

Research to Inform
Passage Spacing for Migratory Amphibians
and to evaluate
Efficacy and Designs for
Elevated Road Segment (ERS) Passages.

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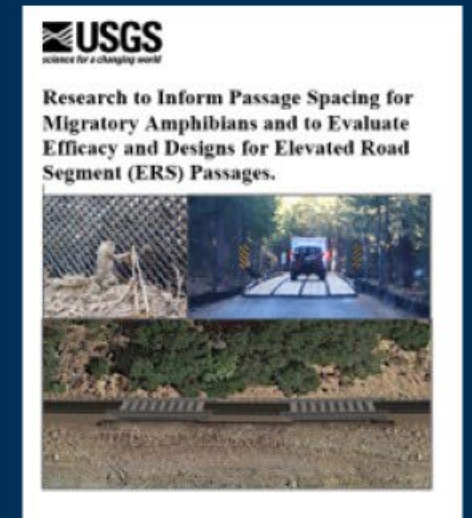
U.S. Forest Service

U.S. Geological Survey

Caltrans, Department of Transportation



Report Reference: Brehme, C., Barnes, S., Ewing, B., Vaughan, C., Hobbs, M., Tornaci C., Gould, P., Holm S., Sheldon H., and R. Fisher. 2022. Research to Inform Passage Spacing for Migratory Amphibians and to Evaluate Efficacy and Designs for Open Elevated Road Passages. USGS Cooperator Report



Objectives

- Spacing of underpasses for migratory species- Yosemite Toad?
- Effectiveness of barrier fencing (opacity).
- Effectiveness of prototype elevated road segment (ERS) passage for Yosemite toads and other small animals.
- Designs for primary roads and highways.

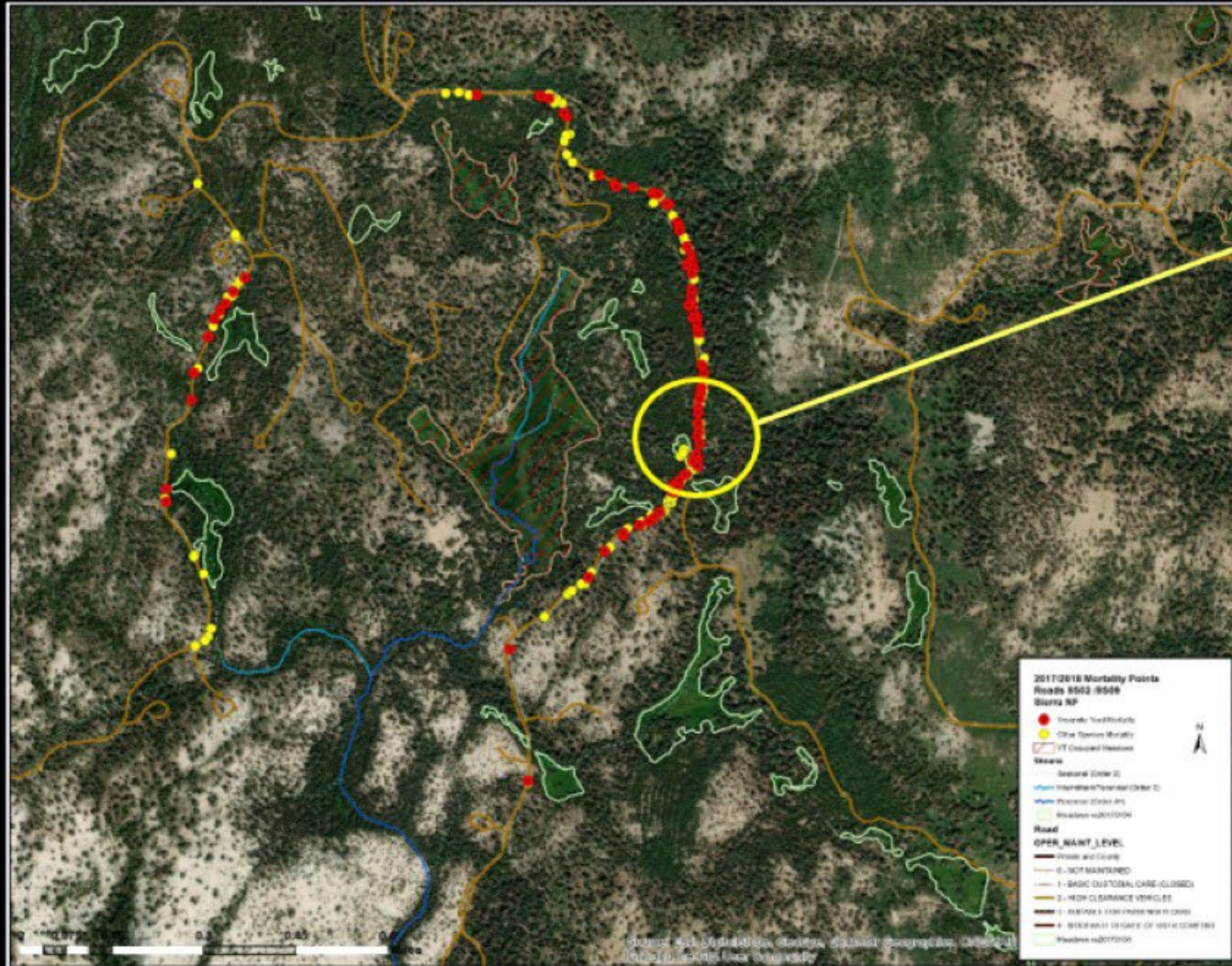


Yosemite Toad

- Listing status: Federally Threatened (April 29, 2014)
- Elevation Range = 6,400-11,000 feet
- Long lived: 12-15 years
- Move up to 1 km or more between terrestrial & aquatic breeding habitats
- Straight-line movement patterns not associated with drainages, roads, or other similar features
- Moves upland throughout the summer, especially during rain events

