Modeling for Monitoring

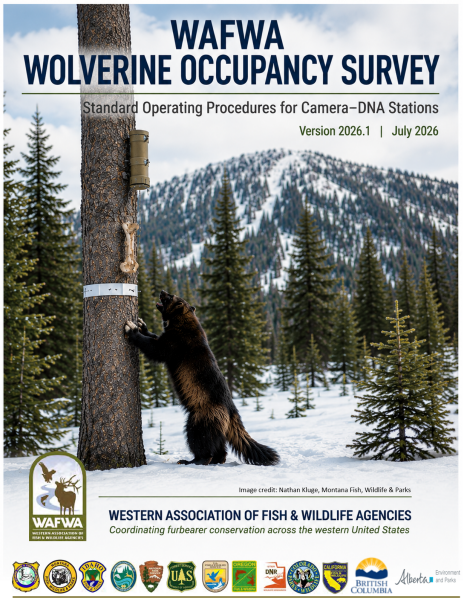
Goal

To consider modeling decisions and tradeoffs:

- Modeling Objective
- Choices among model types and fitting processes
- Explanation/Inference vs Prediction

Case Study





Sampling Frame

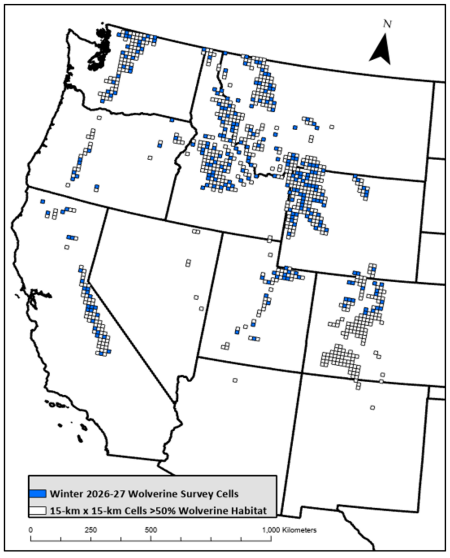


Figure 1. Wolverine sampling framework using the 15-km x 15-km grid system and survey cells (blue) targeted for the winter 2026–2027 occupancy survey across the western United States.

