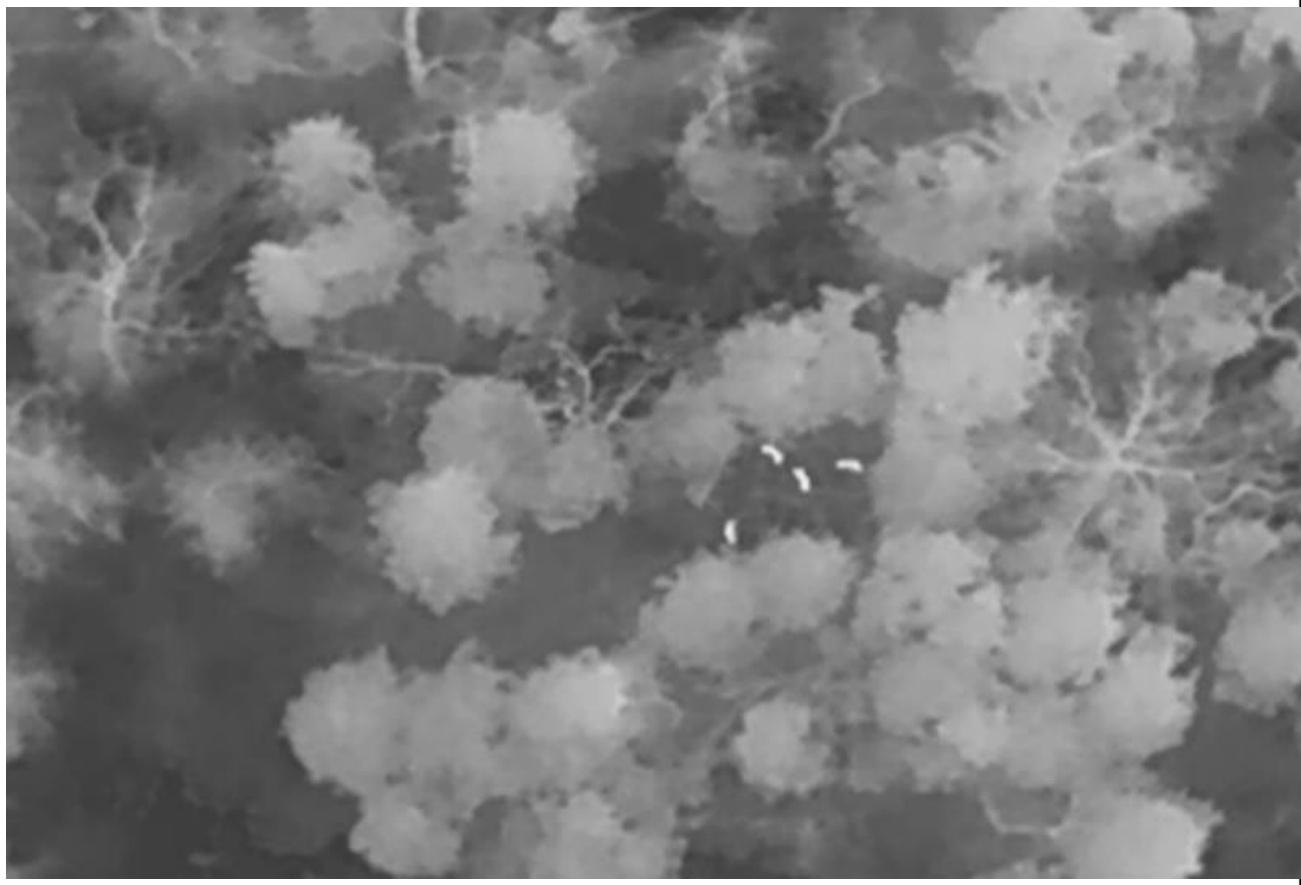
Assessing Deer Populations in Northern NJ



April 16, 2025
NJ Invasive Species Strike Team Conference

Jay F. Kelly, Ph.D.
Center for Environmental Studies, Raritan Valley Community College

White-Tailed Deer Population Trends

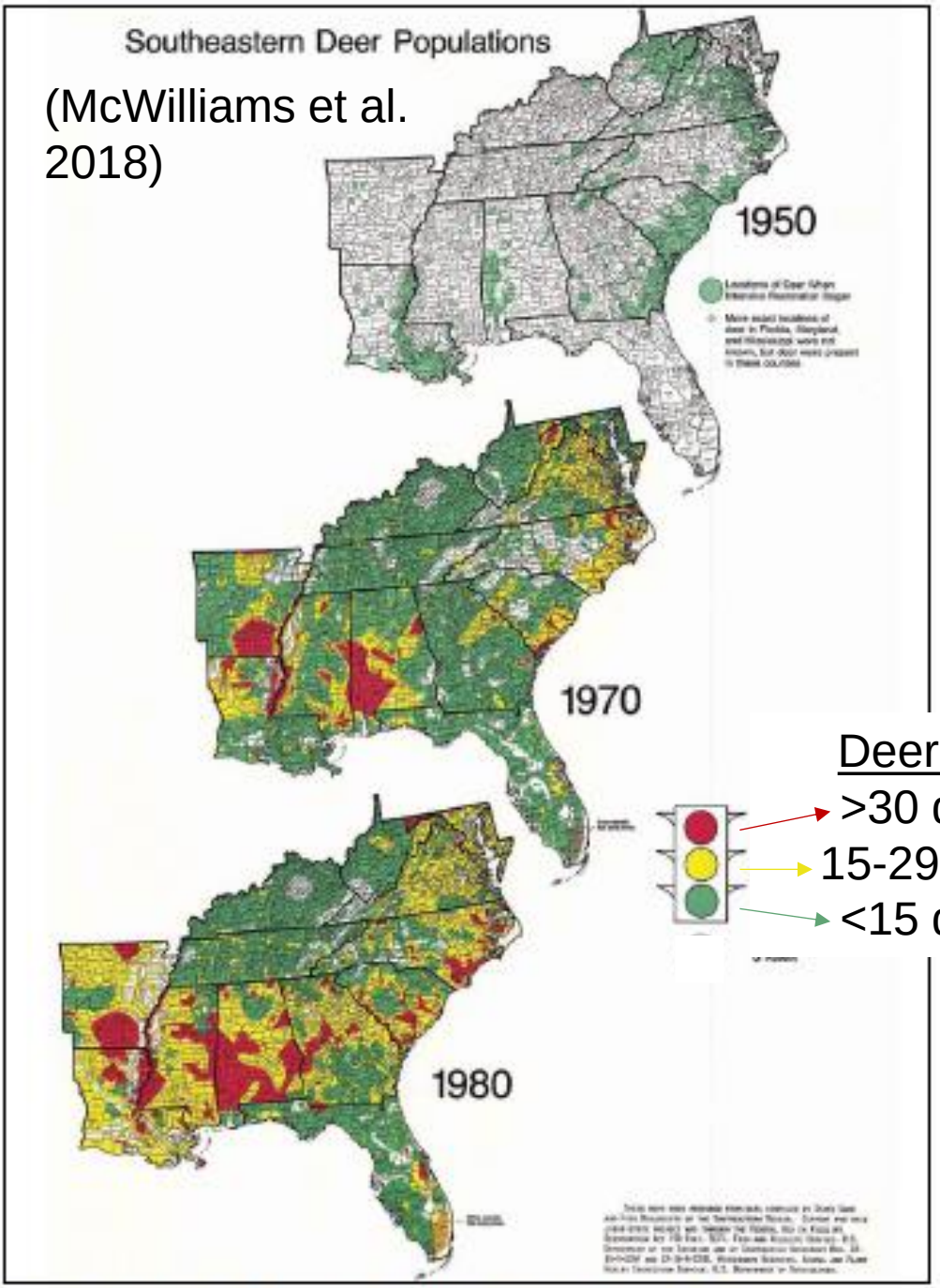
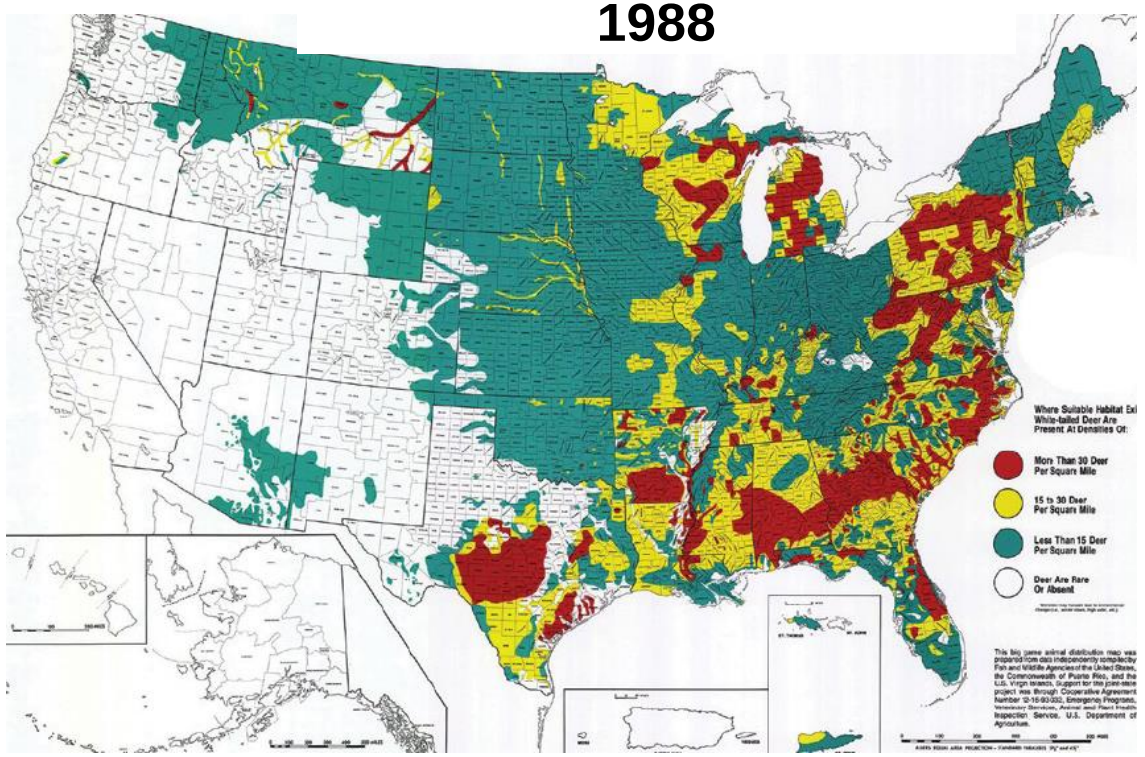


Figure 2.—White-tailed deer population density, southern United States, 1950, 1970, and 1980 (Southeastern Cooperative Wildlife Disease Study [University of Georgia, n.d.], used with permission).

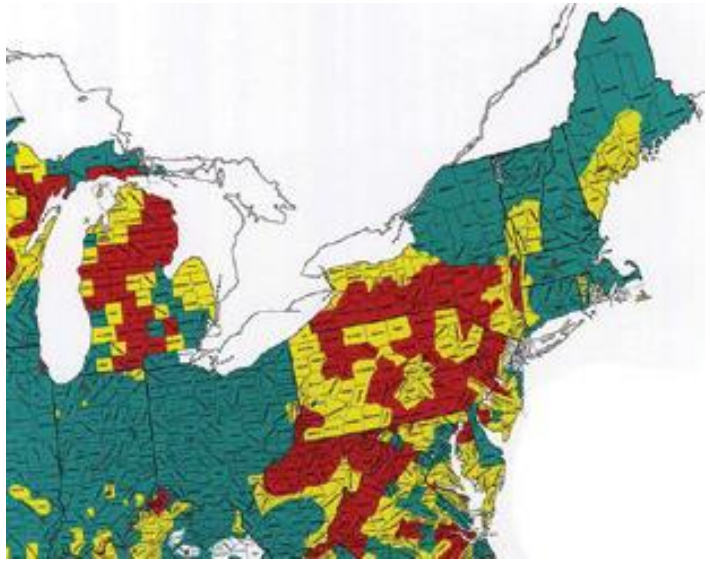
1988



Reasons for Deer Population Growth

1. Extermination of Predators
2. Cessation of Commercial Hunting
3. Increased Food/Refugia – Suburban/Ag.
4. Warming Winters

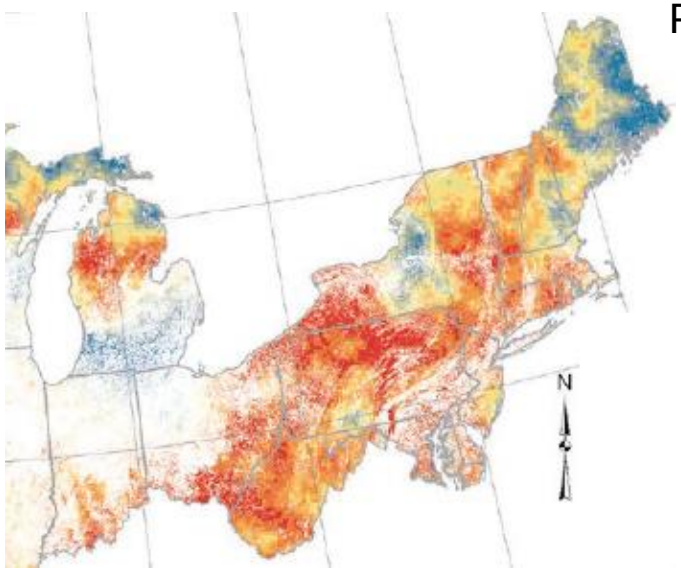
Priorities for Forest Restoration



Deer Density
- >30 deer/mi²
- 15-29 deer/mi²
- <15 deer/mi²

McWilliams et al. (2018)

#1: Deer Browse = Deficits in tree regeneration and native understory cover



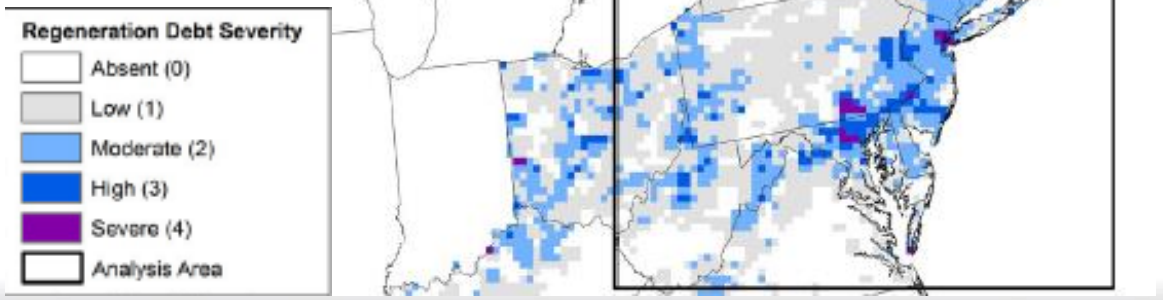
Probability of Moderate/High Browse

41 – 50 | 51 – 60 | 61 – 70 | 71 – 80 | 81 – 90 | 91 – 100

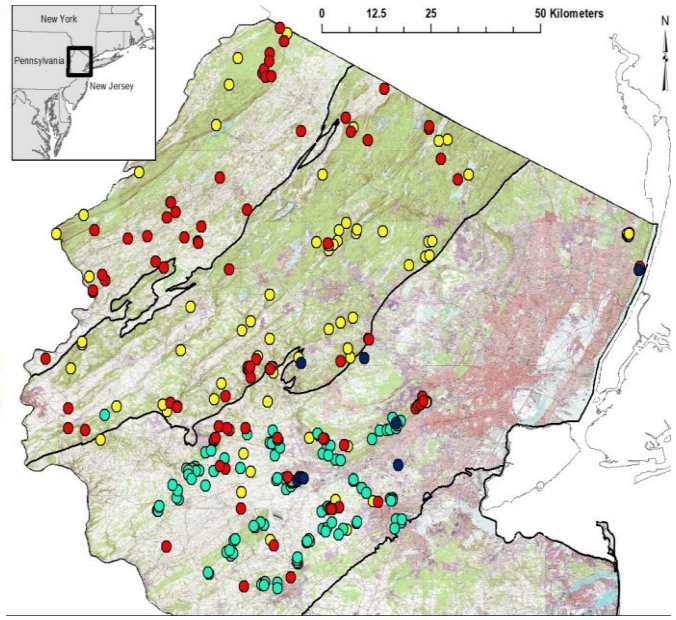
Moderate/High Browse in 79% Forests in Mid-Atlantic

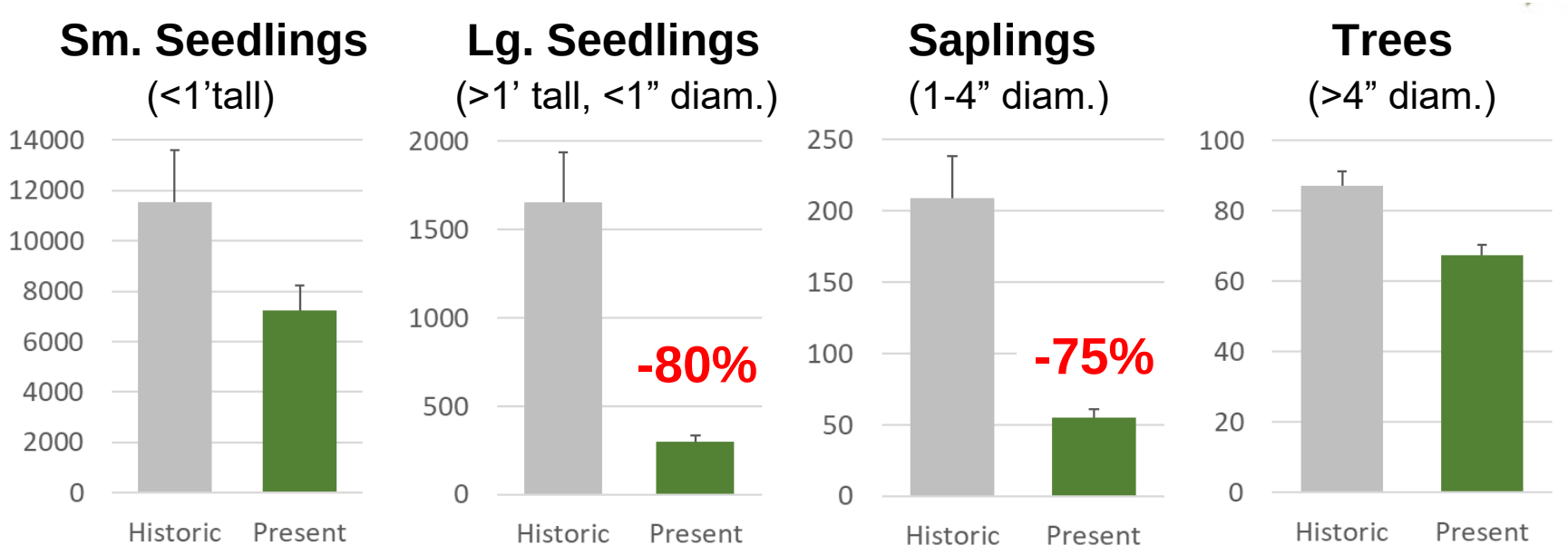
Miller and McGill (2019)

