A comparison of breeding density estimates from fixed-radius point counts, distance sampling, and territory mapping for forest songbirds.

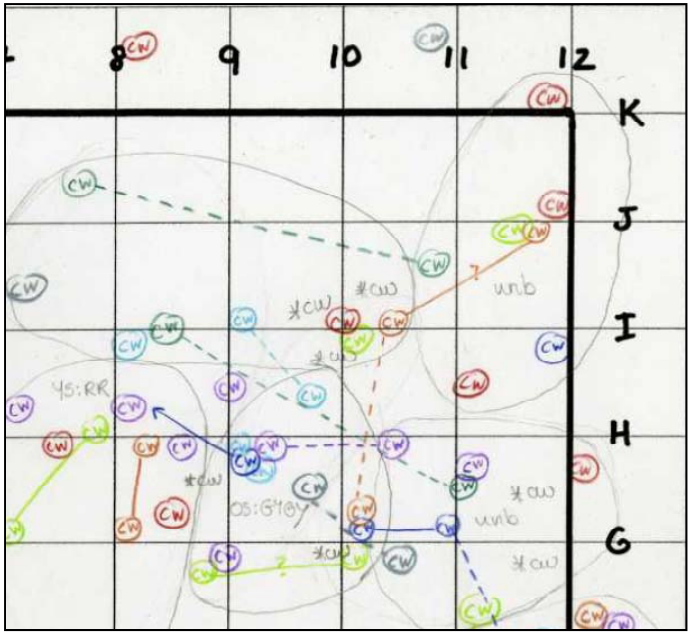
F.L. Newell*, A.D. Rodewald (PI), and M.H. Bakermans, Ohio State University; P.B. Wood (PI, U.S. Geological Survey), J. Sheehan, G.A. George, M.E. McDermott, P.M. McElhone, J. Mizel, K.A. Perkins, West Virginia Cooperative Fish and Wildlife Research Unit, West Virginia University; D.A. Buehler (PI), P.D. Keyser (PI), T.A. Beachy, and T.J. Boves, University of Tennessee; and J.L. Larkin (PI), A. Evans, P. Hartman and M. White, Indiana University of Pennsylvania (PI - Principal Investigator)

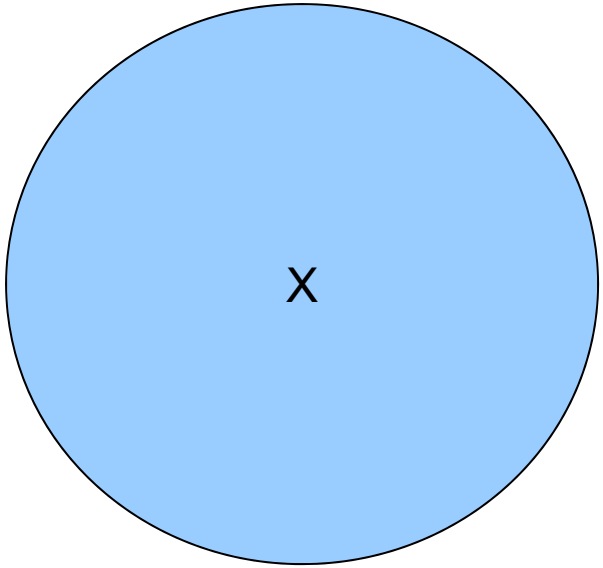
BIRD SURVEYS

- Critical first-step to identify important habitat.
- Examine effects of management, e.g. partial-harvesting.
- Long-term monitoring of bird populations.

SURVEY METHODS

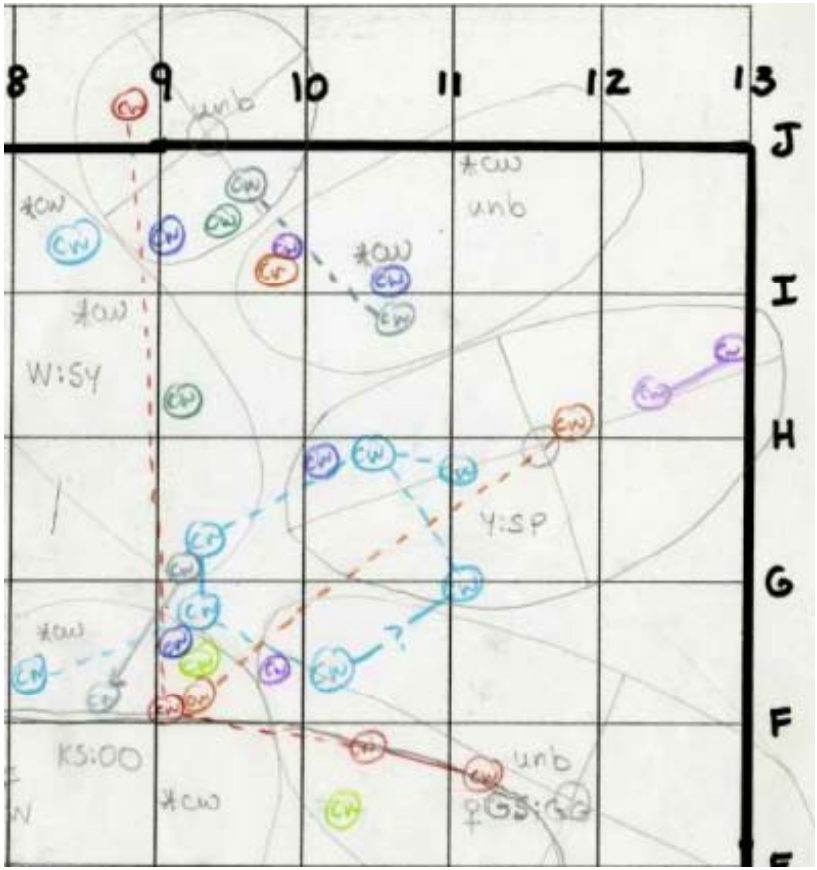
1. Territory mapping (Bibby et al. 1992)
2. Counts (e.g. Ralph et al. 1993, 1995)





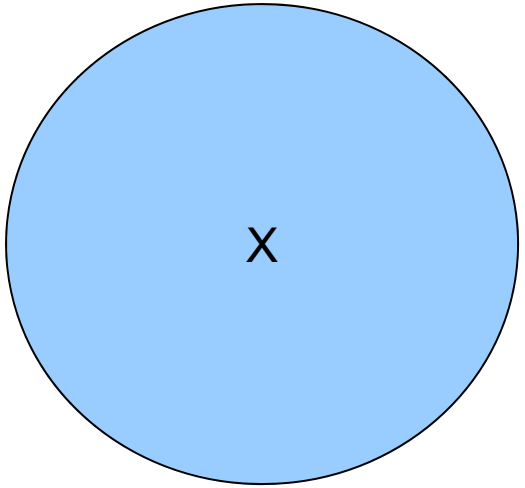
SPOT-MAPPING

- **METHOD:** multiple visits used to map locations of birds, clusters of observations and counter singing males used to delineate territories.
- **PROS:** entire area surveyed. Location of territories known, e.g. along harvest edge.
- **CONS:** some observer and analyst variability (Verner and Milne 1990).



POINT COUNTS

- **METHOD:** timed count of birds at one location over several visits.
- **PROS:** decreased effort per sample, increased sample size for multiple species.
- **CONS**: identify survey area and account for birds present but not detected.



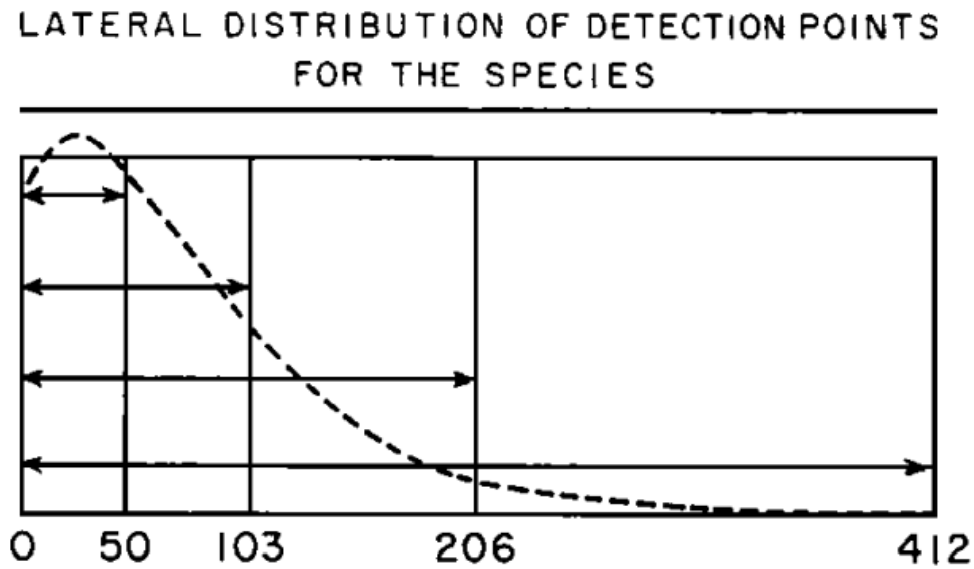
SOURCES OF ERROR

- Area surveyed, and individuals missed in that area (Buckland et al. 2001, 2004).
- Available for detection, e.g. bird vocalizes during the survey (Farnsworth et al. 2002).
- Bird identification and measurement error (Alldredge et al. 2006–2008).
- Bird abundance spatially autocorrelated (Lichstein et al. 2002, Fewster 2009).

COUNT APPROACHES

1. Indices of relative abundance (e.g. Johnson 2008).
2. Account for detection probability:
   - Distance sampling (Buckland et al. 2001)
   - Occupancy modeling (MacKenzie 2006)
   - N-mixture models (e.g. Royle 2004)
   - Multiple observers (e.g. Nichols et al. 2000)
   - Time of detection (Farnsworth et al. 2002)

DETECTION PROBABILITY BASED ON DISTANCE



Emlen 1971

Birds farther from the observer less likely to be detected.

CONTINUING DEBATE

- Alldredge et al. says survey error; DISTANCE fails to meet assumptions (2006–2008).
- Buckland says DISTANCE relatively robust (Buckland 2006, Marques 2007, Gale et al. 2009).
- Johnson says don’t throw out indices, practical approach with long history (2008).
- Efford and Dawson model detection based on distance and suggest best approach, although conclude currently no effective method (2009).

PREVIOUS COMPARISONS

- Spot-mapping considered closest to “true density estimate”.
- Point count methods generally correlated with spot-mapping.
- Point counts overestimate at low density but underestimate at high density.

Jones et al. 2000. Density influences census technique accuracy for Cerulean Warblers in eastern Ontario. Journal of Field Ornithology 71:45–56.

Howell et al. 2004. Breeding density affects point-count accuracy in Missouri forest birds. Journal of Field Ornithology 75:123–133.

Toms et al. 2006. Are point counts of boreal songbirds reliable proxies for more intensive abundance estimators? Auk 123:438–454.

OBJECTIVE

- How do survey methods and analysis approach affect results and overall management application?

- Compare survey methods and analysis approaches for large-scale dataset with experimental study design.

DATASET

- Central Appalachians in Tennessee, West Virginia, Kentucky and Ohio (7 study area, 28 sites).
- Light, intermediate, heavy treatments, and no harvest control. 1-2 years before, 4 years after. 20 ha site with 10 ha treatment/buffer.
- Spot-mapping and point counts for 7 species of conservation concern, 2005–2010.

SURVEY METHODS

- Spot-mapping: observer walked within 50-m of each point and mapped locations of birds using 50-m grid, 8 visits throughout the season, each visit 3–4 hours.
- Point Counts: 10 min counts, 2 visits per season. Distance recorded as bands in the field (0–25, 25–50, 50–100, >100 m).
- Multiple observers trained on bird identification and distance estimation. Surveys ½ hour after sunrise to 10:30 am.

COMPARE TERRITORIES HA^{-1}

1. Spot-mapping: territories delineated to nearest ¼ territory in 10 ha unit, converted to per ha.
2. Point Counts: average of 2 points per 10 ha.
   - Fixed-radius: maximum number of singing males ≤ 100 m over 2 visits per season and adjusted for area (3.14 ha).
   - Distance: singing males adjusted for detection probability using hazard-rate cosine model in Program DISTANCE; output per point per year.

DATA ANALYSIS

1) Error by density (Jones et al. 2000).

$$\text{error} = \text{density point count method} - \text{density spot-map}$$

2) Spearman rank-order correlations (Jones et al. 2000).

3) Compared ability to detect treatment effects and effect magnitude relative to spot-mapping:

   Type I and II Errors for p-values ≤ 0.10, change in slope.

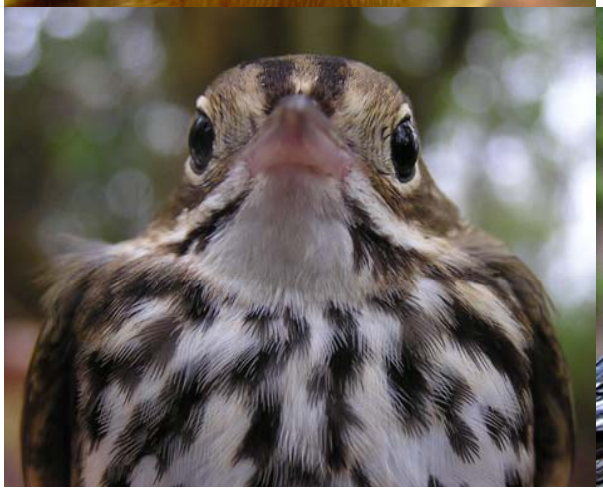
   Pre/post harvesting to control (Wiens and Parker 1995). Repeated measures with nlme package in Program R.

$$\text{diff} = \text{after} - \text{before}$$

$$\text{lme}(\text{diff} \sim \text{factor}(\text{Treatment}) + \text{Year}, \text{random} = \sim 1 \mid \text{SA})$$

STUDY SPECIES

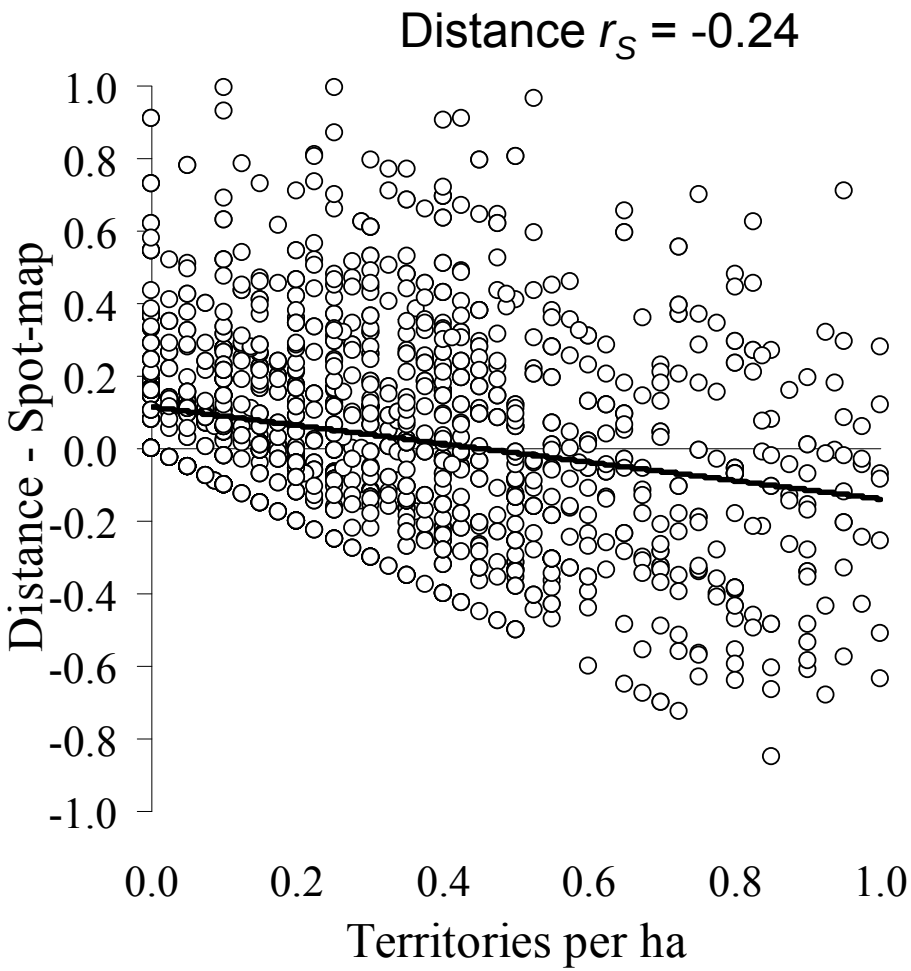
Wood Thrush
Cerulean Warbler
Worm-eating Warbler
Ovenbird
Kentucky Warbler
Hooded Warbler
Scarlet Tanager