Station Setup

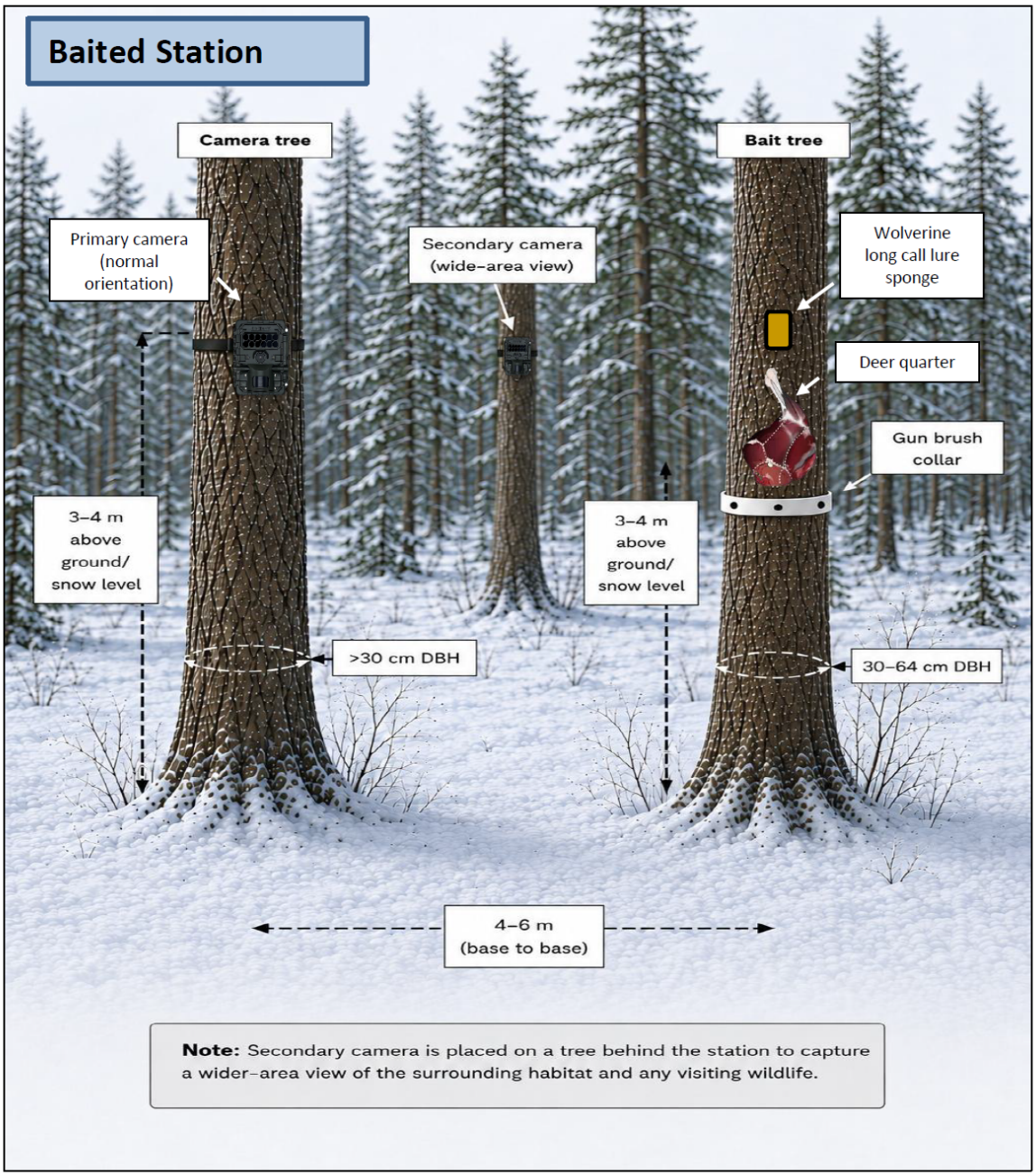


Figure 3. Baited station deployment includes wolverine scent lure sponge, a large meat bait, and a wolverine gun brush collar. During monthly visits components are moved up the tree if necessary to stay above accumulating snow. Equipment shall not be placed on whitebark pine trees.

Project Goals

- **Primary:** To map winter wolverine distributions across the western U.S. to track changes in occurence over time (i.e., contraction or expansion)

. . .

- **Secondary:** To understand the factors that govern wolverine occurence in the western United States.

Modeling Option 1

Naive Occupancy:

$\hat{\psi} = \frac{\sum y_i}{n}$, $y \in \{0, 1\}$

Modeling Option 2

Fit occupancy model with covariates:

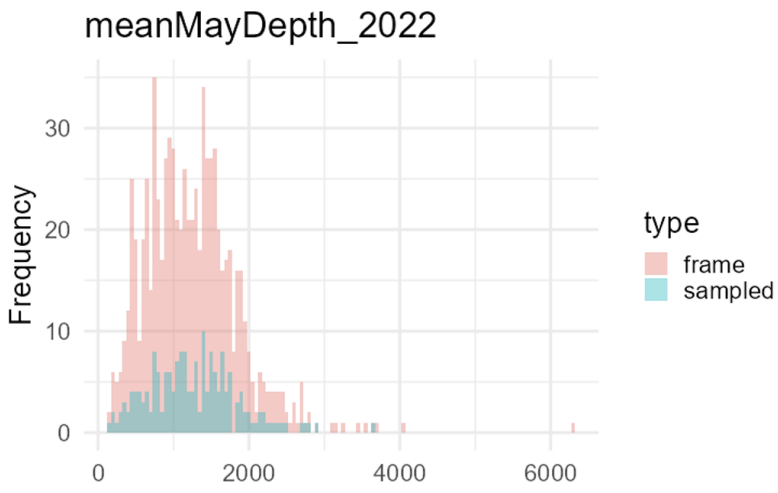
$$\begin{aligned}
\mathbf{y}_i &\sim \text{Binomial}(z_i \times p_i, J) \\
z_i &\sim \text{Bernoulli}(\psi_i) \\
\text{logit}(\psi_i) &= \alpha_0 + \alpha_1 \times \text{human.mod}_i + \\
&\quad \alpha_2 \times \text{elev}_i + \alpha_3 \times \text{snow.depth}_i \\
\text{logit}(p_i) &= \beta_0
\end{aligned}$$

