



Florida Panther Demography and Population Viability

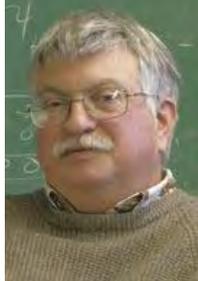
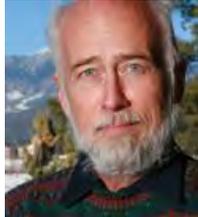
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April 25, 2016



Scientific Review Team (SRT, 2003)

- Rigorous estimates of survival and reproductive parameters not currently available
- Previous population viability analyses unreliable
- Genetic restoration
 - Important management experiment
 - Potentially wide-ranging consequences
 - Critical to measure effects



Outline

- Demography
- Population dynamics and viability
- Genetic restoration
- Thoughts on current and future work





Survival and Reproduction of Florida Panthers

Data

- Radio-tracking
- Cause of death
- Den checks
- PIT tagging
 - Recaptures
 - Recoveries
- Litter failures
- Genetic ancestry and heterozygosity
- Abundance index



Statistical Methods

- Adult survival: Cox proportional-hazard
- Kitten survival: mark-recapture-recovery
- Probability of reproduction: binomial regression
- Litter size: cumulative logit regression
- Information-theoretic

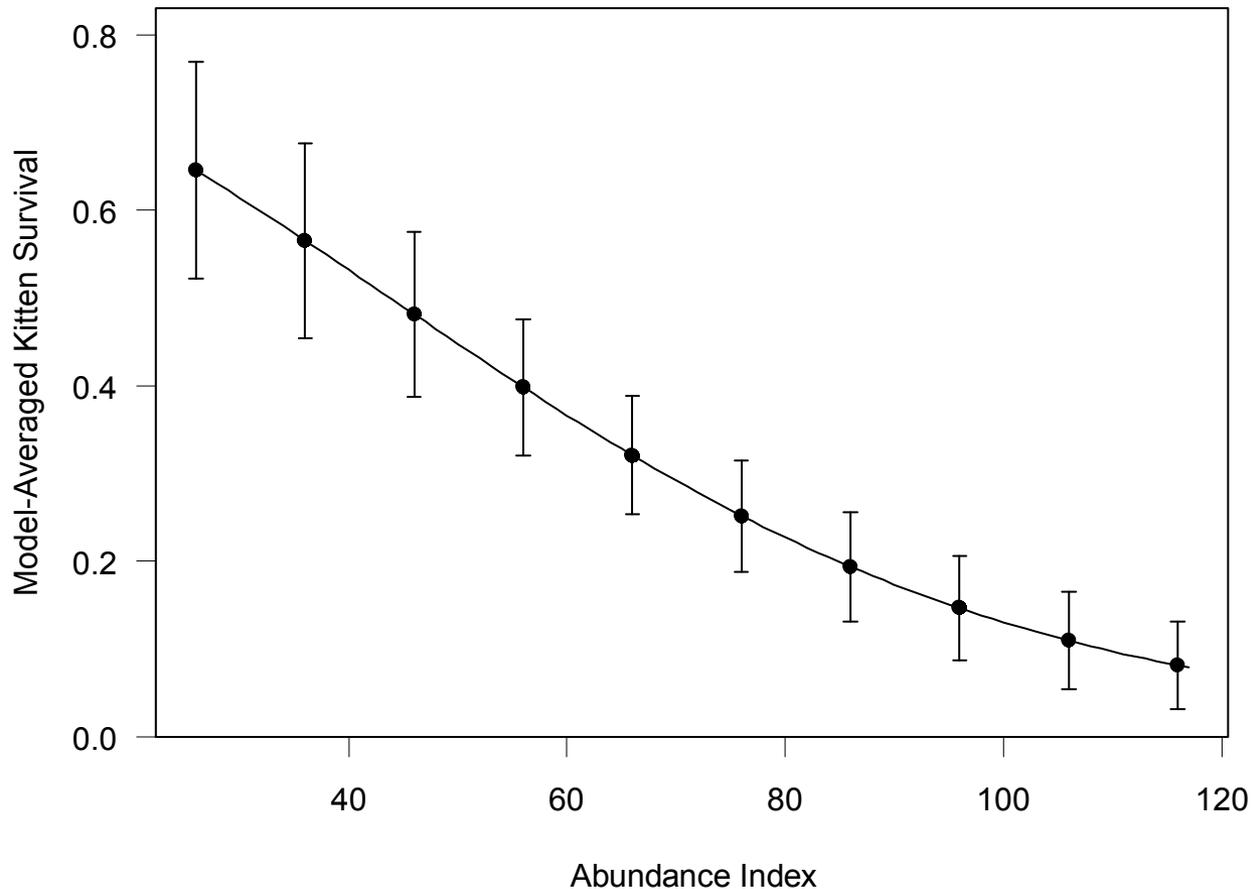


Sub-Adult and Adult Survival

- Sex and age
 - Females survive better, fewer intraspecific aggression deaths
 - Female survival peaks early, male later
- No evidence of effect of abundance

Benson et al. 2011. *Journal of Animal Ecology* 80: 958-967.

Density-Dependent Kitten Survival



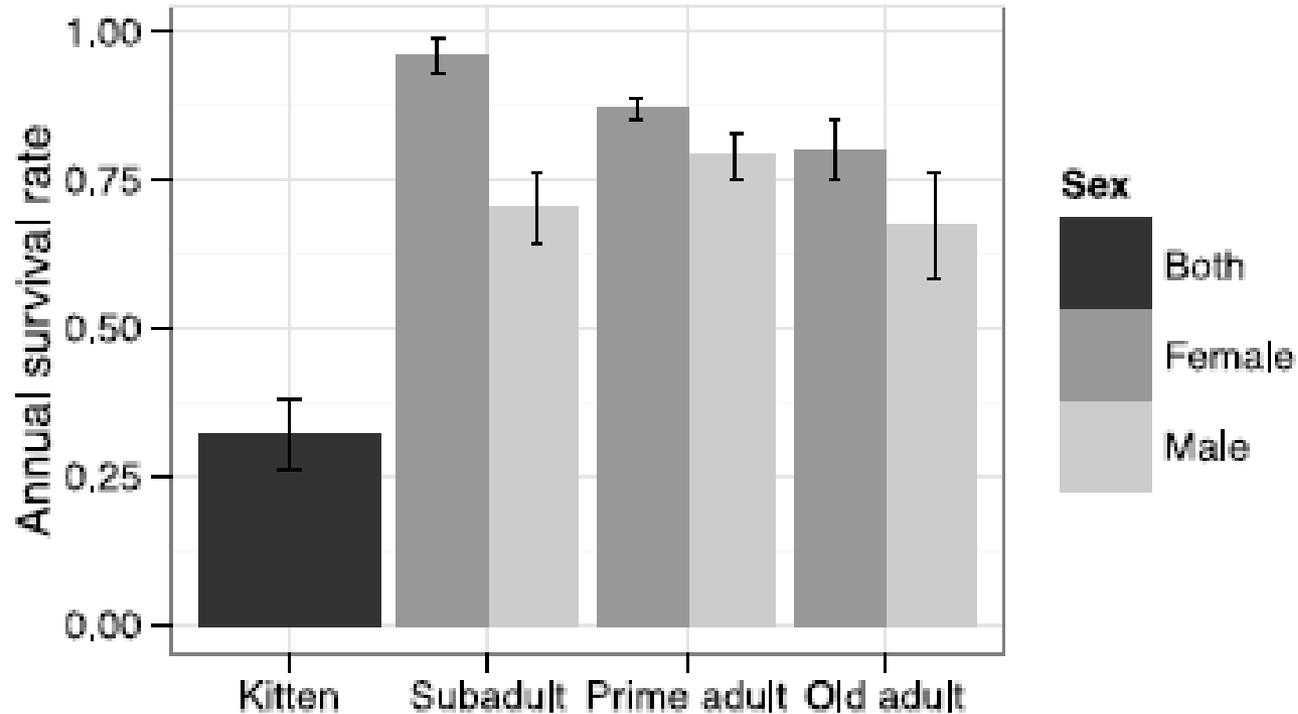
Hostetler et al. 2010. *Biological Conservation* 143: 2789-2796.

