DoD Natural Resources Program

Enabling the Mission, Defending the Resources

Methods for Estimating Densities and Detection Probabilities of Secretive Reptiles

November 14, 2019

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Methods for Estimating Densities and Detection Probabilities of Secretive Reptiles

DoD Legacy Program project 14-754

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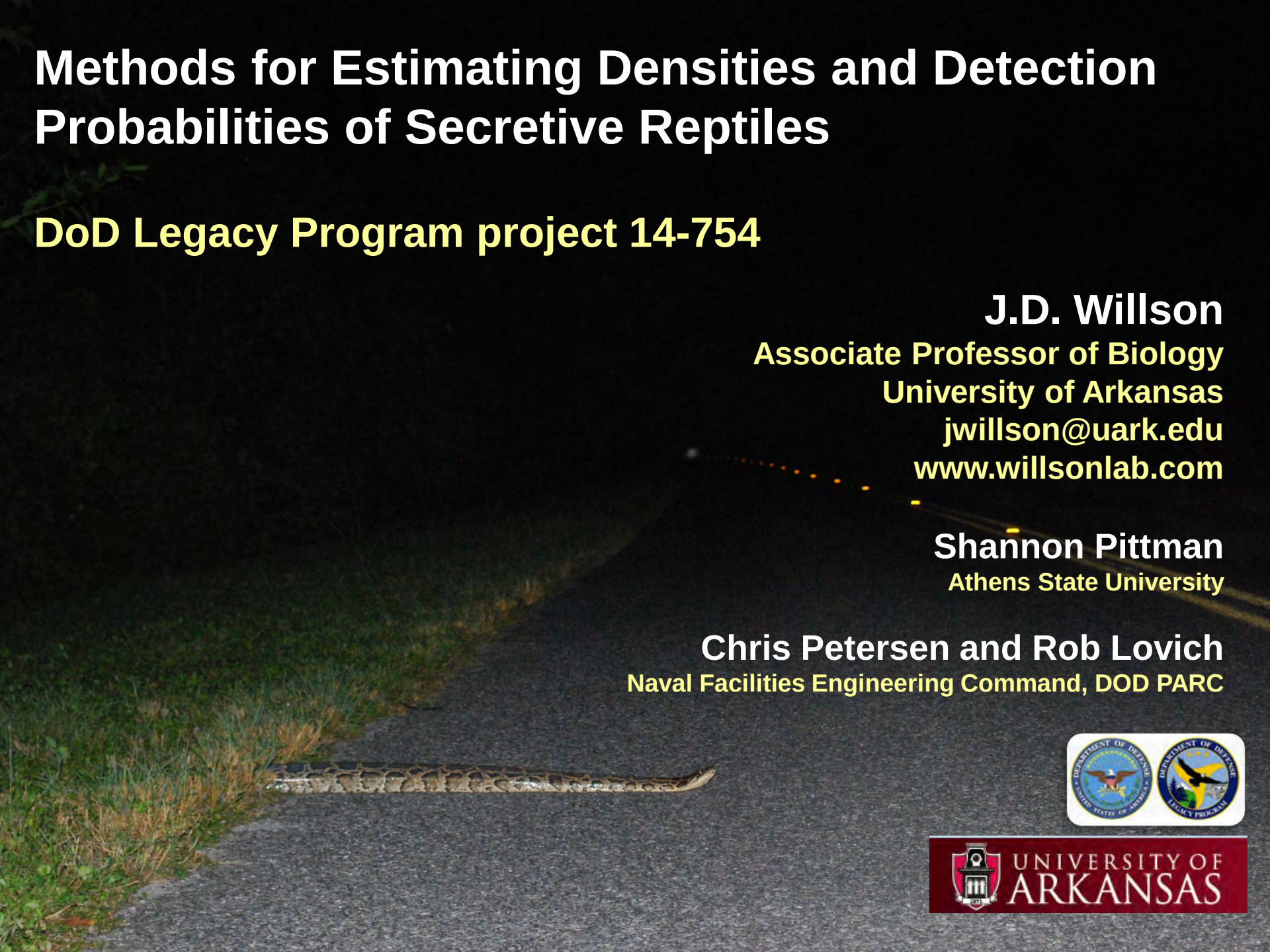


Where does a species occur?

How large are populations?

Are populations growing or declining?

How do we know if a species is gone?

Capture-Mark-Recapture (CMR)

Standard method to estimate abundance

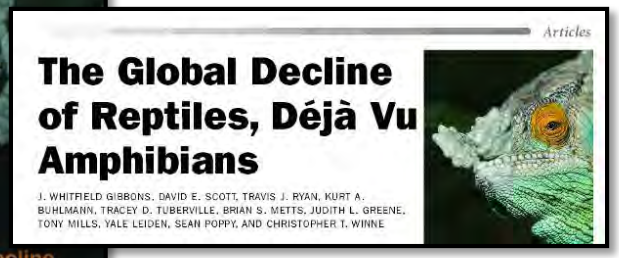
A subset of individuals is captured, marked, and released

Population is re-sampled and the ratio of marked to unmarked individuals is used to estimate population size.

Requires recapturing individuals

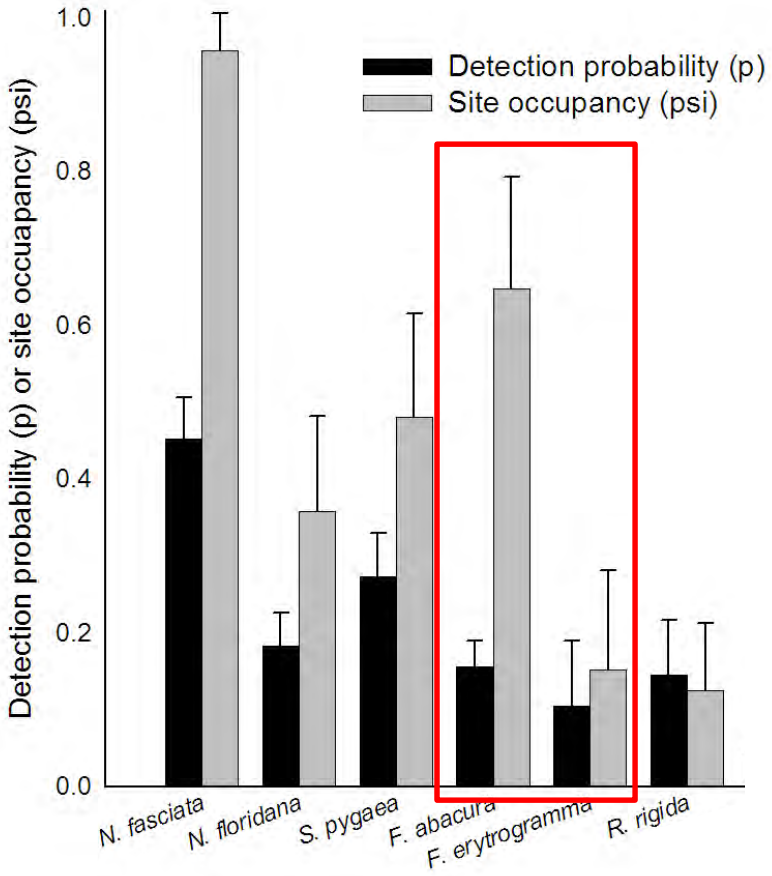
Why Snakes?

