Conservation in changing ecosystems, from fragmentation to invasive species

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The importance of scale in amphibian conservation: species responses to fragmentation

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RESEARCH ARTICLE

Journal of Animal Ecology 2020, 90: 685–697.

The influence of species life history and distribution characteristics on species responses to habitat fragmentation in an urban landscape

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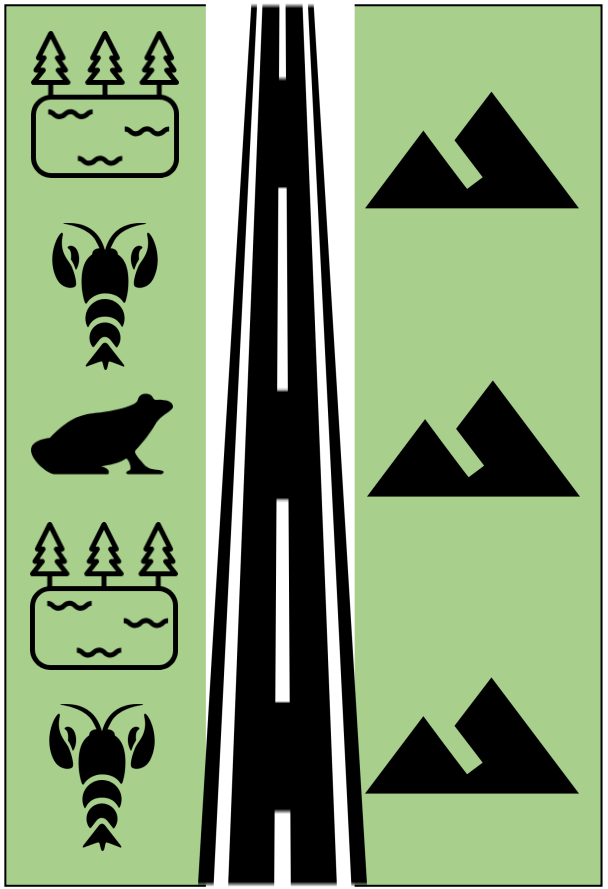
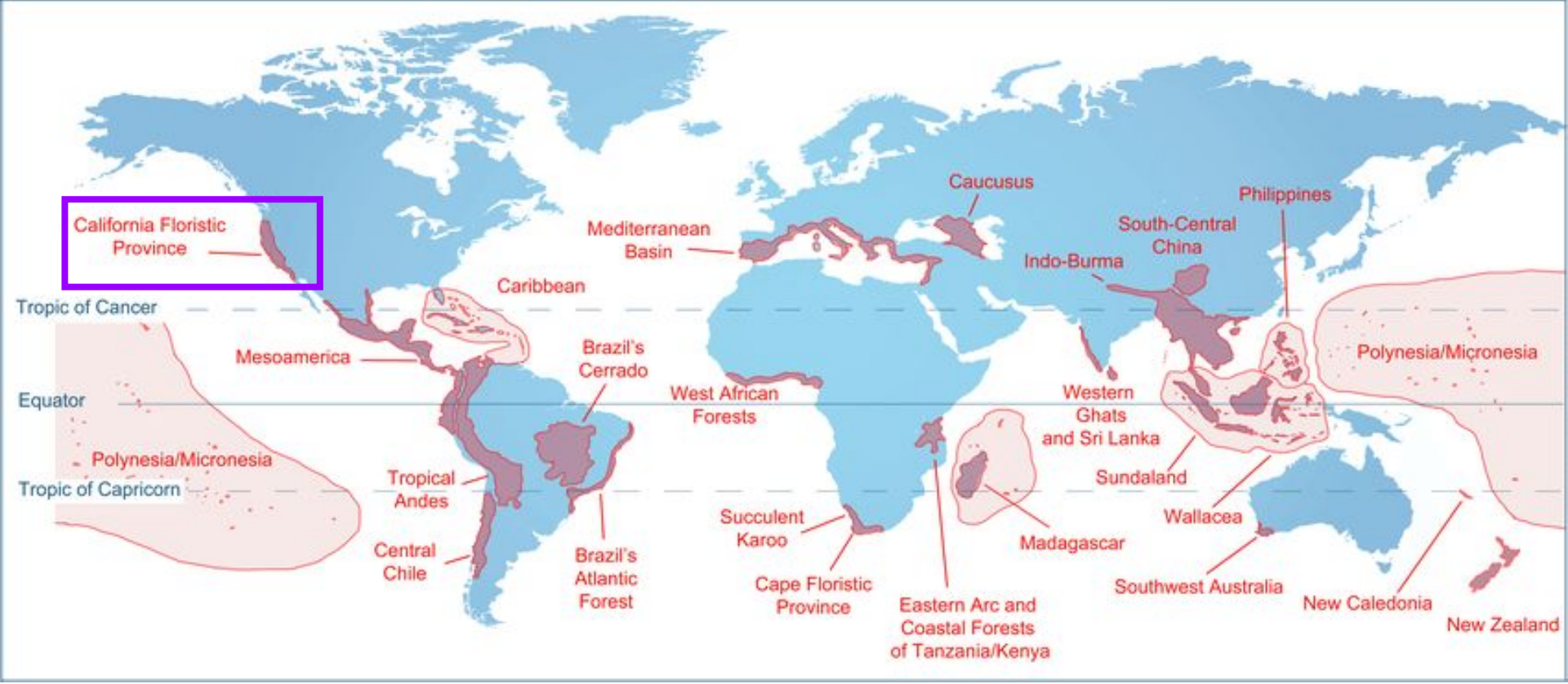


Fahrig 2003; McKinney 2006, 2008



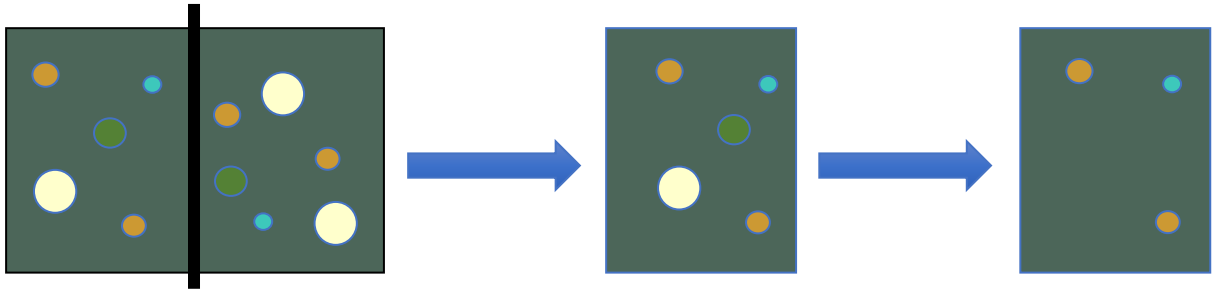
30-50% of all plant and vertebrate species in these 25 areas

Myers et al. 2000 Nature 403; Spicer 2017 Plant Diversity 39


CV2-05
CV2-01
CV2-04
CV2-02
CV2-03

Ecological Consequences of Fragmentation

1. Extinction debt



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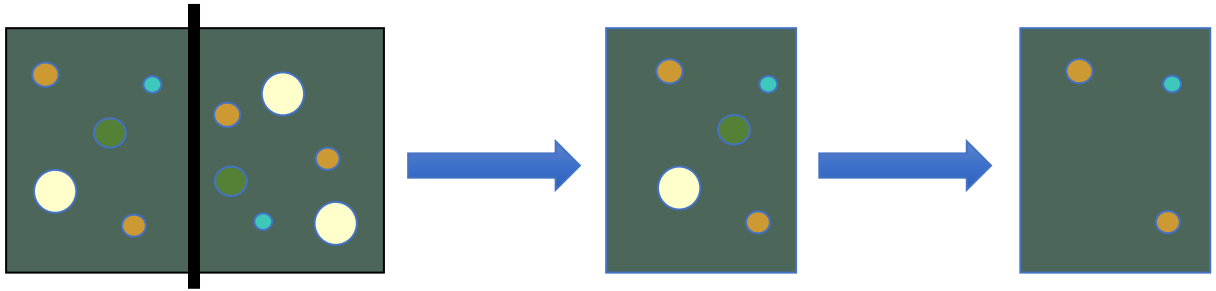
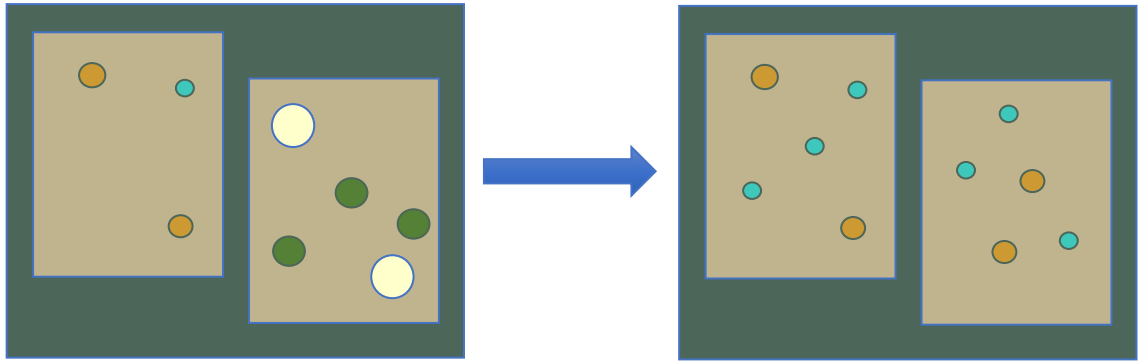
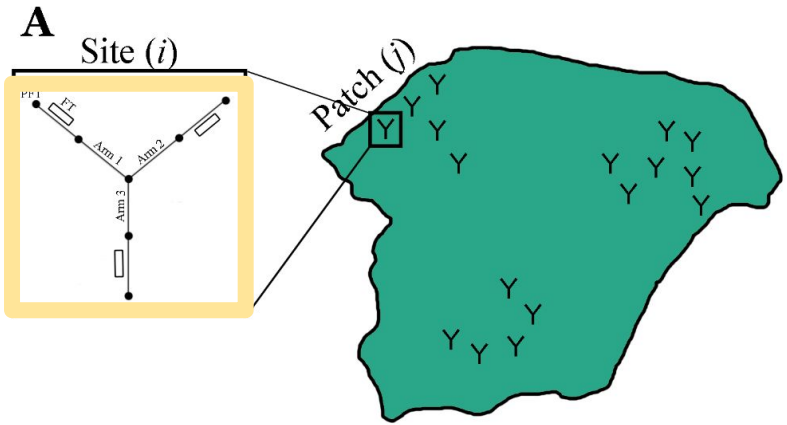
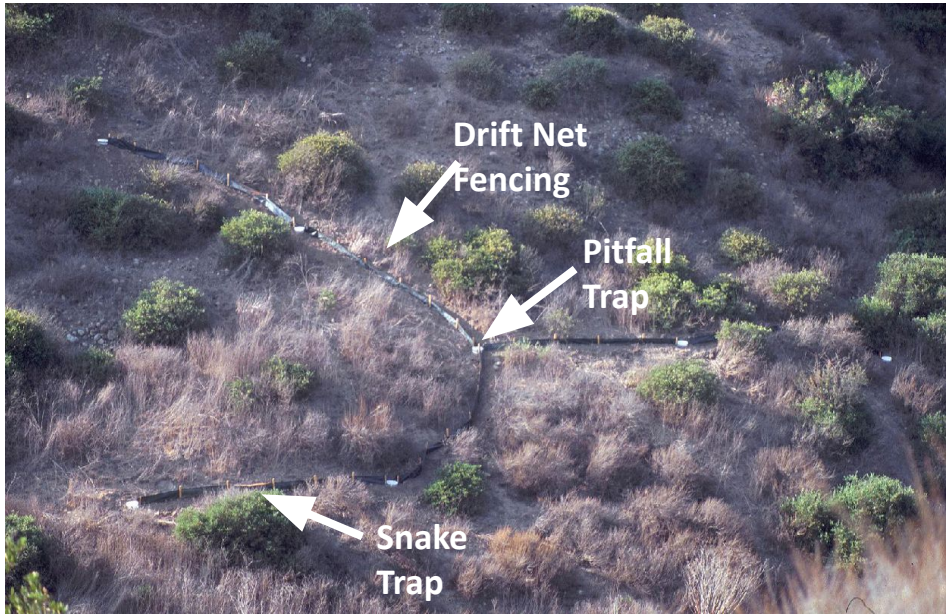


