The Power of Sampling Method Designs: Detecting Changes in the Abundance of Invasive Species

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Are Our Monitoring Programs Adequate?

- **"Why conservation monitoring usually is, but should not be, a waste of time."**

  (Legg and Nagy 2006)

- **We must evaluate the statistical power and utility of monitoring programs at the *outset*.**

  (Peterman 1990, Legg and Nagy 2006)

Great Lakes Inventory & Monitoring Network

http://www1.nature.nps.gov/im/units/glkn/index.htm

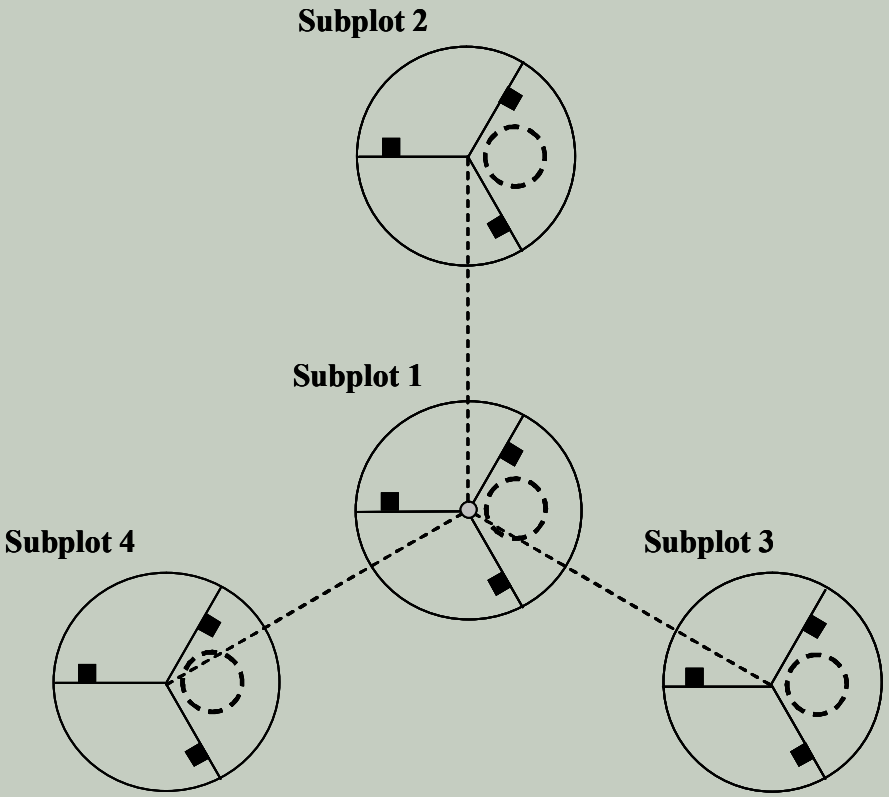
Long-term Vegetation Monitoring

- **Changes in Community Composition**
  - Richness
  - Relative Abundance
  - Similarity
- **Changes in Community Structure**
  - Distribution of Tree/Sapling Sizes
  - Shrub Density/Cover
  - Herb Cover
- **Species-Specific Changes**
  - Abundance (relative frequency)
  - Size

Research Objective

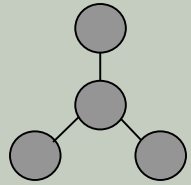
To evaluate the efficiency, sensitivity and precision of 3 vegetation sampling methods being considered for use in the GLKN long-term terrestrial vegetation monitoring protocol