Regeneration Deficits in >50% Forests

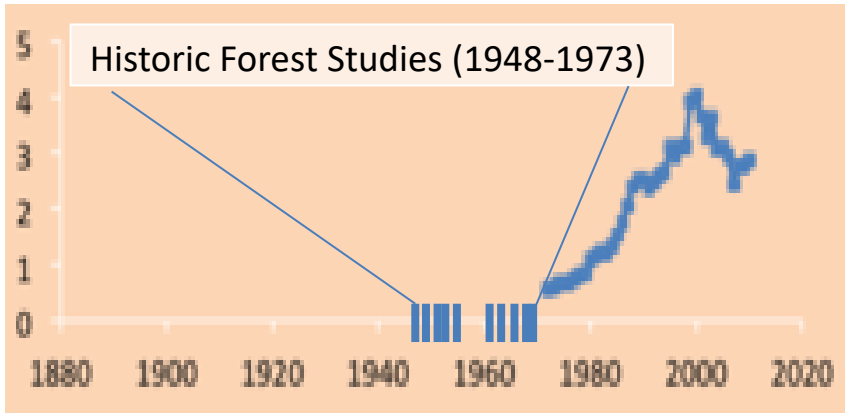


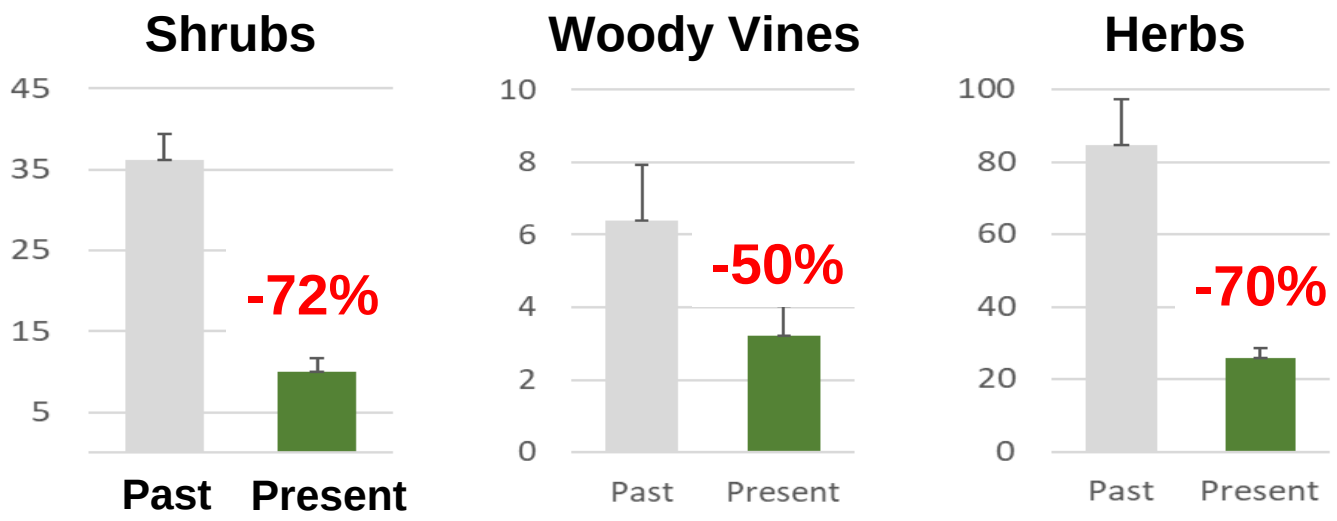
Major Declines in Native Understories in NJ Since Mid - 1900s





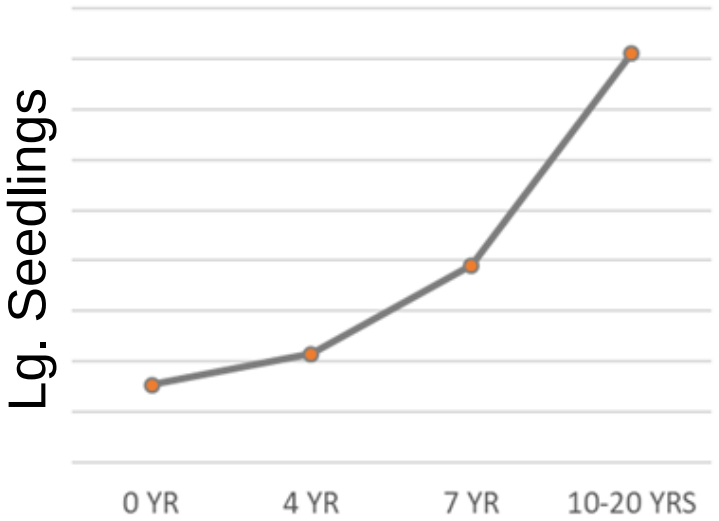
23 Historical Studies = 62 Plots Revisited



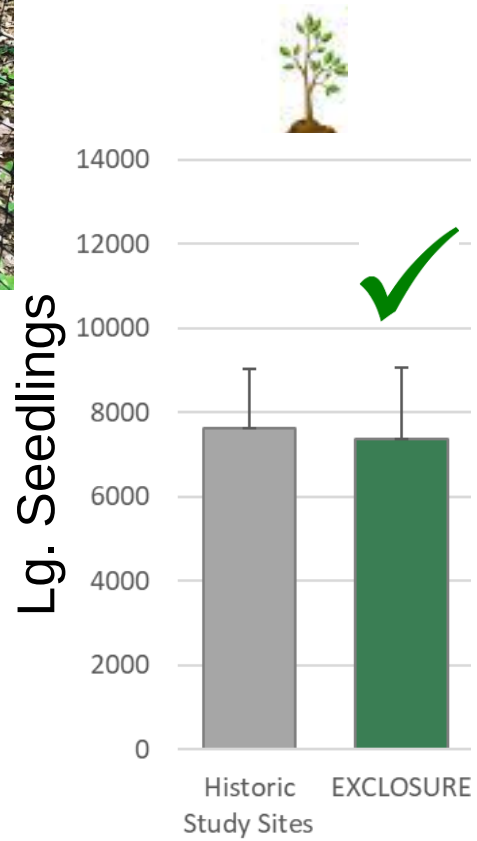


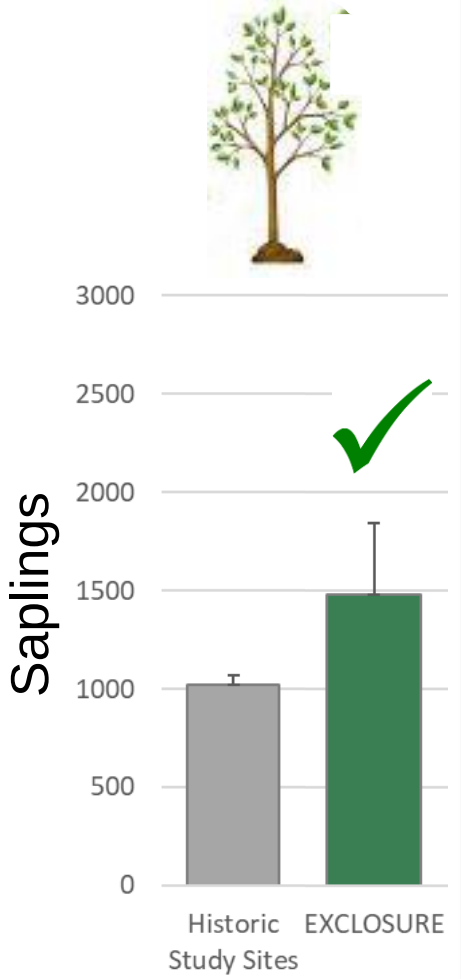
(Kelly 2019)

Establishing Causation - *Long-Term, Large Deer Exclosures*



(after 15+ years…)

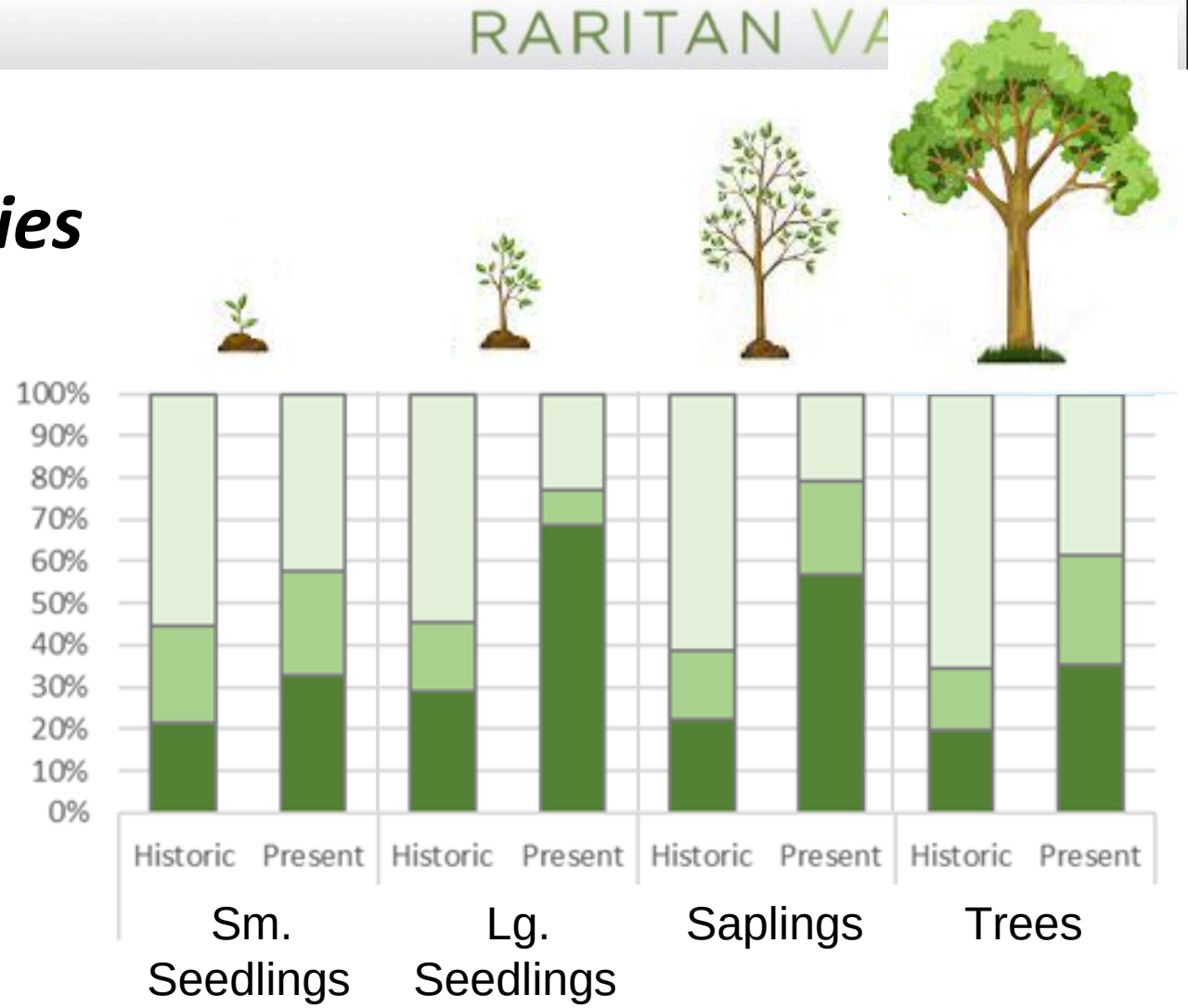




(Kelly 2019, Almendinger et al. 2020, Kelly and Ray 2020)

Shifting Species Composition – *Increases in Browse-Resistant Species*

Selective Regeneration (Kelly 2019)



Decreased:
(Oaks, Dogwood, Hemlock)

Browse-Resistance:

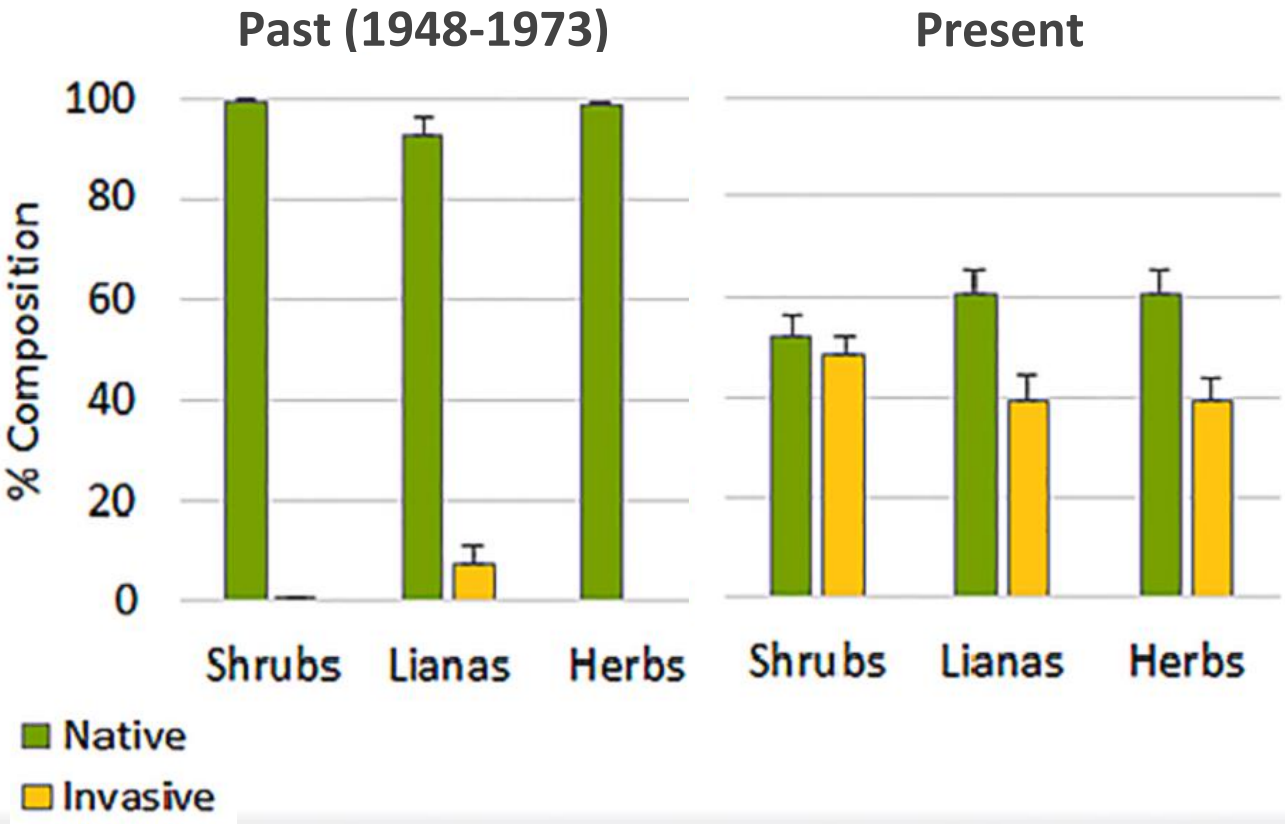
Low **Medium** **High**

Increased:
(Birches, Hickories, Ironwood, Hornbeam)

Priorities for Forest Restoration

#2: Shifting Plant Species Composition –

Increased Invasive Plant Species



Species	Max. %Cover Past	Present
Japanese Barberry	1%	49%
Privet	2%	32%
Multiflora Rose	4%	83%
Japanese Wineberry	<1%	46%
Japanese Honeysuckle	19%	95%
Moneywort	2%	39%
Japanese Stiltgrass	*NA*	*66%*
Oriental Bittersweet	*NA*	*50%*
Linden Arrowwood	*NA*	*38%*
Oriental Photinia	*NA*	*44%*
Autumn Olive	*NA*	*59%*
European Buckthorn	*NA*	*21%*

(Kelly 2019; Kelly and Ray 2023)

Priorities for Forest Restoration

#3: *Land Use History Effects*

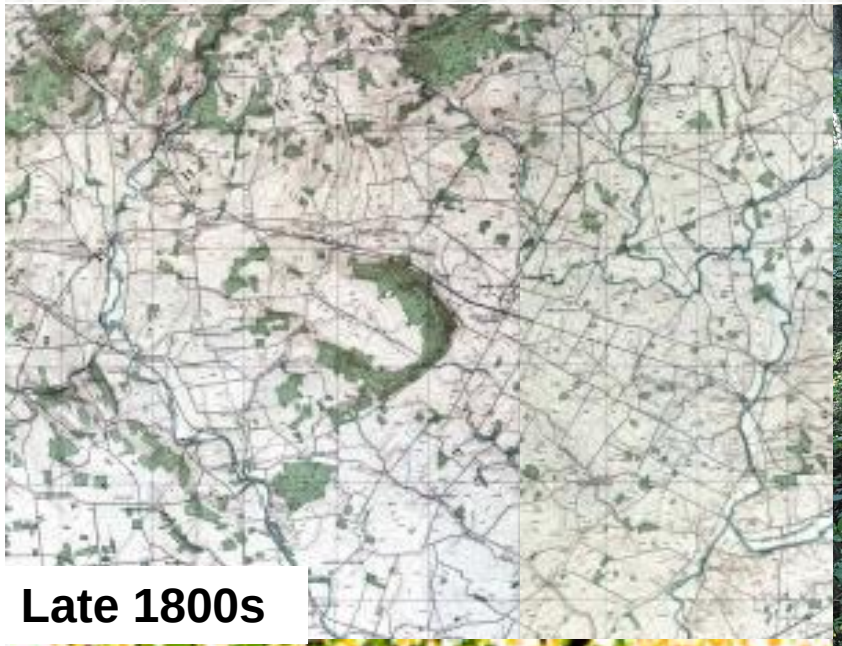
Forest Cover Late 1800's

Forest Cover 2015

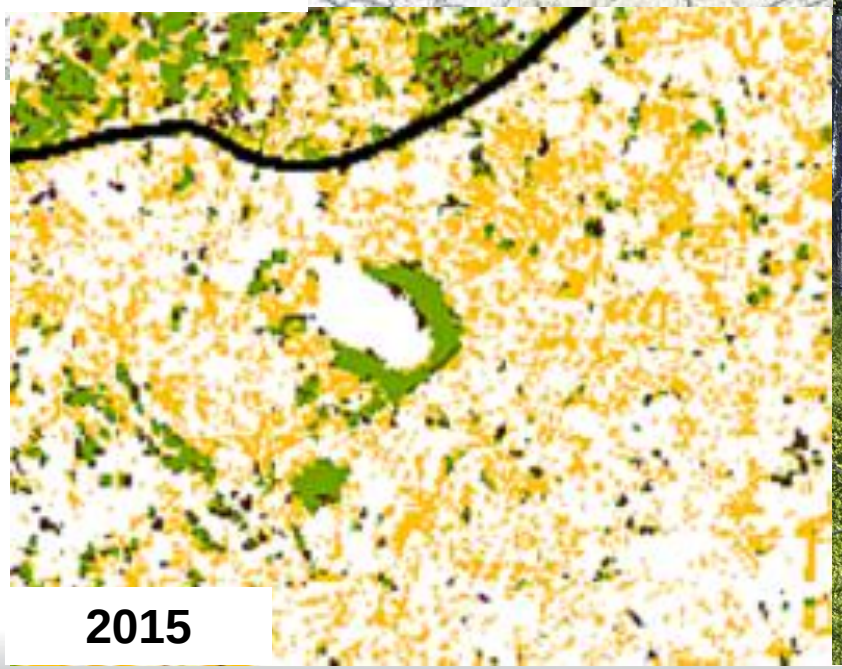
Post-Agricultural Forest =

46% of Forestland (1,407 km^2)

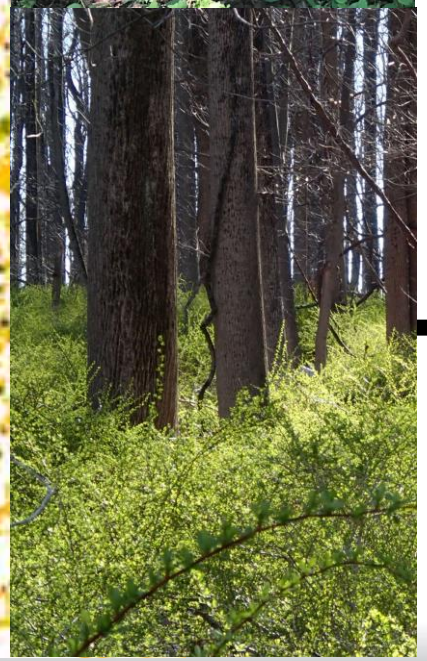
Natives vs. Invasives by Land Use History



