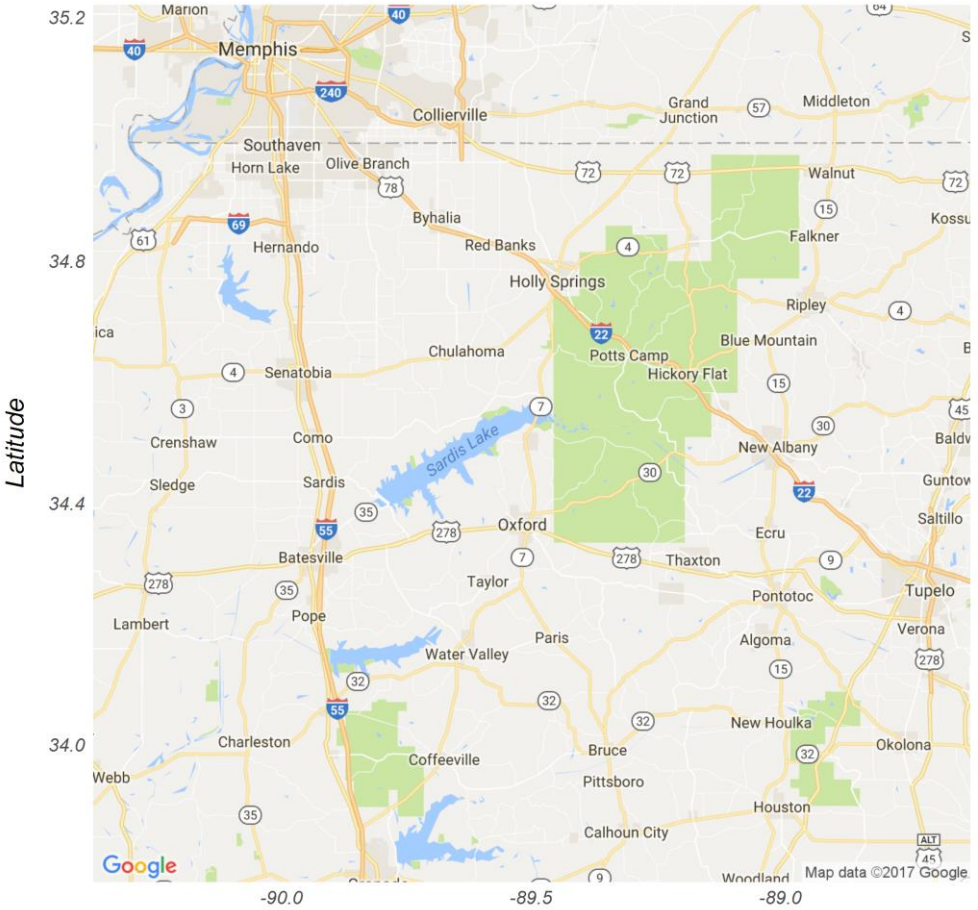
The effect of road-crossings on stream-associated salamanders within Holly Springs National Forest

Thesis Seminar Defense by
Caleb A. Aldridge
March 29th, 2017 - 14:00

THE UNIVERSITY of MISSISSIPPI

North Mississippi Roadmap



Holly Springs National Forest (HSNF) boundaries and area represented by green polygon northeast of Oxford. Roads are represented by color and line hierarchy - Thickest and orange (US Interstate), thick-yellow (US Highways), thin-yellow (4-lane State HWY), thick-white (2-lane State HWY), and thin-white (municipal streets and county roads).

Road Ecology: Direct effects

Road Ecology: Indirect effects

ROADS AND THEIR MAJOR ECOLOGICAL EFFECTS

Richard T. T. Forman and Lauren E. Alexander
Harvard University Graduate School of Design, Cambridge, Massachusetts 02138

The Ecological Road-Effect Zone of a Massachusetts (U.S.A.) Suburban Highway

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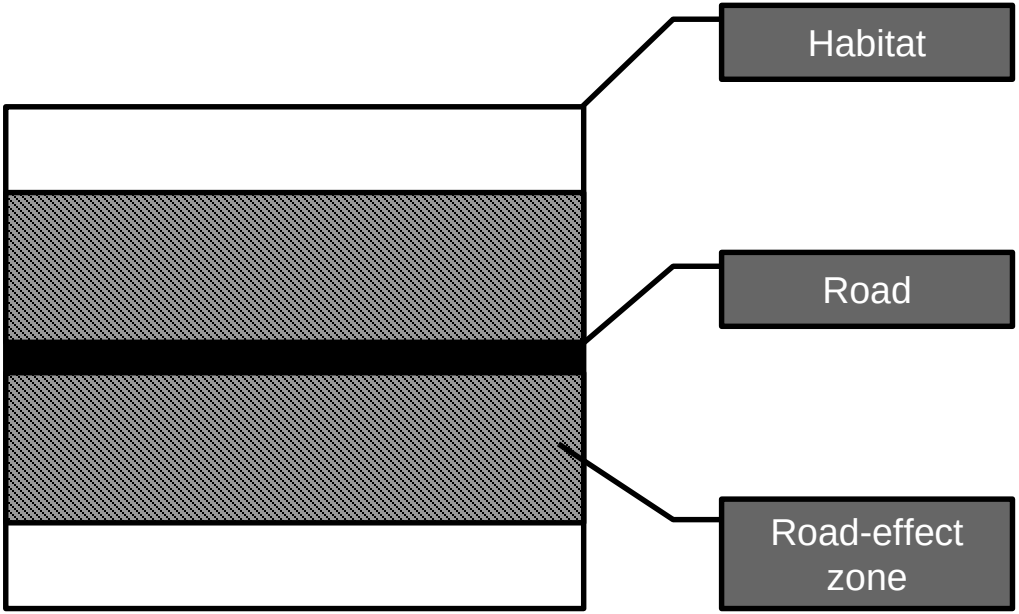
†Commonwealth of Massachusetts, Division of Fisheries and Wildlife, One Rabbit Hill Road, Westborough, MA 01581, U.S.A.

The Road-effect Zone



REZ and Salamanders

Annu. Rev. Ecol. Evol. Syst. 2004. 35:405–34
doi: 10.1146/annurev.ecolsys.35.112202.130116
First published online as a Review in Advance on July 26, 2004

ON THE ECOLOGICAL ROLES OF SALAMANDERS*

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- Food source
- Detritivore moderator
- Energy store
- Connect habitats

REZ and Salamanders

Ecological Applications, 14(6), 2004, pp. 1882–1891
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EFFECTS OF FOREST ROADS ON THE ABUNDANCE AND ACTIVITY OF TERRESTRIAL SALAMANDERS

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Research Article

Edge Effects of Gated and Ungated Roads on Terrestrial Salamanders

DAVID M. MARSH,[1] *Department of Biology, Washington and Lee University, Lexington, VA 24450, USA*

Salamander Abundance along Road Edges and within Abandoned Logging Roads in Appalachian Forests

RAYMOND D. SEMLITSCH,* TRAVIS J. RYAN,† KEVIN HAMED,‡ MATT CHATFIELD,§
BETHANY DREHMAN,** NICOLE PEKAREK,†† MIKE SPATH,‡‡ AND ANGIE WATLAND§§

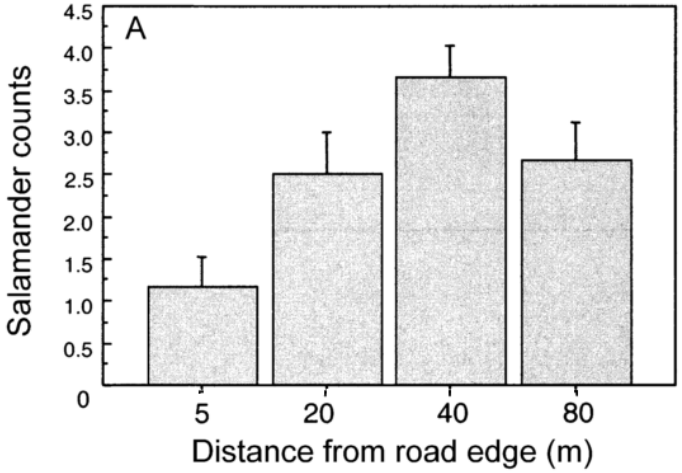


FIG. 2. Red-backed salamander densities at different distances from the road edge for the Big Levels data set: (A) red-backed salamander counts;