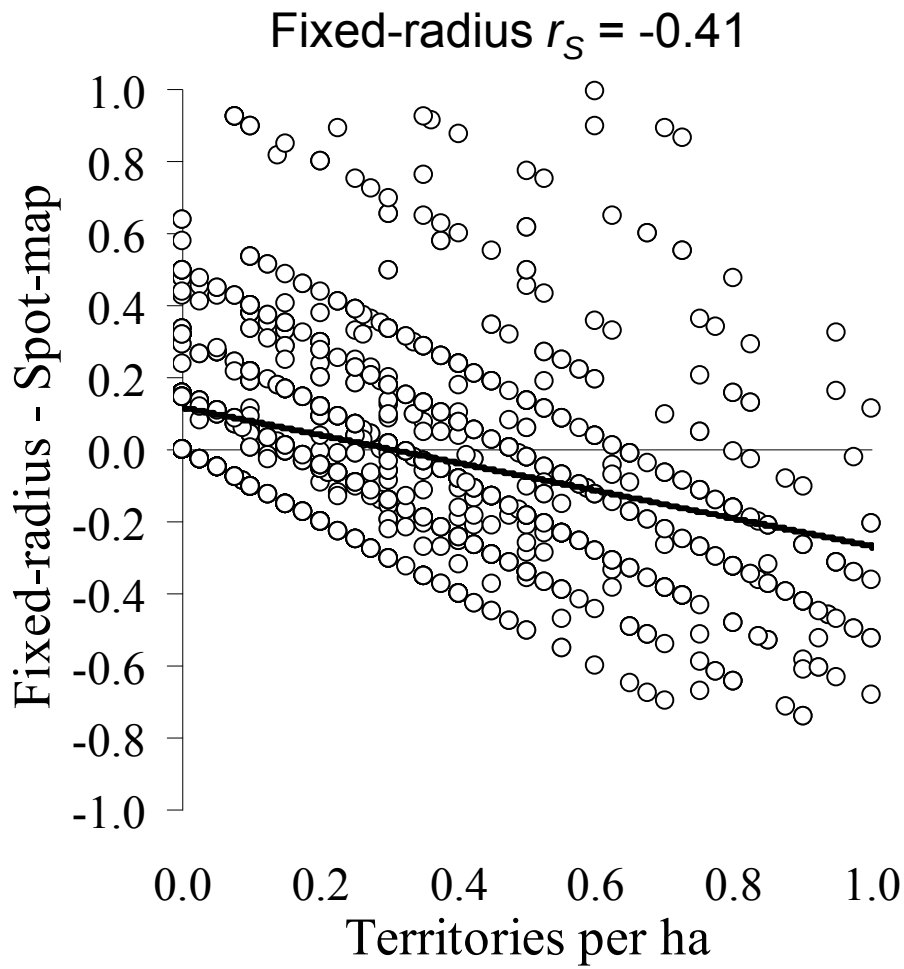


OCCURRENCE AND DENSITY

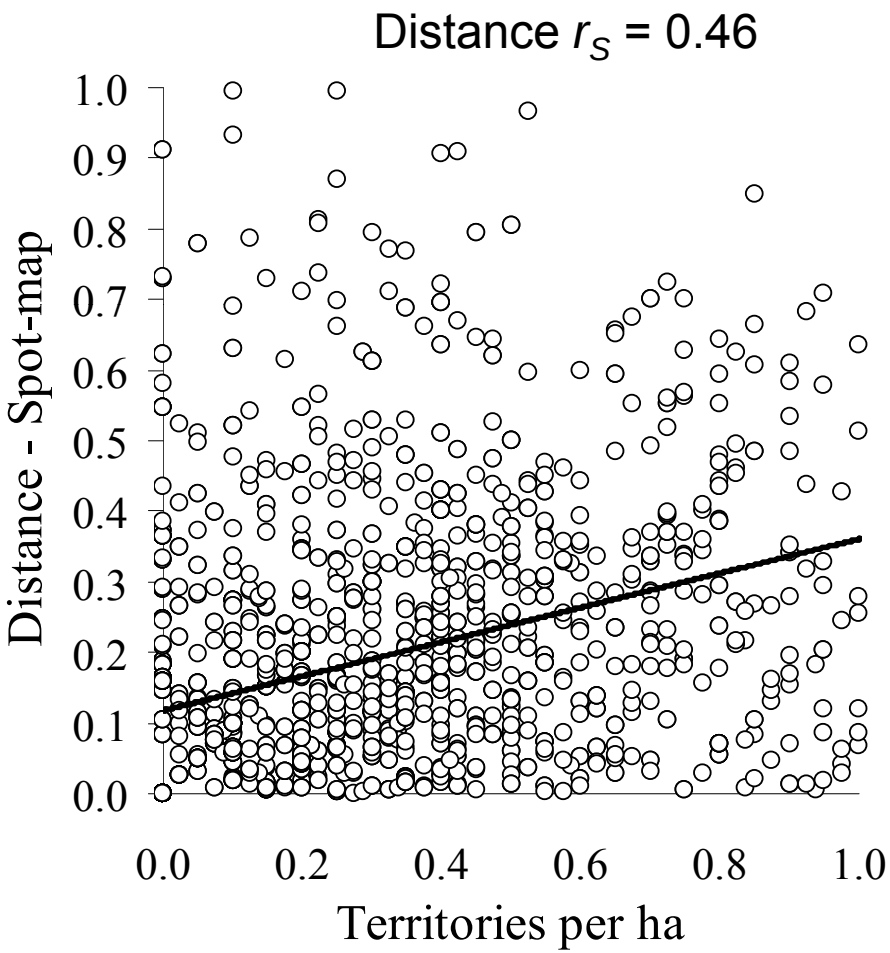
Species	% Points	Territories ha^{-1}
Wood Thrush	66	0.24 ± 0.01
Cerulean Warbler	70	0.56 ± 0.03
Worm-eating Warbler	28	0.12 ± 0.01
Ovenbird	84	0.65 ± 0.03
Kentucky Warbler	22	0.07 ± 0.01
Hooded Warbler	79	0.53 ± 0.02
Scarlet Tanager	72	0.40 ± 0.01

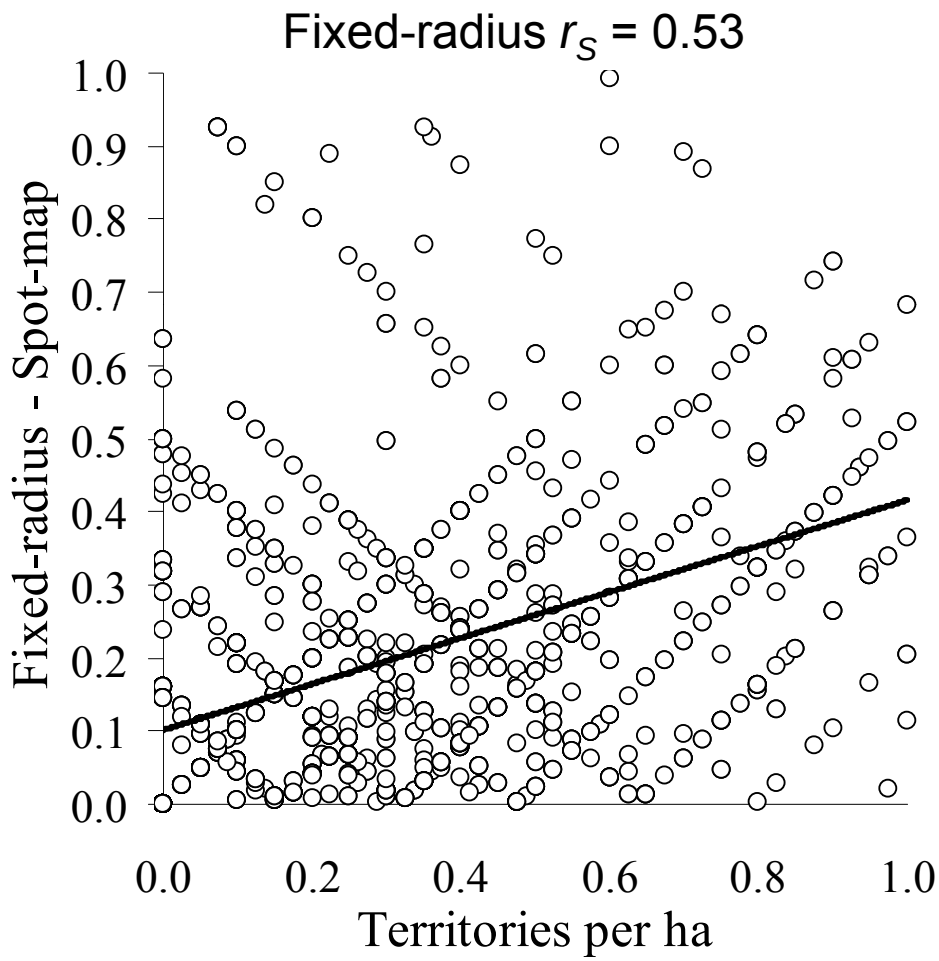
ERROR BY DENSITY



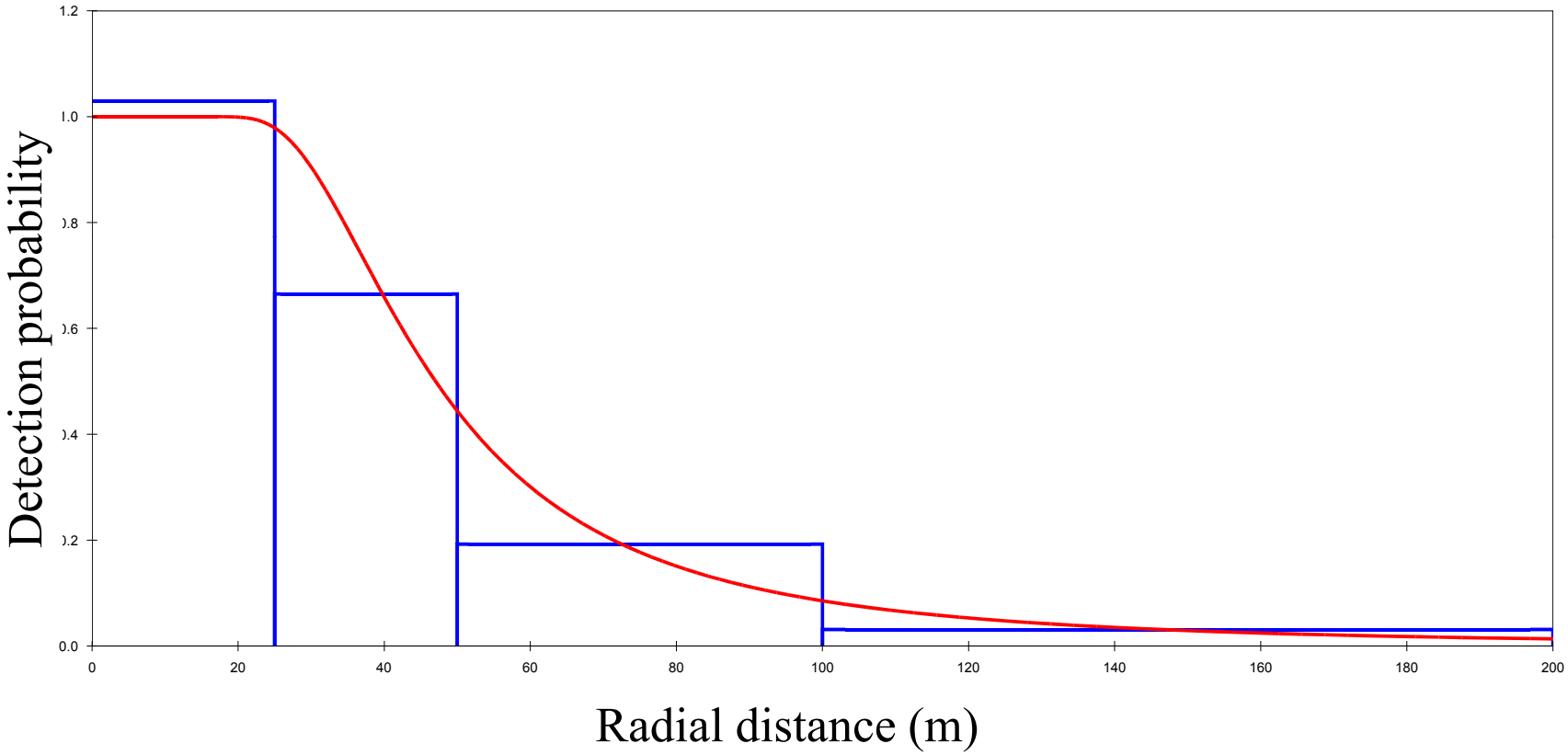


ERROR MAGNITUDE BY DENSITY



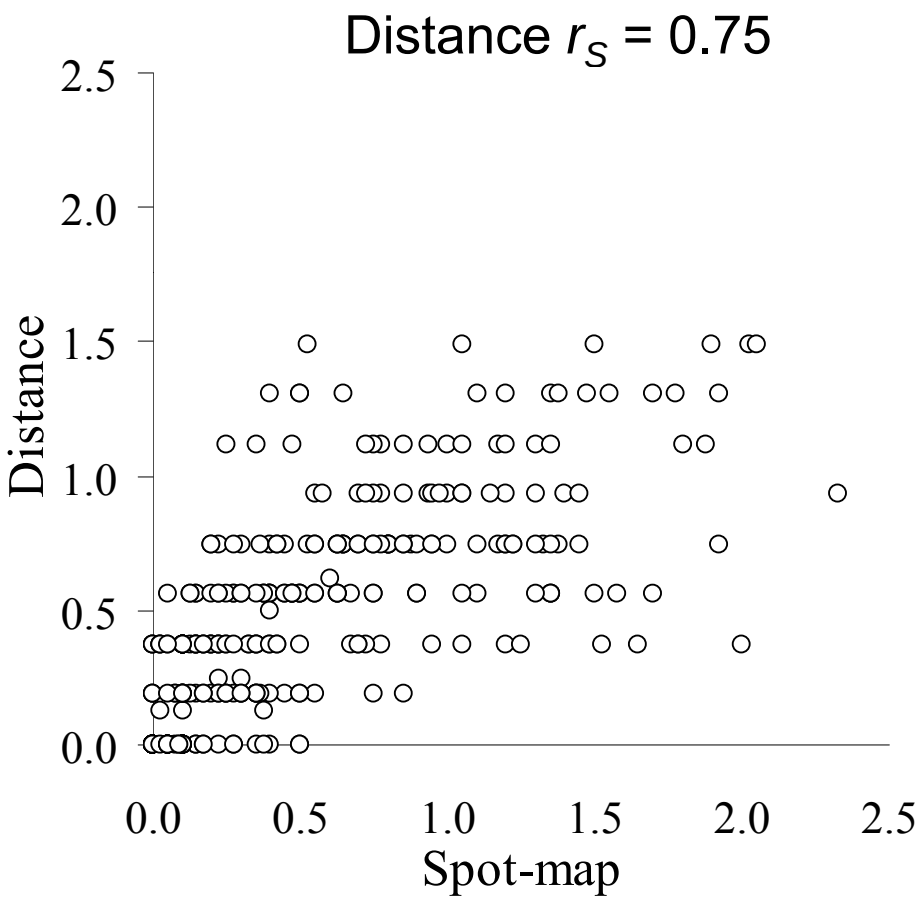


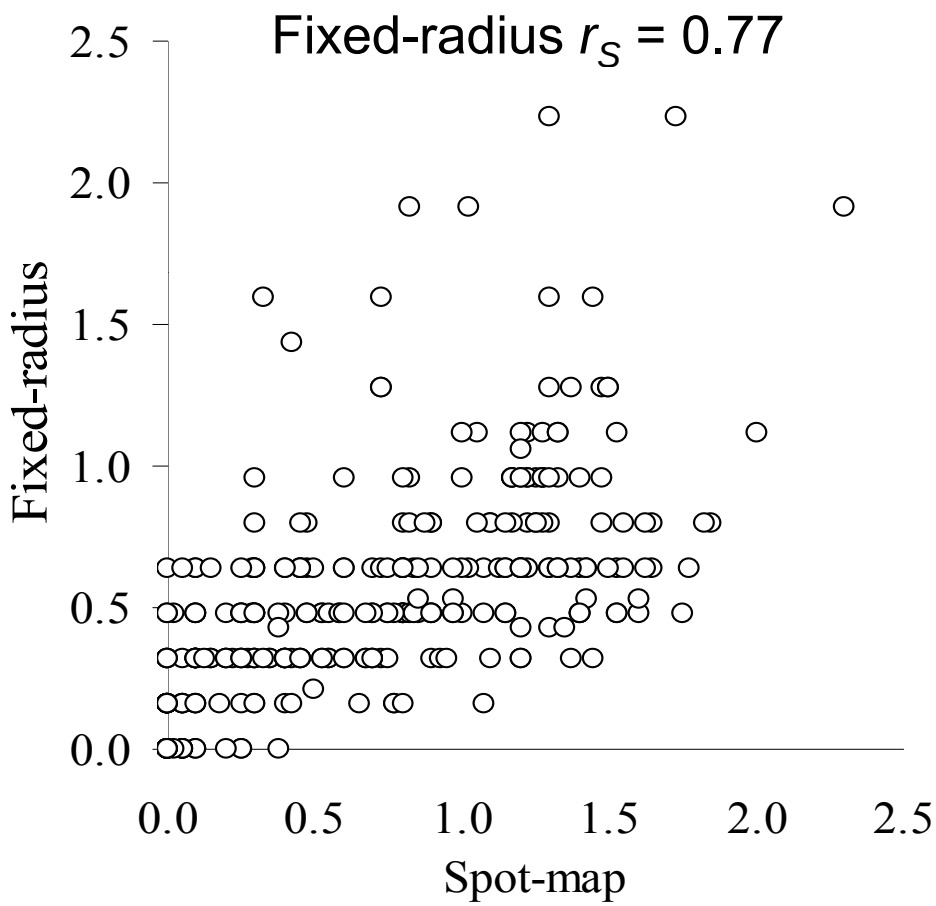
CERULEAN WARBLER



Detections = 849
Effective distance radius = 65 m
Detection probability = 0.10
Goodness of fit chi-squared p-value = 0.37