Kitten Survival Summary

- Kitten survival estimated lower than expected (0.32)
- Panther abundance reduces kitten survival

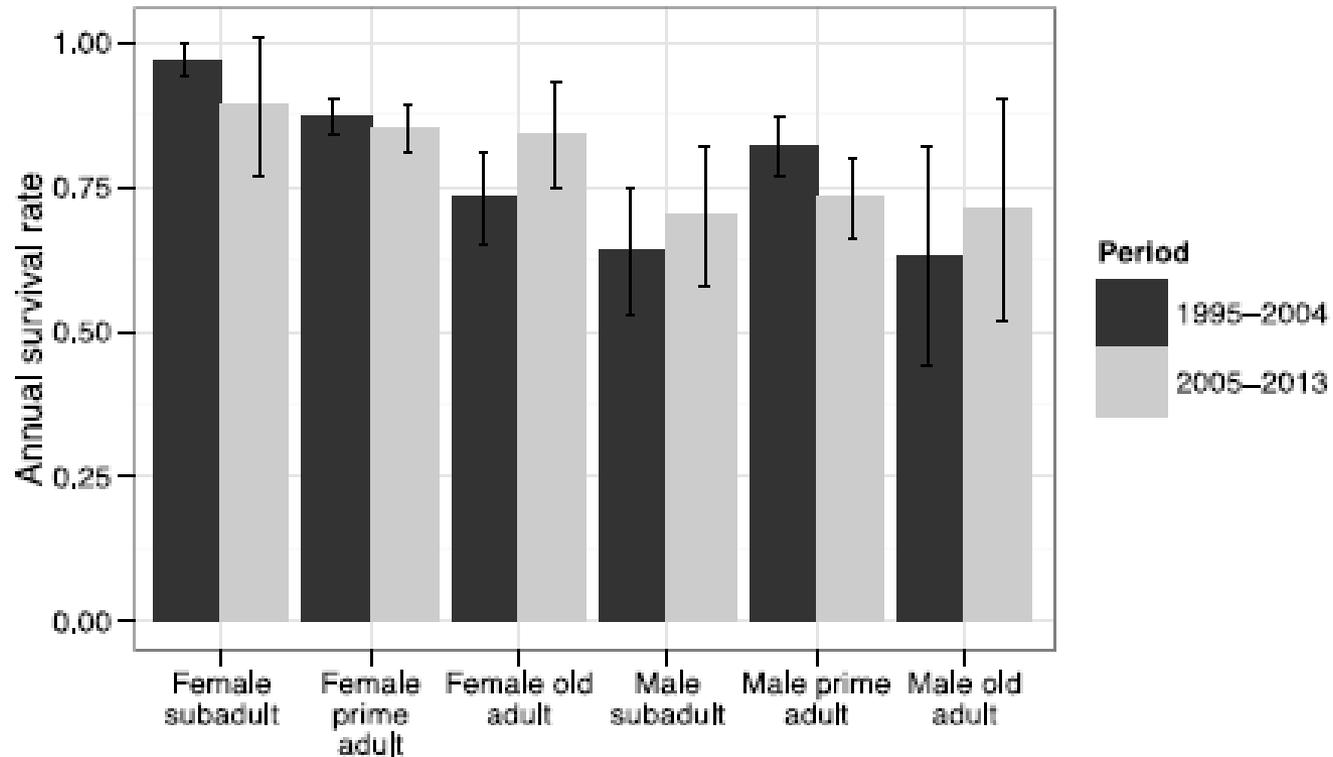
Hostetler et al. 2010. *Biological Conservation* 143: 2789-2796.

Survival Results Update



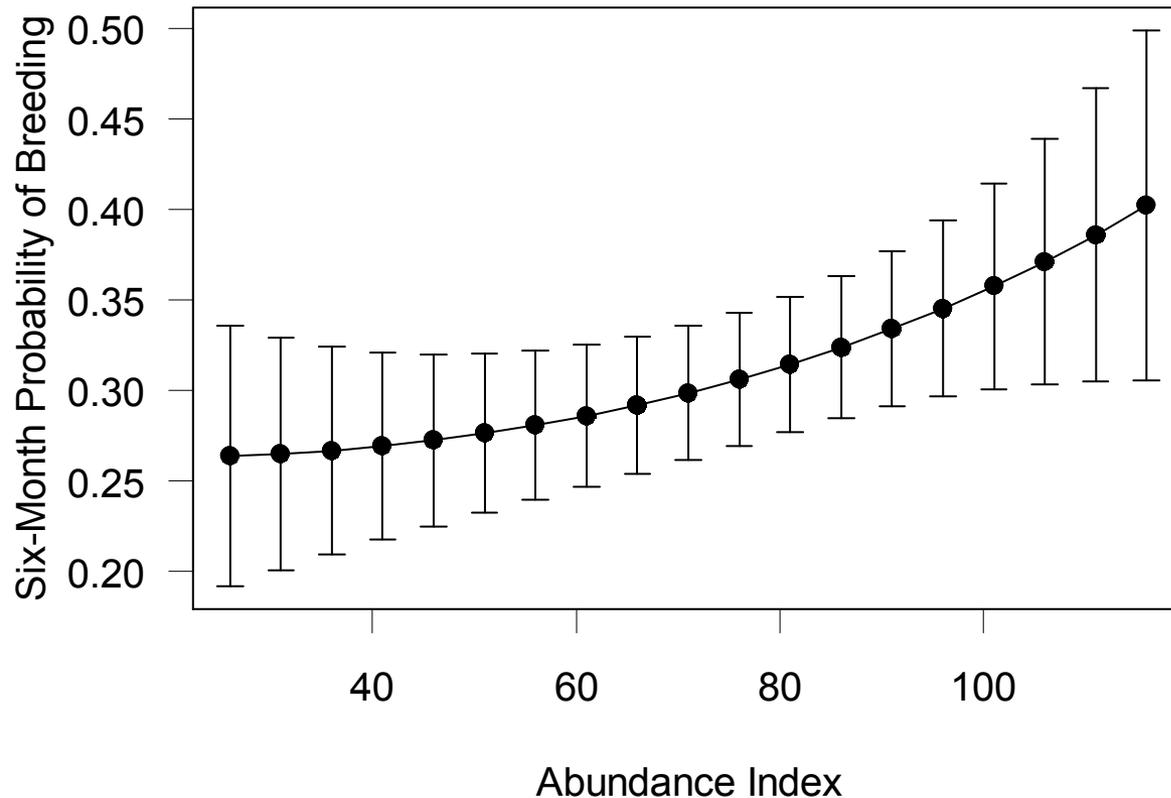
Very similar results with data through 2013
van de Kerk et al. in revision. *Conservation Biology*.