2. Density compensation



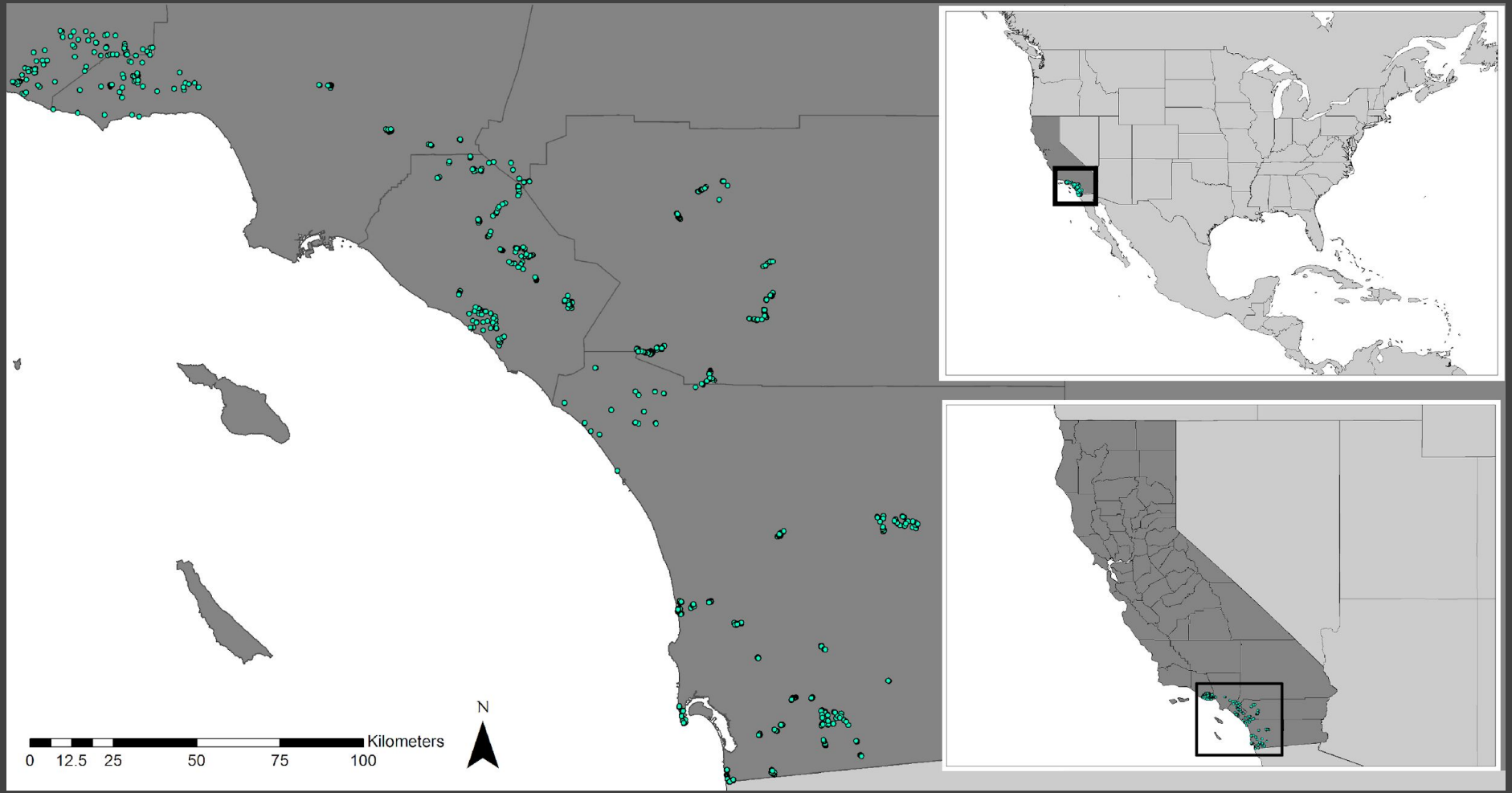
Data Collection





i = site

j = patch


Kilometers
0 12.5 25 50 75 100
N

45 native species

7 mammals
7 amphibians
31 reptiles

Amphibia
Mammalia
Reptilia

Legless Lizard
Orange-Throated Whiptail
CA Kingsnake
W. Fence Lizard
Alligator Lizard
CA Vole
Racer
Gopher Snake
Rosy Boa
Gilbert's Skink
Granite Night Lizard
Glossy Snake
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Black-Headed Snake
Mice
Side-blotched Lizard
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Two-lined Gartersnake
S. Pacific Rattlesnake
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Ring-necked Snake
Bottae's Pocket Gopher
Slender Salamander
Western Skink

Speckled Rattlesnake
Lyresnake
Long-Nosed Snake
Night Snake
Coachwhip
Red Diamond Rattlesnake
Broad-footed Mole
W. Harvest Mouse
Threadsnake
CA Whipsnake
Blainsville's Horned Lizard
Pocket Mice
Arboreal Salamander
Ensatina
Tiger Whiptail
Arroyo Toad
Shrew
Spadefoot
Treefrog
Western Toad

Occupancy Model Framework

State process
Occupancy

TRUTH (I can never observe this perfectly)

Observation process
Detections

My imperfect (but wonderful) observations

i = site
j = patch
t = time

Occupancy Model Framework

State process
Occupancy

$$z_i \sim Bernoulli(\psi_i)$$

Observation process
Detections

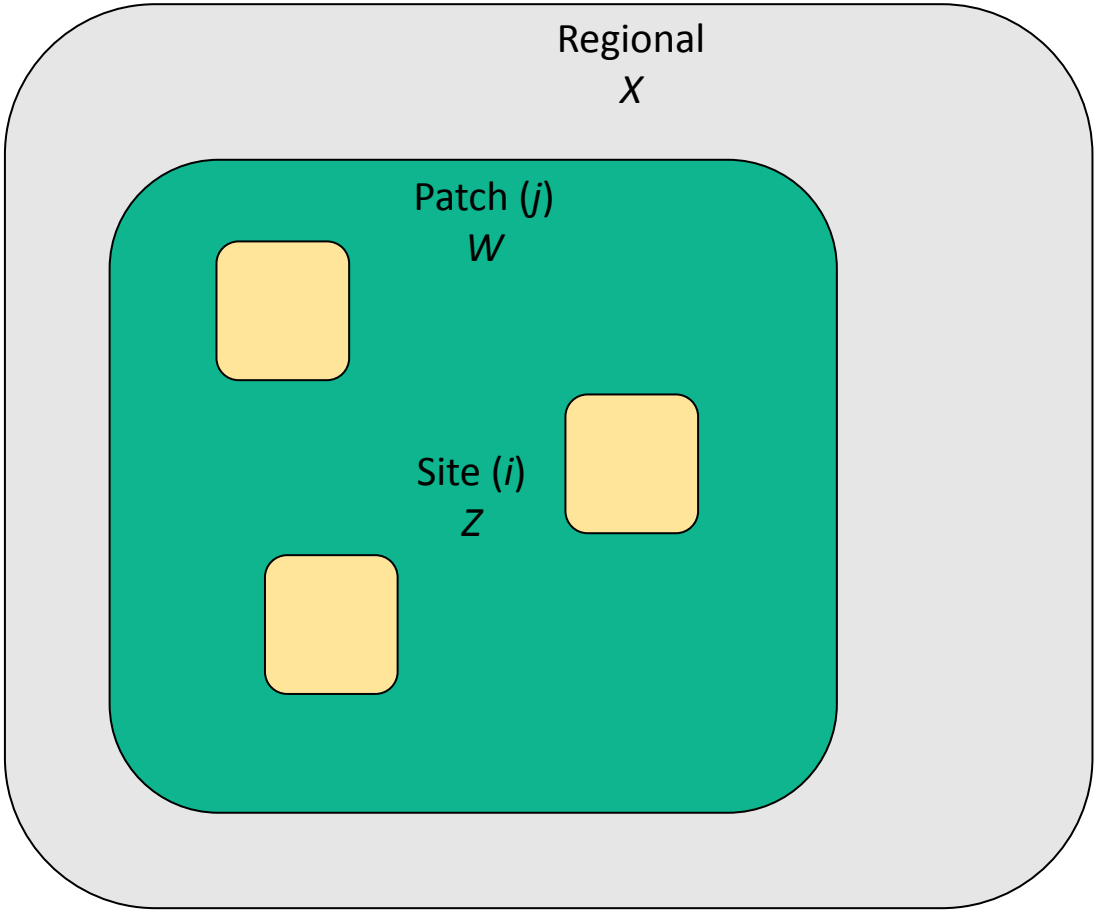
$$y_{it} \sim Bernoulli(z_i * p_t)$$

$$\text{logit}(\psi_i) = \beta_0 + \beta_1 * \text{Covariate}_i$$

$$\text{logit}(p_t) = \alpha_0 + \alpha_1 * \text{Covariate}_t$$

i = site
j = patch
t = time

The Model



Visit (*t*)

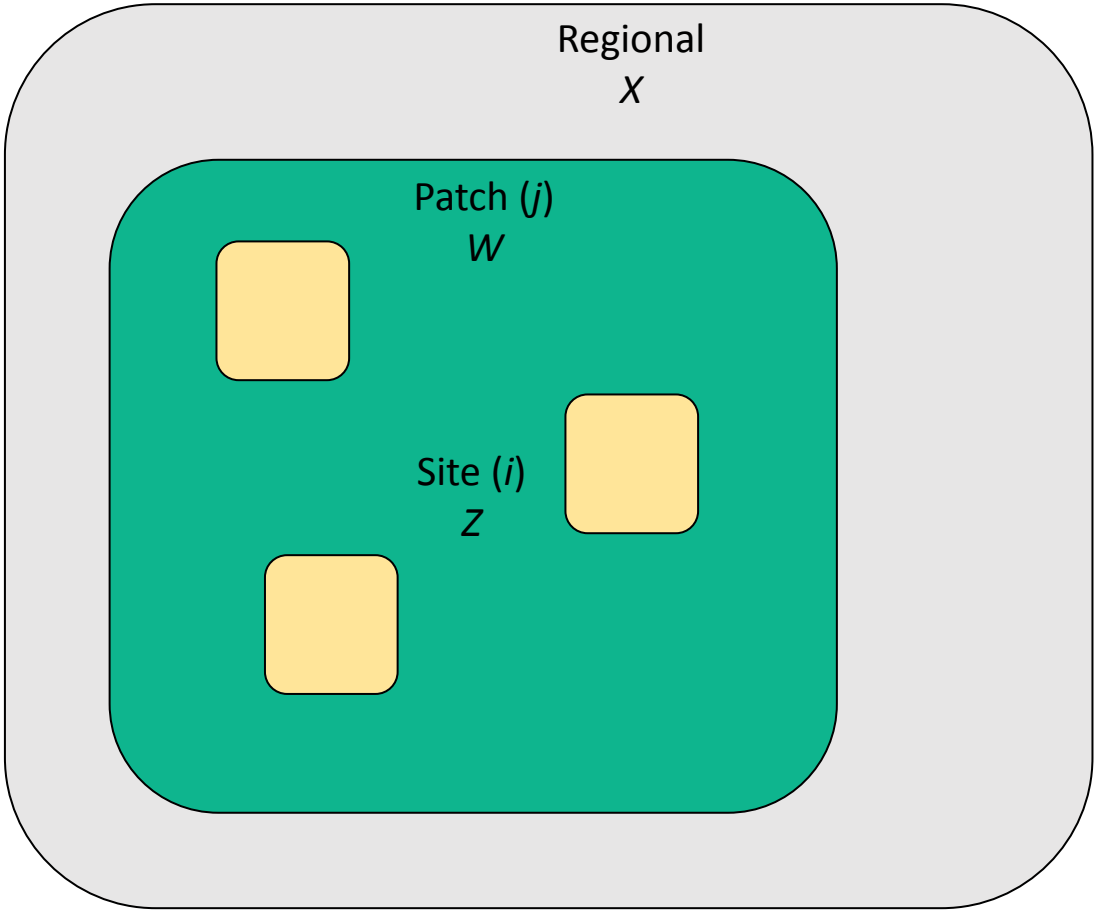
Species (*s*)