FIA Method

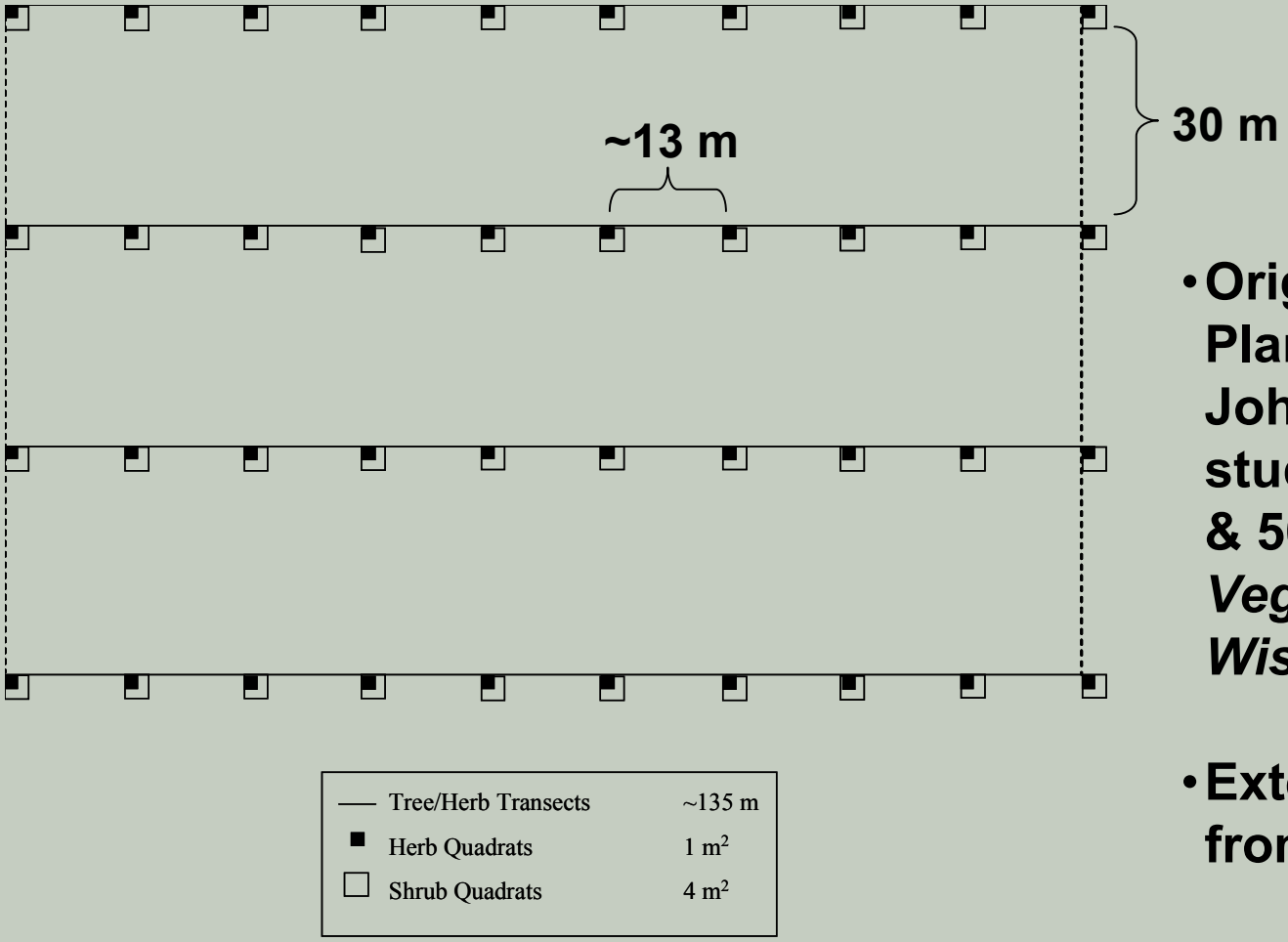


- Extensive legacy data
- Sites and plots are dispersed evenly on a grid
- Designed in the 1930's to estimate timber volume
- Modified to provide additional data on shrubs, herbs, and CWD

