IMPROVEMENTS TO STEELHEAD MONITORING FROM A SPATIO-TEMPORAL MODEL

ROADMAP

- Background on Spatio-temporal models
- Redd Density
- Redd Life
- Example from Lower Cowlitz Steelhead
- Future plans

A BETTER WAY TO EXPAND COUNTS

Traditional Redd Expansion

- Assumes fixed relationship between index and expansion areas
- Locked into a survey design; inflexible
- Must capture the peak
- No estimates of uncertainty
- Difficult to incorporate outside data

Spatio-temporal Model

- Measures correlation between all areas in a stream
- Adjusts to changes in total survey effort and footprint
- Flexible timing, can estimate missed surveys
- Statistical basis for uncertainty
- Expandable
- Automatically updates and improves over time

SPATIO-TEMPORAL FRAMEWORK

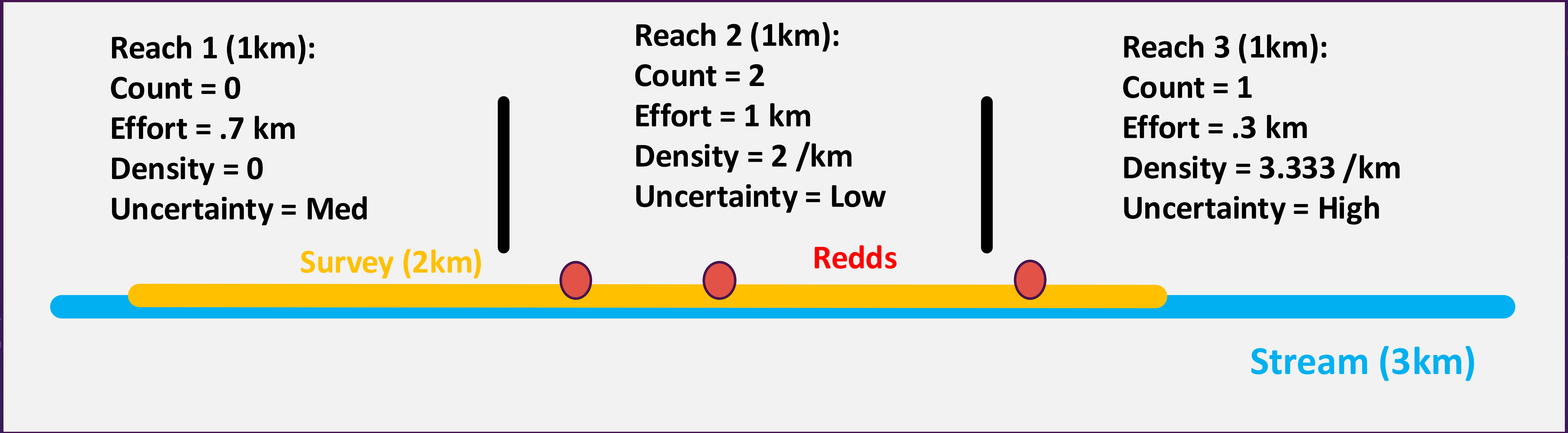
- Framework called tinyVAST

$$\underbrace{c_i}_{\text{Count}} = \underbrace{\mu}_{\text{Intercept}} + \underbrace{L_x X(t_i)}_{\text{Seasonal variation}} + \underbrace{L_\beta \beta(t_i)}_{\text{Annual variation}} + \underbrace{L_\omega \omega(r_i)}_{\text{Spatial variation}} + \underbrace{L_\varepsilon \varepsilon(r_i t_i)}_{\text{Spatio-temporal variation}} + \underbrace{\text{offset}(a_i)}_{\text{Survey Effort Adjustment}}$$

- Intercept – Long-term average
- Variation within a year (Mar ≠ May)
- Variation between years (2016 ≠ 2024)
- Variation by space (mouth ≠ headwaters)
- Interaction btw space and time (mouth in 2016 ≠ mouth in 2024)

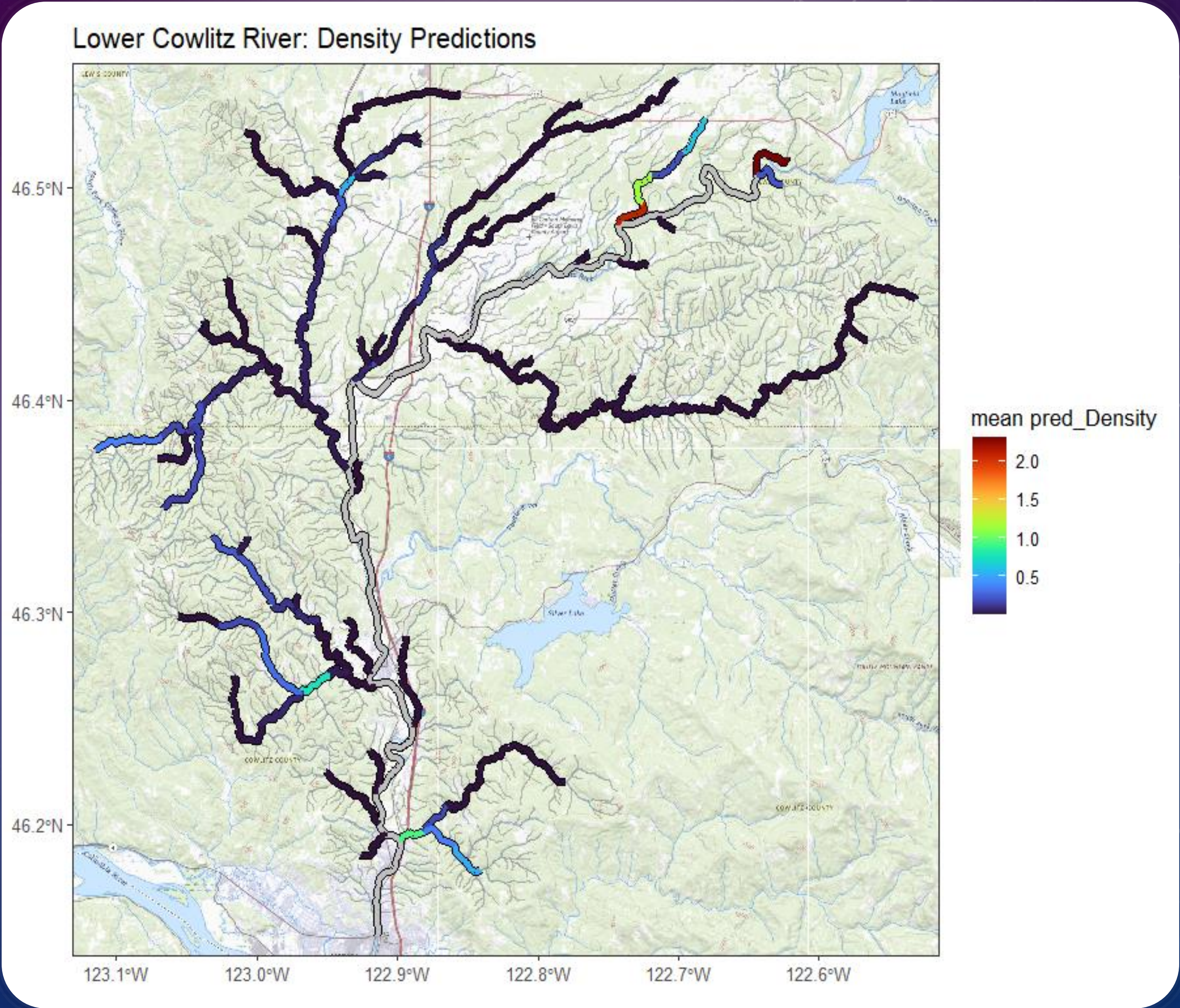
DATA EXAMPLE

- Break data into key components such as Count and Effort
- Flexible control over reach placement – no need to be even
- Scales to a wide variety of survey methods