Late 1800s

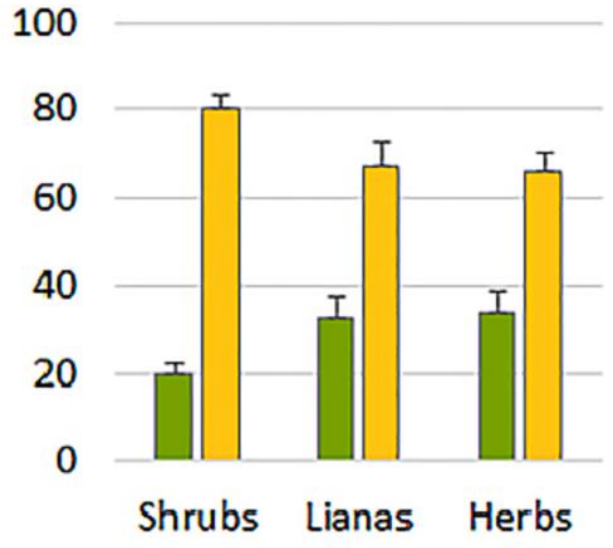


2015



Primary Forests -

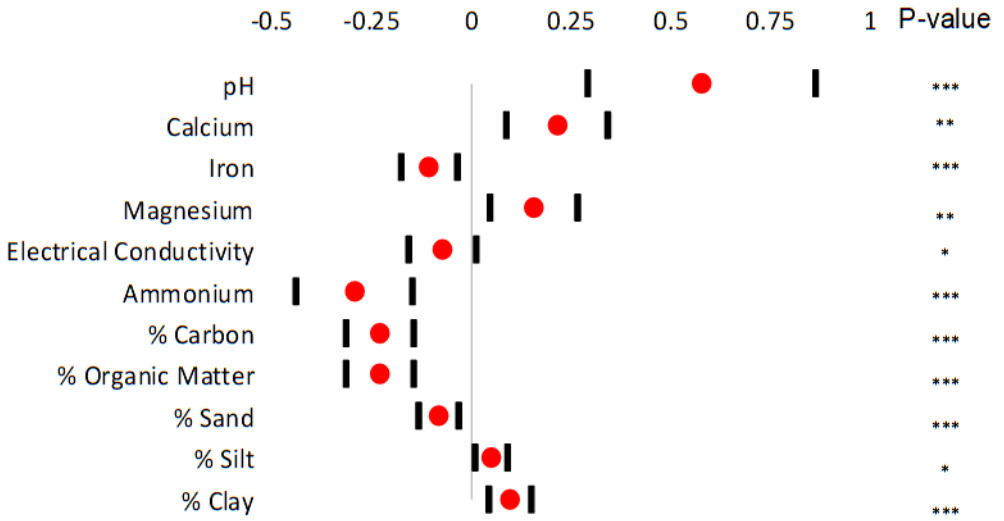
Post-Ag Forests

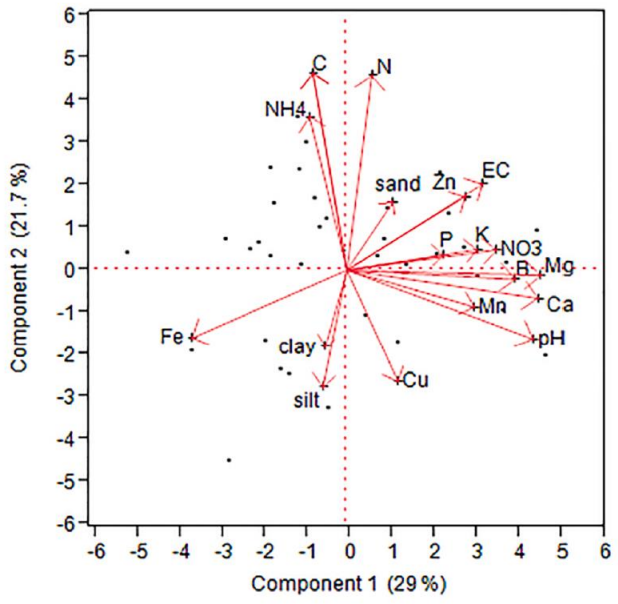


(Kelly 2019,
Kelly & Ray 2023)

Comparing Soils in Primary vs. Post-Agricultural Forests

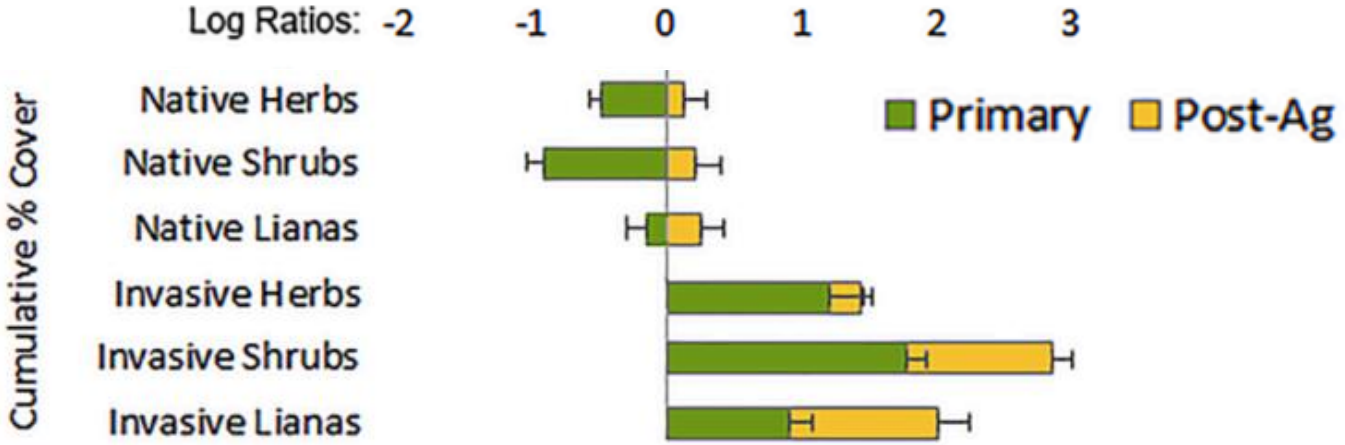
(e.g., 50% less Carbon…)





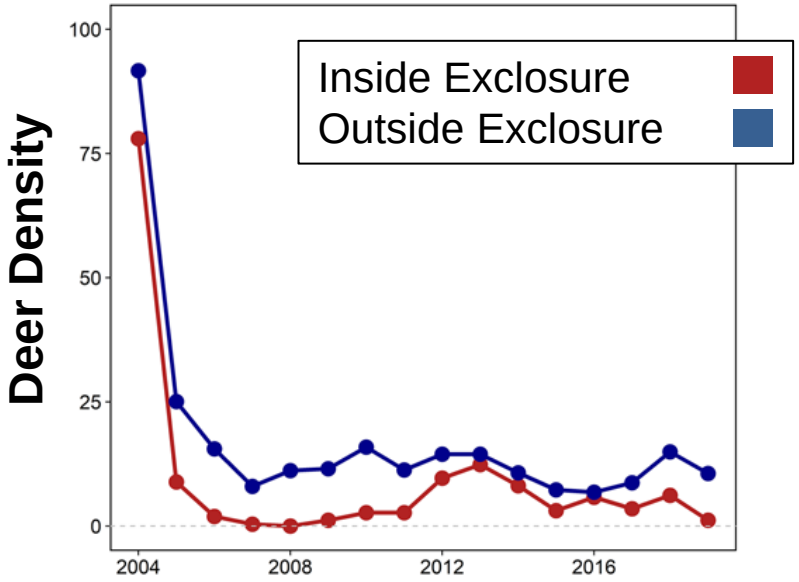
Kelly & Ray (2023)

Additive Effects of Deer Browse and Ag. Land Use History

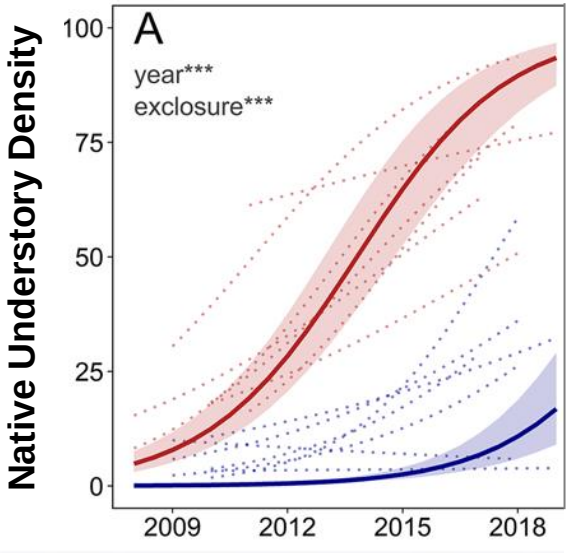


Significant Declines in Native Species & Significant Increases in Exotic, Invasive Species

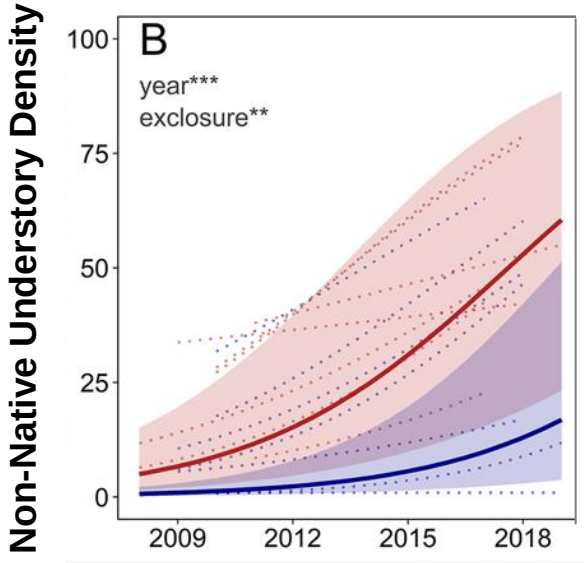
Establishing Causation – *Duke Farms* (Almendinger et al. 2020)



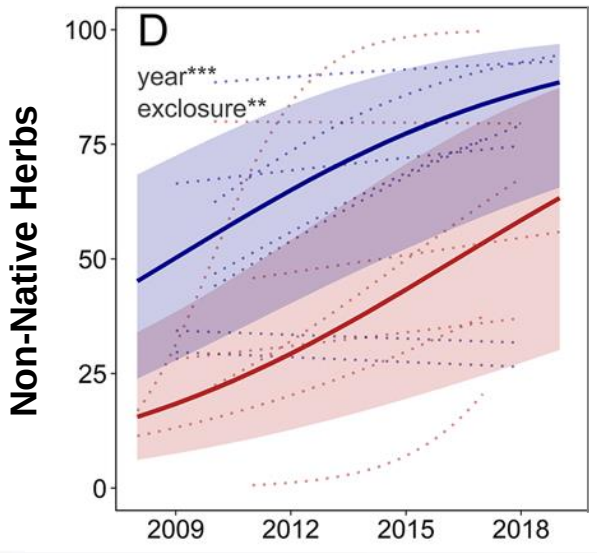
Native



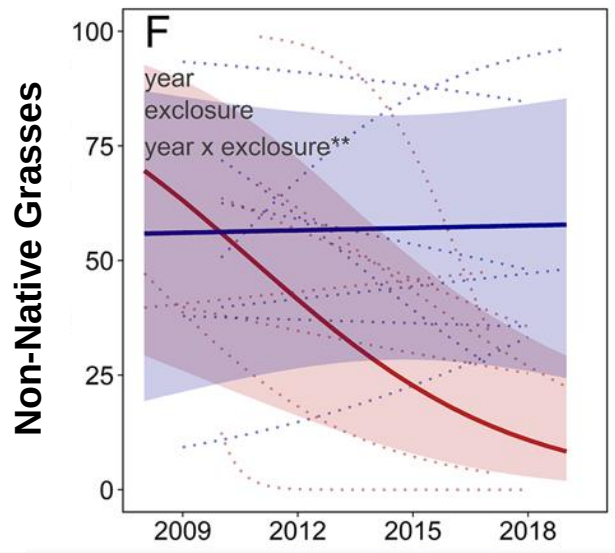
Non-Native



Non-Native Herbs



Non-Native Grasses



Deer Population Benchmarks

>10 deer/mi²
impacts preferred browse species

>15 deer/mi²
impacts to tree regeneration

>20 deer/mi²
impacts to wildlife, food web effects

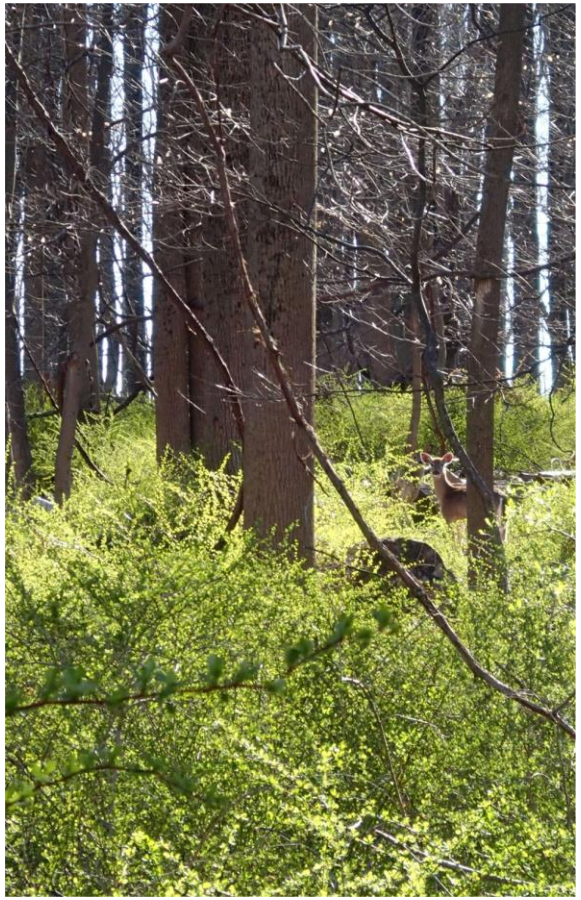
(Drake et al. 2002, Almendinger et al. 2020, Russell et al. 2017)

Historic: **8-11 deer/mi²**

Healthy forest with dense understory vegetation and native plant species.

NJDEP (1999): **38 (13-76) deer/mi²**

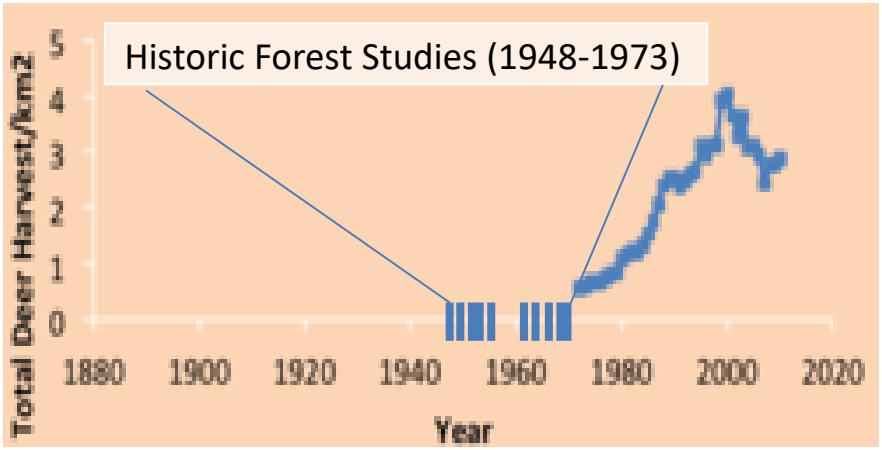
Overbrowsed forest at Hutcheson Memorial Forest in Franklin Township (2012)

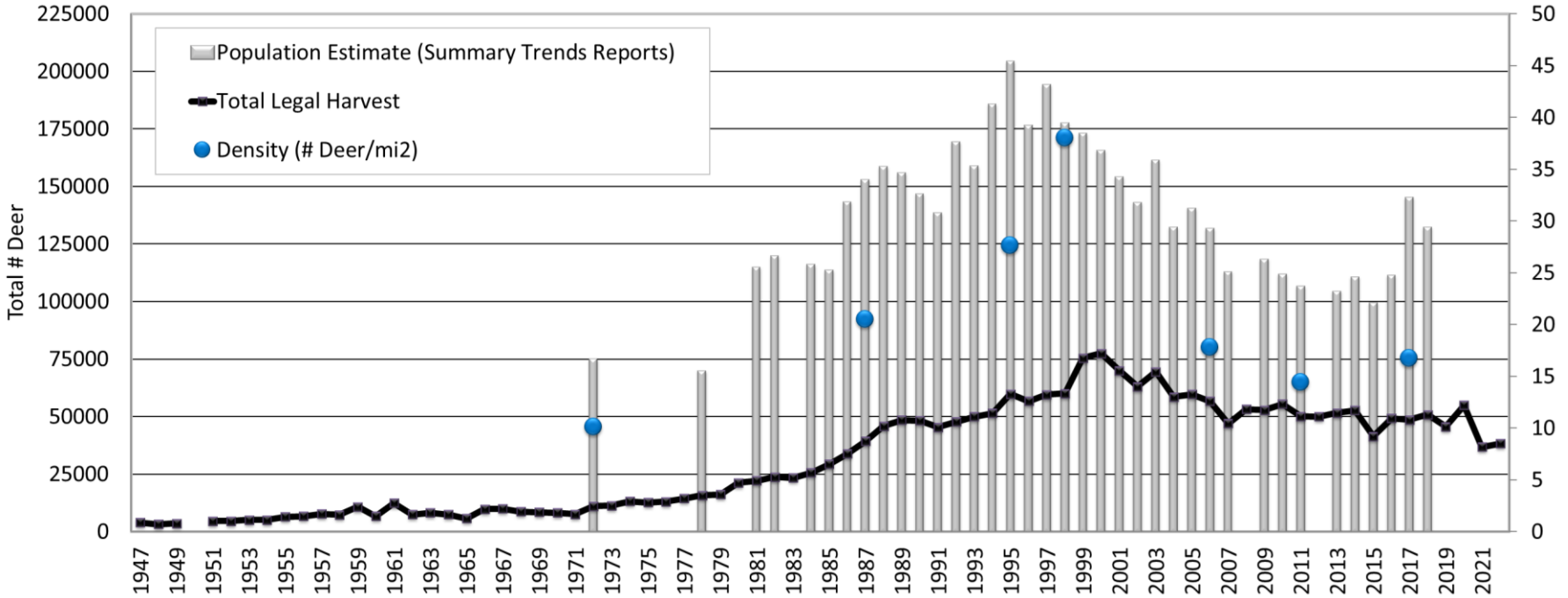


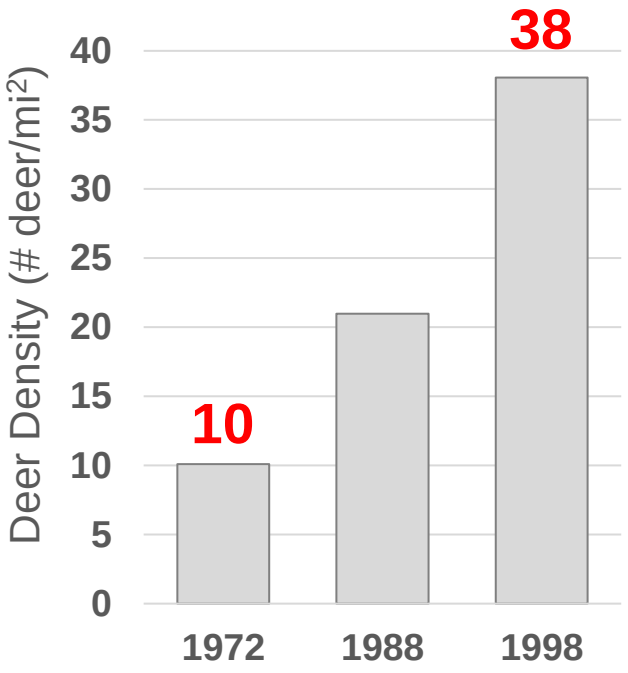
Overbrowsed forest with invasive barberry shrubs at Peter's Tract in Bernardsville (2016)

How many deer are/were there in NJ…?