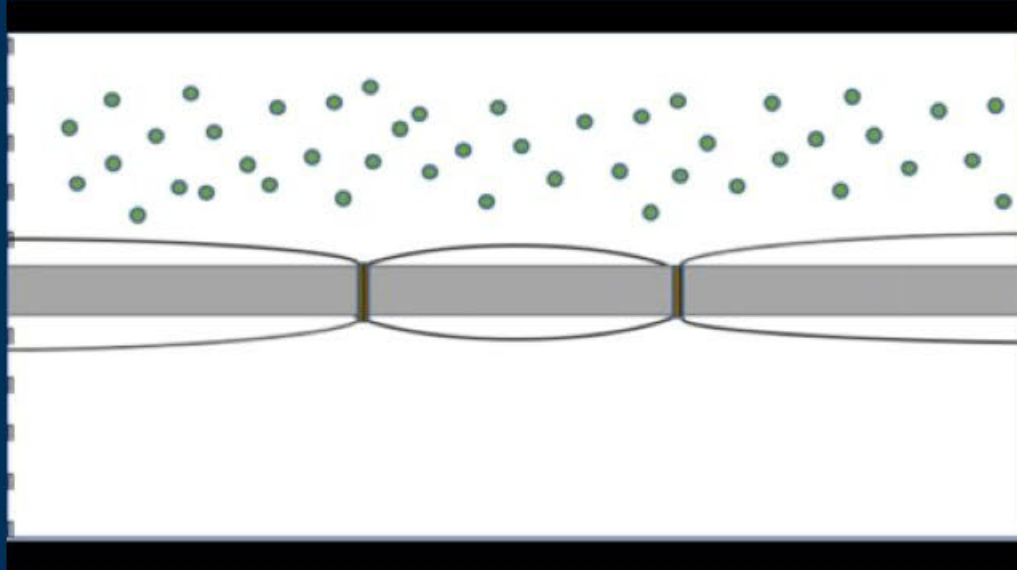


Sierra National Forest Study Area



Mitigation Possibilities- 1?

- Barrier Systems & Wildlife Passages can reduce mortality and help to maintain connectivity
- However... can be unintended consequences...
 - *e.g. Woltz et al. 2008, Matos et al. 2016, Ottburg and van der Grift 2019, Hedrick et al. 2019, Brehme et al. 2021*



Why Filter Effect? Fence “Give-up” Distances California Tiger Salamander

Global Ecology and Conservation 11 (2011) e01037

Contents lists available at ScienceDirect

Global Ecology and Conservation

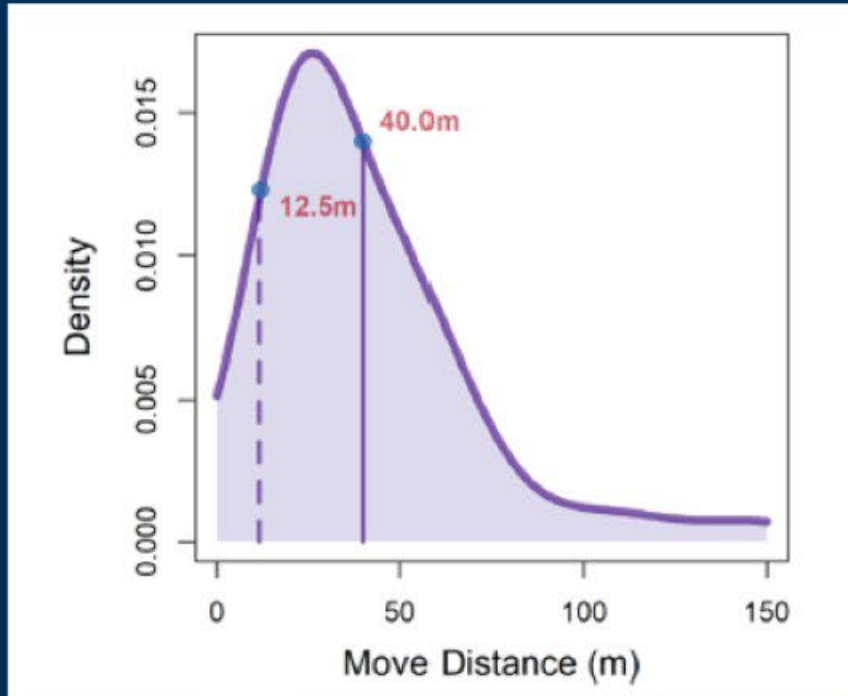
journal homepage: www.elsevier.com/locate/gecco

Responses of migratory amphibians to barrier fencing inform the spacing of road underpasses: a case study with California tiger salamanders (*Ambystoma californiense*) in Stanford, CA, USA

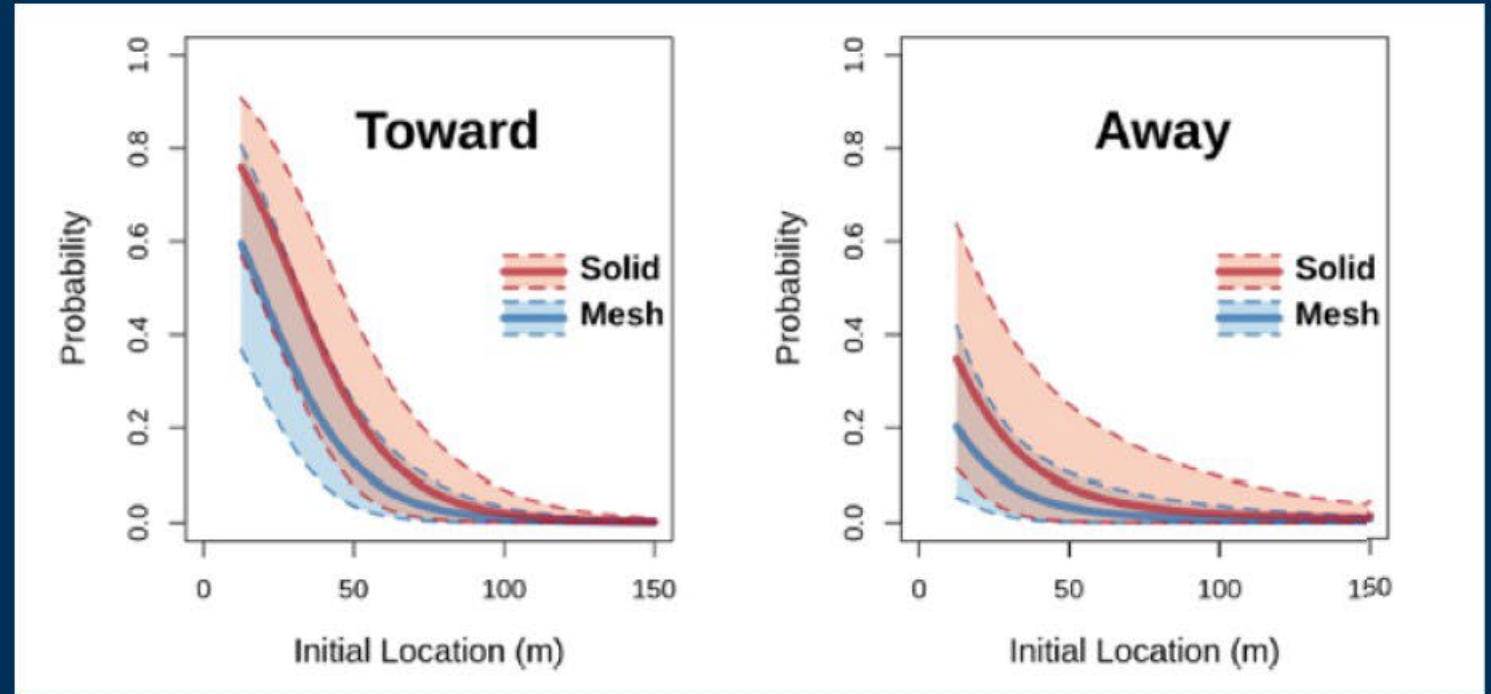
Cheryl S. Brehme^{a,*}, Jeff A. Tracey^a, Brittany A.L. Ewing^a, Michael T. Hobbs^b, Alan E. Launer^c, Trittia A. Matsuda^a, Esther M. Cole Adelsheim^c, Robert N. Fisher^a