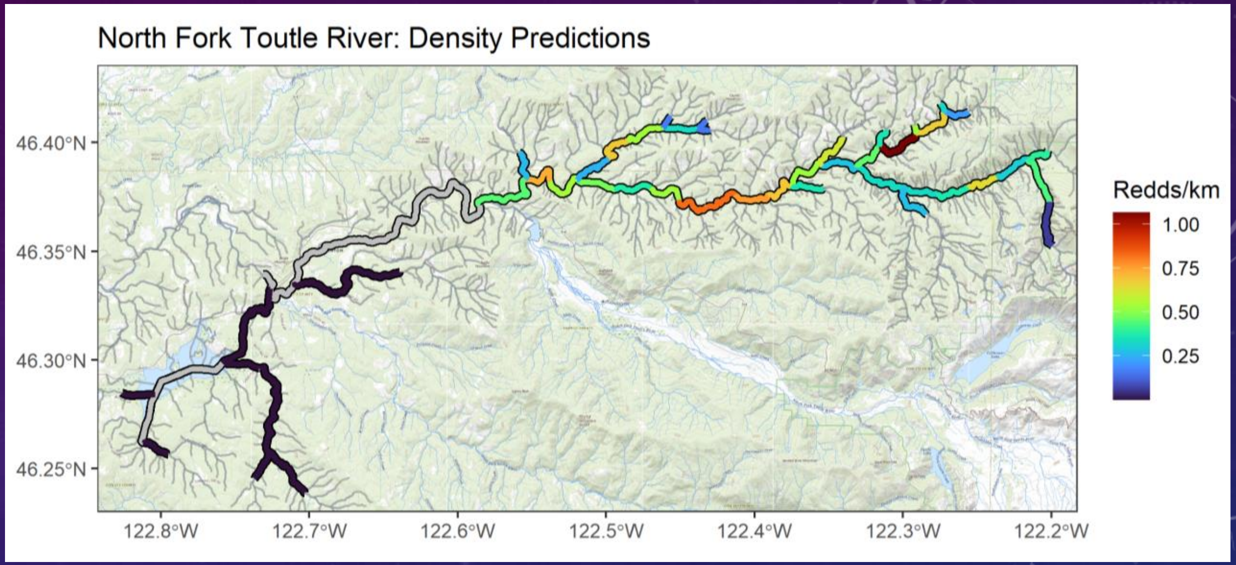


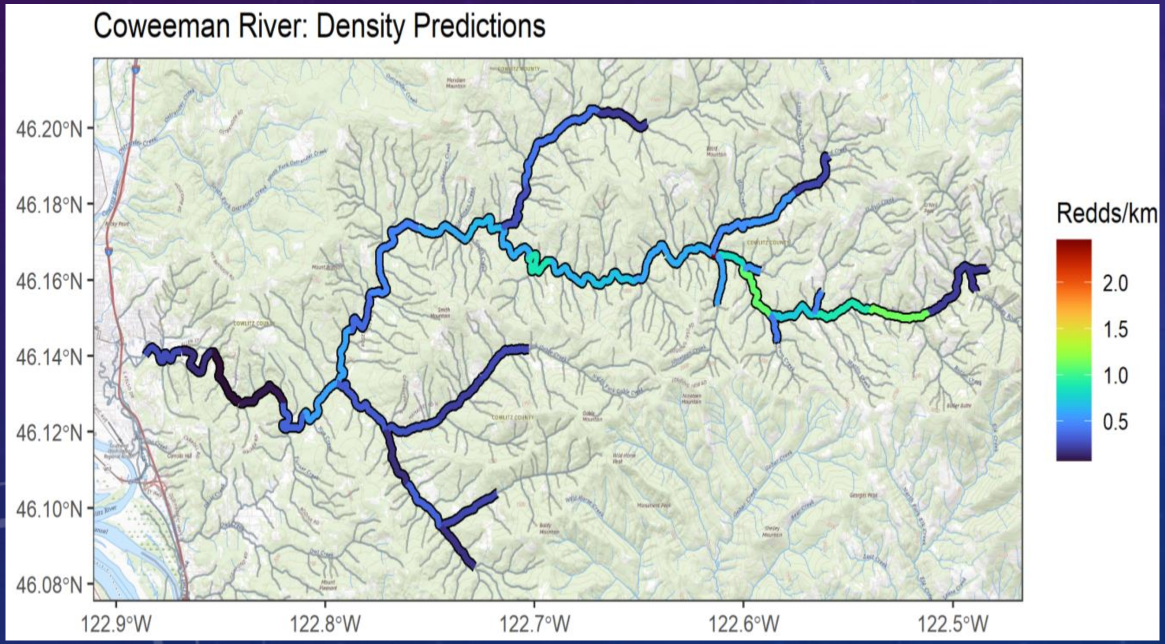
LOWER COWLITZ

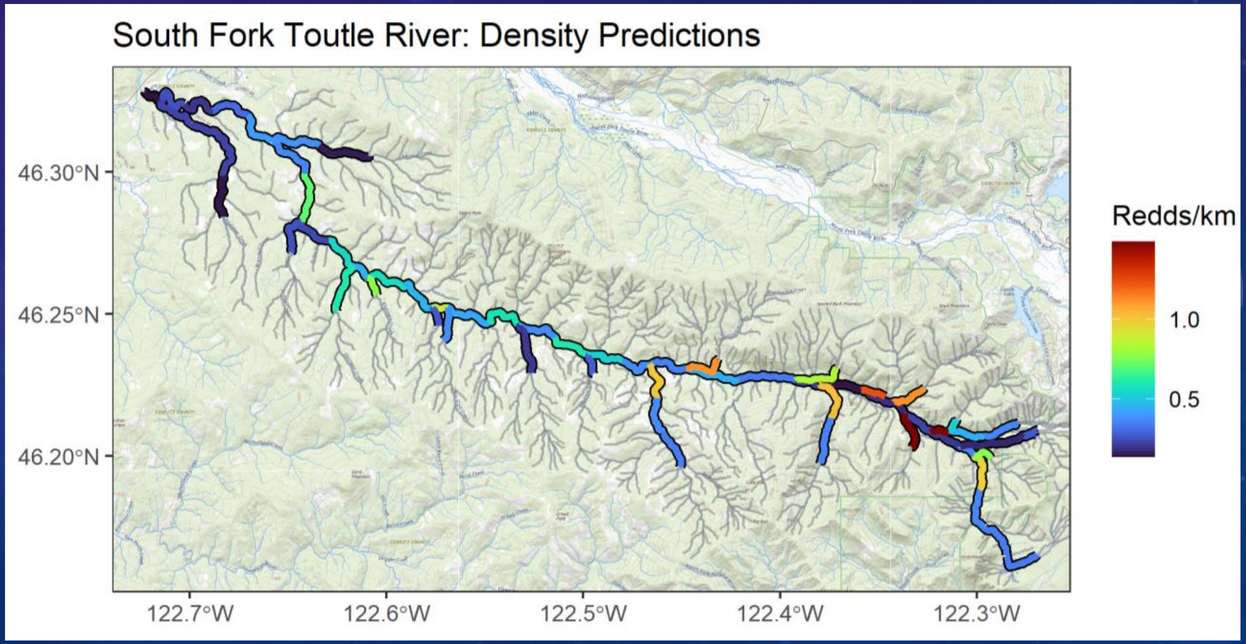
- Spatial models make it easy to design maps
- Lower Cowlitz (not including Toutle or Coweeman) is broken into 164 2km sections
- Maps of the long-term average, as well as each individual year (or any subset of years, or of peak spawning)



