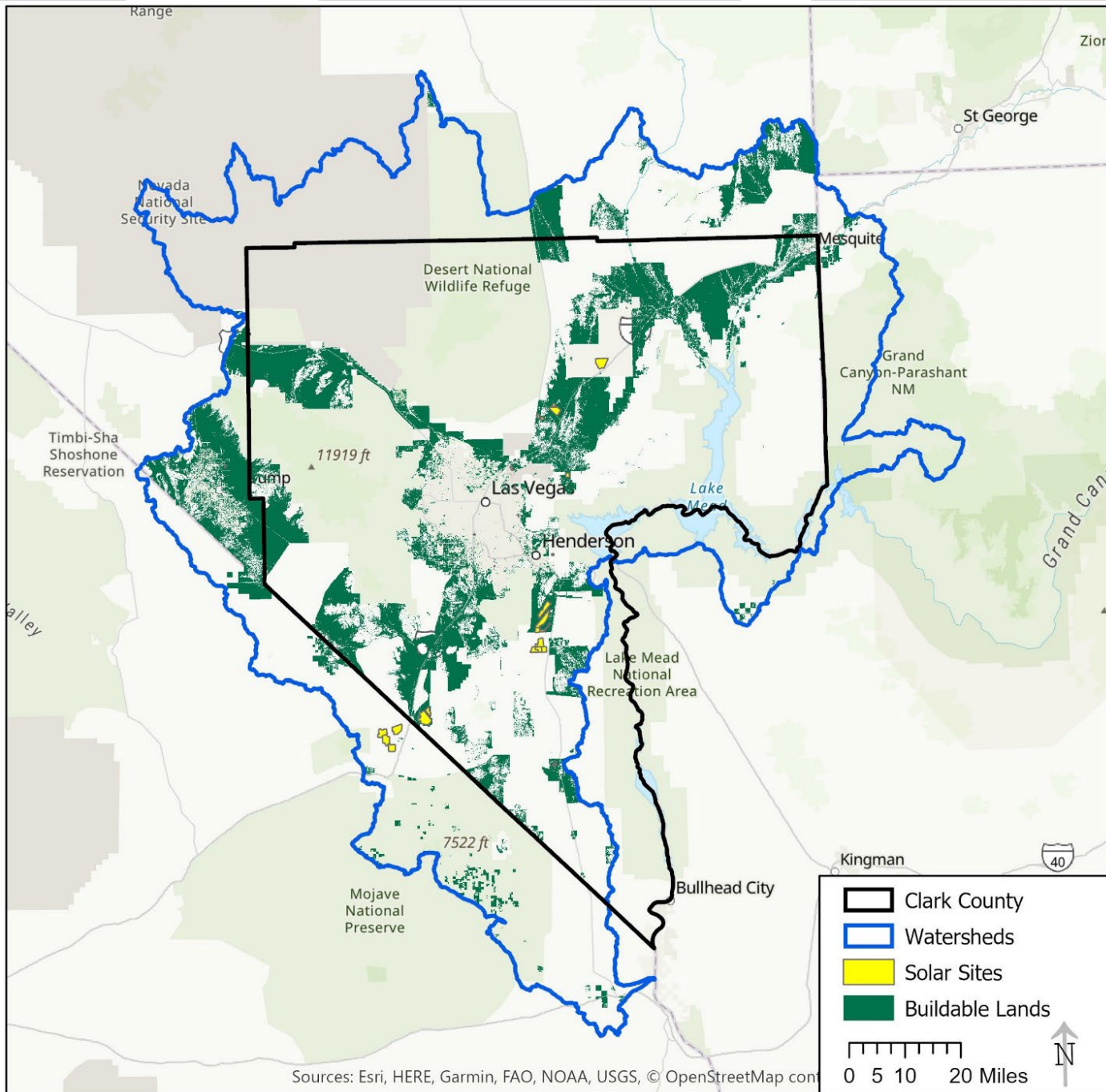


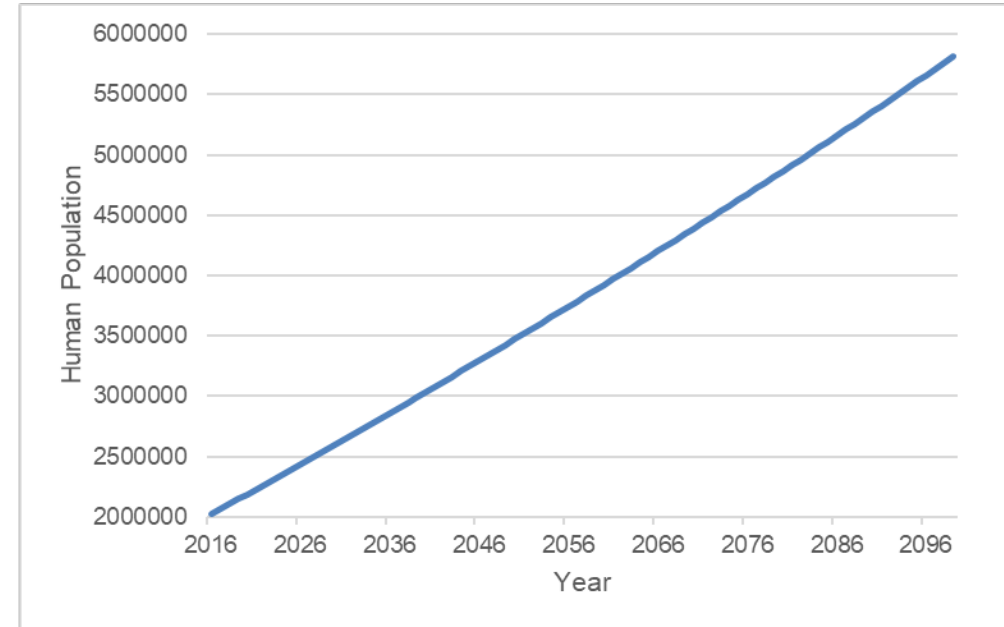
The background features several overlapping, semi-transparent grey shapes of various sizes and orientations, creating a layered, abstract effect. The shapes are positioned primarily on the left and bottom sides of the slide, leaving the right side more open for text.

