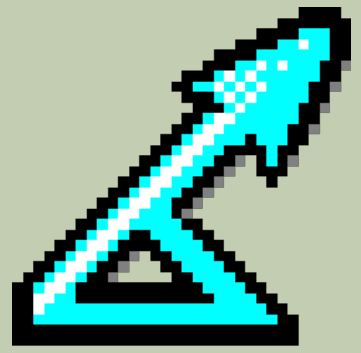
PPC Measurements

1. Perpendicular distance from line to PPC (rangefinder and tape measure)
2. Height of PPC in cm from the ground to top of the tallest spine

Data Analyses

1. Quantified total transect effort; abundance and density of PPC by plot

2. Program DISTANCE 6.2
   - Simple detection function
   - Detection function with environmental covariates



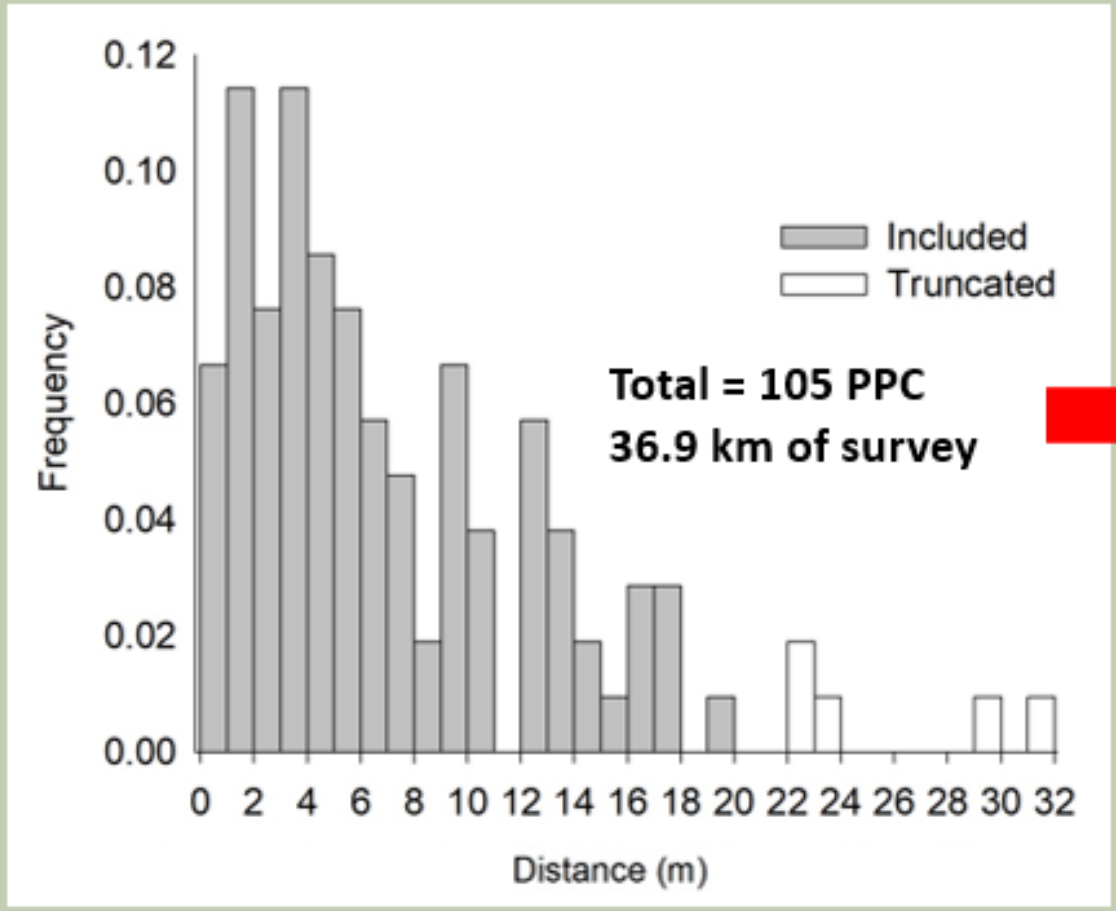
http://distancesampling.org/

3. Multiple regression
   - Factors that affected observation process
   - Model: Detection distance ~ all environmental covariates