- Unusual ecology, behavior, and physiology
- Diverse, but many are declining
- Top predators in many food webs
- Poorly understood



Snake Density

- **Population size/density unknown for most snakes**
- **Perceptions of abundance can be misleading**
- **CMR requires relatively high recapture probability**
- **Difficult & costly for most snakes**
- **Logistically impossible for many secretive species**



Durso et al. 2011. Biological Conservation

Road Surveys

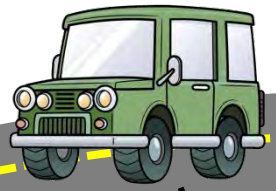
- Most efficient way to capture many species
- More systematic than many other methods
- Under-used for population monitoring

Objective: develop a method to translate observation rates during road surveys to snake density

- Method Description
- Case 1: Southern Hognose
- Case 2: Burmese Python
- Applications & Future Directions

Road-Based Density Estimation

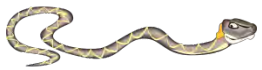
Systematic Road Surveys

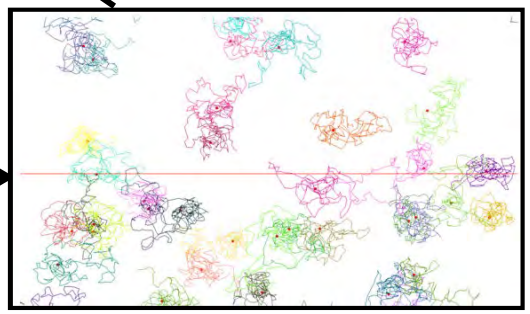


Observation Frequency

Probability of Crossing X Detection Probability While Crossing = Snake Density

Radiotelemetry





Movement Simulations

Measurements of Crossing Time

Willson, et. al. 2018. Wildlife Research

Case Study – Southern Hognose (*Heterodon simus*)

- **Fossorial, restricted to sandy uplands of Southeast**
- **Declining – considered for federal listing**
- **Abundance unknown**
- **Most often encountered on roads**
- **Substantial existing road survey and telemetry data**
- **Focused on fall movement peak**

Systematic Road Surveys

Copeia 2014, No. 1, 168–175

Natural History of the Southern Hognose Snake (*Heterodon simus*) in North Carolina, USA

Jeffrey C. Beane[1], Sean P. Graham[2], Thomas J. Thorp[3], and L. Todd Pusser[4]

- 9 years of systematic road survey data in NC Sandhills
- 656 h across 236 days (1 Sept – 15 Nov)
- 54 live H. simus captured
- Average encounter rate = 0.082 per h

PROJECT SIMUS

Road Crossing Speed

- Observations of natural road crossing events
- Stopped vehicle well away from snake, timed crawling speed
- Excluded individuals that reversed or exhibited lateral undulation movement

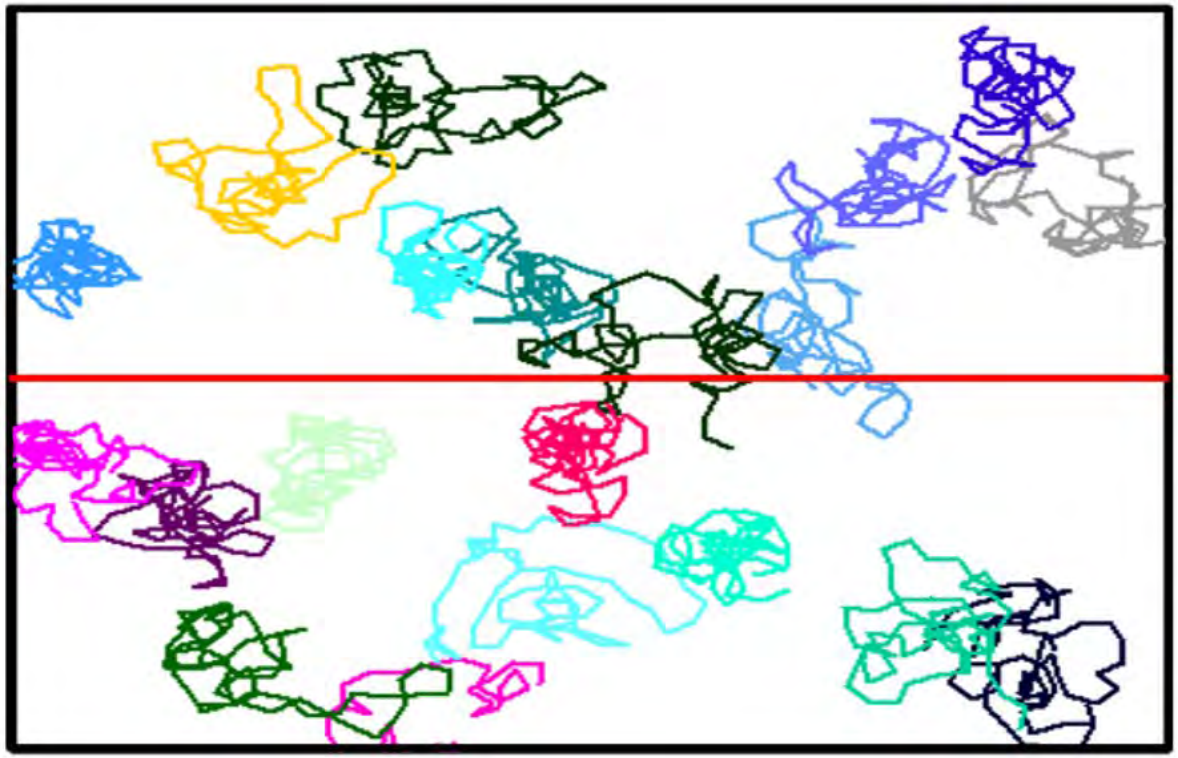
- 9 crossing events in 2014
- mean speed = 1.5 cm/sec
- Mean crossing time = 7.7 min

Snake Movement – Radiotelemetry

- 18 *H. simus* tracked in N.C. and S.C.
- 1 Sept – 15 Nov
- Only periods of daily tracking
- GIS Analyses
  - Movement distance
  - Movement frequency
  - Orientation
    - Home range center
    - Road

