



Using multiple Approaches to evaluate Floodplain Restoration across Scales

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Introduction

- Floodplain restoration projects are implemented to affect Chinook Salmon populations, primarily as juveniles.
- Larger scale effects can be difficult to detect even with long term data.

Key Questions

- Is floodplain restoration effective?
- Can larger scale effects be inferred from short-term, small-scale data?
- Can results be reproduced with different methods to strengthen conclusions?



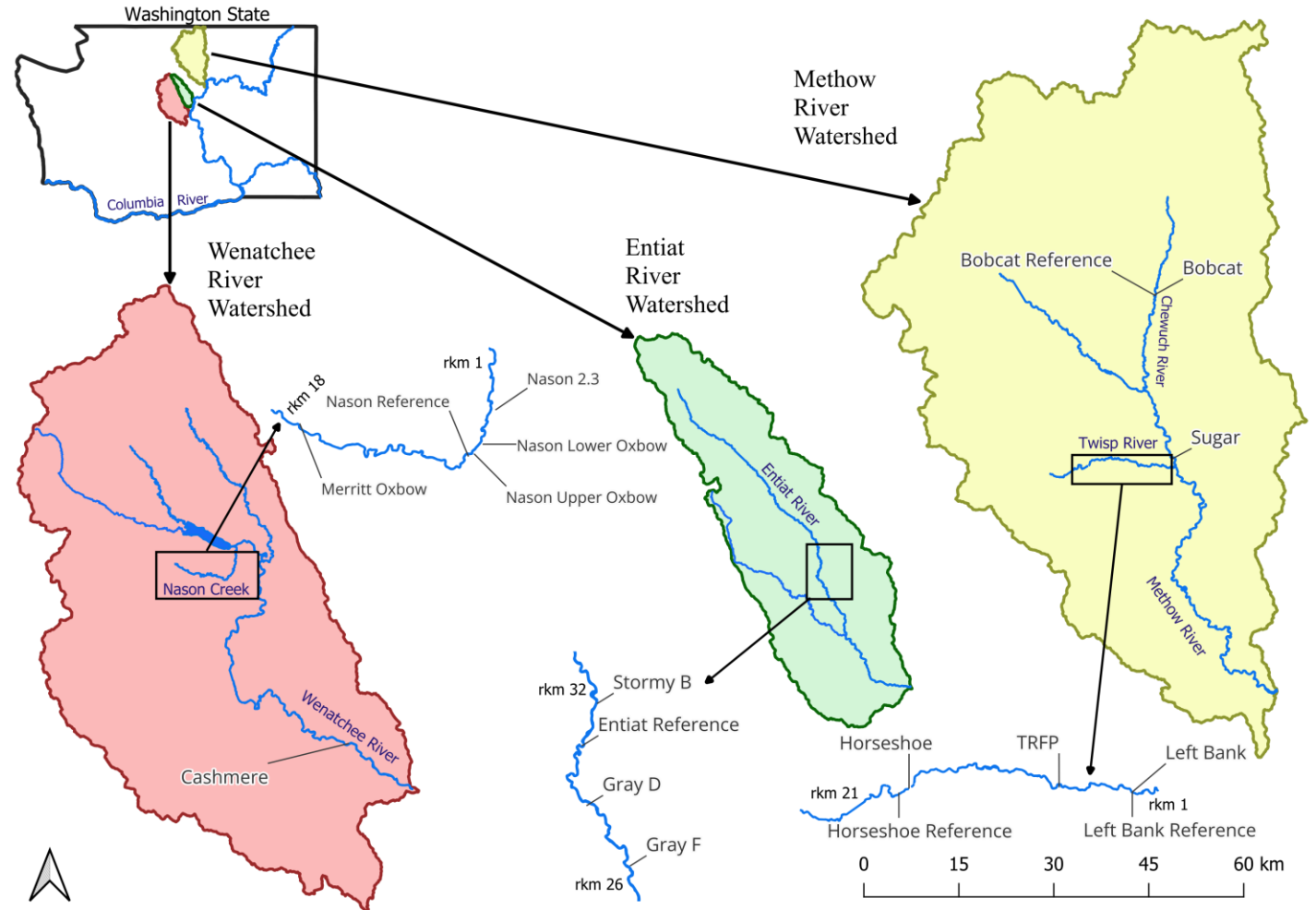
Data Collection

2023:

- randomly selected and non-randomly selected habitat sampling units
- No abundance estimates

2024:

- non-randomly selected habitat sampling units only
- Abundance estimates



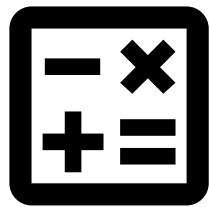


Field Data



- **Fish density:**
 - No. Chinook / m²
- **Physical habitat parameters:**
 - Depth
 - Flow
 - Water temperature
 - Substrate
 - Restoration status
 - Habitat type
 - natural log jams (NLJ)
 - engineered log jams (ELJs)
 - vegetation
 - open area
 - channel
 - riffle
- **Habitat distribution:**
 - % habitat type / floodplain

Descriptive Models



- Estimate the effect of different variables on an outcome.
- How do physical habitat parameters (variables) effect Chinook Salmon density (outcome)?
 - Generalized Linear Mixed Models (GLMMs)
 - Decision Trees

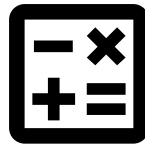
Descriptive \longrightarrow Predictive Models

- **Model Training**

Field data



Descriptive Model



Coefficients

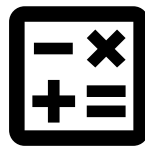
depth:	0.345
flow:	-0.823
temperature:	0.542
...	

- **Model Predictions**

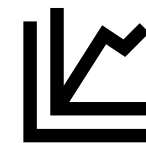
New / simulated data



Predictive Model



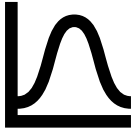
Predictions



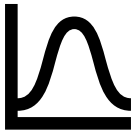
density: 0.263

Generating Simulated Data from Distributions

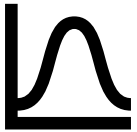
Depth



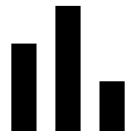
Flow velocity



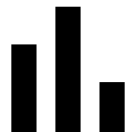
Temperature



Substrate

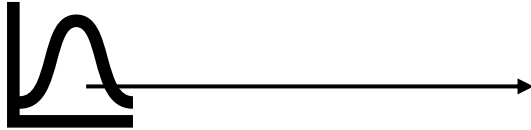


Habitat type



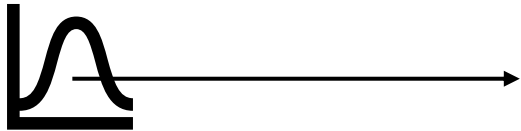
Generating Simulated Data from Distributions

Depth



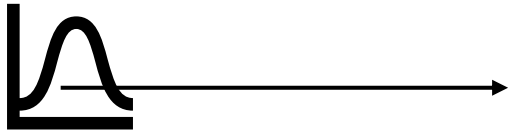
Depth: 0.2 m

Flow velocity



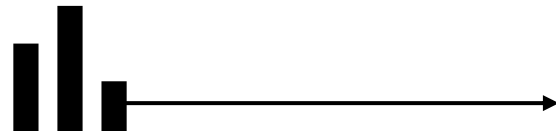
Flow velocity: 0.5 m/s

Temperature



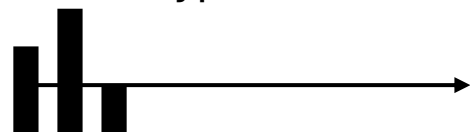
Temperature: 13 °C

Substrate



Substrate: sand

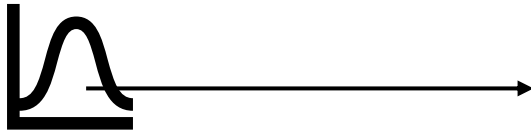
Habitat type



Habitat type: Vegetation

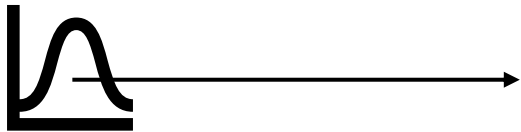
Generating Simulated Data from Distributions

Depth



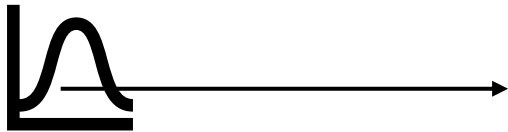
Depth: 0.2 m

Flow velocity



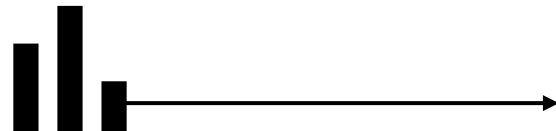
Flow velocity: 0.5 m/s

Temperature



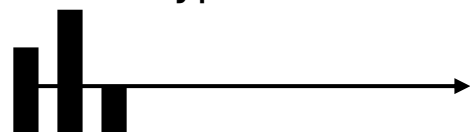
Temperature: 13 °C

Substrate



Substrate: sand

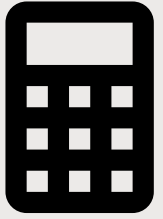
Habitat type



Habitat type: Vegetation

Simulated data
with the same
Distribution as
Field data





Density Weighted Habitat Diversity as a predictor for population estimates on larger scales