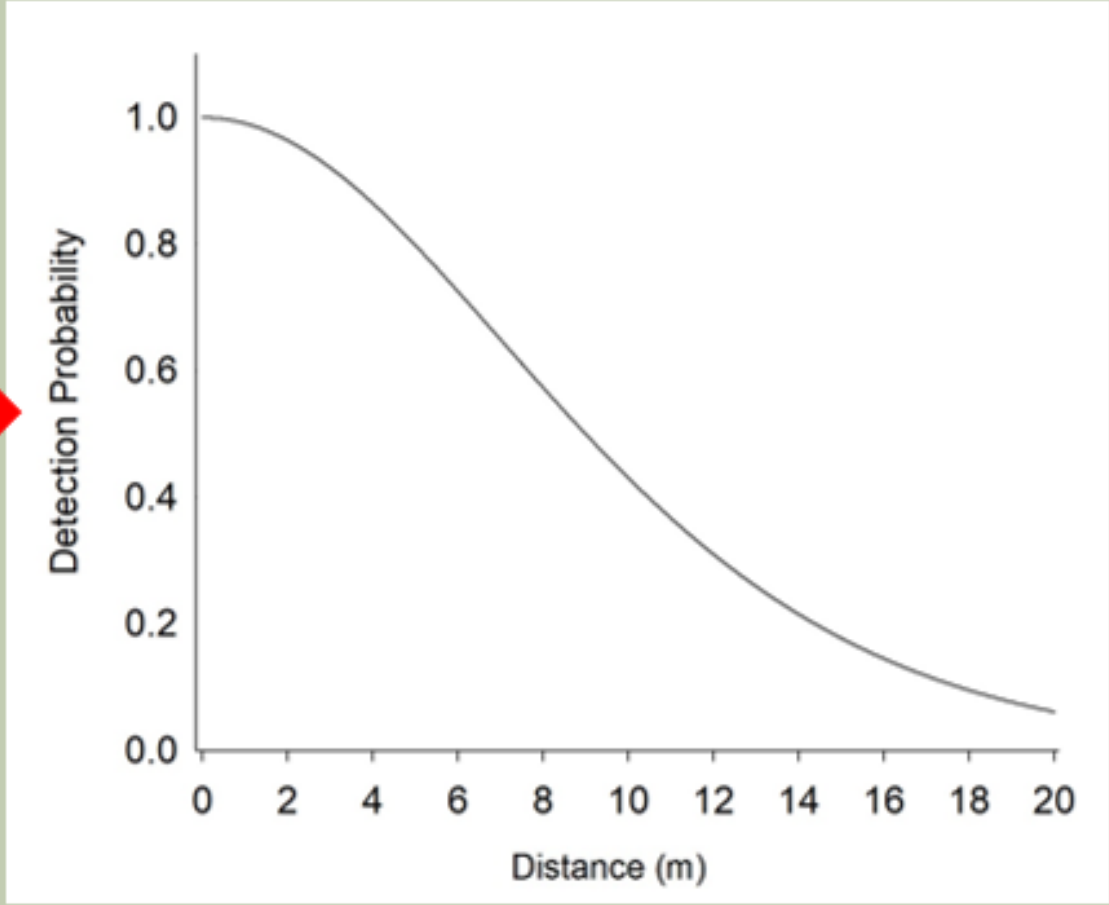
4. Bias estimate: Compared distance sampling estimates to Roller method results