CERULEAN WARBLER

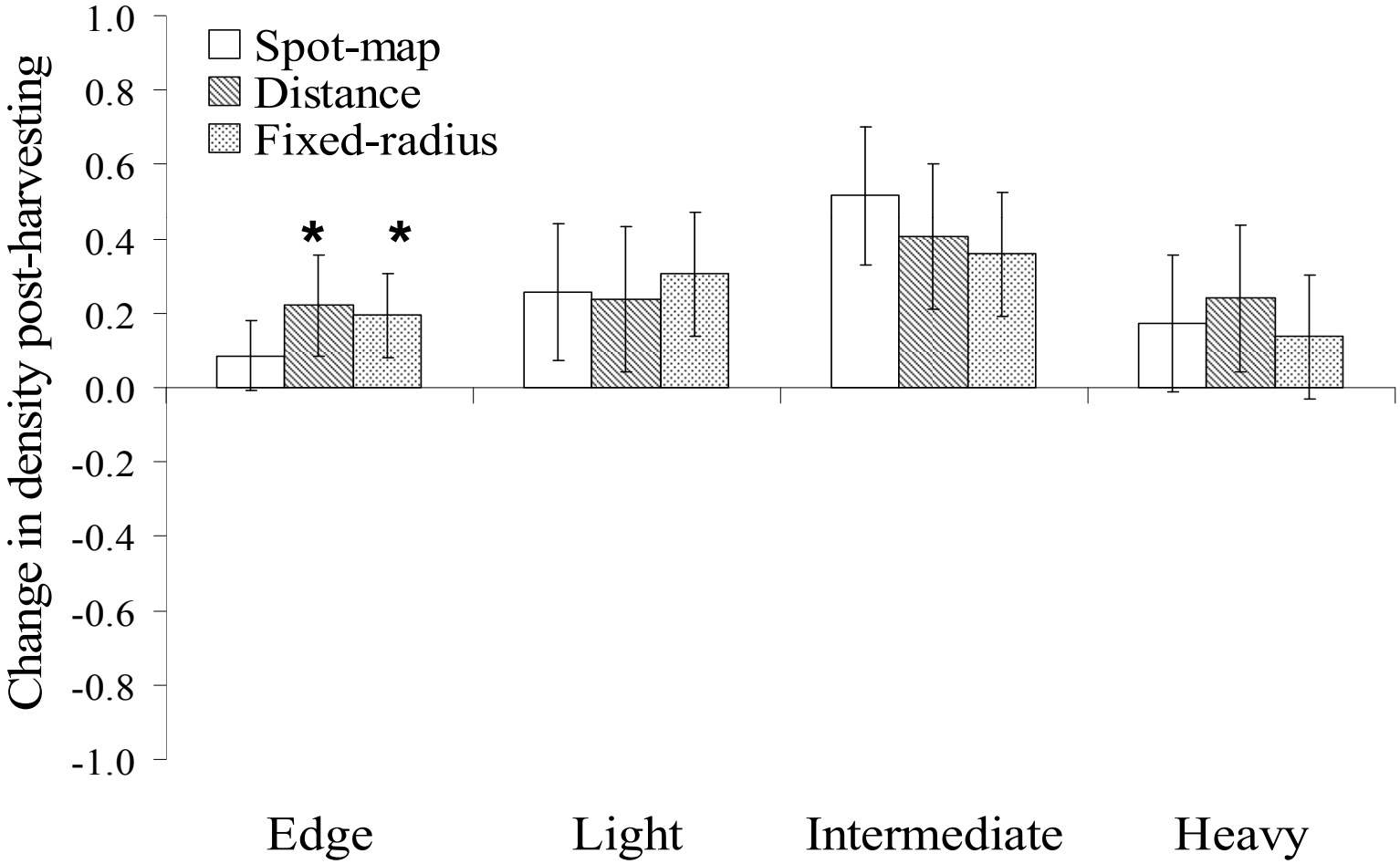




Jones et al. r_S = 0.46–0.67

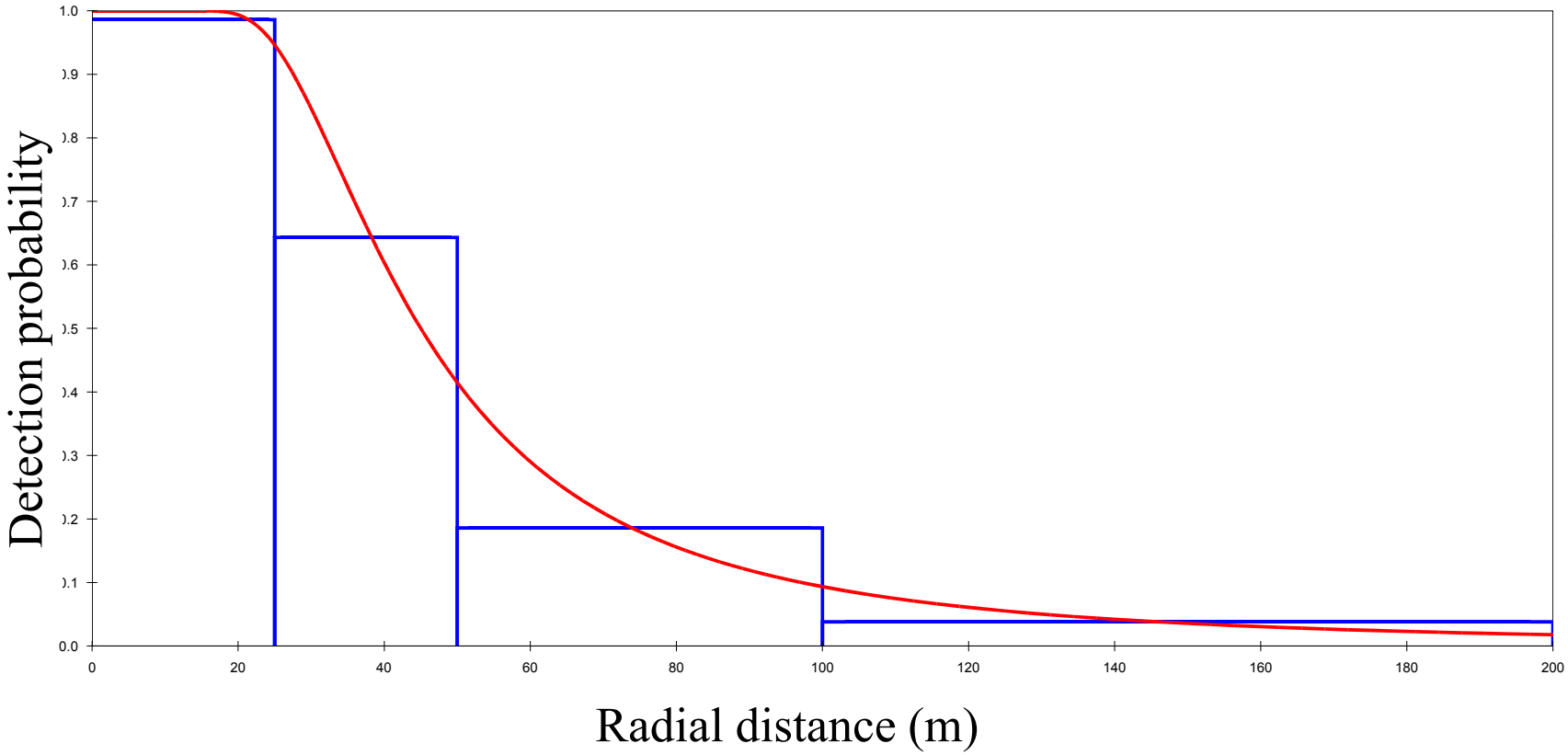
Jones et al. 2001 r_S = 0.57–0.77

CERULEAN WARBLER



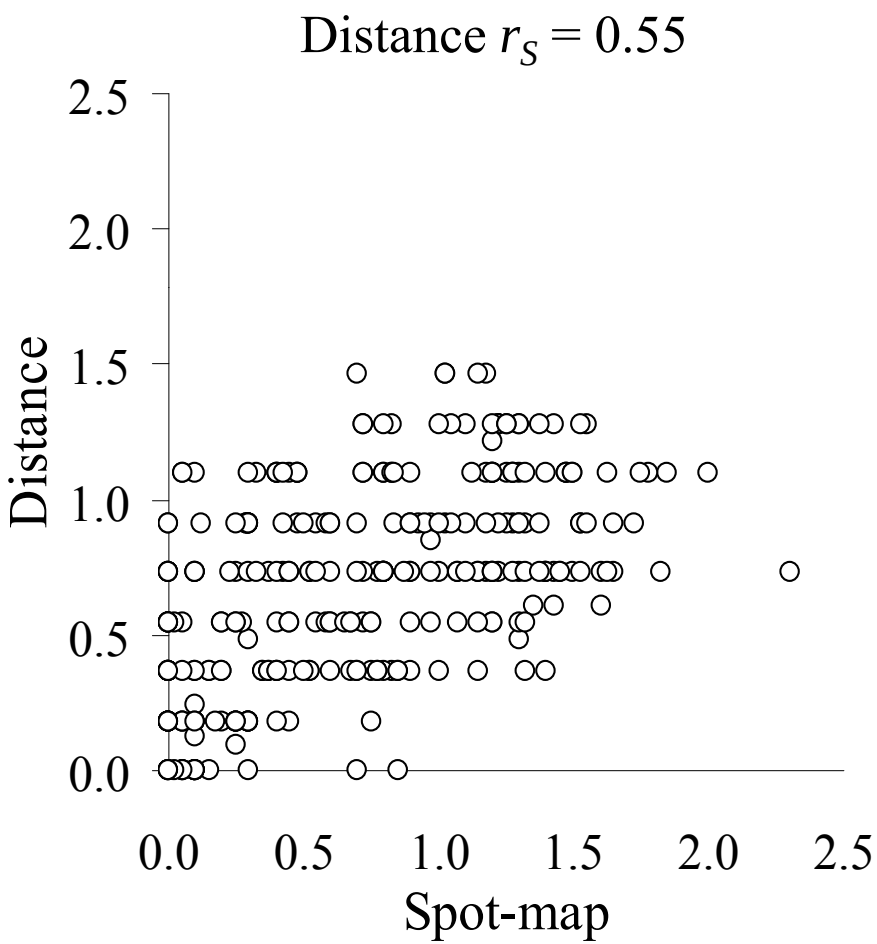
Observations:112, Groups:7

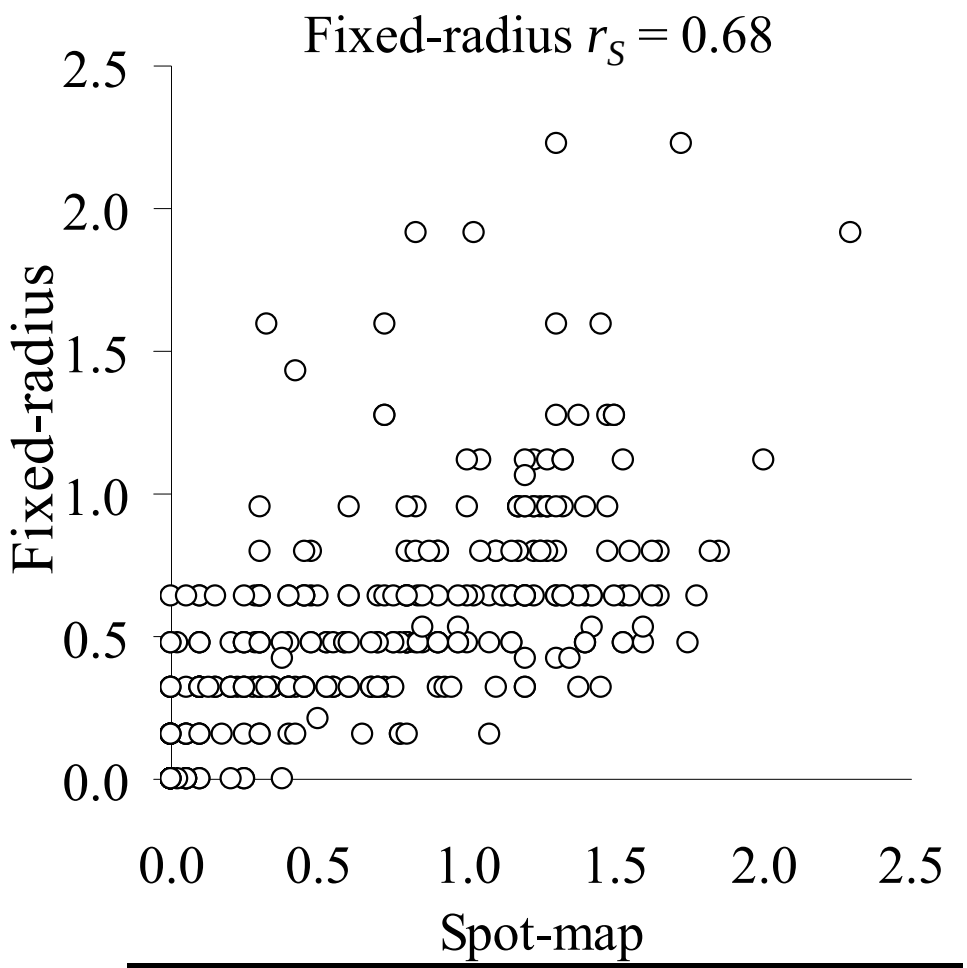
OVENBIRD



Detections = 1160
Effective distance radius = 66 m
Detection probability = 0.10
Goodness of fit chi-squared p-value = 0.86