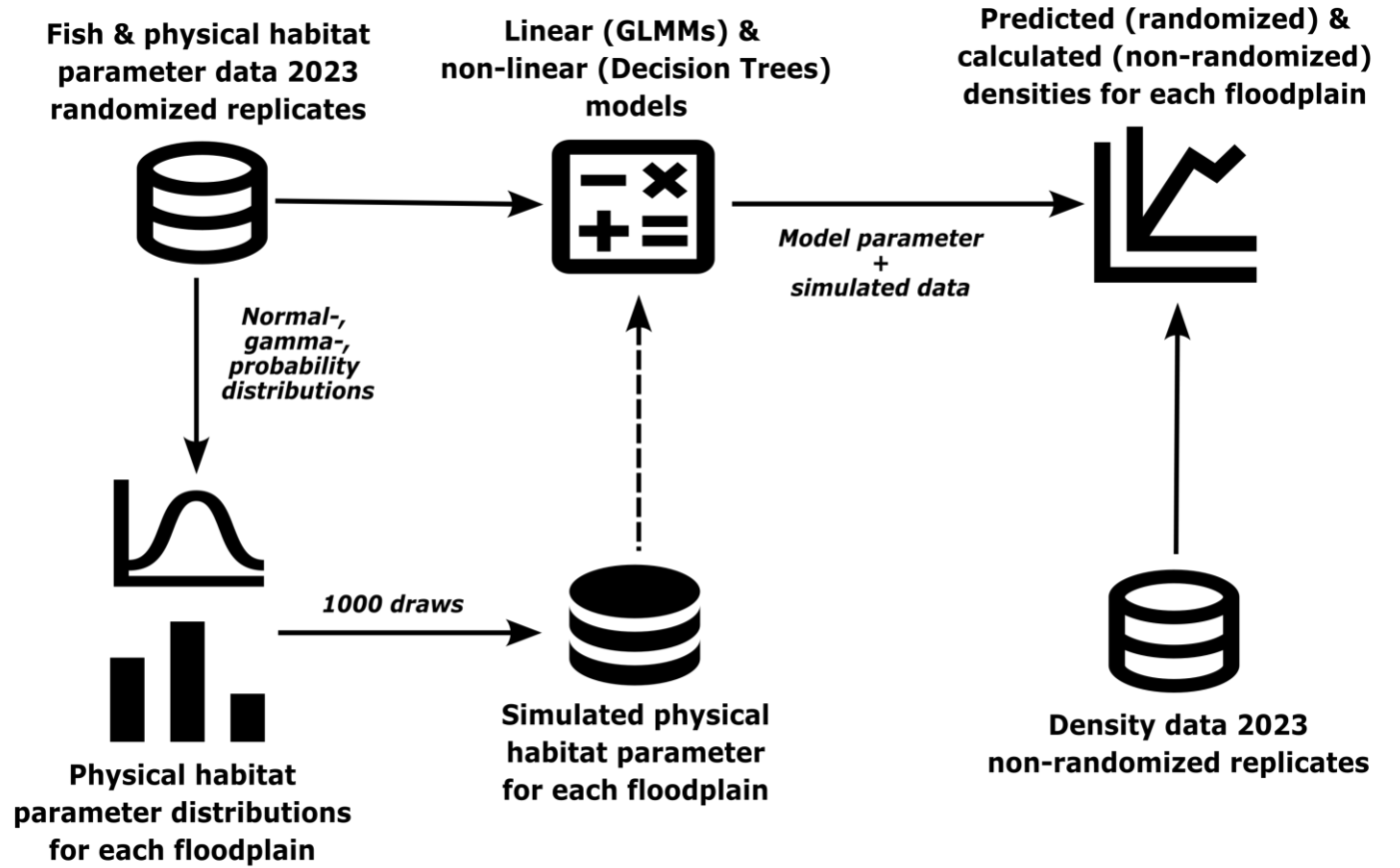
- Derived from the Shannon Diversity Index, with habitat types weighted by their effects on fish density (GLMM)
 - Habitat types associated with higher fish densities weigh more.
 - Even floodplains with low habitat diversity could get higher rating if the habitat present is associated with higher fish densities.



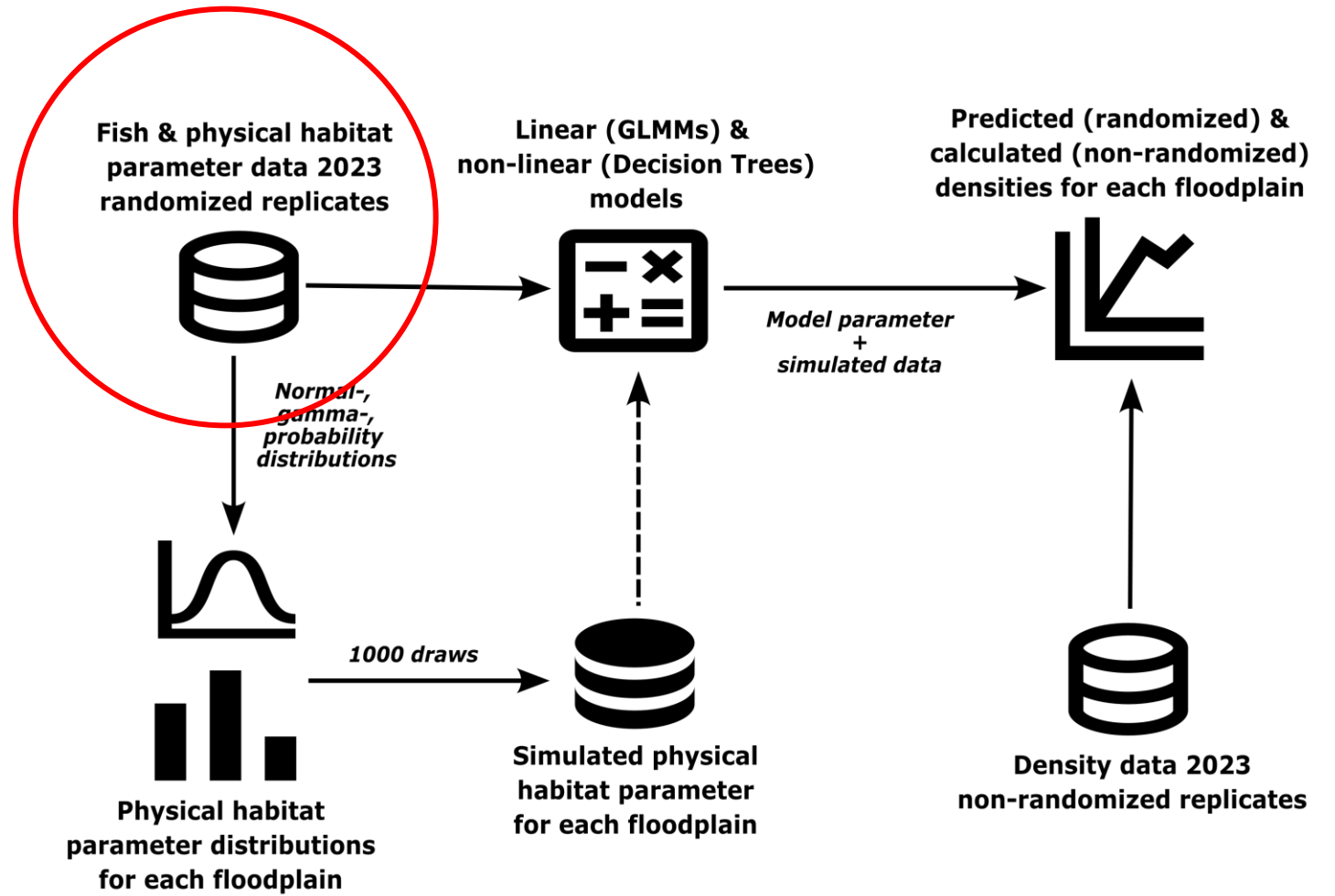
Analytical Steps

1. Show that non-random samples are representative for Chinook density (fry, parr, fry & parr).
 - Floodplain population sizes could only be estimated in 2024
 - Sampling in 2024 was limited to non-randomly selected habitat units.
2. Create a habitat diversity metric as a predictor for reach scale population estimates.