1	0	1	1	0	1	0	1	0	1	0	0	1	0	0	0	1	1	1	
0	0	0	0	0	1	0	1	0	0	1	0	0	0	0	1	0	0	0	
1	1	1	0	1	0	0	1	0	1	0	0	0	1	1	1	1	0	0	
0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	
0	0	1	1	1	1	0	1	1	0	1	0	0	0	0	1	1	0	0	
1	1	1	0	0	0	1	0	0	0	0	1	1	1	0	0	0	0	0	
1	1	0	1	0	1	0	0	0	1	1	1	1	0	0	0	0	1	1	0
1	1	1	1	1	1	1	1	1	0	1	1	1	0	0	0	0	0	0	
0	0	0	0	1	1	1	0	0	0	0	1	1	0	0	0	0	1	0	0
1	0	1	0	1	0	0	0	0	1	1	0	0	0	1	0	1	0	1	0

Observations *(Y)*

i = site
j = patch
t = time
s = species

The Model



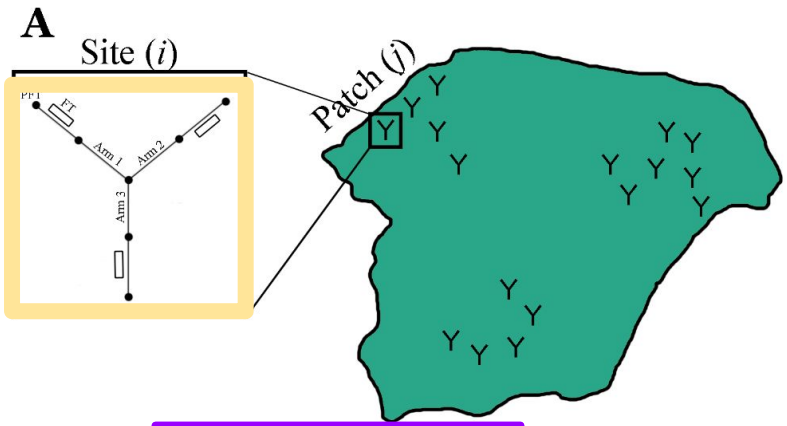
Patch Level Occupancy (Ω_{sj})

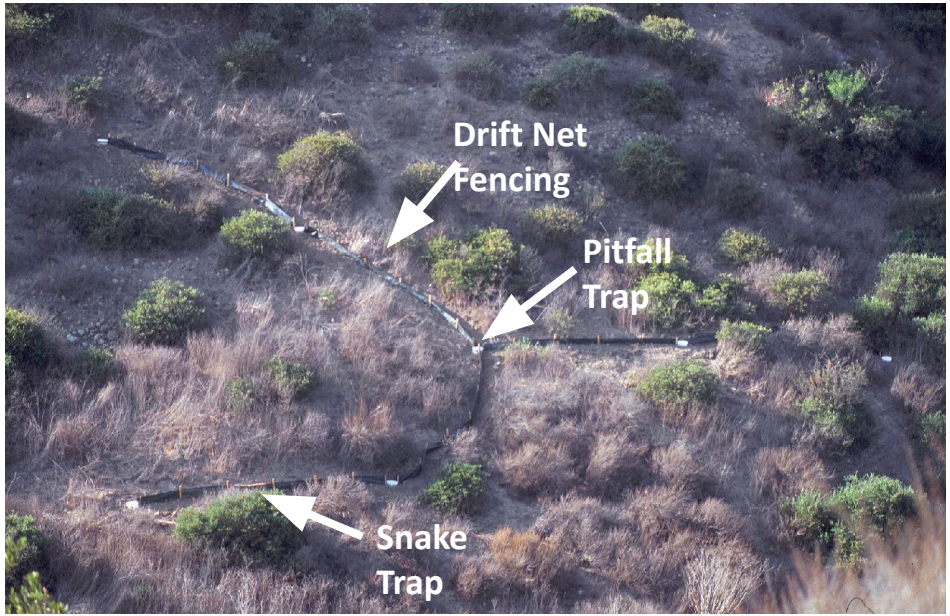
$$W_{sj} \sim Bernoulli(X_{sj} * \Omega_{sj})$$

$$\log it(\Omega_{sj}) = \delta_{0s} + \delta_{1s} + PatchSize_j$$

i = site
j = patch
t = time
s = species

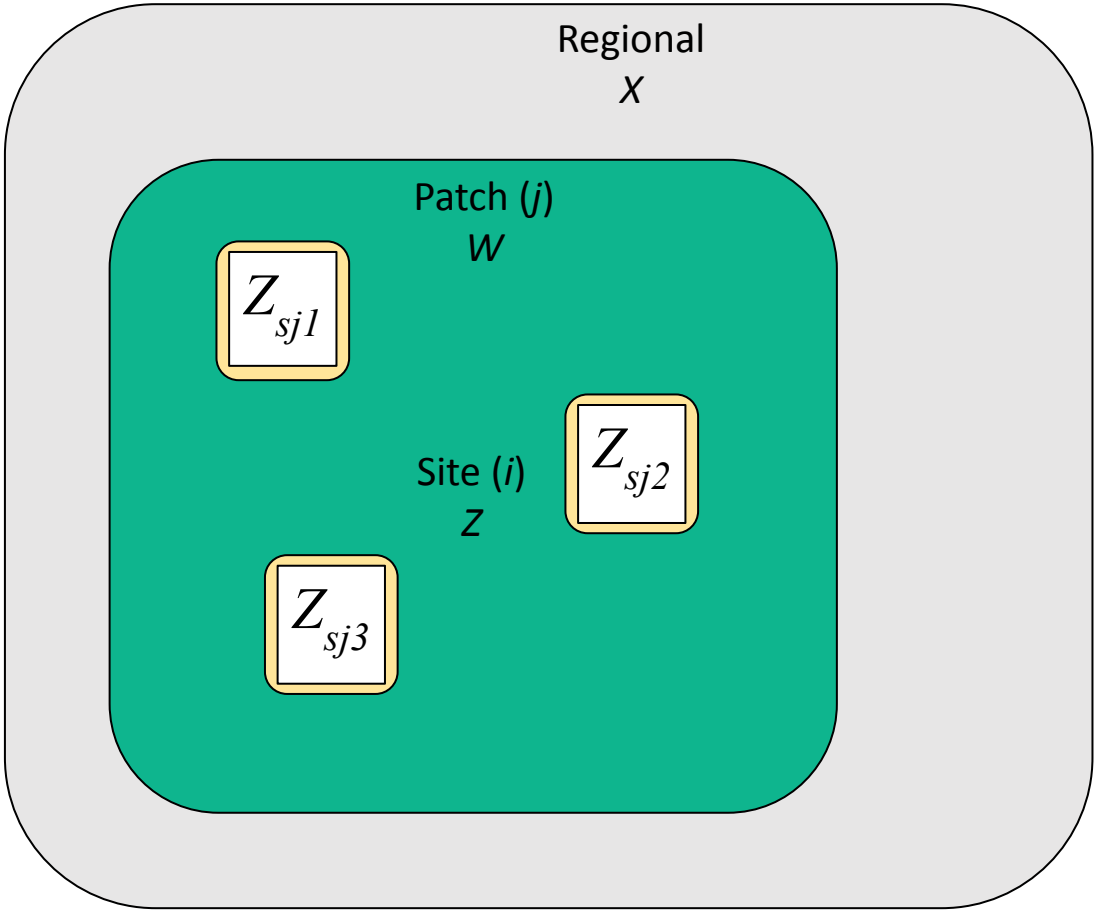
Data Collection





i = site
j = patch
t = time

The Model



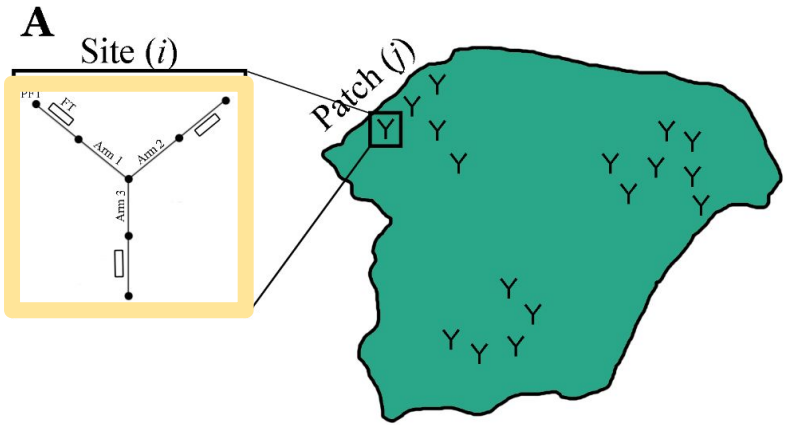
Site Occupancy (Z_{sji})

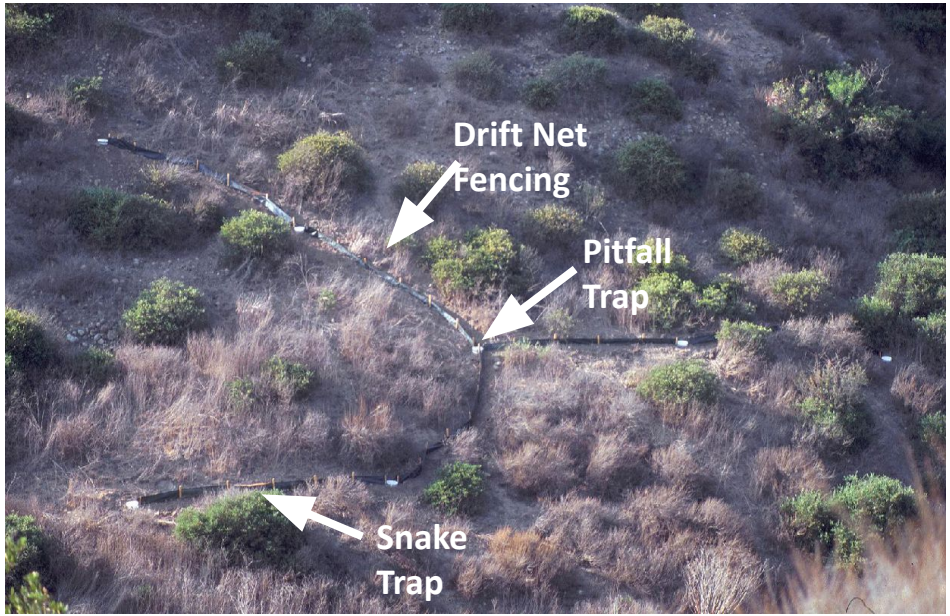
$$Z_{sji} \sim Bernoulli(W_{sji} * \psi_{sj})$$