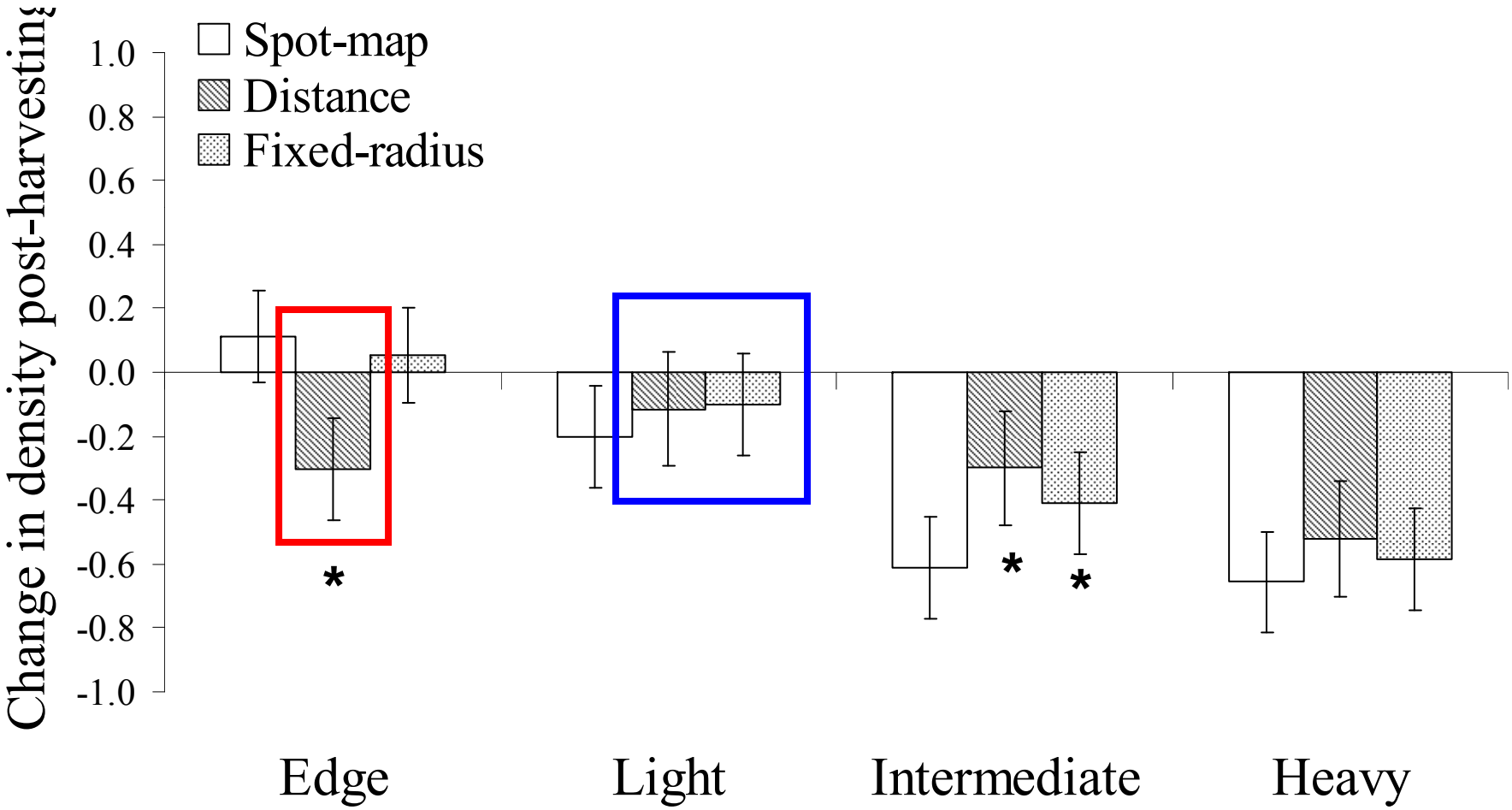
OVENBIRD





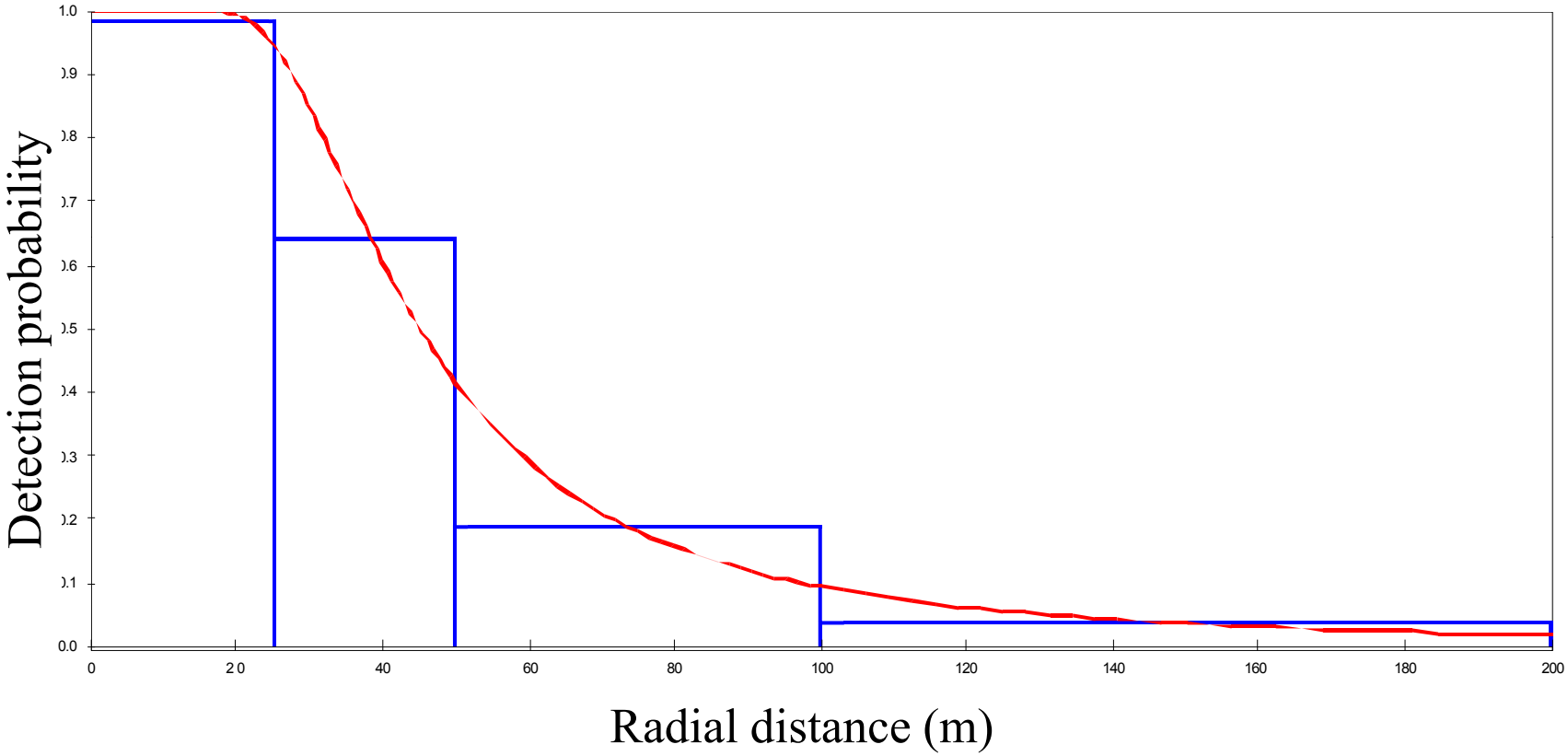
Howell et al. 2004 r_P = 0.85
Toms et al. 2006 r_P = 0.43–0.54

OVENBIRD



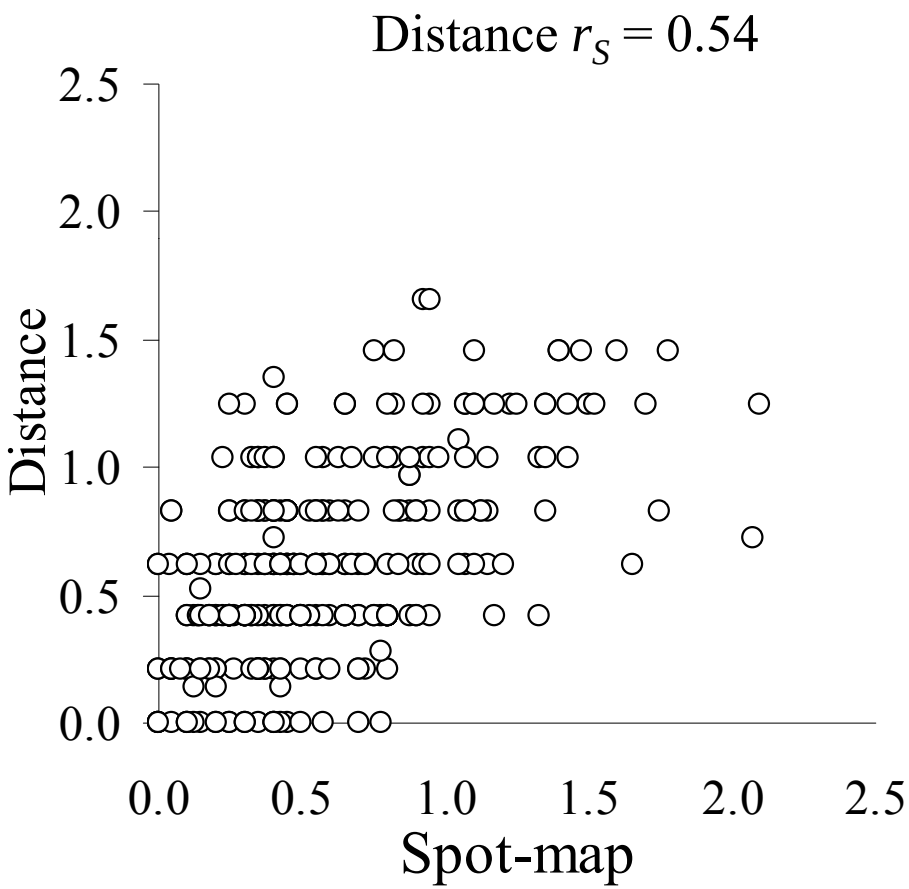
Observations:112, Groups:7

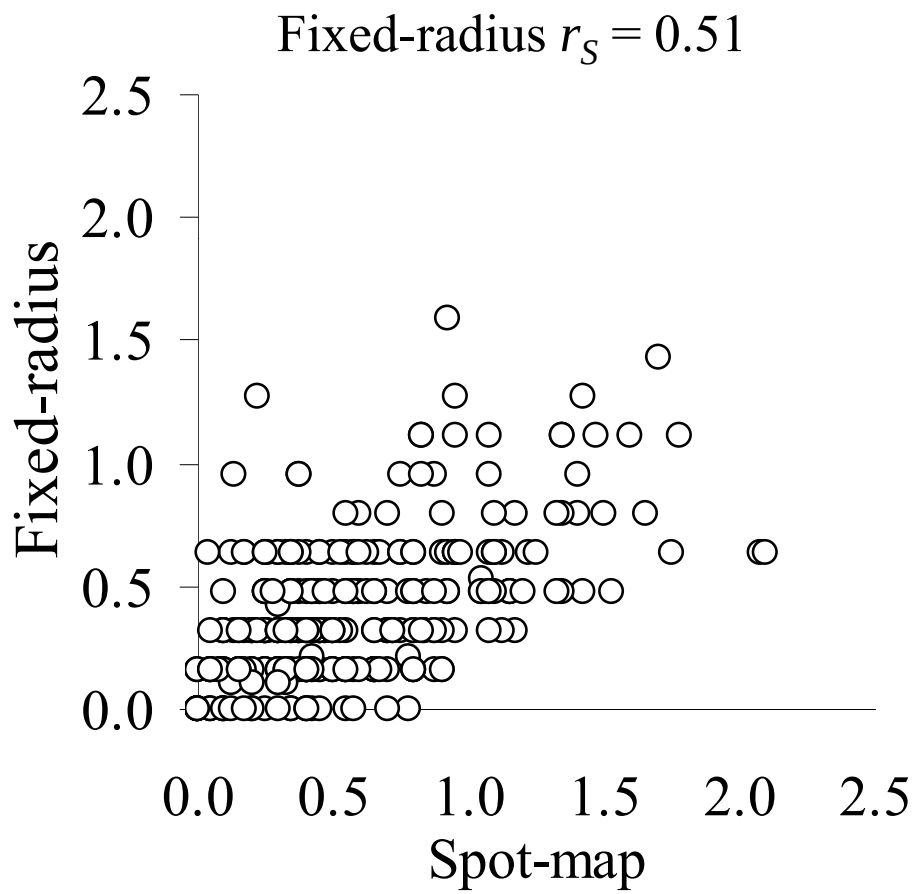
HOODED WARBLER



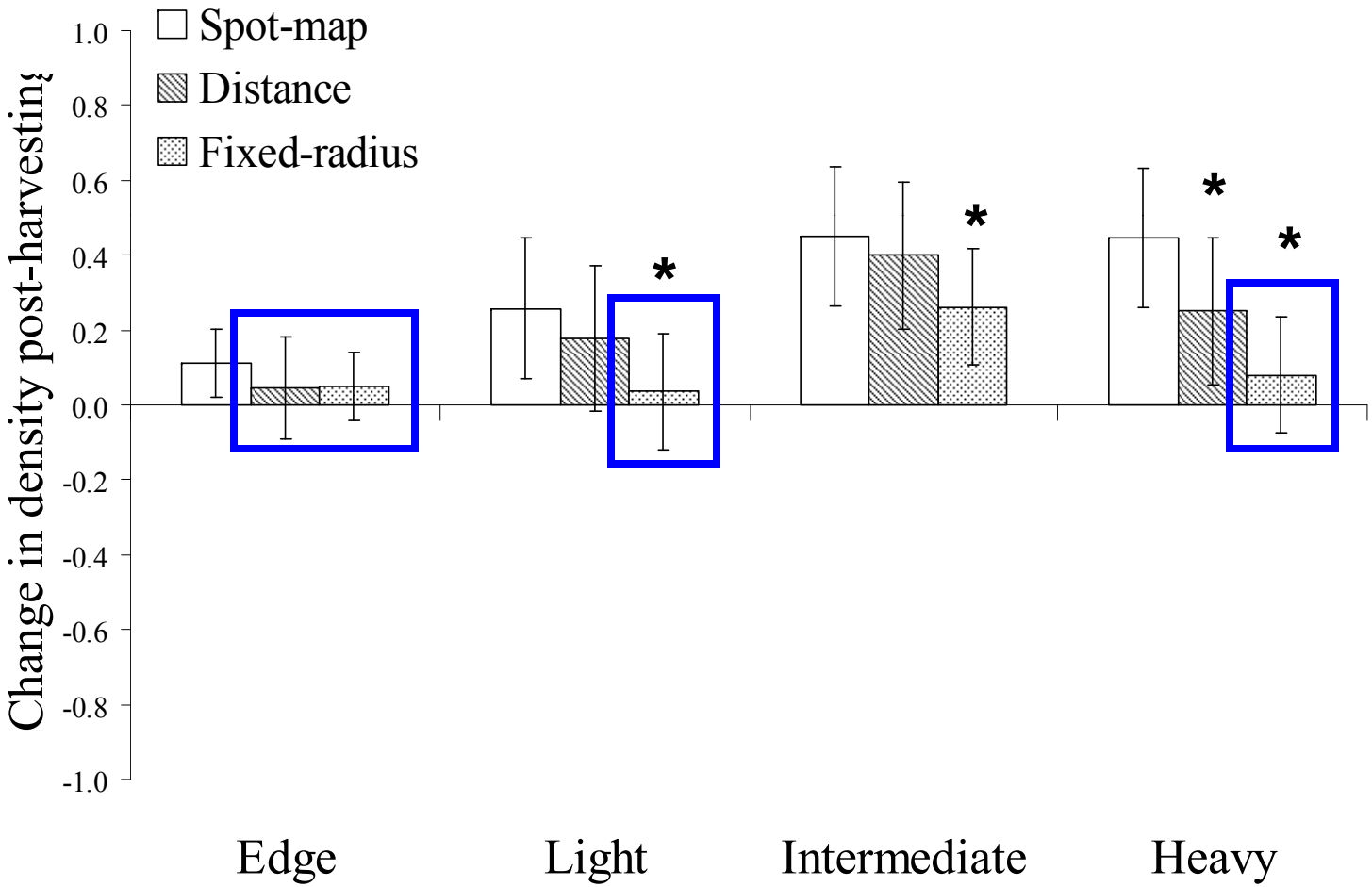
Detections = 928
Effective distance radius = 61 m
Detection probability = 0.09
Goodness of fit chi-squared p-value = 0.10