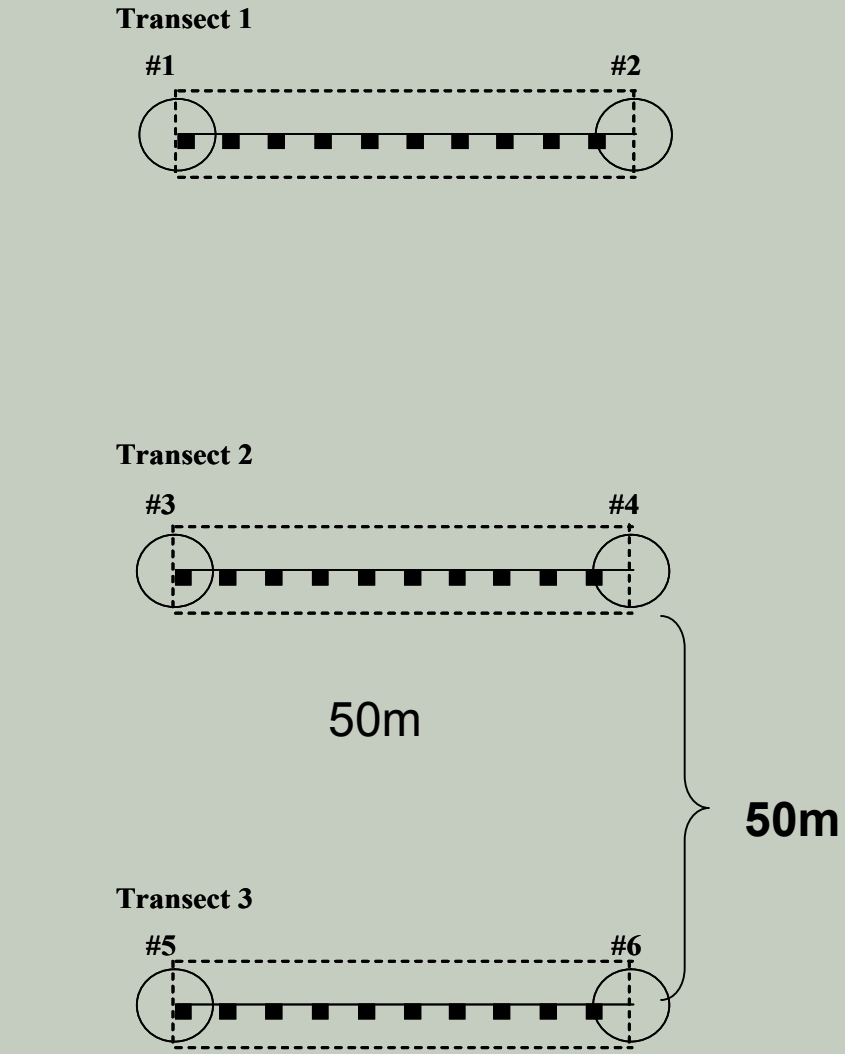
Subplot	7.32 m (24.0 ft) radius
Microplot	2.07 m (6.8 ft) radius
Herb Quadrats	1.0 m^2 area
Coarse Woody Debris Transects	7.32 m
Plot Center (PC)	



PEL Method



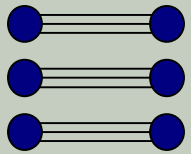
- Originated with the Plant Ecology Lab of John Curtis and his students in the 1940's & 50's for *The Vegetation of Wisconsin* work.
- Extensive legacy data from 1000+ sites.



HYBRID Method

Goals:

- ***Simple*** **to set up**
- ***Efficient*** **to sample**
- ***Adequate*** **to characterize the site**
- ***Balanced*** **in terms of relative effort and quality of data obtained for herbs, shrubs, saplings, and trees**



Research Locations

APIS

FIA

vs.

PEL

PIRO

FIA

vs.

Hybrid

n = 20 sites

n = 20 sites

Statistical Issue:
Ability to Detect True Change (Power)

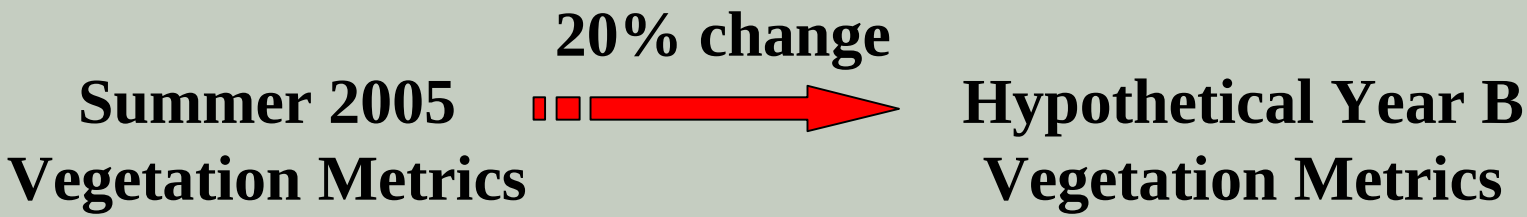
	No Change	Change
Monitoring Program Detects Change	False-Change Error (Type I) α	**No Error (Power) 1-β**
Monitoring Program Detects *No* Change	No Error (1-α)	Missed-Change Error (Type II) β