Survival Results Update



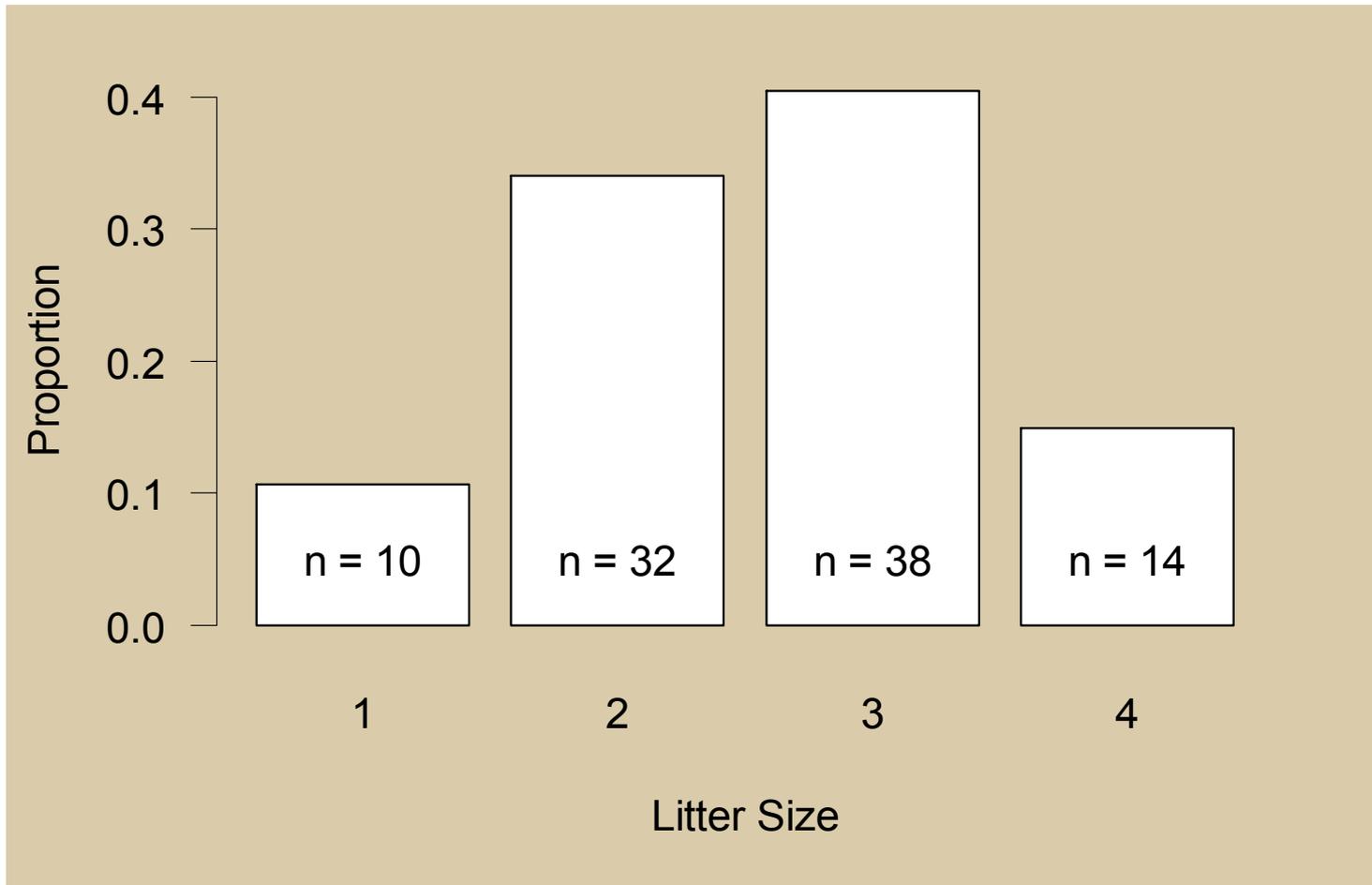
van de Kerk et al. in revision. *Conservation Biology*.

Inverse Density-Dependent Probability of Breeding



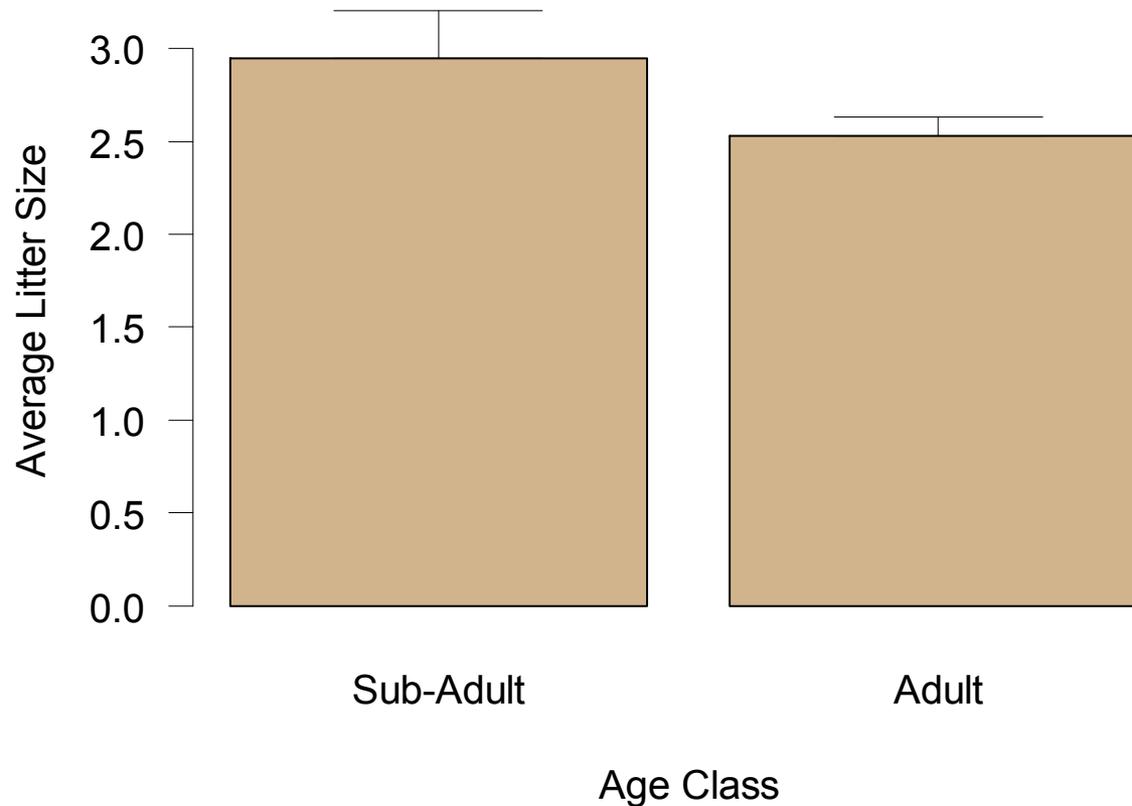
Hostetler et al. 2012. *Oecologia* 168: 289-300.

Litter Size



Hostetler et al. 2012. *Oecologia* 168: 289-300.