Desert Tortoise Connectivity Solutions Modeling

Ken Nussear, Kirsten Dutcher,
Scott Bassett, Derek Friend



Buildable Lands



Slope < 20%

Non-urban lands

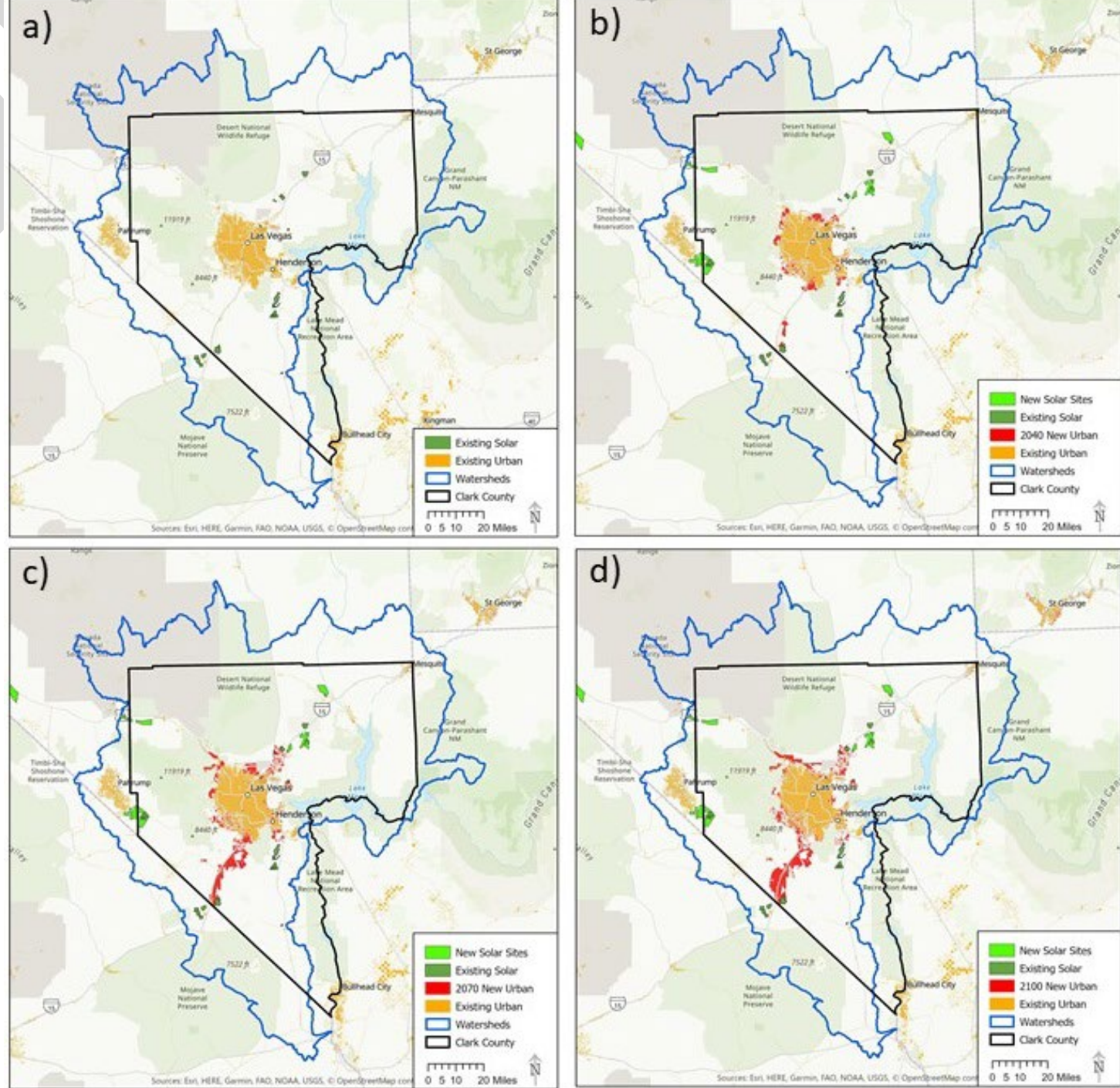
Not open water or wetland

Private land or land owned by the U.S. Bureau of Land Management (BLM) in Nevada

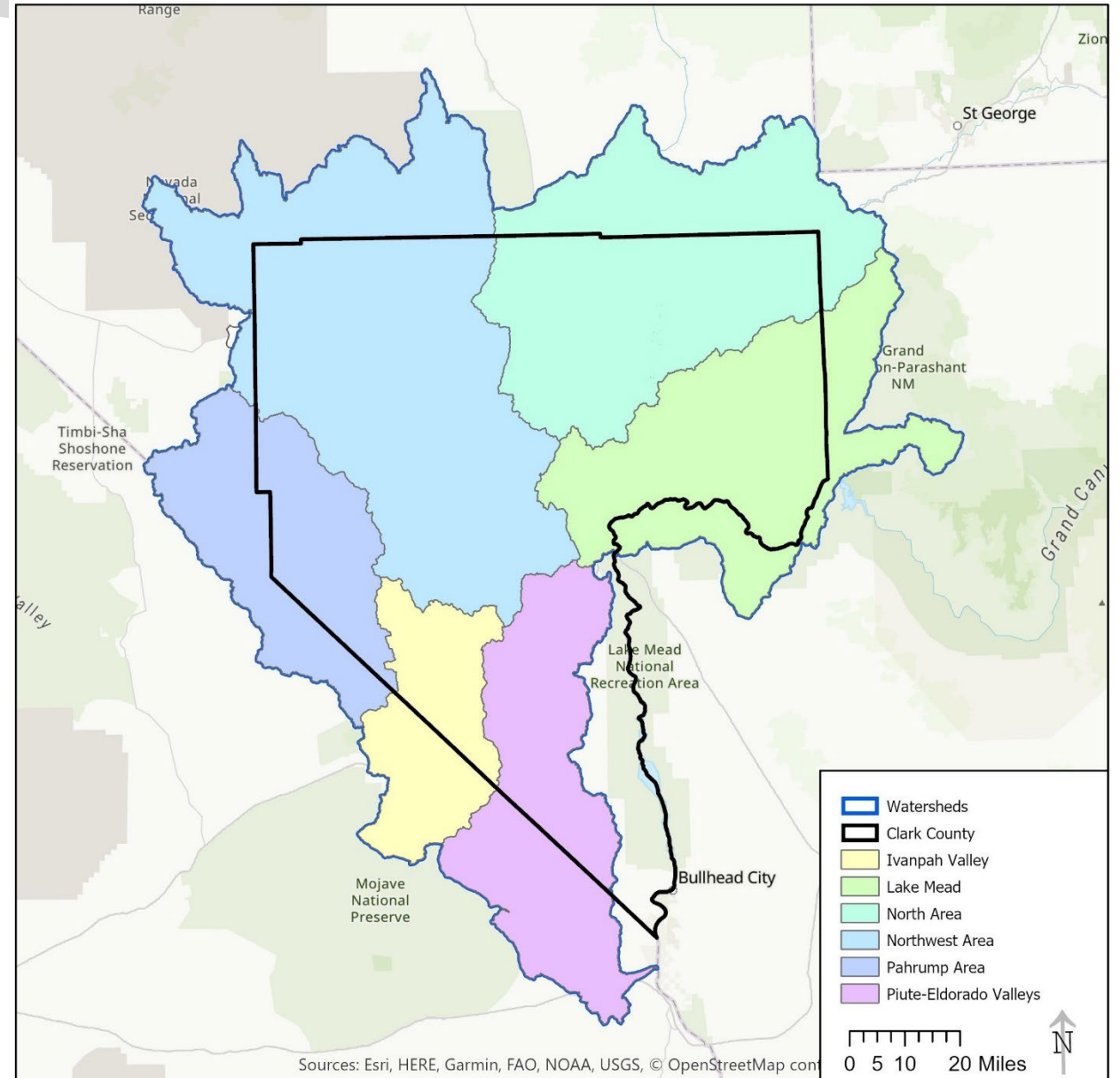
Land not designated with a conservation or preservation category

Urbanization

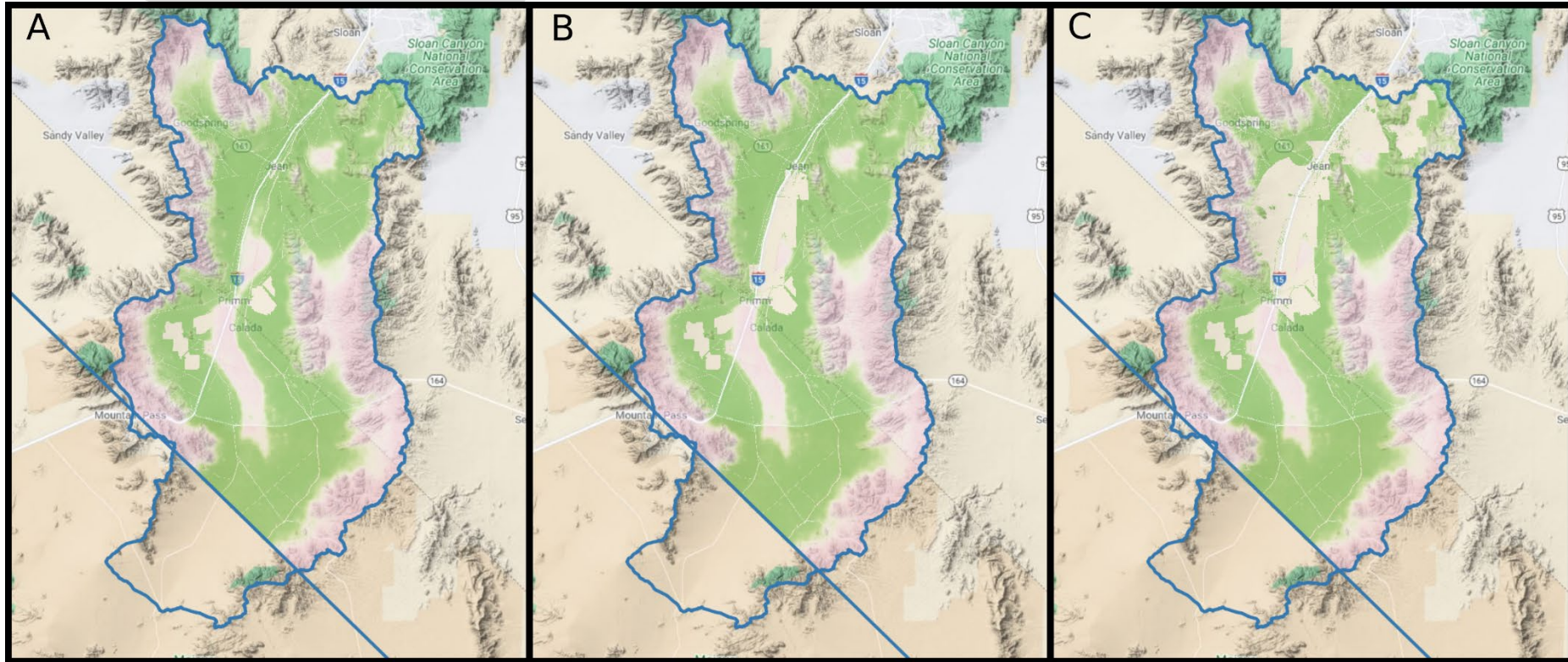
- Current Urbanization and future land use change in Clark County, Nevada for
- a) current 2021
- b) future to 2040
- c) future to 2070
- d) future to 2100



- Study Regions – identified using combination of watershed boundaries, and natural tortoise connectivity barriers



Population Growth – Habitat effects

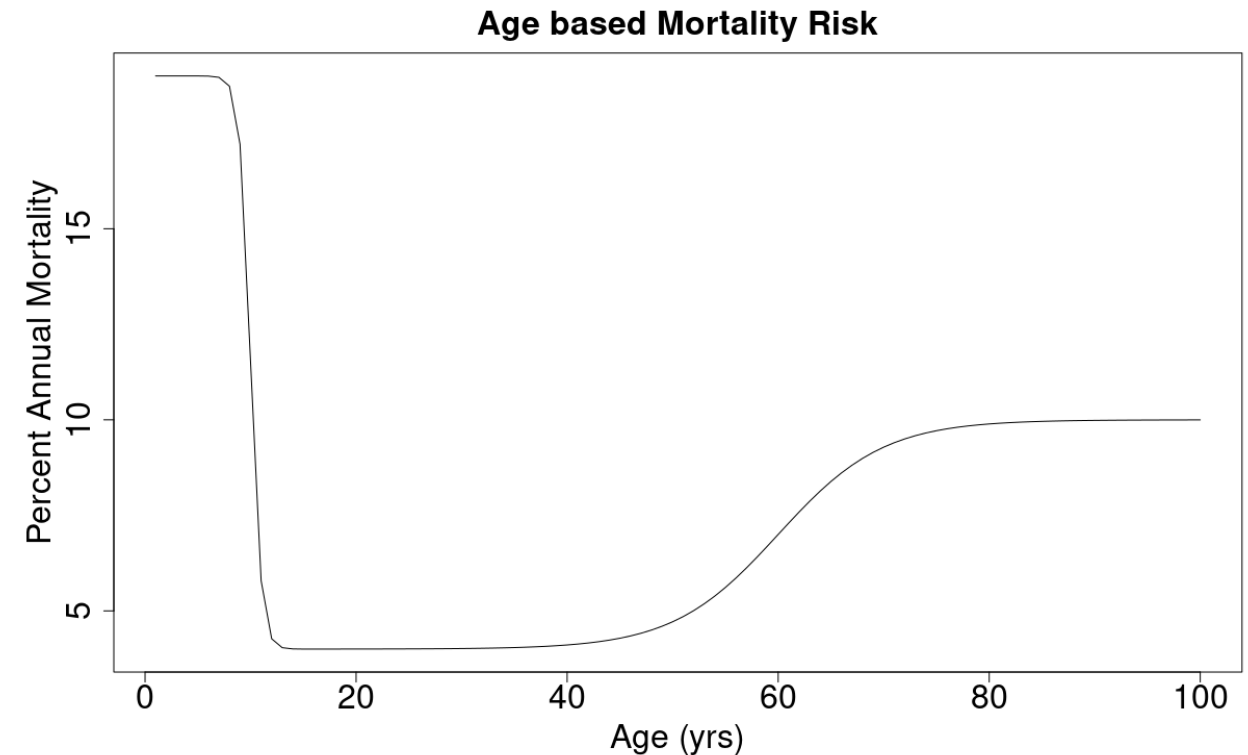
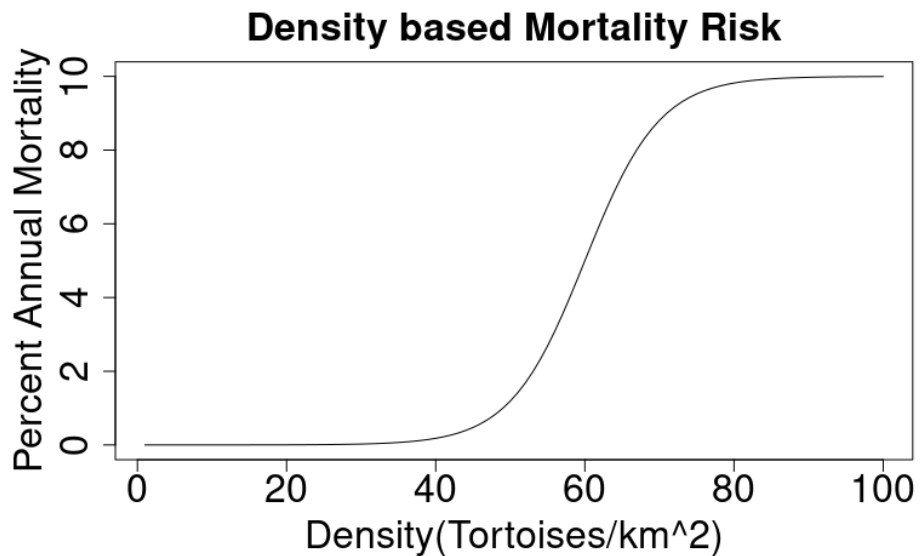
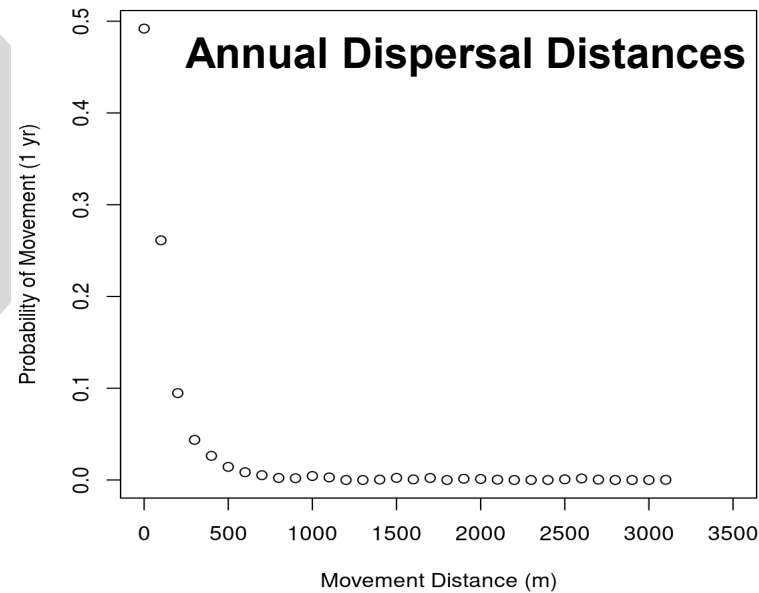