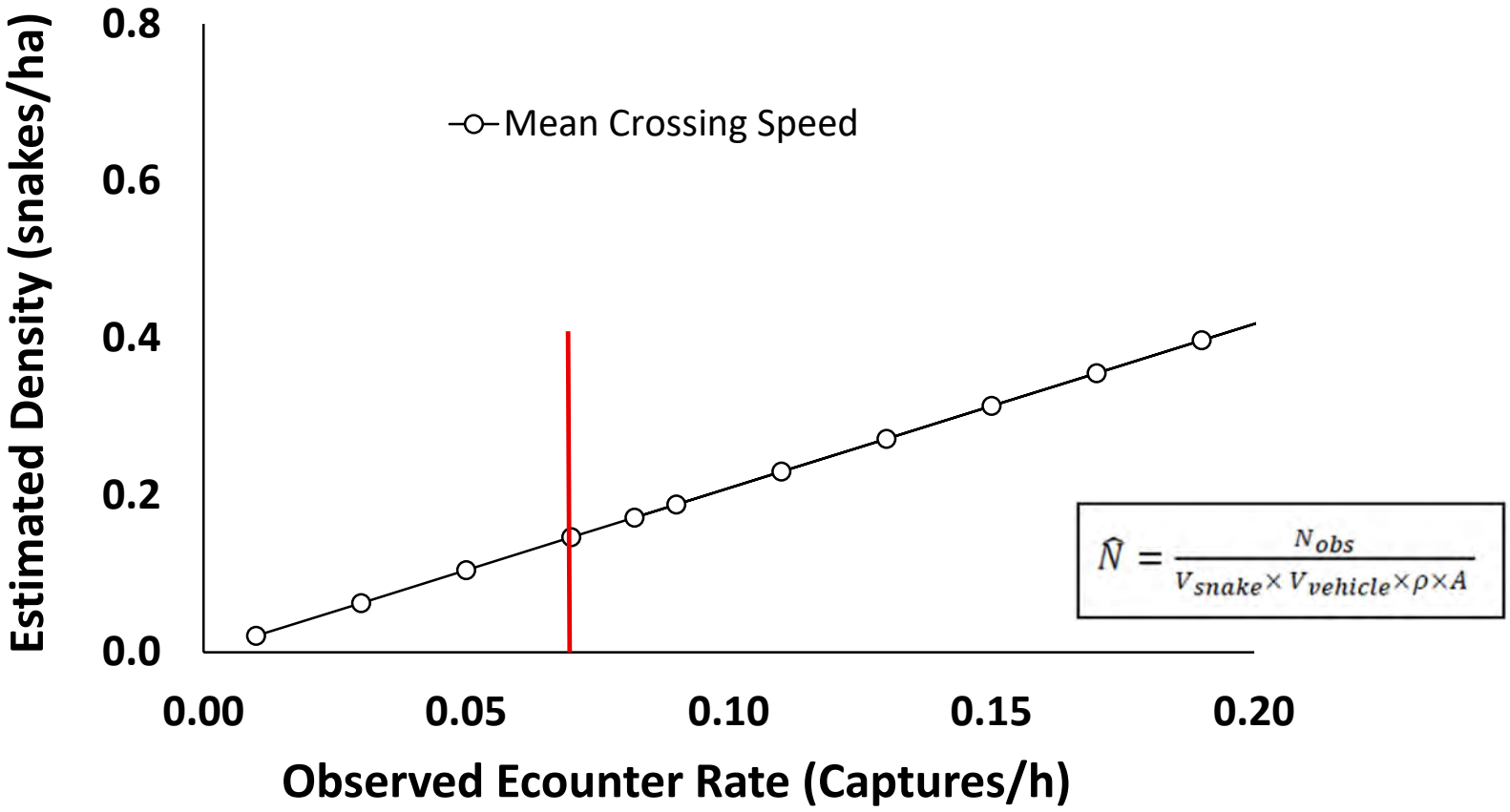
Movement Modeling

- Individual-based spatial movement models in R
- Correlated biased random walk in uniform landscape
- Parameterized based on telemetry data (movement distance, frequency, turning angle, orientation to road)