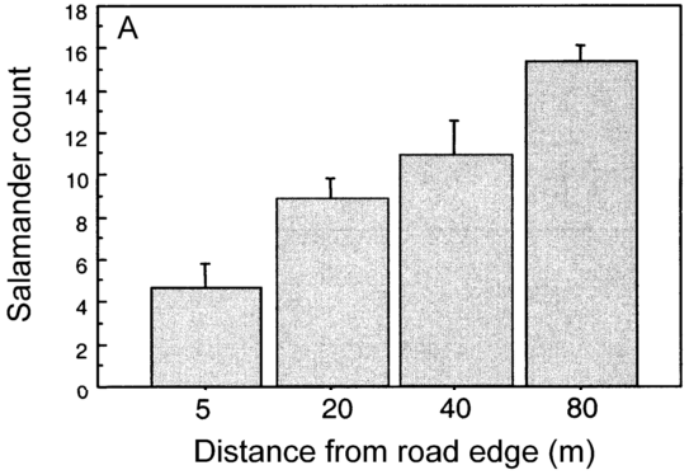


FIG. 3. Red-backed salamander densities at different distances from the road edge for the Mountain Lake 2002 data set: (A) red-backed salamander counts;

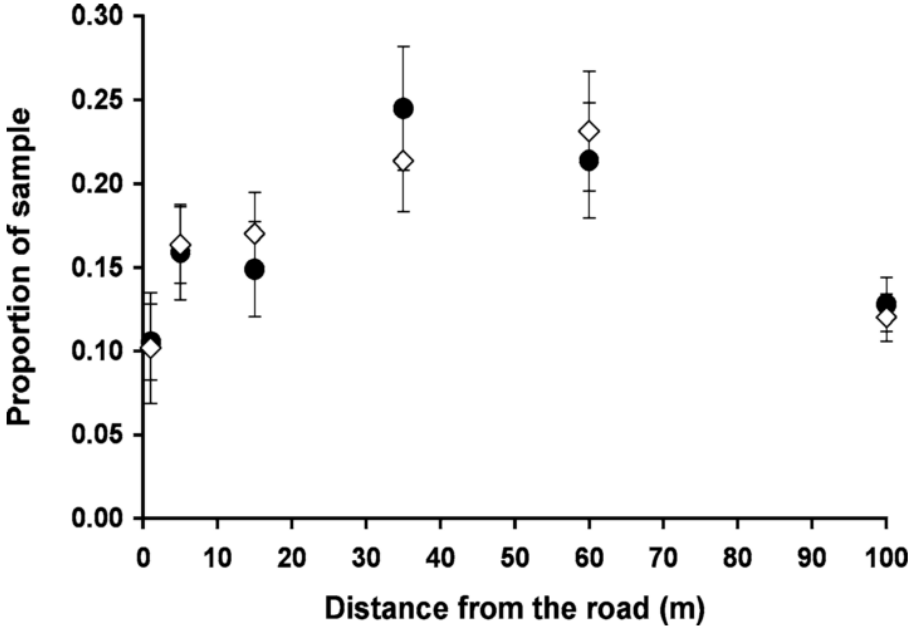
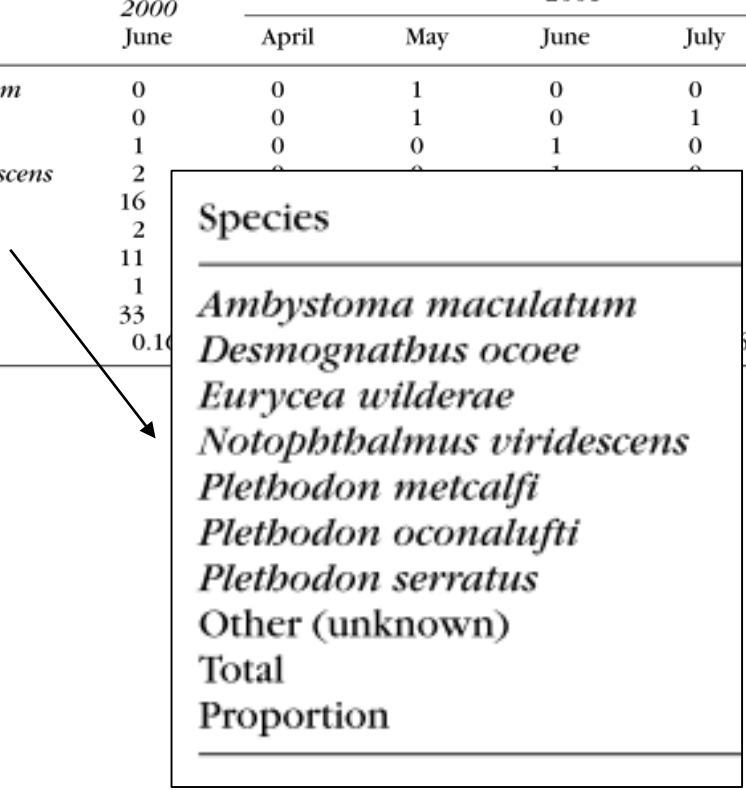


Figure 1. Abundance of salamanders at six distances (1, 5, 15, 35, 60, 100 m) from roads in the Nantahala National Forest, Highlands, North Carolina. Filled circles represent means (+1 SE) of all species combined; open diamonds represent means (+1 SE) of only Plethodon metcalfi *captures.*

REZ and Salamanders

Table 2. Summary of species and the number of salamanders collected at 11 road sites in the Nantahala National Forest, Highlands, North Carolina during six sampling periods.

Species	*2000* June	*2001* April	May	June	July	August	Total	Proportion
Ambystoma maculatum	0	0	1	0	0	0	1	0.005
Desmognathus ocoee	0	0	1	0	1	1	3	0.015
Eurycea wilderae	1	0	0	1	0	0	2	0.010
Notophthalmus viridescens	2					0	3	0.015
Plethodon metcalfi	16					41	153	0.769
Plethodon oconalufti	2					1	23	0.116
Plethodon serratus	11					0	13	0.065
Other (unknown)	1					0	1	0.005
Total	33					43	199	
Proportion	0.1					0.216		

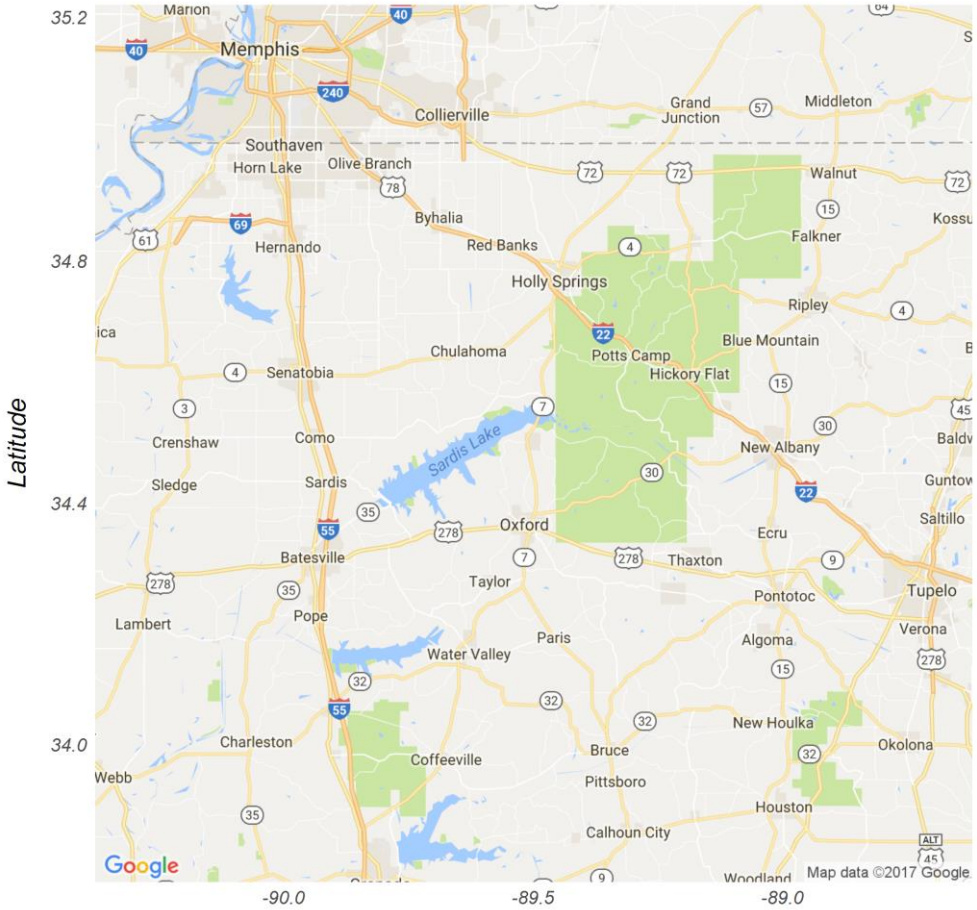


Management and Conservation Article

Effects of Road Crossings on Stream and Streamside Salamanders

RYAN L. WARD, *Division of Forestry and Natural Resources, West Virginia University, P.O. Box 6125, Morgantown, WV 26506, USA*
JAMES T. ANDERSON,[1] *Division of Forestry and Natural Resources, West Virginia University, P.O. Box 6125, Morgantown, WV 26506, USA*
J. TODD PETTY, *Division of Forestry and Natural Resources, West Virginia University, P.O. Box 6125, Morgantown, WV 26506, USA*

North Mississippi Roadmap



Holly Springs National Forest (HSNF) boundaries and area represented by green polygon northeast of Oxford. Roads are represented by color and line hierarchy - Thickest and orange (US Interstate), thick-yellow (US Highways), thin-yellow (4-lane State HWY), thick-white (2-lane State HWY), and thin-white (municipal streets and county roads).