Ivanpah Habitat Effects

Zone	Name	Area (km2) 2020	Area (km2) 2050	Area (km2) 2100	Area Loss	Mean (cost) 2020	Mean (cost) 2050	Mean (cost) 2100	Cost Change
8	Goodsprings North	254.44	254.44	247.70	6.74	0.39	0.39	0.40	0.01
19	Nipton North	677.73	659.12	587.22	90.50	0.30	0.30	0.33	0.03
28	Goodsprings South	402.35	398.55	332.21	70.14	0.33	0.33	0.38	0.06
29	Dry Lake	172.89	143.56	137.78	35.12	0.26	0.25	0.26	0.00
30	MNP Rd West	224.15	224.15	224.15	0.00	0.18	0.18	0.18	0.00
31	MNP Rd East	244.10	244.10	244.10	0.00	0.49	0.49	0.49	0.00

- Agent based modeling – modeled lifecycle of individual tortoises moving, maturing, mating, dying
- Life history parameters were based in empirical data
- Populations initialized using genetics from Ivanpah Valley from Dutcher et al. 2020 – with a 100 year burn-in

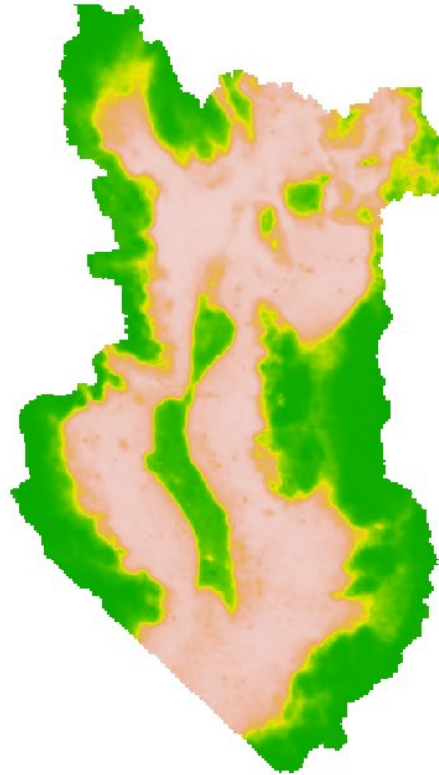
Approach



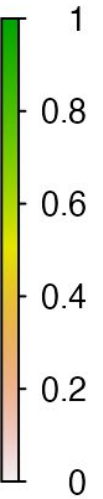
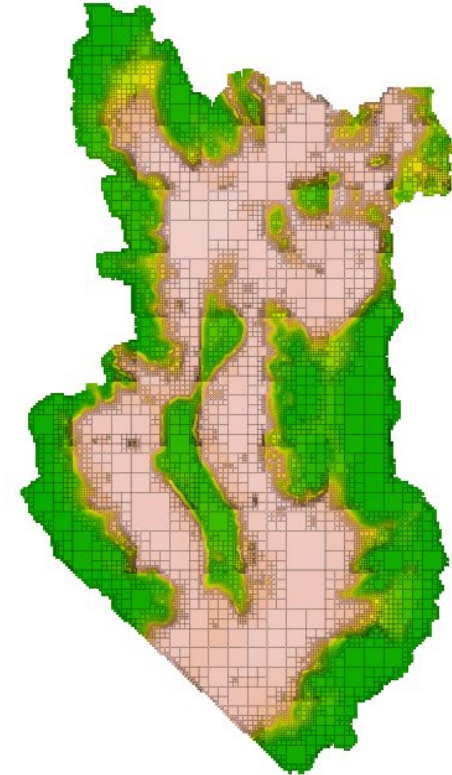
- Quadtree allows us to have fine scale raster coverage in areas of interest – e.g. Roads and culverts – while reducing memory requirements in areas that have little information or need for higher resolution

Quadtree Raster

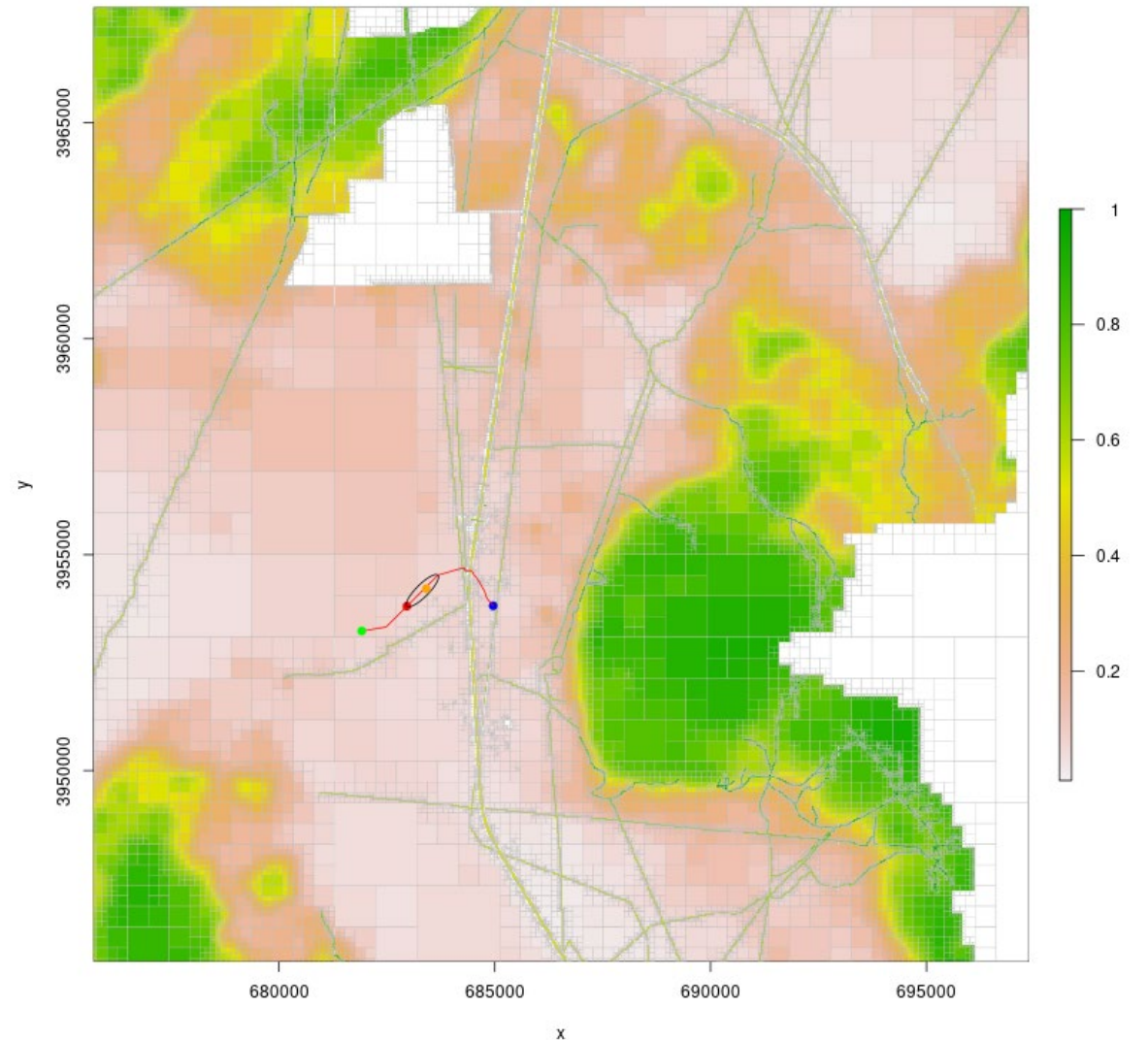
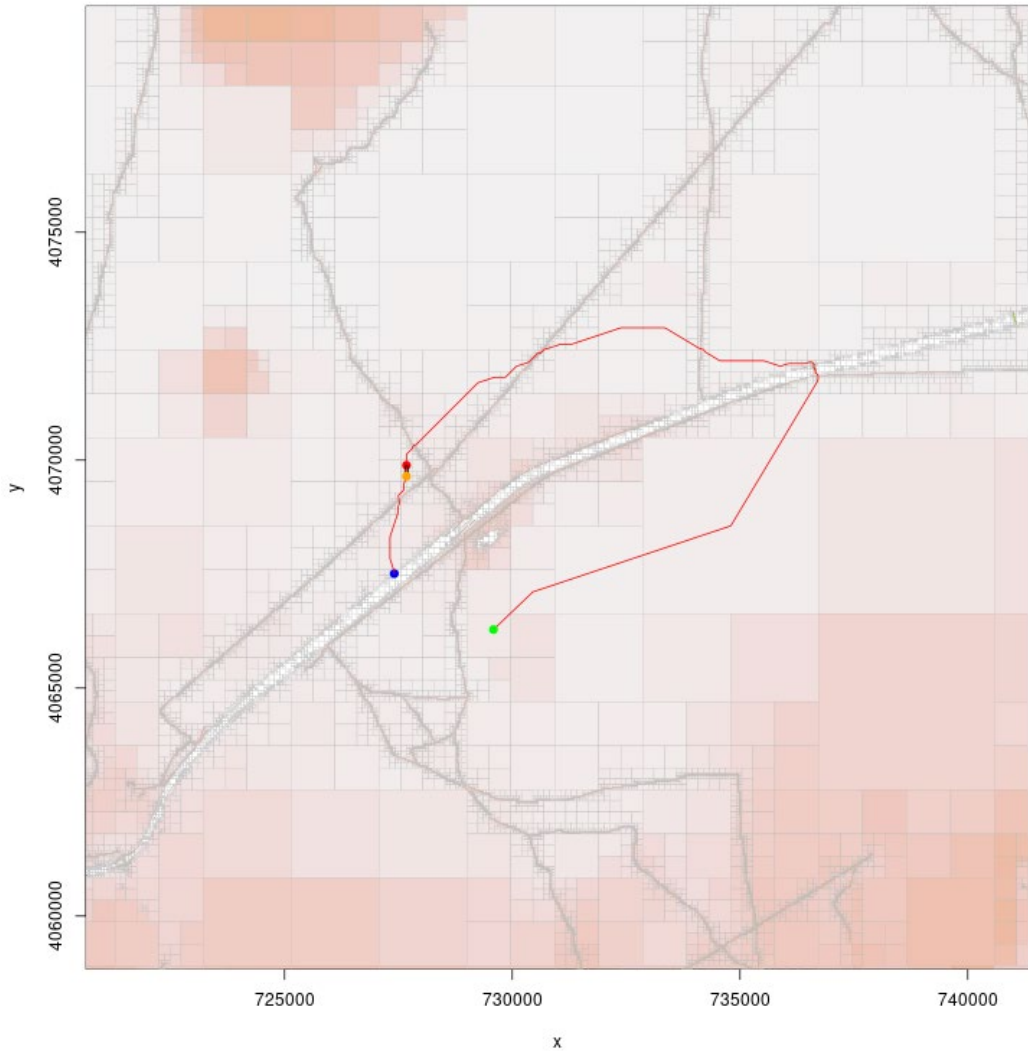
Raster