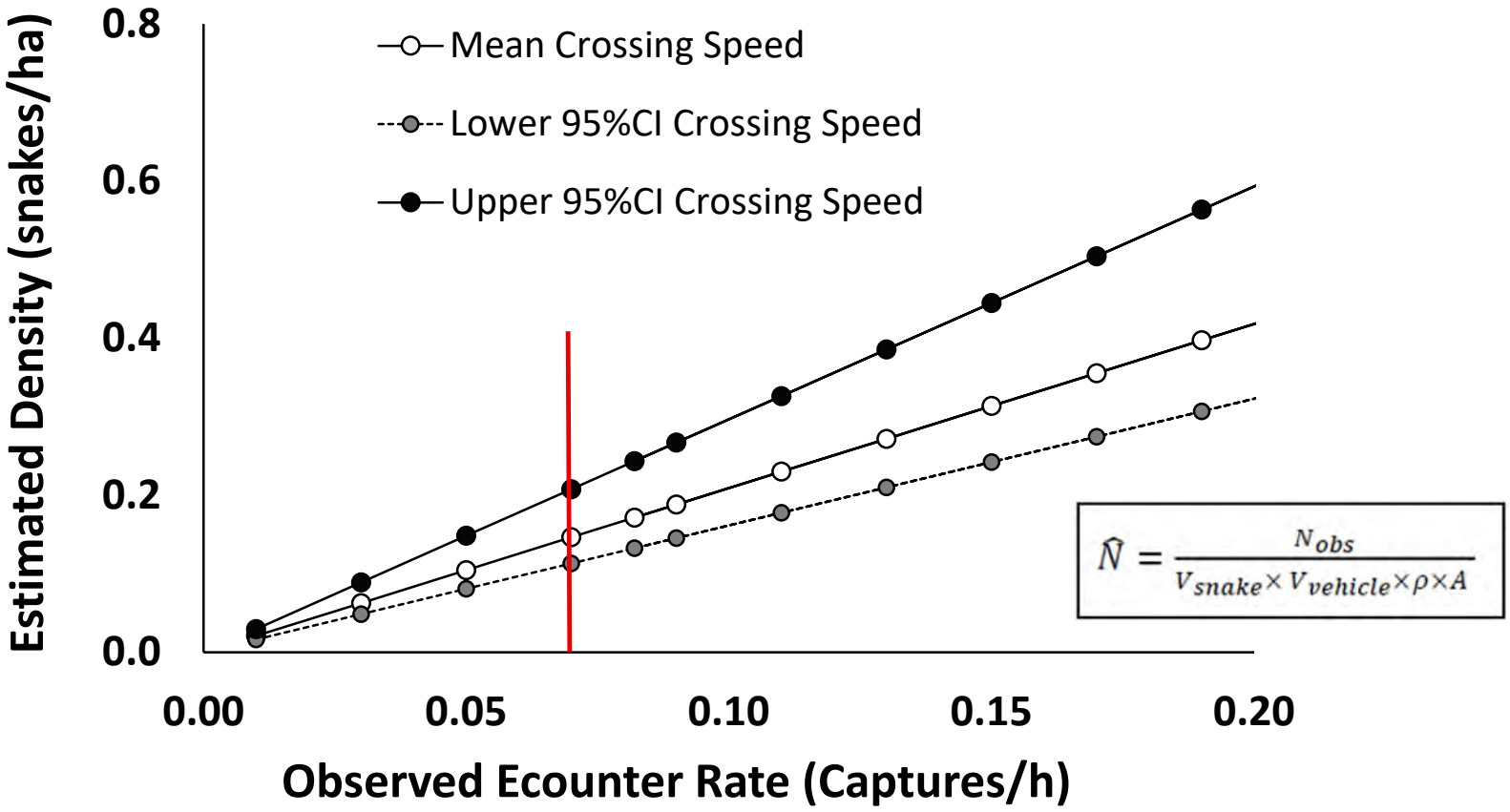
Results

- **Estimated density of 0.17 *H. simus* per ha**



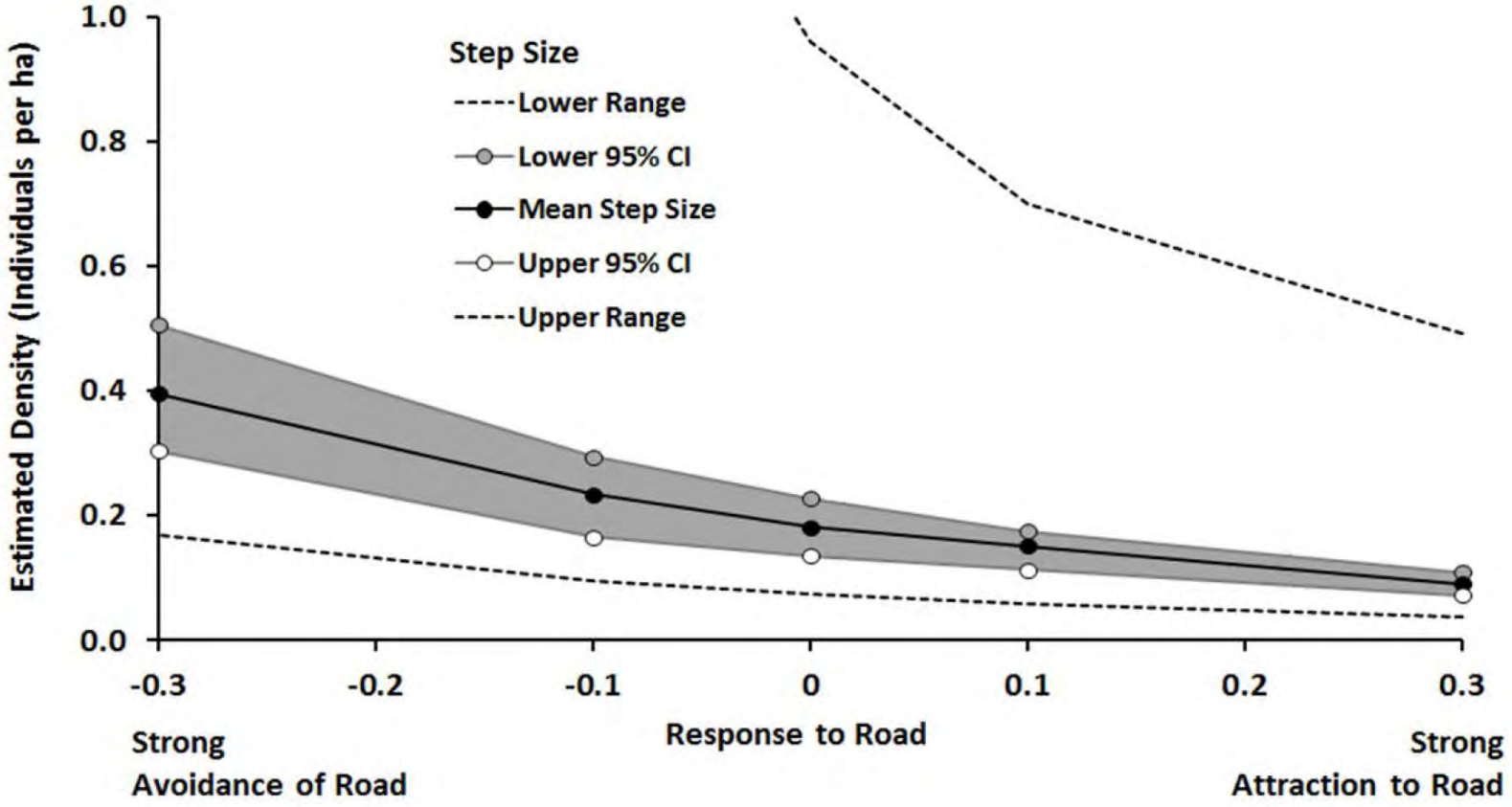
Results

- **Estimated density of 0.17 *H. simus* per ha**
- **Sensitivity of model results to snake crossing speed**



Results

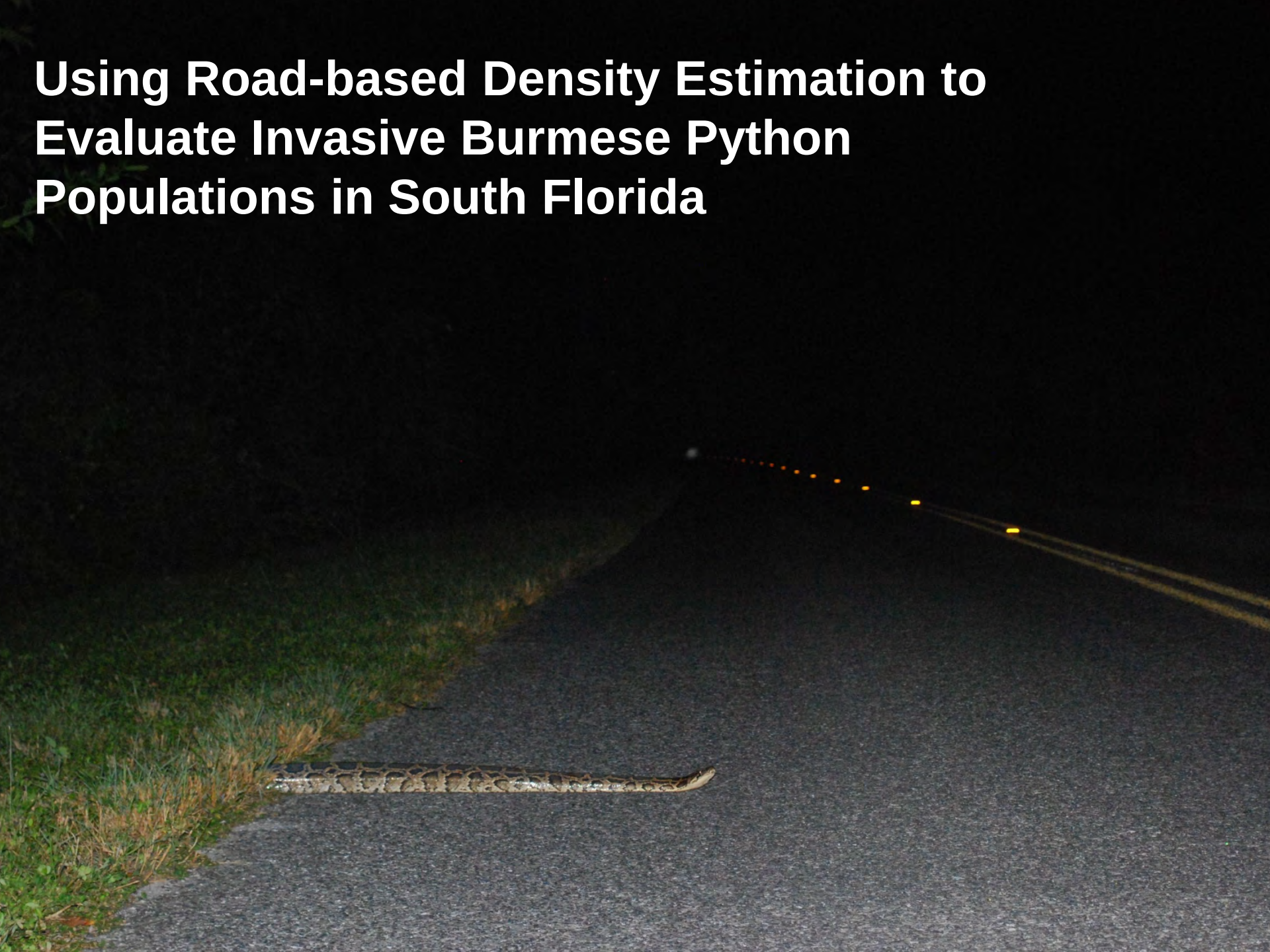
- **Sensitivity to step size and road attraction**