- Do roads impact stream-associated salamanders?
- — Do roads impact stream-associated salamander abundance?
- — Do roads impact stream-associated salamander species richness?

- Is this impact localized (within 36 m)?

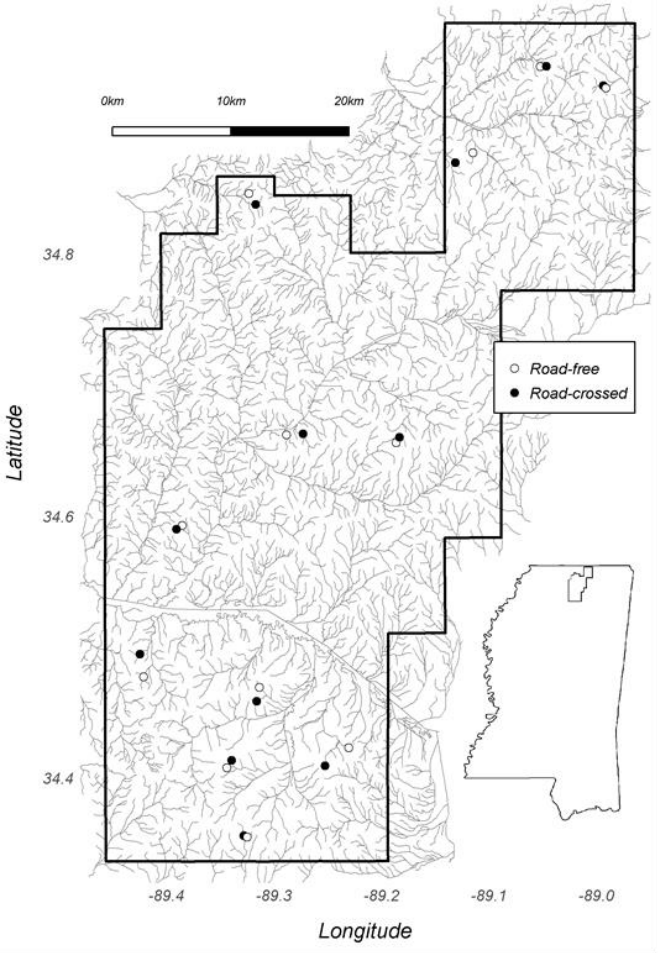
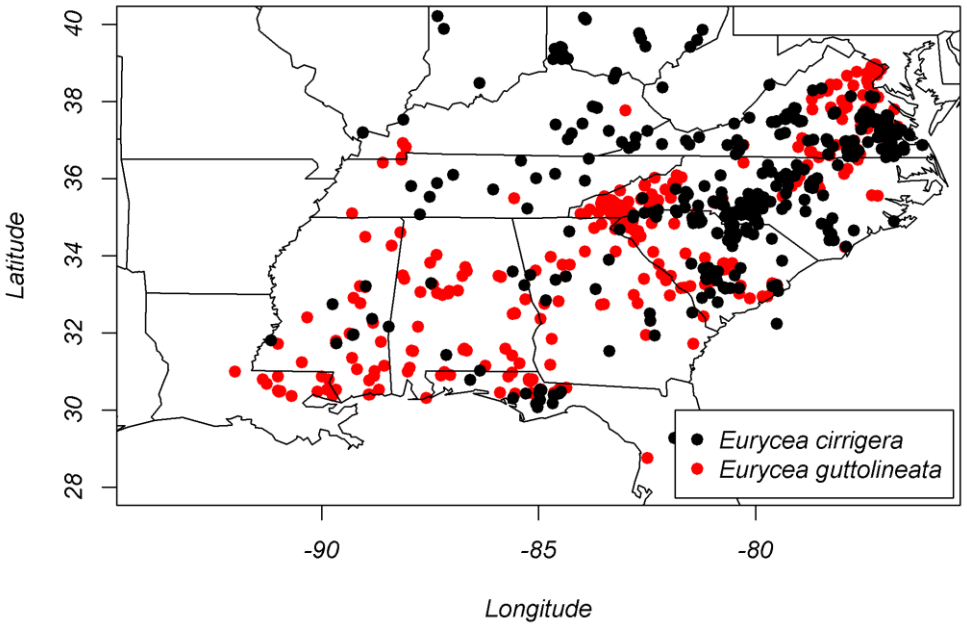
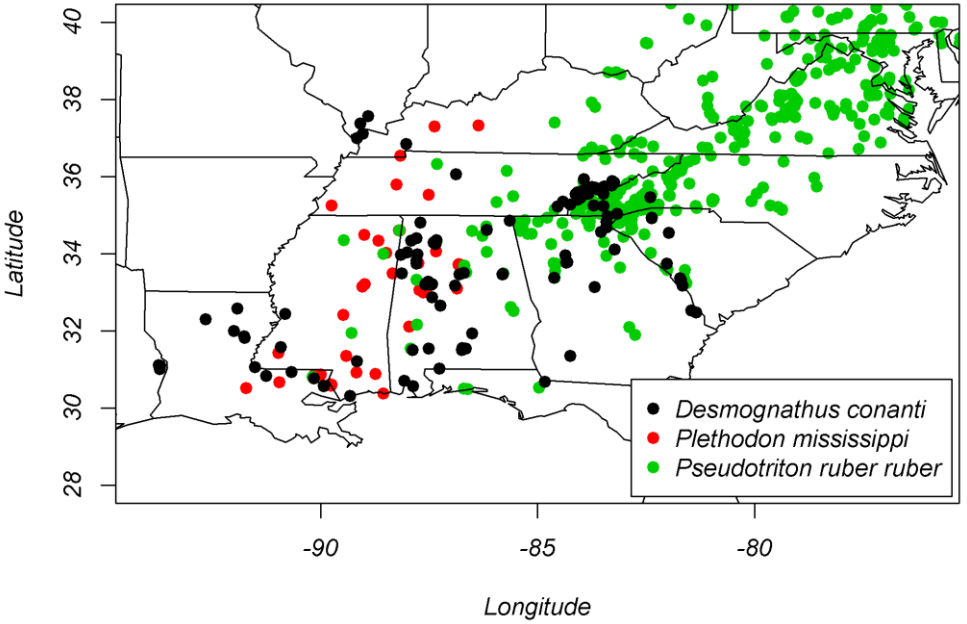


Figure 1. Map of stream network and paired stream sampling sites within Holly Springs National Forest. Road-free streams are designated by open circles and road-crossed streams by filled circles .Pairs of sampling sites are within 3 km of one another and located on 1st or 2nd order streams. Inset map shows location of the HSNF boundary within the state of Mississippi.