Litter Size by Age

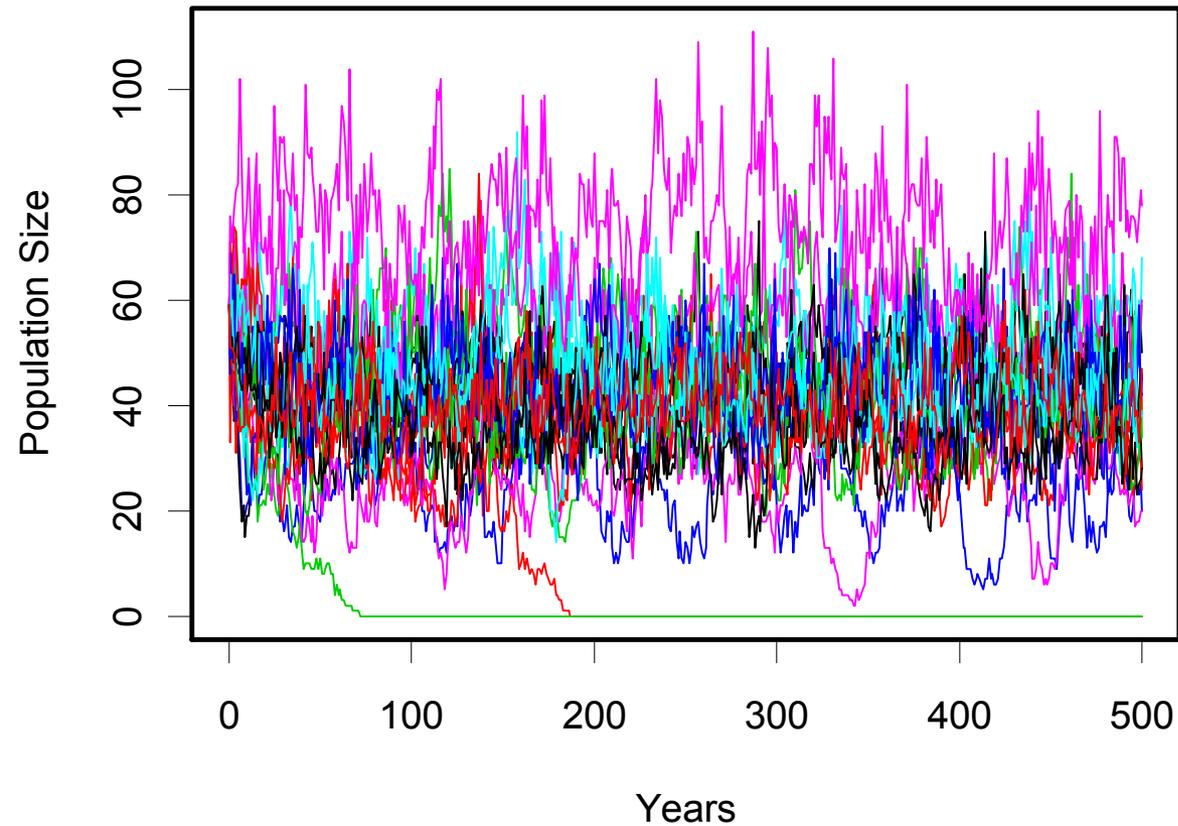


Hostetler et al. 2012. *Oecologia* 168: 289-300.

Reproduction Summary

- Age
 - Older-adults lower probability of breeding
 - Sub-adults higher litter sizes
- Panther abundance increases probability of breeding but not litter size

Hostetler et al. 2012. *Oecologia* 168: 289-300.



Population Dynamics and Viability of Florida Panthers

Population Modeling

- Data
 - Survival and reproductive estimates from previous section
- Growth analyses
 - Population projection matrices
 - Female or two-sex, age-structured, birth-flow
 - Estimated deterministic and stochastic
 - Growth rates (λ and λ_s)
 - Elasticities

$$\mathbf{n}(t+1) = \mathbf{A}(t)\mathbf{n}(t)$$

Population Viability Analysis

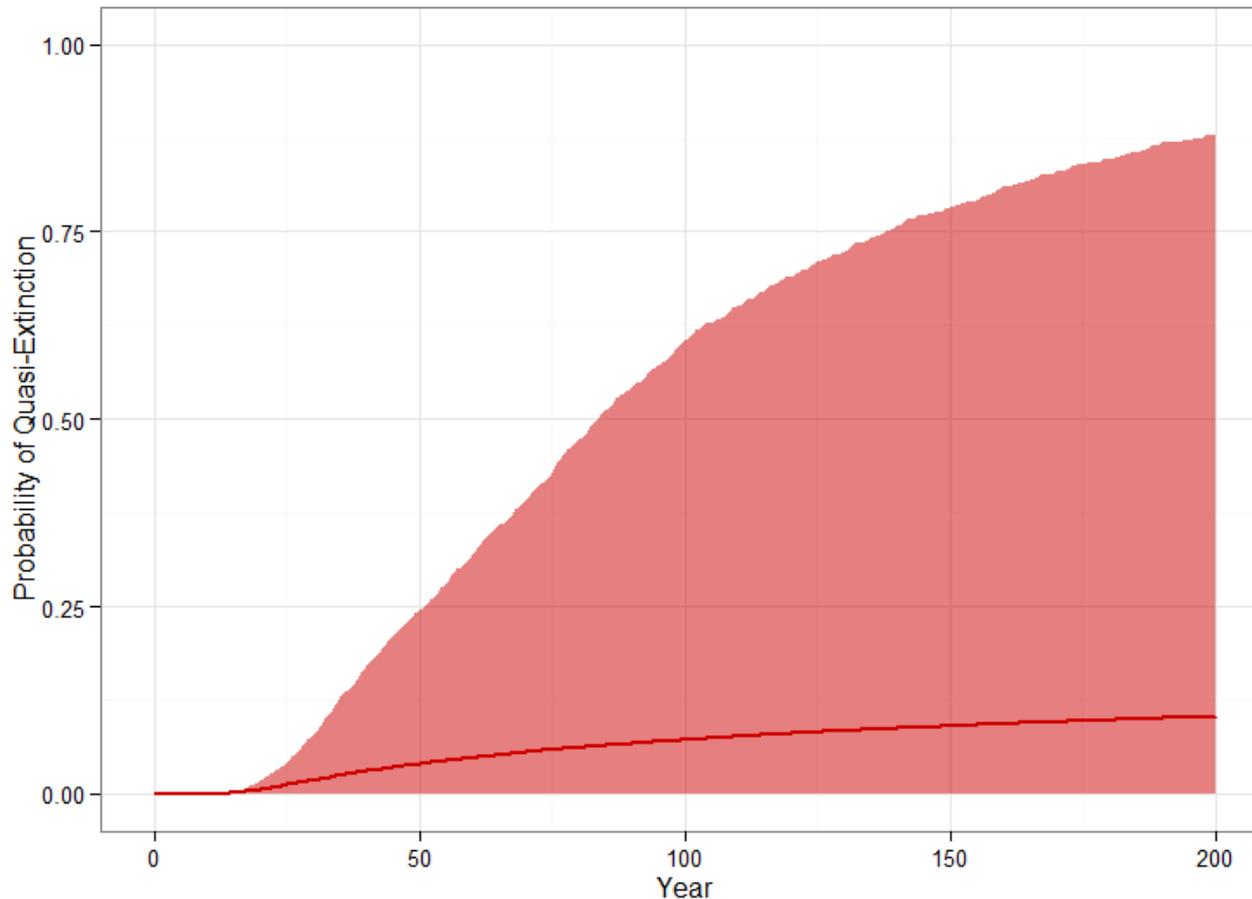
- Environmental and demographic stochasticity
- Density-dependence
- Uncertainty
- Estimated
 - Probabilities of extinction
 - Probabilities of quasi-extinction