Workflow Random vs. Non- Random

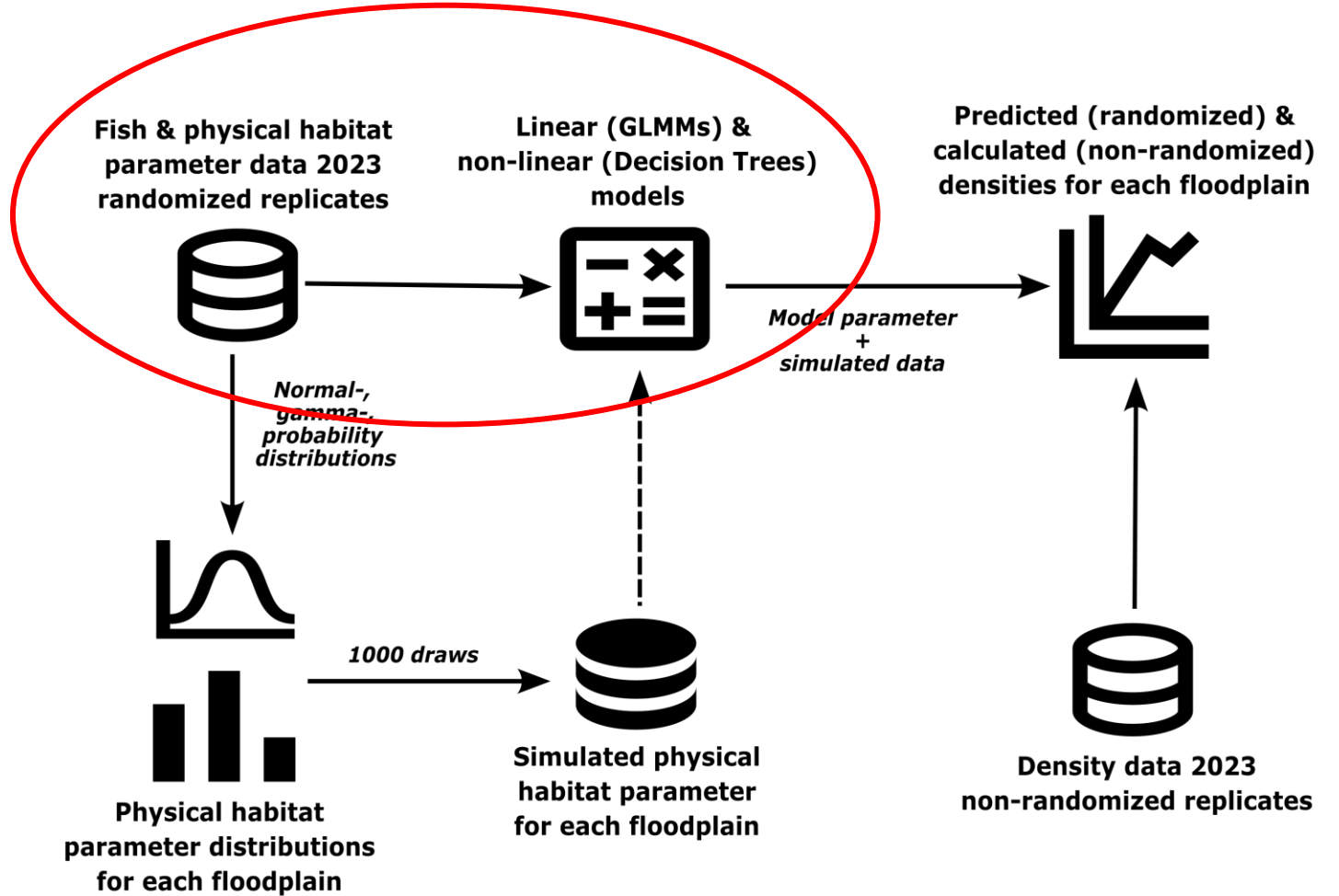


Workflow
Random vs.
Non-
Random

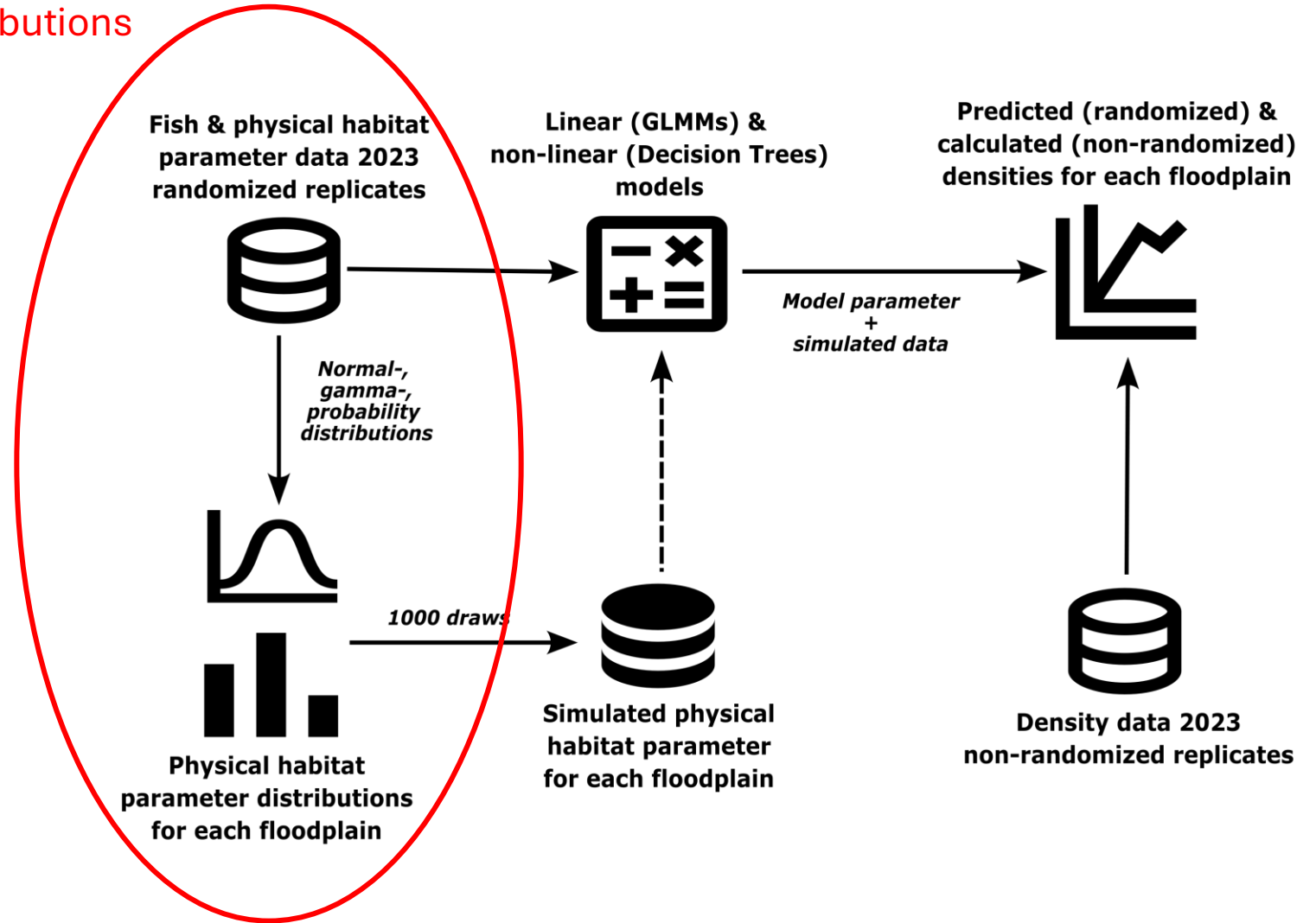
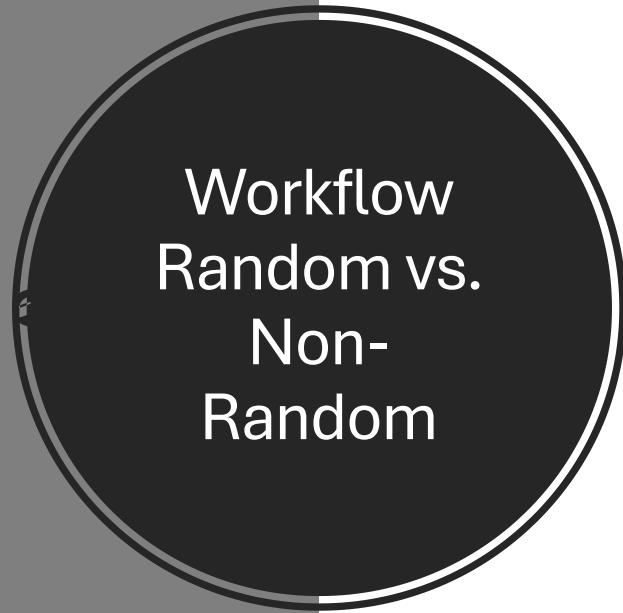