MAJOR TRIBUTARIES



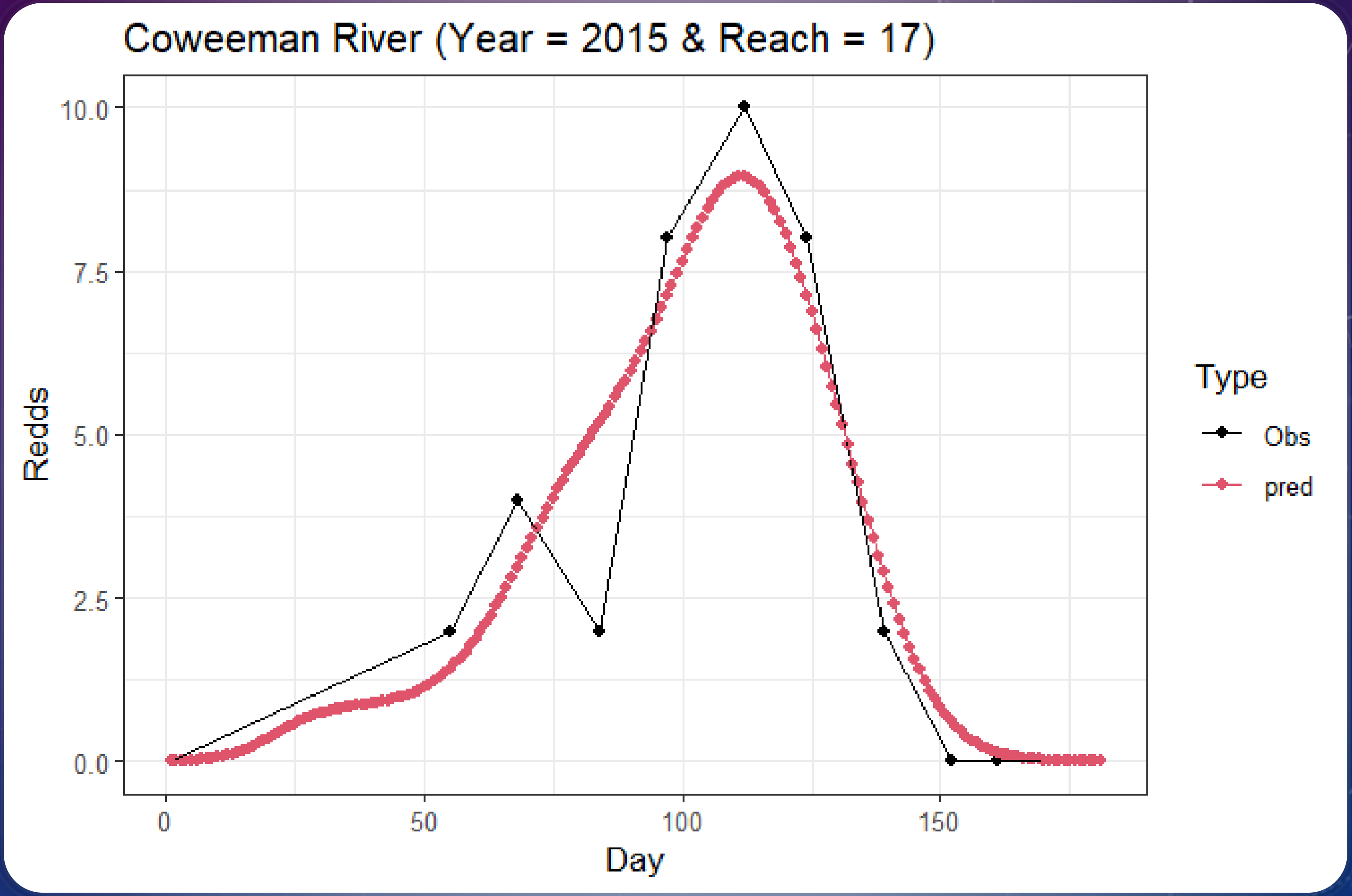




FROM DENSITY TO REDDS

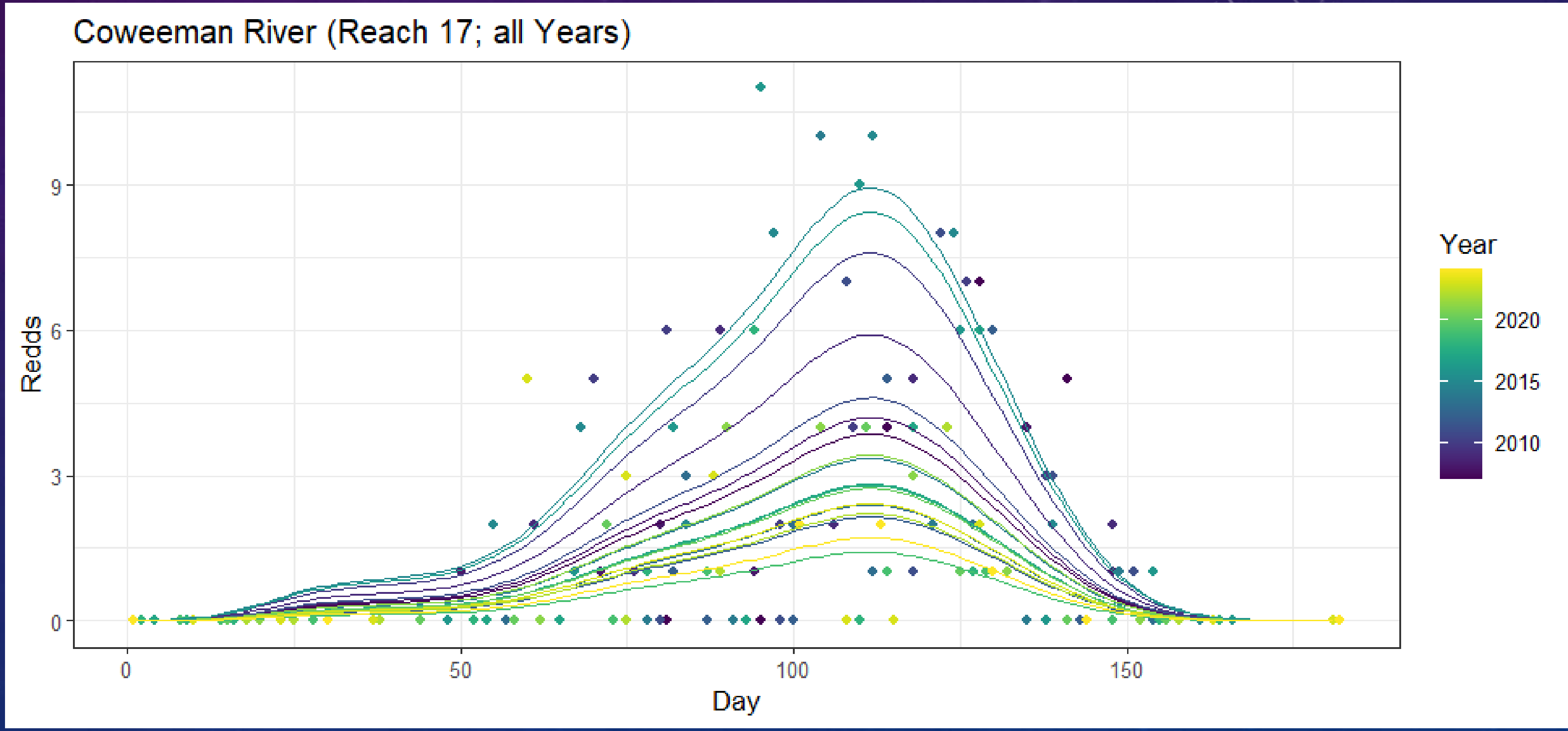
- Goal is to reconstruct the pattern of redd formation over the year
- If some observations are missing, we can still recover the overall pattern
- Determine total number of redds via the AUC method – robust to changes in survey frequency