1. Are past & present deer population and density estimates accurate?
2. What densities exist(ed) in northern NJ where our forest research was conducted?



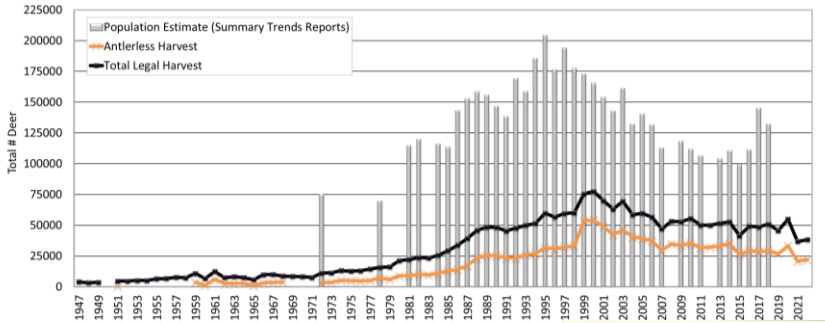




Down the Rabbit Hole…

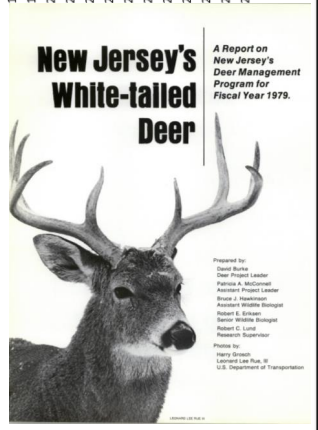
"average minimum statewide deer density"

$$= \frac{\text{Estimated pre-harvest deer population}}{\text{Total "deer range" or area of huntable lands}}$$



"minimum statewide deer population"

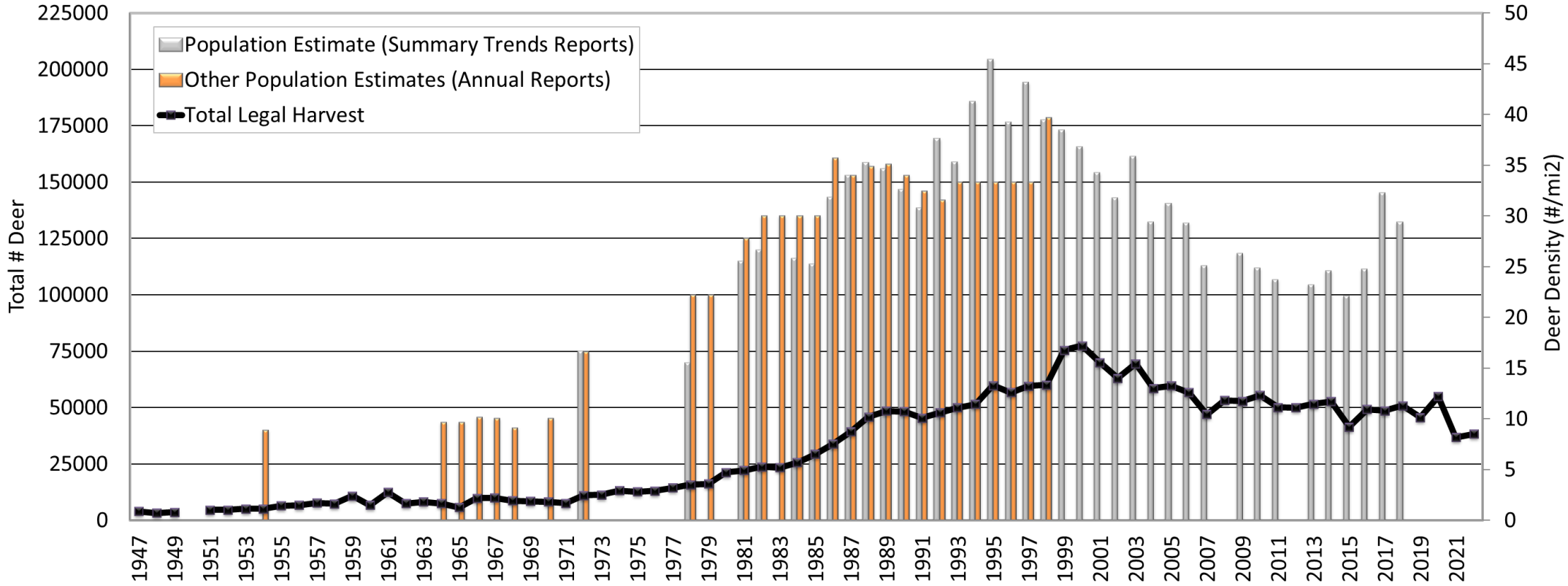
based on annual known mortality (from deer harvest *only*)
estimate of hunted population size prior to hunting (late summer)
[developed from system used in PA (NJDEP 1978)]



Adult males (calculated using buck harvest and age structure)
\+ # Adult females (use male & female age structures to determine male/female ratio, then multiply by number of bucks in herd)
\+ # Fawns (harvest and female gestational data)

= Minimum pre-harvest deer population

Fuzzy Numerators: "*Minimum Deer Population Size*"



Two methods differing in fawn production estimates yield:

114,850 and 101,150 deer (13,700 or 14% difference)(NJDEP 1982)

Third method used in 1982 predicting reproductive rates from yearling male antler beam:

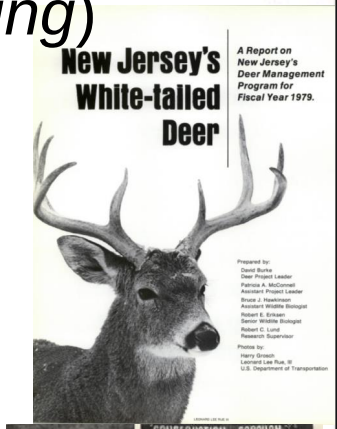
119,898, 110,998 and 125,290 (14292 or 13% difference)(NJDEP 1983)

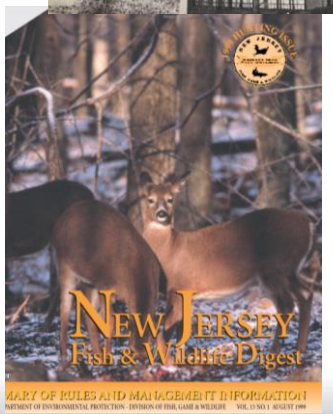
Fuzzy Denominators: "Deer Range" (i.e., *Area subject to hunting*)

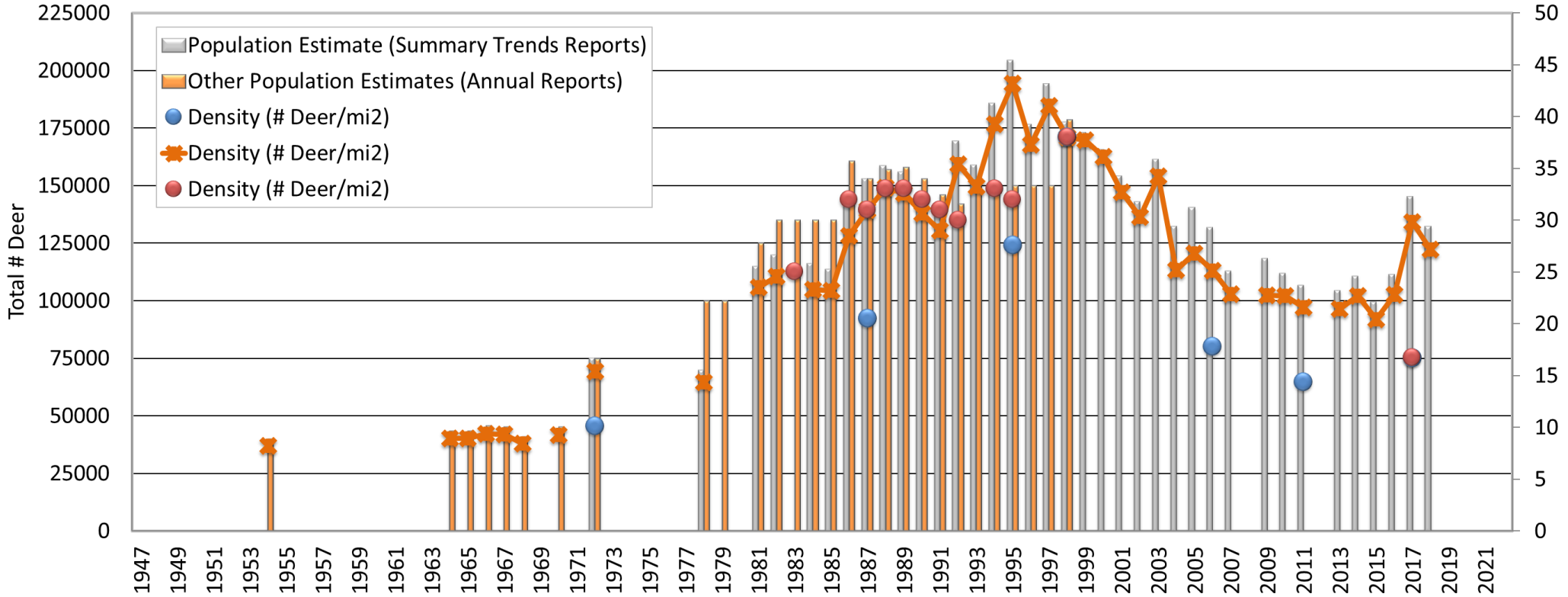
Deer range = agricultural + woodlands (excludes developed, water, beaches and marshlands)(NJDEP 1977)

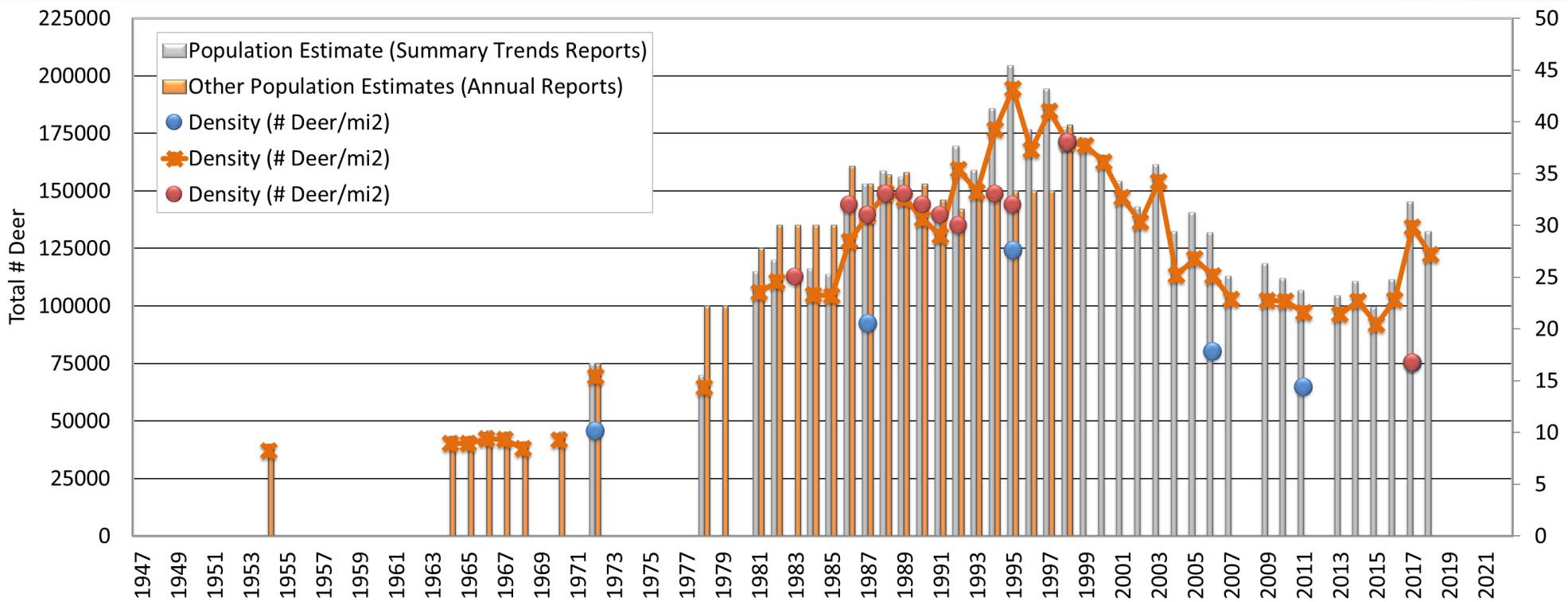
32,719 ± 246 sq mi. of deer range (NJDEP 1984-2012)

= 66% of total NJ land area









Are past/present reported deer densities accurate…?

10.1 deer/mi^2 in 1972 (SC and FoHVOS 2014)

20.5 deer/mi^2 in 1987 (Van Clef 2004)

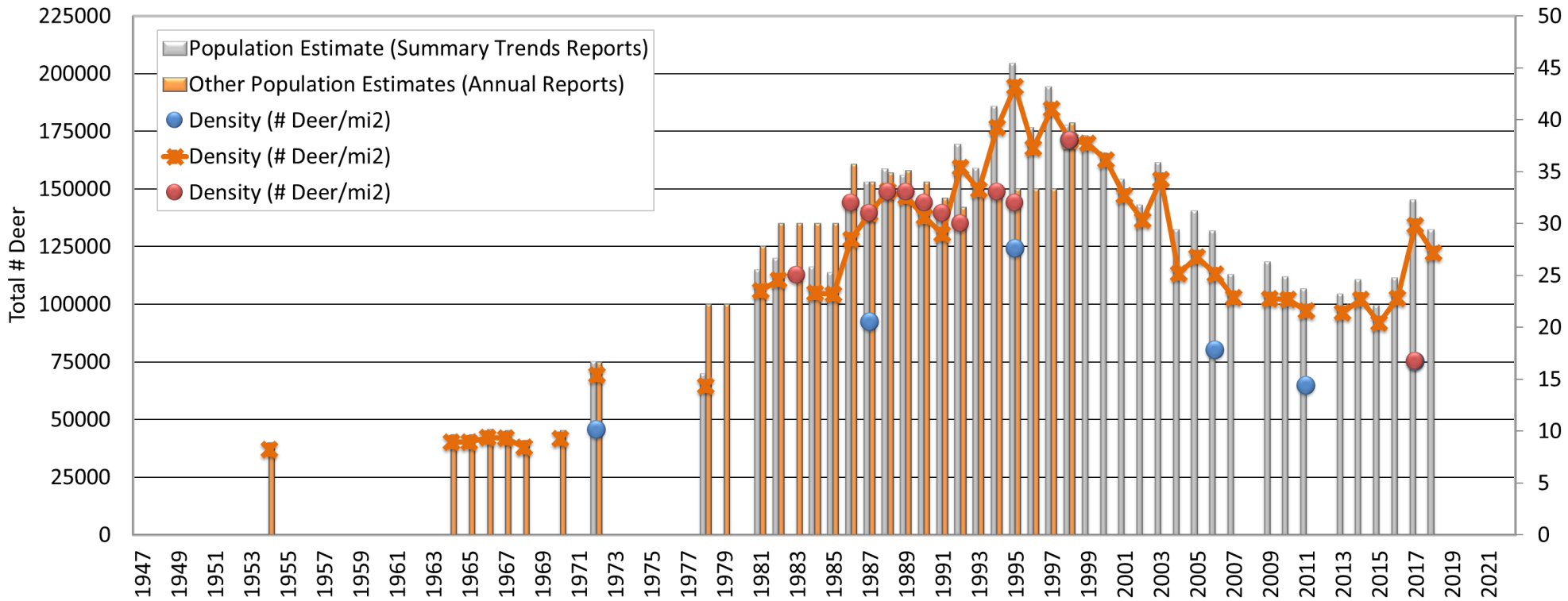
27.6 deer/mi^2 in 1995 (SC and FoHVOS 2014)

38.0 deer/mi^2 in 1998 (NJDEP 1999)

17.8 deer/mi^2 in 2006 (NJ Invasive Species Council 2009)

14.4 deer/mi^2 in 2011 (SC and FoHVOS 2014)

16.7 deer/mi^2 in 2017 (NJDEP 2019)



Are past/present deer densities accurate…? ***Nope…*** **Deer range ≠ NJ Land Area**

~~10.1~~ deer/mi² in 1972 (SC and FoHVOS 2014) → 15 deer/mi²

~~20.5~~ deer/mi² in 1987 (Van Clef 2004) → 31 deer/mi²

~~27.6~~ deer/mi² in 1995 (SC and FoHVOS 2014) → 43 deer/mi²

38.0 deer/mi² in 1998 (NJDEP 1999) → 38 deer/mi²

~~17.8~~ deer/mi² in 2006 (NJ Invasive Species Council 2009) → 25 deer/mi²

~~14.4~~ deer/mi² in 2011 (SC and FoHVOS 2014) → 22 deer/mi²

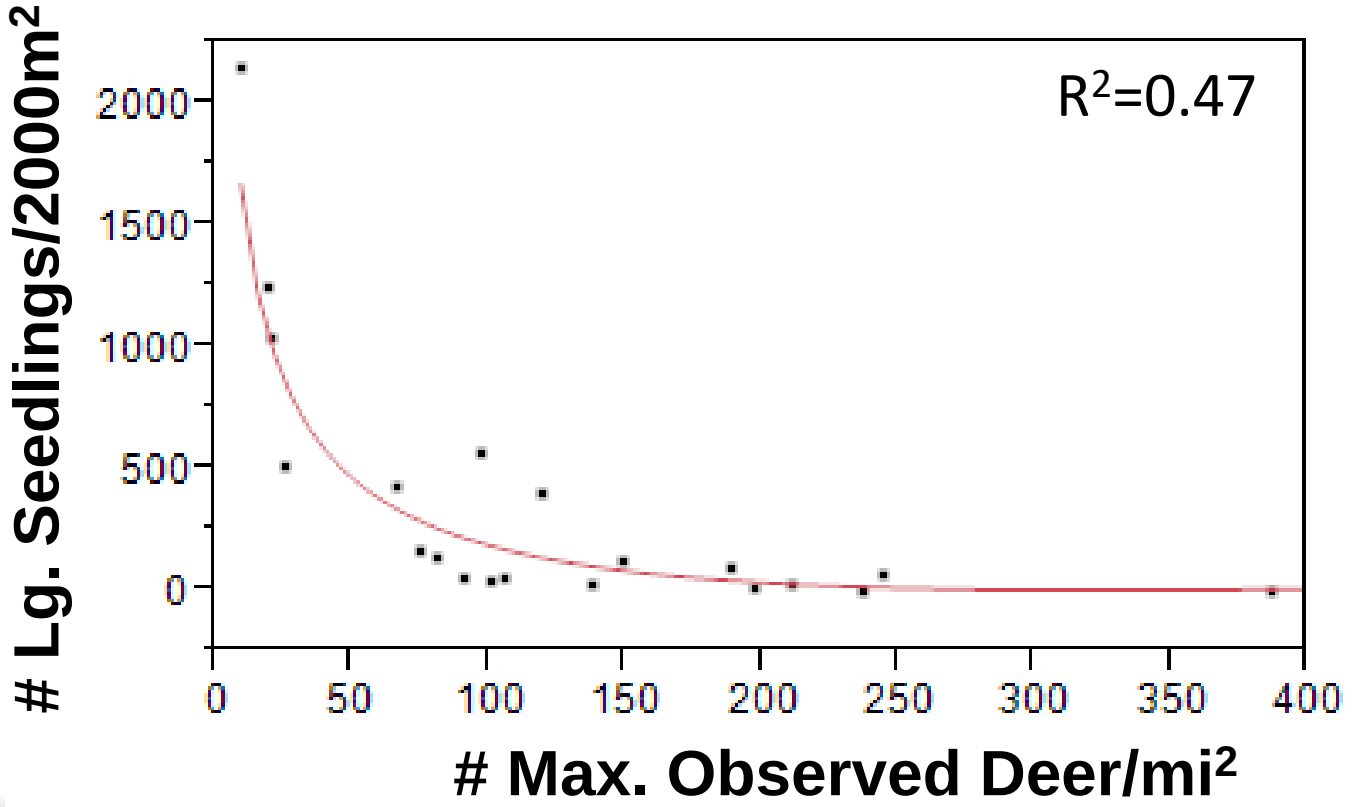
~~16.7~~ deer/mi² in 2017 (NJDEP 2019) → 30 deer/mi² (NJ Land + Water…)

Why not just count the deer…?