$$\text{logit}(\psi_{sj}) = \beta_{0s} + \beta_{1s} + PatchSize_j$$

i = site
j = patch
t = time
s = species

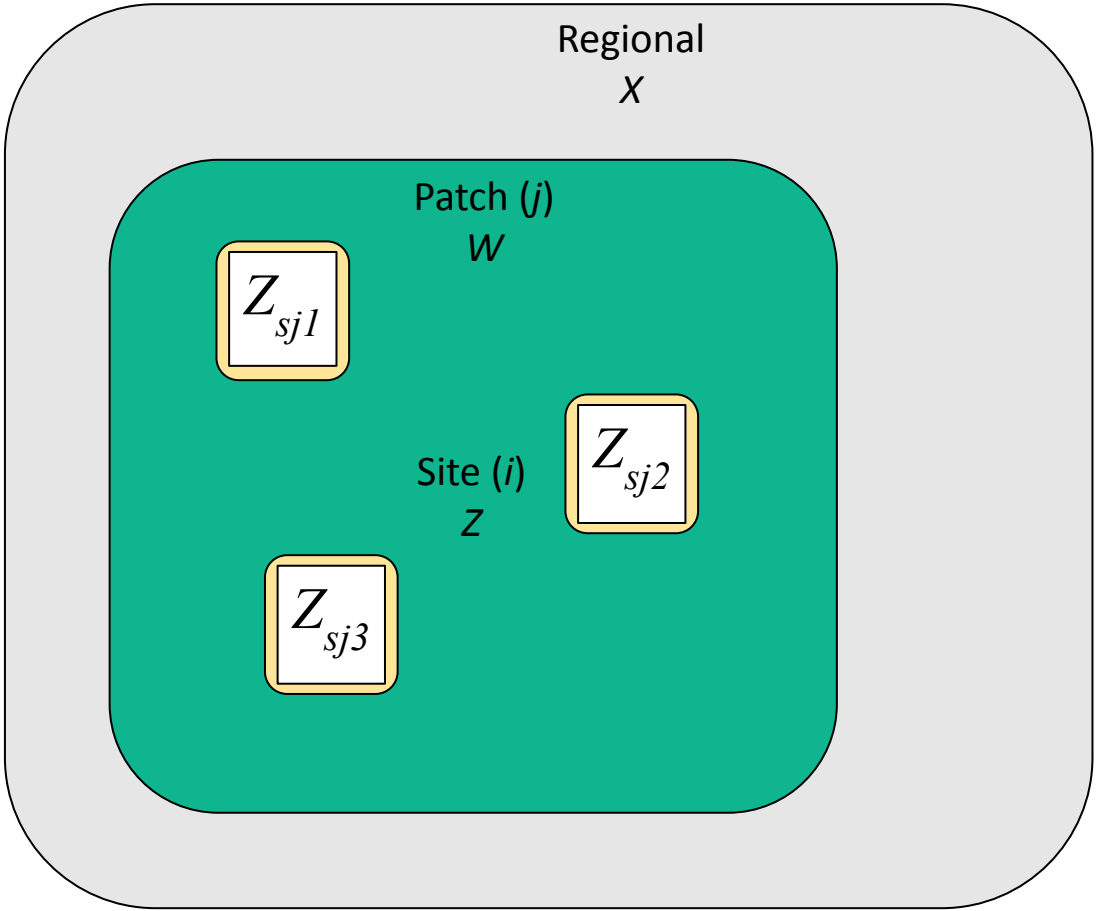
Data Collection





i = site
j = patch
t = time

The Model



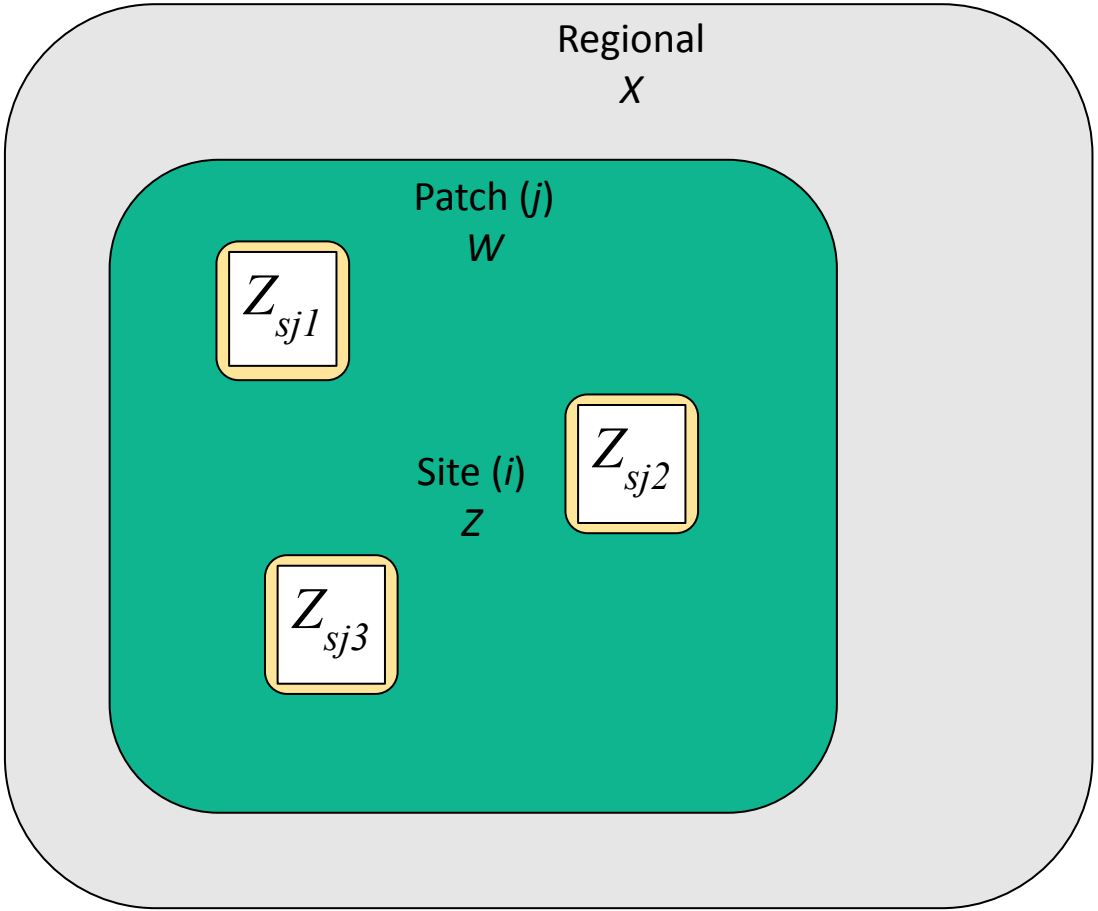
Detection Probability (p_{sj})

$$Y_{sjit} \sim Bernoulli(p_{sj} * Z_{sji})$$

$$\text{logit}(p_{sj}) = \alpha_{0s} + \alpha_{1s} + PatchSize_j$$

i = site
j = patch
t = time
s = species

The Model



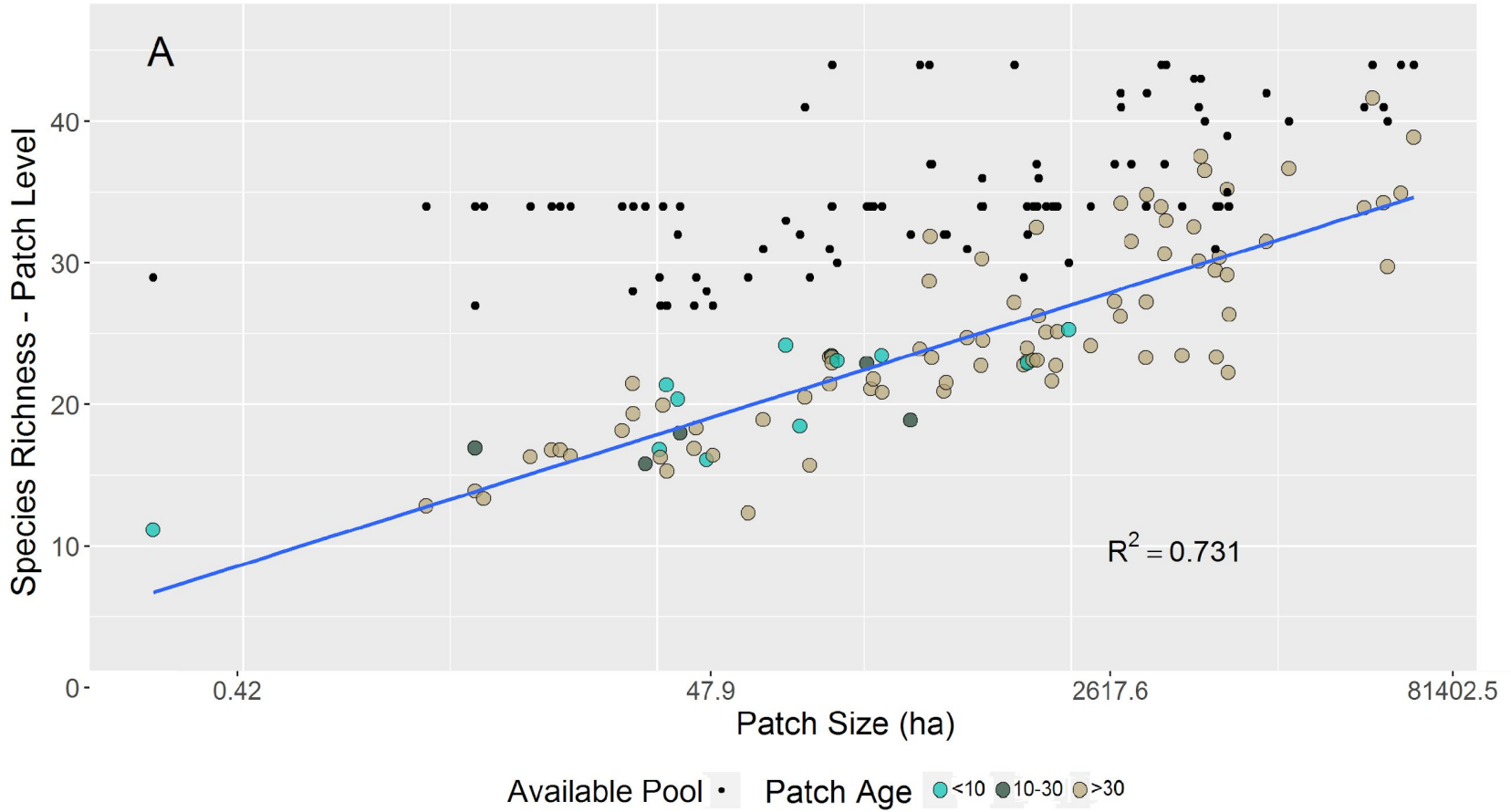
Species Richness

$$\text{Patch Richness} = \sum_{s=1}^{45} W_{sj}$$

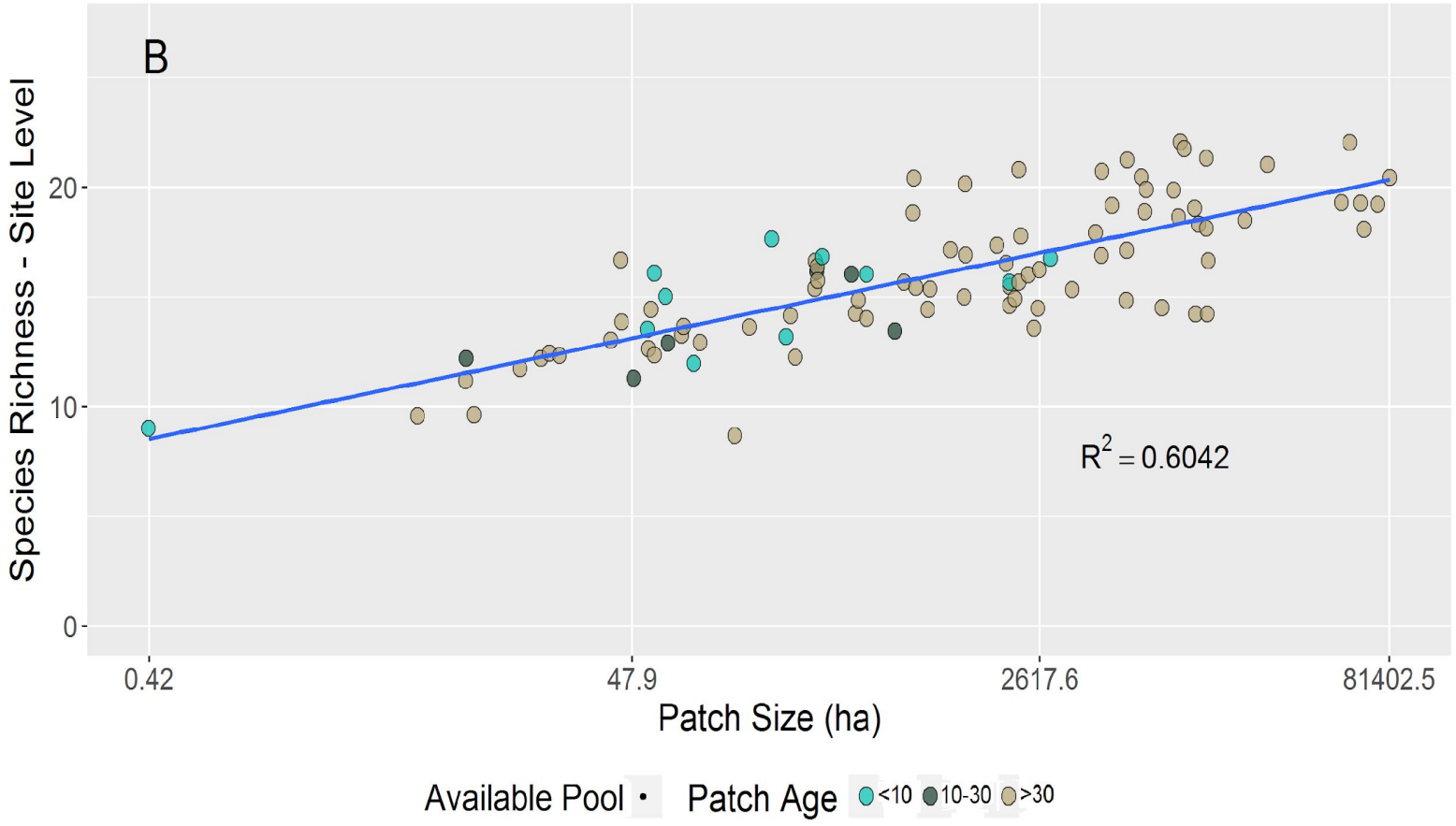
$$\text{Site Richness} = \sum_{s=1}^{45} Z_{sj}$$