- How many observations could we drop and still get approximately right answer?
- What else could you do with that extra time and money?



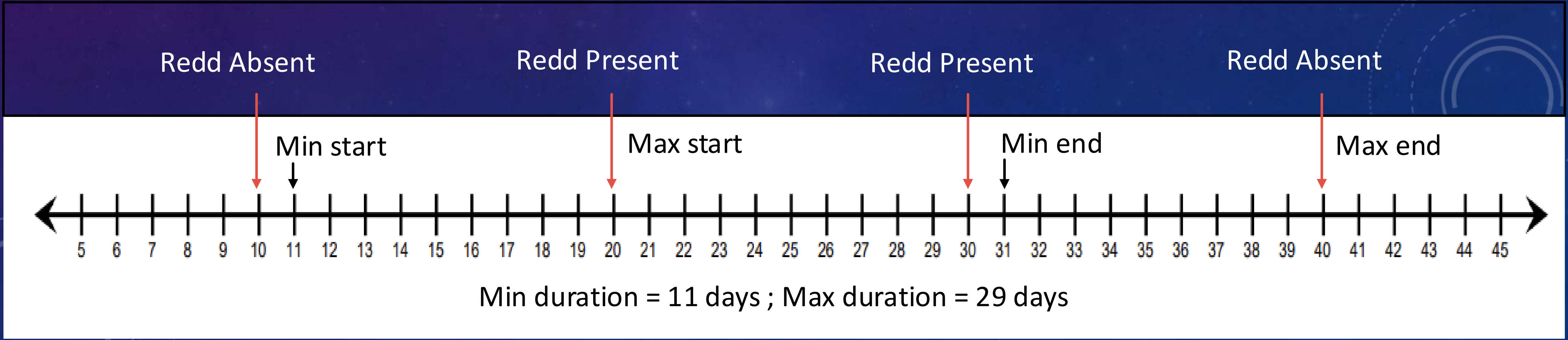
MODEL PREDICTIONS ACROSS YEARS

- While the model may miss in any given year, it is more stable than count expansions in the long run
- The more years of data you give it, the stronger the model gets
- If you miss an entire year, can use other years to infer a pattern