Workflow
Random vs.
Non-
Random

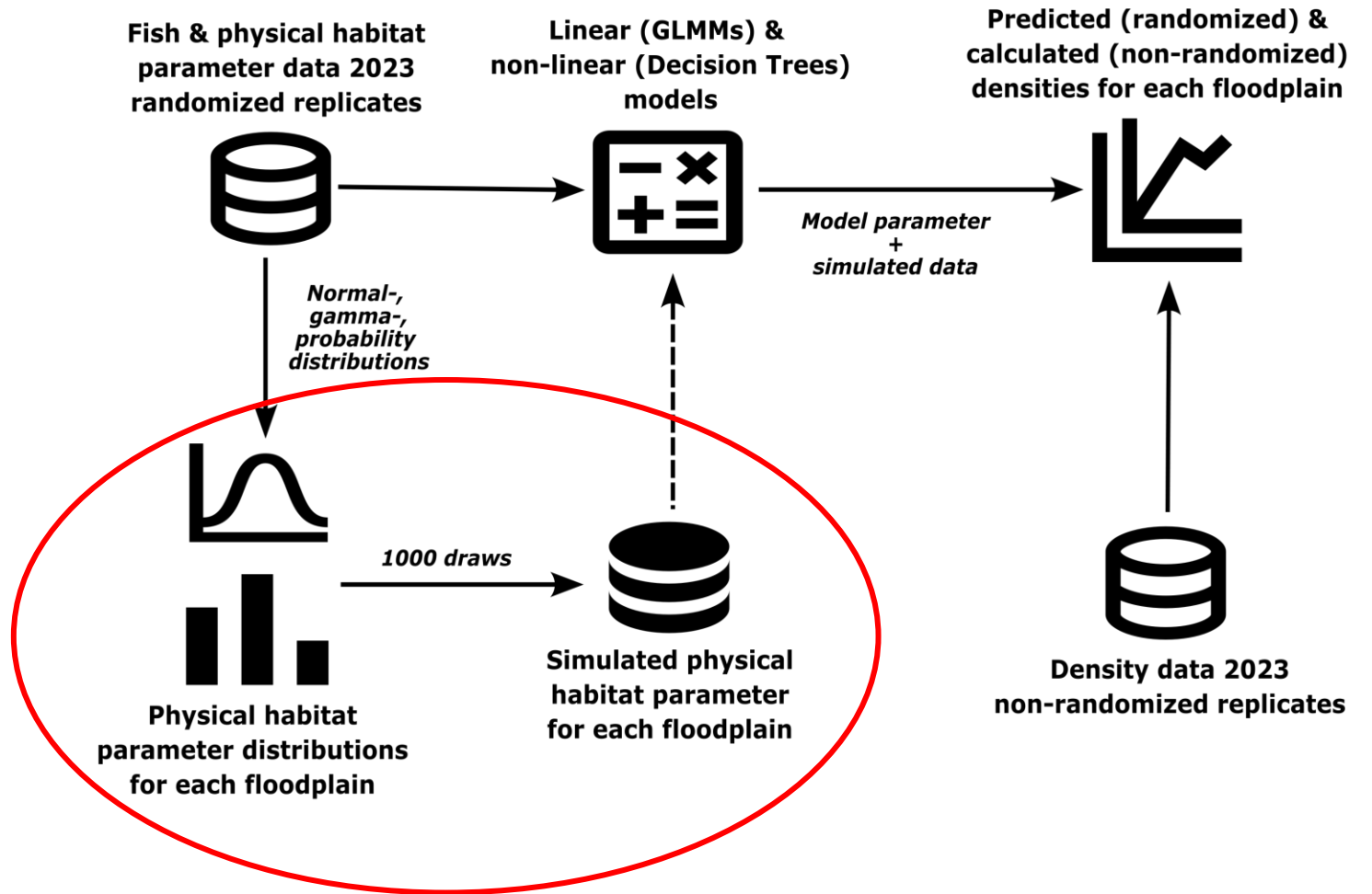
Descriptive Model



Generate Simulated Data from Distributions

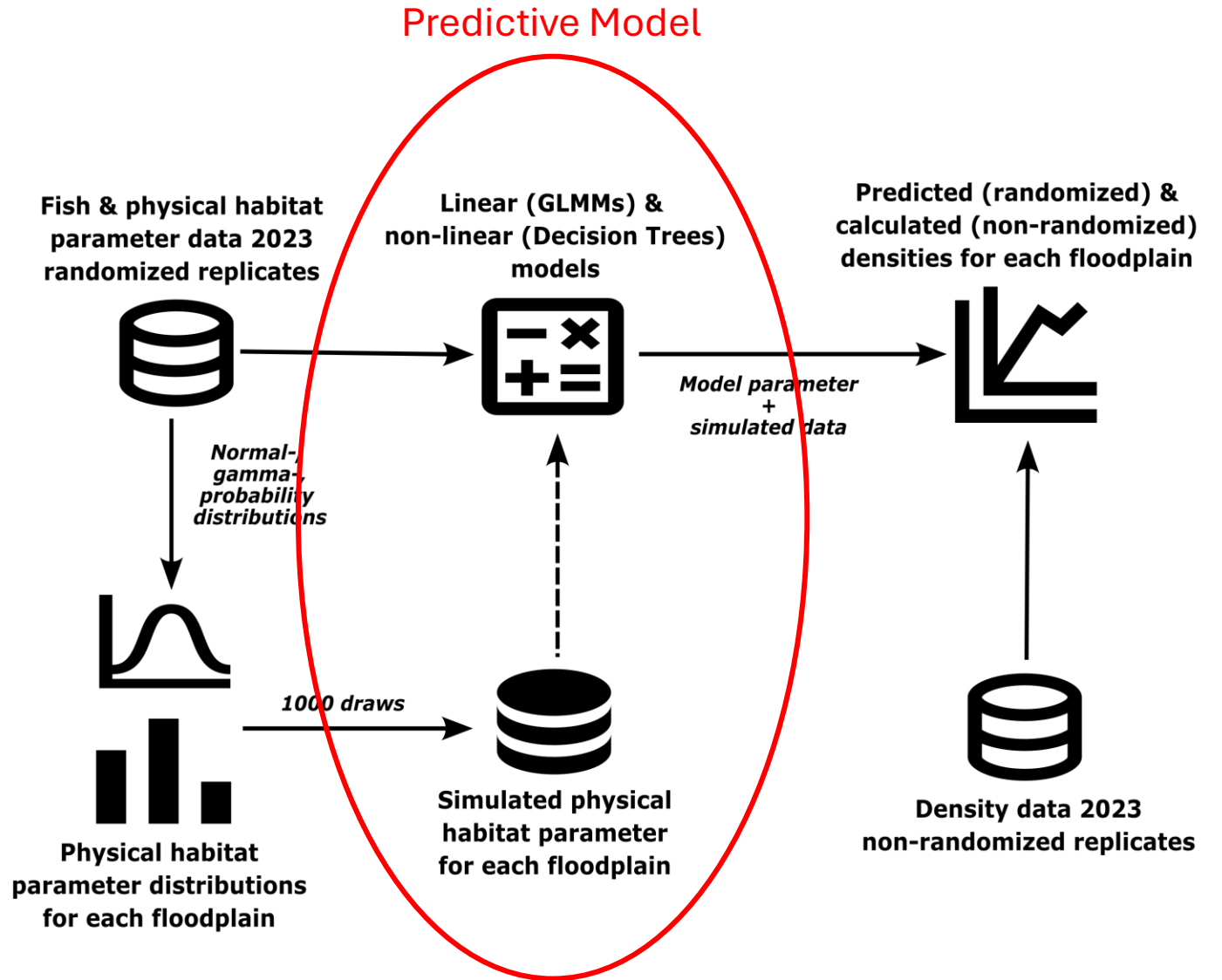


Workflow
Random vs.
Non-
Random

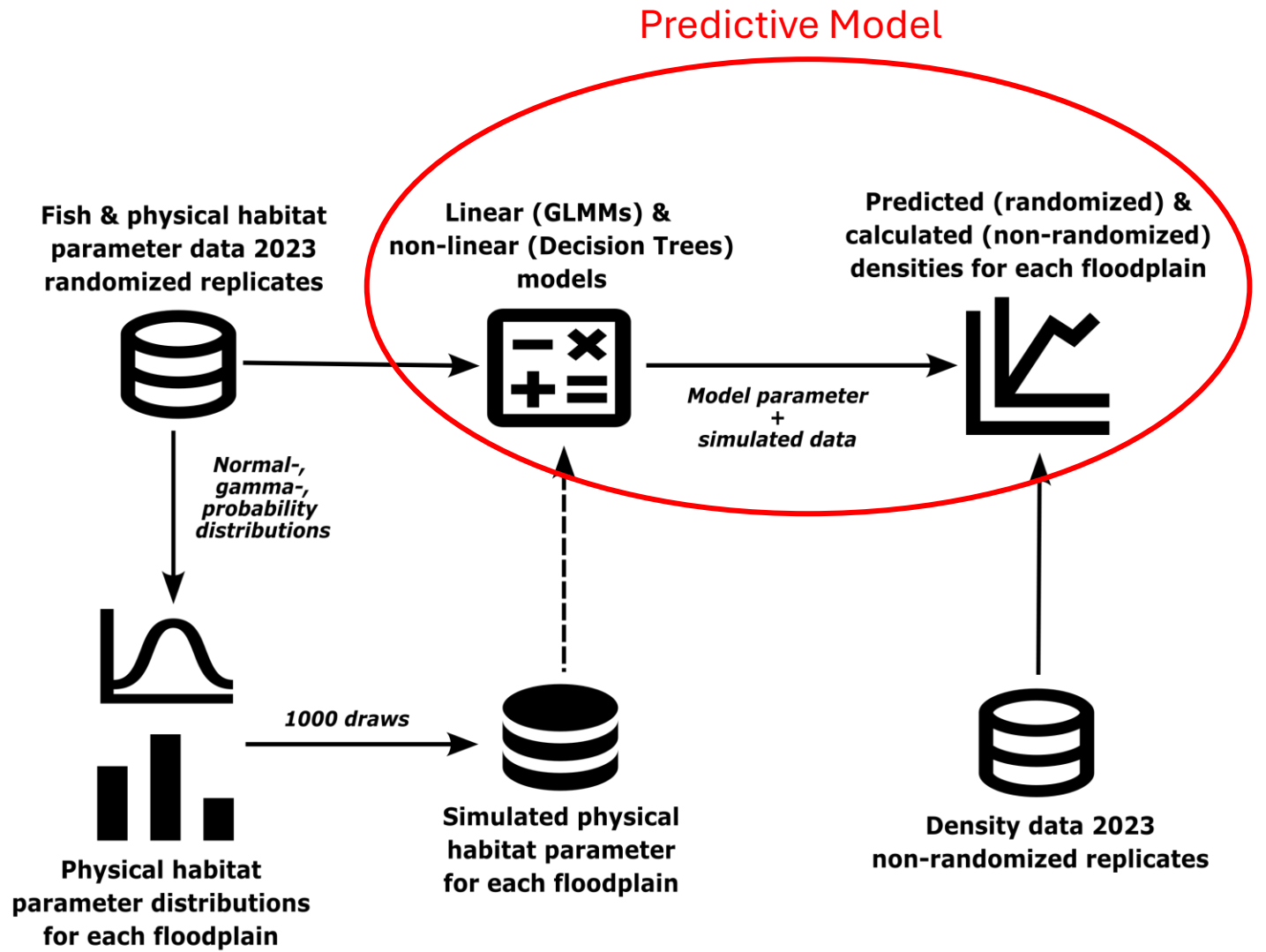


Generate Simulated Data
from Distributions

Workflow
Random vs.
Non-
Random



Workflow
Random vs.
Non-
Random



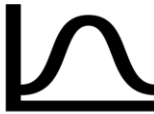
Workflow Random vs. Non- Random

Compare Random
vs. Non-Random