Results: Detections and Detection Probability

Raw PPC observations



Detection curve
Binned observations

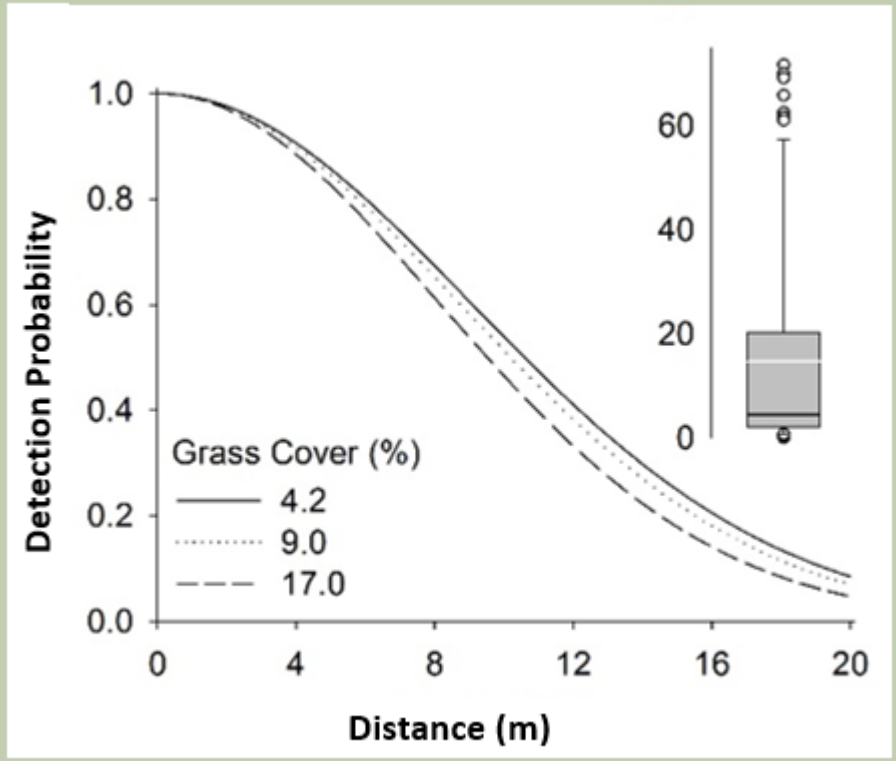


Results: Factors Effecting Detection

- Top model used substrate size
  - *P* ↓ as size ↑

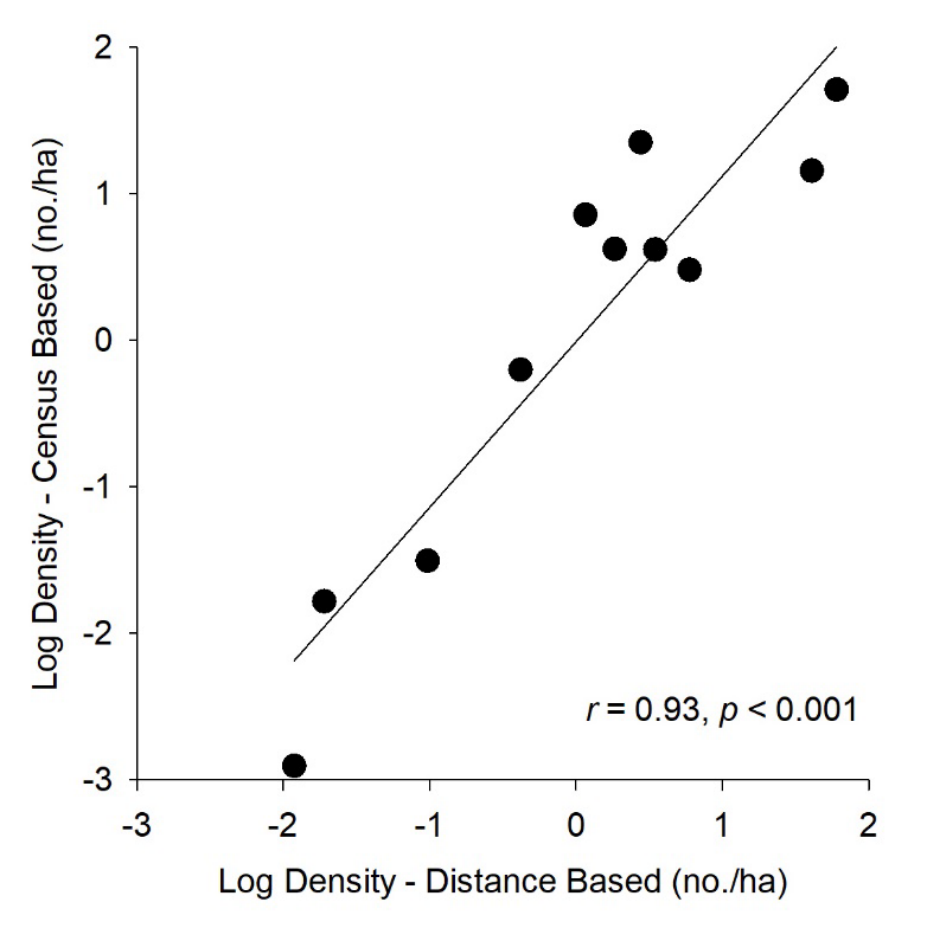
- Detection distance ↑with ↑ PPC height

- Detection distance ↓ with ↑ grass cover



Results: Bias, Density, & Abundance

- Bias range per site = **- 61.3%** to **+ 200.0%**
- Mean bias (all sites) = **- 2.3%** (vs. Roller)
- Estimates highly correlated with known values



Estimates for all sites

- 1.47 live PPC / ha
- 294 total PPC across all plots

By vegetation type

- Desert-scrub = 1.00 / ha (CI = 0.64-1.56)
- Semi-desert grassland = 1.84 / ha (CI = 1.15-2.93)

- Density ↑ ~1.5% for every 1% ↓ in grass cover

Recommendations:

1. Reduce distance between transects from 50 to 40m

2. Better effort to find 100% of individuals on the line

3. Place transects parallel to slope to minimize navigating steep topography

4. Perform DS transects when herbaceous vegetation is lowest (Nov – June)

Lessons Learned:

1. Distance sampling is suitable for PPC!

2. DS can complement census methods for broader scale abundance estimates

3. Coordinate with project partners well ahead of time

4. Method potentially useful for other cryptic / low density plant species (with testing)

Thank you

Funding from USFWS Section 6 Funding for Research on T&E Arizona Plants

More info on Pima Co. MSCP/EMP: pima.gov/mscp

Copies of Plant Ecology paper available:

Plant Ecol (2019) 220:1029–1042
https://doi.org/10.1007/s11258-019-00972-7

Check for updates

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