HOODED WARBLER



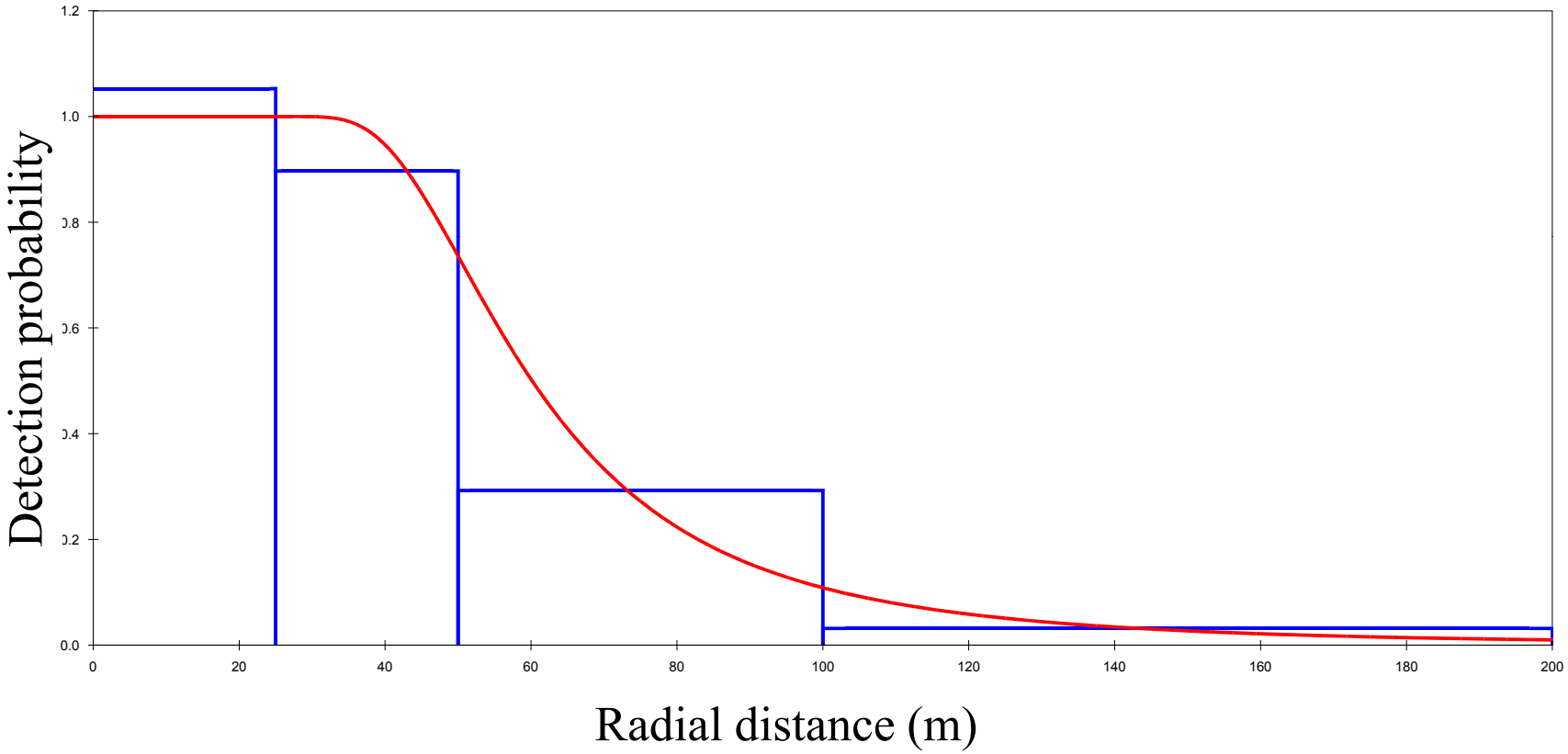


HOODED WARBLER



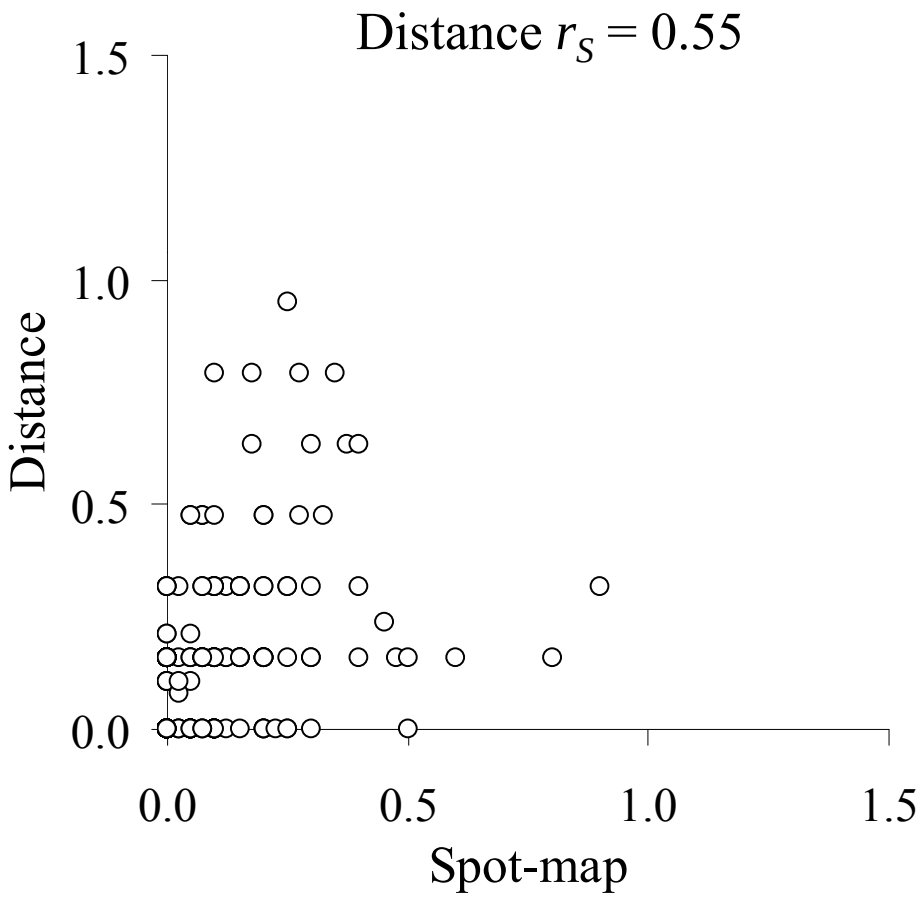
Observations:112, Groups:7

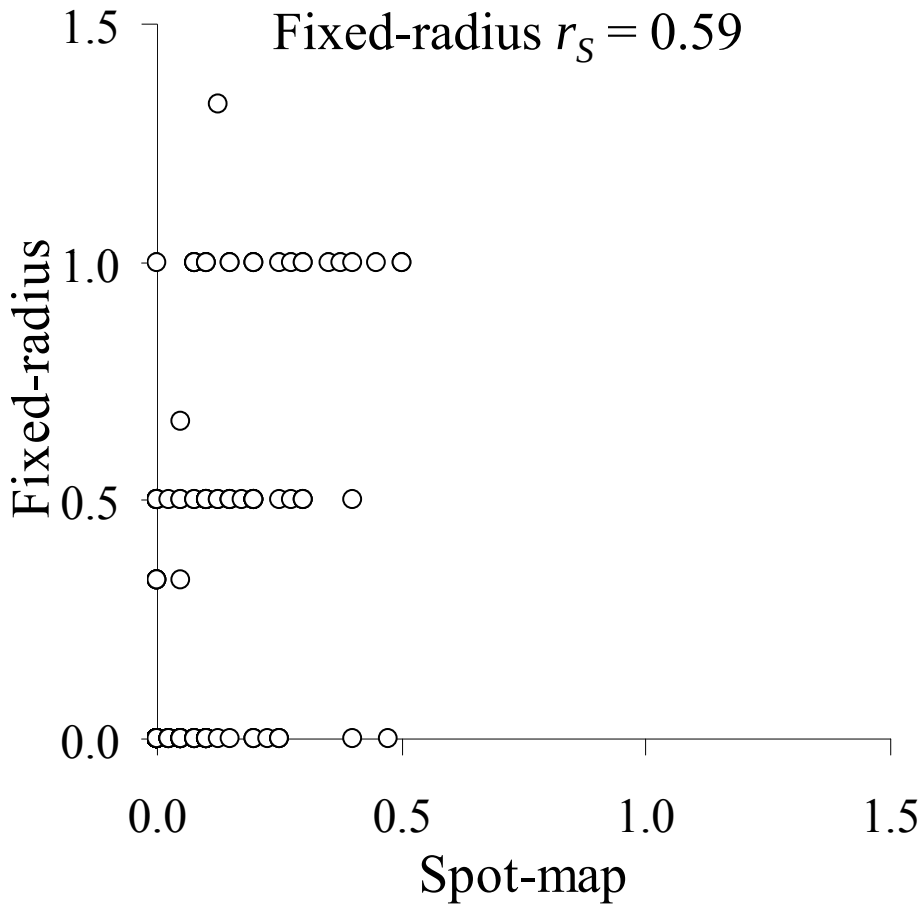
KENTUCKY WARBLER



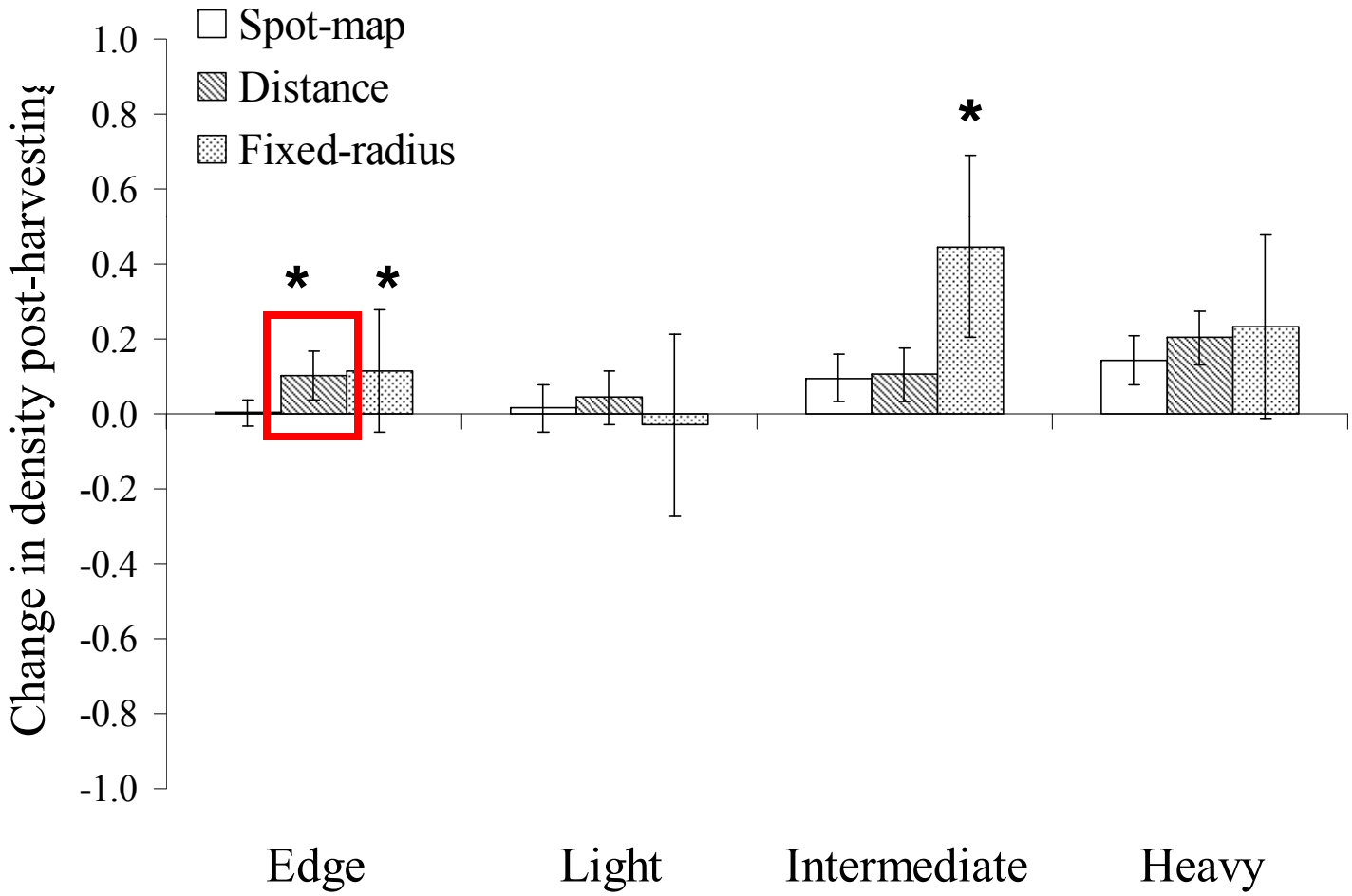
Detections = 184
Effective distance radius = 70 m
Detection probability = 0.12
Goodness of fit chi-squared p-value = 0.92