Fish & physical habitat
parameter data 2023
randomized replicates



Normal-,
gamma-,
probability
distributions



Physical habitat
parameter distributions
for each floodplain

1000 draws



Simulated physical
habitat parameter
for each floodplain

Linear (GLMMs) &
non-linear (Decision Trees)
models



Model parameter
+
simulated data

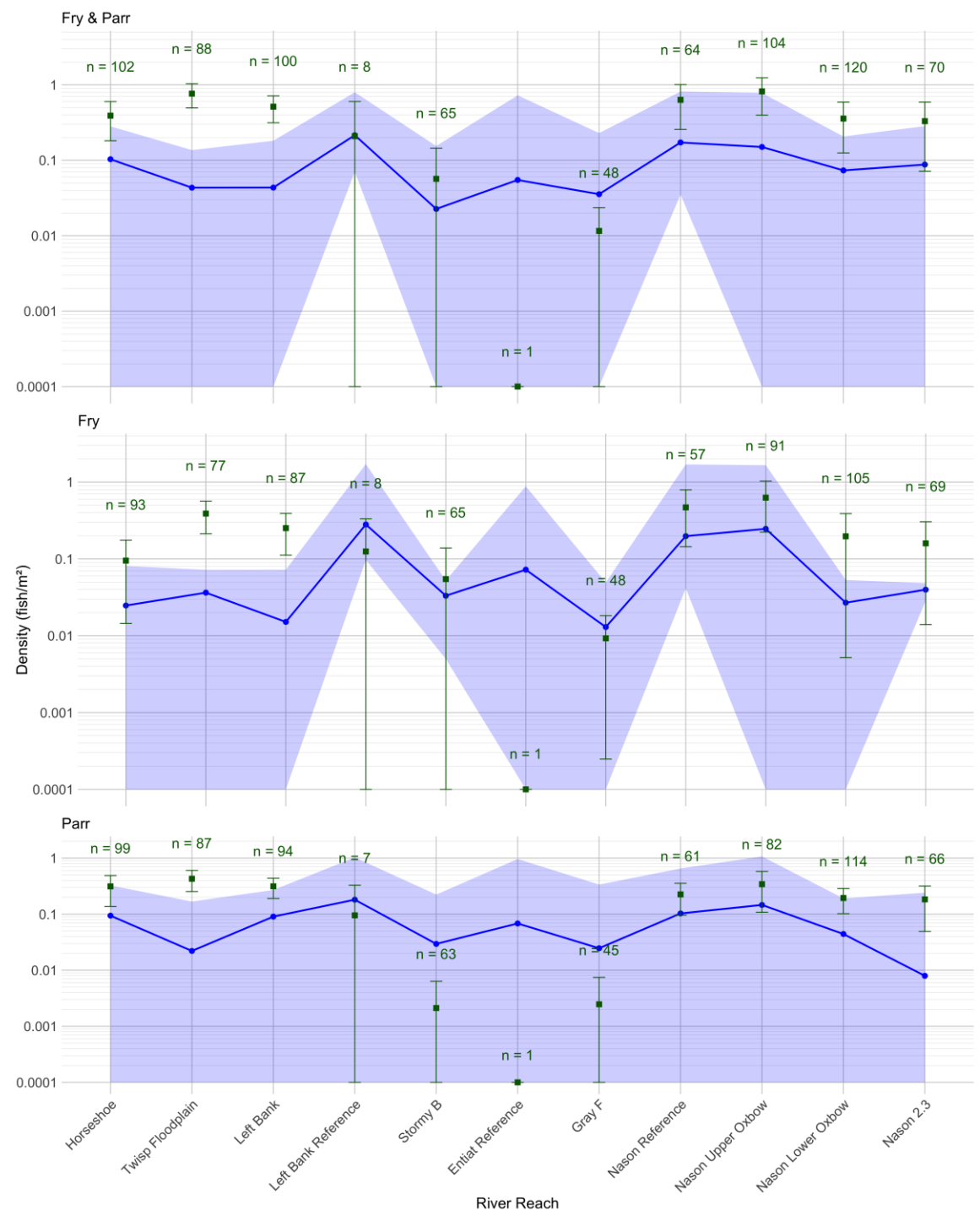
Predicted (randomized) &
calculated (non-randomized)
densities for each floodplain