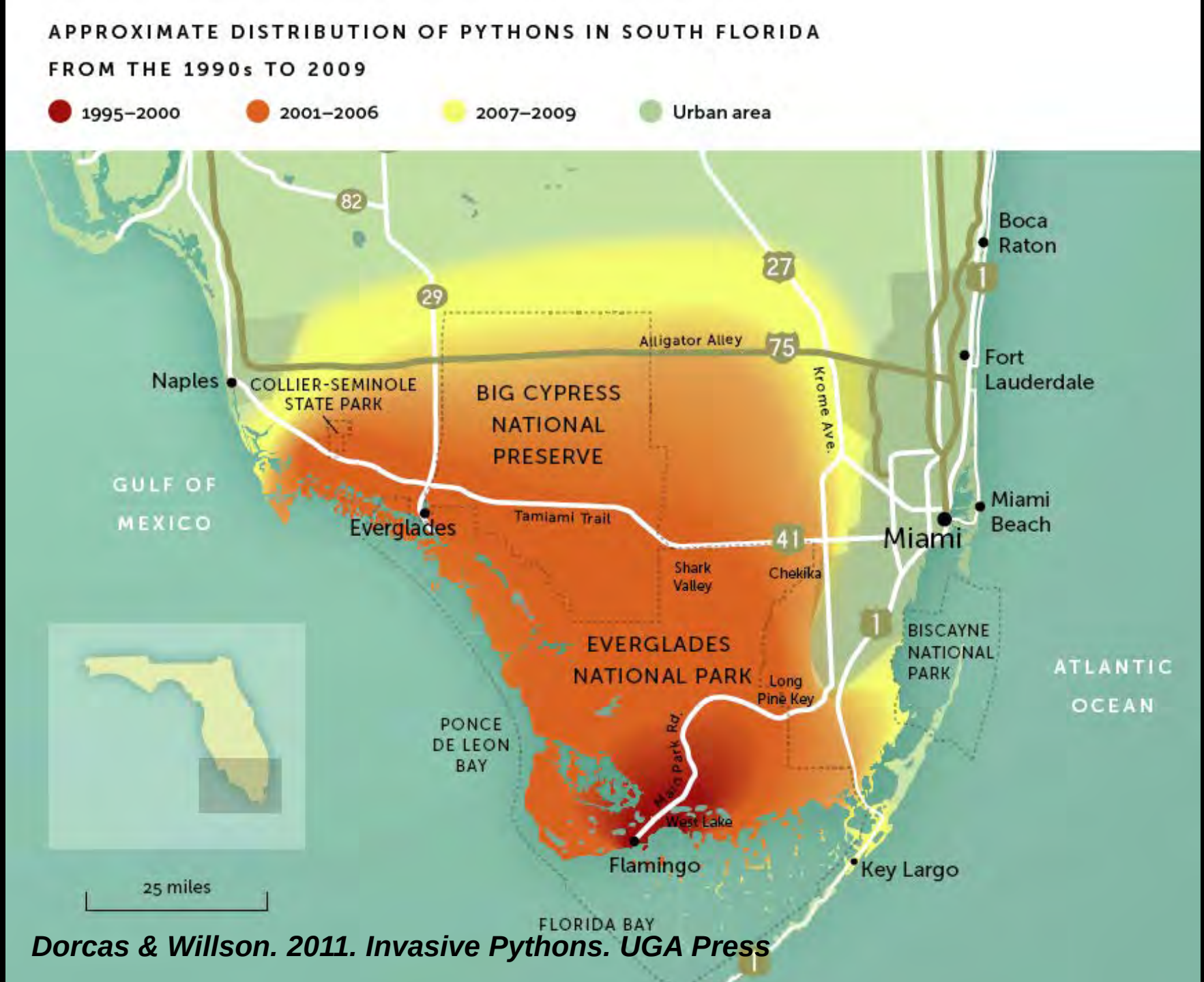


H. simus density

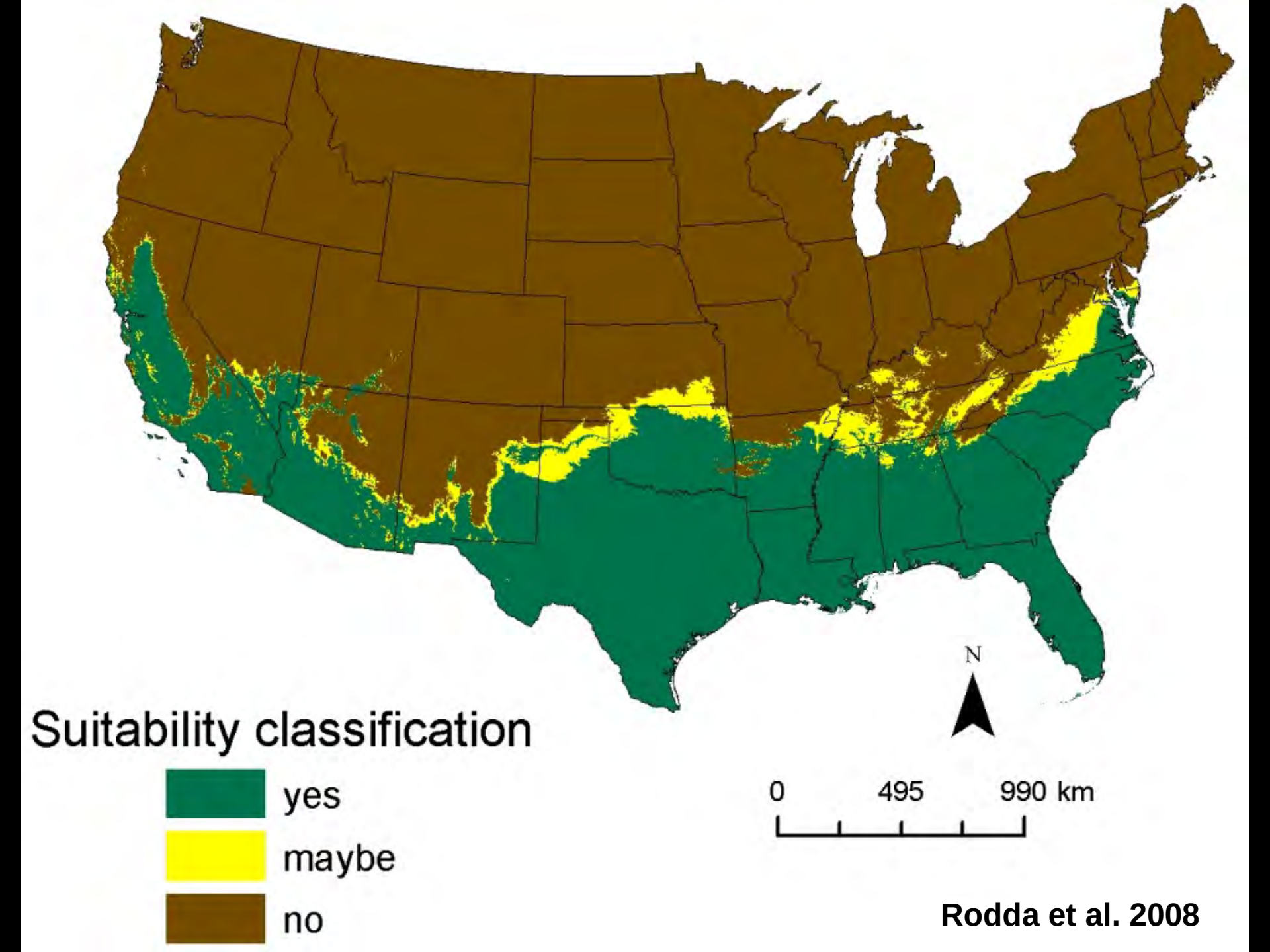
- Estimated density (0.17 per ha) relatively low
- *H. simus* not only restricted in distribution, but also occur at low densities in 'core' areas of remaining range
- Caveats:
  - Density is averaged over survey area
  - Specific to areas around roads
    - 80% of US with 1 km of road (Riitters and Wickham 2003)
  - Road-kills and removal

Using Road-based Density Estimation to Evaluate Invasive Burmese Python Populations in South Florida