Quadtree



Movement Examples

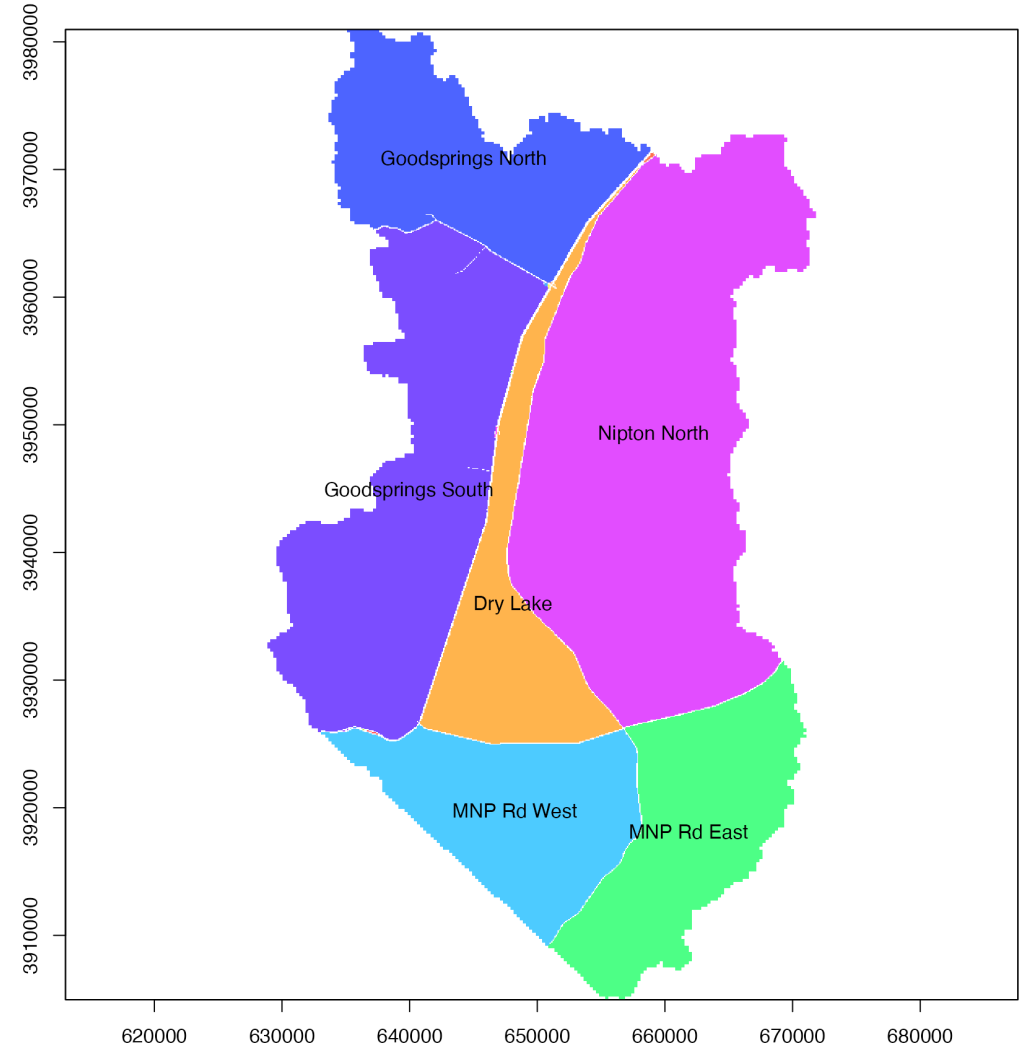


Scenarios

- **No Barrier** – landscape with no anthropogenic disturbance based only on the habitat model/cost was run to create a 100 year baseline for an unimpeded landscape.
- **Closed Culverts** – roadways, solar facilities, and railways were considered to be barriers to movement with all available culverts closed; however unintended barrier crossovers were infrequent, but possible.
- **Culvert 1** – roadways and railways were considered barriers relative to traffic loads with culverts assigned values from 0% – 80 % passable (provided by Clark County, Nevada), as described above.
- **Culvert 2** – roadways, railways, and culvert values followed the Culvert 1 scenario, except in the Ivanpah Valley, where culverts along a section of I-15 were given values of 80% passable, as described above.
- **Culvert 3** – roadways, railways, and culvert values followed the Culvert 1 scenario, except in the Ivanpah Valley, where culverts **that are tied in with tortoise fencing** along a section of I-15 were given values of 80% passable, as described above.
- **Open Culverts** – roadways and railways were considered barriers relative to traffic loads with all culverts assigned a value of 80% passable.

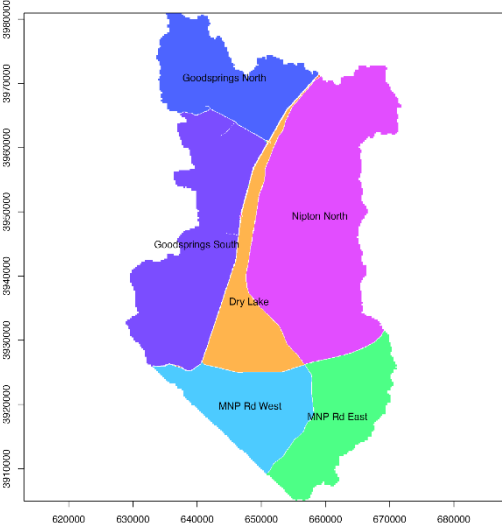
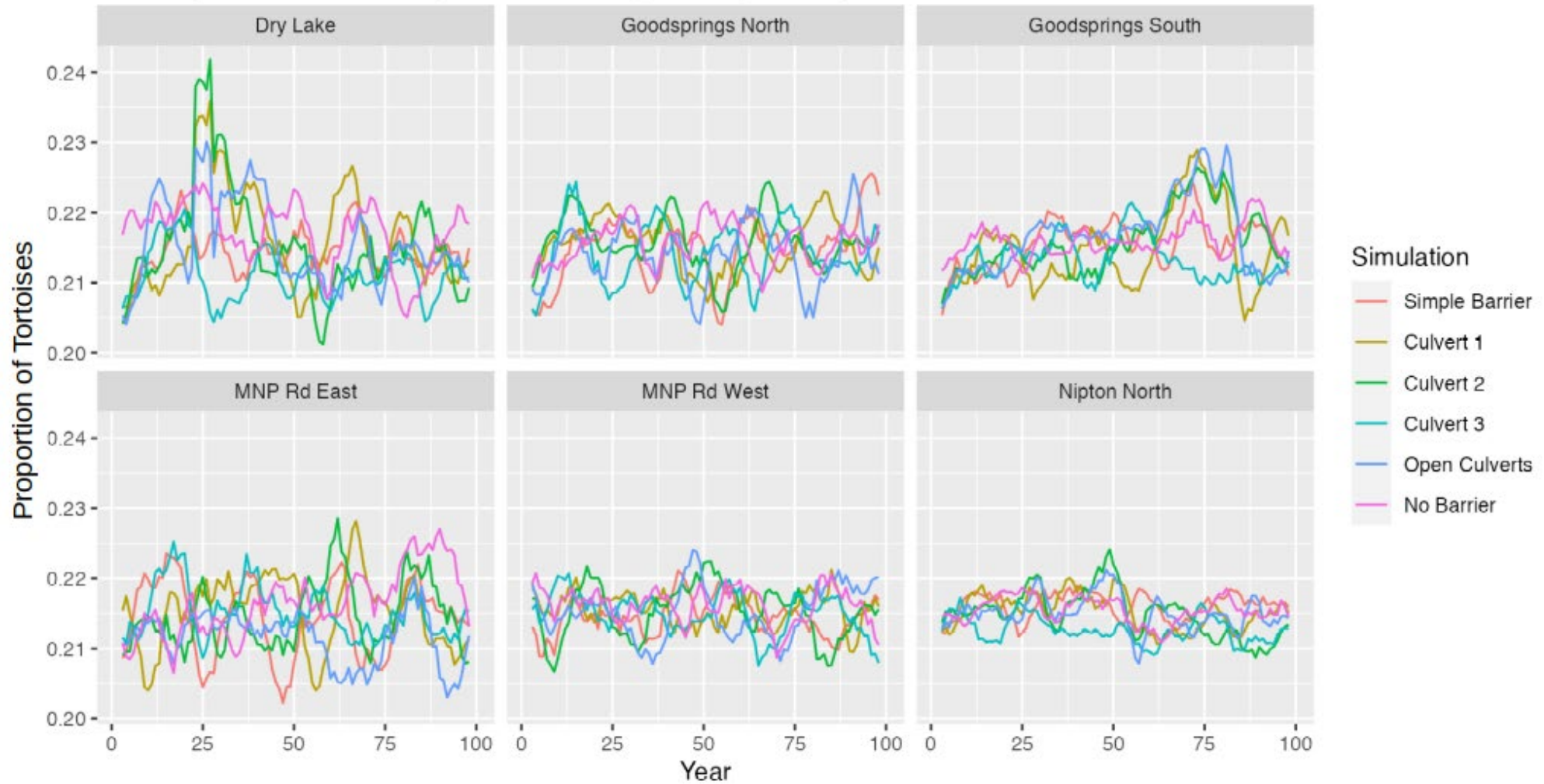
Metrics