Density data 2023
non-randomized replicates

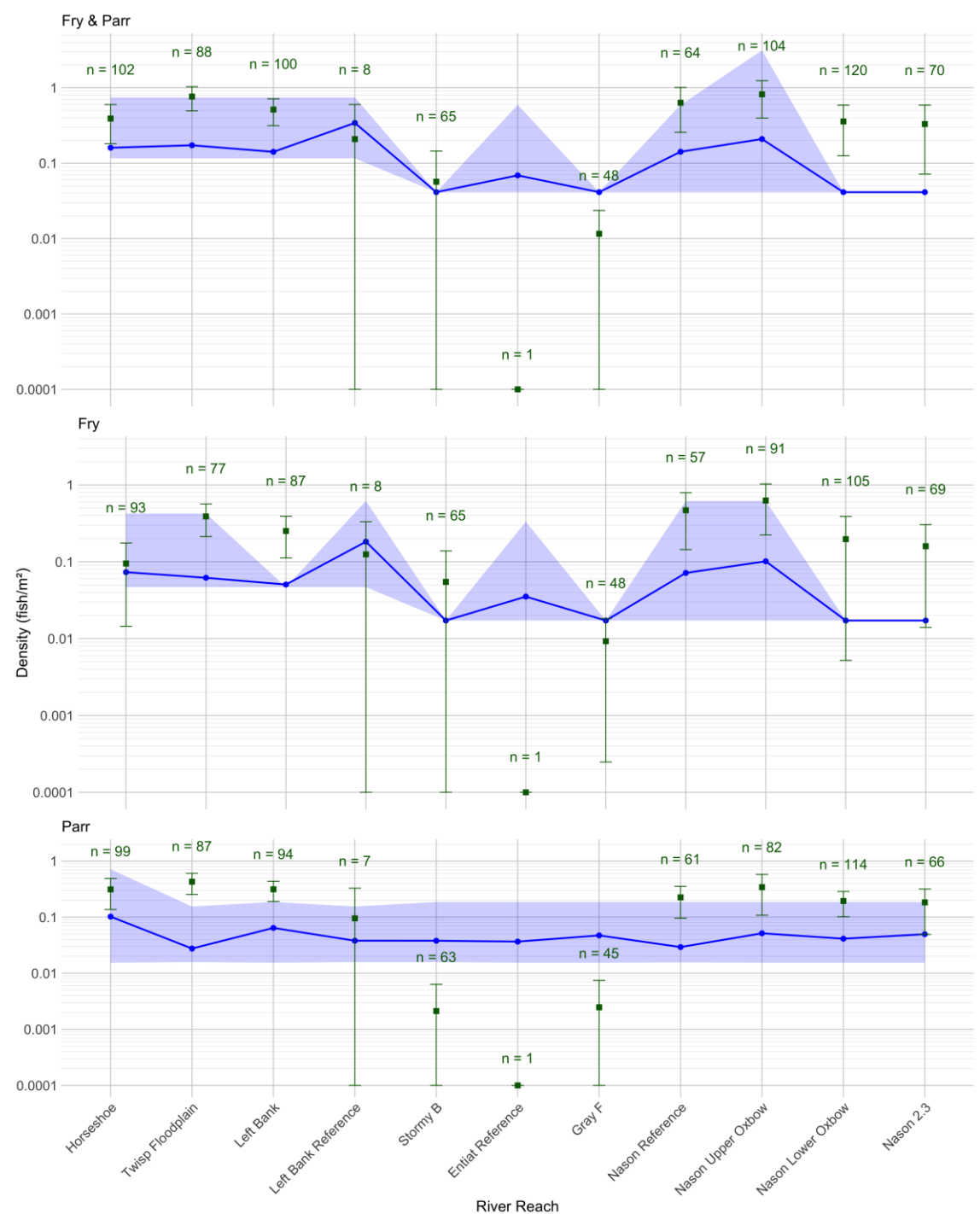
Random vs. Non-Random (GLMM)

- Chinook density predicted using simulated habitat unit data closely matches density measured at non-random sampling units.
 - 95% confidence intervals overlap.
- Non-random samples are representative for Chinook density.

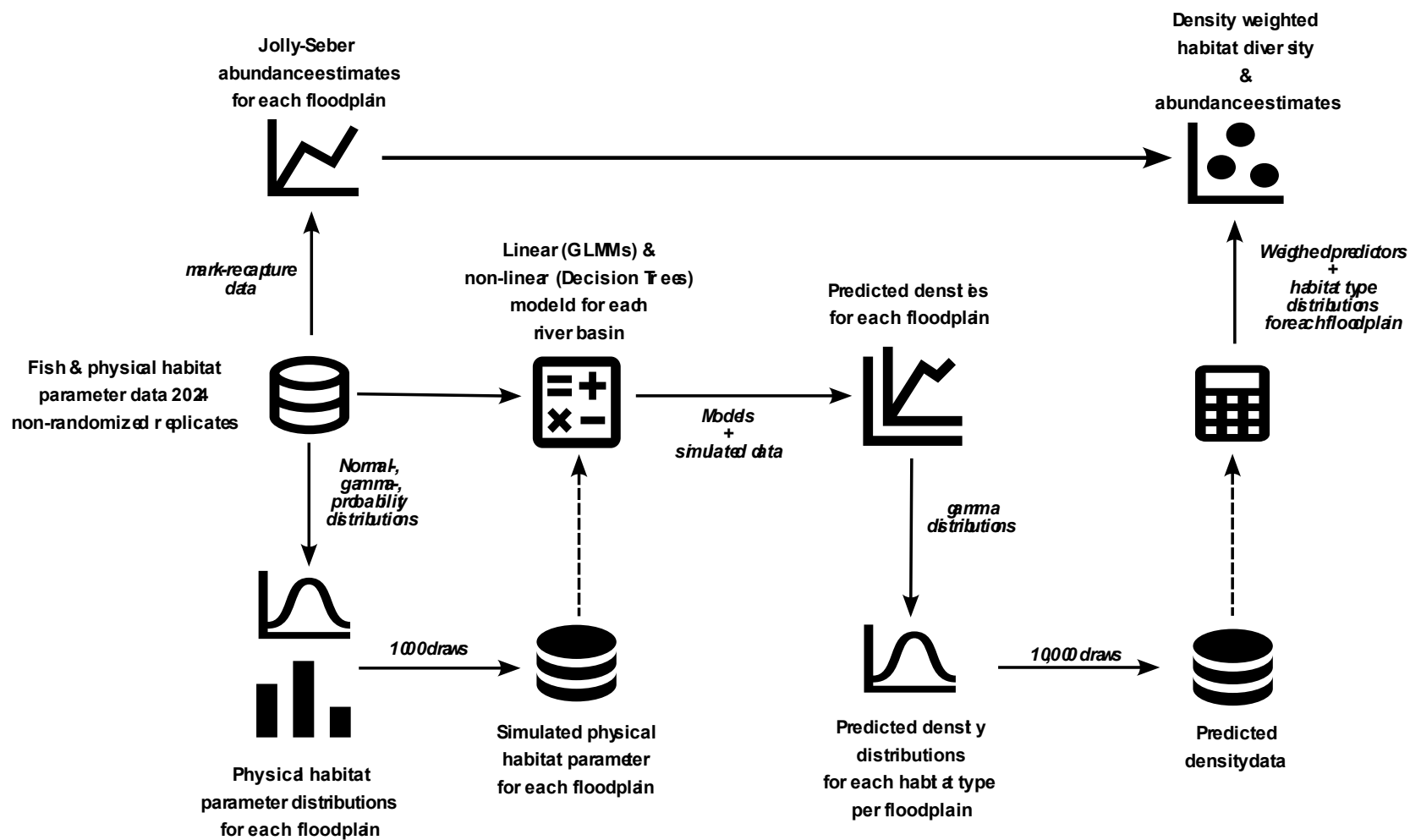


Random vs. Non-Random (Decision Tree)

- Results based on decision trees support results based on GLMMs.