RVCC Spotlight Surveys 2015-2018

Drake et al. (2005) – Duke Farms

Comparable results of spotlight and infrared



Spotlight Surveys –

Location	Year	Density	Range	Standard Deviation as % Mean
Watchung	2019	61±15	(47-76)	25%
	2018	41±12	(29-53)	29%
Raritan	2019	112±13	(99-124)	12%
	2018	81±13	(68-95)	16%
Readington	2019	132±39	(93-170)	30%
Princeton	2015	36±11	(27-48)	31%
(deNicola	2014	45±17	(31-65)	38%
Unpubl.data)	2011	39±27	(20-74)	69%

Solebury, PA (USDA)

Survey Period	Average Deer Density Estimate	Population Estimate
2006-2007	155 deer/square mile	4,121
2007-2008	99 deer/square mile	2,633
April 2008	86 deer/square mile	2,287
October 2008	42 deer/square mile	1,117
2009-2010	112 deer/square mile	2,979
2010-2011	120 deer/square mile	3,192
March 2012	141 deer/square mile	3,750
March 2013	162 deer/square mile	4,276
March 2014	167 deer/square mile	4,415
March 2015	126 deer/square mile	3,338
March 2016	197 deer/square mile	5,211
March 2017	146 deer/square mile	3,860
March 2018	169 deer/square mile	4,453
March 2019	189 deer/square mile	4,992

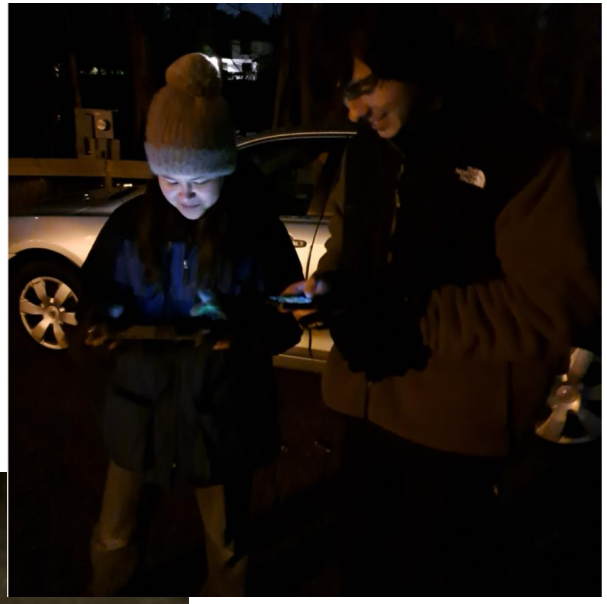
Plot-Based Sampling

Distance Sampling

Average = ± 31% of Mean*!!!*

Average = ± 24% of Mean

Infrared sUAS Deer Surveys



<u>Methods</u>:

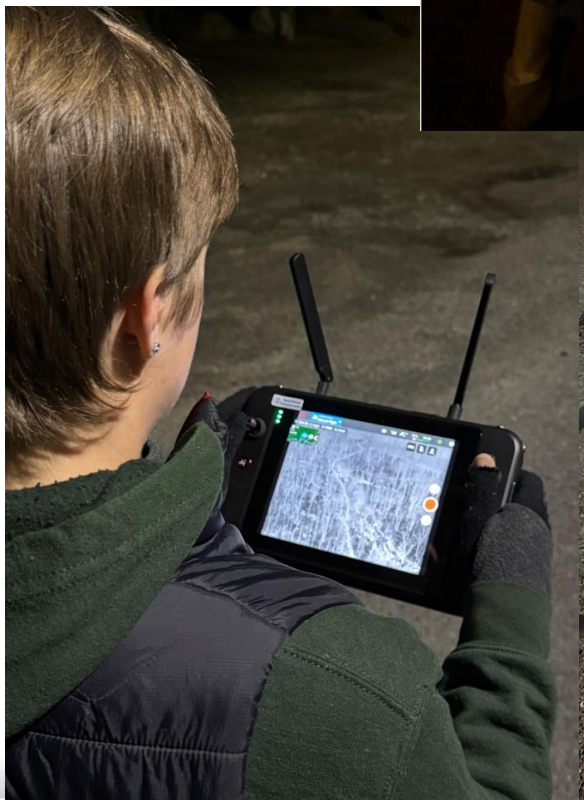
Consecutive Nights

Weather Conditions
(No Precip, Winds <15 mph, >20^{o}F)

FAA Remote Pilot License (w/Certified Visual Observers)

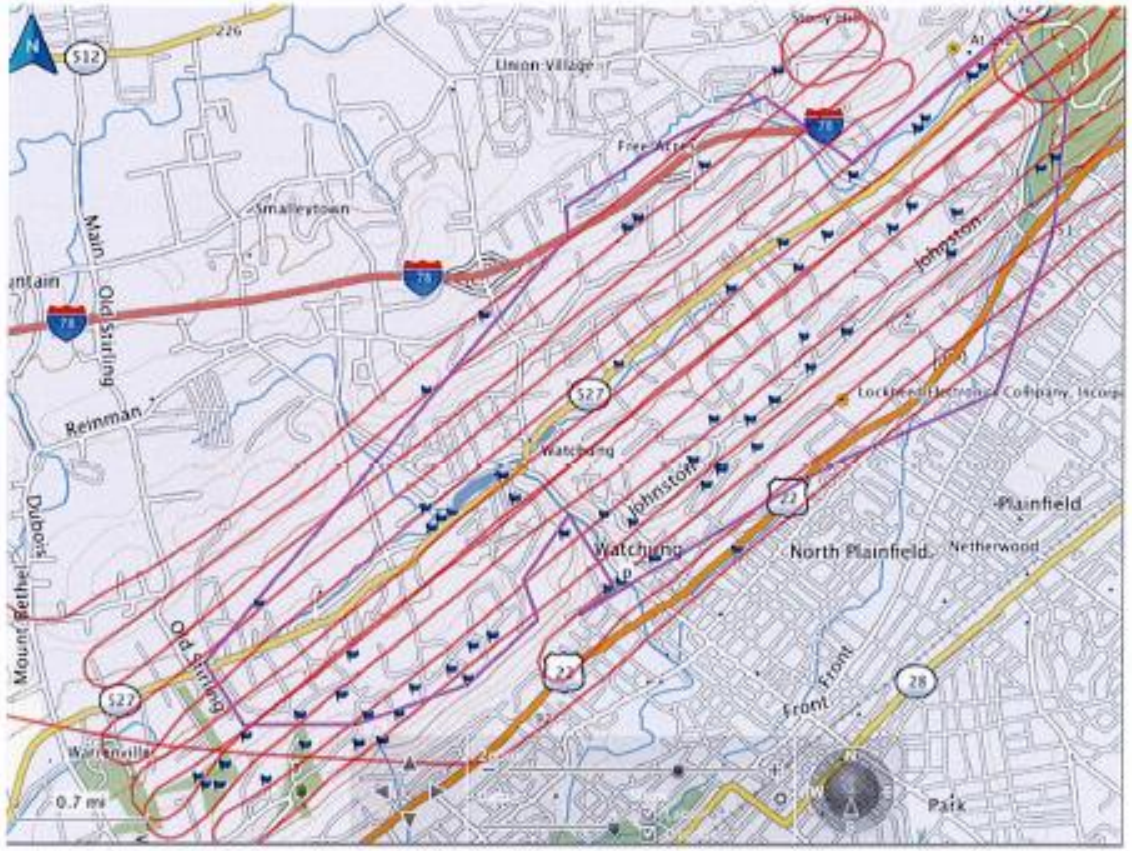
Autel Evo II Dual Drone, w/FLIR 640 Thermal Sensor

Class G Airspace, <400’ Above Ground

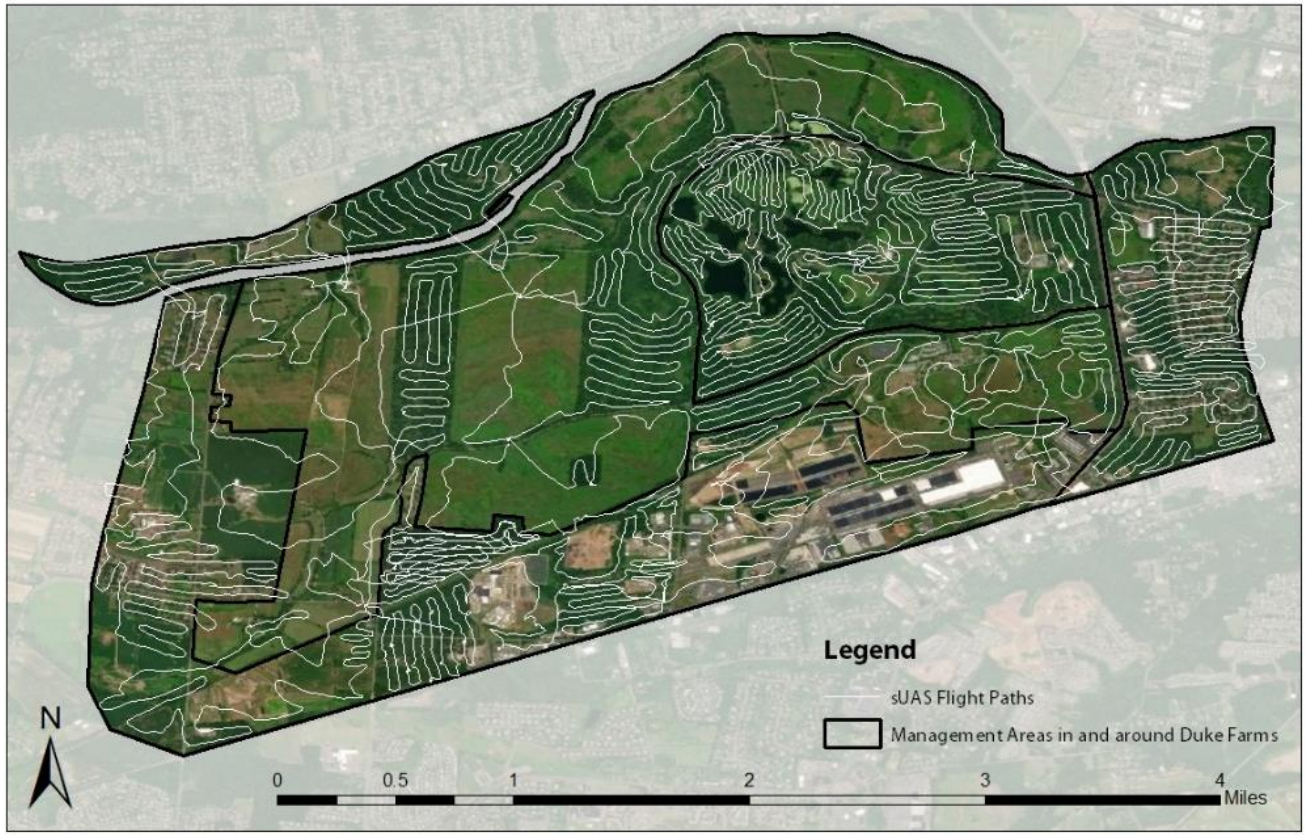


Complete Spatial Coverage – Fixed Wing vs. Drone

Watchung Borough (Vision Air Research 2017)

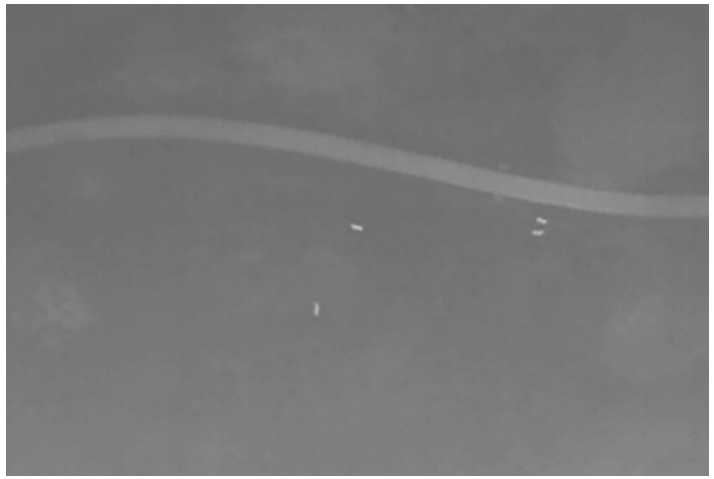


Duke Farms (RVCC 2021)