Growth Rates and What Affects Them

- $\lambda = 1.04$ (90% CI: 0.95 – 1.14)
- Suggestive of growing population
- λ has highest elasticity to female prime-adult survival
- $\lambda_s = 1.03$ (95% CI: 0.95 – 1.11)

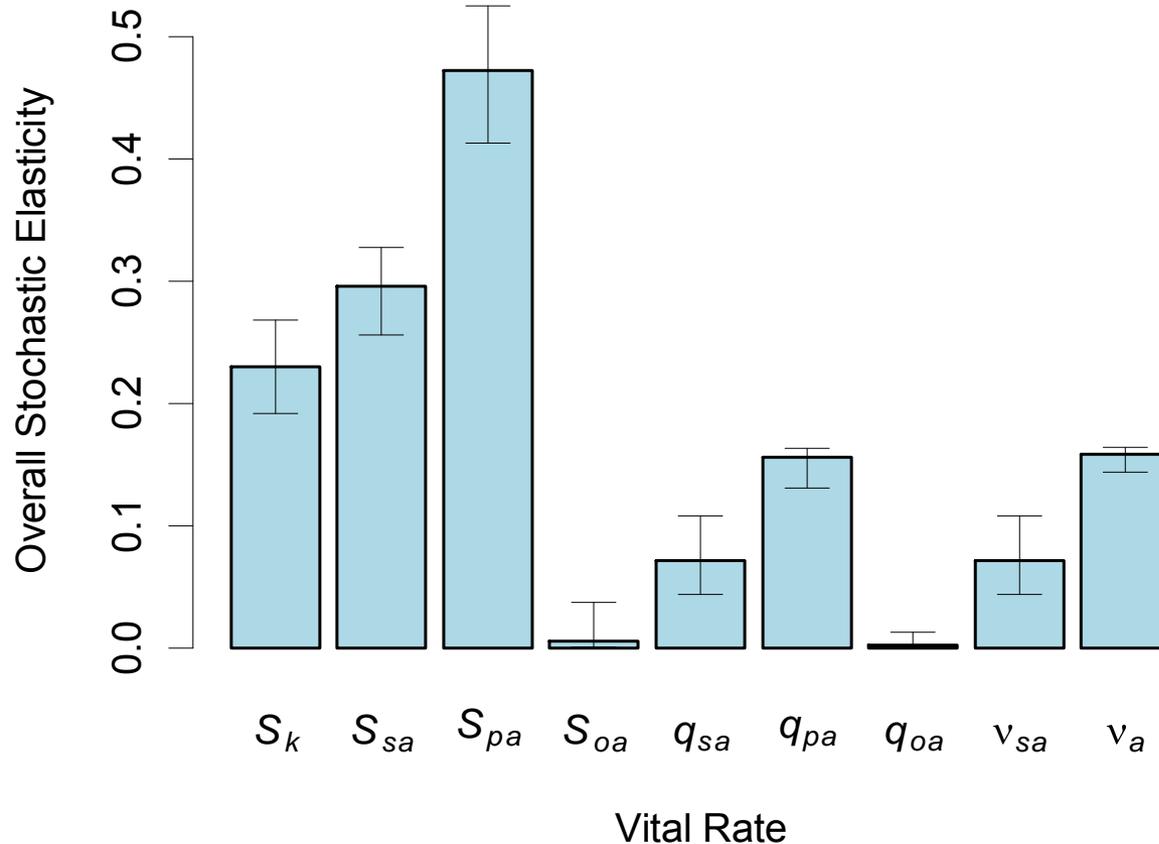
Hostetler et al. 2013. *Journal of Animal Ecology* 82: 608-620.

Cumulative Probability of $N < 10$



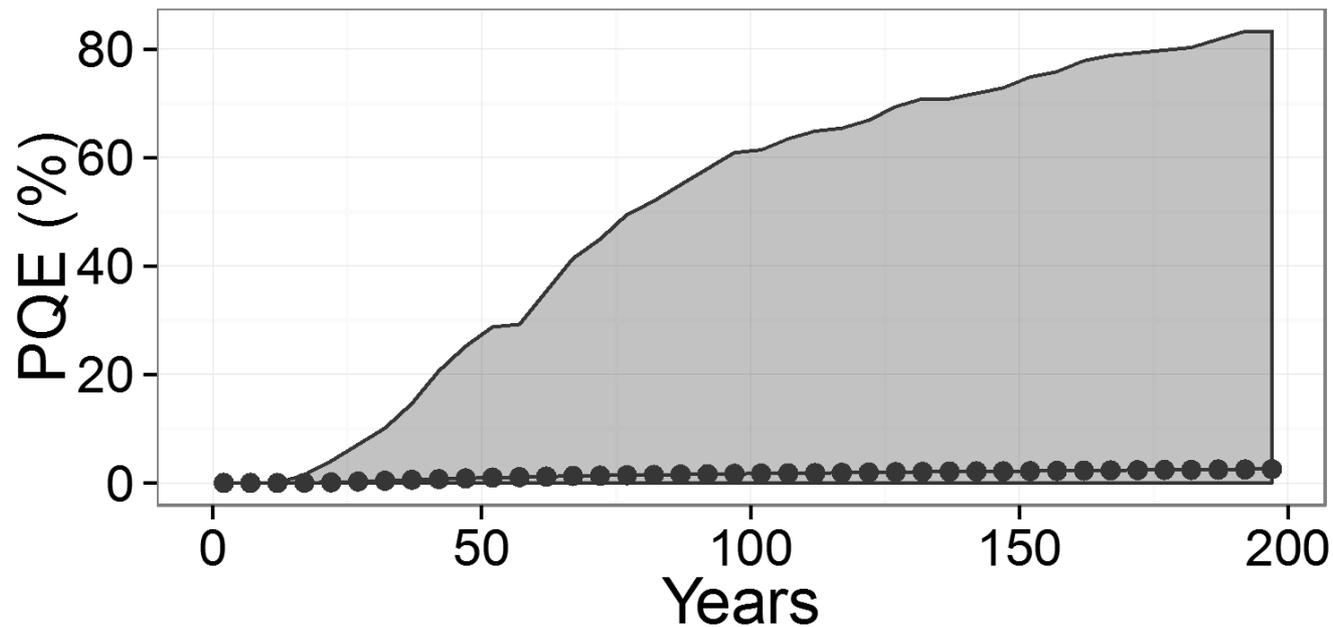
Hostetler et al. 2013. *Journal of Animal Ecology* 82: 608-620.

Stochastic Elasticities



Hostetler et al. 2013. *Journal of Animal Ecology* 82: 608-620.