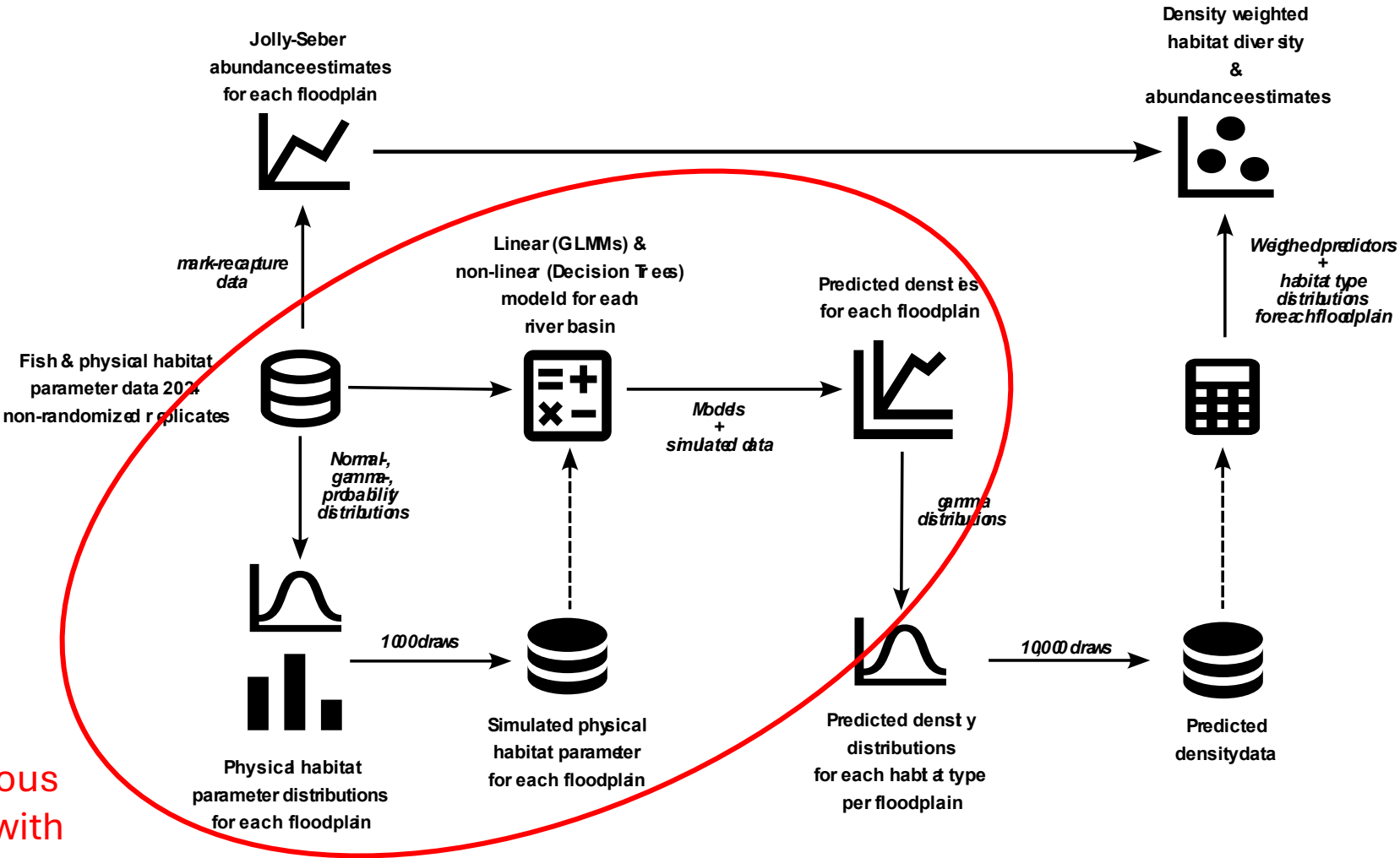


Workflow Density Weighted Habitat Diversity

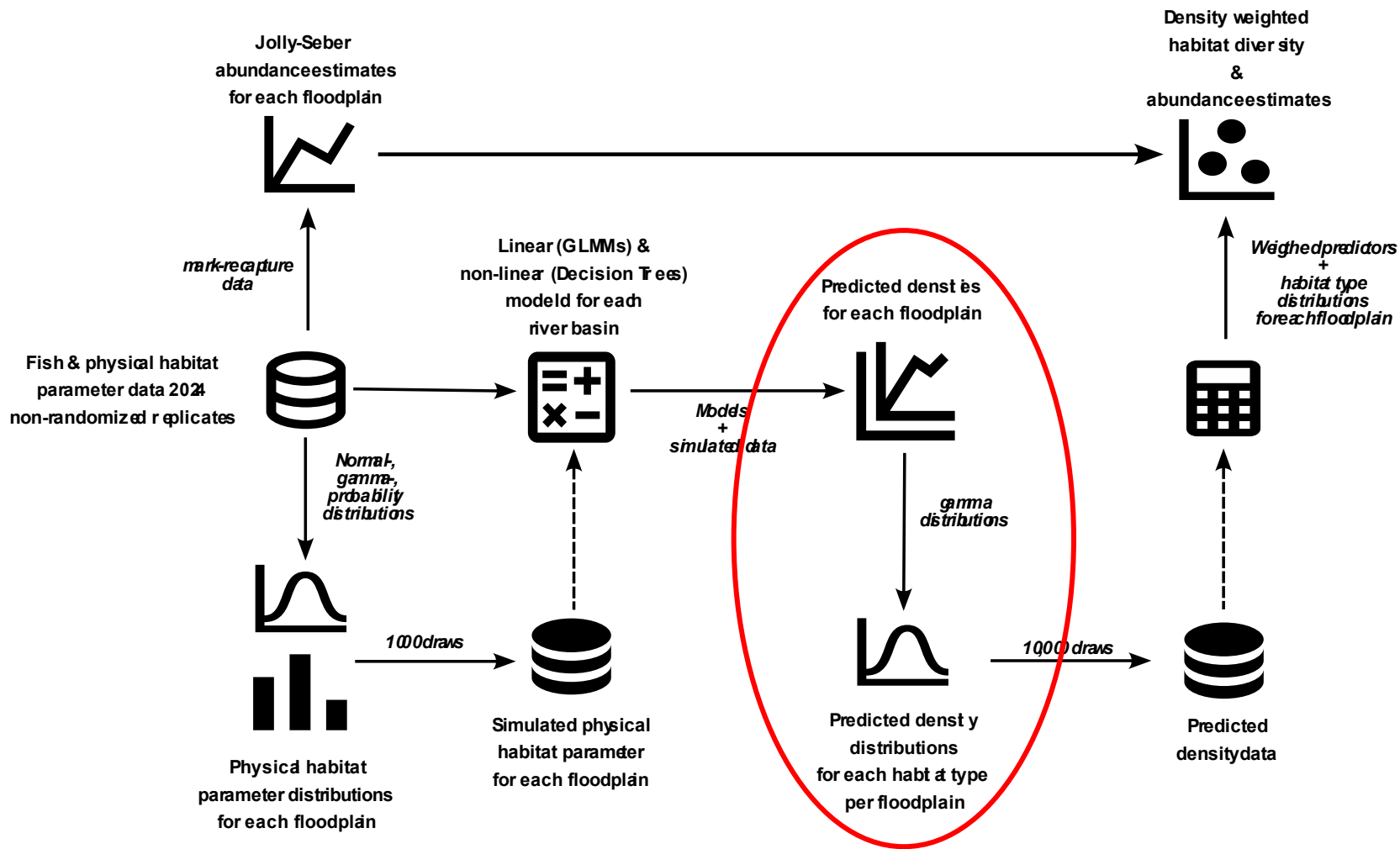


Workflow Density Weighted Habitat Diversity

Same as previous
Workflow but with
2024 Non-Random
Data

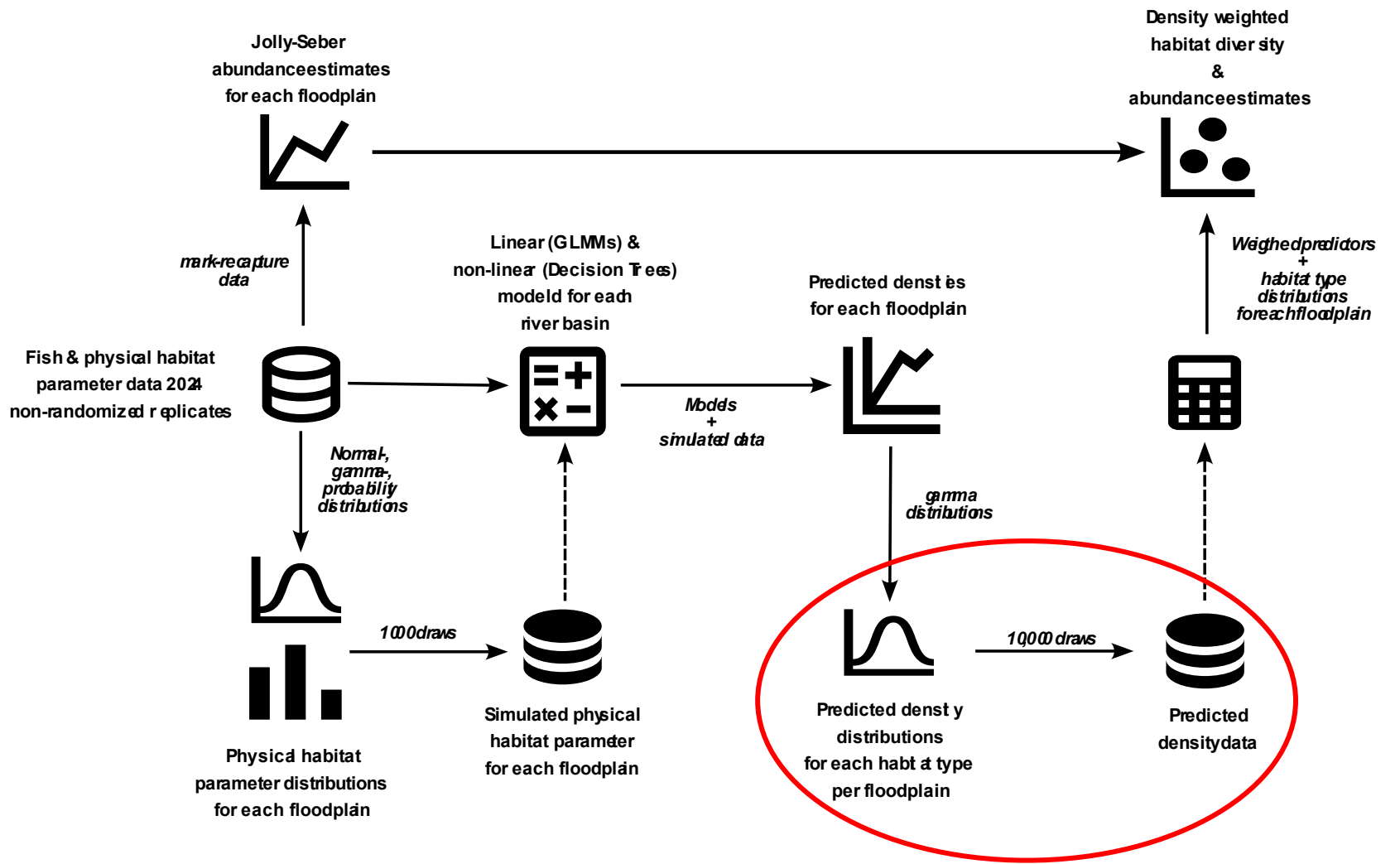