Modeling Option 2a

Predict occupancy for the whole sampling frame . I.e., prediction with covariates.

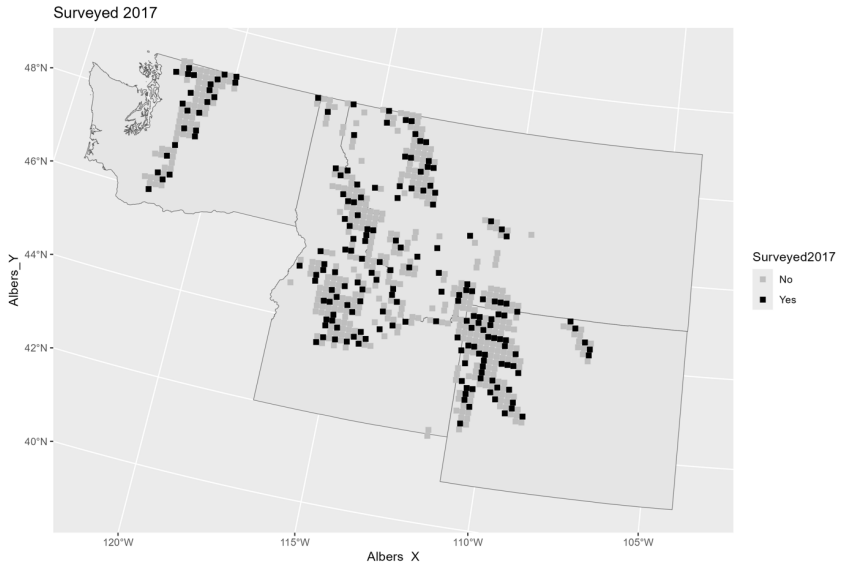
. . .





Modeling Option 2b

Predict occupancy only at sampled sites



Modeling Option 3

Multi-model comparison; predict occupancy at the whole sampling frame or only

sampled sites

model	AIC	DeltaAIC	AIC.Weights
psi ~ 1			
psi ~ human.mod			
psi ~ elev			
psi ~ snow.depth			
psi ~ human.mod + elev + snow.depth			

Modeling Option 4a

Predictions from a spatial occupancy model at the whole sampling frame. For example, intrinsic conditional autoregressive model (ICAR).

- covariates are not needed
- leverages 'closeness' of the detection data to estimate occupancy

. . .



Modeling Option 4b

Predictions from a spatial occupancy model WITH COVARIATES at the whole sampling frame.

- can add covariates on detection or occupancy
- the spatial process and spatial covariates are not necessarily uniquely identifiable (inference may be unclear)

Modeling Option 5

Prediction from a non-linear supervised machine learning algorithm at the whole sampling frame. For example, 'random forests', 'gradient boosting', 'maximum entropy'.

- covariates required
- non-linear relationships are handled
- correlation among variables is fine
- trains model based on cross validation

To do

- Group up and discuss
- List out the benefits/costs of each option, in terms of objectives 1 and 2.
- What option would you pick? Why?
  - If you make your own chimera option (mix match model type and model fitting), you need to say why it's better and how practical it is to accomplish.
- Can ask me questions

Options Summary

1) Naive occupancy
2) Single occupancy model, predict –> sampling frame OR sampled sites
3) Multi-model occupancy approach, predict –> sampling frame OR sampled sites
4) Single spatial occupancy model. No covariates or with covariates. Predict –> sampling frame
5) Non-linear supervised machine learning algorithm. Predict –> sampling frame