Preliminary Updated Probability of $N < 10$

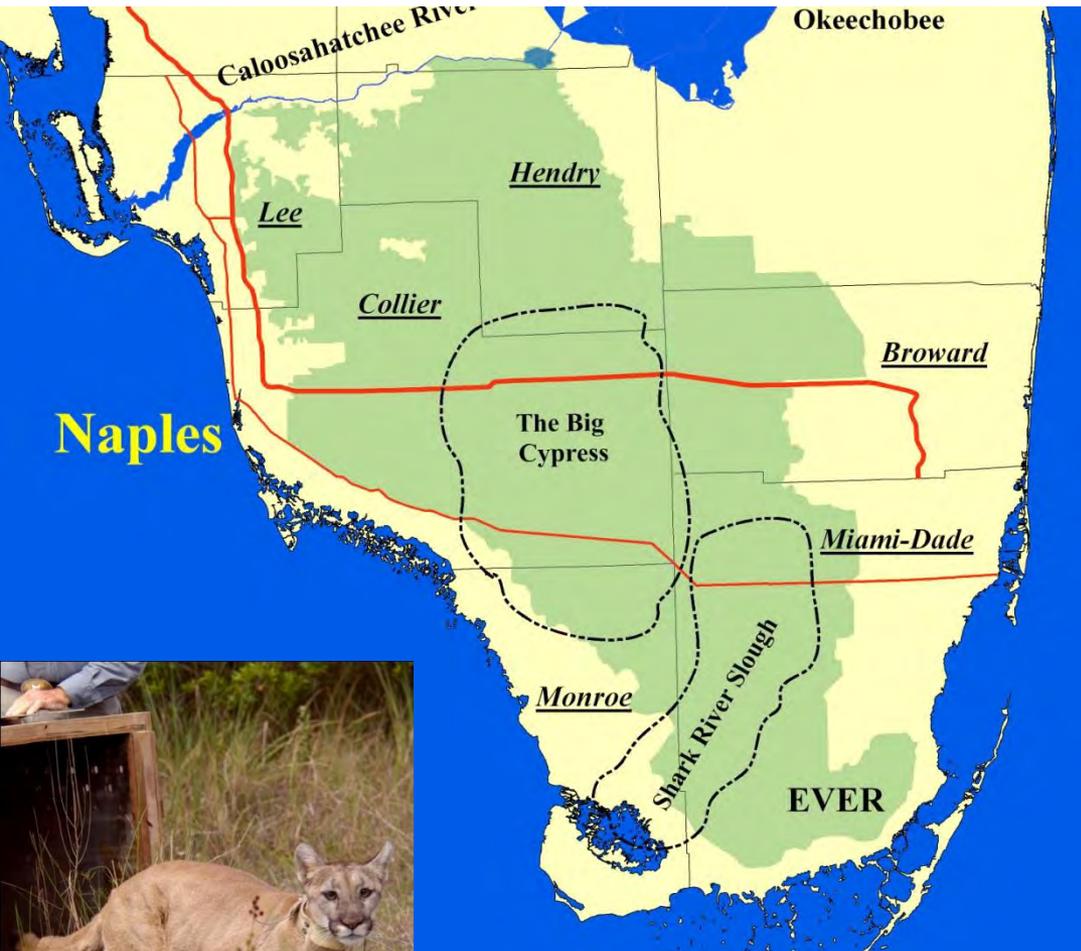


van de Kerk et al. in prep.



Did Genetic Restoration Save the Florida Panther?

Florida Panther Genetic Restoration



- Evidence of inbreeding depression
- 8 adult female Texas pumas released in 1995
- 5 of these reproduced
- Produced 12 litters; \geq 20 admixed kittens
- Dramatic changes in the population

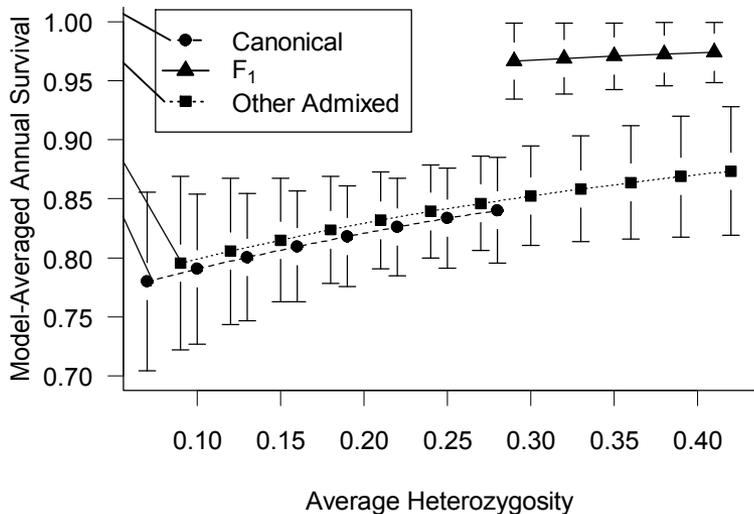


Objectives

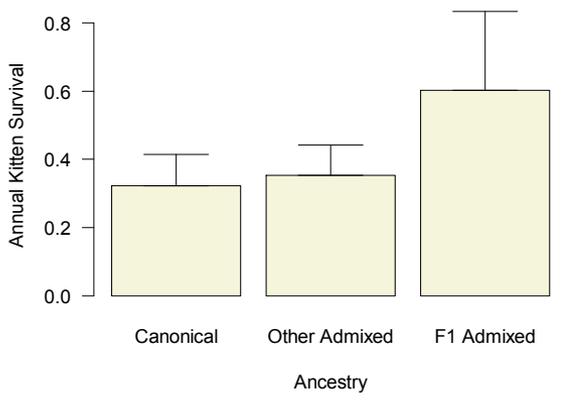
- How genetic restoration affected
 - Demographic parameters
 - Population growth rate
 - Probability of quasi-extinction



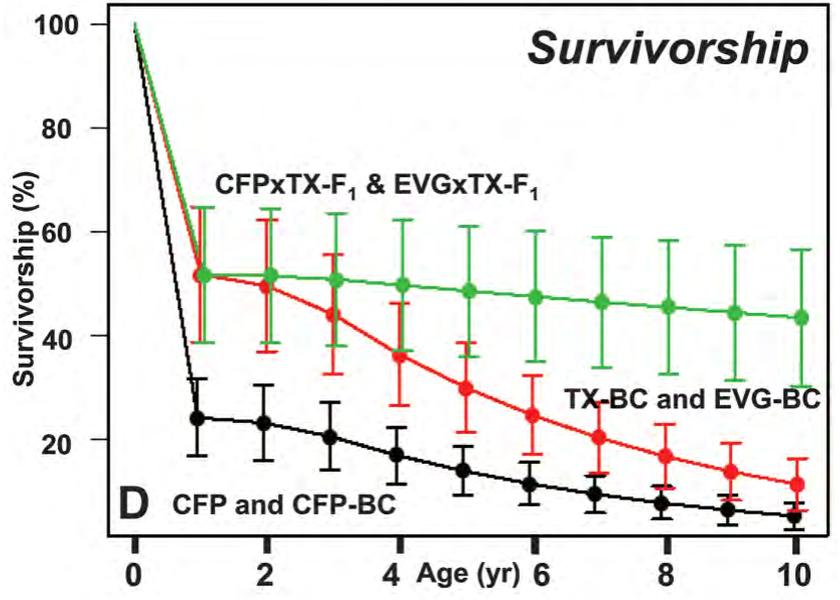
Restoration Increased Survival



Benson et al. 2011. *Journal of Animal Ecology* 80: 958-967.