- Movement of animals between zones – both individuals, and resulting matings over time
- Population Numbers, Mortality Rates, and Density of animals within zones over time
- Genetics – Heterozygosity (H_0), Genetic distance (F_{st}), Allelic Richness (AR)



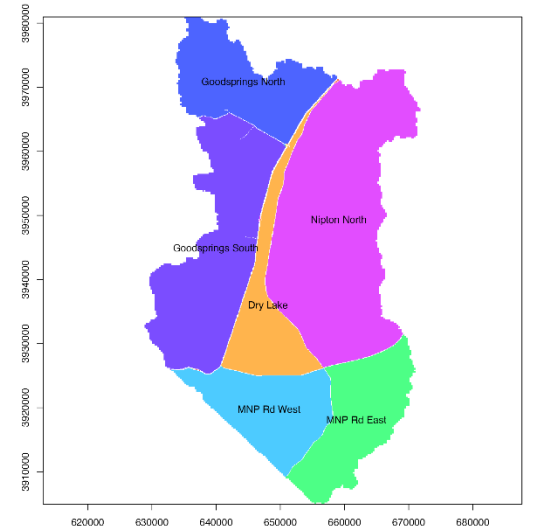
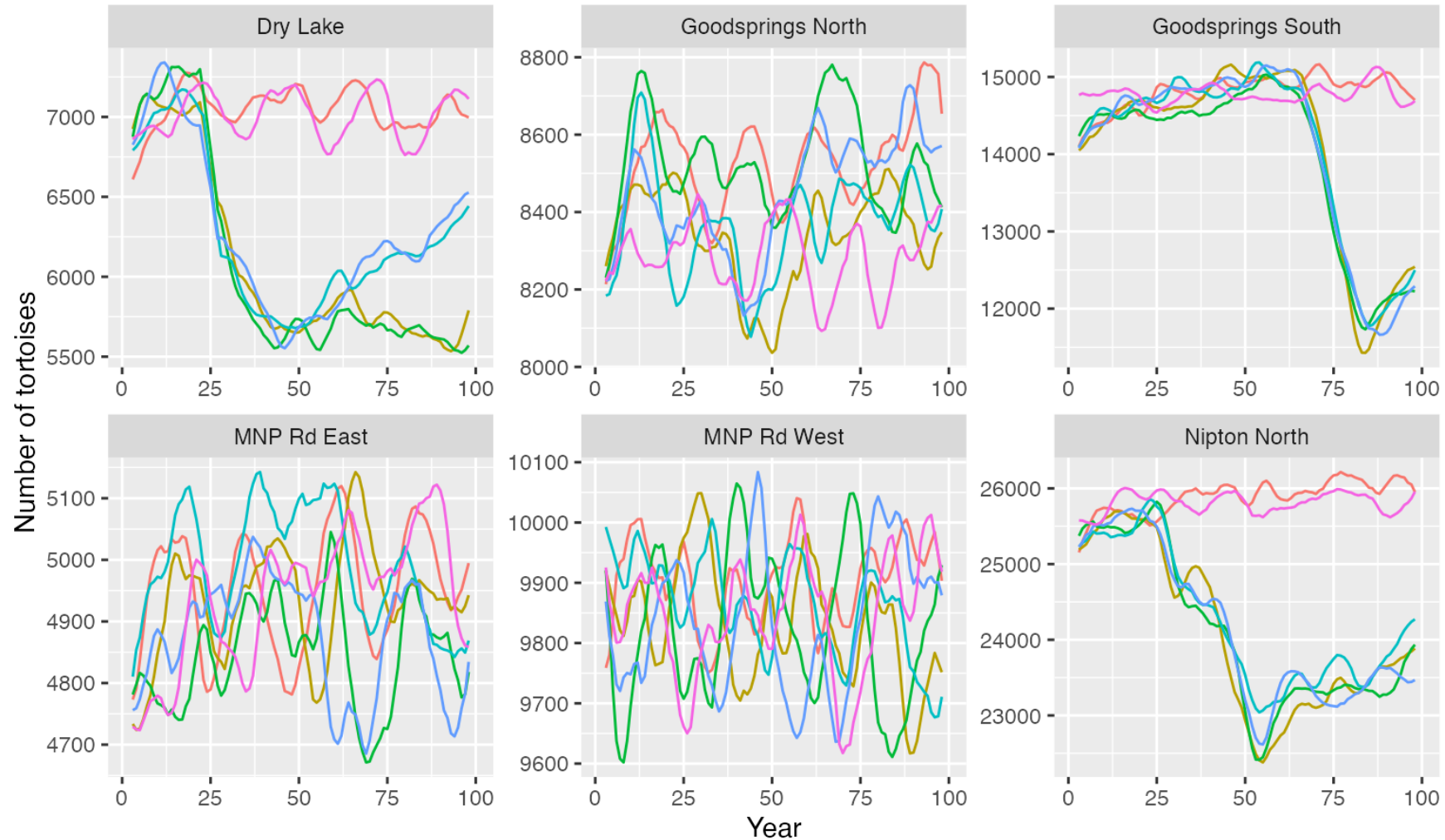
Mortality Rates

Mortality rate over time, by zone | moving average of 5 years



Population Size

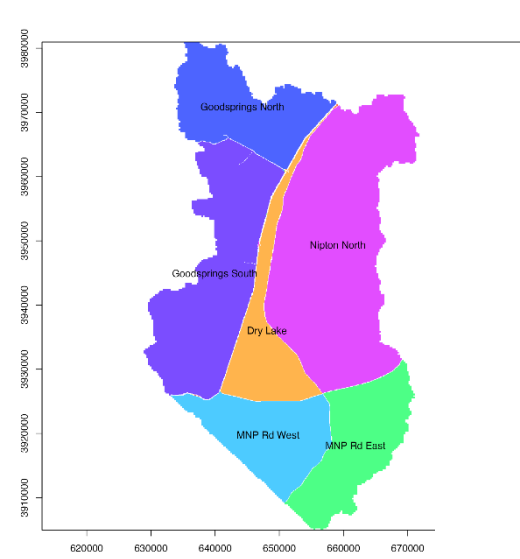
Number of tortoises over time, by zone | moving average of 5 years



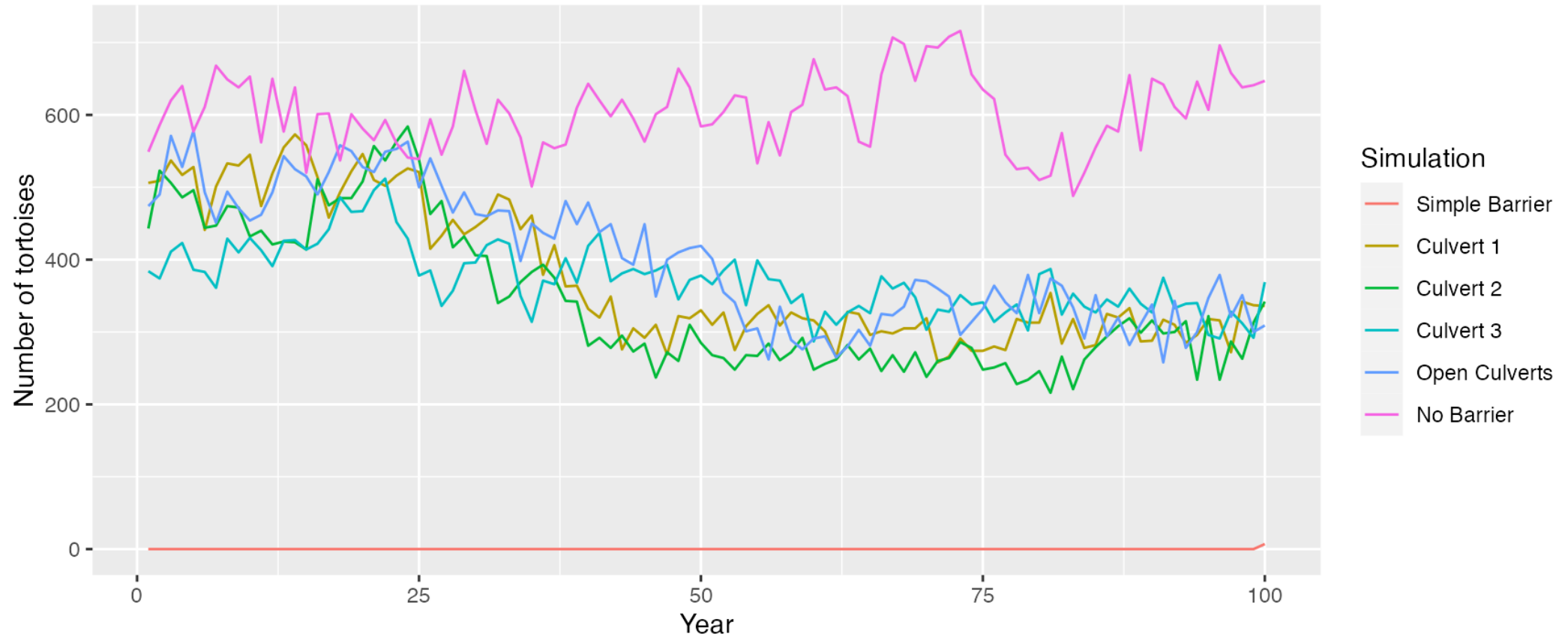
Simulation

- Simple Barrier
- Culvert 1
- Culvert 2
- Culvert 3
- Open Culverts
- No Barrier