From Elzinga et al. (1998) - *Measuring and Monitoring Plant Populations*

GLKN Network Objective: Detect 20% change

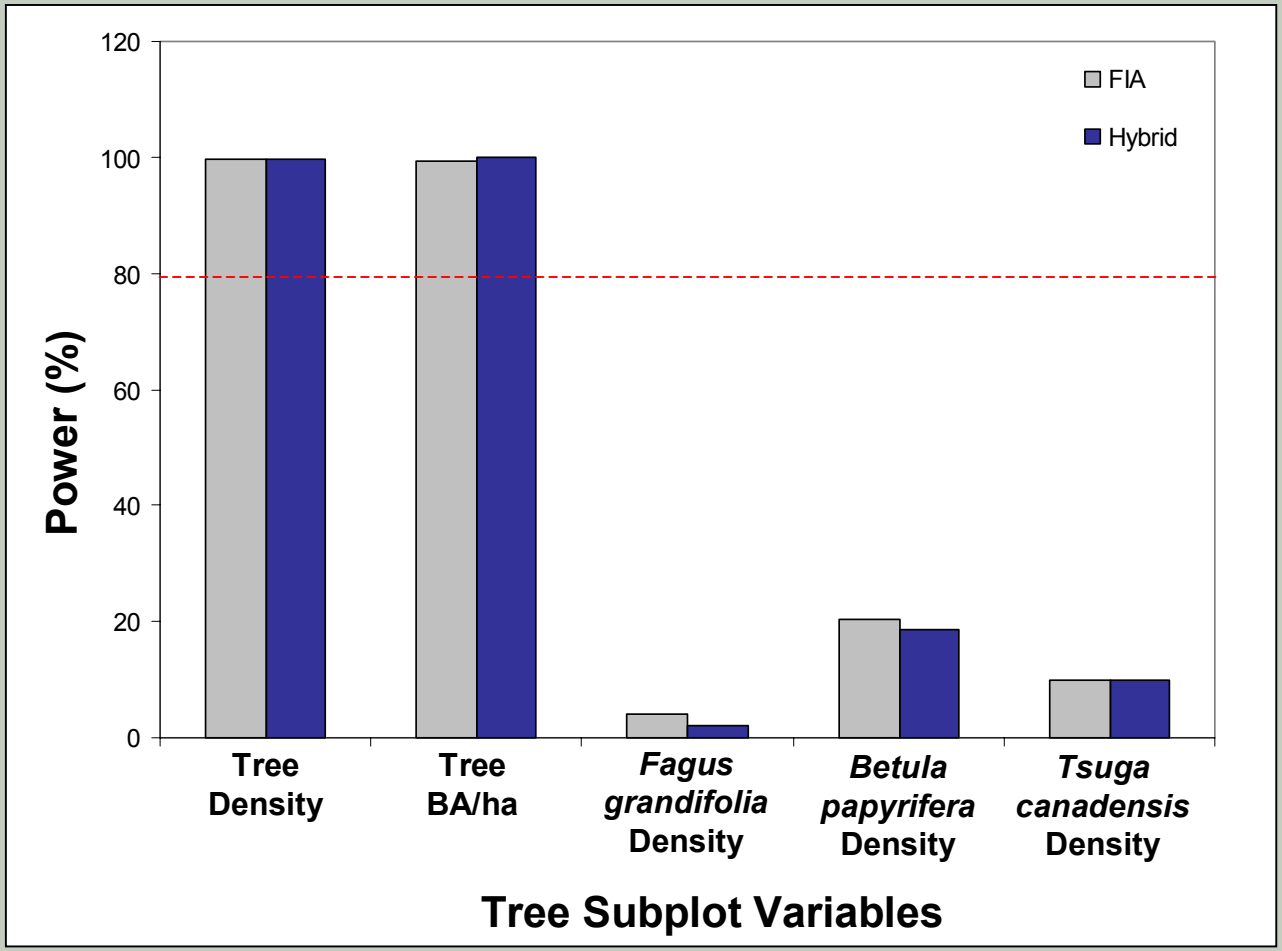
α = 0.1 Power ≥ 80%

Modeling Statistical Power to Detect Change



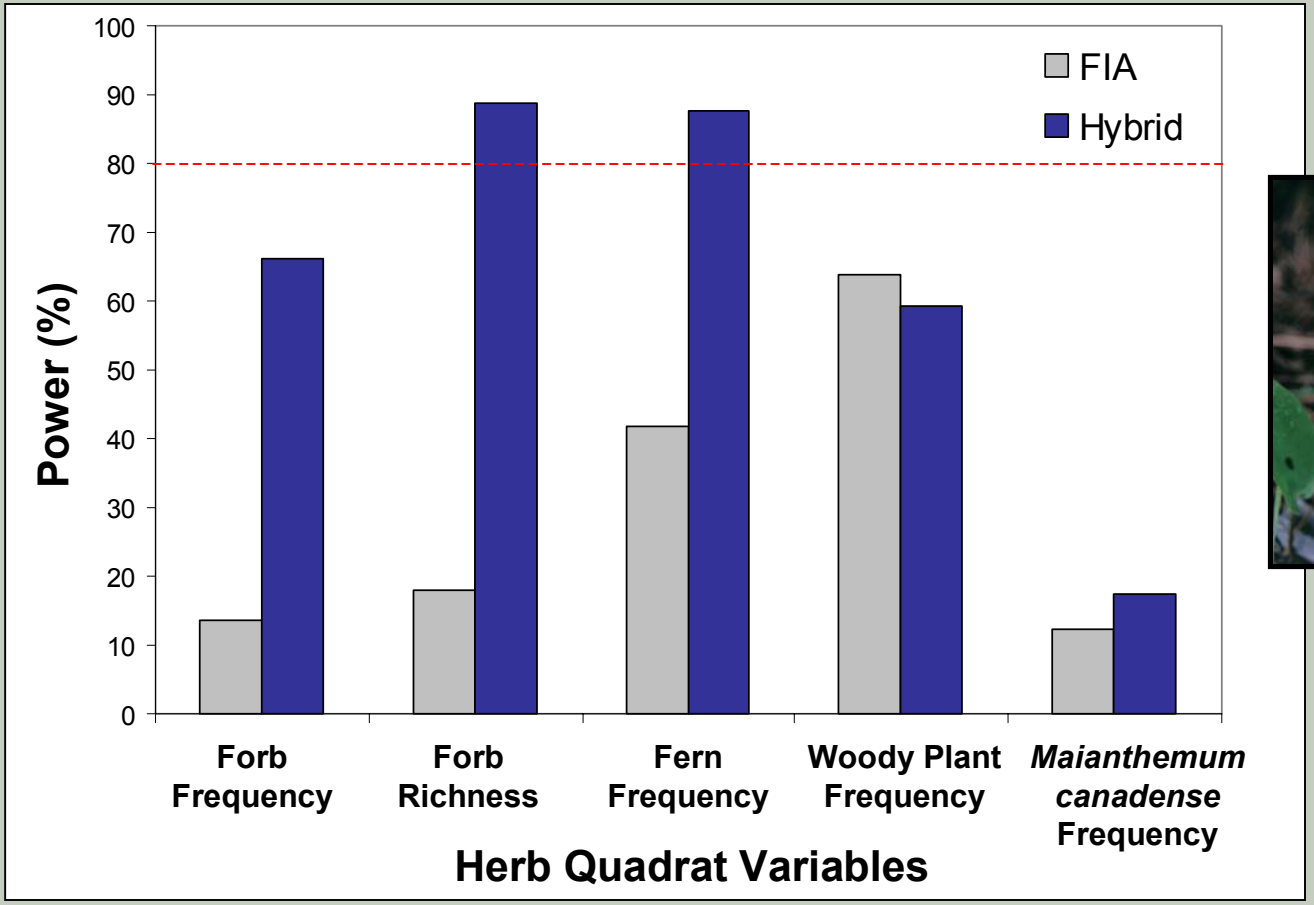
- **The modeled change was normally distributed around 20% change with a given standard deviation**
- **Standard deviations based on values estimated from actual 5-year changes at PIRO and in northern WI**
- **Each simulation was run 1000 times**
- **Wilcoxon tests used to assess significant differences between Summer 2005 and Year B data**
- **Estimated power based on frequency of *P*-values < 0.1**