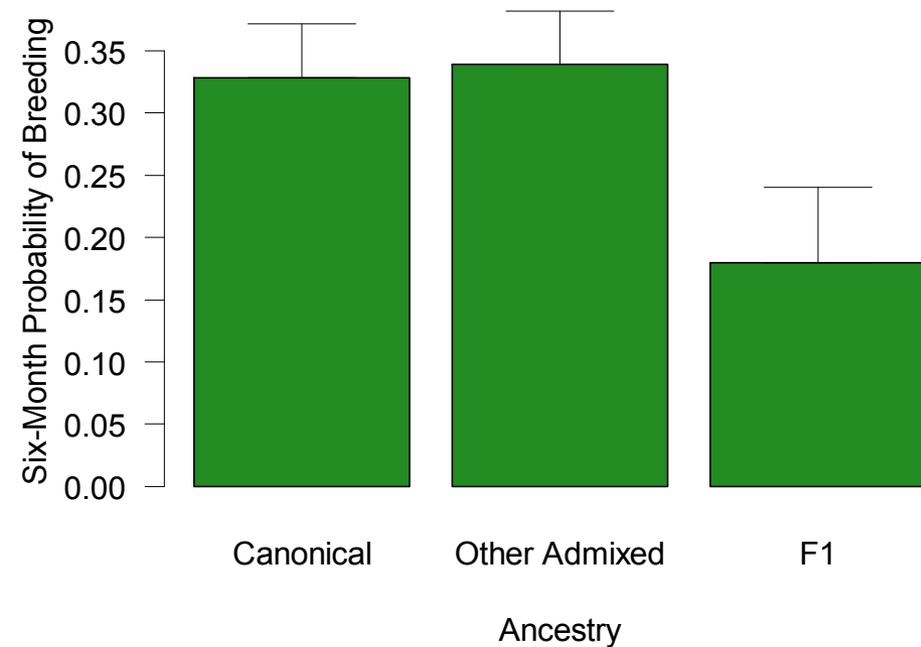


Hostetler et al. 2010. *Biological Conservation* 143: 2789-2796.



Johnson et al. 2010. *Science* 329: 1641-1644.

No Positive Effect of Restoration on Female Reproduction



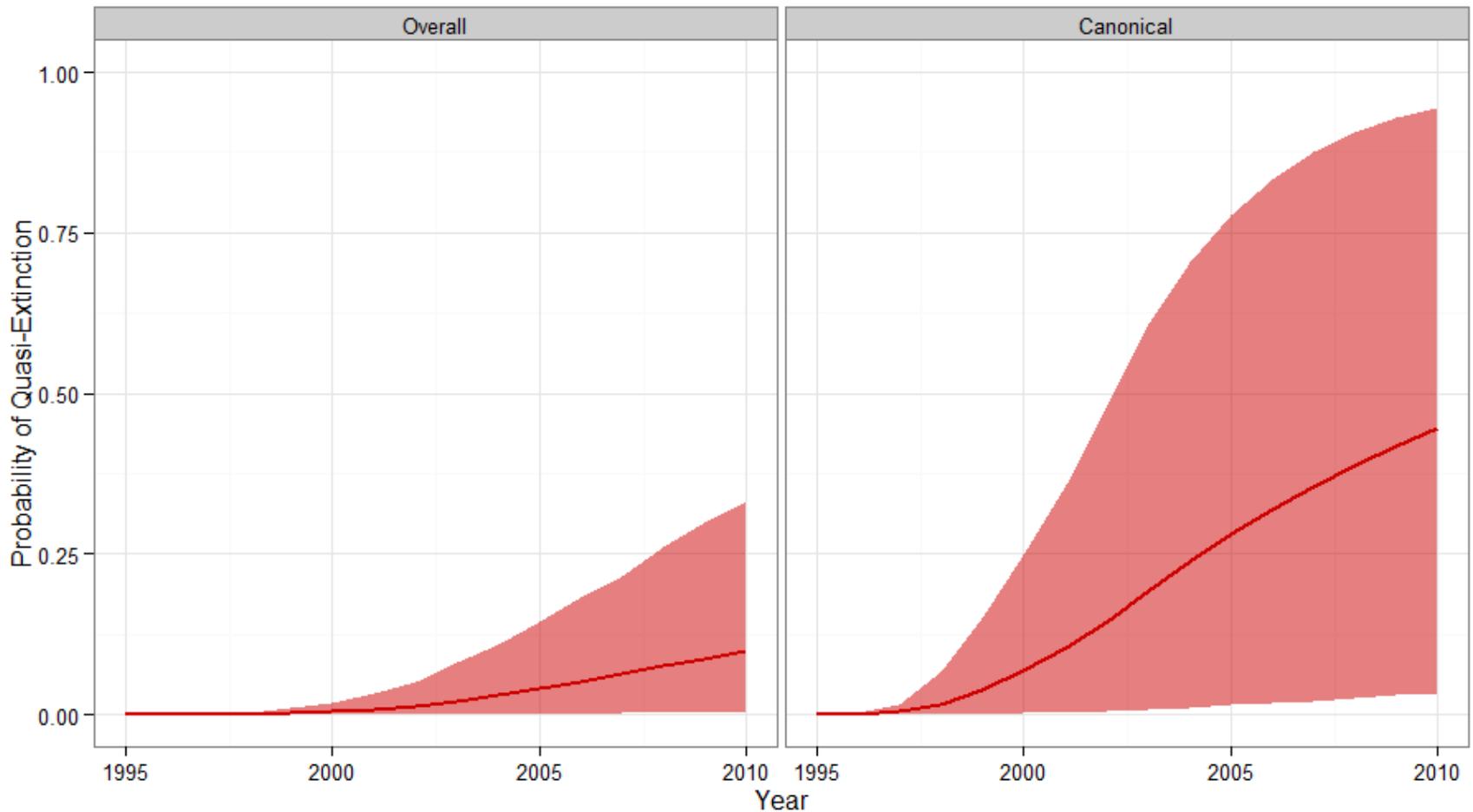
Hostetler et al. 2012. *Oecologia* 168: 289-300.

Restoration Led to Population Growth

- $\lambda = 1.04$ (90% CI: 0.95 – 1.14)
- Suggestive of growing population
- Ran deterministic matrix model for canonical panthers
- $\lambda = 0.95$ (90% CI: 0.83 – 1.08)
- Suggestive of shrinking population
- Main difference due to kitten survival