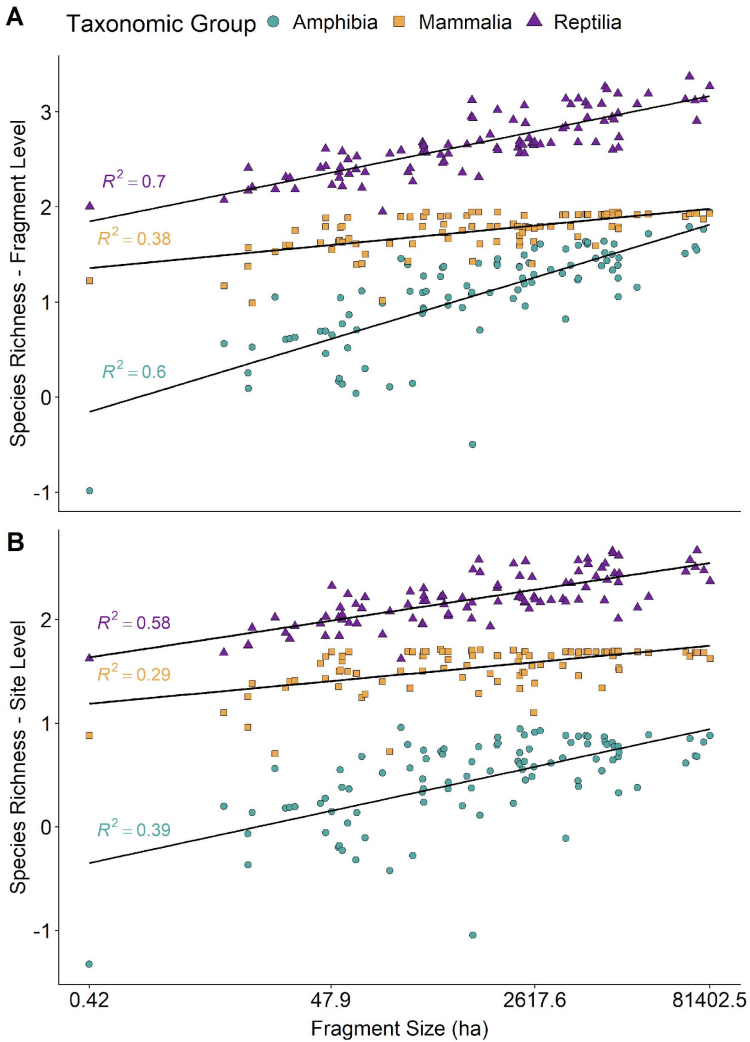
i = site
j = patch
t = time
s = species

Species Richness - Patch



Species Richness - Site

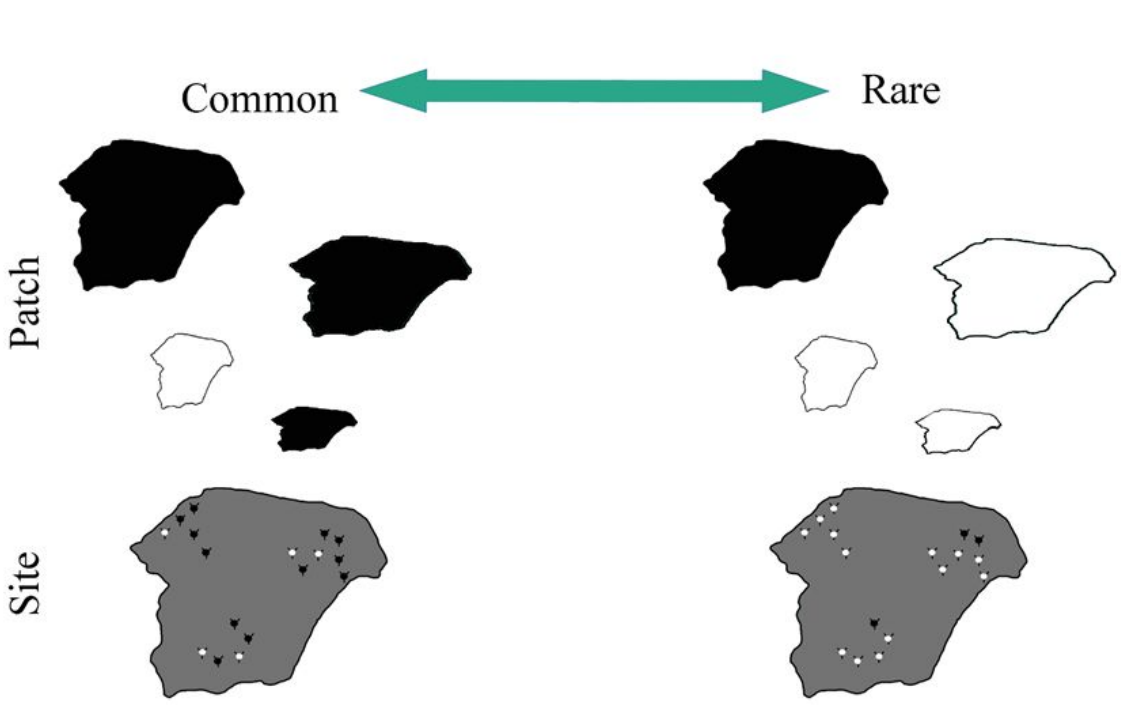


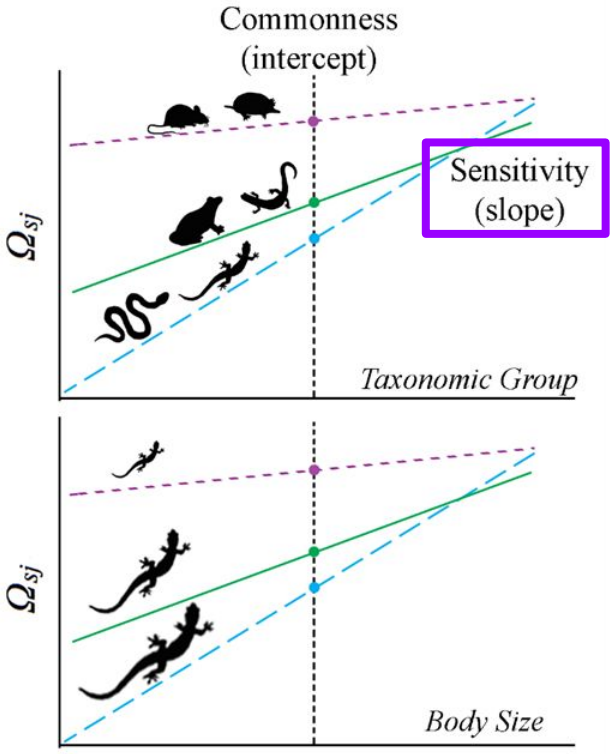


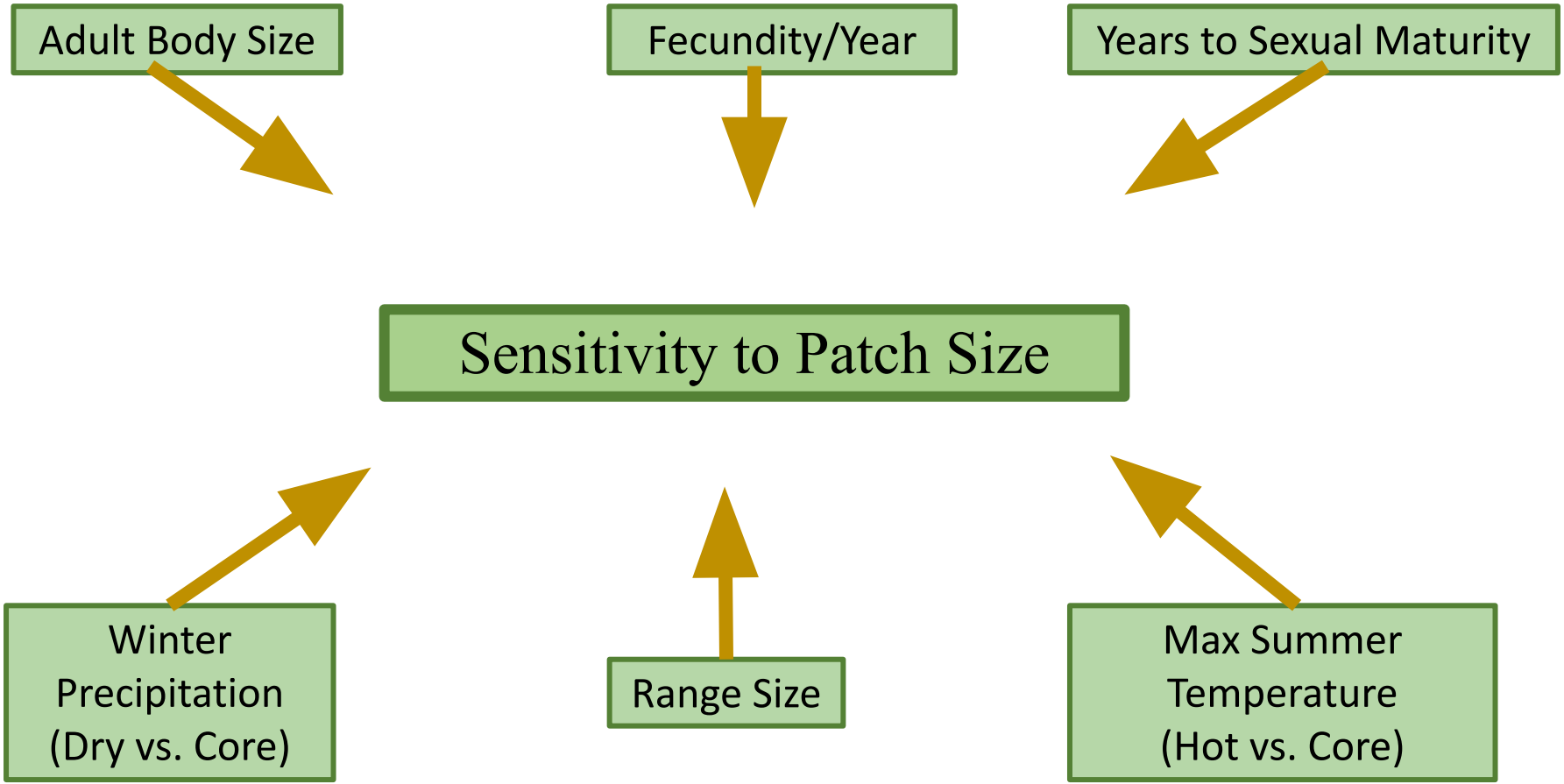
What causes variation in sensitivity to fragmentation?