Power to Detect 20% changes in Trees at PIRO



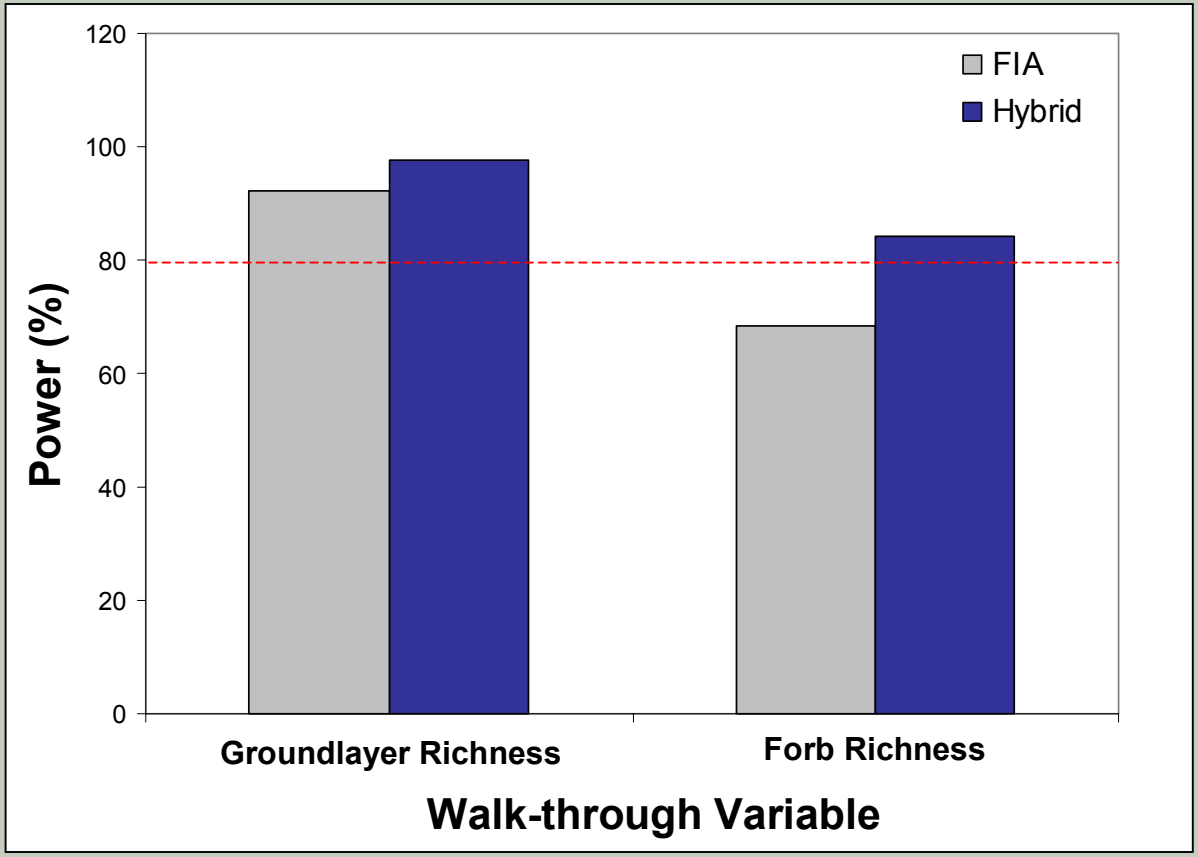
- **FIA and Hybrid had equivalent power for tree density and basal area**
- **Both methods had low power for detecting change in individual species' density**

Power to Detect 20% Changes in Groundlayer Plants Sampled in 1-m^2 Quadrats at PIRO



- The Hybrid method attained higher power for most metrics
- ≥ 80% power was never attained by the FIA method for these variables
- Both methods had low power for detecting a 20% change in *M. canadensis*

Power to Detect 20% Changes in Groundlayer Plants Sampled in Walk-throughs at PIRO



- **Both methods had > 80% power to detect a 20% change in plant richness**
- **The FIA method did not attain 80% power to detect a change in forb richness**

Number of Sites Required by FIA and Hybrid to Acquire 50% Power to Detect a 20% Change

Trait	Level of Analysis	# of Sites Needed for 50% Power to Detect 20% Change	
		FIA	HYBRID
Tree BA (cm^2/ha) and Tree Density	Subplot	< 5	< 5
Individual Tree Species	Subplot	LP	LP
Forb Frequency	Herb Quadrats	LP	12
Forb Richness	Herb Quadrats	LP	9
Fern Frequency	Herb Quadrats	LP	8
Maianthemum canadense Frequency	Herb Quadrats	LP	LP
Understory Vegetation Richness	Walkthroughs	5	< 5
Forb Richness	Walkthroughs	10	6

Conclusions

- **The FIA method is efficient at sampling trees**
- **No method attained adequate power to detect a 20% change in individual tree and herb species**
- **The FIA method consistently had low power for detecting changes in understory variables; sampling this strata more extensively is justified**
- **Composite indicators are more powerful than species-specific indicators**

Recommendations to GLKN

- **The GLKN should consider increasing the number of sites sampled at each park**
- **If the FIA method is selected, then it should be augmented to sample the understory more extensively**
- **Using the Hybrid method could be more cost effective**
- **Data should be aggregated by habitat type to reduce among-site variances and to increase power to detect change**
- **Reduce sampling error by hiring skilled botanists!**

Power to detect changes in Invasive Species?