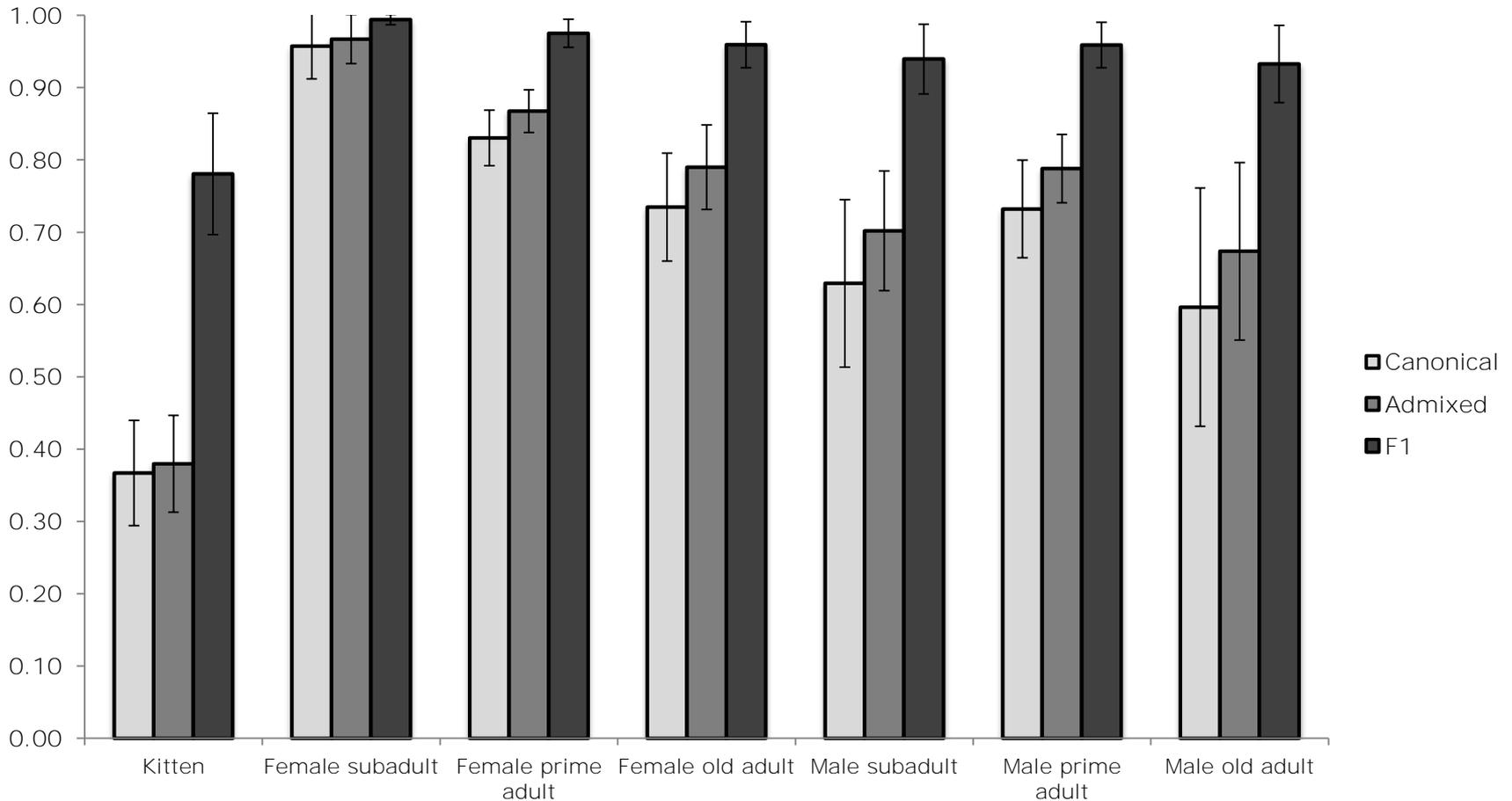
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Restoration Reduced Risk of $N < 10$



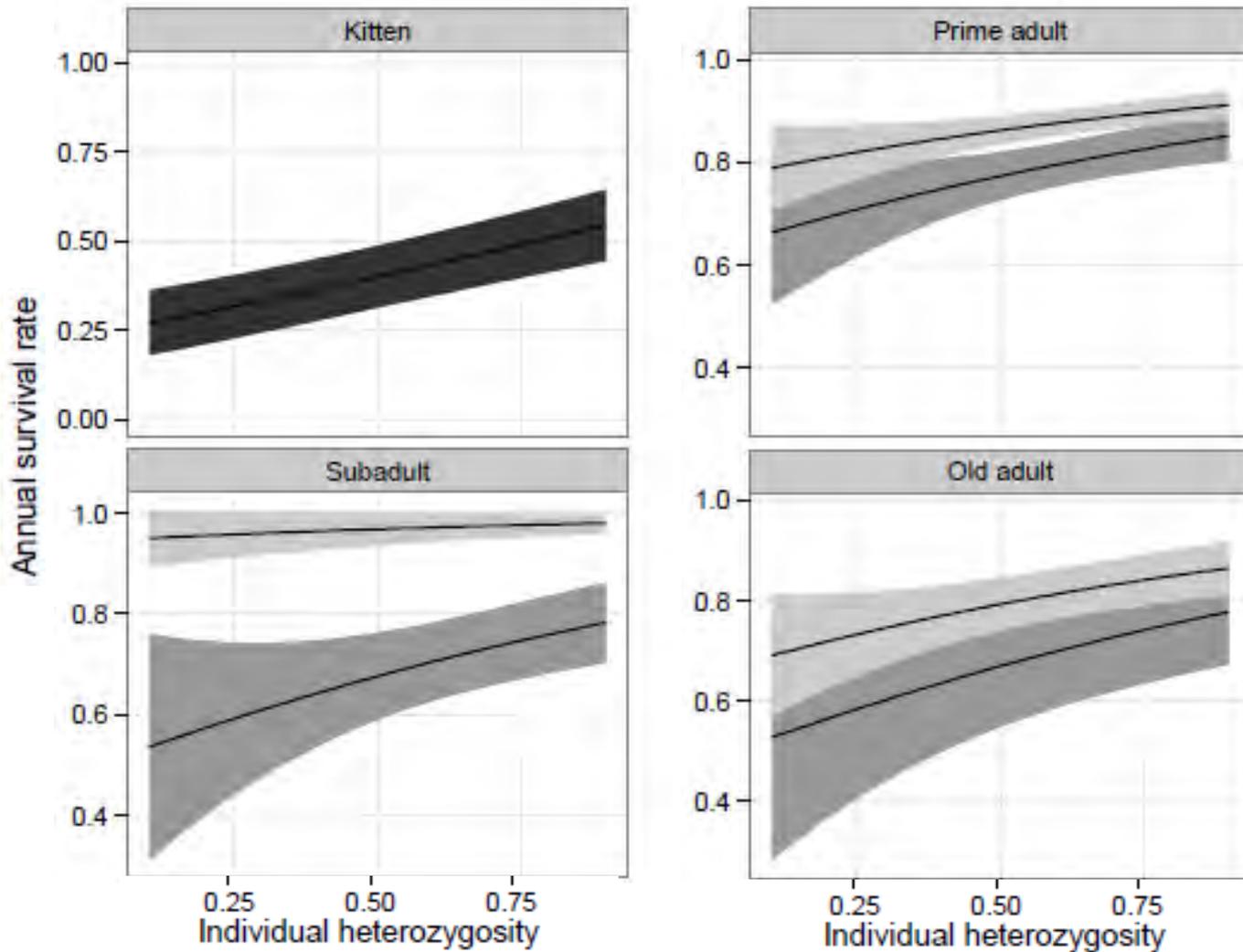
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Introgression Survival Update



van de Kerk et al. in revision. *Conservation Biology*.

Introgression Survival Update



Was the Genetic Restoration a Success?

- Increased genetic diversity, decline in inbreeding traits
- Increased fitness, notably kitten survival
 - Apparently persistent benefits so far
- Increased population size
 - Other factors probably also contributed
- Pretty strong evidence that genetic restoration CAN help save populations

Our PVAs

Caveats

- No catastrophes
- Most data collected during period of population increase
- Assumes no habitat changes
- ~~No genetic stochasticity~~

Strengths

- Incorporates rigorous estimates of vital rates and their variation
- Environmental and demographic stochasticity
- More realistic birth-flow modeling
- Density dependence
- Uncertainty
- “What might have been” scenario

Management Implications

- Florida panthers still exist in small, isolated population
- Future genetic restorations may be required
- New model could be used to address this and other future management scenarios
 - Reintroduction
 - Changes in roadkill mortality
- Assessing other threats may require other approaches



Thank You!

Collaborators

- Madan Oli
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- Madelon van de Kerk
- Ben Bolker
- Jim Nichols
- John Benson
- Warren Johnson
- Melody Roelke
- Stephen O'Brien
- Deborah Jansen
- Darrell Land
- Mark Cunningham
- Robert Belden
- Roy McBride
- Mark Lotz
- Dave Shindle
- And more!