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

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Western Ecological Research Center U. S. Geological Survey

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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

USGS

Slide & Video- Stephanie Barnes, USFS
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...
Why Filter Effect? Fence “Give-up” Distances
California Tiger Salamander

Average movement distances along fence

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

Toward
Away
Mitigation Possibilities - 1?

- Barrier Systems & Wildlife Passages can reduce mortality and help to maintain connectivity
- However... can be unintended consequences...
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**

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

Spacing between passages (90% permeability) = 20 meters
Using Crossing: Yosemite Toads
Using Crossing: Other Species
Results: All Species Activity
Spatially explicit: Amphibians & Reptiles

- Pacific tree frog
- Sierra Nevada Ensatina
- Yosemite toad

- Mountain Gartersnake
- Rubber Boa
- Sierra Alligator Lizard

- Western Fence Lizard

Distance from ERS:
- Forest
- Adjacent to ERS
- Under ERS
Spatially explicit: Mammals

- American marten
- Broad-footed Mole
- Bushy-tailed Woodrat

- California Ground Squirrel
- Chipmunk
- Douglas Squirrel

- Golden-mantled Ground Squirrel
- Long-tailed Weasel
- Mountain Pocket Gopher

- Northern Flying Squirrel
- Peromyscus spp.
- Shrew

- Spotted skunk
- Vole
- Yellow-bellied Marmot

Camera location:
- Forest
- Adjacent-ERS
- ERS

Fence type:
- ERS
- Mesh
- Solid
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
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
Transverse Precast Girders
Repeating Elevated Precast Abutments with short span metal grates
## Cost Considerations

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