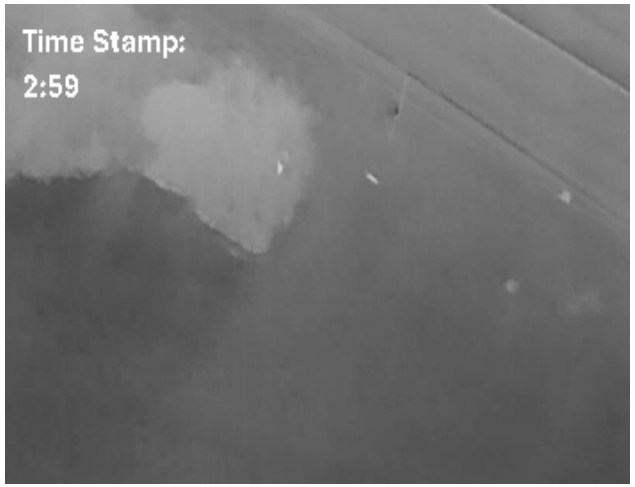


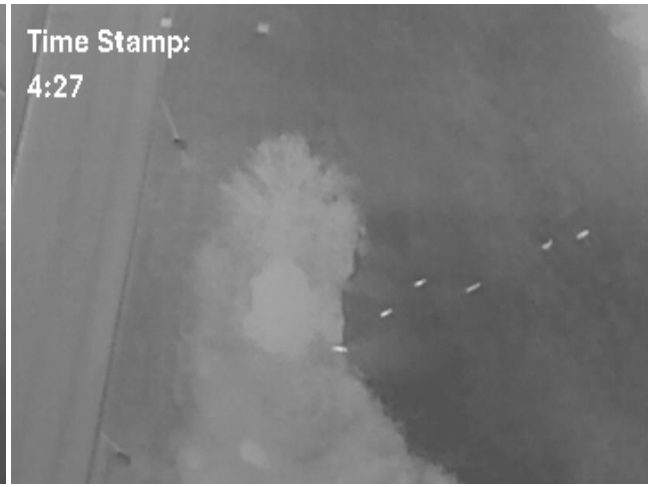
Other Advantages of sUAS/Drones

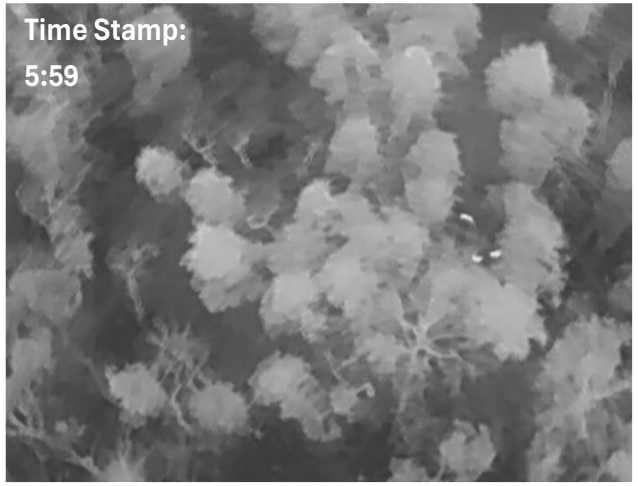
Changing Elevation

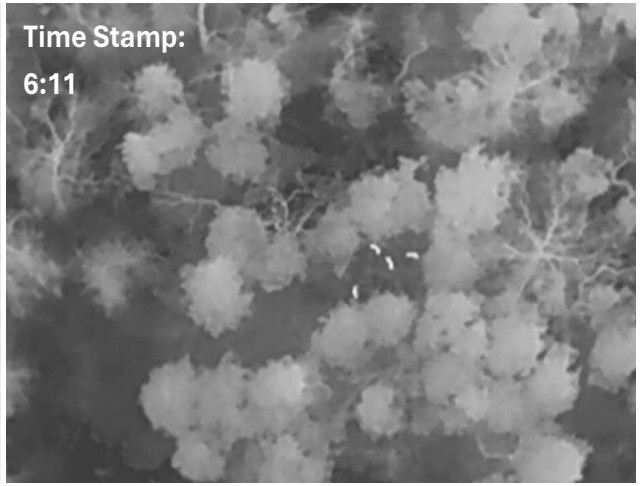


Changing Angle/Duration

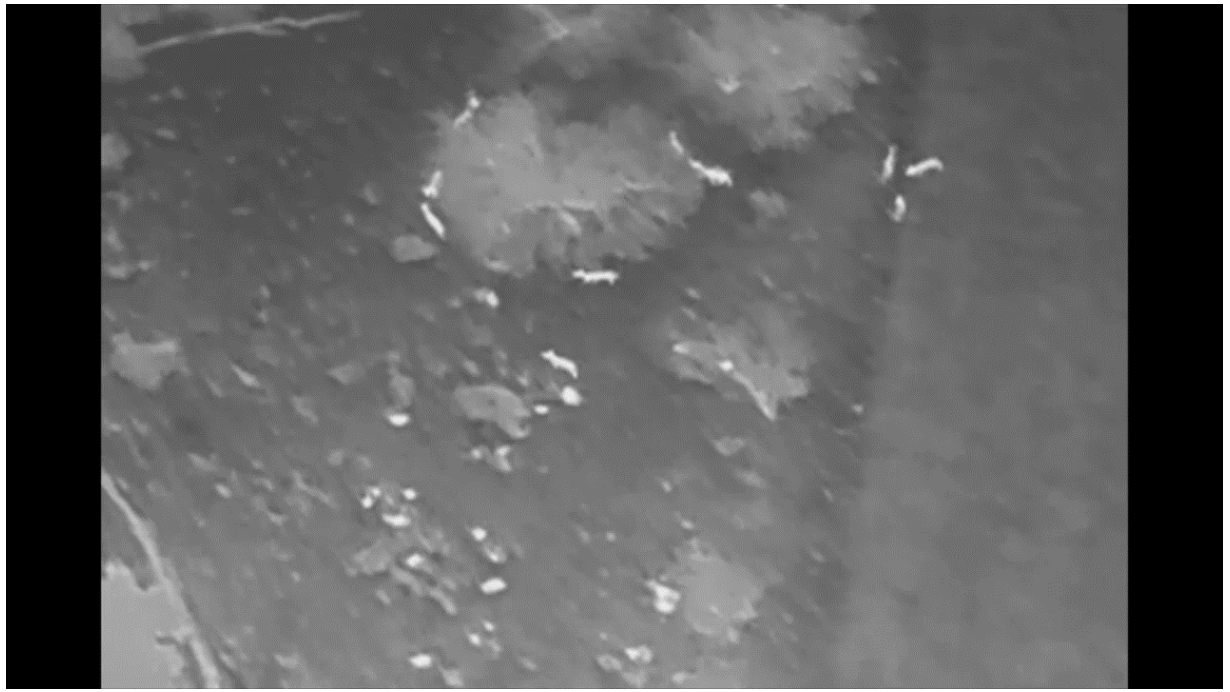


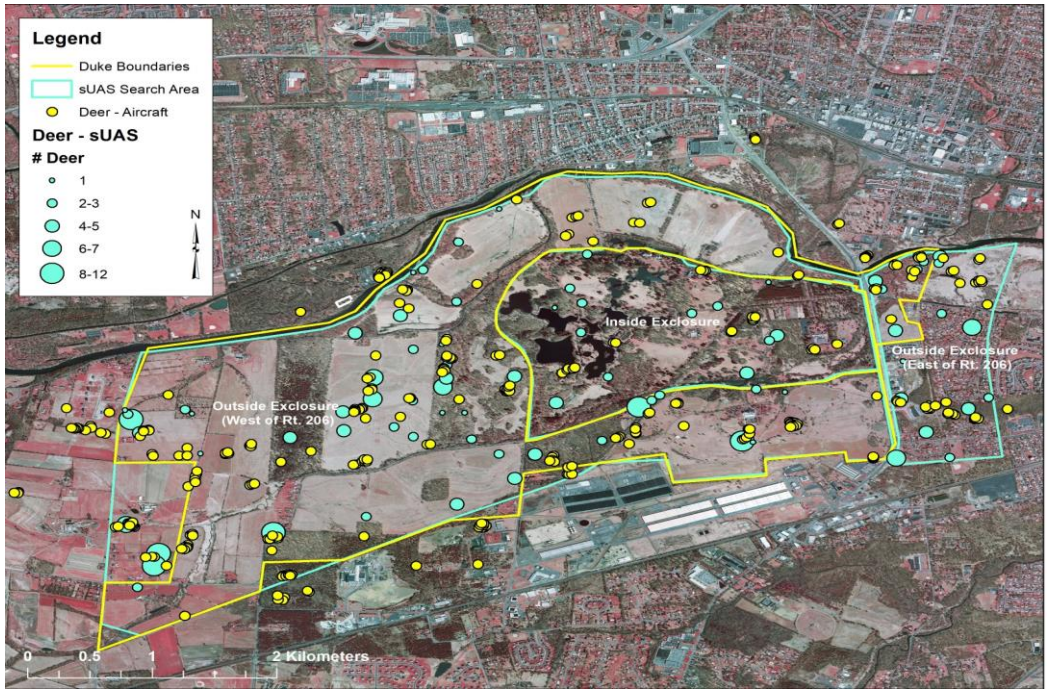






Comparison of Infrared Methods - Fixed Wing vs. Drone





https://youtu.be/2H_JUae06ho

	Duke Boundaries			Overall Search Area		
Duke Farms 2020	# Deer – Aircraft	# Deer – Drone	% Dif.	# Deer – Aircraft	# Deer – Drone	% Dif.
Outside Exclosure (*Low Density Veg.*)	157	167	-6%	184	191	-4%
Inside Exclosure (*High Density Veg.*)	20	27	**-26%**	20	27	**-26%**
Outside Exclosure (*High Density Veg.*)	14	17	**-18%**	44	58	**-24%**
TOTAL	191	211	**-9%**	248	276	**-9%**

RVCC-CES Deer Surveys: *Thermal Drone Data*

63 sites (2019 – 2023)

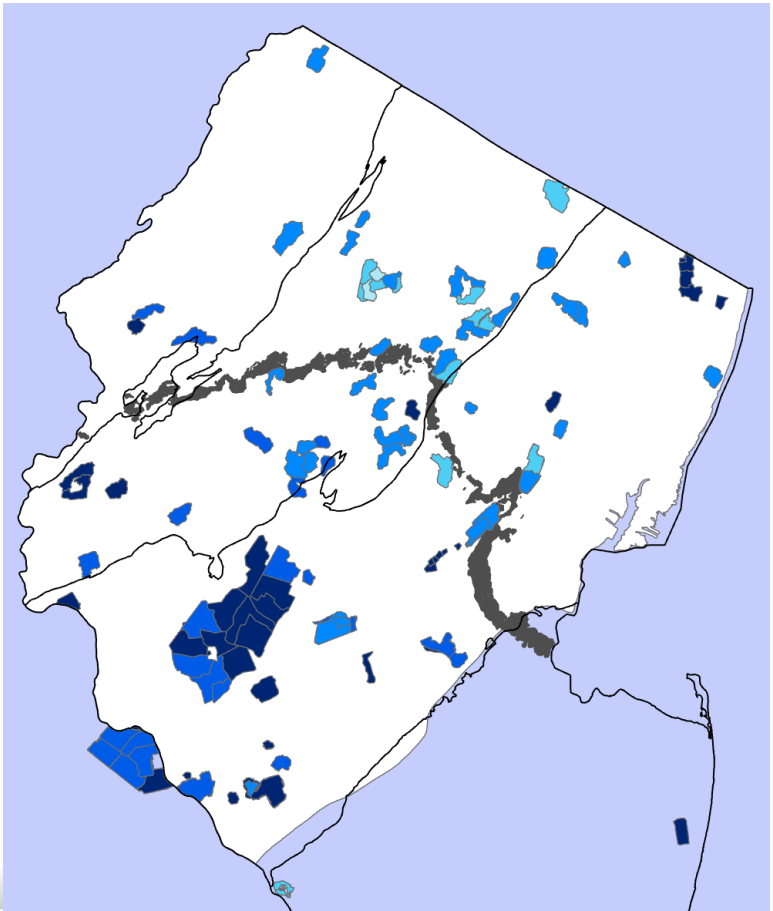
1,333.9 km^2 total

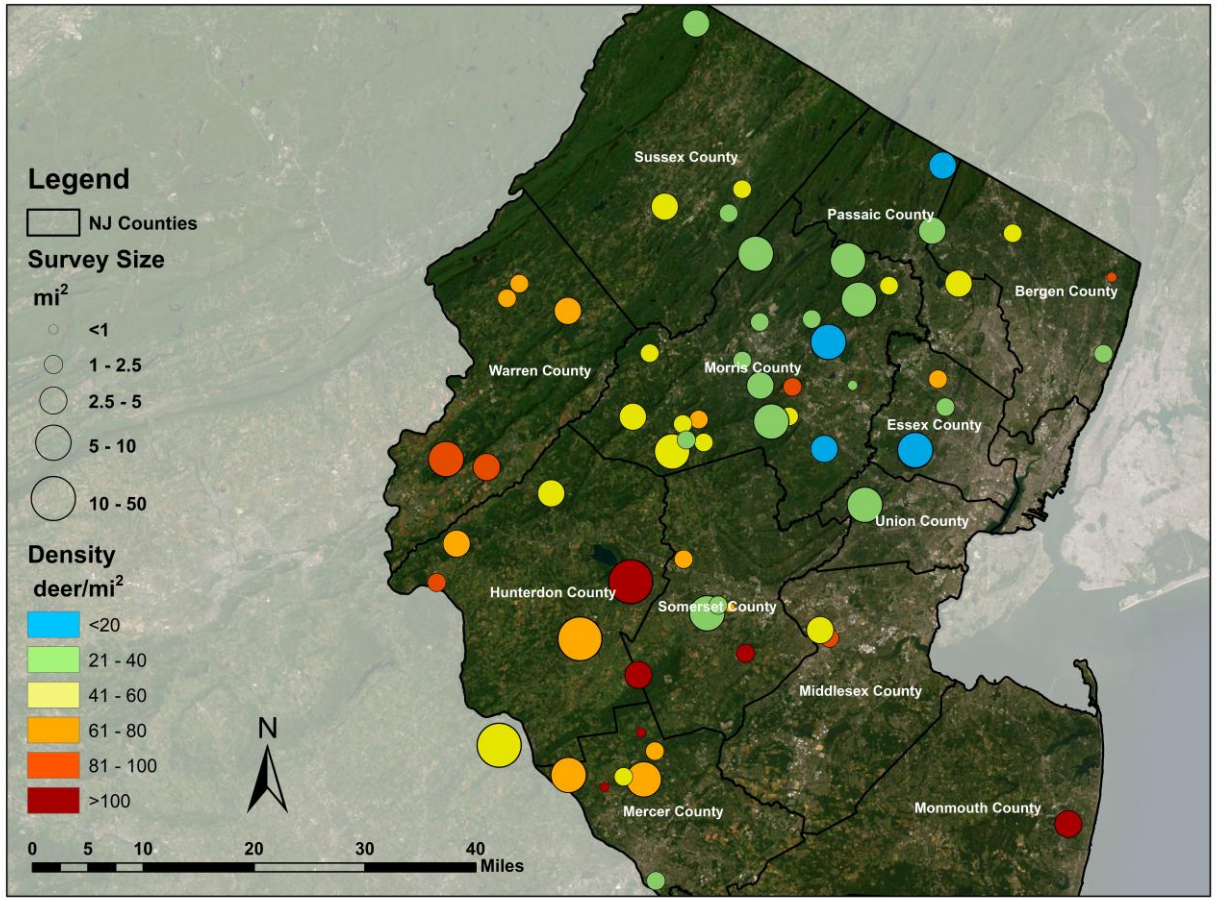
215 nights (avg = 5.7 km^2/night)

Deer Density = 66 deer/mi^2

2 nights <10/mi^2 (1%)

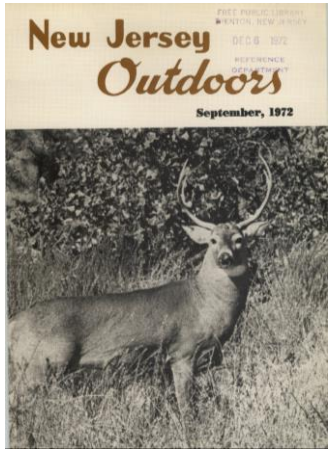
4 sites <20/mi^2 (6%)





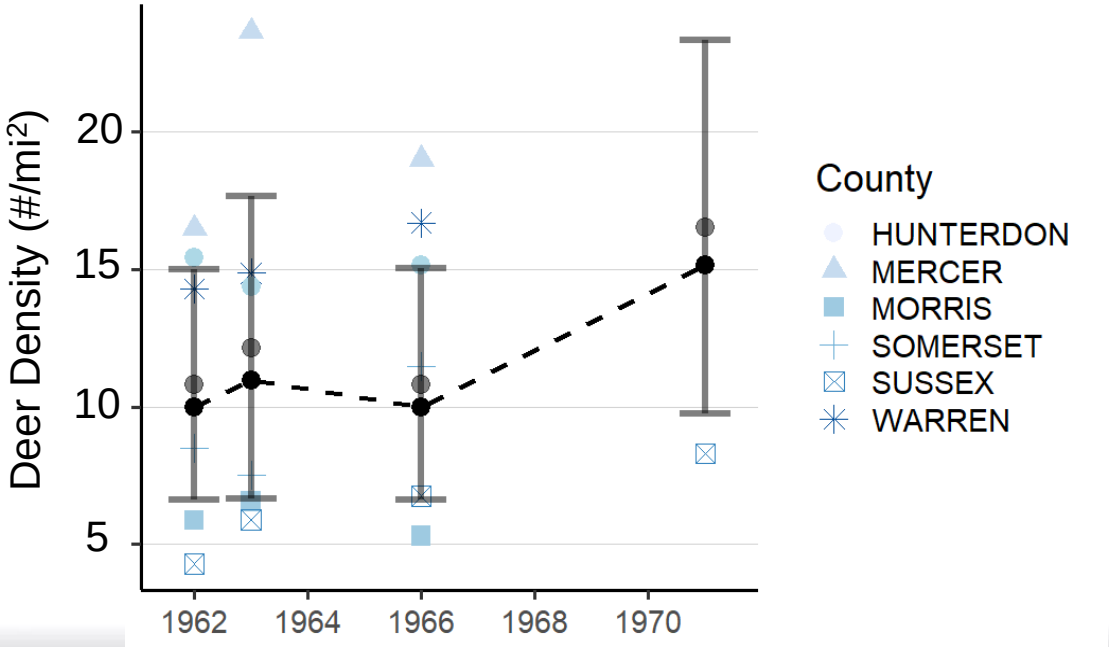
Direct Measures of Past Deer Populations:

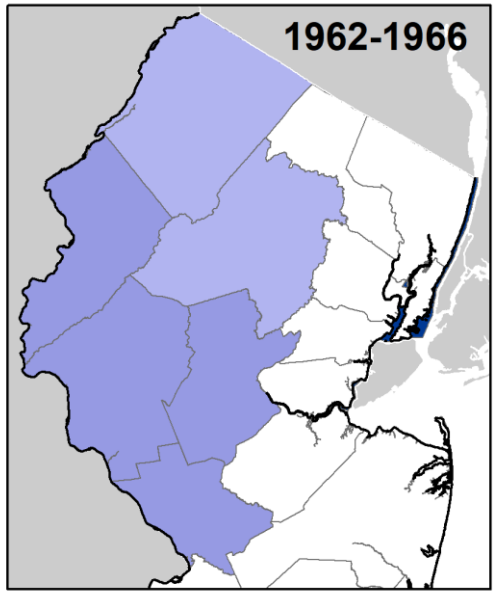
NJDEP Helicopter Surveys Over Snow (1962-1972)



Area Surveyed:
166 plots
1.3 km²
(215.8 km² total)

Deer Density:
≤15 deer/mi²

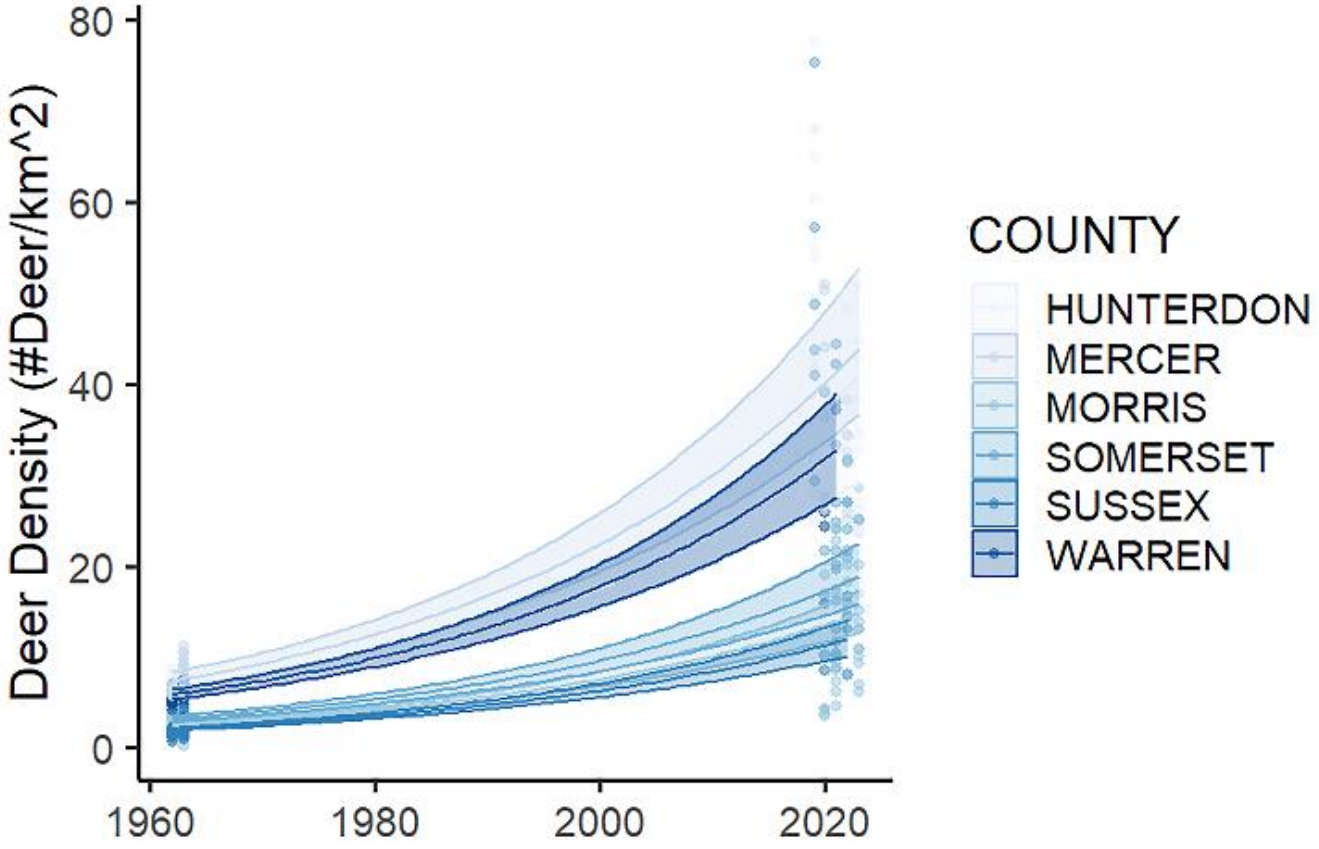


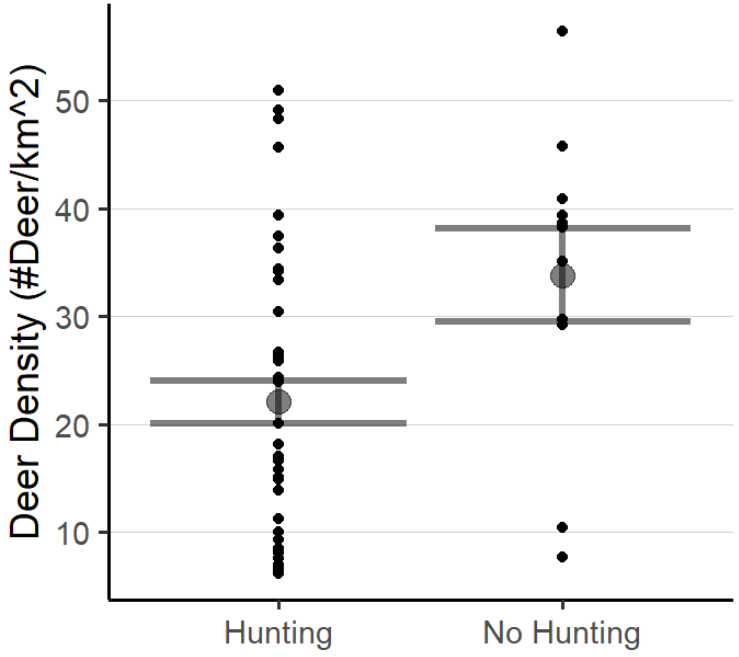


Deer Density Trends: *Past to Present*

Comparing Helicopter Surveys Over Snow (1962-1966) to Thermal Drone Surveys (2019-2023)

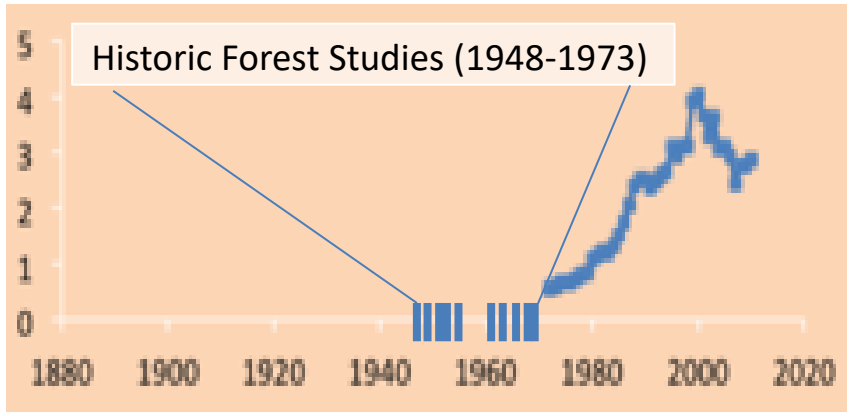
Late Winter/Spring Density
(i.e., *biological* minimum)