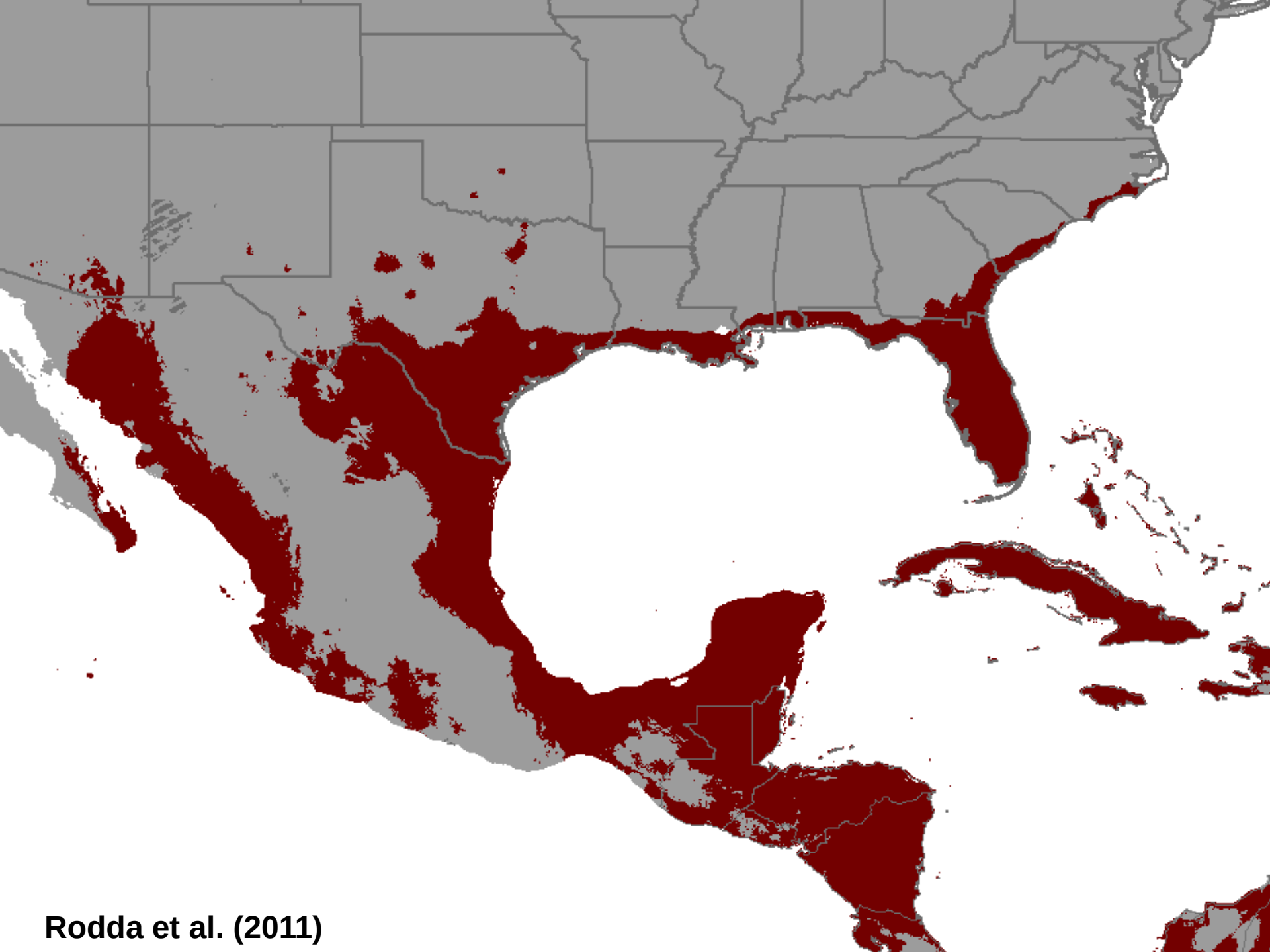




Dorcas & Willson. 2011. Invasive Pythons. UGA Press

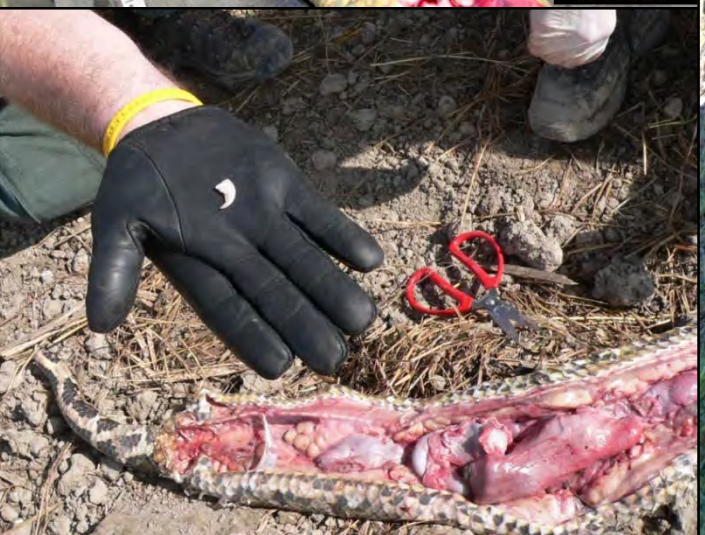


Rodda et al. 2008



Rodda et al. (2011)

Krysko et al. 2012



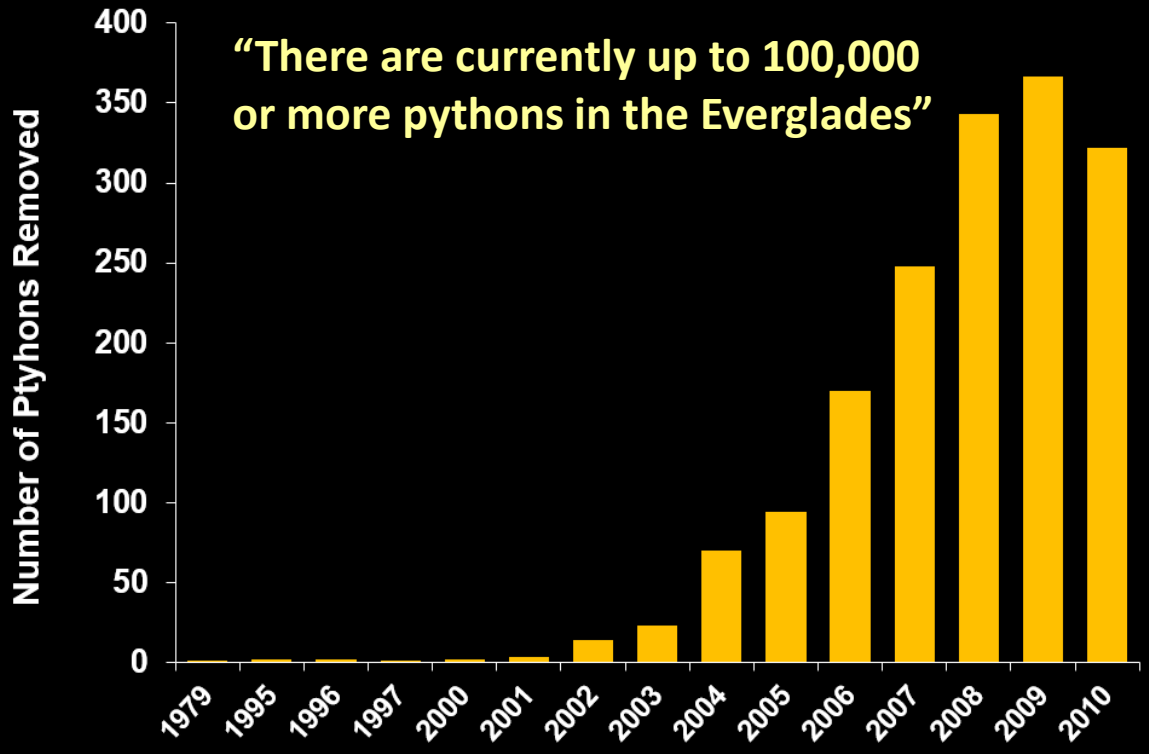
Dorcas, Willson, et. al. 2012. PNAS

Estimating Python Density (Abundance)

Necessary to evaluate success of management

Possible mechanism for impacts

Essentially unknown



Detectability of Burmese Pythons

- 31 x 25 m enclosure
- 10 male radio-tagged pythons
- 19 searchers, 30 min visual search
- 2 detections! (1% detection probability)

Dorcas & Willson 2013. In: Reptiles in Research. Nova Publishers.