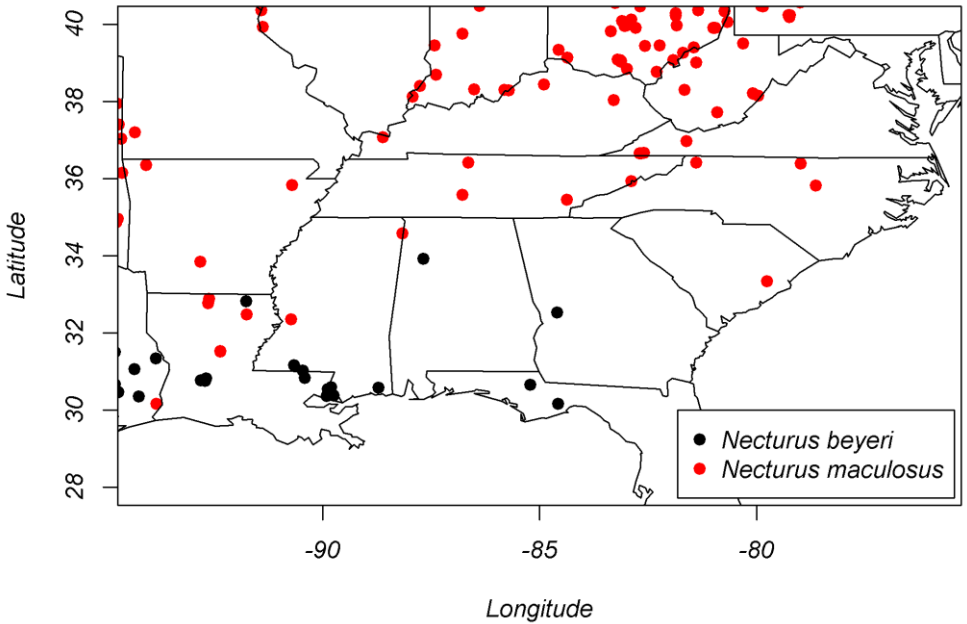
Stream-associated Salamanders



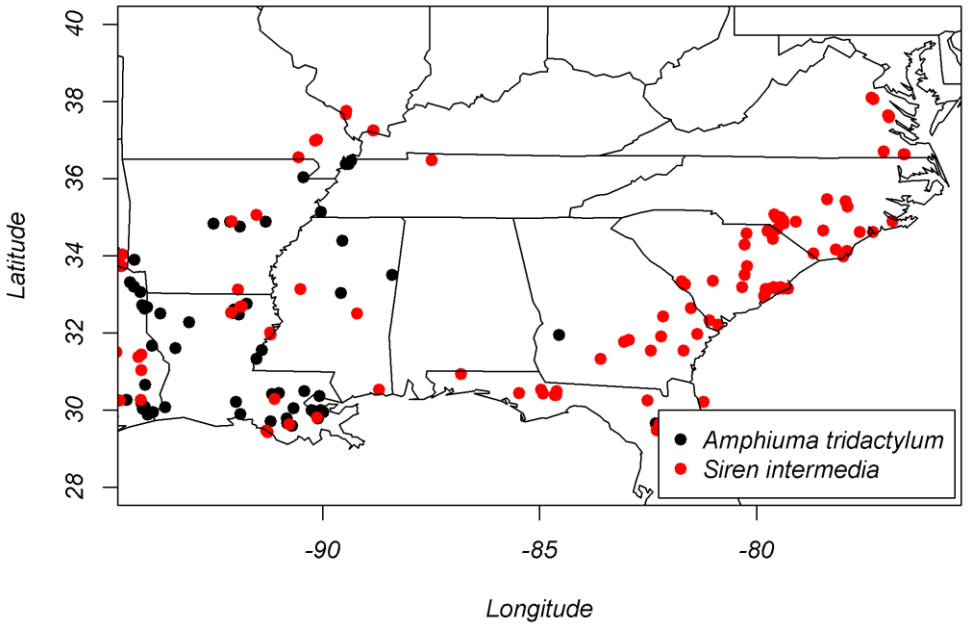
Stream-associated Salamanders



Stream-associated Salamanders



Stream-associated Salamanders



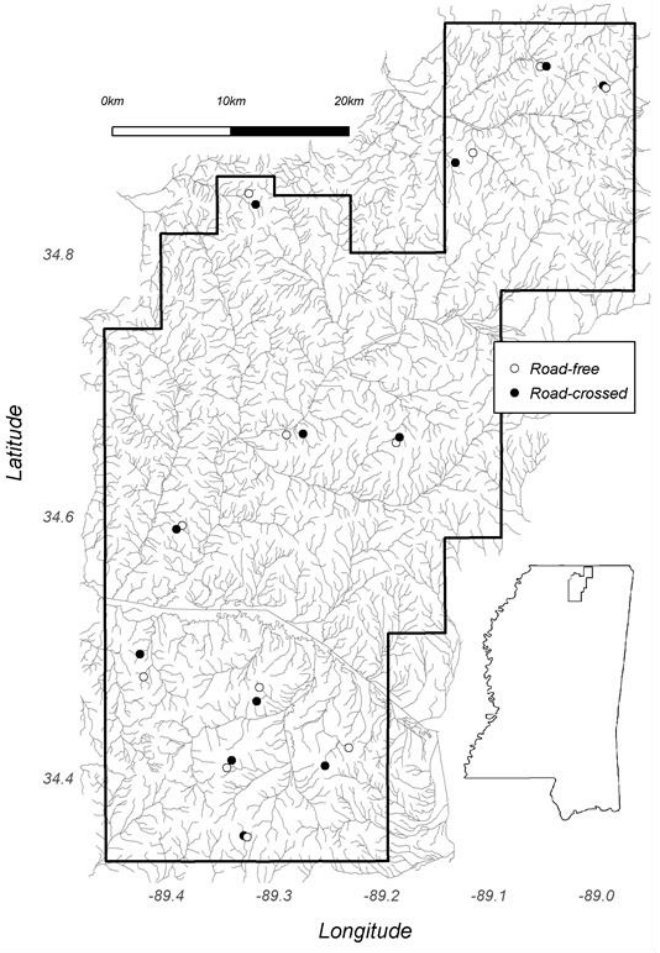
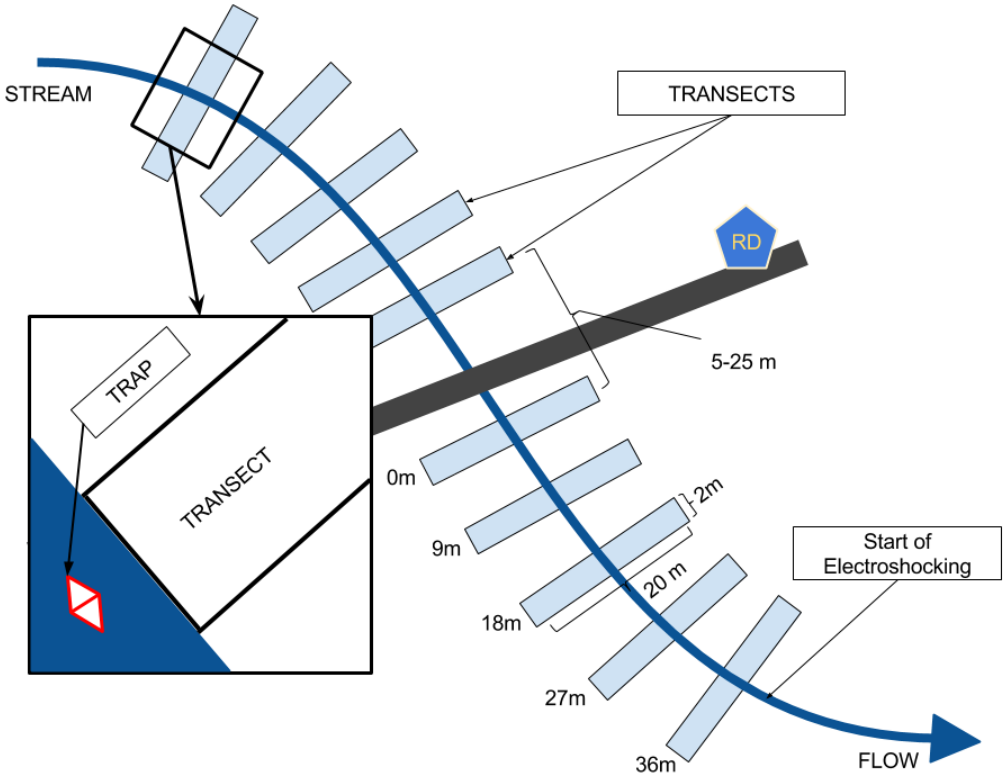
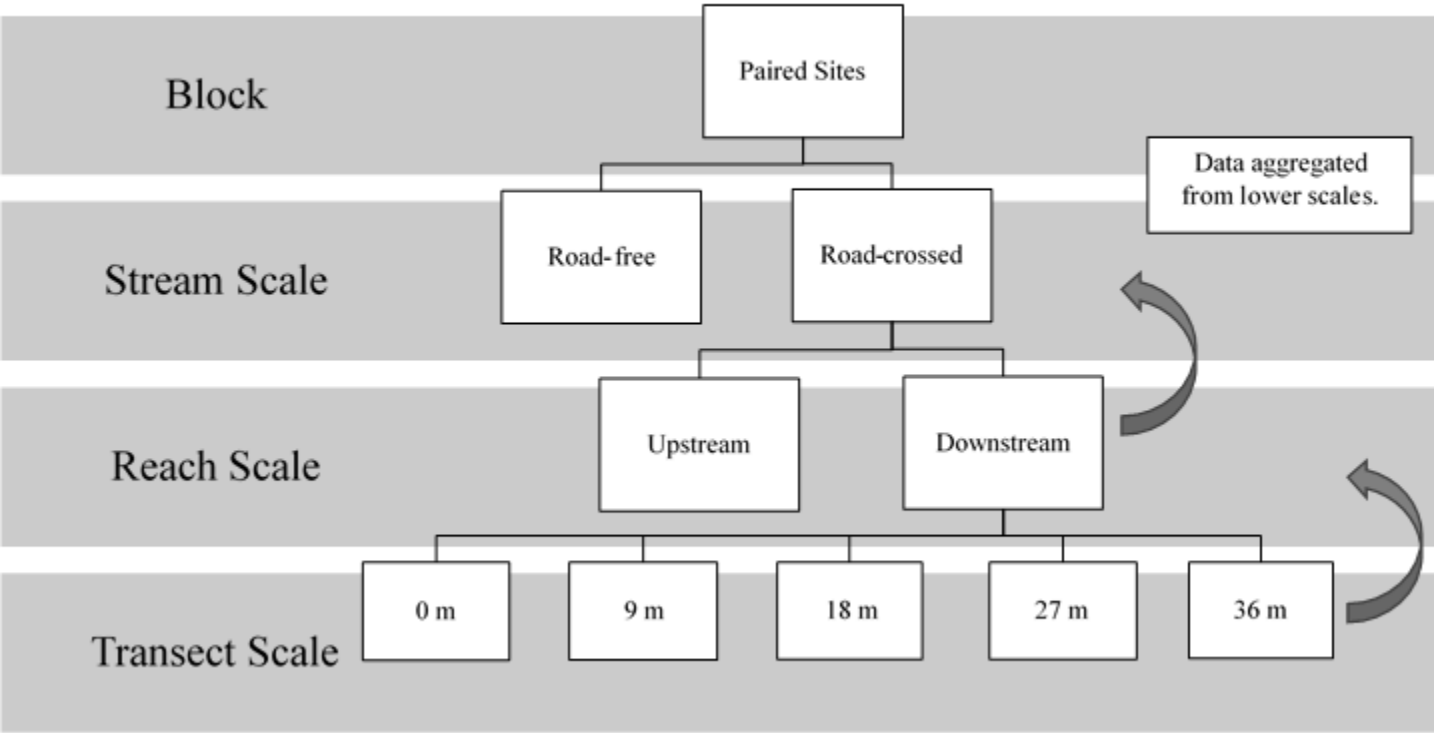