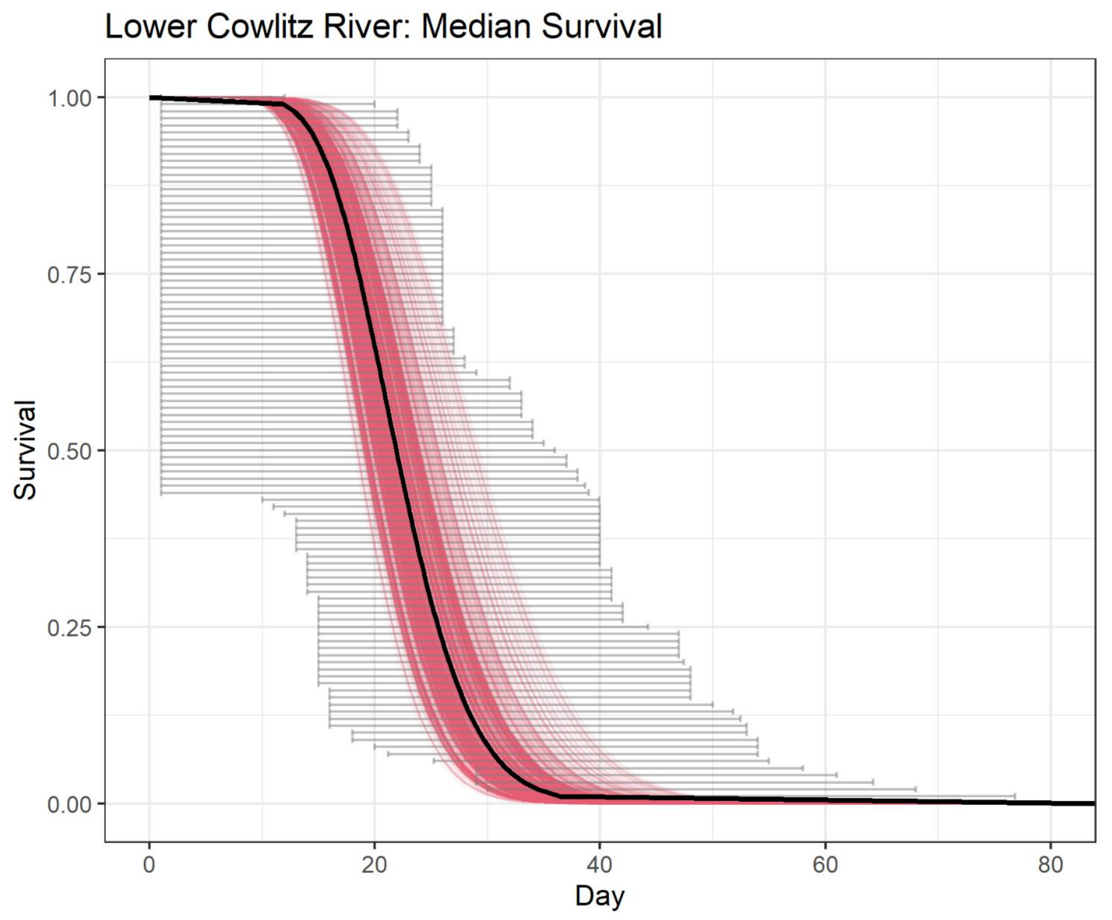
REDD LIFE ANALYSIS

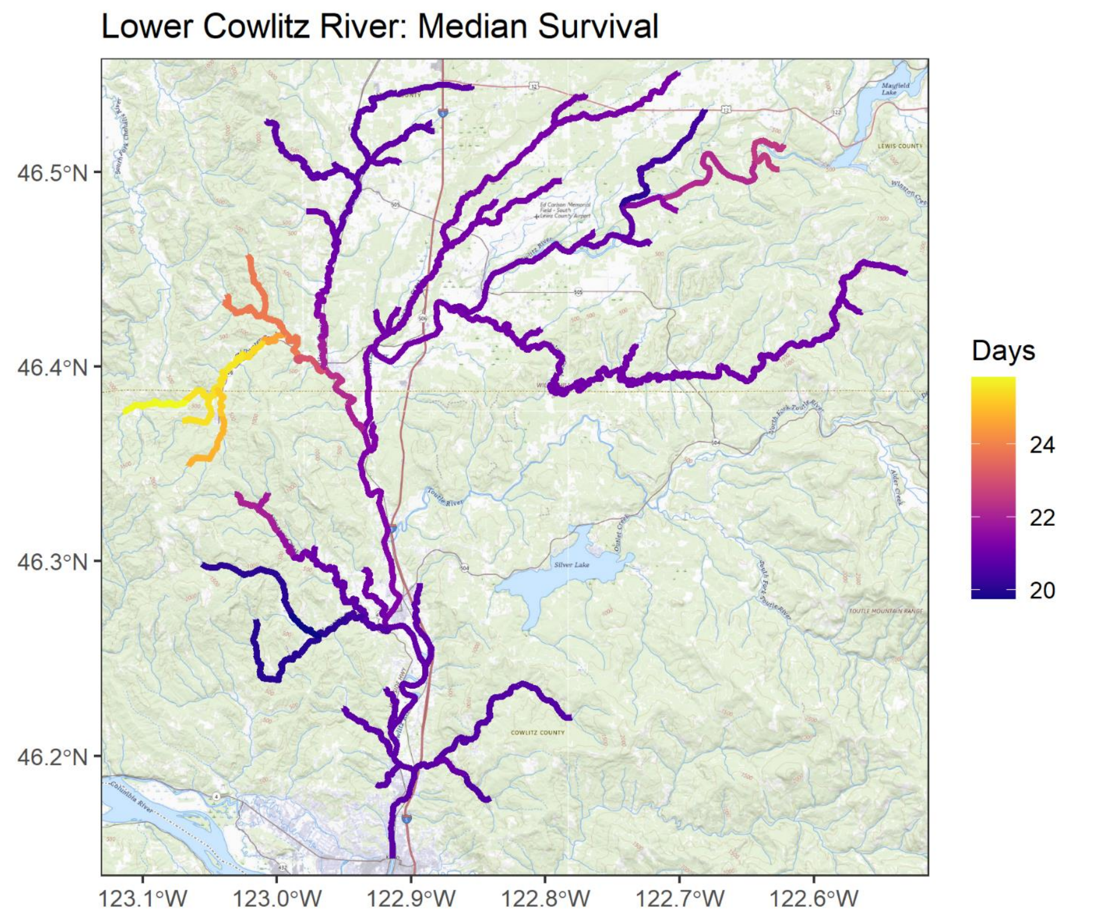
- This is how we use the redd tracking data
- Track first appearance and last appearance of redds
  - Survival methods incorporate range of possibilities
- Model survival time using INLA
  - Spatial random effects (simplified network relationships)
  - Year random effects



REDD LIFE MODEL

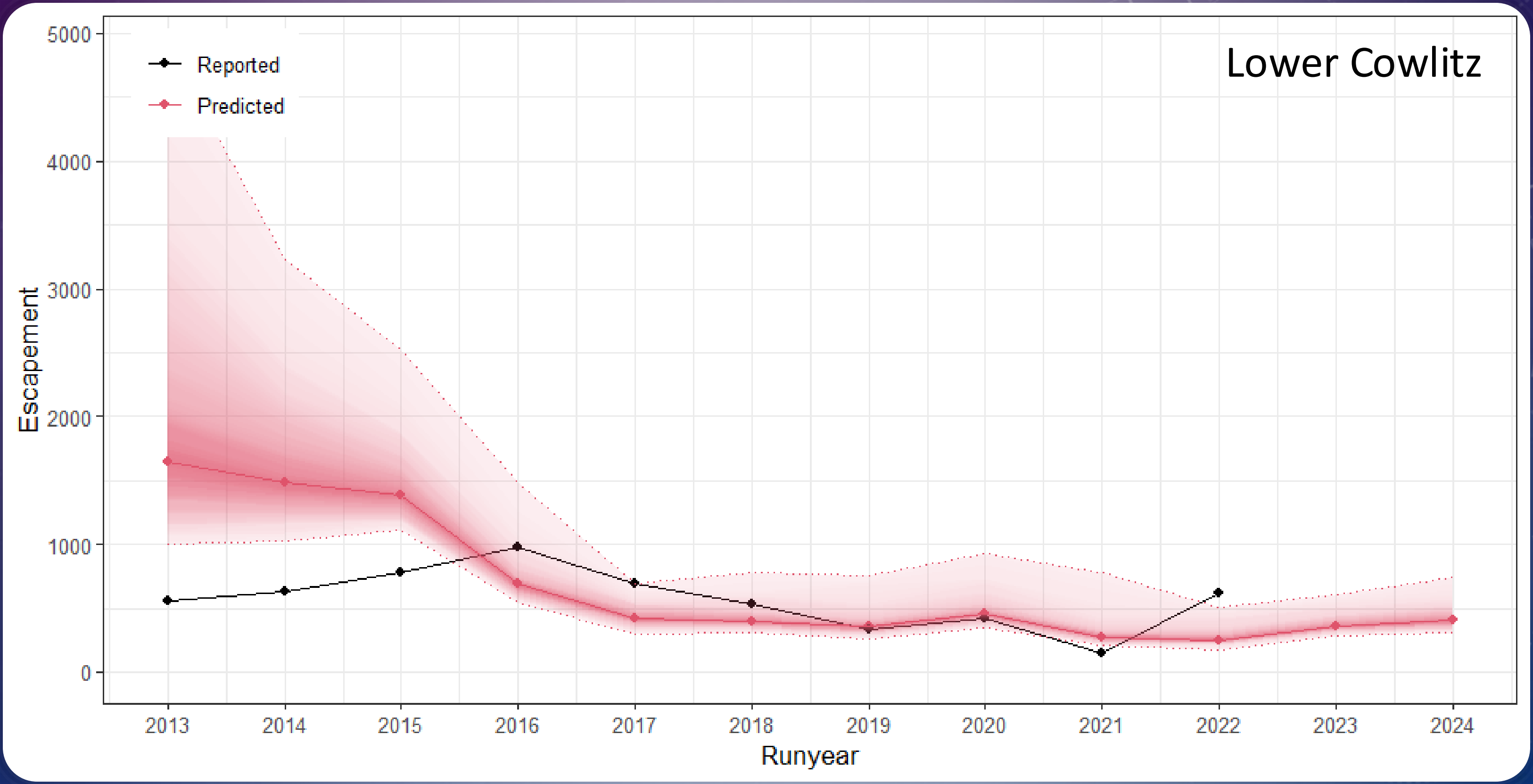
- Even though we don’t have an exact number, it’s possible to fit a model to the interval