Average movement distances along fence

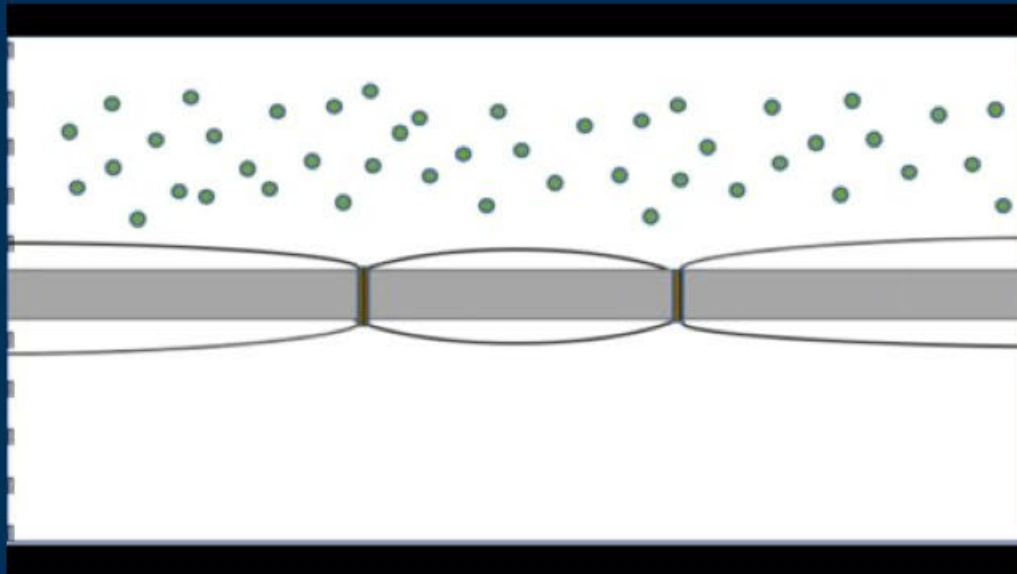


Probability of Reaching Underpass based on distance from underpass based on distance from underpass they encounter a fence



Mitigation Possibilities- 1?

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How about a wider crossing?



Diagram: Side view depiction of elevated road segment (rectangle with vertical lines) with barrier fencing (lines) and openings for toad passage underneath (solid rectangles); not to scale.

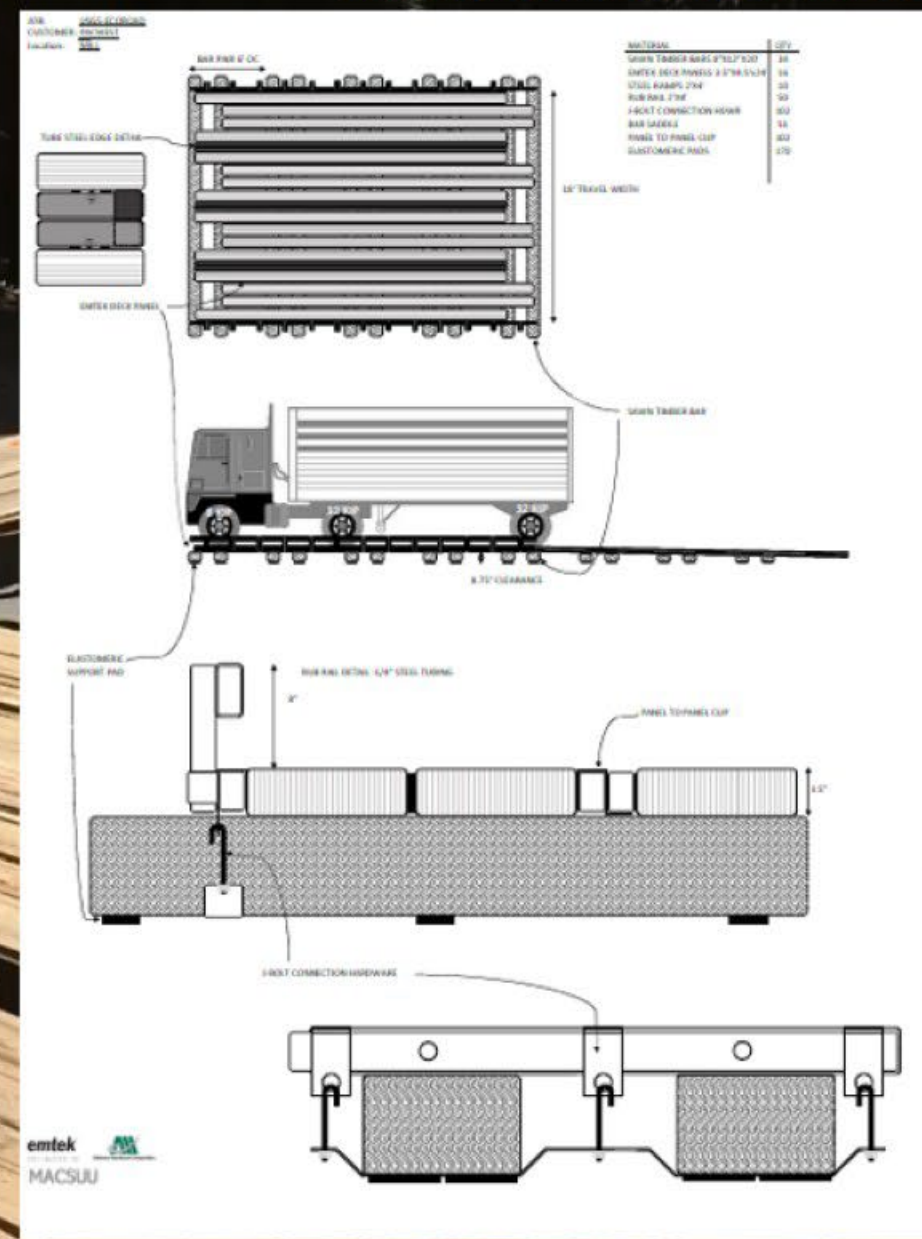
Prototype using road mats for construction projects on sensitive habitats