Figure 1. Map of stream network and paired stream sampling sites within Holly Springs National Forest. Road-free streams are designated by open circles and road-crossed streams by filled circles .Pairs of sampling sites are within 3 km of one another and located on 1st or 2nd order streams. Inset map shows location of the HSNF boundary within the state of Mississippi.

A selection of pictures from the sample sites


STREAM
TRANSECTS
RD
5-25 m
TRAP
TRANSECT
0m
2m
9m
20 m
18m
27m
36m
Start of
Electroshocking
FLOW

Experimental and Sampling Design



Environmental Factors

Aquatic

- Dissolved Oxygen
- Temperature
- pH
- Stream Morphology

Environmental Factors

Aquatic

- Dissolved Oxygen
- Temperature
- pH
- Stream Morphology

Terrestrial

- Air Temperature
- Relative Humidity
- Herbaceous Cover
- Canopy Cover

Sampling

Electroshock sampling

- Sweep wand
- Net specimens
- Id to species

Sampling

Aquatic Funnel Trap

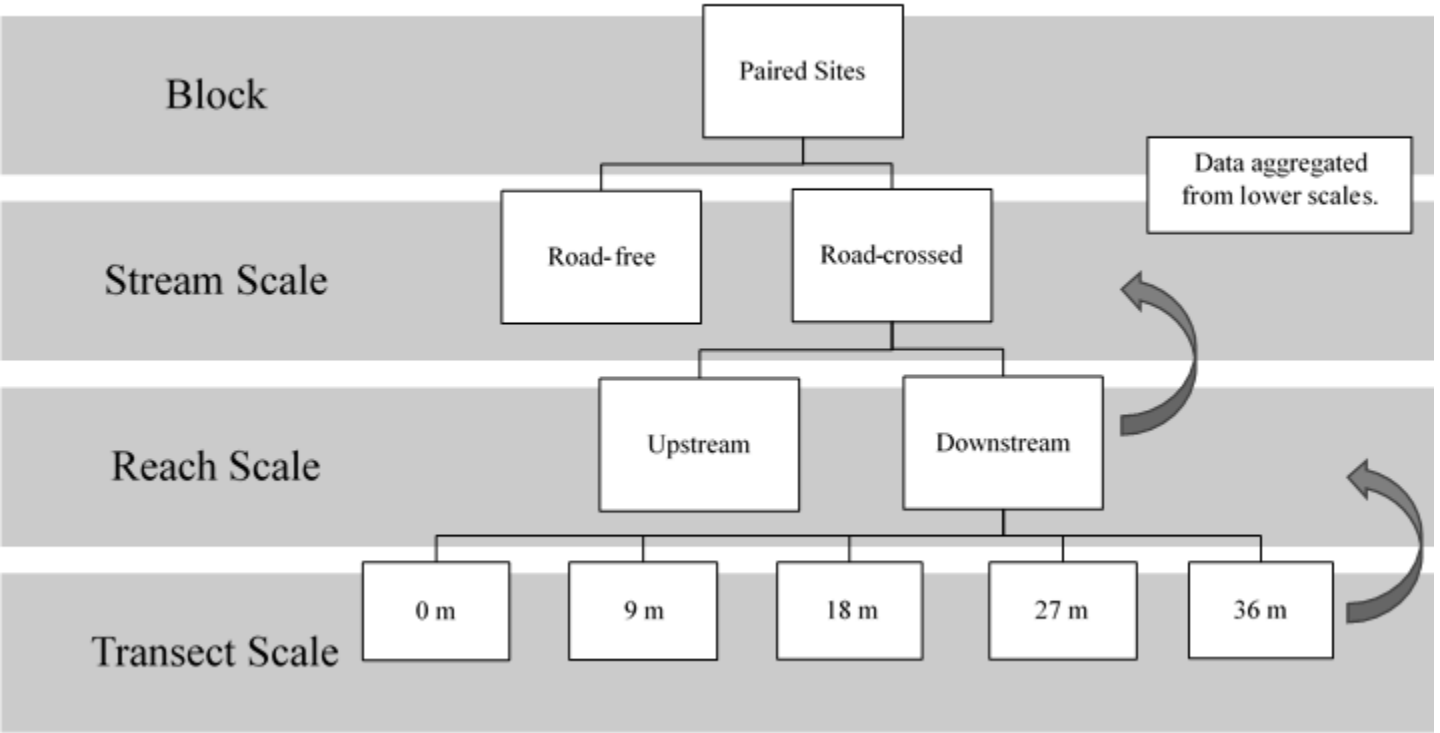
- 32 cm by 62cm
- Left for ~20 hrs
- Retrieve
- ID to species

Sampling

Modified Transect Sampling

- 2 m X 20 m
- Search Fully
- Capture
- ID to species

Analysis


Block
Paired Sites
Data aggregated from lower scales.
Stream Scale
Road-free
Road-crossed
Reach Scale
Upstream
Downstream
Transect Scale
0 m
9 m
18 m
27 m
36 m

(G_5 = 42.39, p = <0.01; Fig. 4)