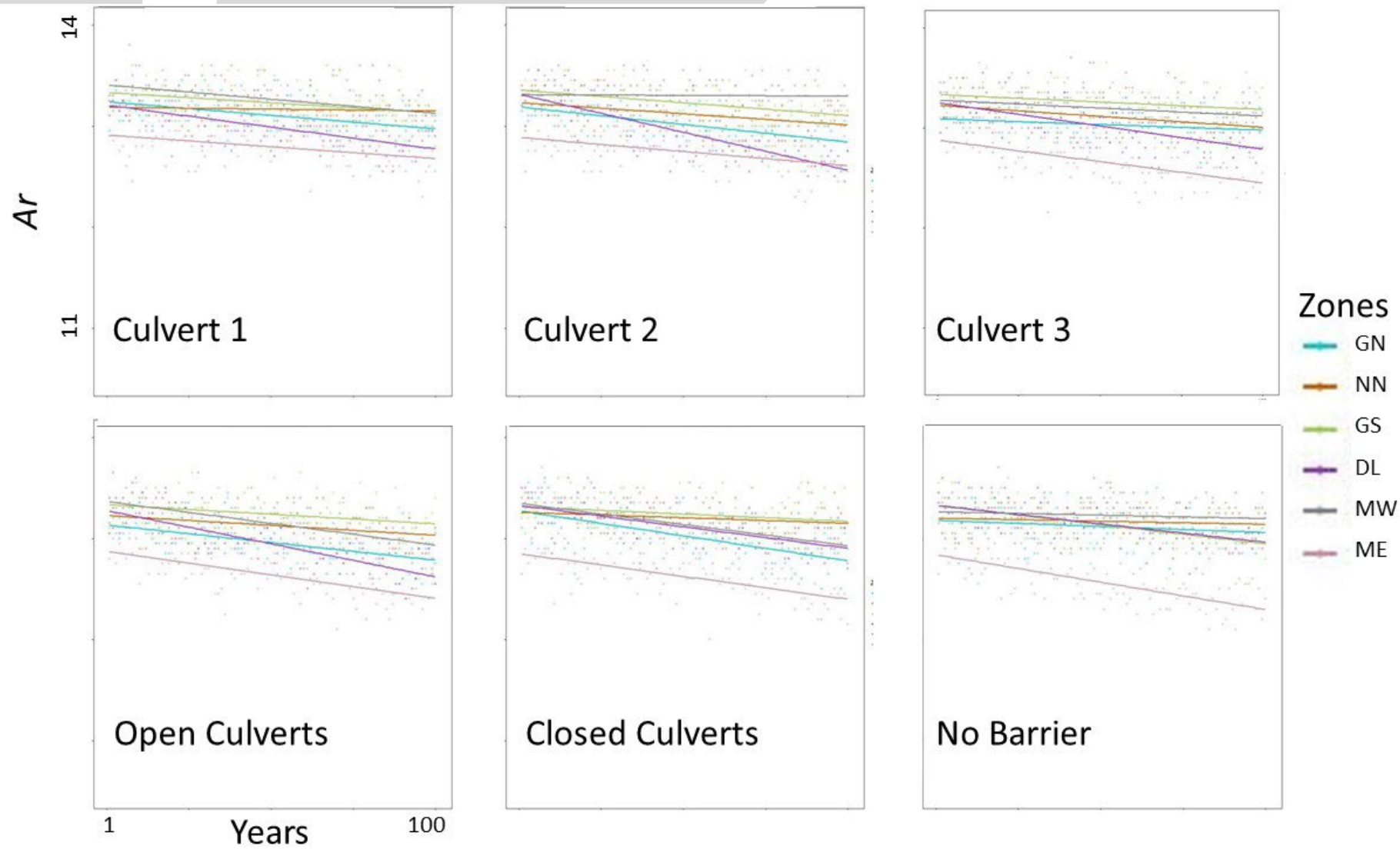
Reproduction



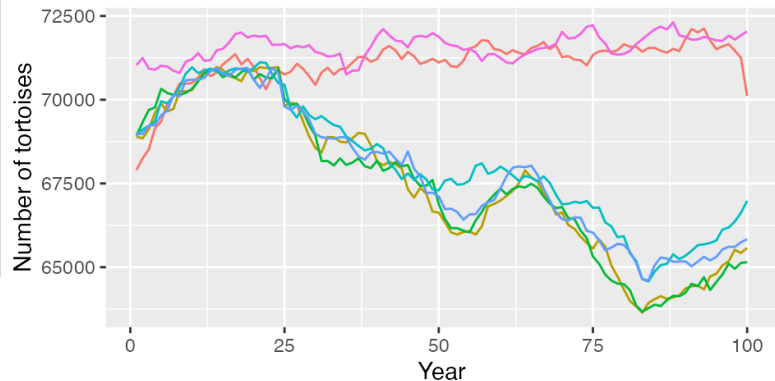
Total number of babies born with parents from two zones (all zones)



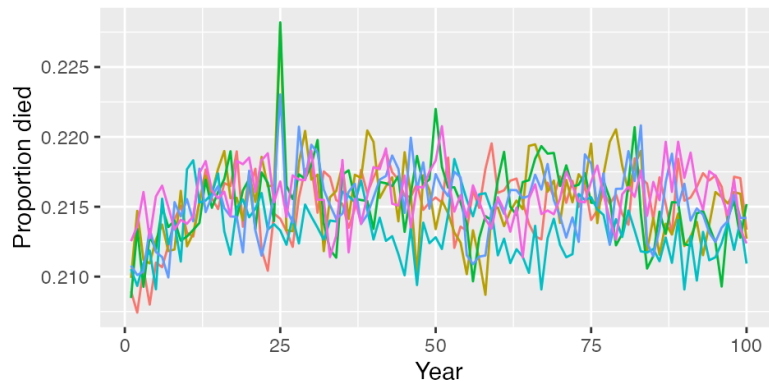
Genetics



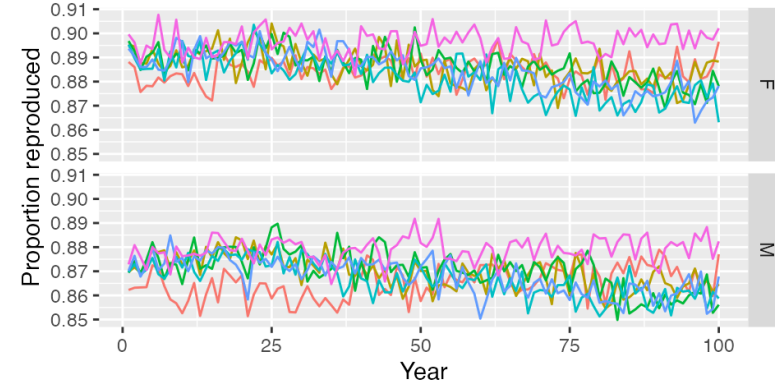
Number of tortoises over time



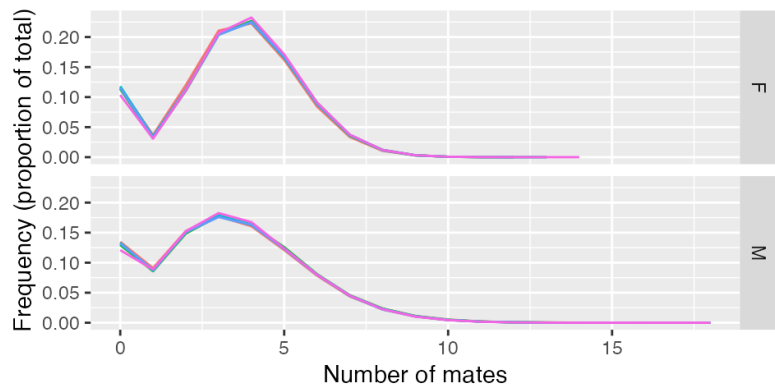
Mortality rate over time



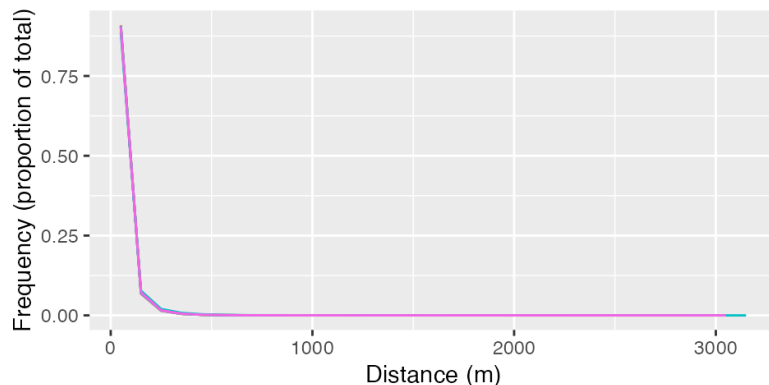
Proportion of adults that reproduced



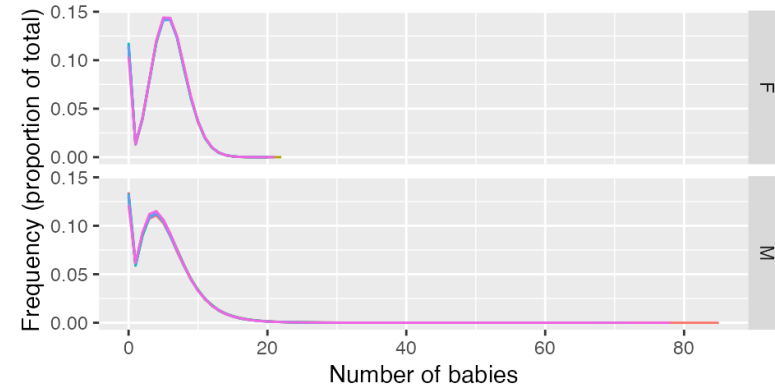
Frequency of number of mates per tortoise per year



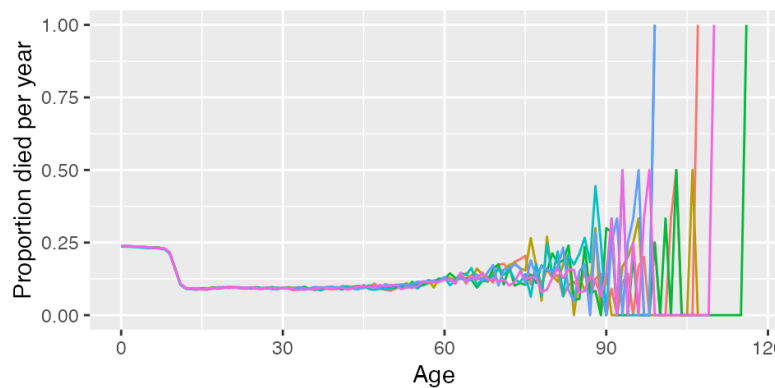
Frequency of yearly movement distances



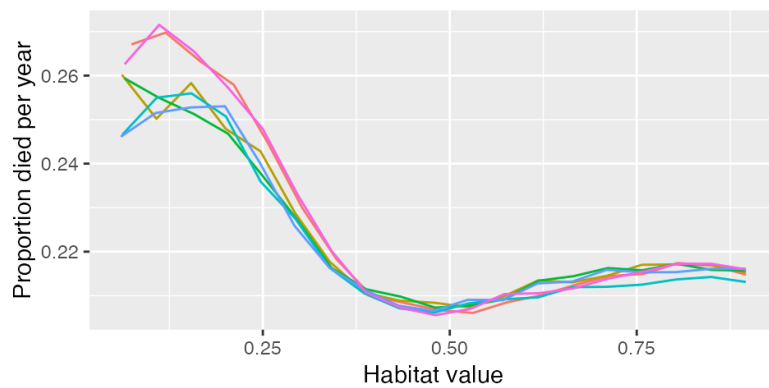
Frequency of number of babies per adult per year