Built to meet codes and specifications for USFS, County, City Roads
(Anthony Composites- Emtek)

Installation! June 2018

Anthony Composites- EMTEK

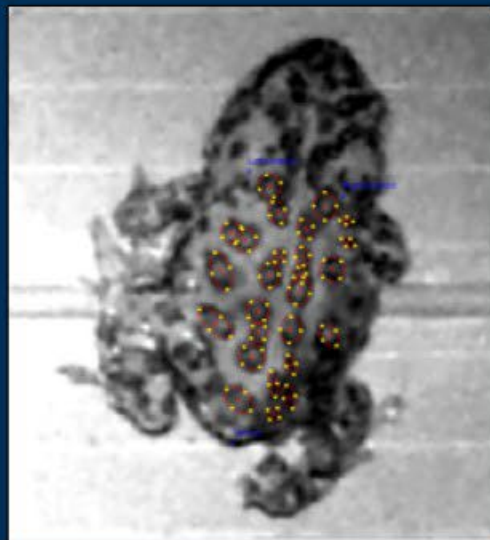
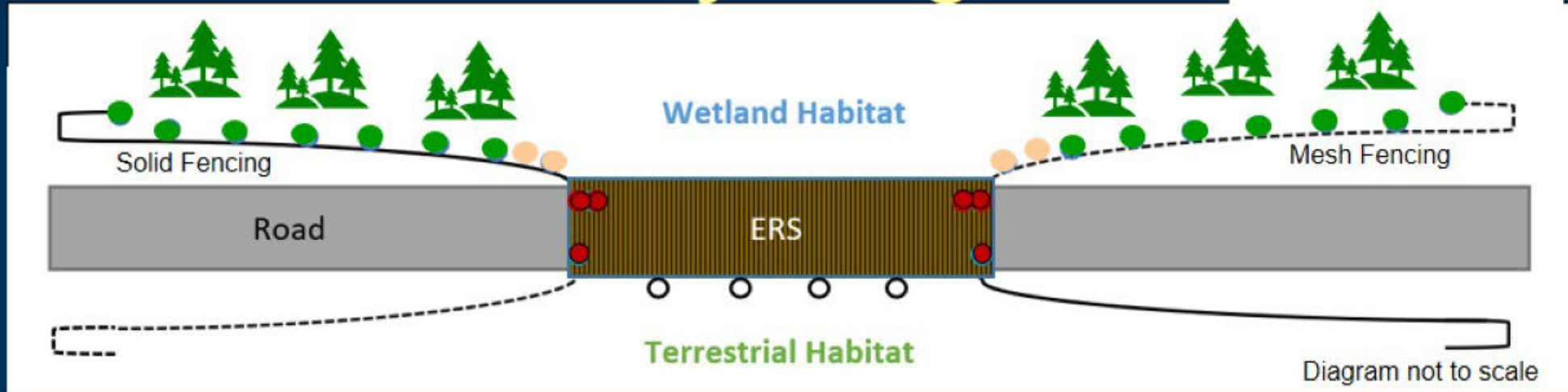






Study Design

- Forest
- Adjacent to ERS
- Under ERS



Movement from meadow to upland terrestrial habitat

Fencing: ERTEC & Animex

- 120 m on each side of passage

Camera spacing= 20 m

- 10m next to road

Cameras:

HALT© Active Light Trigger & Reconyx- Time Lapse

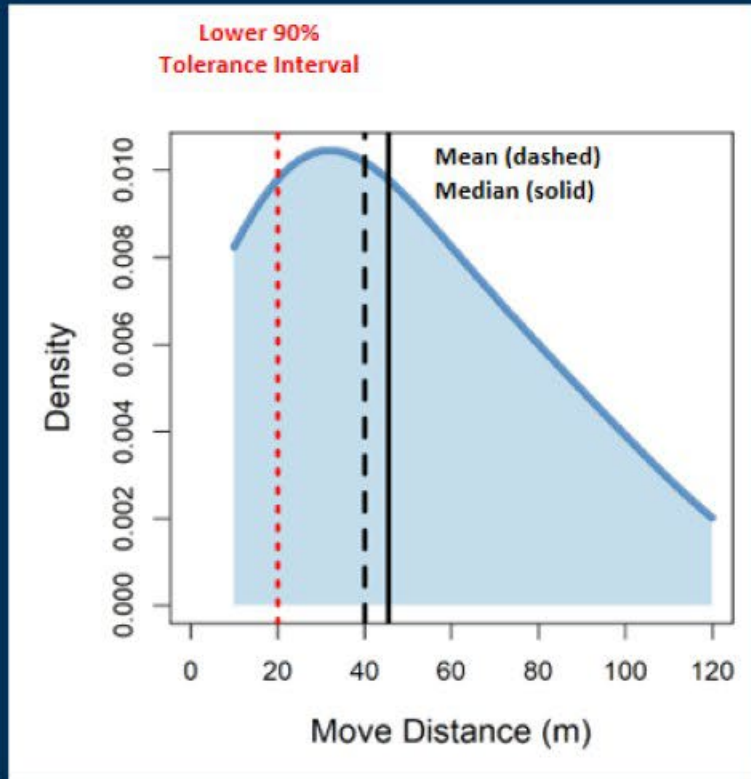
i3s software

Results: Individual Movement

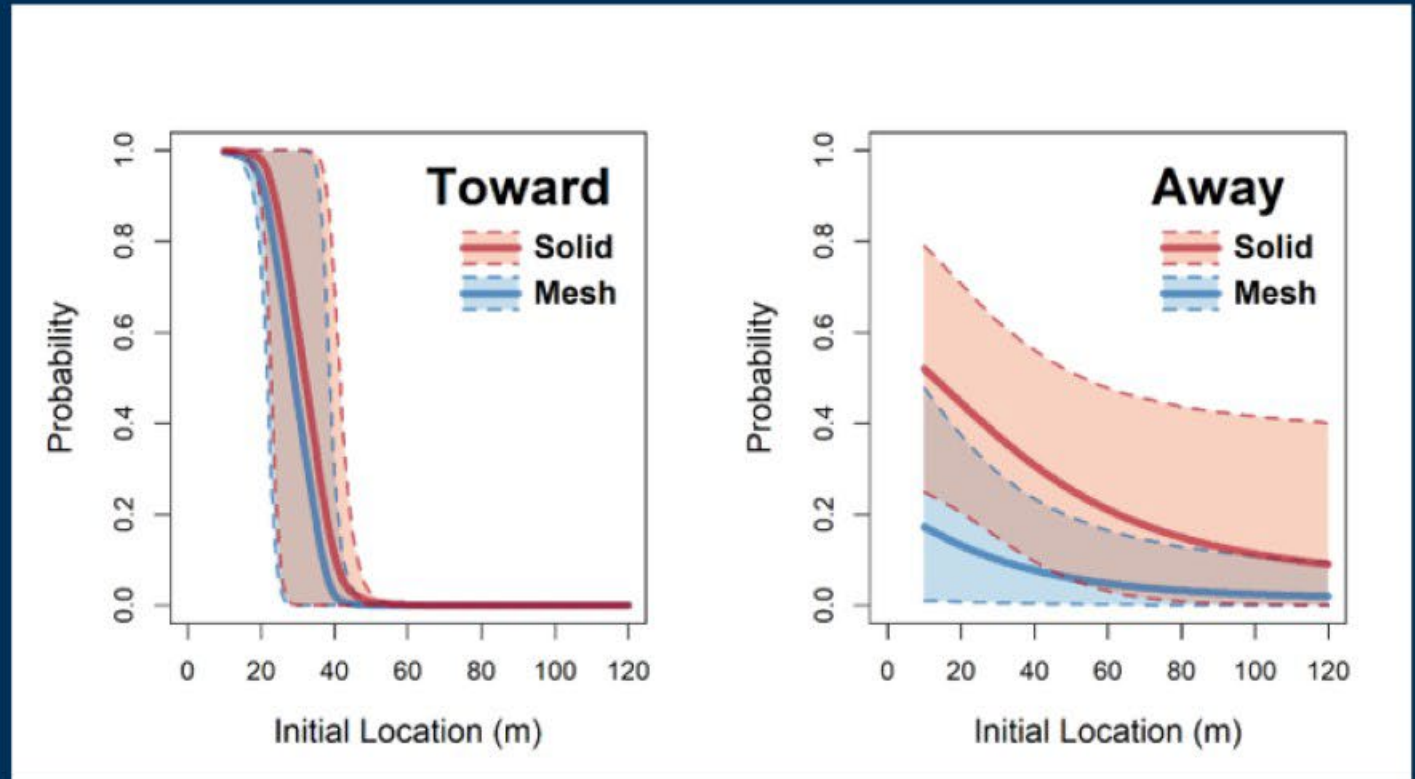
- 42 individual YT along the fence-line
 - 27 in 2018 & only 15 from 2019-21 (drought, fire, forest clearing)
 - 24 mesh fencing, 16 solid fencing, 2 both
 - 24 subadults, 18 adults
- Average “give-up” distance= 46m (median 40m)
- Direction changes (0-4 per individual)
- 29 Individuals detected moving under ERS (estim >100)
- Adults moved farther along solid fencing (80 vs 30 m)
- No difference for subadults (40-50m)

Results: Individual Movement

Fence Movement Distance- ALL



Probability of Reaching Underpass



Using Crossing: Yosemite Toads



HALT

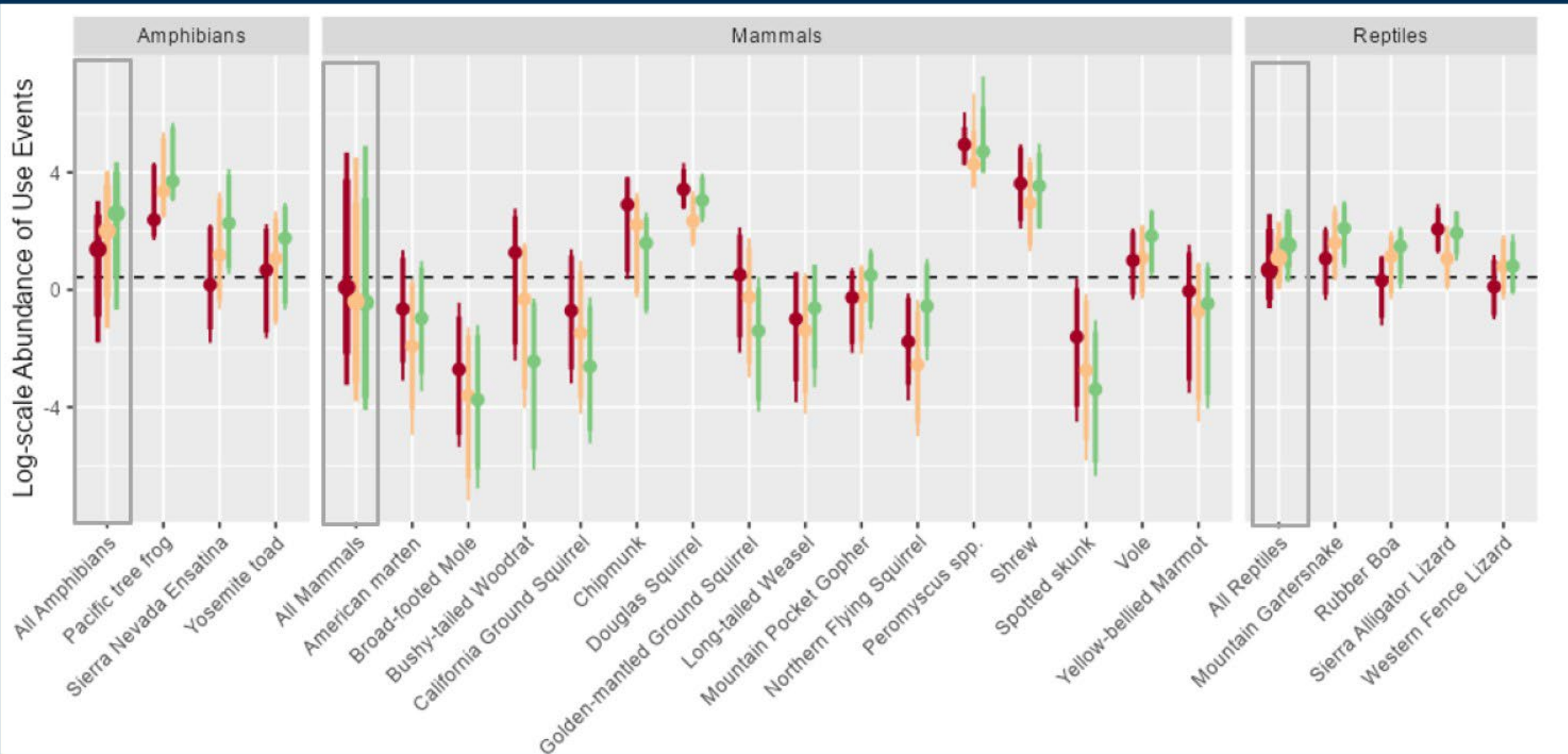
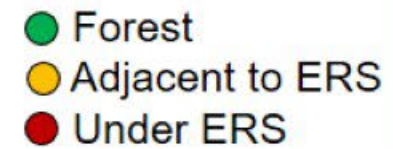
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HALT