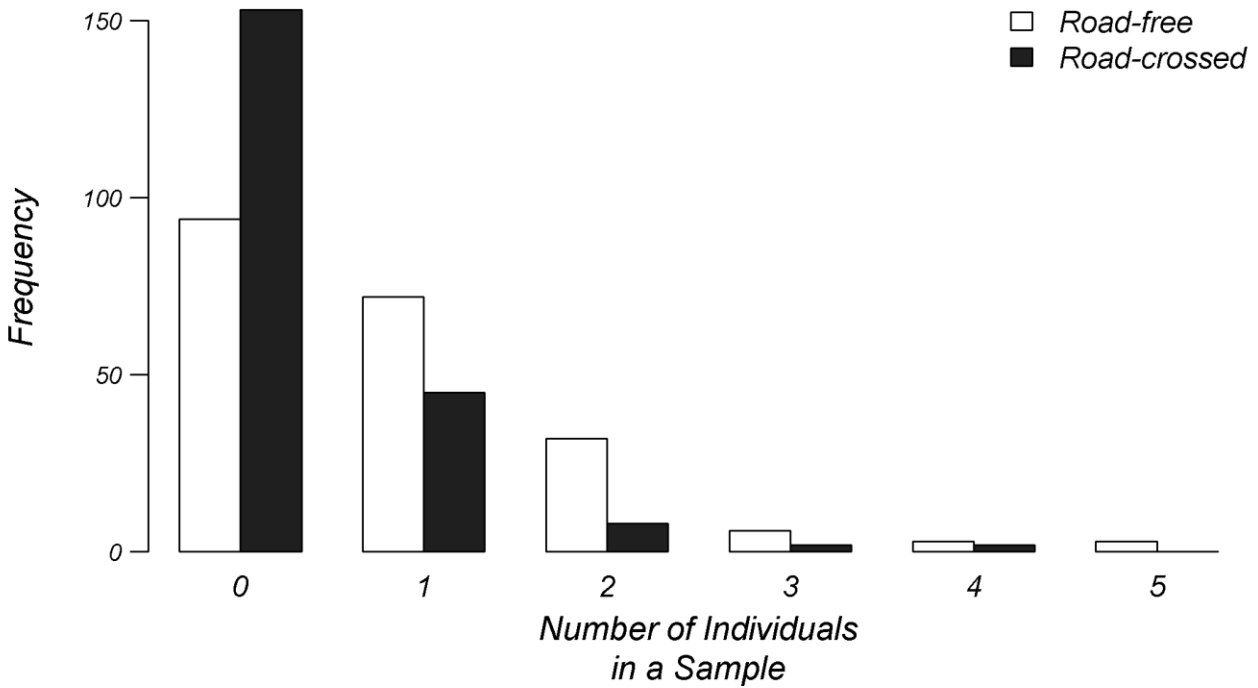


Figure 4. Frequency distributions of total number of individuals in a sample of road-crossed and road-free streams. Road-free streams distribution is identified by open bars and road-crossed stream distribution is identified by filled bars.

Table 1. Analysis of variance table for stream-associated salamander abundance. The stream scale term denotes the hypothesis test for main effects of roads, while reach within stream denotes the effect of direction relative to road or compensated midpoint.

Variable	df	SS	MS	F	p
Block [a]	11	7.84	0.71		
Stream Scale [b]	1	2.66	2.66	14.44	0.00
Residual Error	11	2.03	0.18		
Reach within Stream [c]	2	0.04	0.02	0.34	0.72
Residual Error	22	1.16	0.05		

[a] Paired Stream Sites, [b] Road-crossed v. Road-free, [c] Upstream v. Downstream in Stream

Table 2. Analysis of variance table for stream-associated salamander species richness. The stream scale term denotes the hypothesis test for main effects of roads, while reach within stream denotes the effect of direction relative to road or compensated midpoint.

Variable	df	SS	MS	F	p
Block [a]	11	7.84	0.71		
Stream Scale [b]	1	2.66	2.66	14.44	0.00
Residual Error	11	2.03	0.18		
Reach within Stream [c]	2	0.04	0.02	0.34	0.72
Residual Error	22	1.16	0.05		

[a] Paired Stream Sites, [b] Road-crossed v. Road-free, [c] Upstream v. Downstream in Stream

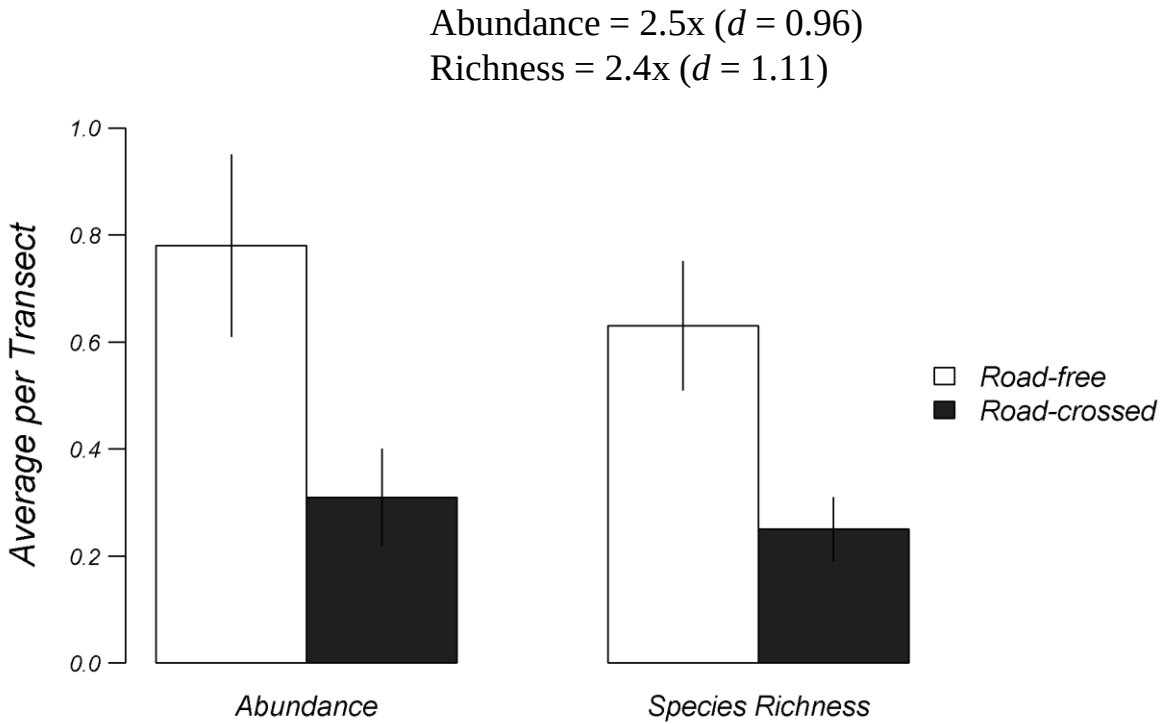


Figure 5. Average abundance and species richness per transect (±1 SE), in road-free versus road-crossed streams. Road-free streams are identified by open bars and road-crossed streams are identified by fill bars.

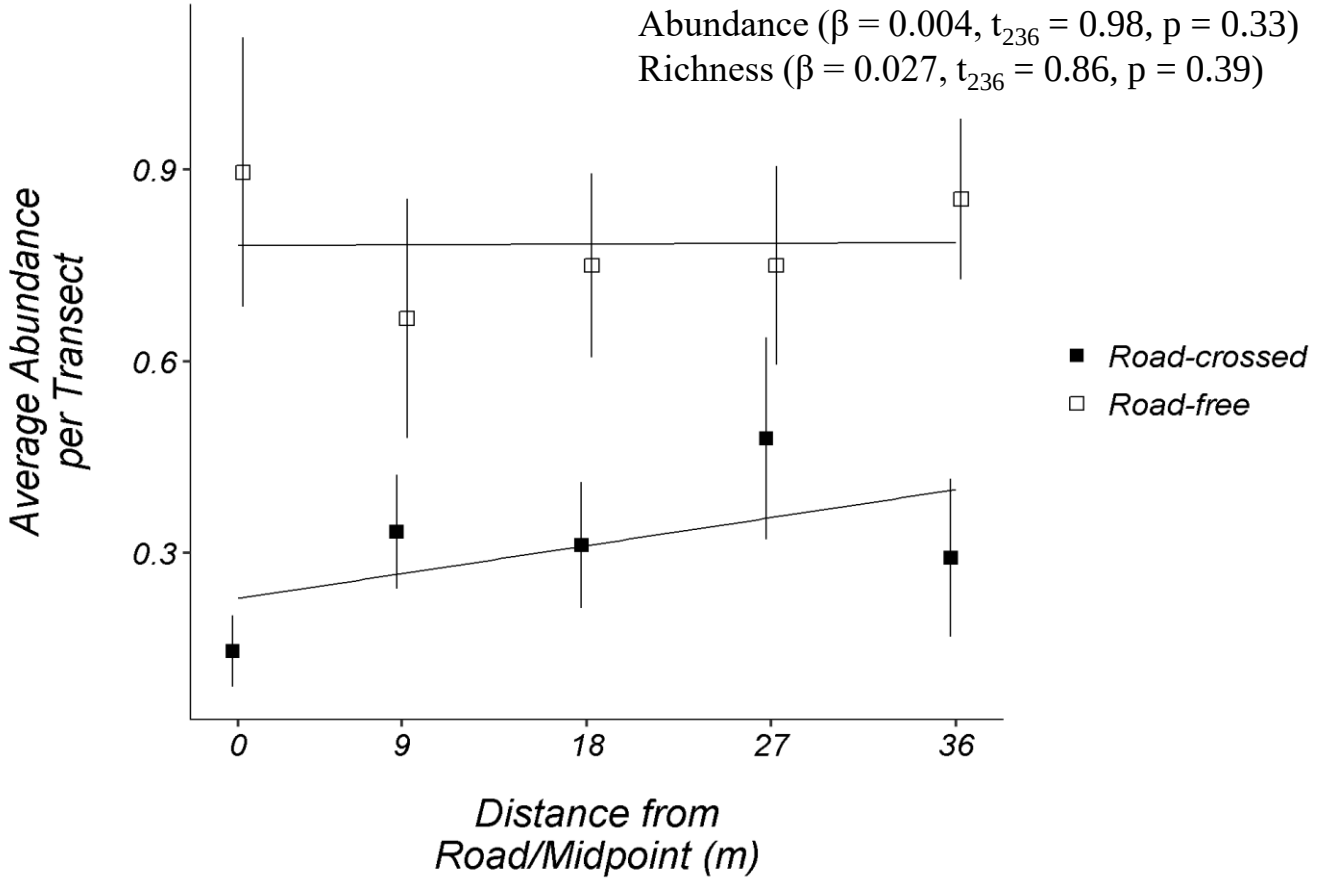


Figure 6. Average abundance per transect (±1 SE) of the five transect locations (sampling unit) at increasing distance from road or compensated midpoint. Road-free streams are identified by open squares in road-free and road-crossed streams are identified by filled squares.