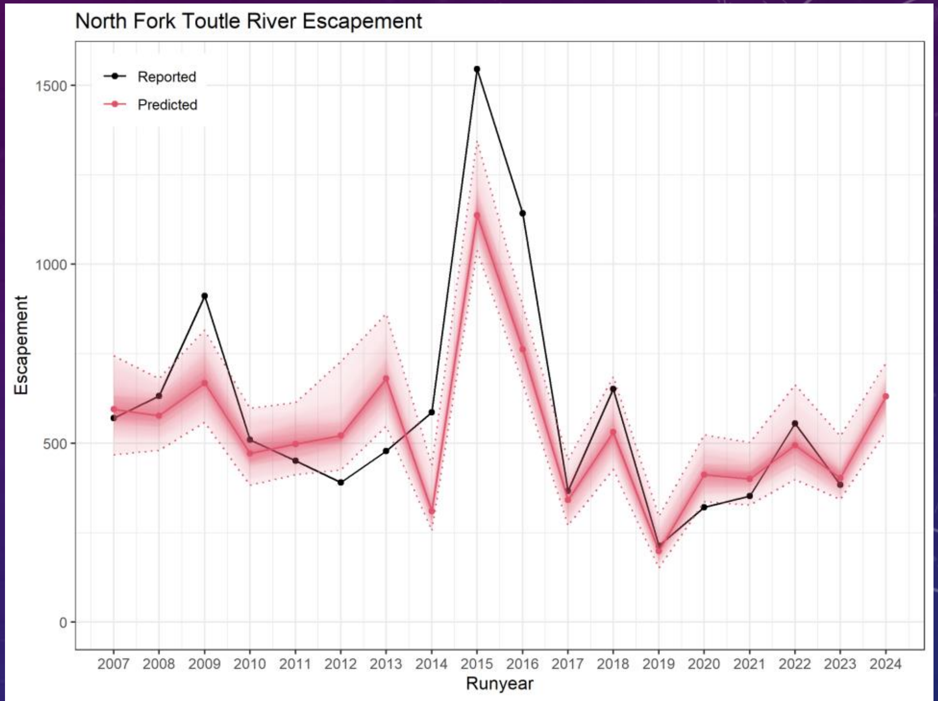


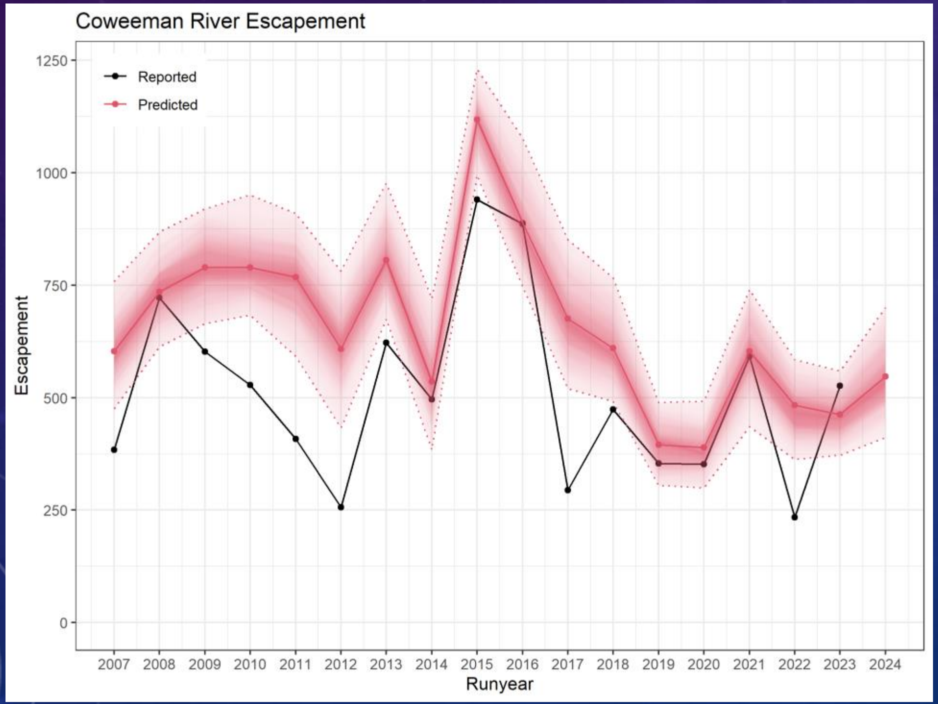
ESCAPEMENT

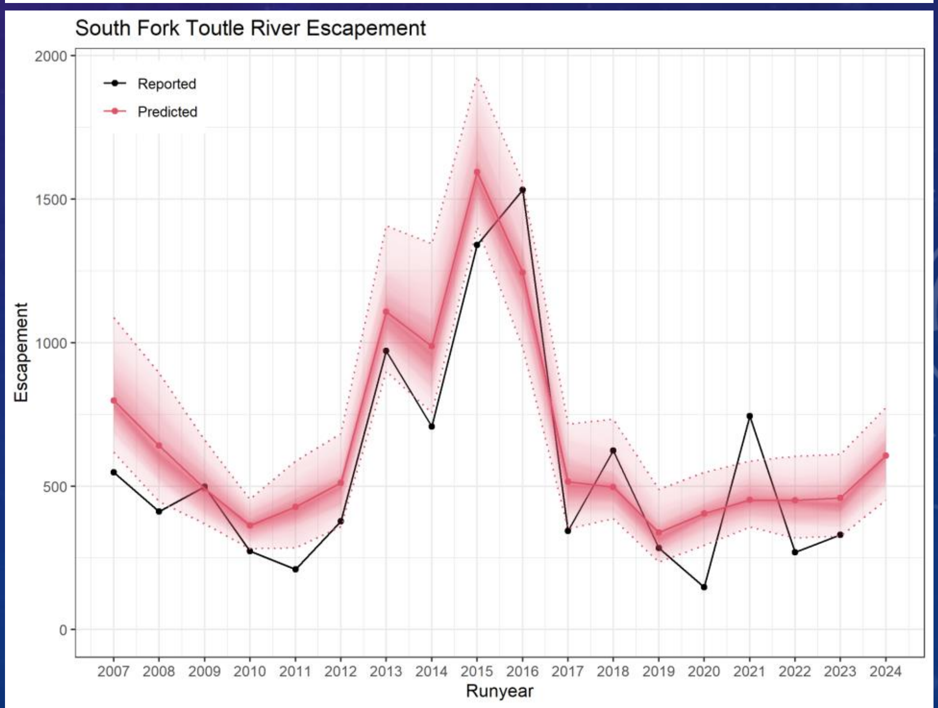
- Take the AUC of each reach
- Divide by the redd life time
- Multiple by 1.62 (Snow Creek estimate of spawners per redd)