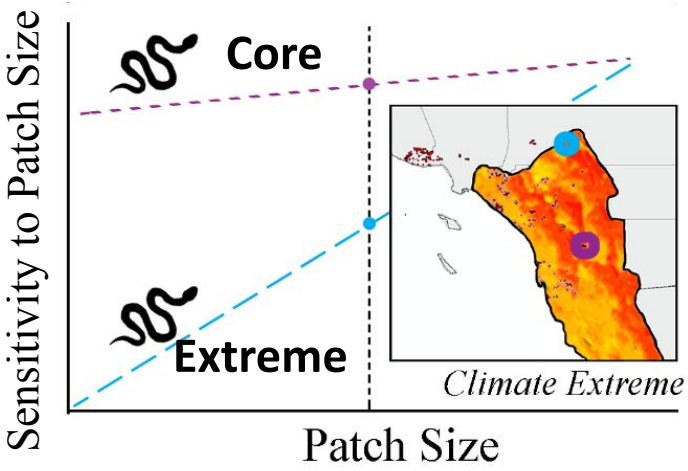






Common
Rare
Patch
Site


Commonness
(intercept)
Sensitivity
(slope)
Ω_{sj}
Taxonomic Group
Ω_{sj}
Body Size


Adult Body Size
Fecundity/Year
Years to Sexual Maturity
Sensitivity to Patch Size
Winter Precipitation (Dry vs. Core)
Range Size
Max Summer Temperature (Hot vs. Core)



C

Red diamond rattlesnake

Western toad

Broad-footed mole

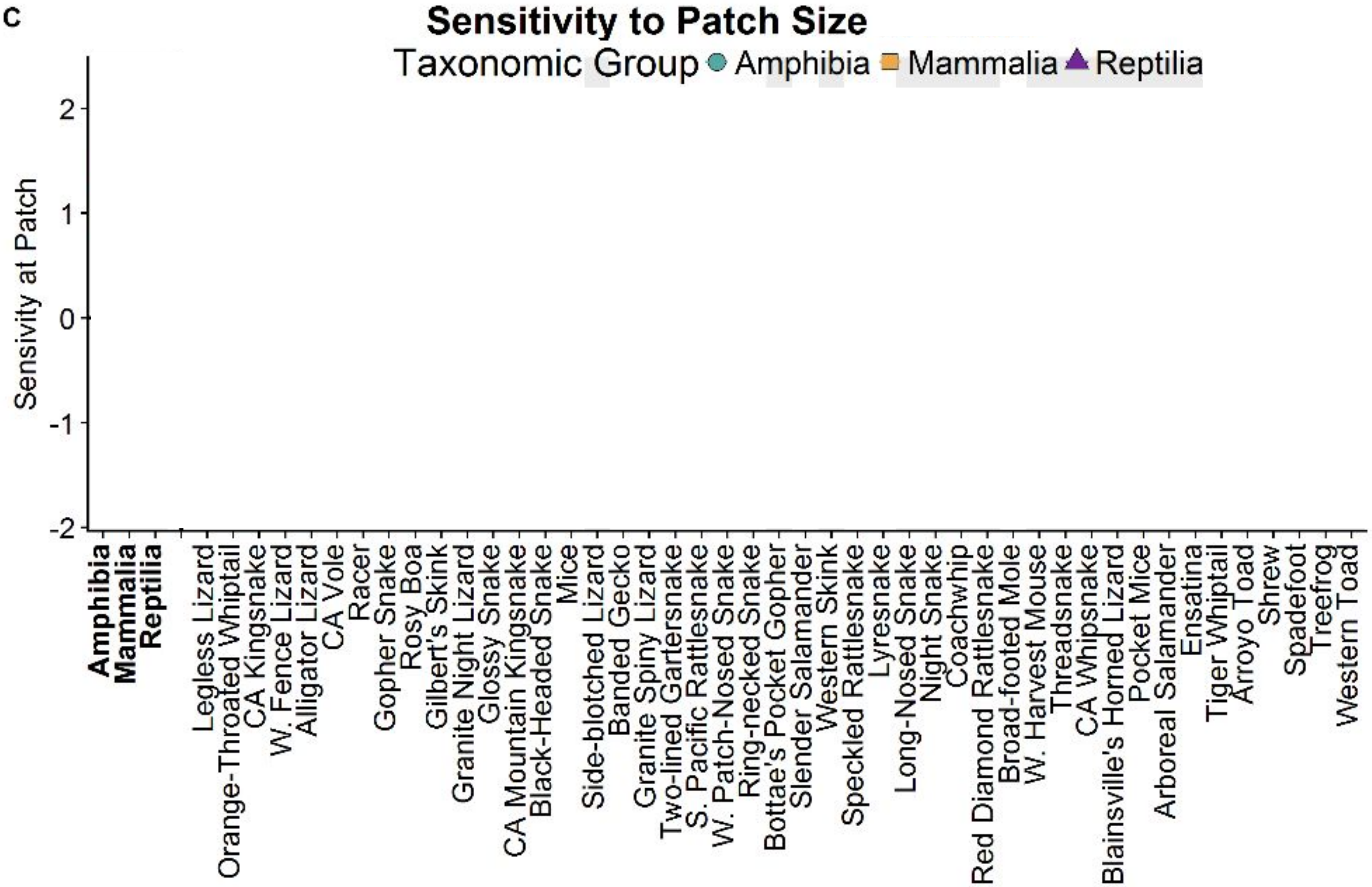
30 year Winter Precipitation (mm)

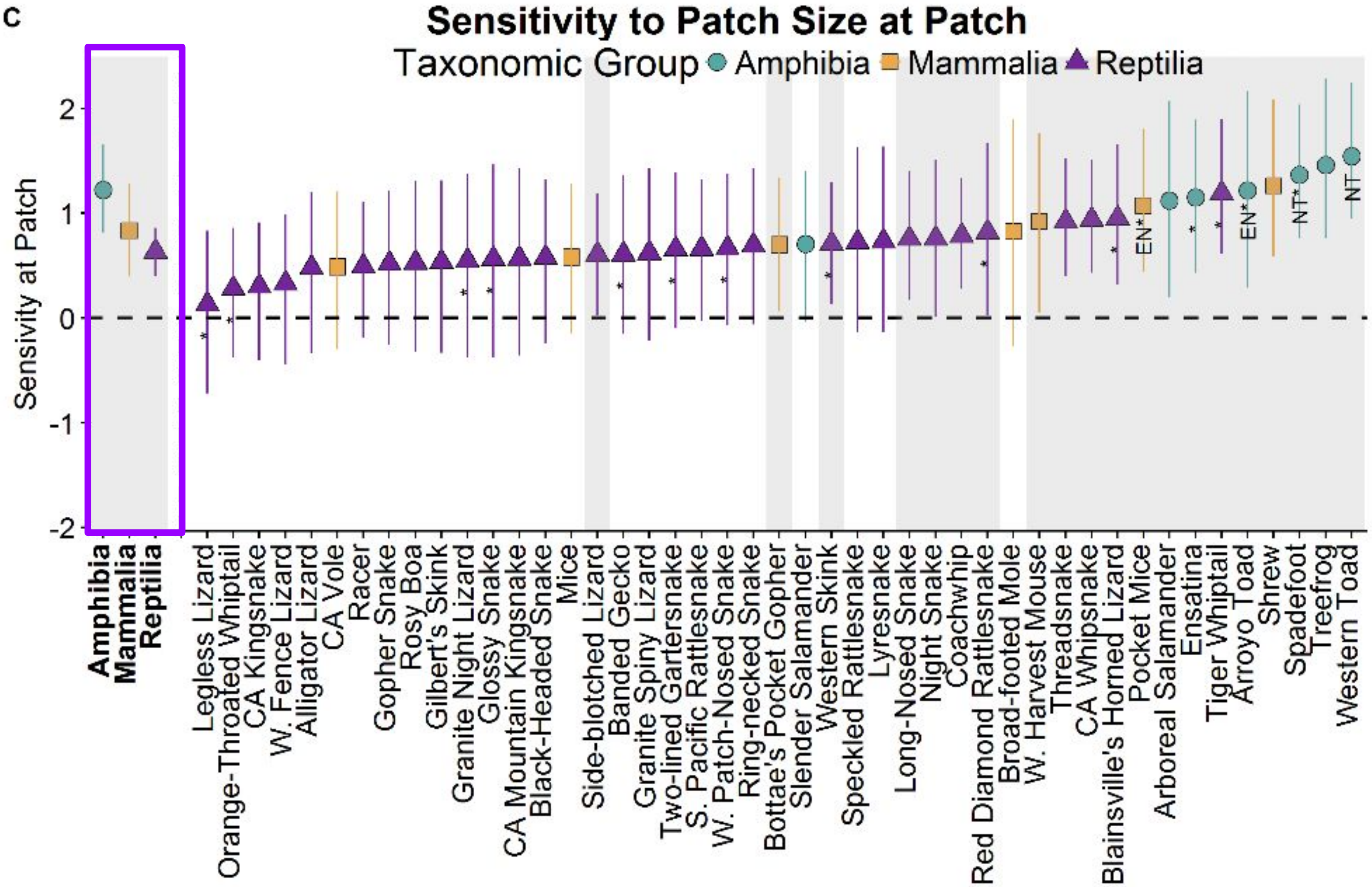
Red diamond rattlesnake

Western toad

Broad-footed mole

30 year Summer Max Temperature (C)


c
Sensitivity to Patch Size
Taxonomic Group
Amphibia
Mammalia
Reptilia
Sensivity at Patch
2
1
0
-1
-2
Amphibia
Mammalia
Reptilia
Legless Lizard
Orange-Throated Whiptail
CA Kingsnake
W. Fence Lizard
Alligator Lizard
CA Vole
Racer
Gopher Snake
Rosy Boa
Gilbert's Skink
Granite Night Lizard
Glossy Snake
CA Mountain Kingsnake
Black-Headed Snake
Mice
Side-blotched Lizard
Banded Gecko
Granite Spiny Lizard
Two-lined Gartersnake
S. Pacific Rattlesnake
W. Patch-Nosed Snake
Ring-necked Snake
Bottae's Pocket Gopher
Slender Salamander
Western Skink
Speckled Rattlesnake
Lyresnake
Long-Nosed Snake
Night Snake
Coachwhip
Red Diamond Rattlesnake
Broad-footed Mole
W. Harvest Mouse
Threadsnake
CA Whipsnake
Blainsville's Horned Lizard
Pocket Mice
Arboreal Salamander
Ensatina
Tiger Whiptail
Arroyo Toad
Shrew
Spadefoot
Treefrog
Western Toad


c
Sensitivity to Patch Size at Patch
Taxonomic Group
Amphibia
Mammalia
Reptilia
Sensivity at Patch
2
1
0
-1
-2
Amphibia
Mammalia
Reptilia
Legless Lizard
Orange-Throated Whiptail
CA Kingsnake
W. Fence Lizard
Alligator Lizard
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Night Snake
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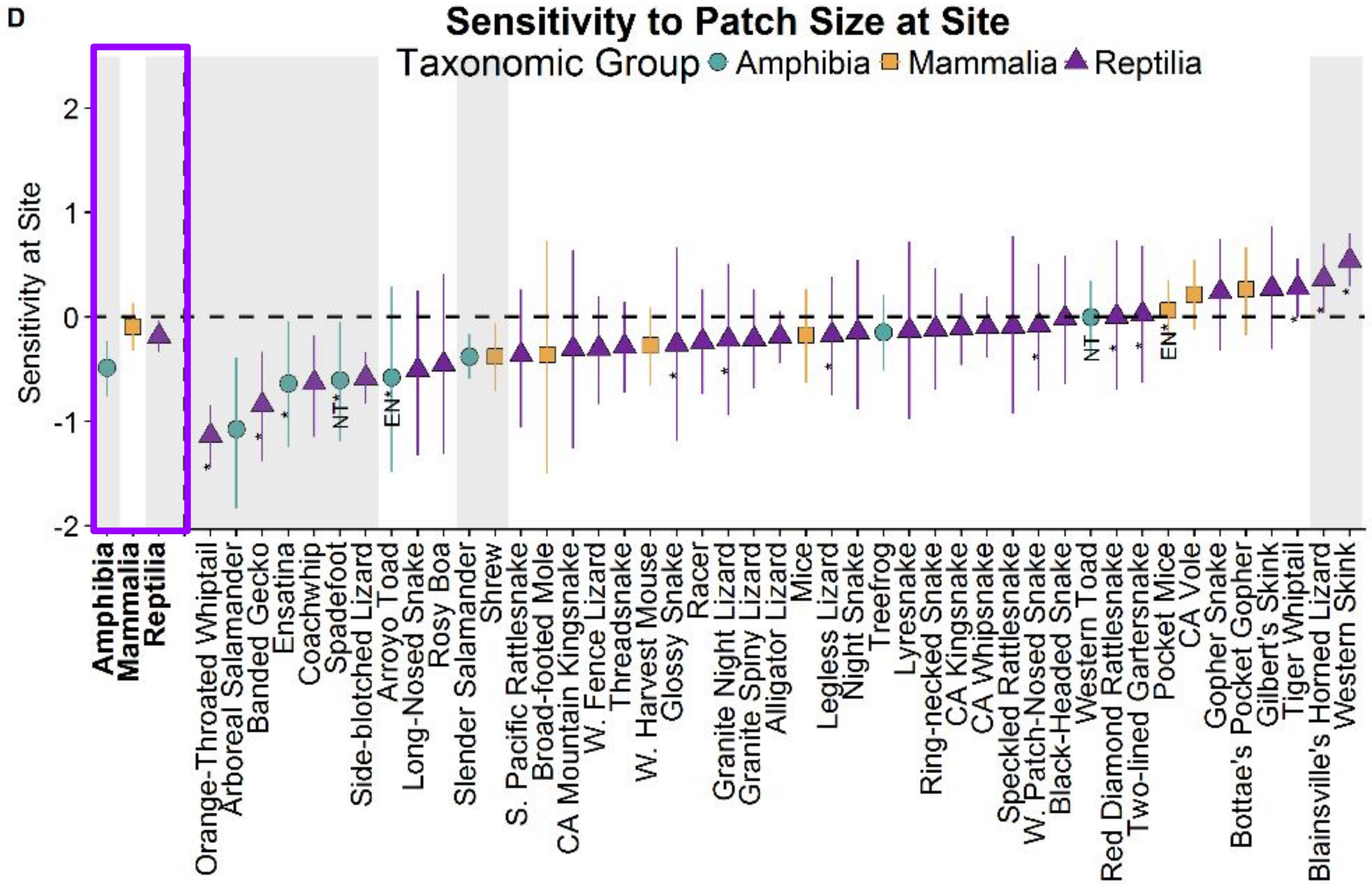
W. Harvest Mouse
Threadsnake
CA Whipsnake
Blainsville's Horned Lizard
Pocket Mice
Arboreal Salamander
Ensatina
Tiger Whiptail
Arroyo Toad
Shrew
Spadefoot
Treefrog
Western Toad
EN*
EN*
NT*
NT