abundance × direct: b = 1.4e-4, t_{10} = 0.74, p = 0.47;

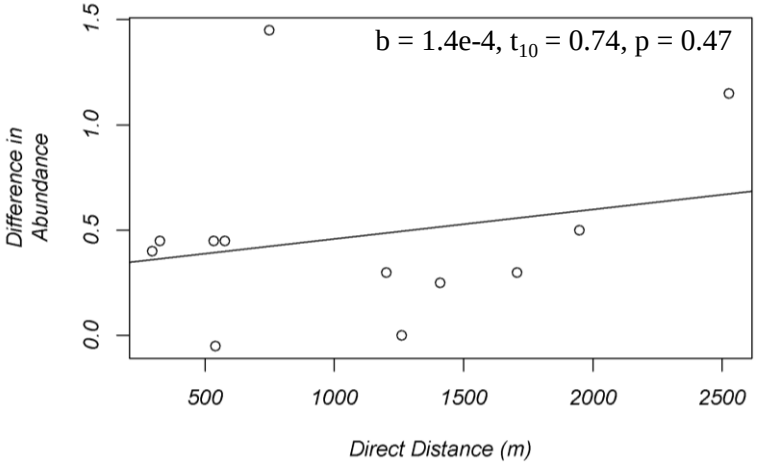
abundance × stream: b = -6.1e-6, t_{10} = -0.11, p = 0.92;

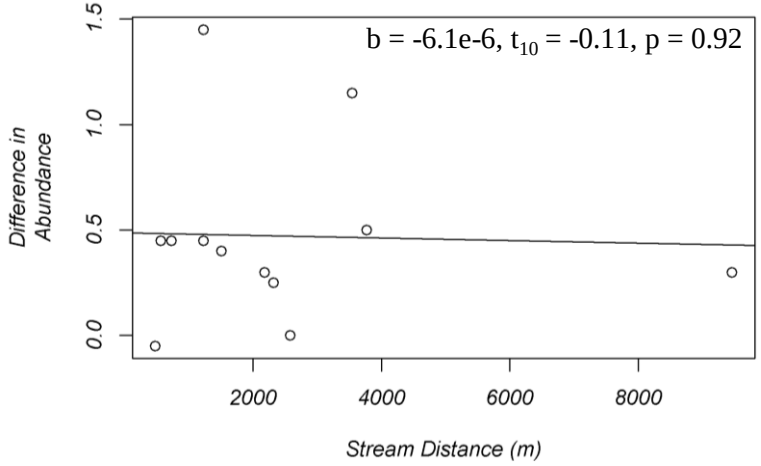
species richness × direct: b = 8.4e-5, t_{10} = 0.68, p = 0.51;

species richness × stream: b = -3.4e-7, t_{10} = -0.01, p = 0.99

Table 3. Direct and stream network distance between paired sample sites and differences in air temperature, canopy closure, abundance and species richness between road-free to road-crossed sites.

Block	Direct (m)	Stream (m)	Air Temp	Canopy Closure	Abundance	Species Richness
1	748.34	1227.929	0.8	21	1.45	1
2	2526.67	3540.56	0.7	21.5	1.15	0.75
3	1947.31	3765.87	1.75	5.5	0.5	0.4
4	1200.57	2108.24	1.75	17	0.3	0.3
5	576.15	725.81	1.35	5	0.45	0.35
6	1409.79	2314.46	1.35	29	0.25	0.3
7	534.3	1226.32	0.8	23	0.45	0.35
8	326.14	556.83	1.75	20.5	0.45	0.45
9	1260.82	2574.95	2.1	9	0	0
10	1705.91	9462.94	1.2	41	0.3	0.3
11	296.57	1506.35	1.2	12.5	0.4	0.3
12	540.74	476.37	0.3	0.5	0.05	0.05


b = 1.4e-4, t_{10} = 0.74, p = 0.47
Difference in Abundance
0.0
0.5
1.0
1.5
500
1000
1500
2000
2500
Direct Distance (m)


b = -6.1e-6, t_{10} = -0.11, p = 0.92
Difference in Abundance
0.0
0.5
1.0
1.5
2000
4000
6000
8000
Stream Distance (m)

abundance × direct: b = 1.4e-4, t_{10} = 0.74, p = 0.47;

abundance × stream: b = -6.1e-6, t_{10} = -0.11, p = 0.92;

species richness × direct: b = 8.4e-5, t_{10} = 0.68, p = 0.51;

species richness × stream: b = -3.4e-7, t_{10} = -0.01, p = 0.99

Table 3. Direct and stream network distance between paired sample sites and differences in air temperature, canopy closure, abundance and species richness between road-free to road-crossed sites.

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8	326.14	556.83	1.75	20.5	0.45	0.45
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11	296.57	1506.35	1.2	12.5	0.4	0.3
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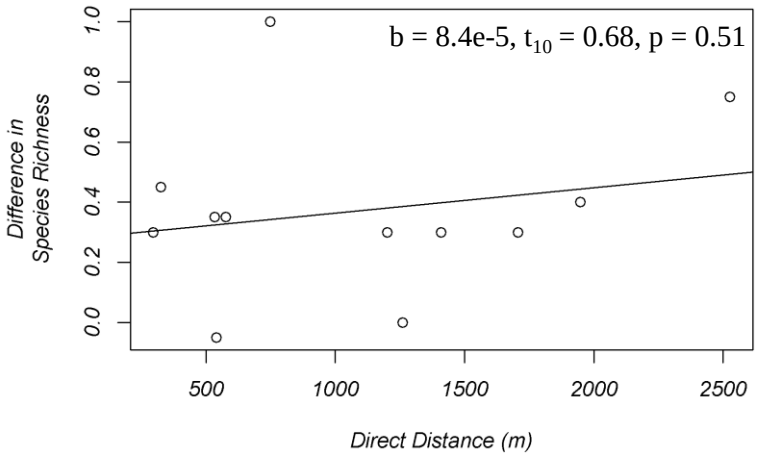
b = 8.4e-5, t10 = 0.68, p = 0.51
Difference in Species Richness
0.0
0.2
0.4
0.6
0.8
1.0
500
1000
1500
2000
2500
Direct Distance (m)

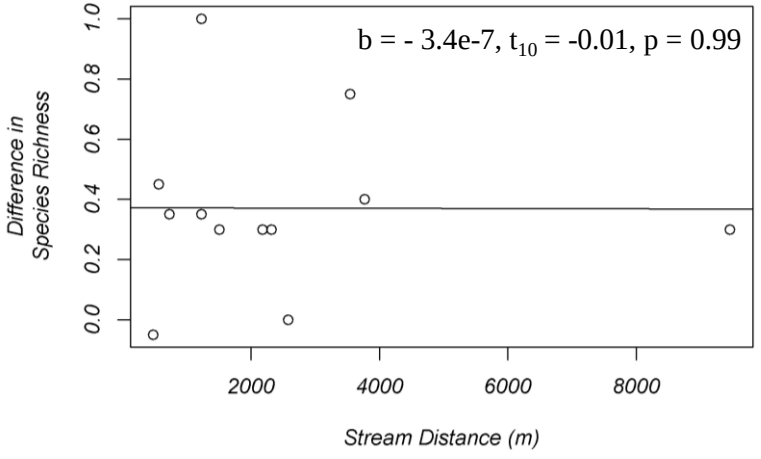
b = - 3.4e-7, t10 = -0.01, p = 0.99
Difference in Species Richness
0.0
0.2
0.4
0.6
0.8
1.0
2000
4000
6000
8000
Stream Distance (m)

Table 4. Analysis of variance table for canopy closure at stream scale.

Variable	df	SS	MS	F	p
Block [a]	11	3589.90	326.35	1.95	0.14
Stream Scale [b]	1	635.50	635.50	3.79	0.08
Residuals	11	1842.60	167.51		

[a] Paired Stream Sites, [b] Road-crossed v. Road-free

Table 5. Analysis of variance table for air temperature at stream scale.