- **Detecting changes in target species could be tricky, and the power of the sample design should be determined**
- **Must establish clear objectives for the monitoring program**
- **Must determine the amount of change that is suitable/unsuitable to meet management goals.**

Acknowledgements

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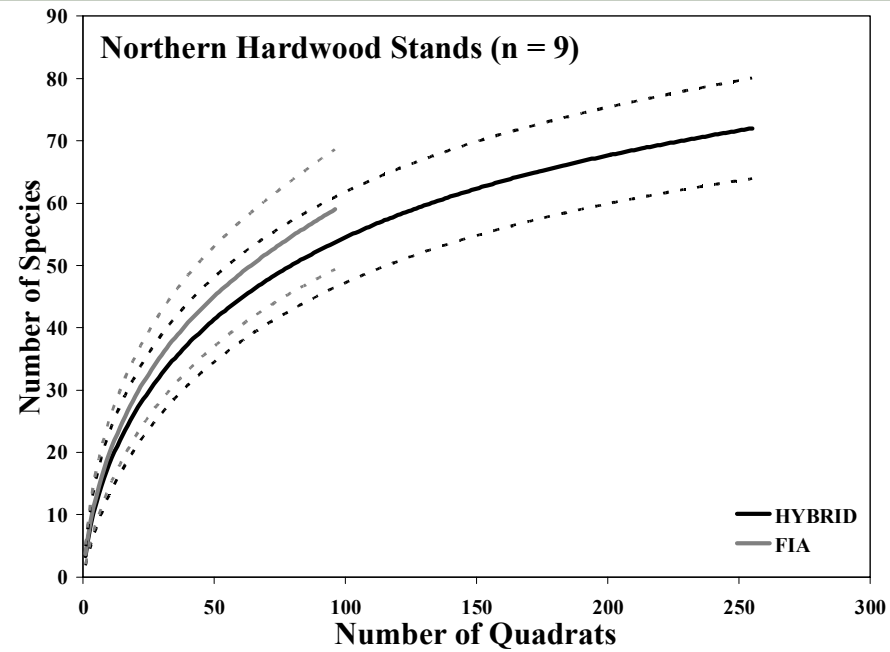
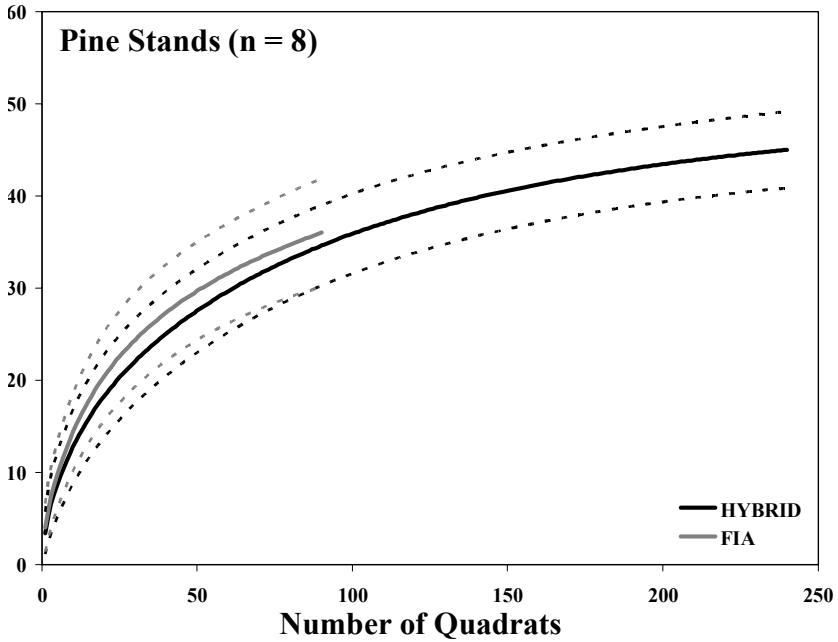