OTHER DRAINAGES

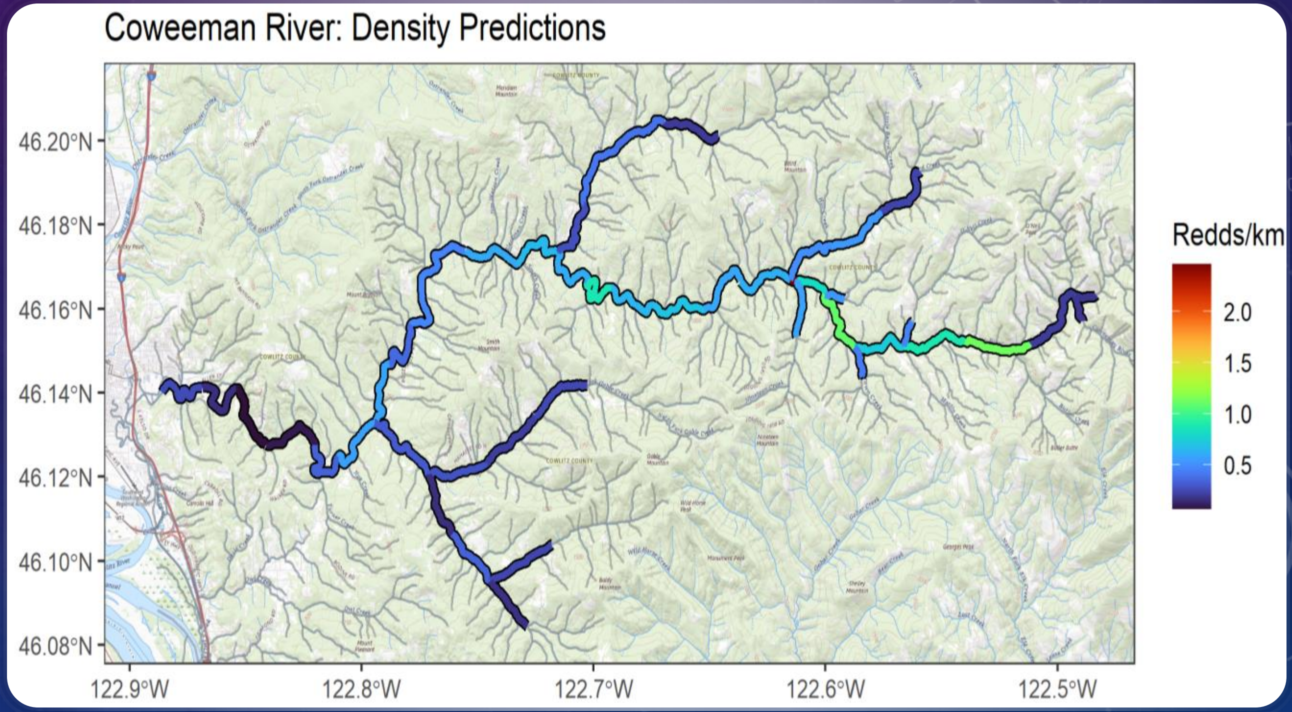






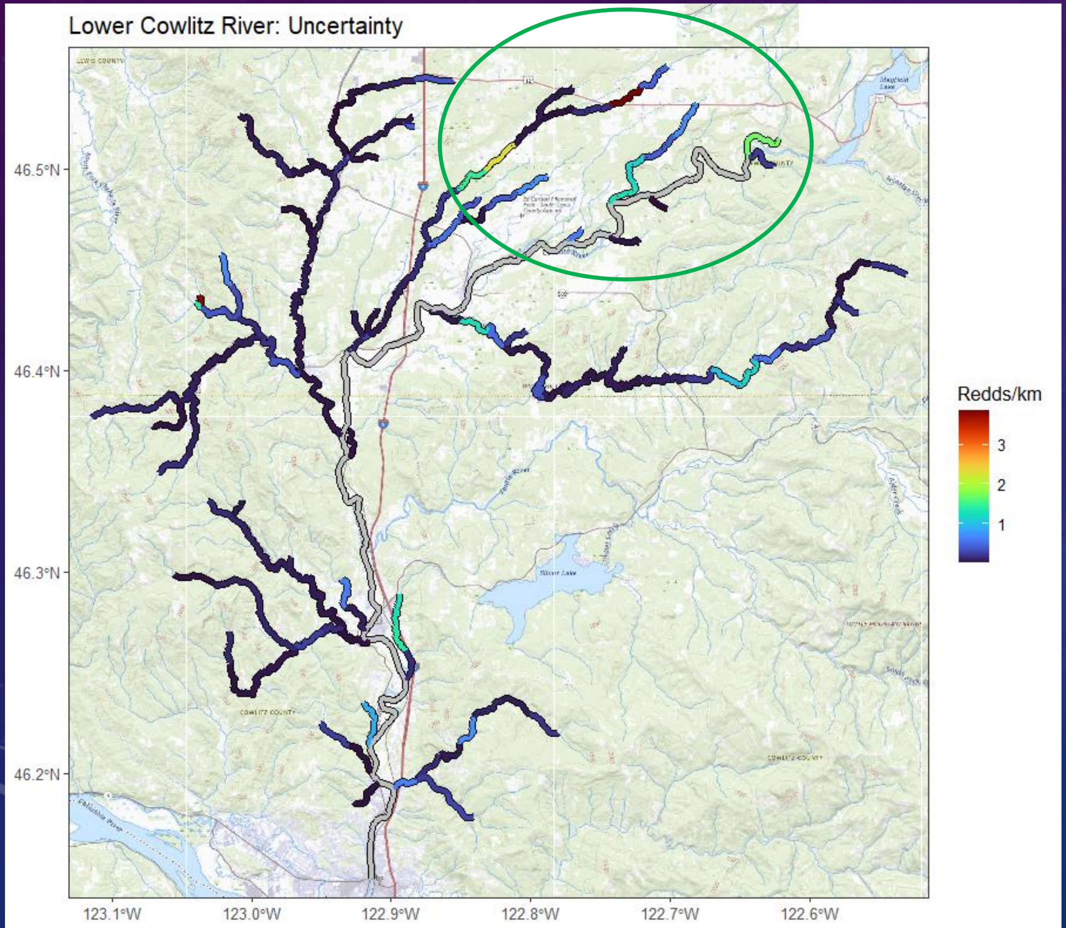
MODELS LEAD TO NEW QUESTIONS

- Models are not meant to replace on-the-ground knowledge or expertise
- Models help synthesize large amounts of complex information
- The predictions of a model can and should be tested with further data collection
- Virtuous cycle: Model guides new data collection which feeds into future model runs