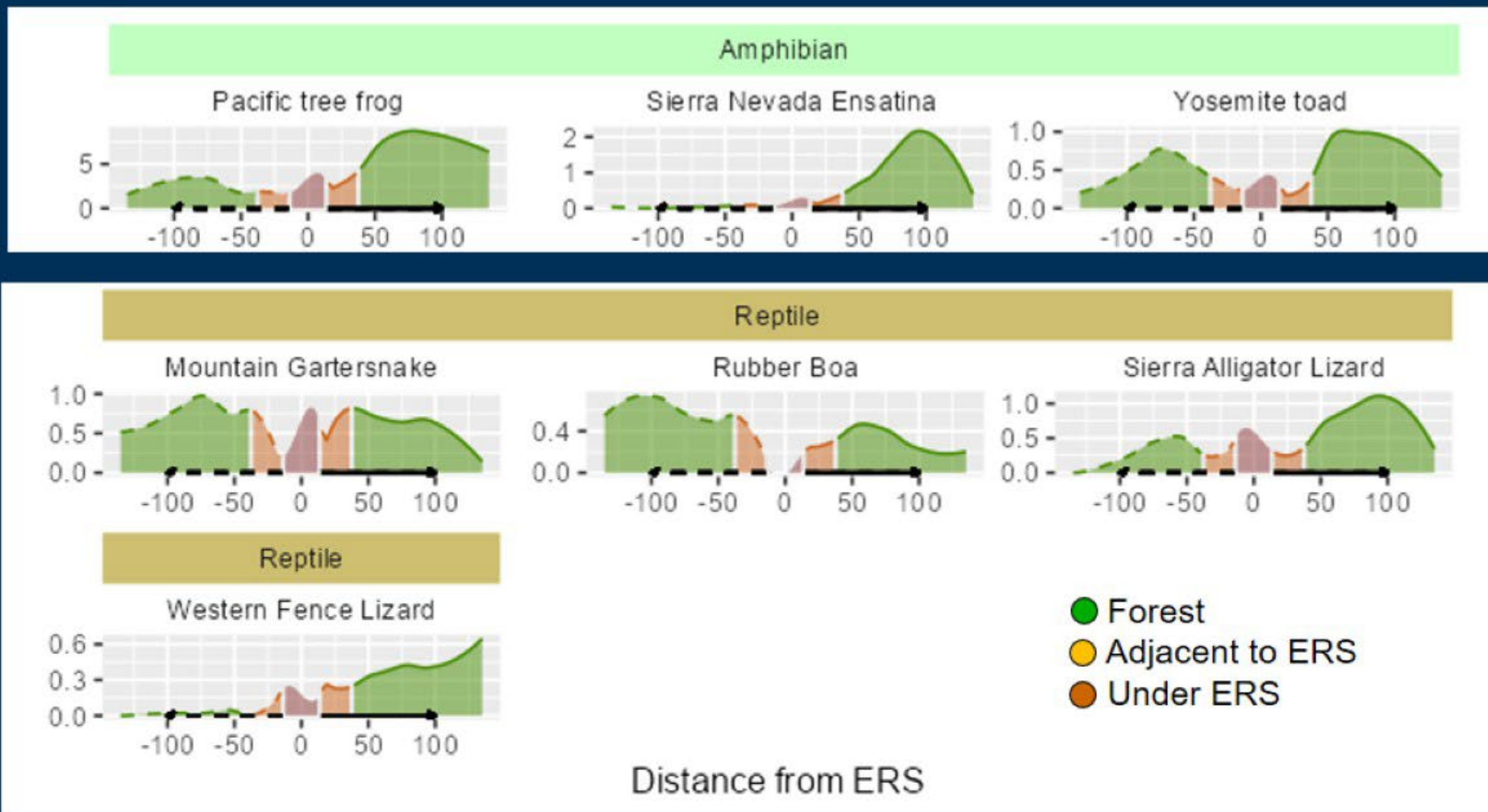
520 ↓

Using Crossing: Other Species

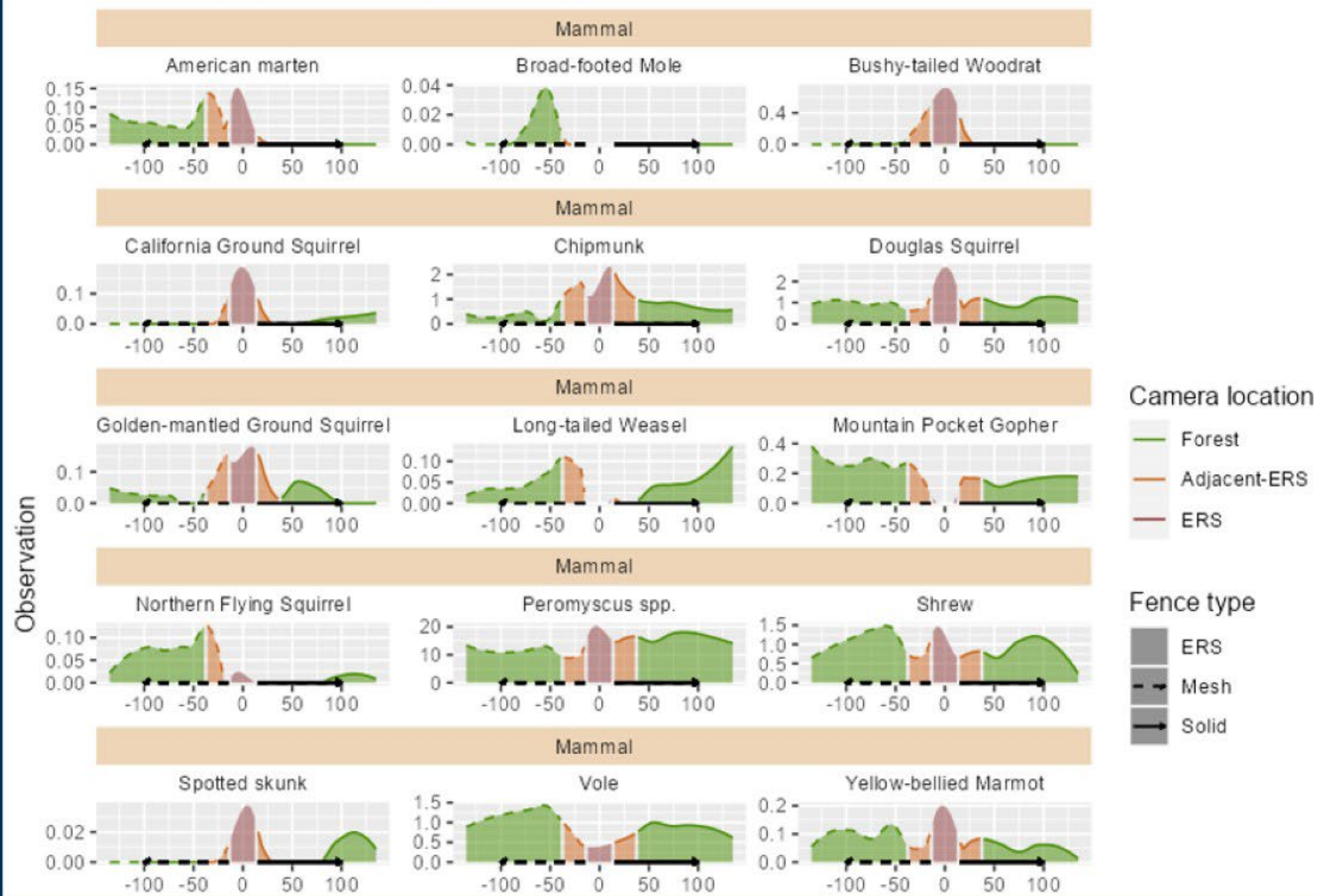
Results: All Species Activity



Spatially explicit: Amphibians & Reptiles



Spatially explicit: Mammals



Conclusions

- 10-20m between passages currently supported by science for migratory amphibians
- Current literature indicates wider passages are more permeable to movement of many amphibian species.
- ERS Highly Permeable to Small Animal Movement
 - Potential to better maintain connectivity over large road spans with widespread mortality.
 - Permeable to rain and light---Incorporates moisture during rain events and more natural climate conditions within passage.