Variable	df	SS	MS	F	p
Block [a]	11	38.51	3.50	5.13	0.01
Stream Scale [b]	1	3.49	3.49	5.12	0.04
Residuals	11	7.50	0.68		

[a] Paired Stream Sites, [b] Road-crossed v. Road-free

abundance × air temp: $r = -0.37$, $t_{10} = -1.25$, $p = 0.24$;

abundance × canopy closure: $r = 0.21$, $t_{10} = 0.67$, $p = 0.52$;

species richness × air temp: $r = -0.30$, $t_{10} = -0.99$, $p = 0.34$;

species richness × canopy closure: $r = 0.30$, $t_{10} = 1.00$, $p = 0.34$

Table 3. Direct and stream network distance between paired sample sites and differences in air temperature, canopy closure, abundance and species richness between road-free to road-crossed sites.

Block	Direct (m)	Stream (m)	Air Temp	Canopy Closure	Abundance	Species Richness
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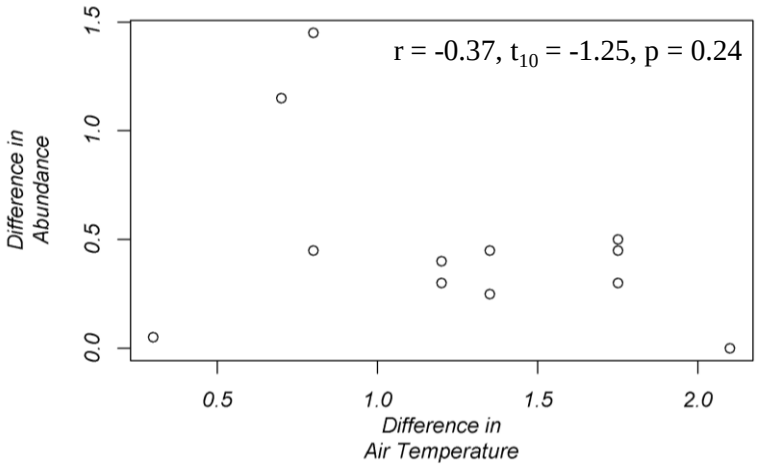
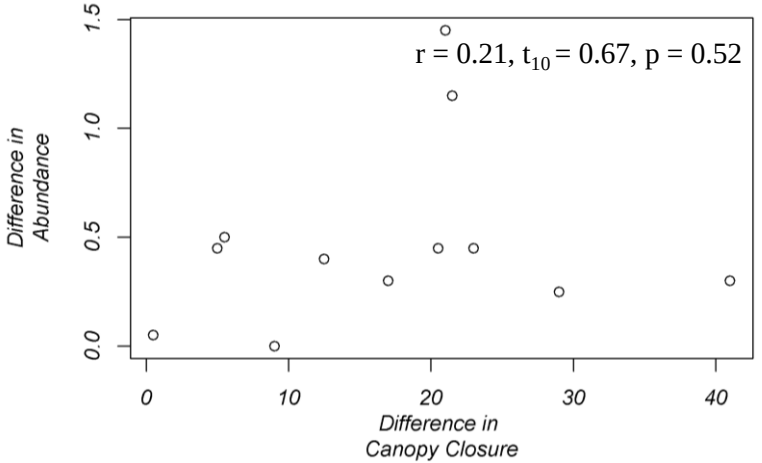

r = -0.37, t_{10} = -1.25, p = 0.24
Difference in Abundance
0.0
0.5
1.0
1.5
0.5
1.0
1.5
2.0
Difference in Air Temperature


r = 0.21, t_{10} = 0.67, p = 0.52
Difference in Abundance
0.0
0.5
1.0
1.5
0
10
20
30
40
Difference in Canopy Closure

abundance × air temp: $r = -0.37$, $t_{10} = -1.25$, $p = 0.24$;

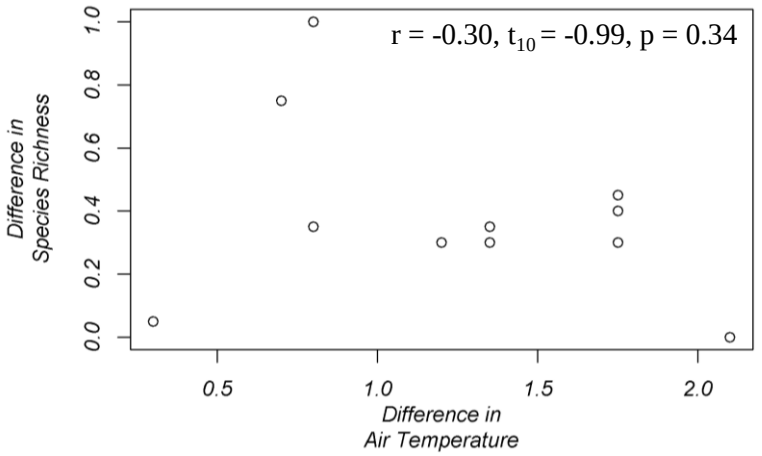
abundance × canopy closure: $r = 0.21$, $t_{10} = 0.67$, $p = 0.52$;

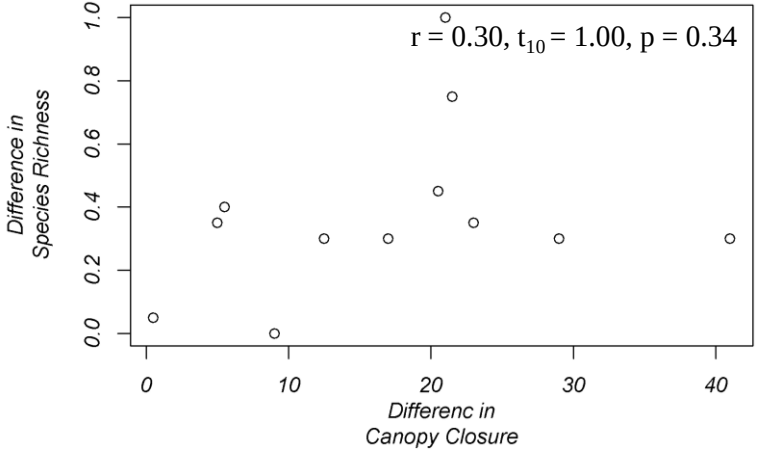
species richness × air temp: $r = -0.30$, $t_{10} = -0.99$, $p = 0.34$;

species richness × canopy closure: $r = 0.30$, $t_{10} = 1.00$, $p = 0.34$

Table 3. Direct and stream network distance between paired sample sites and differences in air temperature, canopy closure, abundance and species richness between road-free to road-crossed sites.

Block	Direct (m)	Stream (m)	Air Temp	Canopy Closure	Abundance	Species Richness
1	748.34	1227.929	0.8	21	1.45	1
2	2526.67	3540.56	0.7	21.5	1.15	0.75
3	1947.31	3765.87	1.75	5.5	0.5	0.4
4	1200.57	2108.24	1.75	17	0.3	0.3
5	576.15	725.81	1.35	5	0.45	0.35
6	1409.79	2314.46	1.35	29	0.25	0.3
7	534.3	1226.32	0.8	23	0.45	0.35
8	326.14	556.83	1.75	20.5	0.45	0.45
9	1260.82	2574.95	2.1	9	0	0
10	1705.91	9462.94	1.2	41	0.3	0.3
11	296.57	1506.35	1.2	12.5	0.4	0.3
12	540.74	476.37	0.3	0.5	0.05	0.05


r = -0.30, t_{10} = -0.99, p = 0.34
Difference in Species Richness
0.0
0.2
0.4
0.6
0.8
1.0
0.5
1.0
1.5
2.0
Difference in Air Temperature


r = 0.30, t_{10} = 1.00, p = 0.34
Difference in Species Richness
0.0
0.2
0.4
0.6
0.8
1.0
0
10
20
30
40
Differenc in Canopy Closure

Conclusion and Discussion

- Roads reduce stream-associated salamander abundance and richness
- There is some evidence to support the hypothesis that the effect of roads on SAS abundance extends beyond the road-forest interface; the extend lie between ~35–350 m
- Roads also change habitat and microclimatic conditions, but these do not seem to be strongly associated with variation in SAS abundance or richness

Image Citations

Google Maps. (2017). [Street Map]. Retrieved from http://maps.googleapis.com/maps/api/staticmap?center=43.2,-89.2&zoom=8&size=640x640$scale=2&maptype=roadmap&language=en-EN&snsor=false

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Acknowledgments

- Committee
  - Steven Threlkeld
  - William Resetarits
  - Marjorie Holland
  - Rebecca Symula
- Carl Kilcrease - USFS
- Hal Robinson – UM Parking
- UM Faculty
- Fellow Students

Questions?

Andrew Snyder 2015