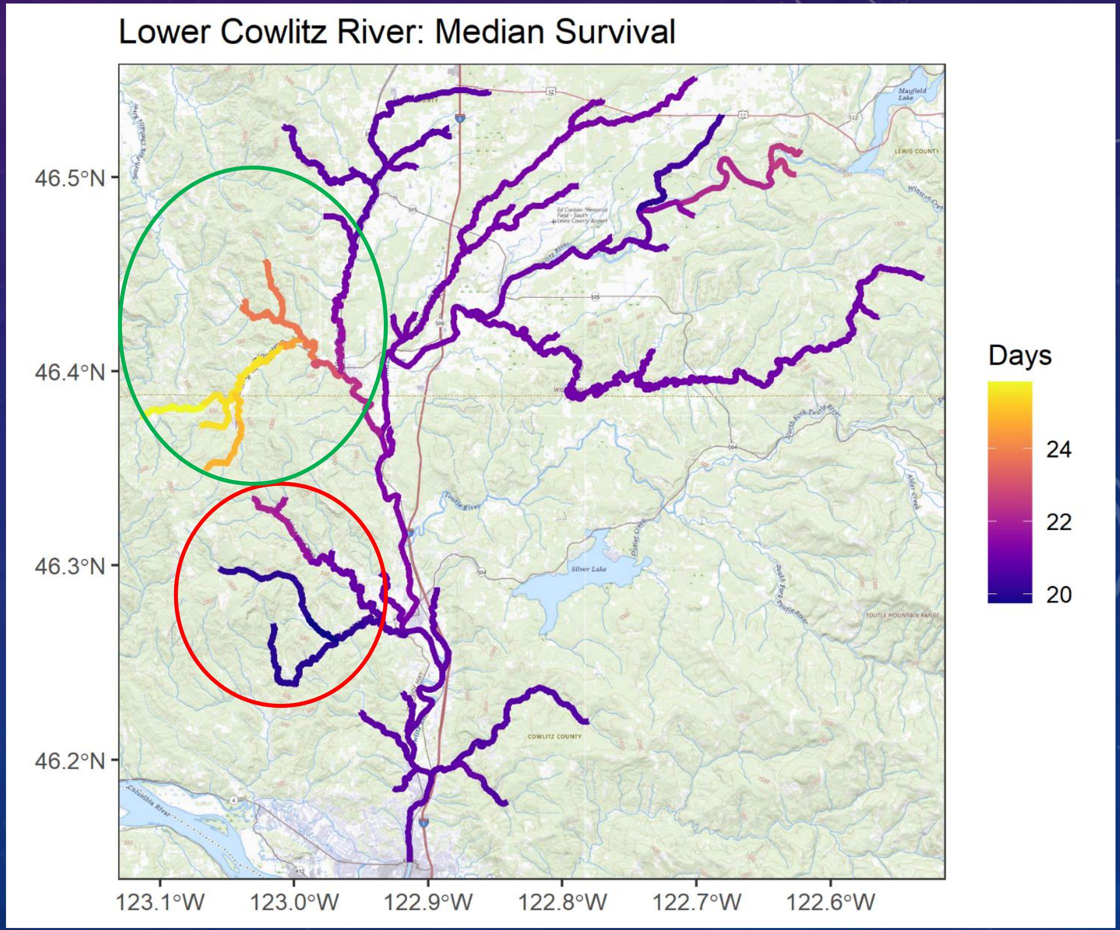


ASK NEW QUESTIONS

What are the most important places to survey?



What determines variation in redd survival?



LINKING HABITAT TO REDDS

- Proving the effectiveness of restoration is very hard, because there is a mix of spatial and temporal trends acting alongside the intervention

- Link network to USGS environmental data
- Numerous options for different kinds of effects

- Barely scratched the surface of what's possible

ACKNOWLEDGEMENTS

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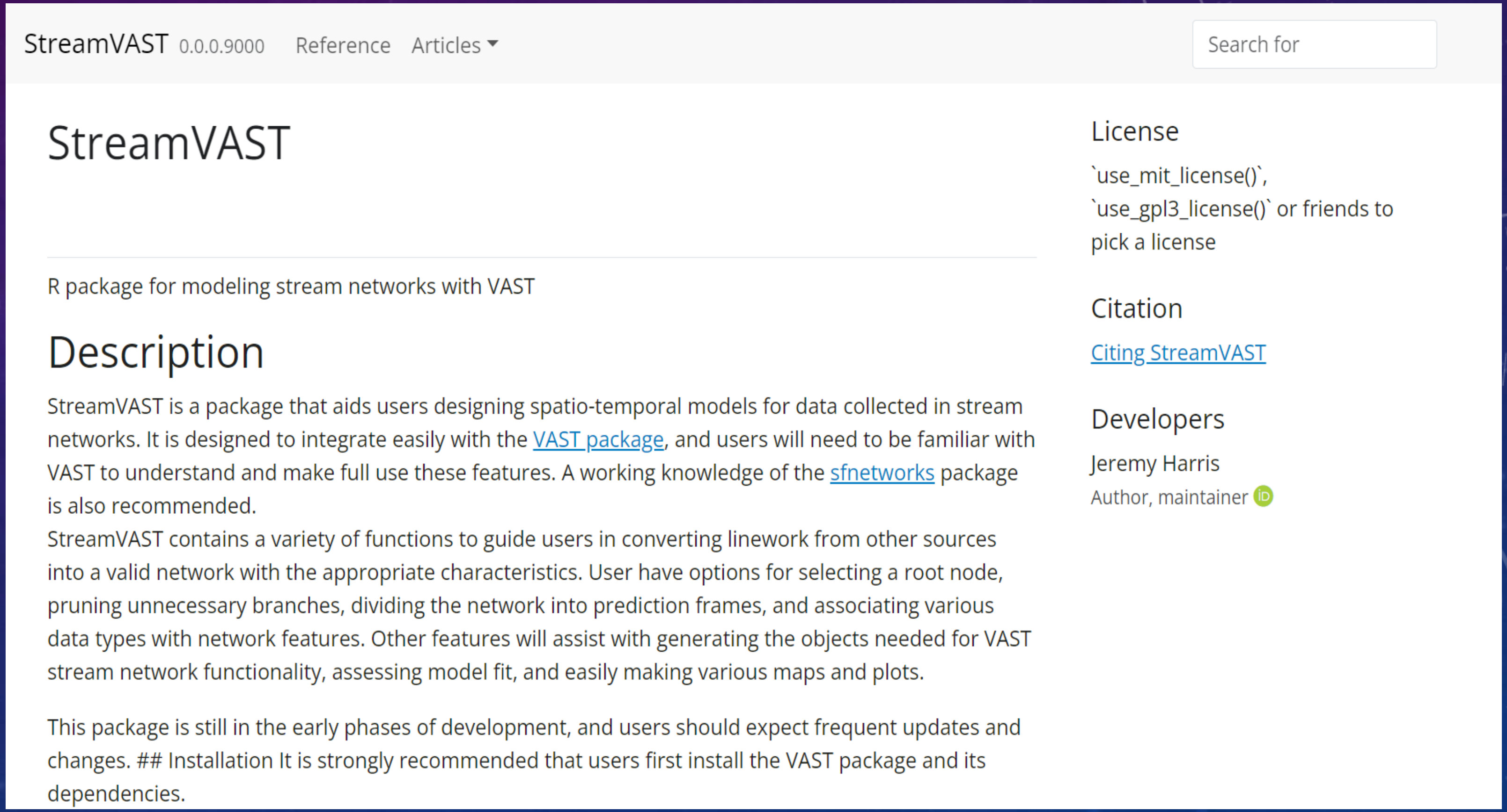
- WDFW data team including Danny Warren, Steve VanderPloeg
- Thanks to James Thorson who designed tinyVAST
- Everyone else in WDFW, especially the rest of SQSR
- Thanks to our hosts!

QUESTIONS

- **Visit the Github**
- https://jpharris7.github.io/StreamVAST/index.html
- Tools for making stream network and fitting model


StreamVAST 0.0.0.9000 Reference Articles

Search for

StreamVAST

R package for modeling stream networks with VAST

Description

StreamVAST is a package that aids users designing spatio-temporal models for data collected in stream networks. It is designed to integrate easily with the VAST package, and users will need to be familiar with VAST to understand and make full use these features. A working knowledge of the sfnetworks package is also recommended.
StreamVAST contains a variety of functions to guide users in converting linework from other sources into a valid network with the appropriate characteristics. User have options for selecting a root node, pruning unnecessary branches, dividing the network into prediction frames, and associating various data types with network features. Other features will assist with generating the objects needed for VAST stream network functionality, assessing model fit, and easily making various maps and plots.

This package is still in the early phases of development, and users should expect frequent updates and changes. ## Installation It is strongly recommended that users first install the VAST package and its dependencies.

License

`use_mit_license()`, `use_gpl3_license()` or friends to pick a license

Citation

Citing StreamVAST

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