EVERGLADES
NATIONAL
PARK
UNITED STATES DEPT. OF INTERIOR

Snake Movement – Radiotelemetry

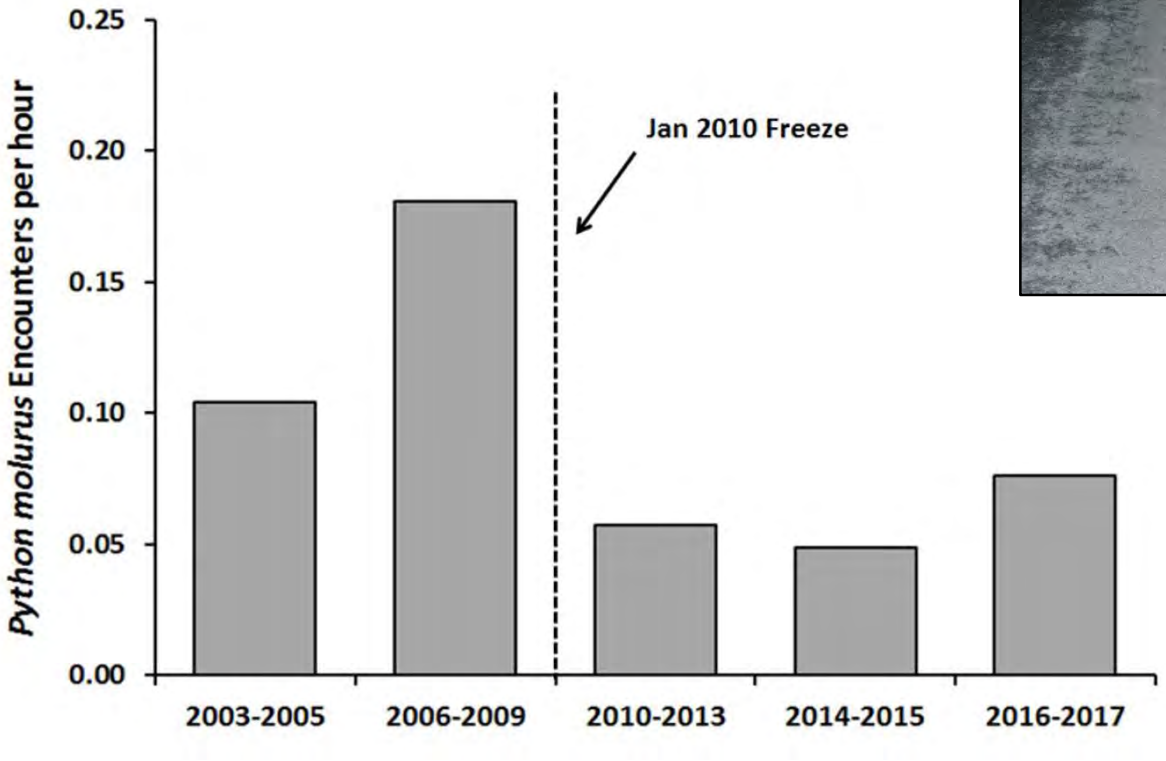
- **19 pythons 2006-2009 in ENP**
  Hart et al. 2015. Animal Biotelemetry.
- **GIS Analyses**
  - **Movement distance**
  - **Movement frequency**
  - **Orientation**

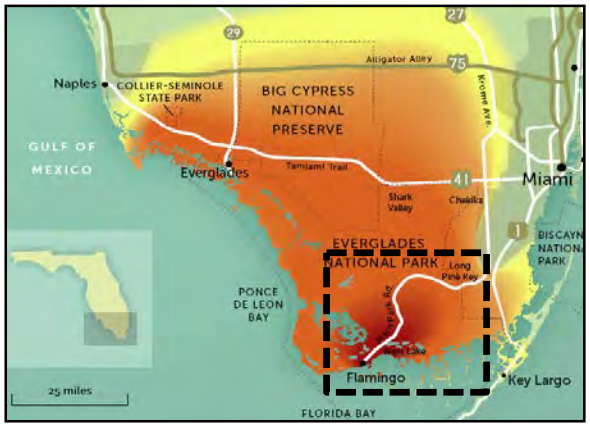
Road Crossing Speed

- **31 crossing events 2010-2017**
- **mean speed = 3.3 cm/sec**
- **Mean crossing time = 5.3 min**

Systematic Road Surveys

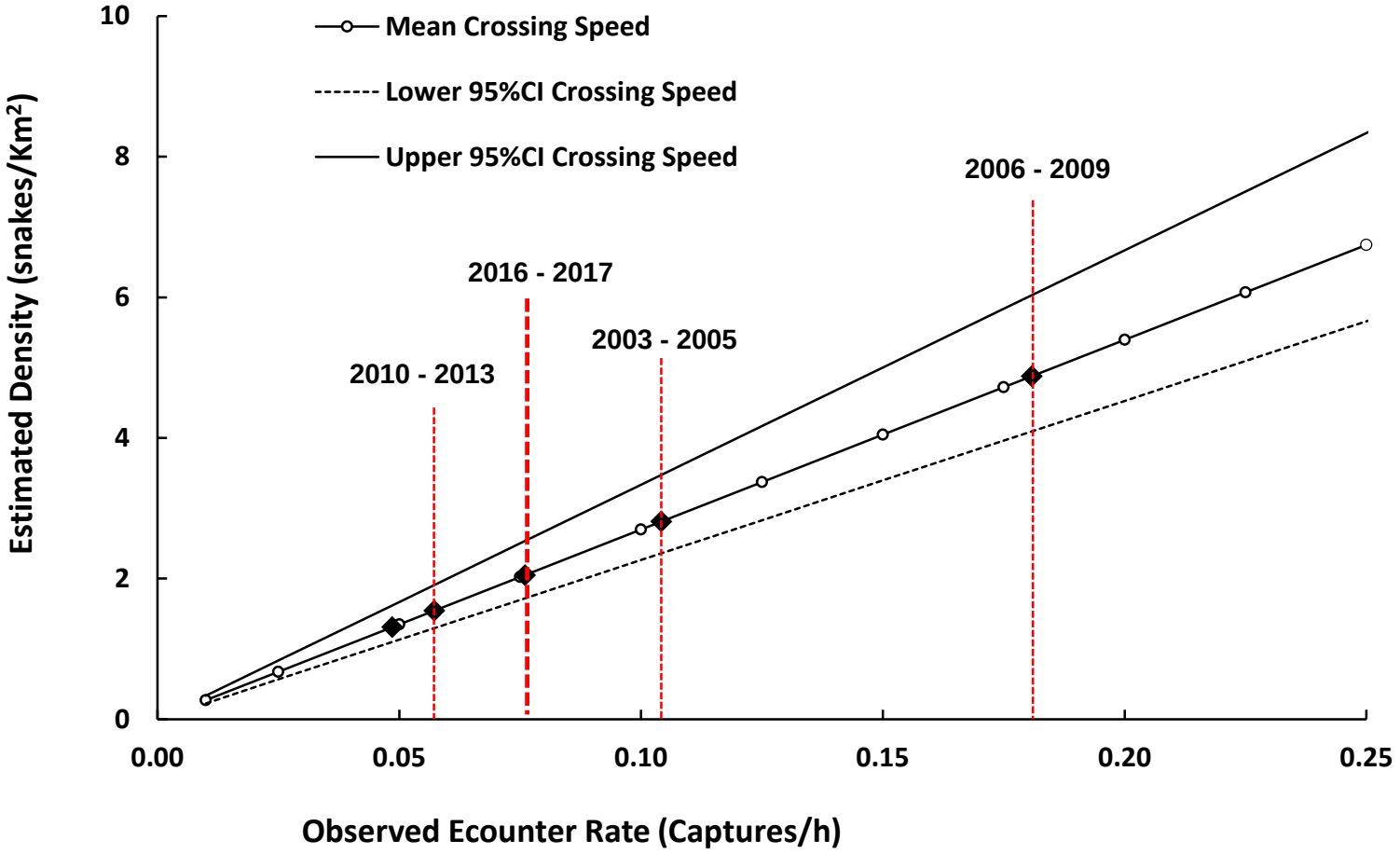
- New + Existing Data: 1 June – 30 November; 2003 - 2016
- 542 nights on Main Park Rd; 2009 h; ~90,000 km
- Capture Rate = 0.08 – 0.18 per h
- 2016-2017 = 0.08 per h





Results

- **2016-2017 estimated density of 2.05 per km^2; 0.02 per ha**



Results

- 2016-2017 estimated density of 2.05 per km^2; 0.02 per ha
- ~8,000 in Everglades NP
- ~20,000 in Everglades NP in 2006-2009
- Now spread over a much larger area of South Florida

Python Density

- Density (2 per km^2) lower than other snakes; variable over time
- Starting point for management
  - Current efforts unlikely to strongly affect populations
- Density not only driver of impacts on mammals
  - Behavioral interactions probably important

Caveats and Limitations

- Specific to area around main park road
  - Heavy collection pressure
  - Pythons might avoid or be attracted to road
  - Effects of 2010 freeze
- Uncertainty in several parameters
- Better understanding of snake behavior
  - Response to roads
  - Habitat preferences
  - Demographic differences in movement