 - No effect on drainage- Passage less prone to flooding- at natural grade
 - No damage to adjacent habitat- small area of impact
 - Eliminate or reduce need for barrier fencing and associated maintenance.
 - Removable

Additional Designs



28C 06/24/2018 01:44PM ROAD UP



21C 06/19/2018 12:22PM ROAD UP



26C 06/20/2018 12:36PM ROAD UP

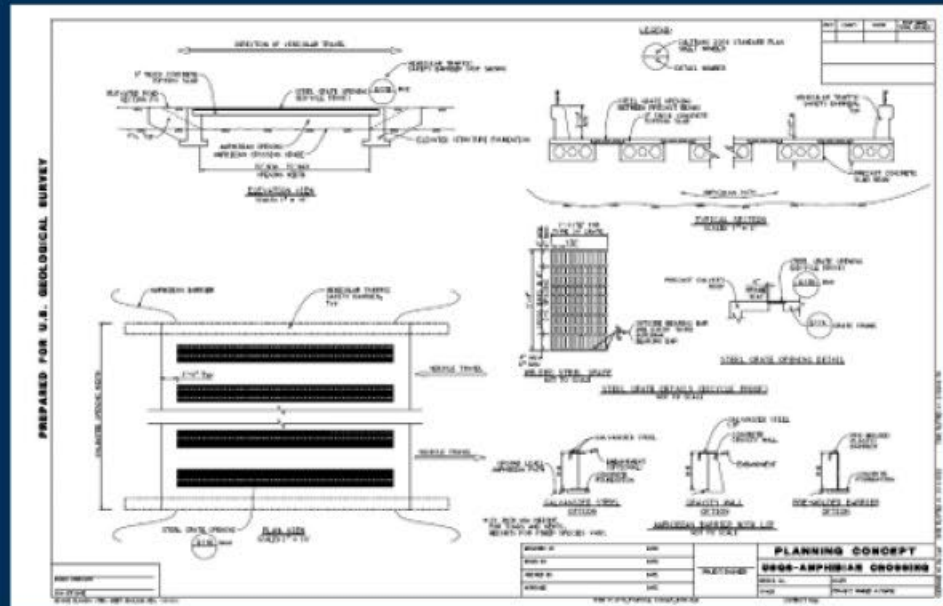


20C 06/10/2018 03:48PM ROAD UP

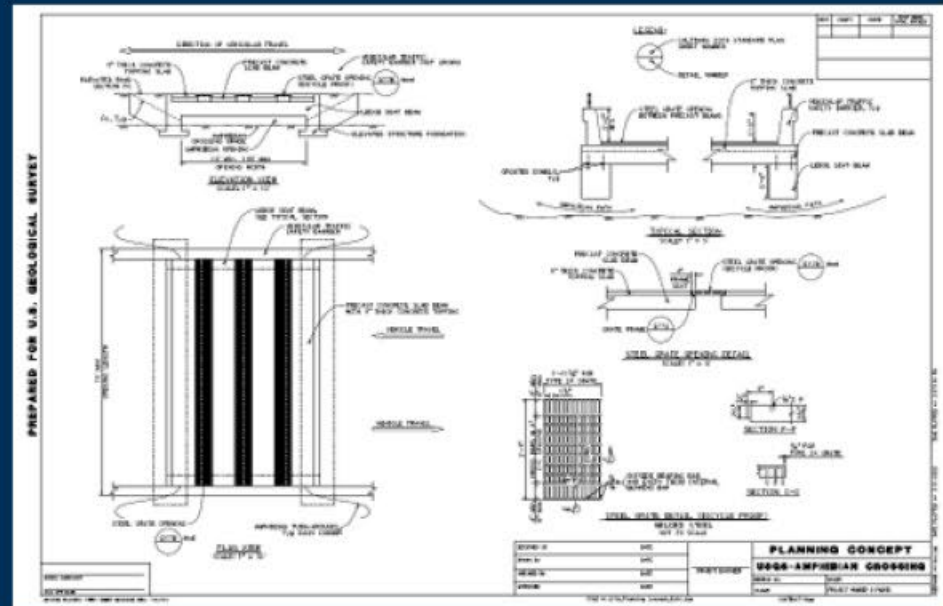
Additional Designs- Goals

- Adapt ERS prototype concept to high volume roads
- Meet AASHTO standards
- Permeable to light and moisture
- Natural soil bottom
- 1 foot passage height
- Safe for vehicles and bicycles