KENTUCKY WARBLER



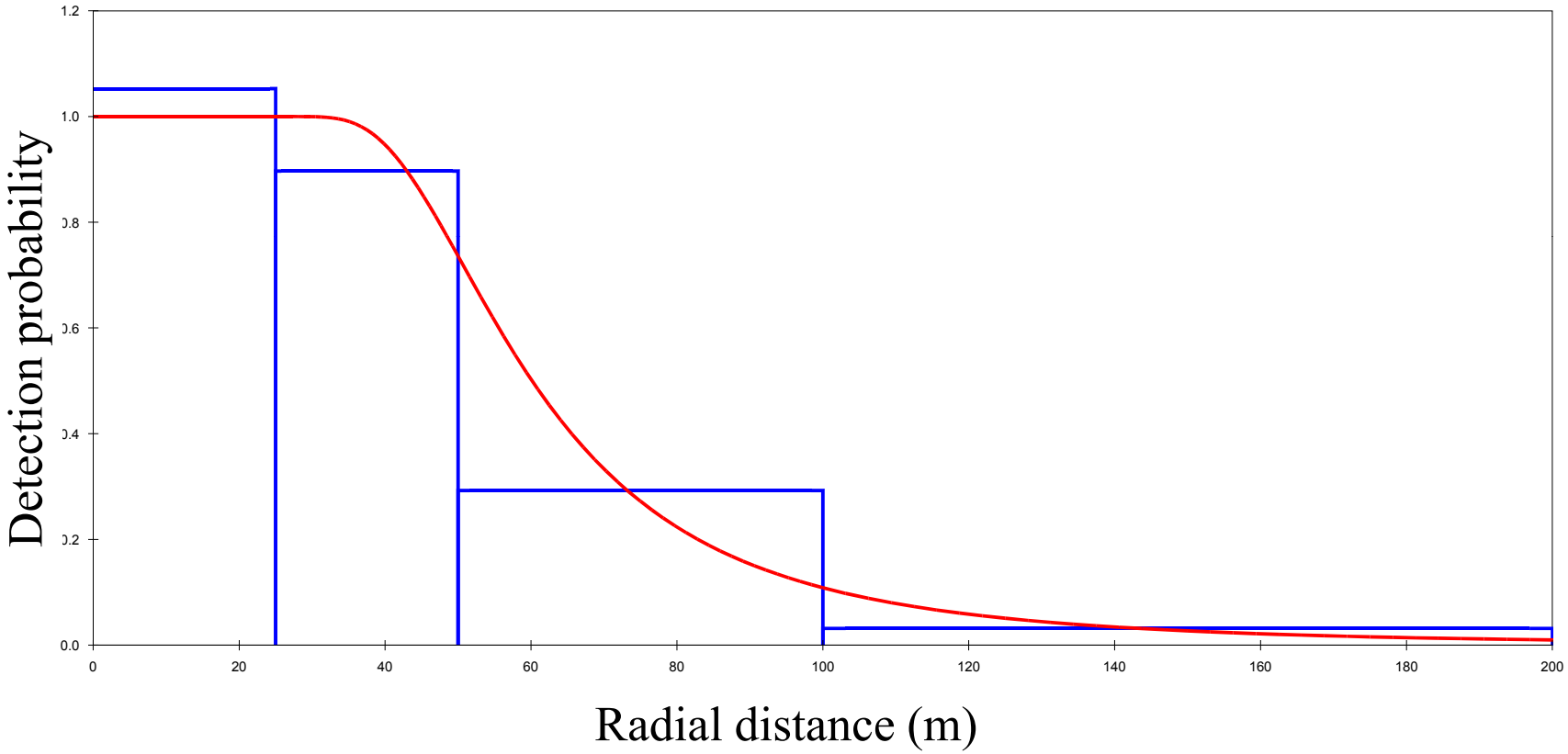


KENTUCKY WARBLER



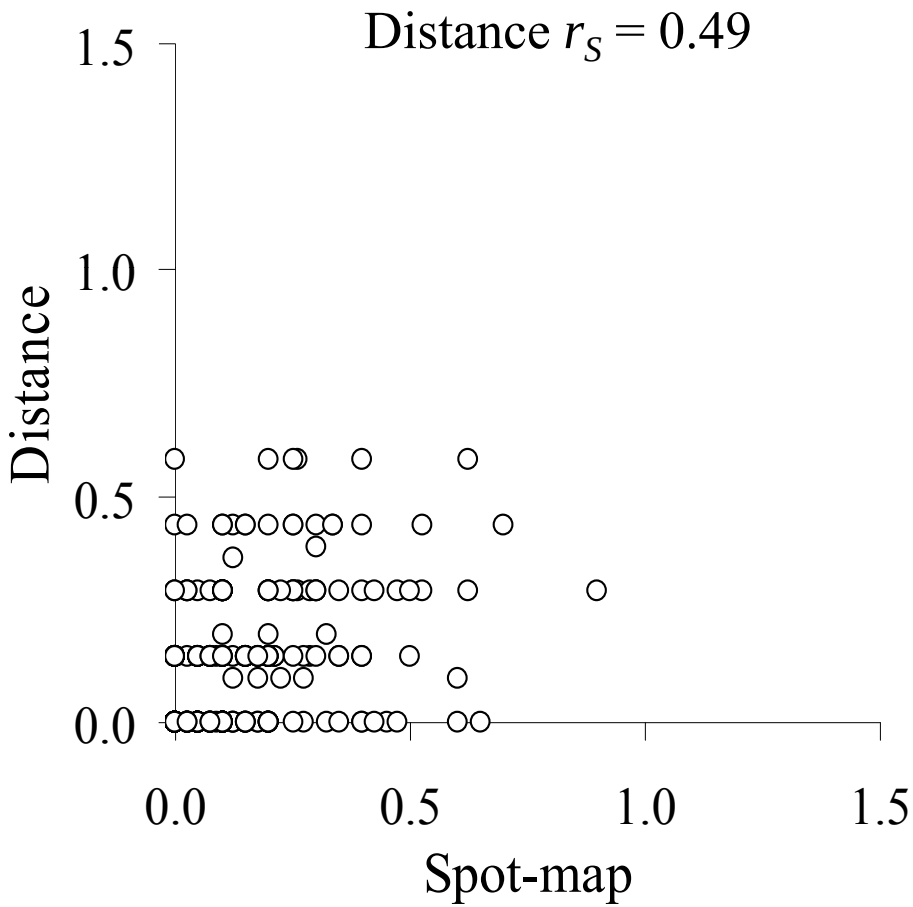
Observations:112, Groups:7

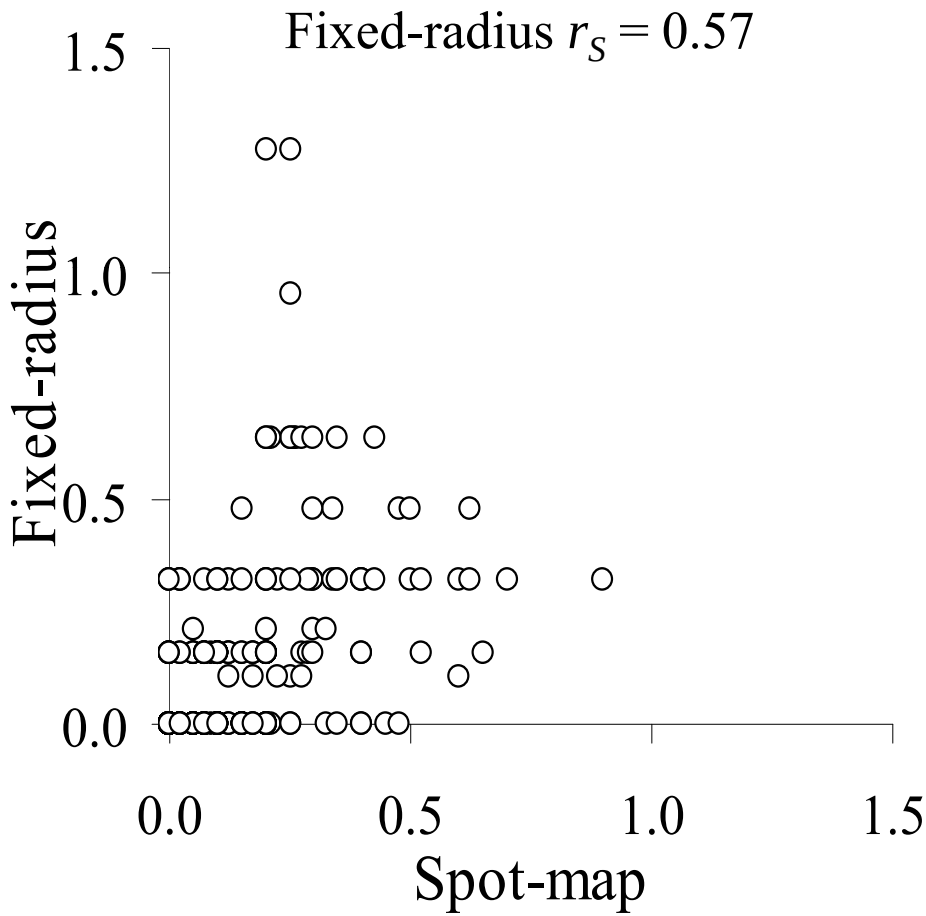
WORM-EATING WARBLER



Detections = 225
Effective distance radius = 74 m
Detection probability = 0.13
Goodness of fit chi-squared p-value = 0.72