D
Sensitivity to Patch Size at Site
Taxonomic Group Amphibia Mammalia Reptilia
Sensitivity at Site
2
1
0
-1
-2
Amphibia
Mammalia
Reptilia
Orange-Throated Whiptail
Arboreal Salamander
Banded Gecko
Ensatina
Coachwhip
Spadefoot
Side-blotched Lizard
Arroyo Toad
Long-Nosed Snake
Rosy Boa
Slender Salamander
Shrew
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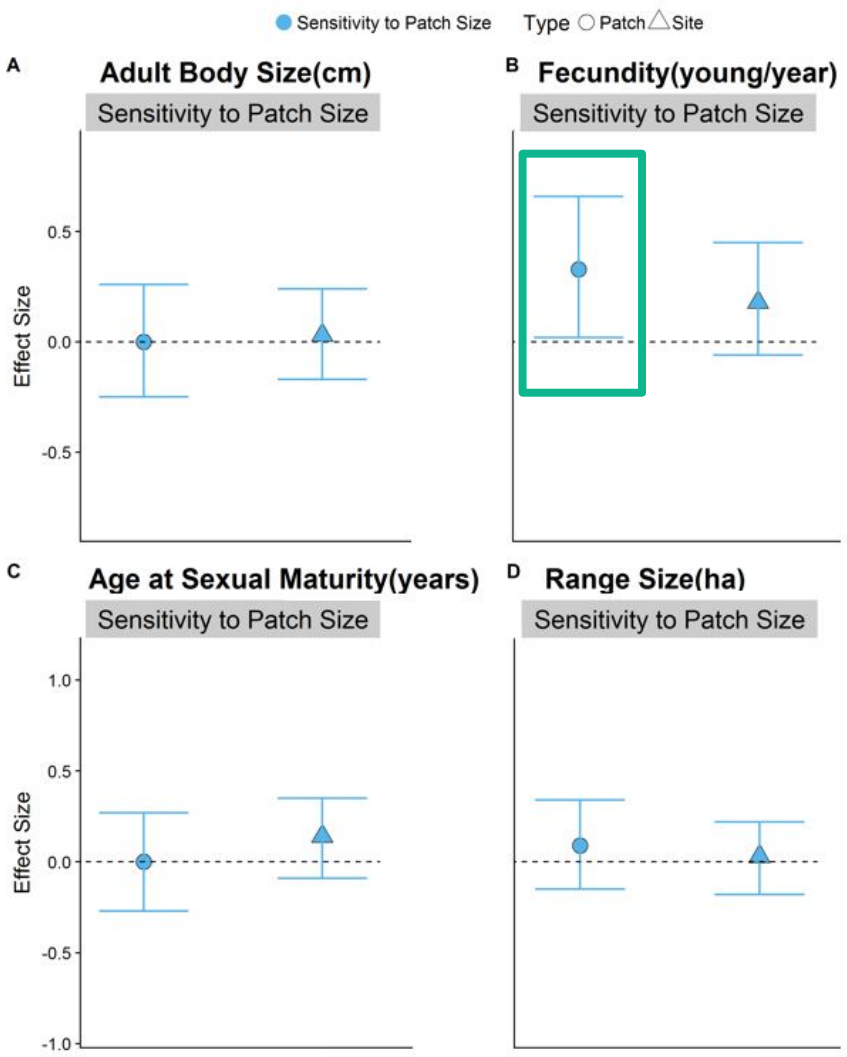
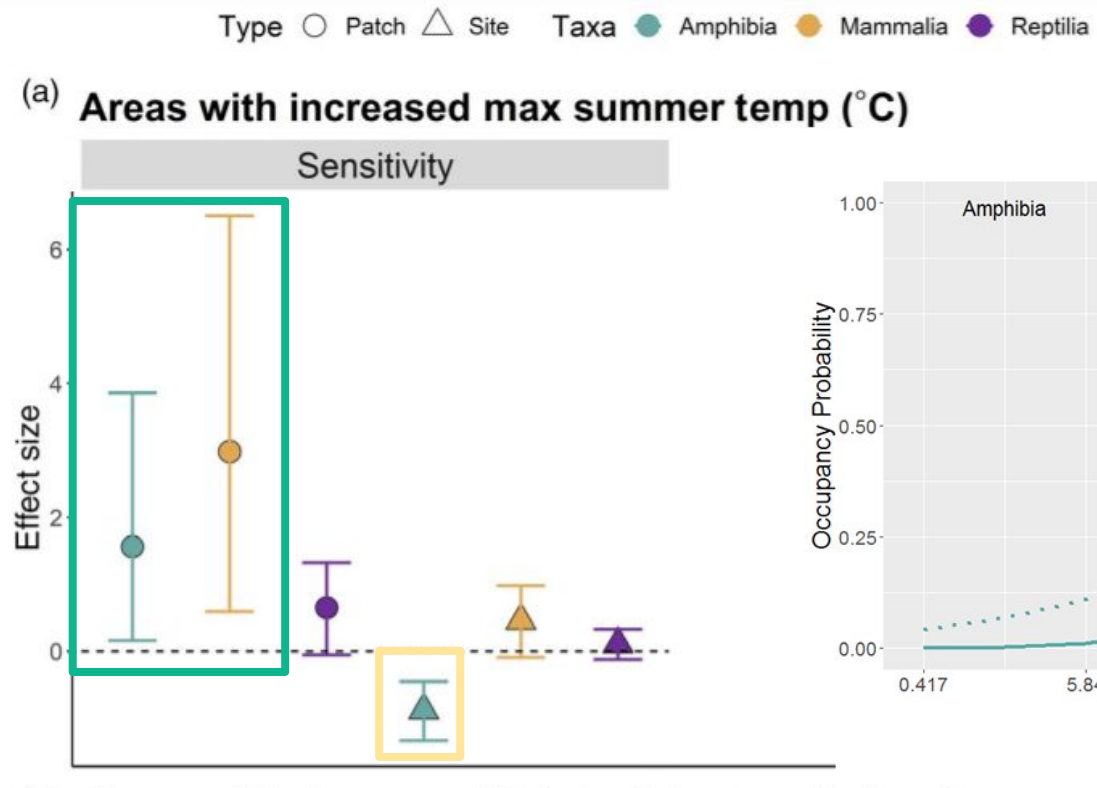
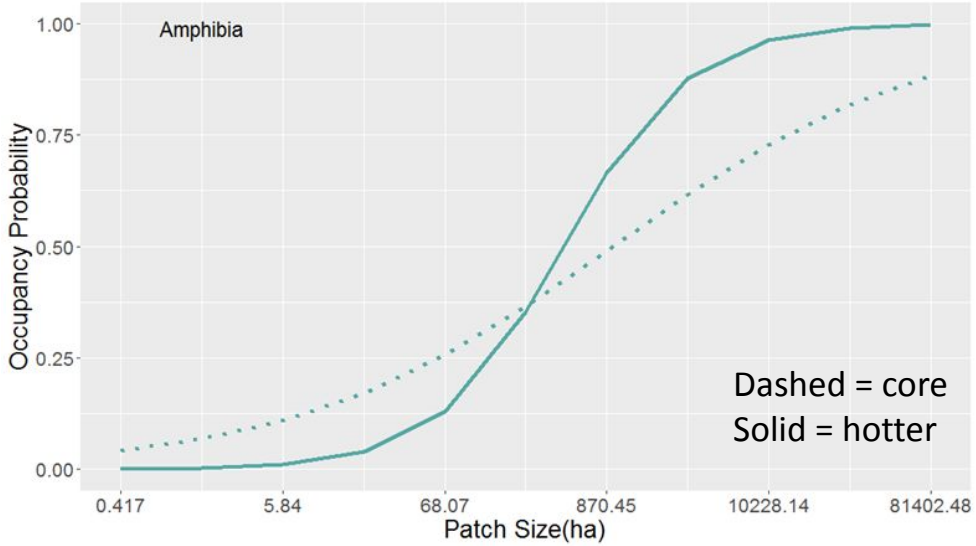
Pocket Mice
CA Vole
Gopher Snake
Bottae's Pocket Gopher
Gilbert's Skink
Tiger Whiptail
Blainsville's Horned Lizard
Western Skink
NT*
EN*
NT
EN*


Sensitivity to Patch Size
Type Patch Site
A
Adult Body Size(cm)
Sensitivity to Patch Size
B
Fecundity(young/year)
Sensitivity to Patch Size
C
Age at Sexual Maturity(years)
Sensitivity to Patch Size
D
Range Size(ha)
Sensitivity to Patch Size
Effect Size
0.5
0.0
-0.5
1.0
-1.0

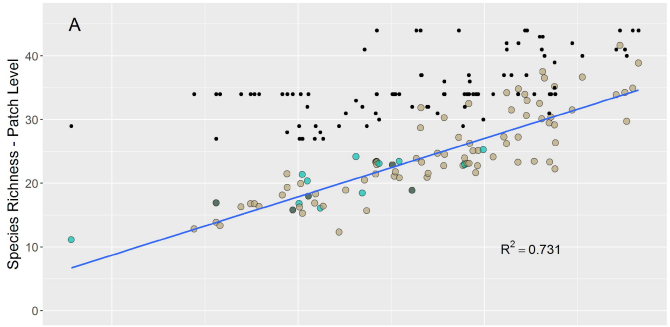




Above the line = MORE sensitive in smaller patch sizes to hotter conditions

Summary

Species richness increased with patch size



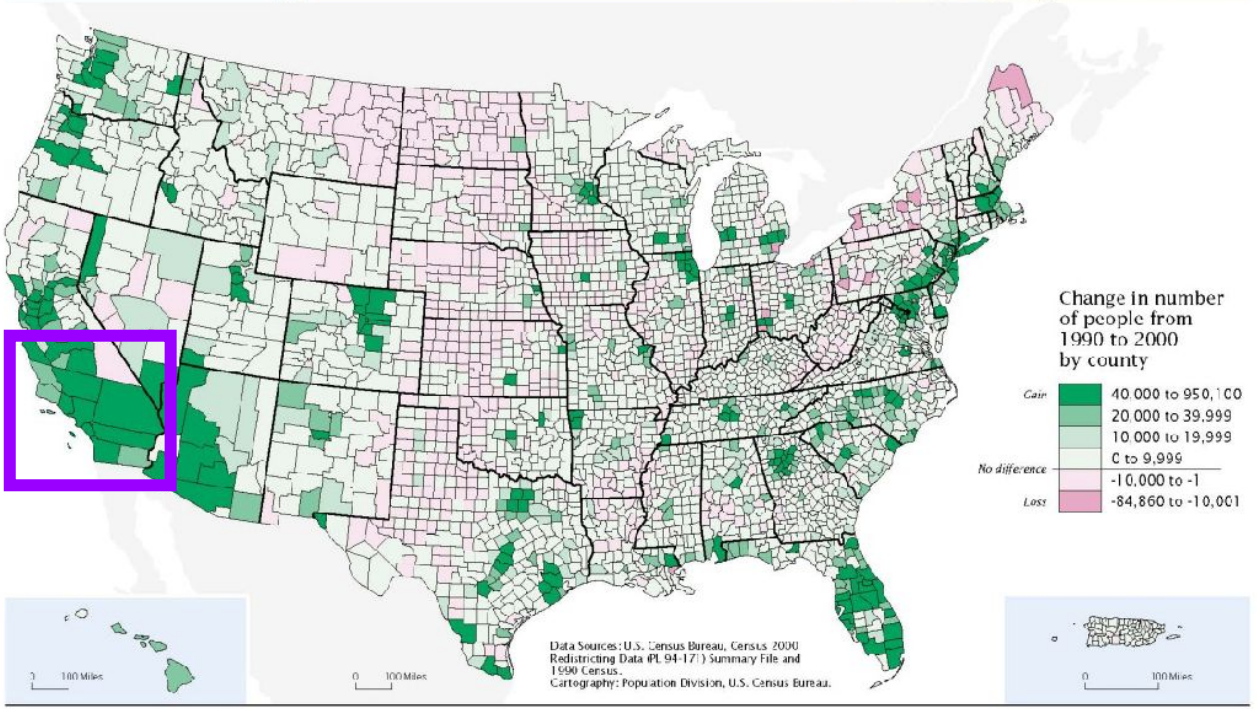
Sensitivity to this fragmentation differed by taxa and species within taxa