Applications

- **Promising approach for studying poorly-understood species**
  - **Many other secretive snake species**
  - **Other species principally found on roads**
  - **Existing data sources**

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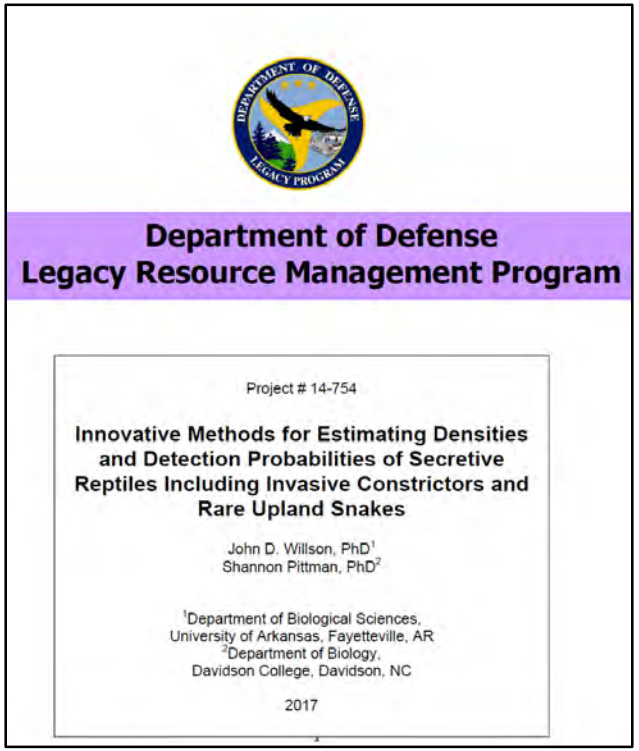

Department of Defense
Legacy Resource Management Program

Project # 14-754

Innovative Methods for Estimating Densities and Detection Probabilities of Secretive Reptiles Including Invasive Constrictors and Rare Upland Snakes

John D. Willson, PhD[1]
Shannon Pittman, PhD[2]

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University of Arkansas, Fayetteville, AR
[2]Department of Biology,
Davidson College, Davidson, NC

2017

Table 6. Suitability of snake species found on DoD lands for road-based density estimation. Table includes all species documented to occur on DoD lands in the continental United States (based on the DoD PARC Herpetofauna Database), attributes that affect their suitability for road-based density estimation (see V. Recommendations for Implementation on DoD Lands), and suitability ranking for each species (1-4 score, with 4 being most suitable). Species attributes based on literature review (Ernst and Ernst 2003) and author's expert opinion. Species most suitable for road-based density estimation are highlighted.

Latin Name	Common Name	Habitat[†]	Telemetry[†]	Road Survey[†]	Active[†]	Ranking[†]
Agkistrodon contortrix	Copperhead	T	Y	Y	N	4
Agkistrodon piscivorus	Cottonmouth	A/T	Y	Y	N	4
Arizona elegans	Glossy Snake	T/F	Y	Y	?	4
Boa constrictor	Boa Constrictor	T/Ar	Y	?	N	4
Bogertophis subocularis	Trans-Pecos Ratsnake	F	Y	Y	N	4
Carphophis amoenus	Common Wormsnake	F	N	N	N	1
Carphophis vermis	Western Wormsnake	F	N	N	N	1
Cemophora coccinea	Scarletsnake	F	N	Y	?	2
Charina bottae	Northern Rubber Boa	T/F	Y	?	N	4
Chilomeniscus stramineus	Variable Sandsnake	F	N	Y	N	2
Chionactis occipitalis	Western Shovel-nosed Snake	F	N	Y	N	2
Clonophis kirtlandii	Kirtland's Snake	A/T	?	N	?	0
Coluber bilineatus	Sonoran Whipsnake	T	Y	N	Y	0
Coluber constrictor	North American Racer	T	Y	Y	Y	3
Coluber flagellum	Coachwhip	T	Y	Y	Y	3
Coluber lateralis	Striped Racer	T	Y	Y	Y	3
Coluber schotti	Schott's Whipsnake	T	Y	Y	Y	3
Coluber taeniatus	Striped Whipsnake	T	Y	Y	Y	3
Contia tenuis	Common Sharp-tailed Snake	F	N	N	N	1
Crotalus adamanteus	Eastern Diamond-backed Rattlesnake	T	Y	Y	N	4
Crotalus atrox	Western Diamond-backed Rattlesnake	T	Y	Y	N	4
Crotalus cerastes	Sidewinder	T	Y	Y	N	4
Crotalus cerberus	Arizona Black Rattlesnake	T	Y	Y	N	4
Crotalus horridus	Timber Rattlesnake	T	Y	Y	N	4

Applications

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  - **Other species principally found on roads**
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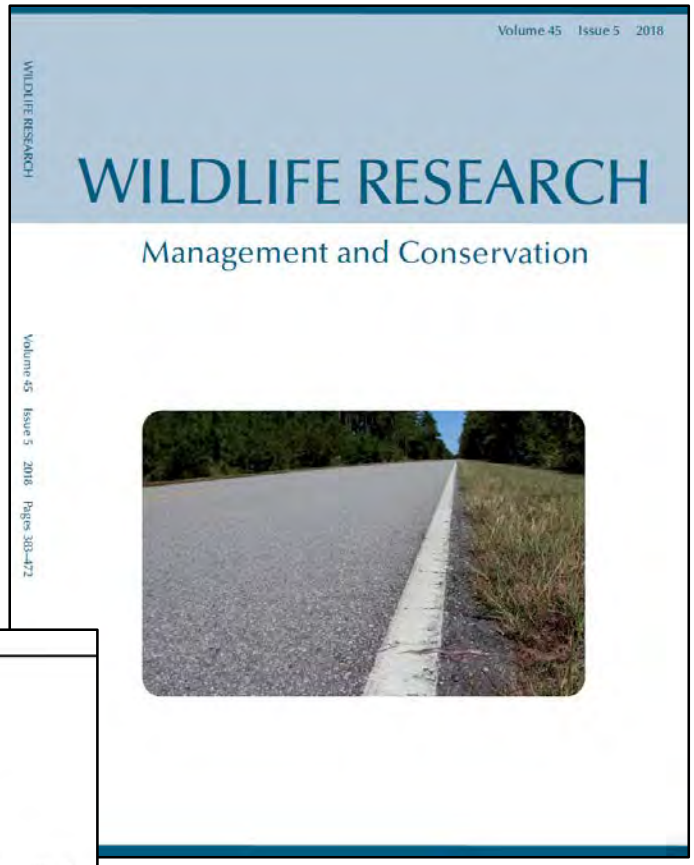

CSIRO PUBLISHING
Wildlife Research, 2018, **45**, 446–456
https://doi.org/10.1071/WR16175

A novel approach for estimating densities of secretive species from road-survey and spatial-movement data

John D. Willson[A,E], *Shannon E. Pittman*[B], *Jeffrey C. Beane*[C] *and Tracey D. Tuberville*[D]

www.willsonlab.com

Applications

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  - **Existing data sources**
- **Current ESTCP project (U. Illinois; CERL; J. Sperry, B. Degregorio)**



	Ratsnake Fort Hood (FH)	Eastern Diamondback Fort Stewart (FS)	Southern Hognose FS & North Carolina (NC)
Road Surveys	Existing (FH)	New (FS)	New (FS)
Road Behavior	New (FH)	New (FS)	Existing (NC)
Radiotelemetry	Existing (FH)	New (FS)	Existing (NC)
Capture-mark-recapture (CMR)	Existing (FH)	New (FS)	New (FS)
Validation (compare CMR/IDEASS)	Yes	Yes	Yes

Applications

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Applications

- Promising approach for studying poorly-understood species
  - Many other secretive snake species
  - Other species principally found on roads
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- Current ESTCP project
- Model Development
  - Better understanding of snake behavior, especially response to roads
  - More spatially-explicit analyses
  - Inclusion of road-kills?

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***P. molurus*:**
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