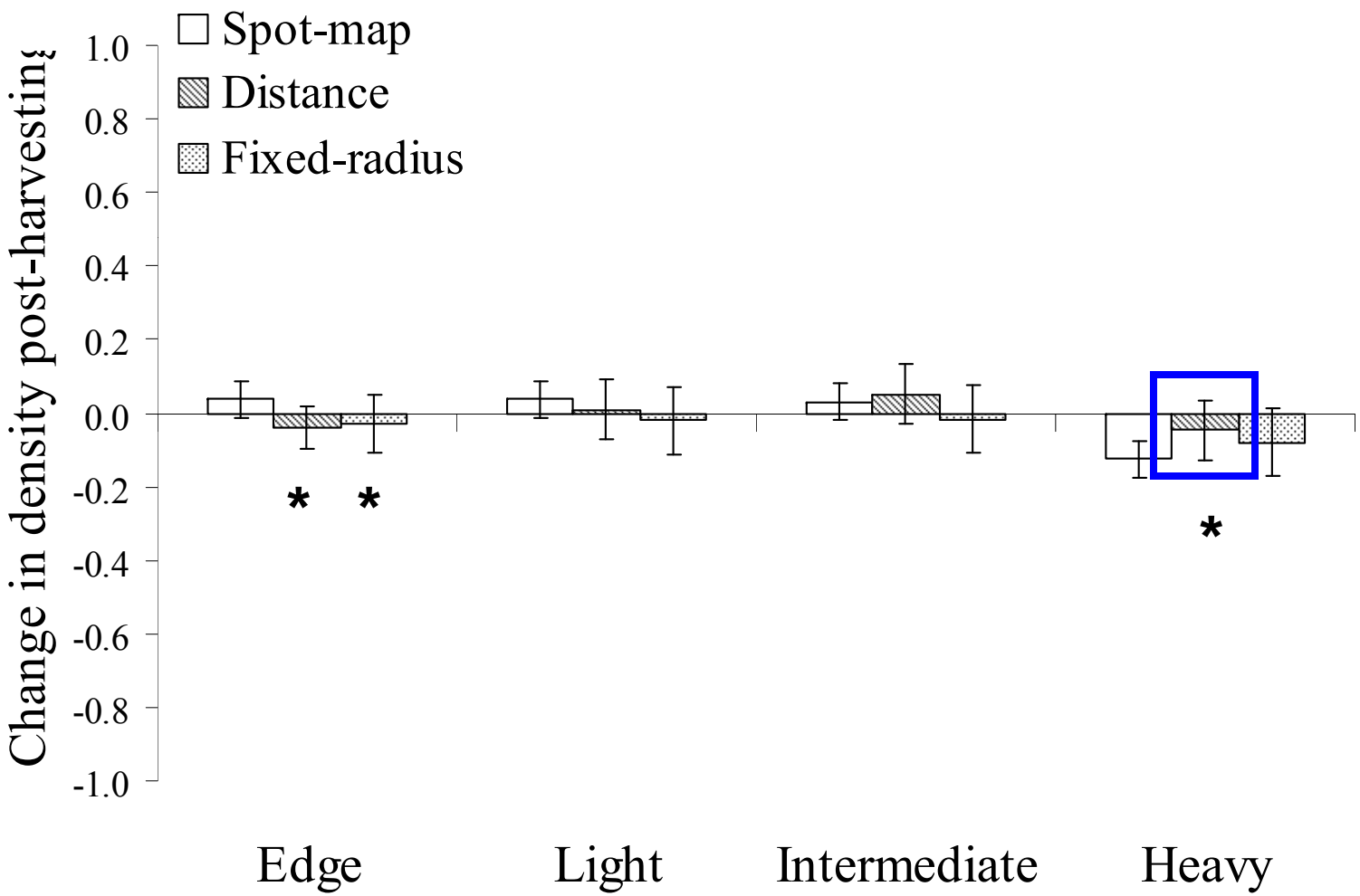
WORM-EATING WARBLER





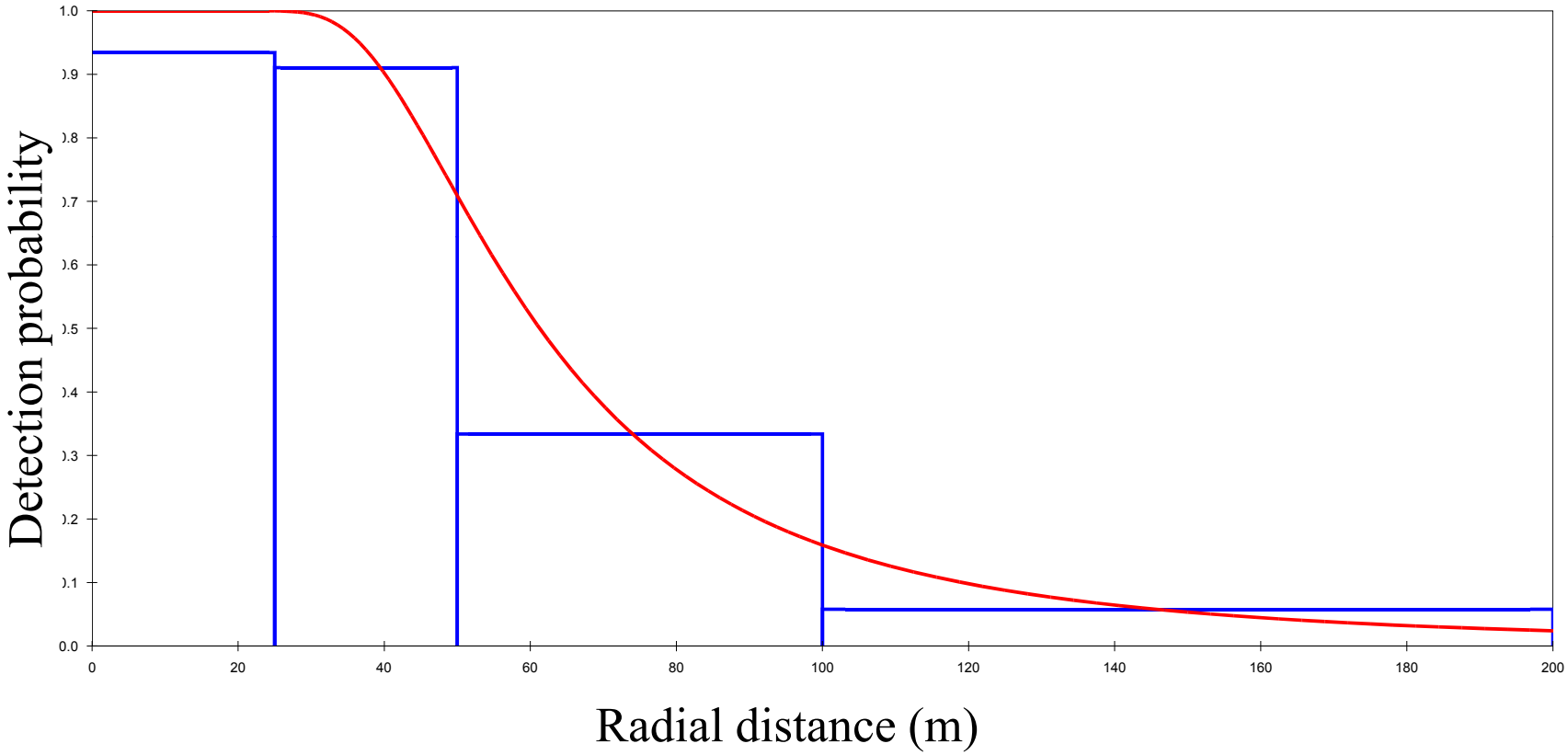
Howell et al. 2004. r_P = 0.39

WORM-EATING WARBLER



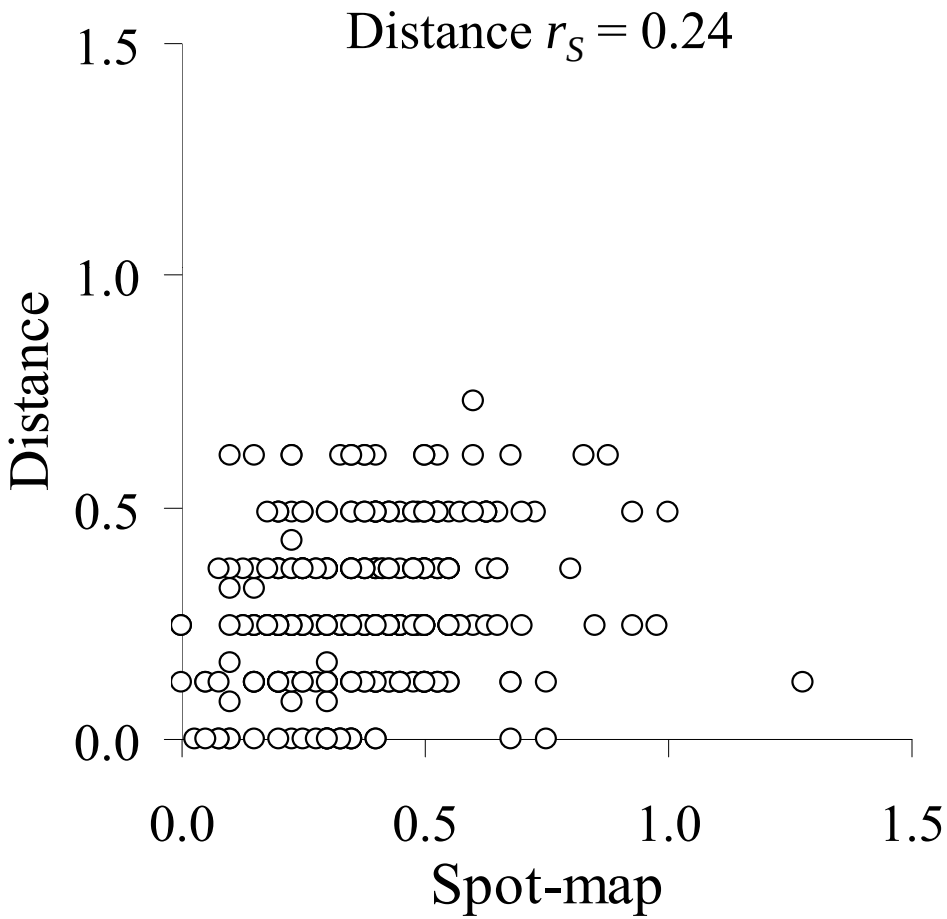
Observations:112, Groups:7

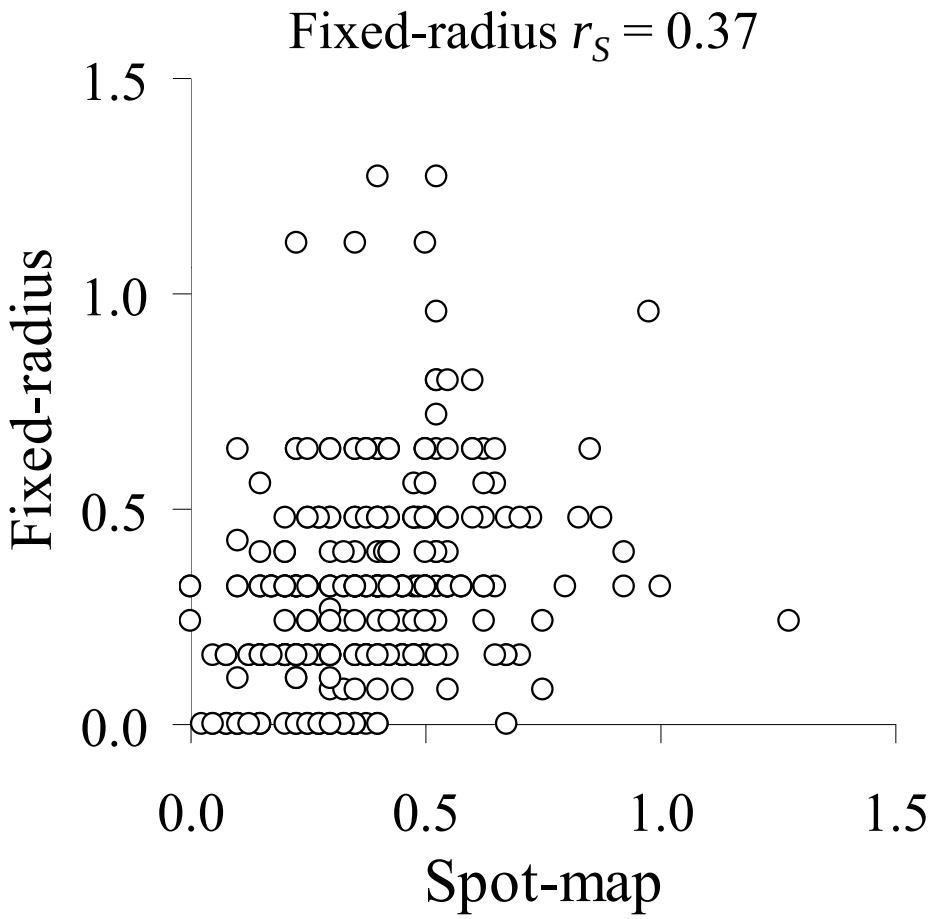
SCARLET TANAGER



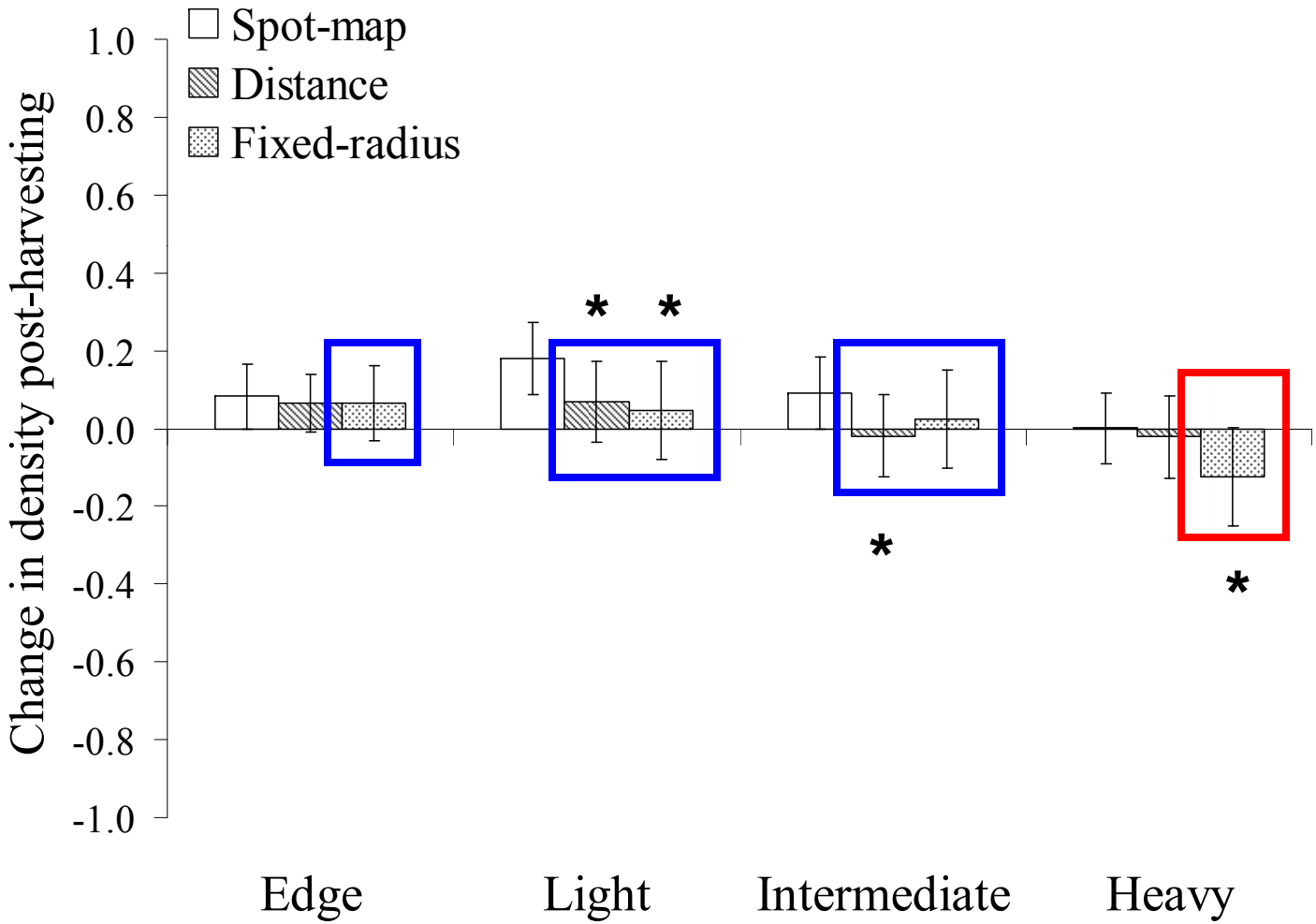
Detections = 738
Effective distance radius = 80 m
Detection probability = 0.16
Goodness of fit chi-squared p-value = 0.51

SCARLET TANAGER



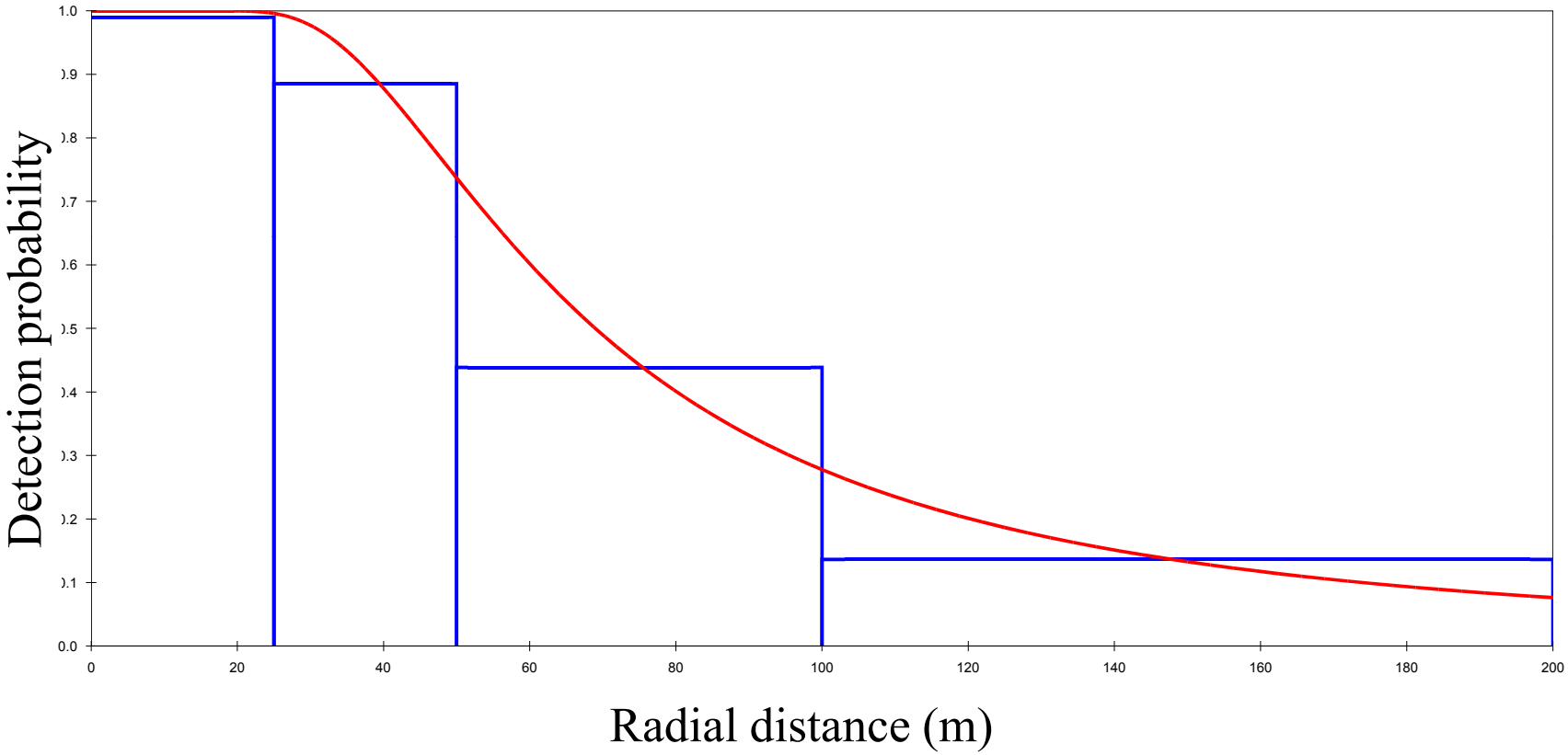


SCARLET TANAGER



Observations:112, Groups:7

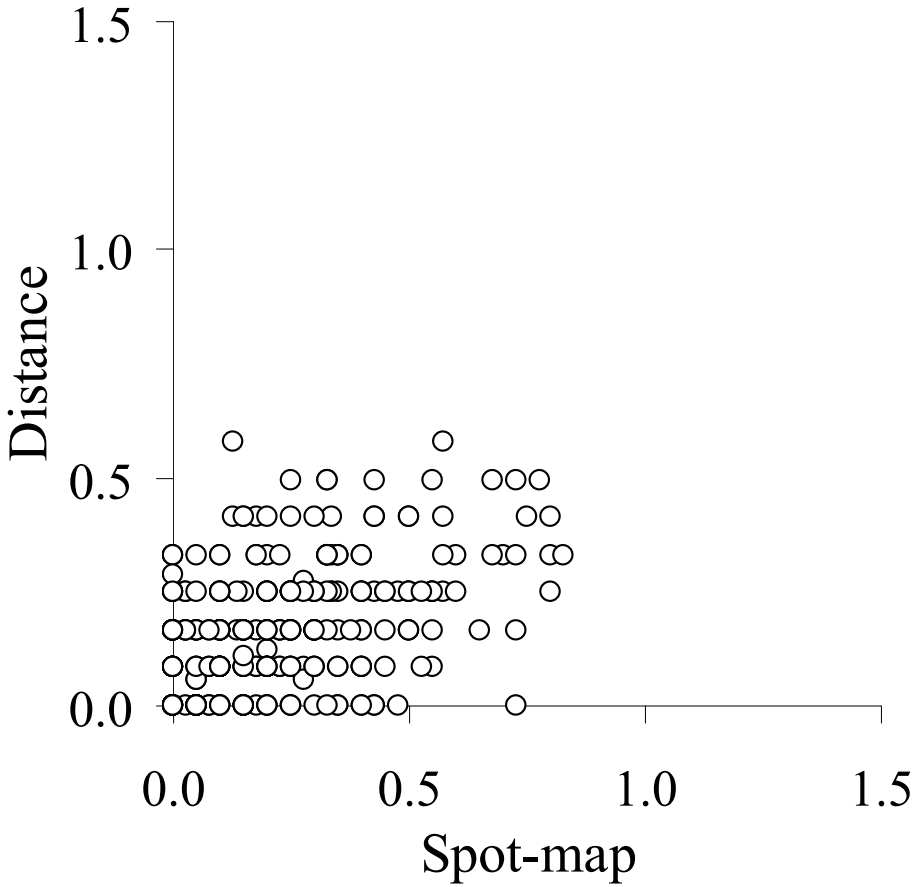
WOOD THRUSH



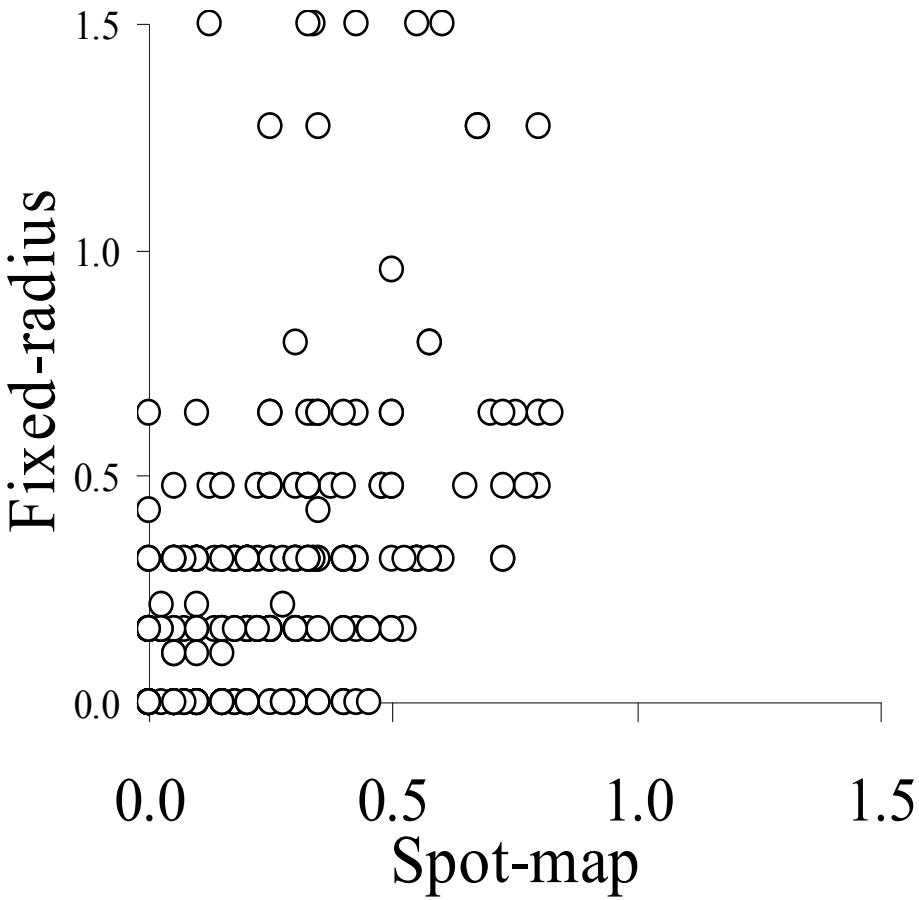
Detections = 640
Effective distance radius = 98 m
Detection probability = 0.24
Goodness of fit chi-squared p-value = 0.92