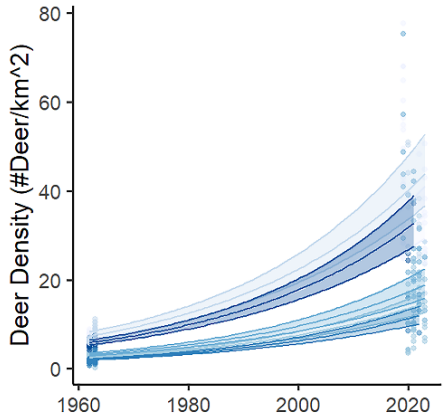




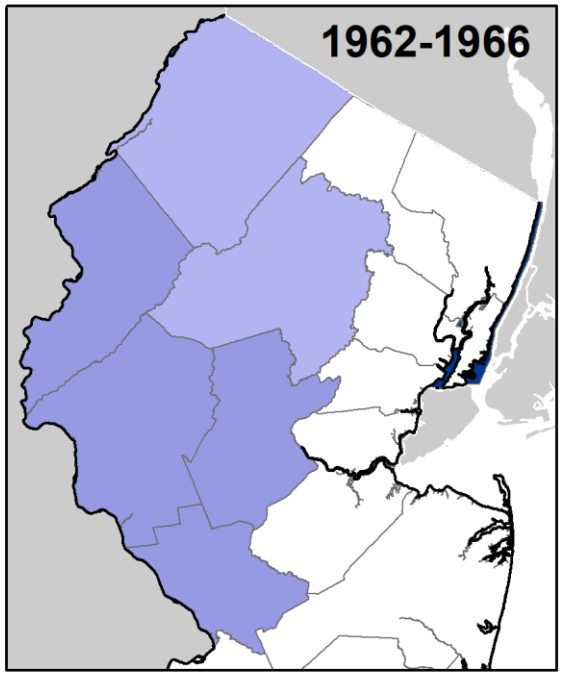
Deer Density Trends: *Past to Present*

Confirmed Increases
Since mid-1900's
In Northern NJ

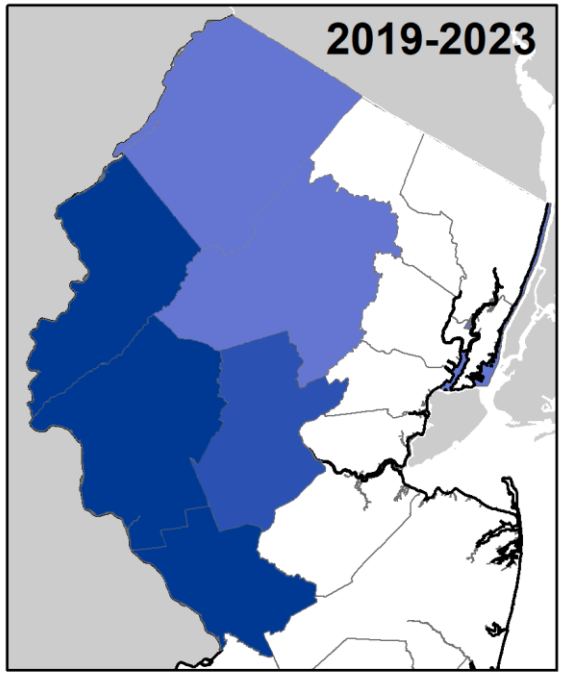




≤10 deer/mi²

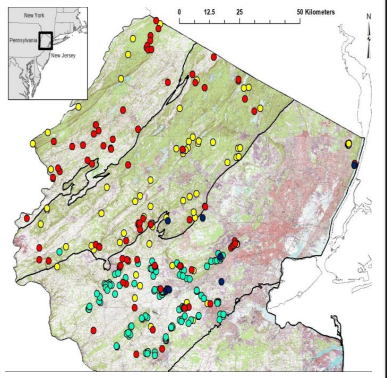


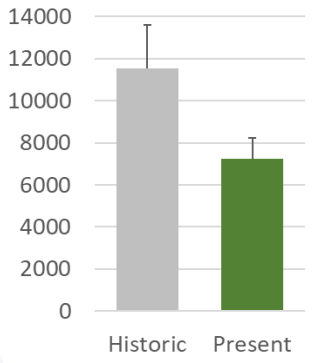
66 deer/mi²

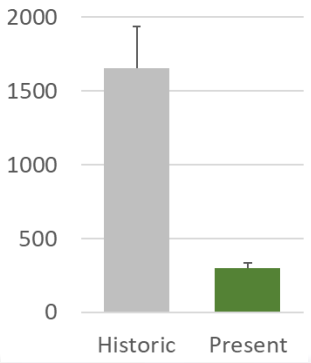


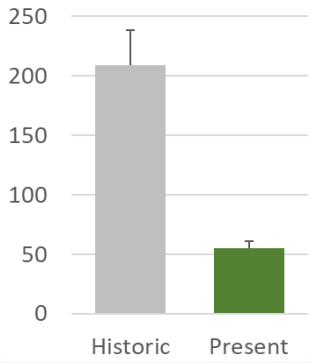
Deer Density

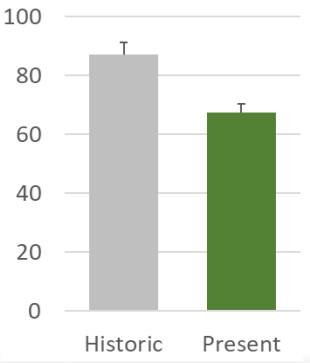
- <10deer/mi²
- 10-20 deer/mi²
- 20-30 deer/mi²
- 30-40 deer/mi²
- >40 deer/mi²

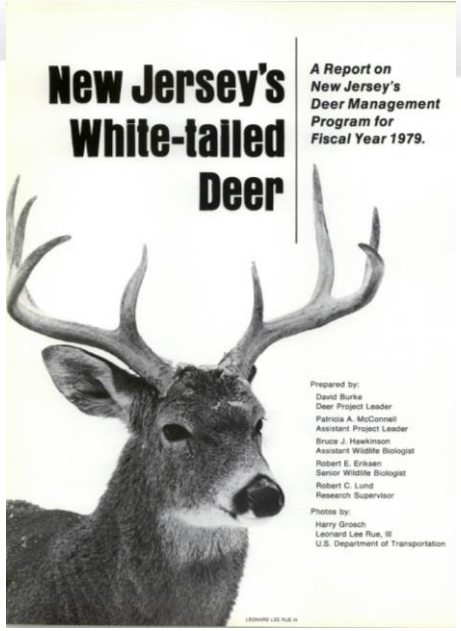










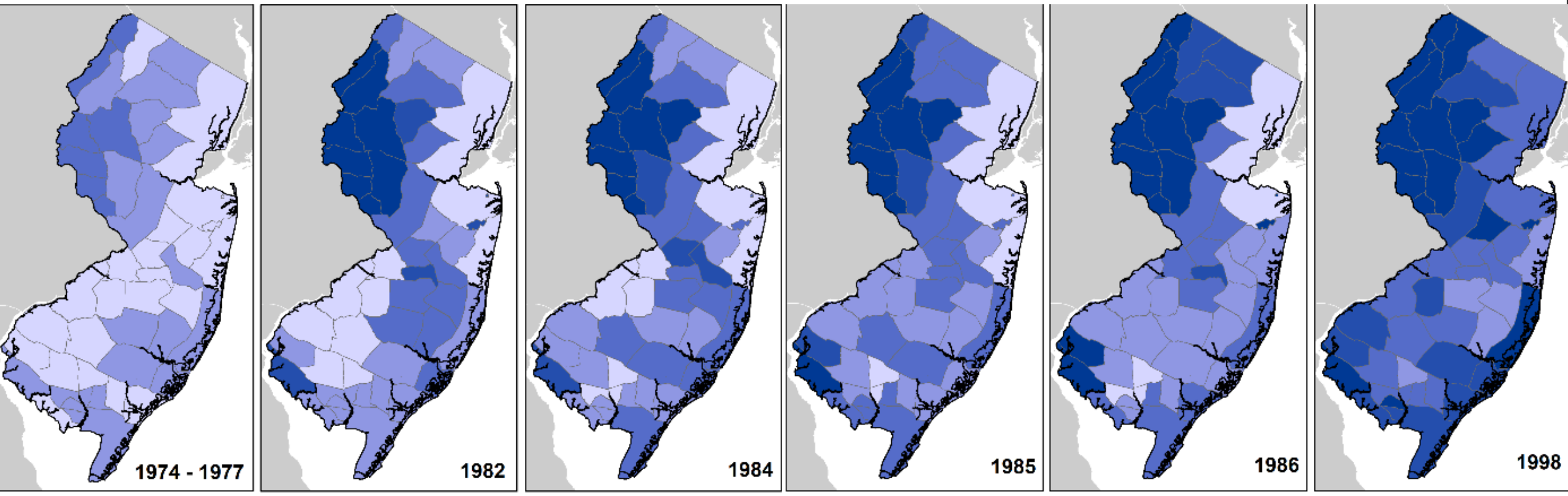


NJDEP Density Estimates by DMZ

Regional Variation in NJ Deer Population Trends

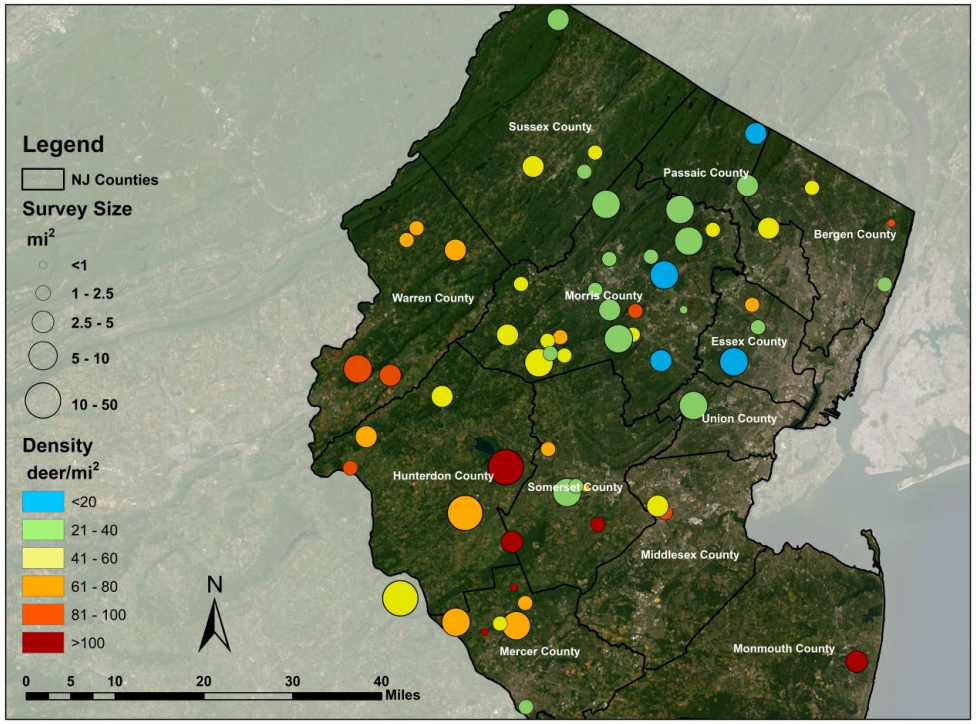
Deer Density

- <10deer/mi^2
- 10-20 deer/mi^2
- 20-30 deer/mi^2
- 30-40 deer/mi^2
- >40 deer/mi^2



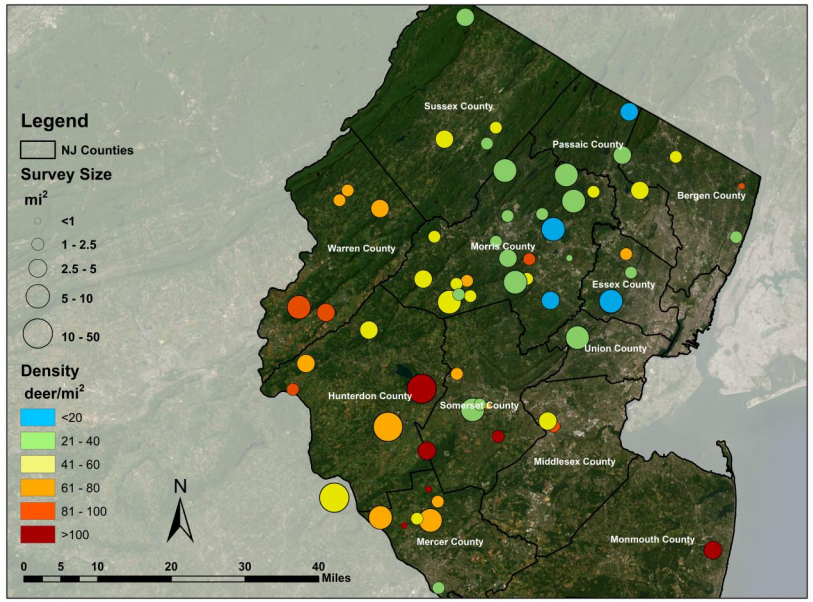
Conclusions & Next Steps

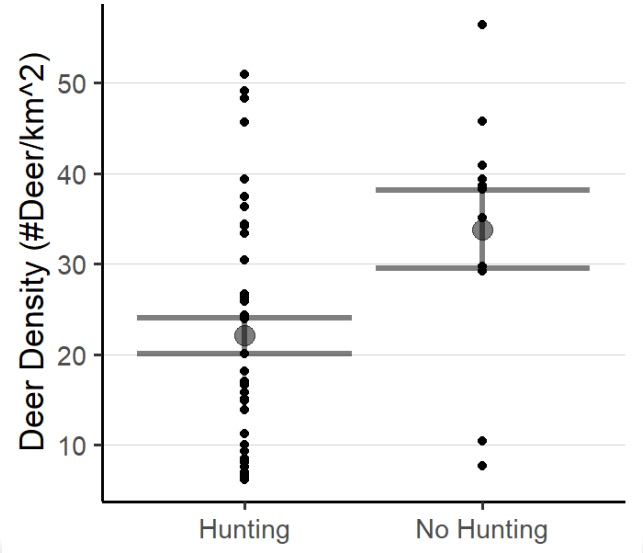
- Minimum Statewide Density Estimates Insufficient (NJDEP)
- Past/Present Densities in Northern NJ
  - ≤15 deer/mi^2 (1962-1972)
  - 66 deer/mi^2 (2019-2023)
- Future Research
  - Relationships of Deer Density to Land Use, Deer Management, Understory Condition, Prescribed Fire Effects, Etc.
- Revising Past Deer Density Studies



Deer Density Relationships:

Deer Management



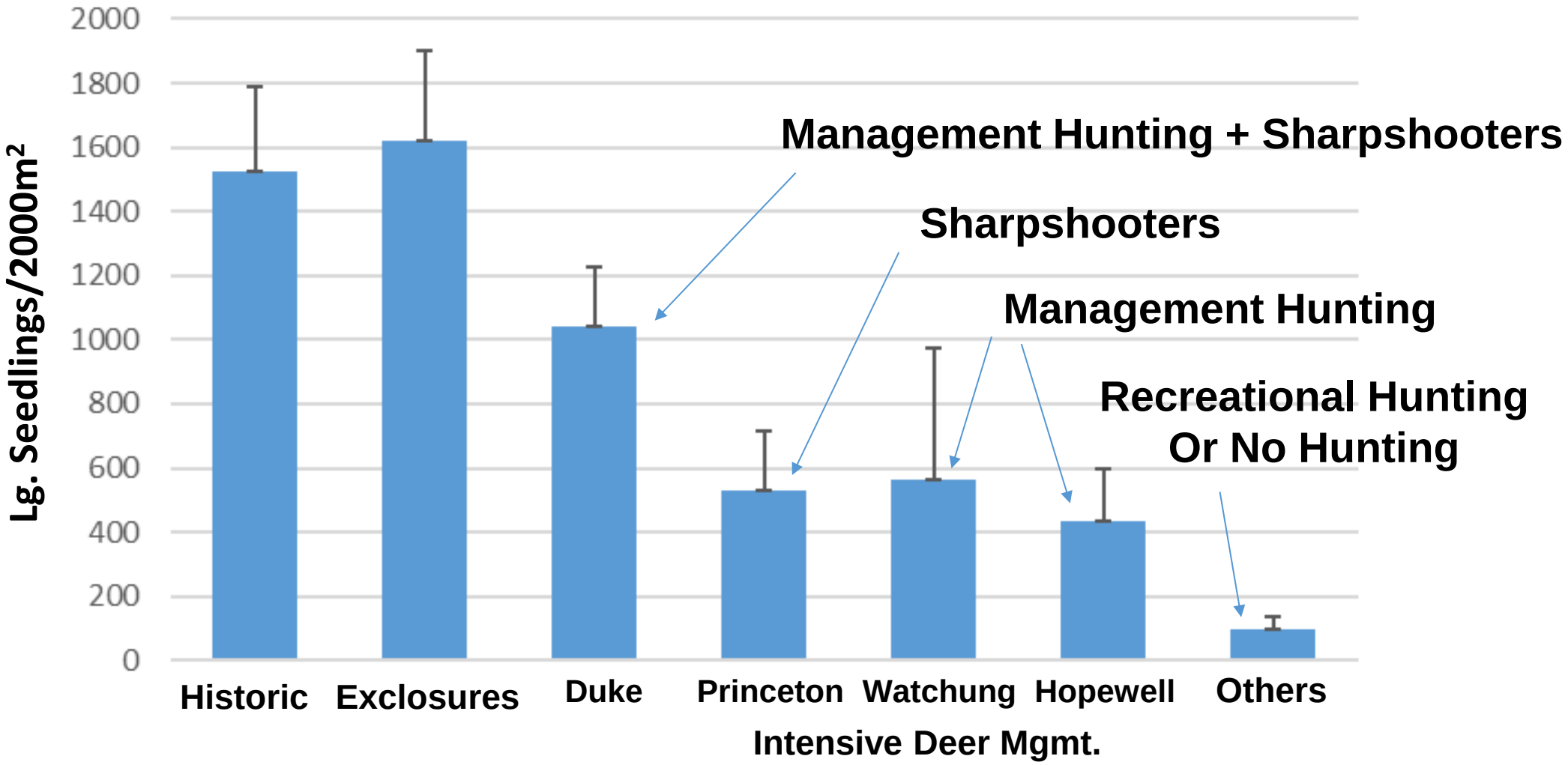


Natural Lands Trust Preserves

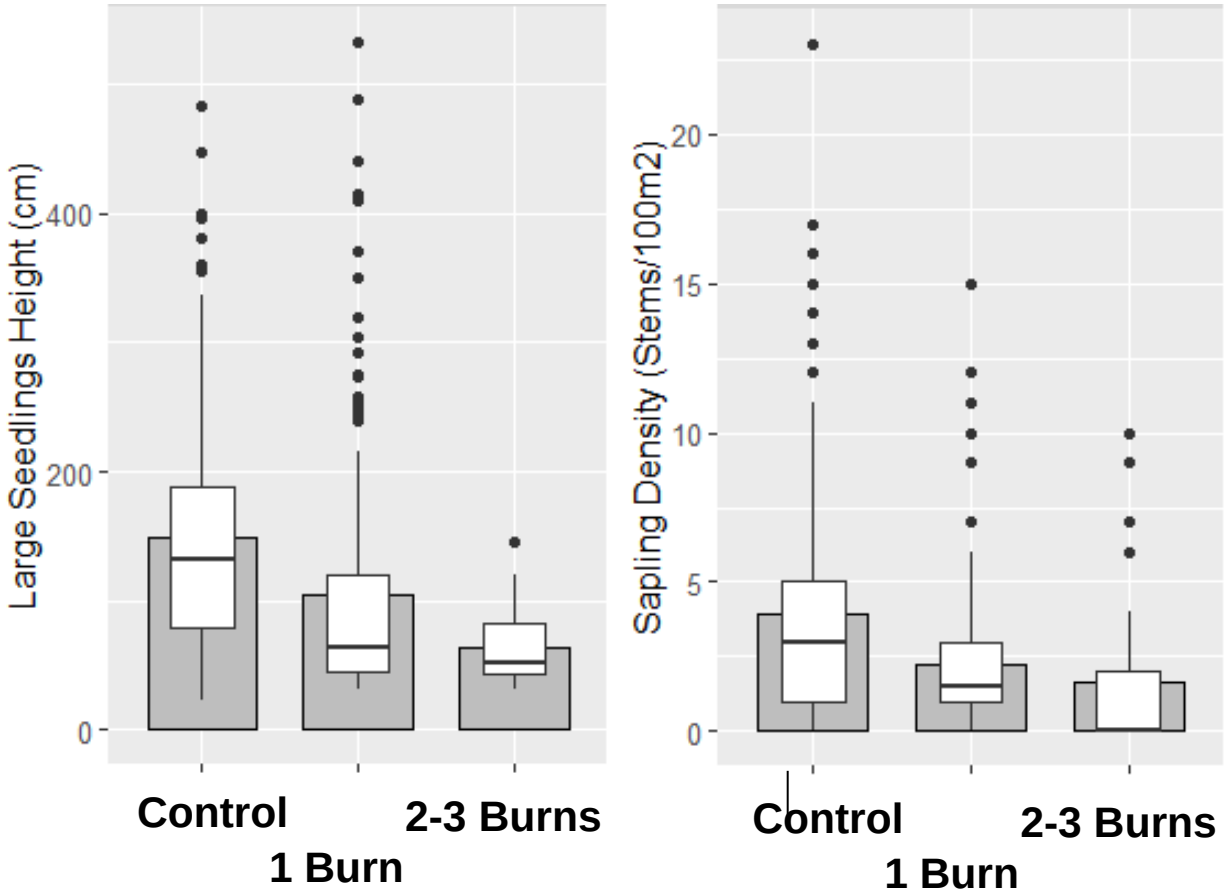
Suvey Area	Hunting Status	Survey Area (sqmi)	# Deer Observed	Density (deer/sqmi)	
Bear Creek Preserve	Hunting Permitted	3.70	233	63	
Budd Lake Bog Preserve	Hunting Permitted	1.86	82	44	
Wallkill Preserve North	Hunting Permitted	1.21	50	41	43
Wallkill Preserve South	Hunting Permitted	1.92	43	22	
Hagedorn Preserve	Bow Only	2.62	137	52	
Limestone Ridge Preserve	Bow Only	2.37	158	67	63
Sweet Hollow Preserve	Bow Only	3.15	219	69	
Beech Ridge Preserve	No Hunting	1.64	126	77	
Buttermilk Bridge Preserve	No Hunting	2.56	234	91	89
Milford Bluffs Preserve	No Hunting	1.85	183	99	

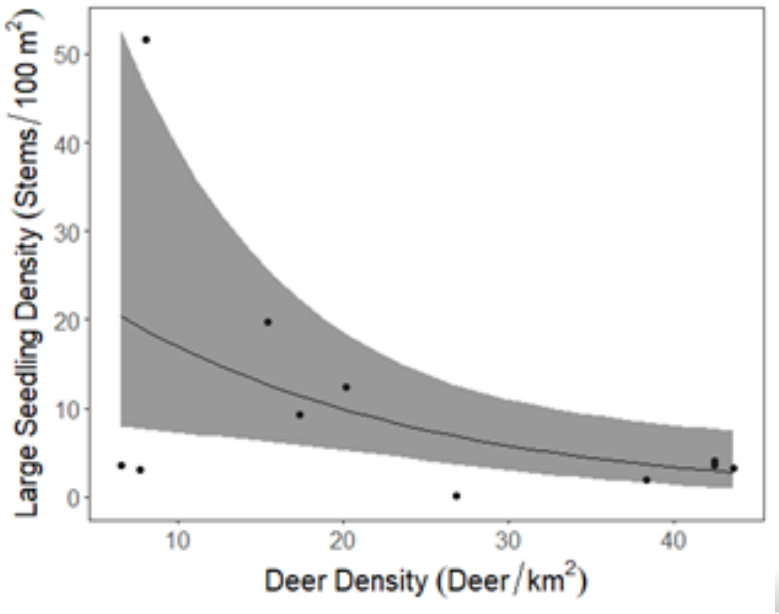
Deer Density Relationships:

Deer Management & Tree Regeneration



Deer Density Relationships to Tree Regeneration *After Prescribed Fire*





(Kelly et al. 2021)

Deer Density Relationships:
Deer-Vehicle Collisions

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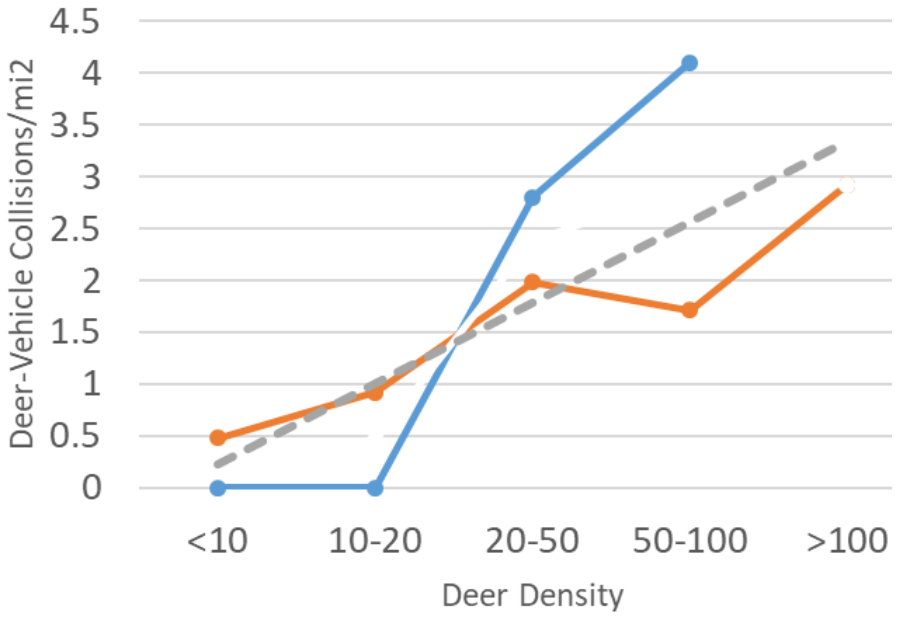
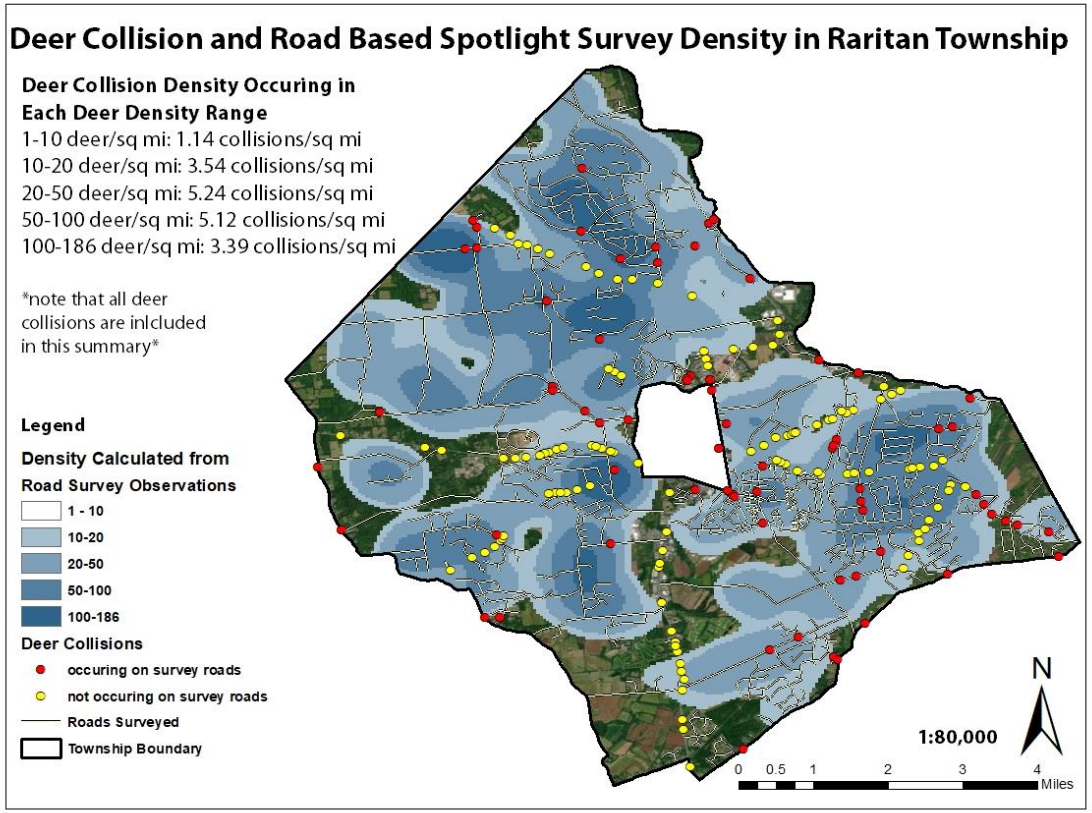
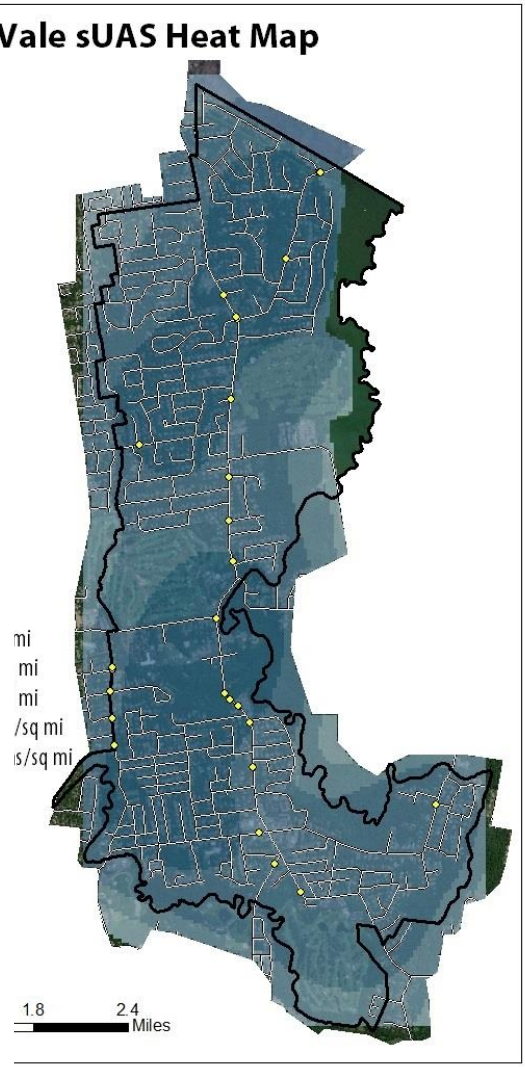
Average $4,000 vehicle damage per reported collision (State Farm Insurance 2018)

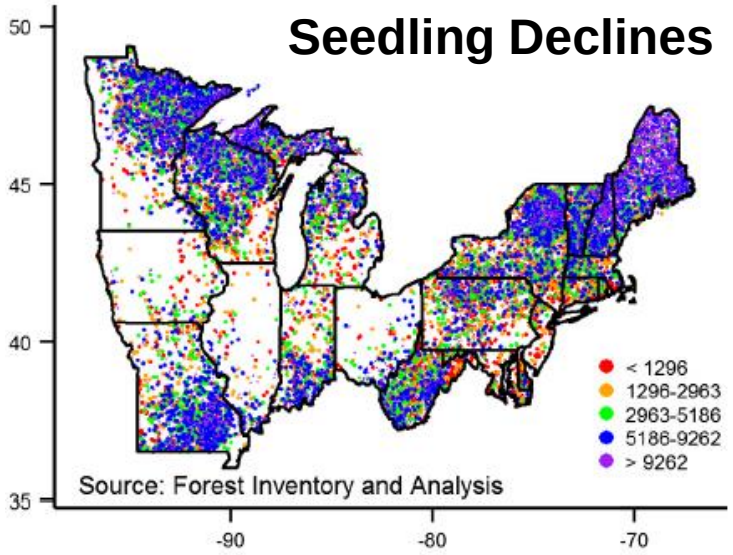
Princeton reduced population by 60%, and collisions declined by the same amount that year (Williams et al. 2013)



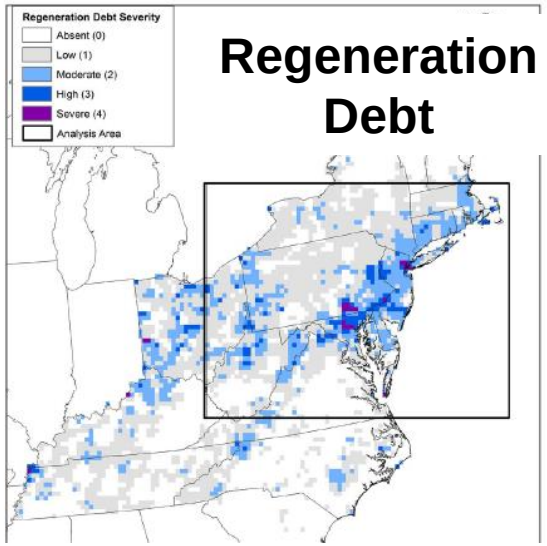




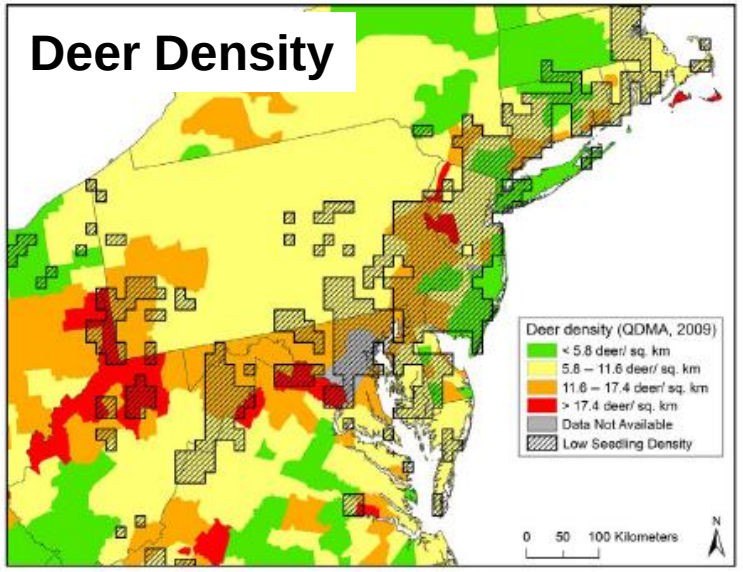
Revisiting Past Studies: *A Can of Worms…?*



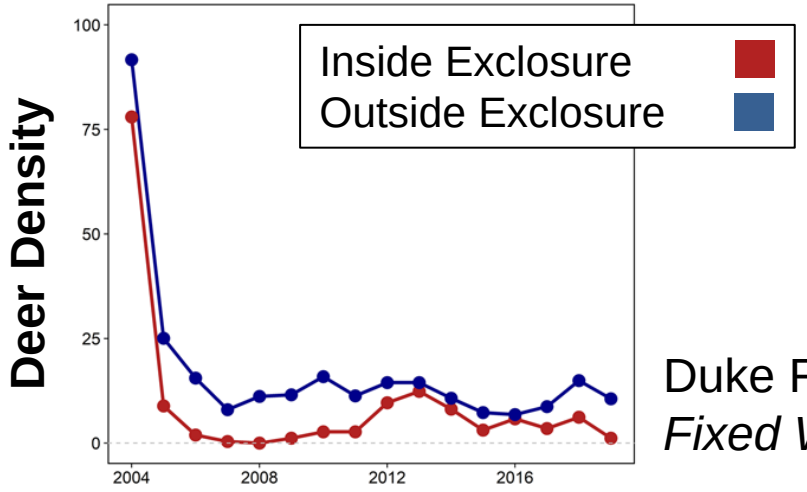
(Russell et al. 2017)



(Miller and McGill 2019)



(QDMA 2009) - *Harvest Data*



Duke Farms (Almendinger et al. 2020)
Fixed Wing Infrared Data

A Can of Worms…(continued)

Deer Density Thresholds

Historic: **8-11 deer/mi²** NJDEP (1999): **38 (13-76) deer/mi²**

Healthy forest with dense understory vegetation and native plant species.

Overbrowsed forest at Hutcheson Memorial Forest in Franklin Township (2012)

Overbrowsed forest with invasive barberry shrubs at Peter's Tract in Bernardsville (2016)

Census

- **Aerial surveys** (Helicopter) – ≤80-90% accurate
- **Infrared Aerial Surveys** (Fixed-wing Aircraft) – 60-90%
- **Infrared sUAS Surveys** (Drone) – 95-100% accurate

Sampling

- **Spotlight Surveys** – 31-88% accurate, highly variable
- **Fecal Pellets** – high variability, temperature dependent
- **Trail Cameras** – high variability, error/double-counting
- **Harvest Statistics** – high variability, limited to hunted population
- **Mark-Recapture** - ???

>10 deer/mi²
impacts preferred browse species

>15 deer/mi²
impacts to tree regeneration

>20 deer/mi²
impacts to wildlife, food web effects

(Drake et al. 2002, Almendinger et al. 2020, Russell et al. 2017)

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Acknowledgements

Acknowledgements

- Funding: NJDEP-NJSeaGrant; US Forest Service; Morris County Park Commission; NJDEP-ONLM; National Science Foundation SENCER-ISE Program; RVCC Foundation; RVCC Foundation; RVCC Enviro. Club; Highlands Coalition
- Project Partners: Duke Farms – Thom Almendinger, Charles Barreca, Dr. Jon Wagar; NJDEP – Joe Bilinski, Bob Cartica, Greg McLaughlin, Jeremy Webber; US Forest Service – Dr. Mike Gallagher; NJ Audubon – Dr. Nellie Tsipoura
- RVCC Staff & Student Interns – Jessica Ray, Allyson Schmieder, Sarah Crosby, Chris Balajadia, Peter Evanowski, Timothy Semmling, Chase Craig, Justin Daniel, Jose Farfan, Aaliyah Padilla, Rebekah Buczynski, Lee Minicuci, Jason Hafstad, Cory Snyder, Dylan Hardy, Adam Kohler, Ali Severino, Dani Yashinovitz, Bri Primiani, Zachary Sparta, Kristen Greaney, Alvin Chin, Willie Grosch, Eric Williams, Bonnie Semmling, Michael Allers, Samantha Naulty, Valeria Izeppi, Noah Motz, Raquel Menella, Sasha Kovalyev, Chris Baron, Stephanie Murphy, Zach Nekola, Ray Zamora, Jess Tirado, Max Spann, Juaquin Goodbar, Lina Rivetti, Justin Andell, Deidre Supple

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The RVCC Center for Environmental Studies engages approximately 100 students each year in real-world learning experiences, both inside and outside the classroom. These experiences empower them to transform their academic knowledge into real-world research and problem solving skills that prepare them to pursue successful careers in environmental science, sustainability, ecology, natural resources management, and related fields.

Thanks!!!

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