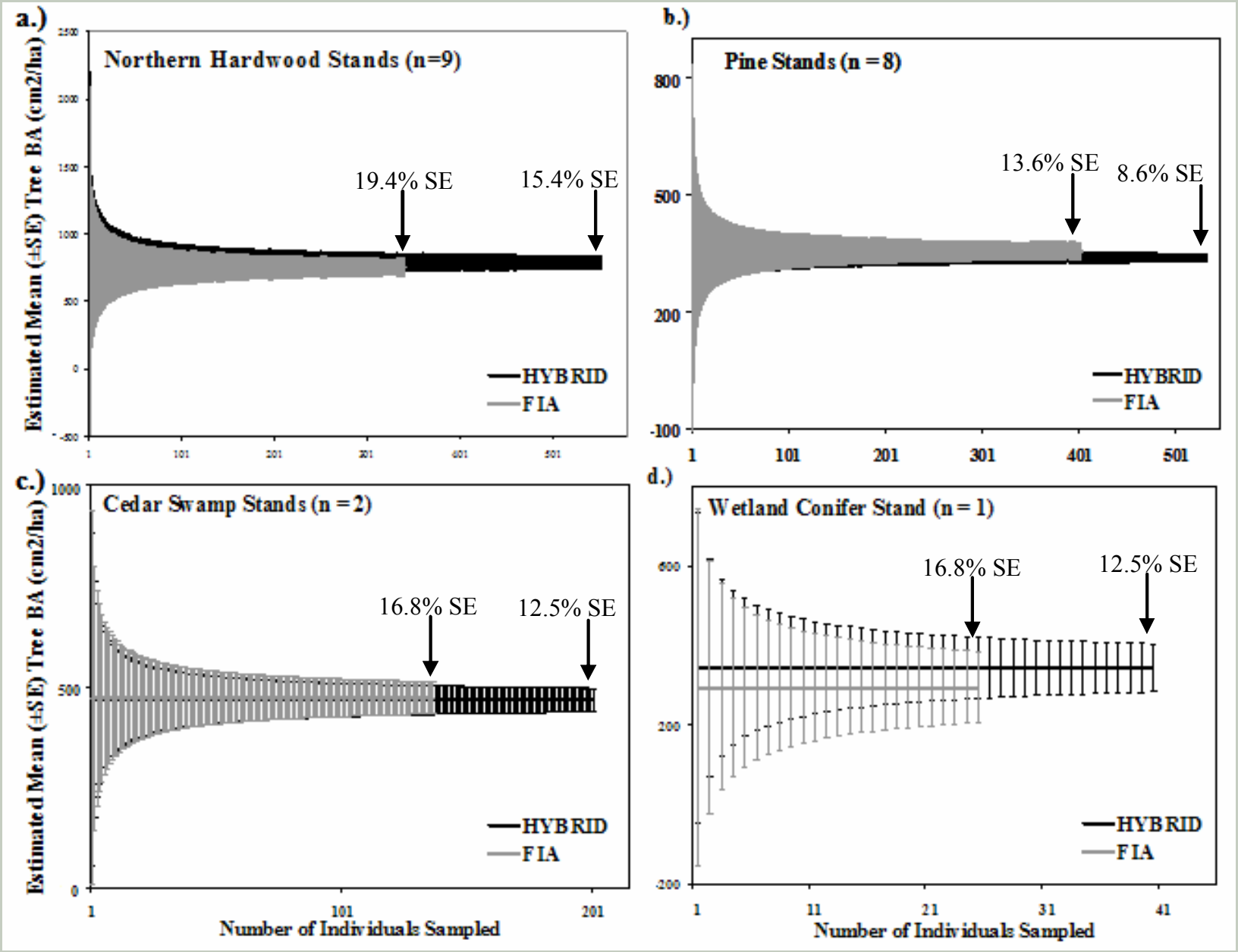
FIA and Hybrid Sampled a Comparable Number of Species per Unit Area up to a Point, but Hybrid Detected More Groundlayer Species Overall





Curves created with EstimateS version 7.5 (Colwell 2005 – http://purl.oclc.org/estimates)

FIA and Hybrid Estimates of Tree BA w/ Increasing Number of Individuals was Similar at PIRO



FIA Consistently had Lower Estimates of Tree BA than PEL