WOOD THRUSH

Distance r_S = 0.42

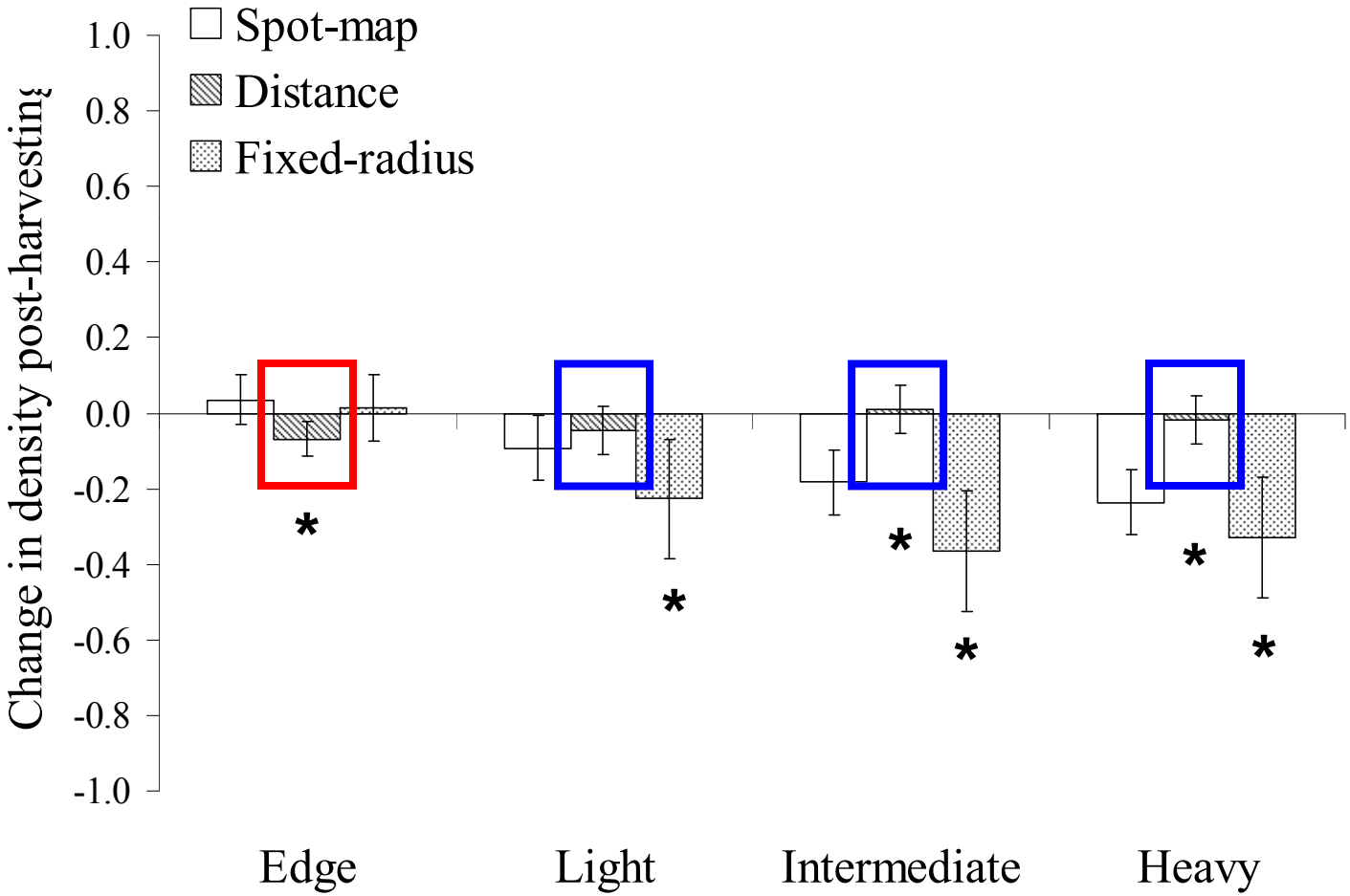


Fixed-radius r_S = 0.55



Howell et al. 2004. r_P = 0.57

WOOD THRUSH

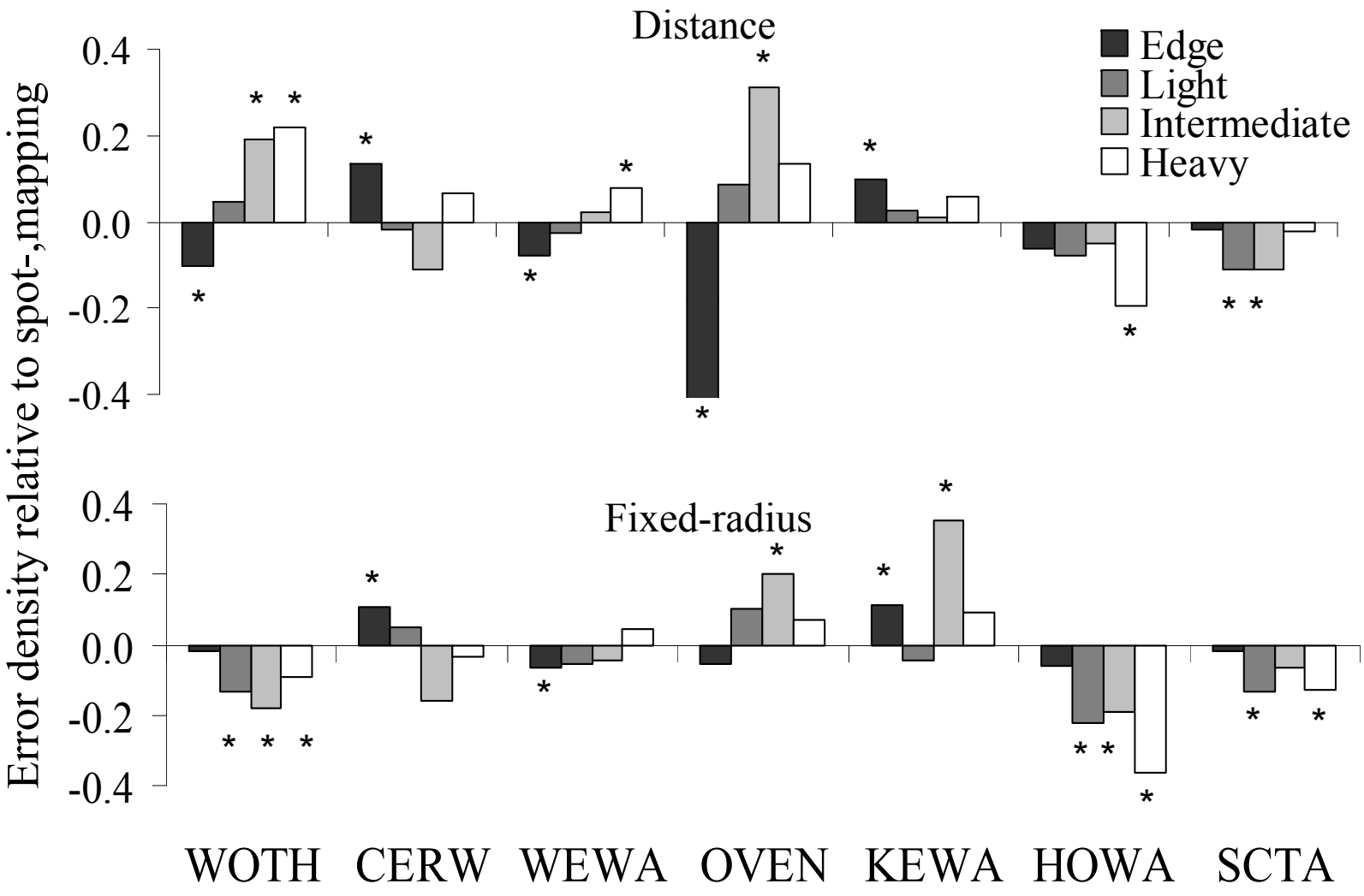


Observations:112, Groups:7

DETECTING AN EFFECT

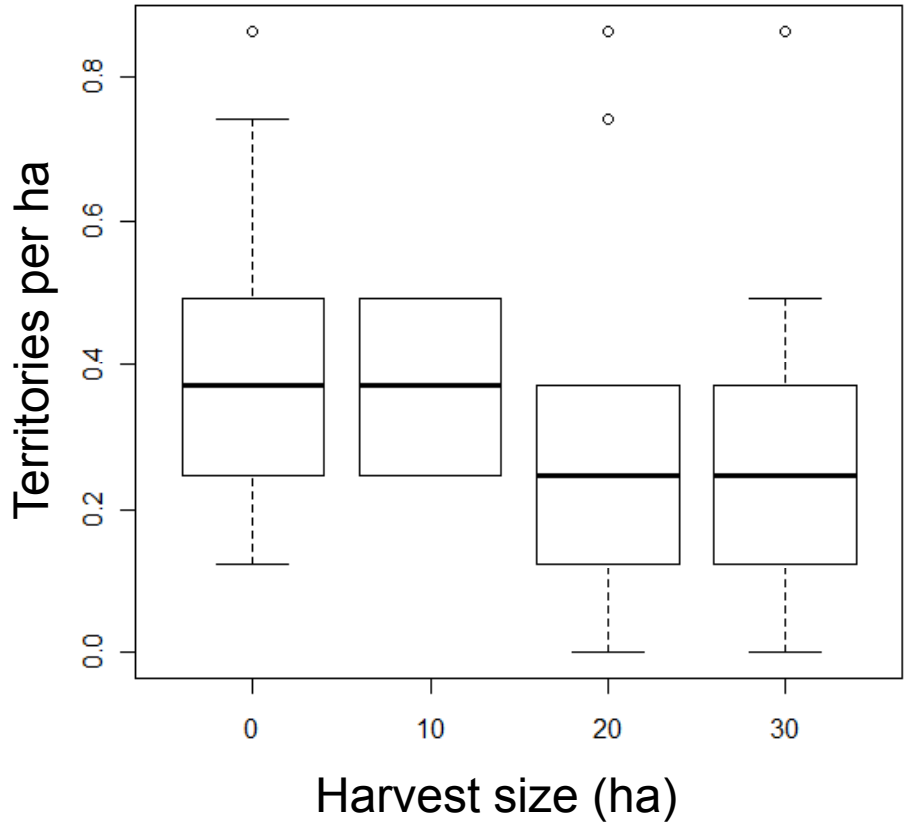
	Distance				Fixed-radius			
Species	Edge	Light	Med	Heavy	Edge	Light	Med	Heavy
Wood Thrush	**I**	**II**	**II**	**II**	-	√	√	√
Cerulean Warbler	√	√	√	√	√	√	√	√
Worm-eating warbler	-	-	-	**II**	-	-	-	√
Ovenbird	**I**	**II**	√	√	√	**II**	√	√
Kentucky warbler	**I**	-	√	√	-	-	√	√
Hooded warbler	**II**	√	√	√	**II**	**II**	√	**II**
Scarlet Tanager	√	**II**	**II**	-	**II**	**II**	**II**	**I**

ESTIMATE ACCURACY

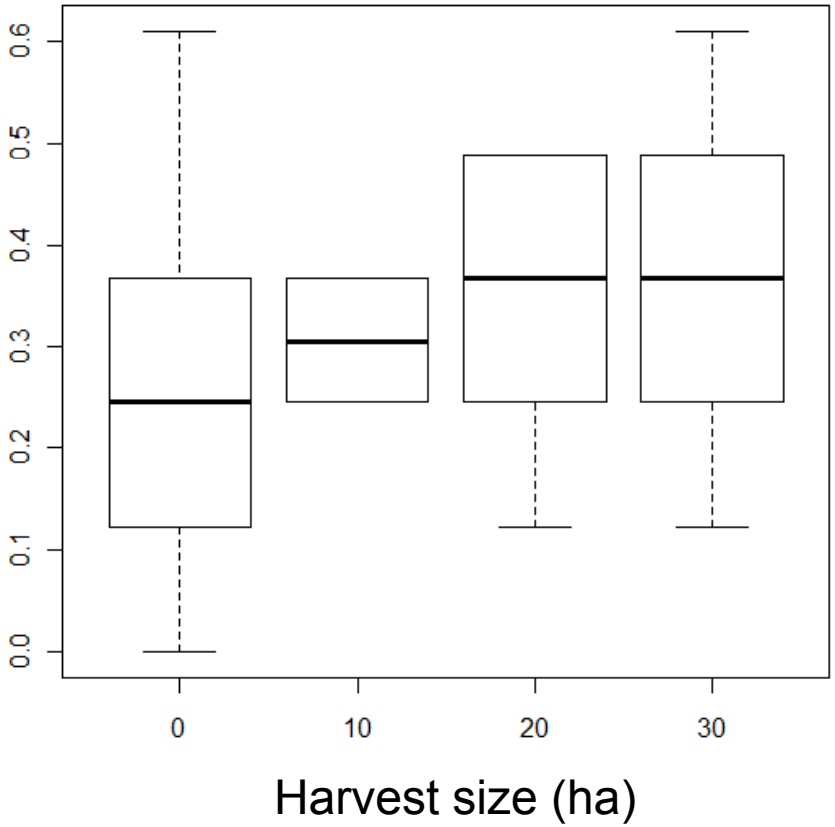


DISTANCE ESTIMATE AND HARVEST SIZE

Wood Thrush



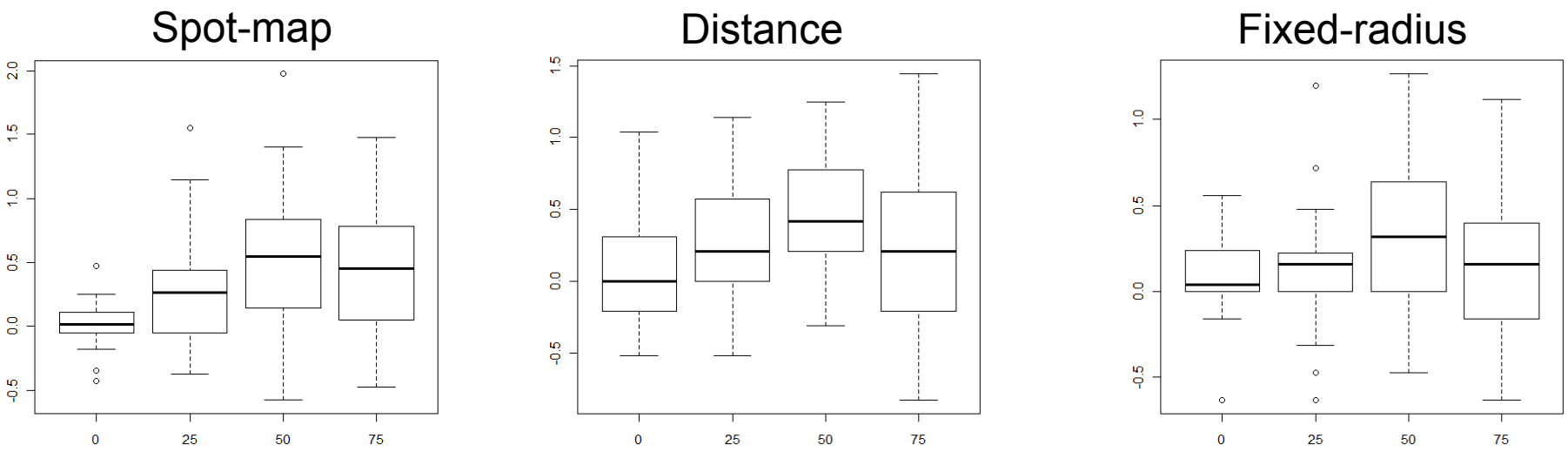
Scarlet Tanager



Density estimates from 56 line-transects in southeastern Ohio, 2007-2008

DETECTION PROBABILITY?

Difference between heavy and light treatments for Hooded Warblers.



SUMMARY:DISTANCE-ESTIMATE VS. FIXED-RADIUS COUNT

- Effectiveness of methods varied among species;
- Both analytic approaches failed to detect weak effects such as Ovenbirds in light harvest and Scarlet Tanagers.
- Distance error for Wood Thrush with largest EDR in this study. Error generally associated with edge effects.
- Fixed-radius error for Hooded Warblers, perhaps related to detection probability.
- Methods both over and underestimated density.

TIME AND EFFORT

- Spot-mapping 8x time/effort of point counts.
- Accurate density estimates versus sample size.
- Territory locations versus other data collection.

	Spot-map	Point counts
Hours day^{-1}	4	2
Days site^{-1}	8	2
Total hours	32	4

MANAGEMENT APPLICATION

- *Question:*
  Best partial-harvesting level to benefit Cerulean Warblers?

- *Answer:*
  Spot-map: Intermediate
  Distance: Intermediate
  Fixed-radius: Intermediate

Step 1. Examine breeding density

MANAGEMENT APPLICATION

- *Question:*
  Best partial-harvesting level to benefit Cerulean Warblers?
- *Answer:* Intermediate

Birds are abundant, but does that mean it is quality habitat?

Step 2. Examine everything else!!!

CONCLUSIONS

It's a tie!

Neither approach perfect, but both work.

<u>Careful study design and data collection to answer question.</u>

ACKNOWLEDGEMENTS

Funding:

- National Fish and Wildlife Foundation through a grant with the
- National Council for Air and Stream Improvement, Inc.
- U.S. Fish and Wildlife Service
- U.S. Forest Service Monongahela National Forest
- U.S. Forest Service Daniel Boone National Forest
- MeadWestvaco Corporation
- Kentucky Department of Fish and Wildlife Resources
- Ohio Division of Wildlife
- Tennessee Wildlife Resources Agency
- Department of Forestry, Wildlife and Fisheries at University of Tennessee
- School of Environment and Natural Resources at Ohio State University
- The Nature Conservancy through a US Fish and Wildlife Service HCP planning grant with the Tennessee Wildlife Resources Agency
- West Virginia Division of Natural Resources Wildlife Diversity Program
- USGS West Virginia Cooperative Fish and Wildlife Research Unit

Assistance of many field assistants for their hard work and dedication to Cerulean Warbler conservation.

NCASI Co-author, T. Bentley Wigley

Assistance of forest management personnel for study site selection and especially design and implementation of harvest treatments:

- USFS Daniel Boone National Forest
- USFS Monongahela National Forest
- Tennessee Wildlife Resources Agency
- West Virginia Division of Natural Resources
- Forest Land Group/Wagner Forest Management
- MeadWestvaco/Vinton Furnace Experimental Forest.

Cooperating universities:
West Virginia University
University of Tennessee
Indiana University of Pennsylvania
Ohio State University

Questions?