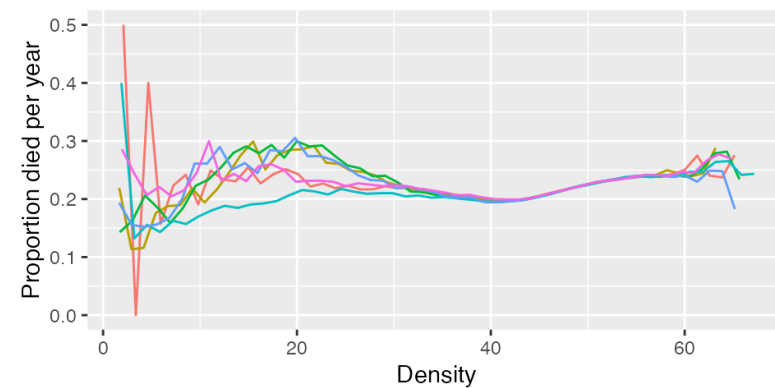
Average yearly mortality rate by age



Average yearly mortality rate by habitat value

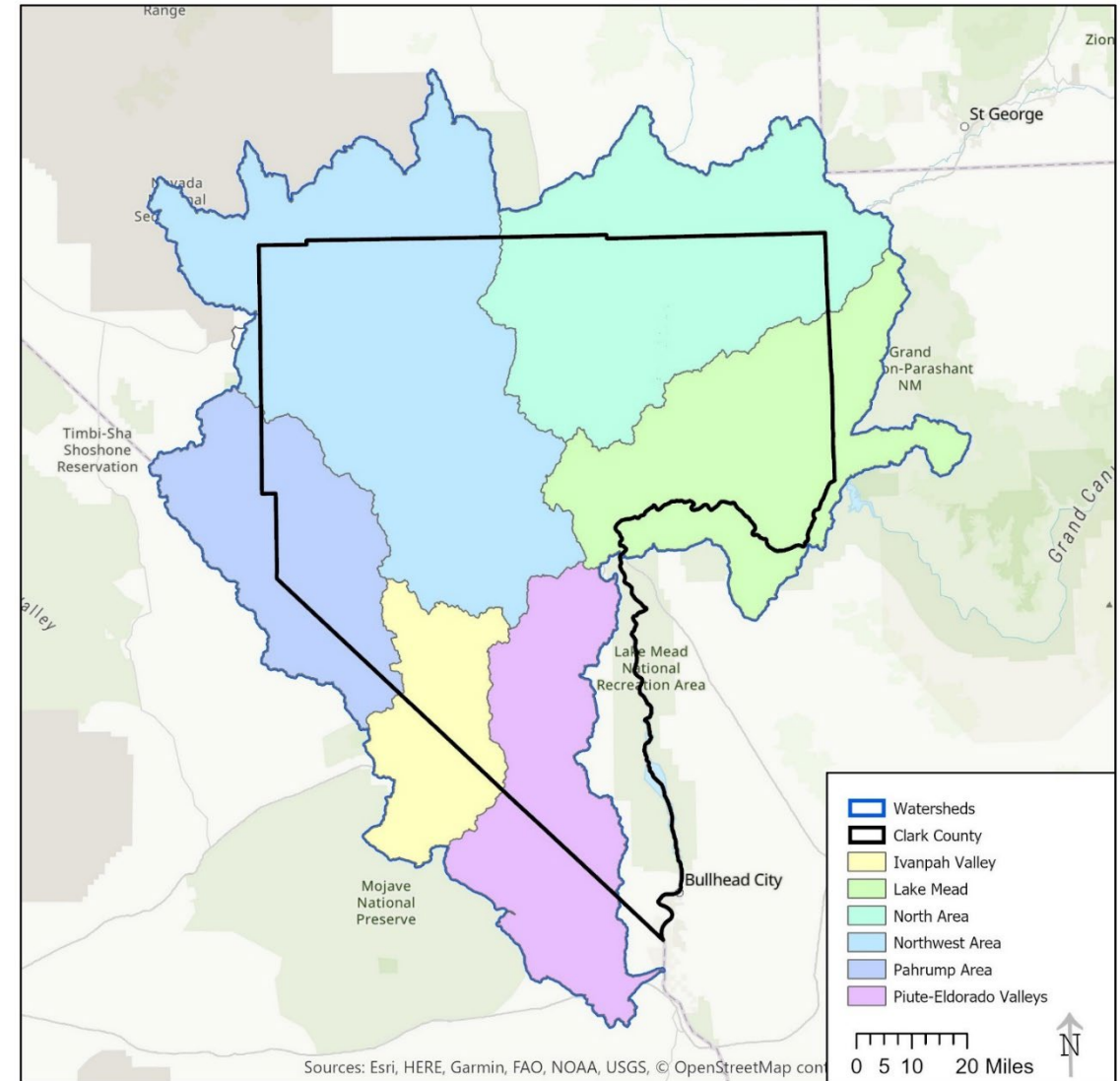


Average yearly mortality rate by density



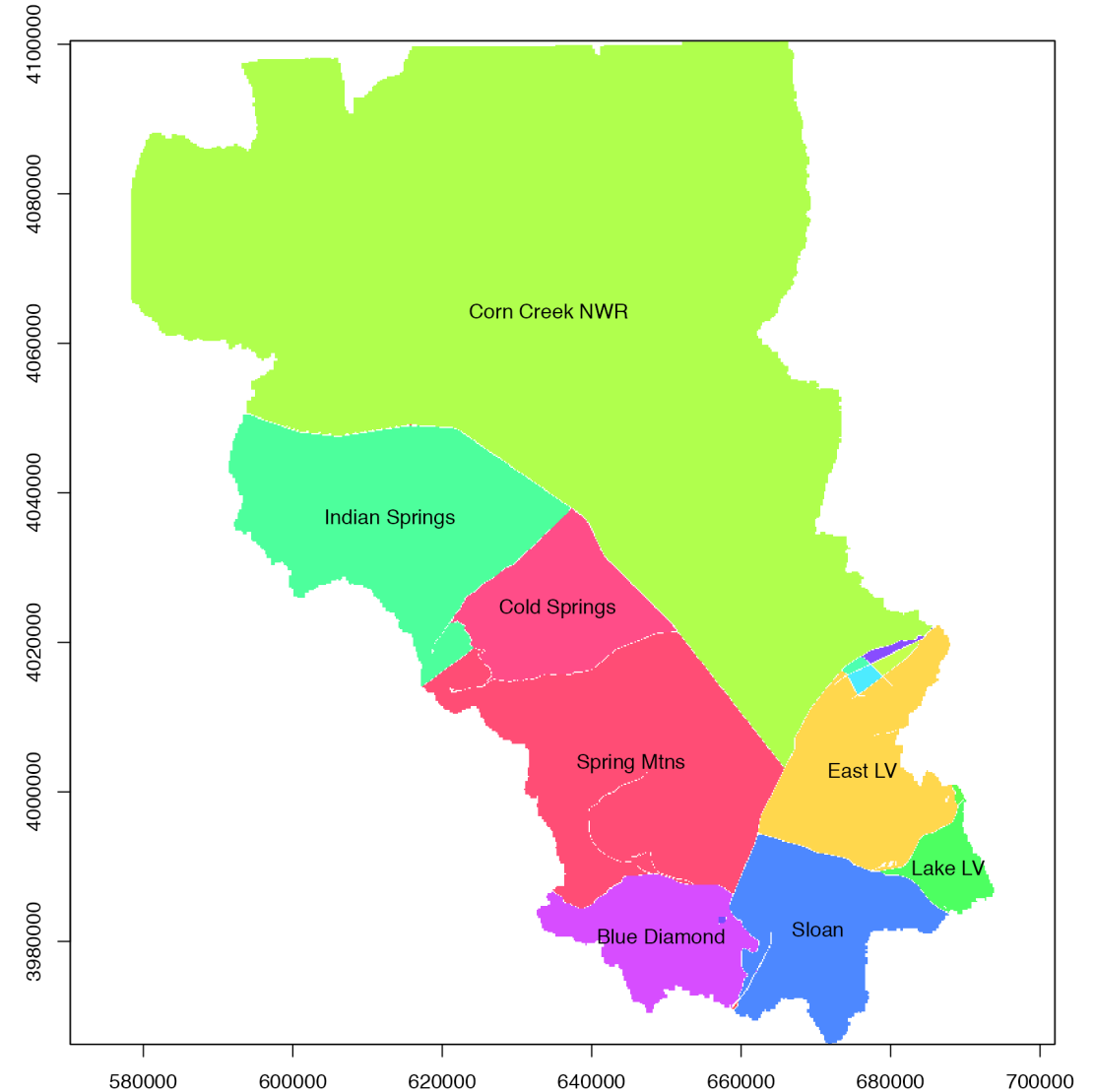
Habitat Loss (County Wide)

Area	Estimated Habitat Loss (Km2)
Northwest Corridor	331
Ivanpah	202
Pahrump	75
North/Northeast	72
Paiute Eldorado	13
Lake Mead	10



“Northwest”

Zone	Area (km2) 2020	Area (km2) 2050	Area (km2) 2100	Area Loss
Sloan	335.52	295.45	273.61	61.92
Blue Diamond	311.40	304.14	288.52	22.89
Spring Mtns	793.52	754.09	721.53	71.98
Cold Springs	364.28	361.06	351.19	13.09
Indian Springs	866.73	837.12	837.12	29.61
Corn Creek NWR	5225.31	5181.38	5125.75	99.56
Lake LV	83.09	82.03	80.60	2.49
East LV	258.81	252.34	229.05	29.76