Bridges

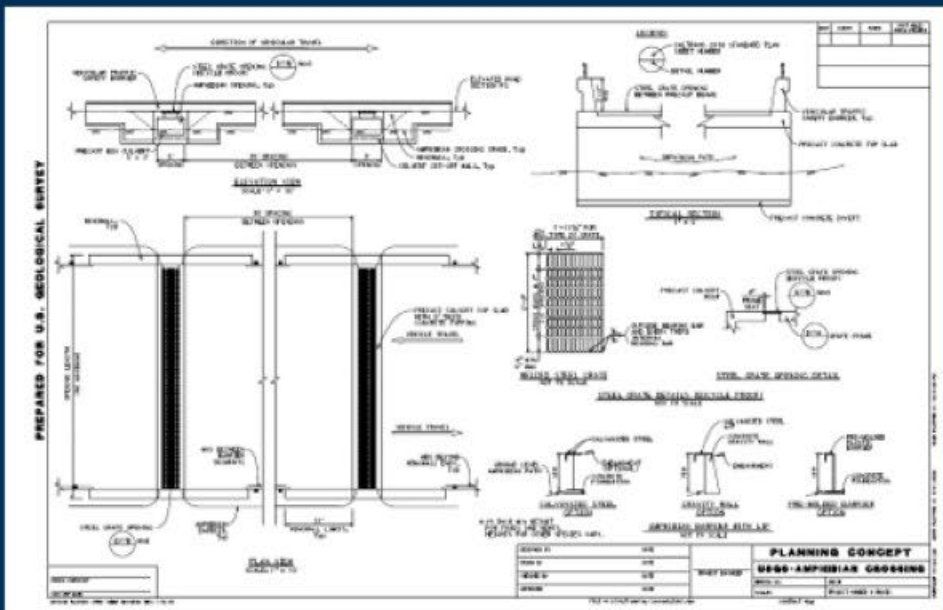


Longitudinal Precast Girders

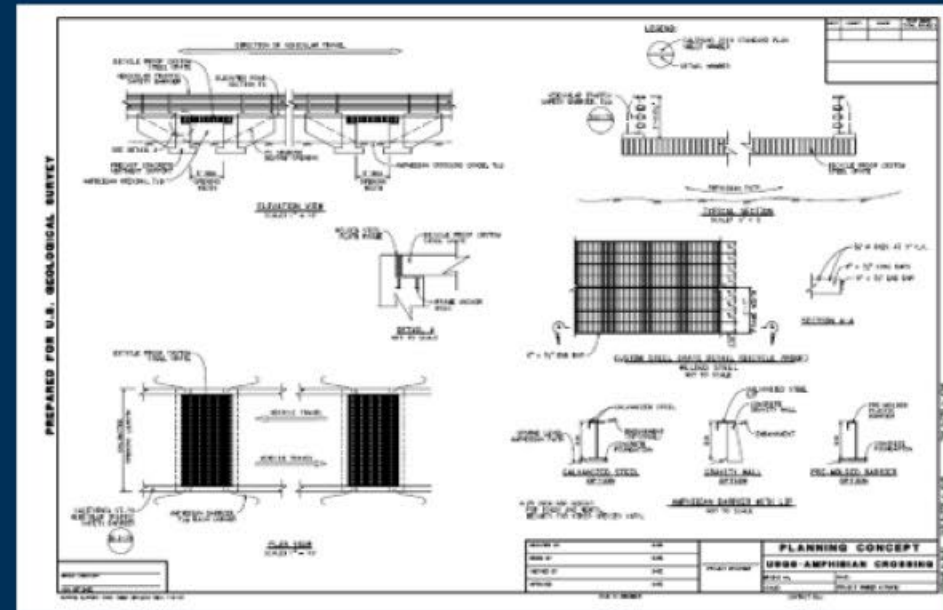


Transverse Precast Girders

Repeating Culverts in Raised Road



Precast culverts



Precast Abutments





Longitudinal Precast Girders





Transverse Precast Girders



Repeating Elevated Precast Box Culverts



Repeating Elevated Precast Abutments
with short span metal grates



Cost Considerations

Itemized Tasks	Cost Range (square foot)	Cost Range (100 linear feet- 2 lane road)	Remarks
Original ERS Design Sierra NF		14' wide= \$47K 20' wide = \$68K	Removable, can be made to meet local, city, county road standards. Requires regular check-ups and maintenance
ERS Bridge Structures	\$250/SF - \$350/SF (Structure only)	14' wide= \$500K 20' wide = \$700K	Includes Foundation Improvements/Preparation, Structural Concrete Supports and Span Elements, Vehicular Safety Railing, and Steel Grates
ERS Repeating Culvert and Short Span Structures	\$250/SF - \$350/SF (Structure only) \$75/SF - \$100/SF (Structure + Road Improvements with structures spaced at 10 m apart)	10 m spacing 14' wide= \$150K 20' wide = \$200K 20 m spacing 14' wide= \$101K 20' wide = \$136K	Includes Raising Roadway, Traffic Handling/Staging, Drainage, Amphibian Barriers, Lighting/Signals, and Safety Improvements Structure Includes Foundation Improvements/Preparation, Structural Concrete Supports and Span Elements, Vehicular Safety Railing, and Steel Grates
Construction Management	10% - 15% CON		Includes Construction Inspection and Documentation, Materials Submittal Reviews, As-Built Documentation

Considerations- Elevated Road Segments (ERS)

- Challenging topography
- No alteration of drainage patterns
- Property Constraints

Cost savings- high volume designs

- Stage Construction
- ABC- accelerated bridge construction 3-5 days
- Repeating culvert:
 - Smaller culvert (i.e. 2x4' vs. 3x5' or reduced height (Pre-cast abutment)
 - Grading and excavation outside road footprint to reduce height
 - \$ Reduction- grade

Final Take-aways

- Passages systems for migratory species should consider filtering effect from barrier fencing and “give-up” distances so that the mitigation solutions both reduce mortality and increase connectivity.
- Elevated road segment designs can provide another alternative to provide high permeability to movement for migratory amphibians and other species.
- Many design options available depending upon road characteristics and site-specific considerations.

Acknowledgments