Fecundity/Year

Insight can be gained by incorporating life history and climate-range position information

Max Summer Temperature (Hot vs. Core)

Change in the number of people from 1990 to 2000



14 Mapping Census 2000: The Geography of U.S. Diversity

U.S. Census Bureau

Focal area:

24 million people

56,505 mile^2

424.7 people/mile^2

Bin	Mean Null	Mean patch richness	Mean Site Richness	Frequency of Patches	% missing Species in Patch
<=30 ha	32.7	14.9	11.1	9	54.30%
>30 ha, <=300 ha	31.5	19.0	14.0	26	39.25%
>300 ha, <=1000 ha	35.2	23.3	15.8	13	33.75%
>1000 ha, <=5000 ha	35.0	25.4	16.6	22	27.14%
>5000 ha, <=11000 ha	39.4	31.2	19.0	12	20.97%
>11000 ha, <=82000 ha	38.5	31.8	18.6	15	17.37%

Patches >5000 ha have about 80% of species they could have

The smallest patches lack about 50% of species they could have

Emily Perkins***

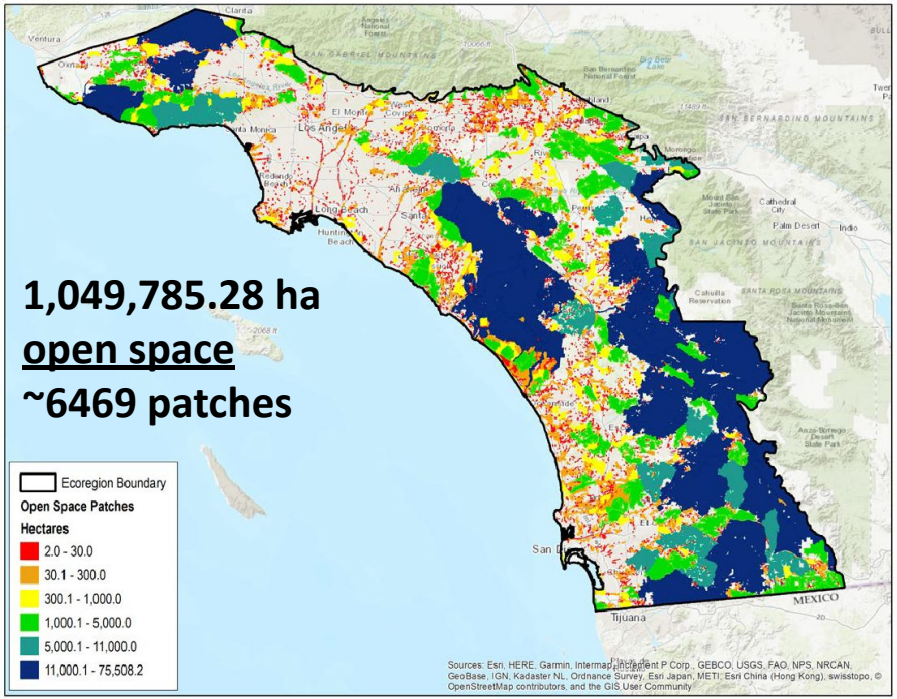
Natural Community Conservation Plan (NCCP)

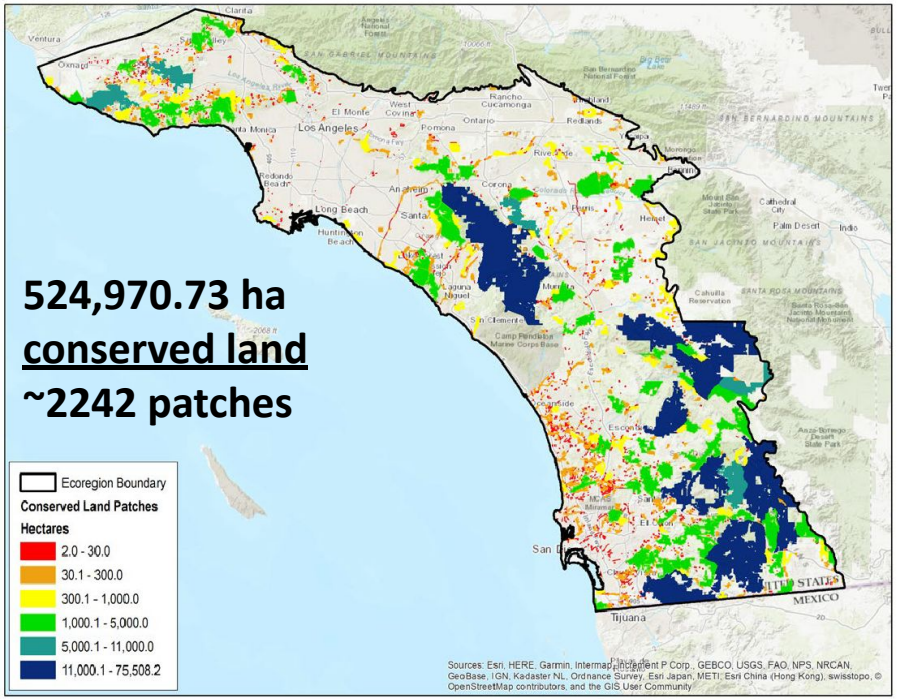
-Coordinated regional response
-Resolve biodiversity and development conflicts
-Overarching goals and subarea goals
-Deliver habitat and species protections

Bin	Number of Open Space patches	Ha of open space	Percent of Open Space in patch size	Number of Conserved Land patches	Ha of Conserved land	Percent of Conserved Land in patch size
<=30 ha	5325	39960.96	3.81	1533	14322.4	2.73
>30 ha, <=300 ha	894	74637.92	7.11	542	48958.53	9.33
>300 ha, <=1000 ha	125	67231.43	6.40	88	49198.94	9.37
>1000 ha, <=5000 ha	90	208412.66	19.85	63	151669.42	28.89
>5000 ha, <=11000 ha	17	127335.75	12.13	5	34415.82	6.56
>11000 ha, <=82000 ha	18	532206.56	50.70	11	226405.62	43.13
	6469	1049785.28		2242	524970.73	

These smallest patches are numerous but only 2-4% of the open space or conserved land

Percentage of area in conservation is dominated by larger patches (49.69%), which contain greater species diversity



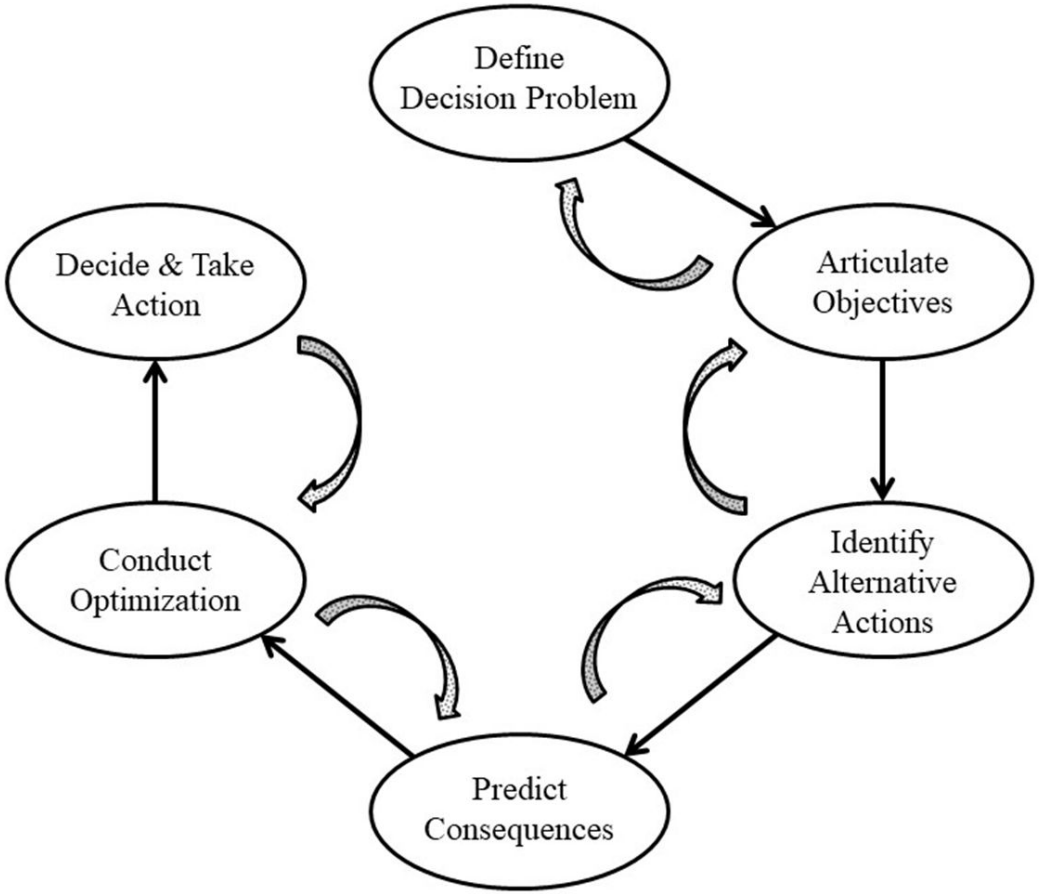


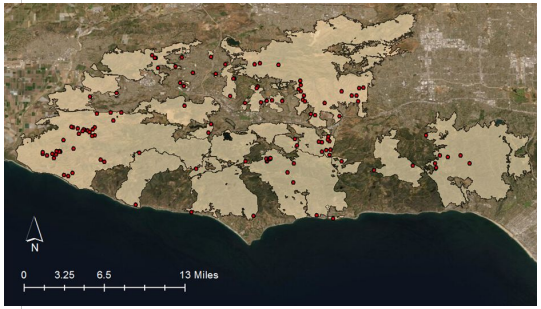
Future:

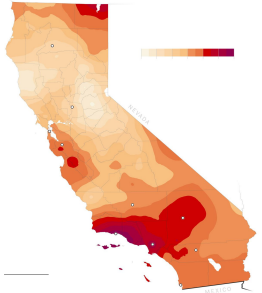
Add to patches vs. adding disconnected patches?

Use species life history and climate-range position information in planning

There are different dynamics at patch vs. site level







modified from Converse, Moore, Armstrong. 2013. Demographics of reintroduced populations: estimation, modeling, and decision analysis. Journal of Wildlife Management 77:1081-1093.

Acknowledgments

Countless USGS and NPS researchers

*Adam Backlin *JP Montagne

*Gary Busteed *Drew Stokes

*Denise Clark *Samantha Weber

USGS John Wesley Powell Center

ARCS Foundation

NASA Pennsylvania Space Grant Consortium

PSU Ecology Program

Applied Population Ecology lab

Photos: WERC

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