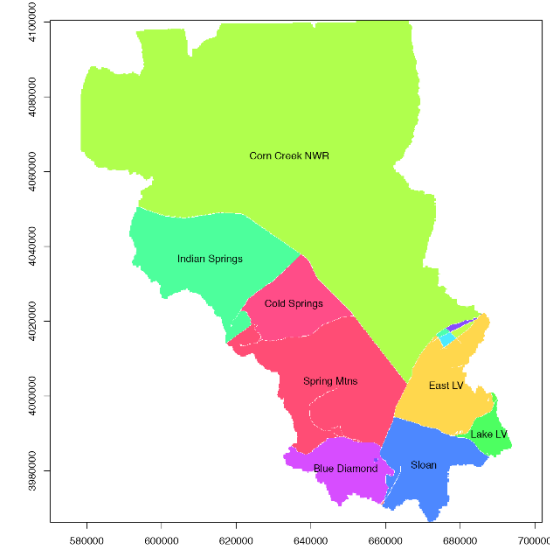
Number of tortoises over time, by zone | moving average of 5 years

Northwest



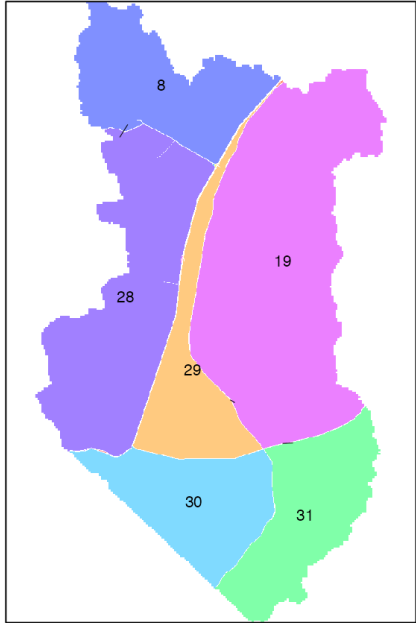
Simulation

- Simple Barrier
- Culvert 1
- Culvert 3
- Open Culverts
- No Barrier

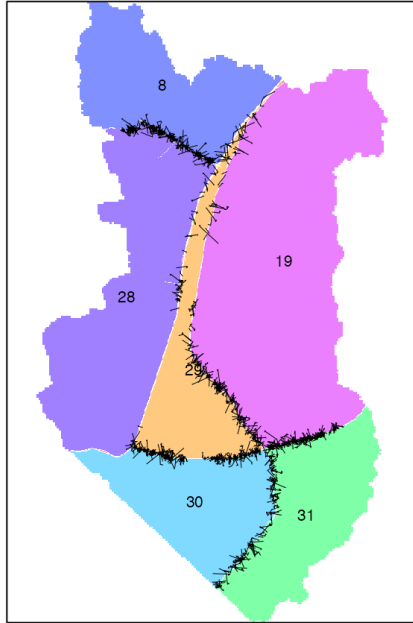


lifetime cross-zone movements between selected zones

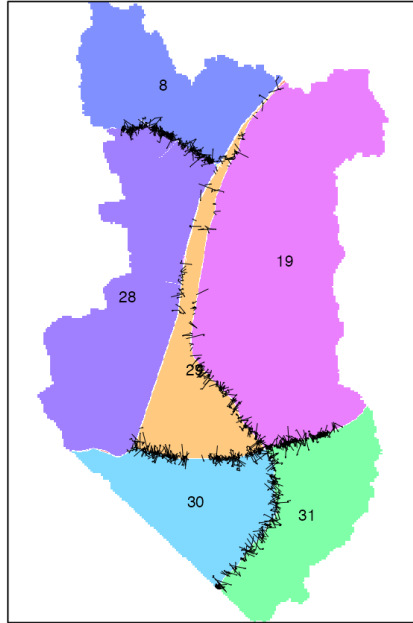
Simple Barrier



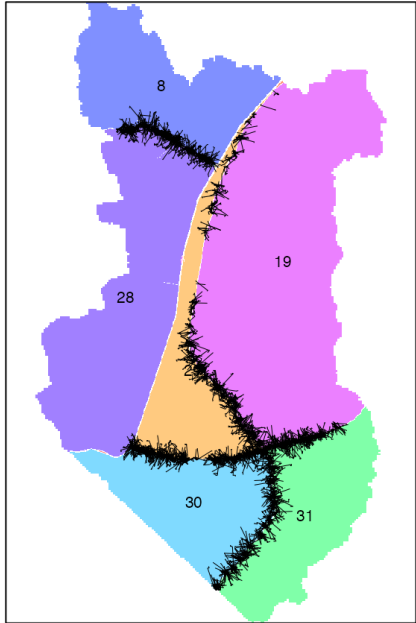
Culvert 1



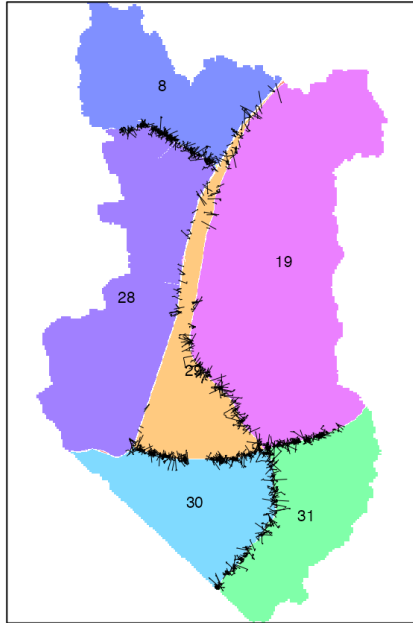
Culvert 2



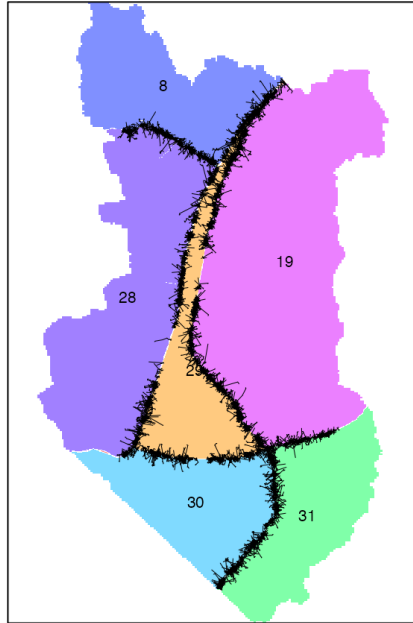
Culvert 3



Open Culverts



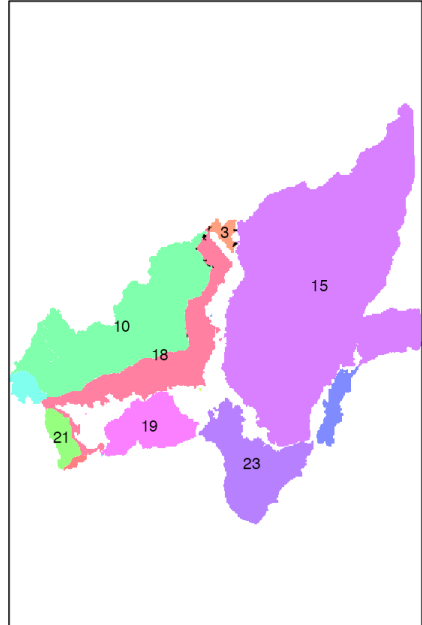
No Barrier



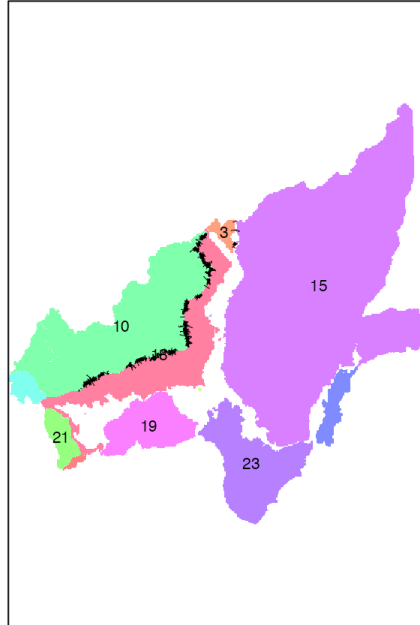
Movements

lifetime cross-zone movements between selected zones

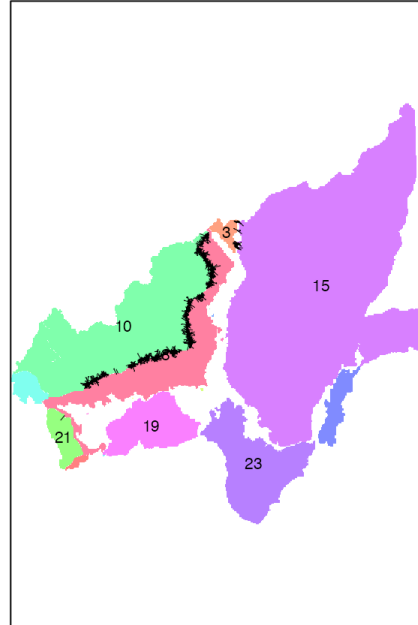
Simple Barrier



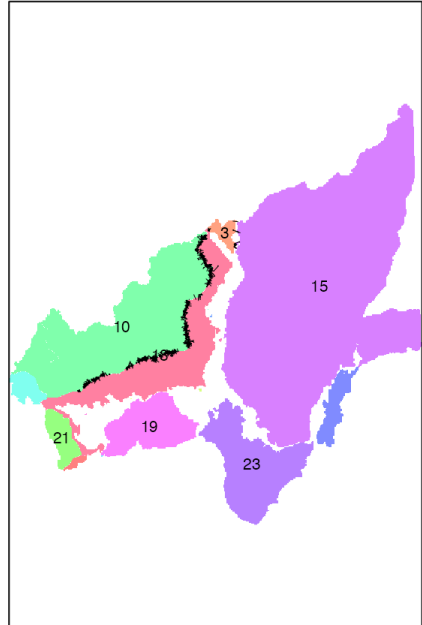
Culvert 1



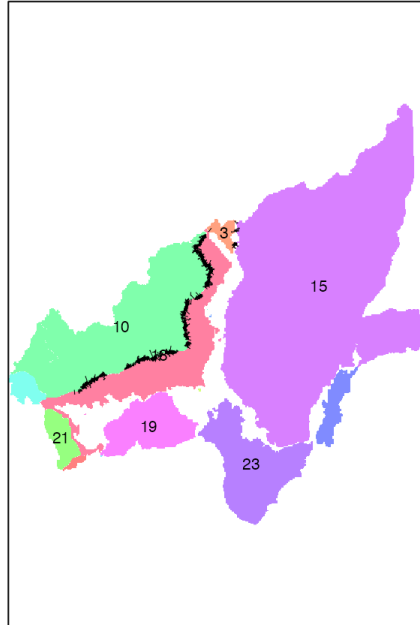
Culvert 3



Open Culverts



No Barrier



Movements

Conclusions

- The models provided stable populations for simulation purposes
- Culverts provided passage, but decreased movements in each of our modeled analysis areas.
- The combination of reduced movements, and continued growth influenced population levels within sections (zones) within analysis areas
- When populations were small within zones we could detect predicted genetic influences within the 100 year simulation period