Workflow Density Weighted Habitat Diversity



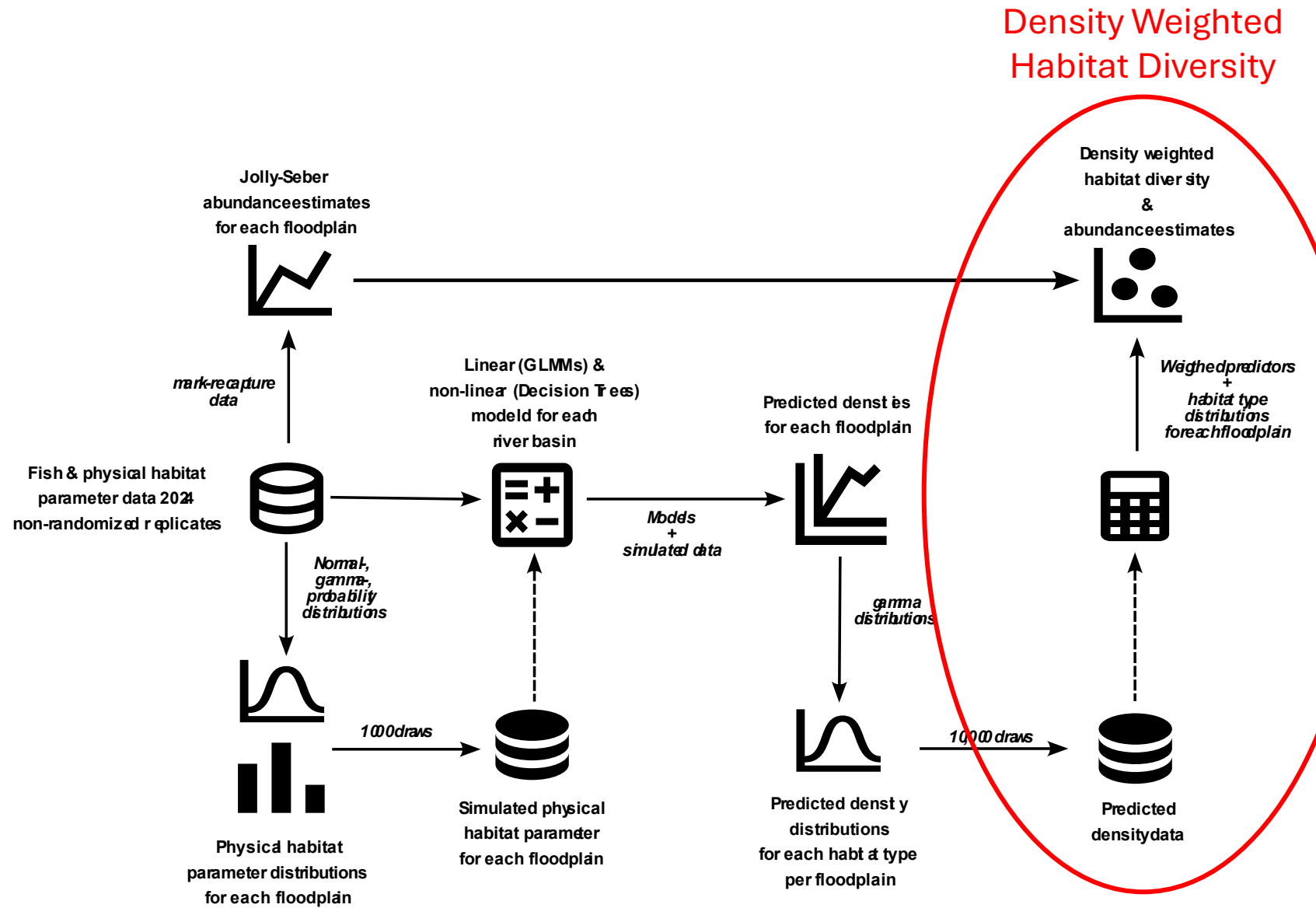
Generate Simulated Data
from Distributions

Workflow Density Weighted Habitat Diversity

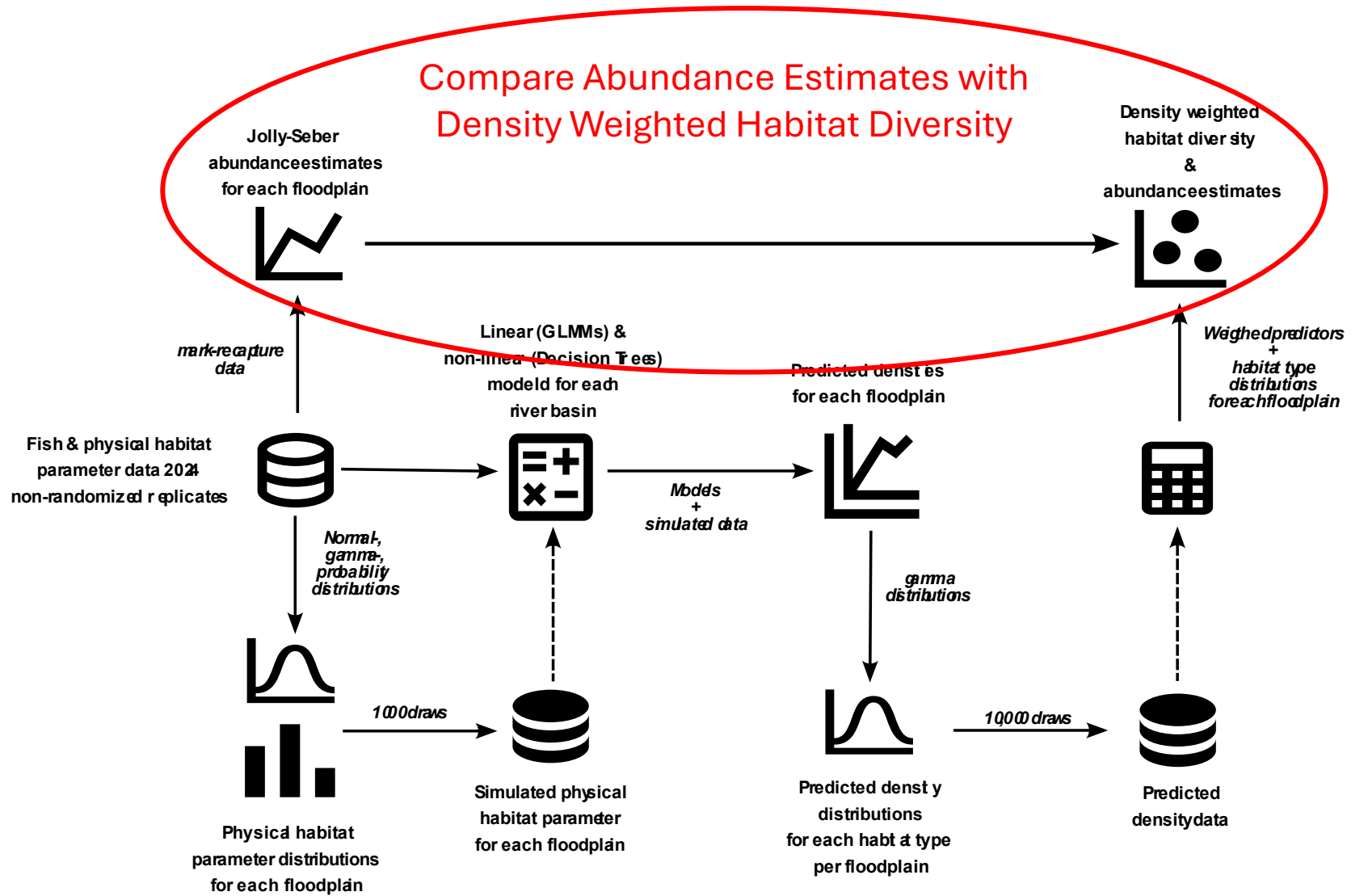


Generate Simulated Data
from Distributions

Workflow Density Weighted Habitat Diversity

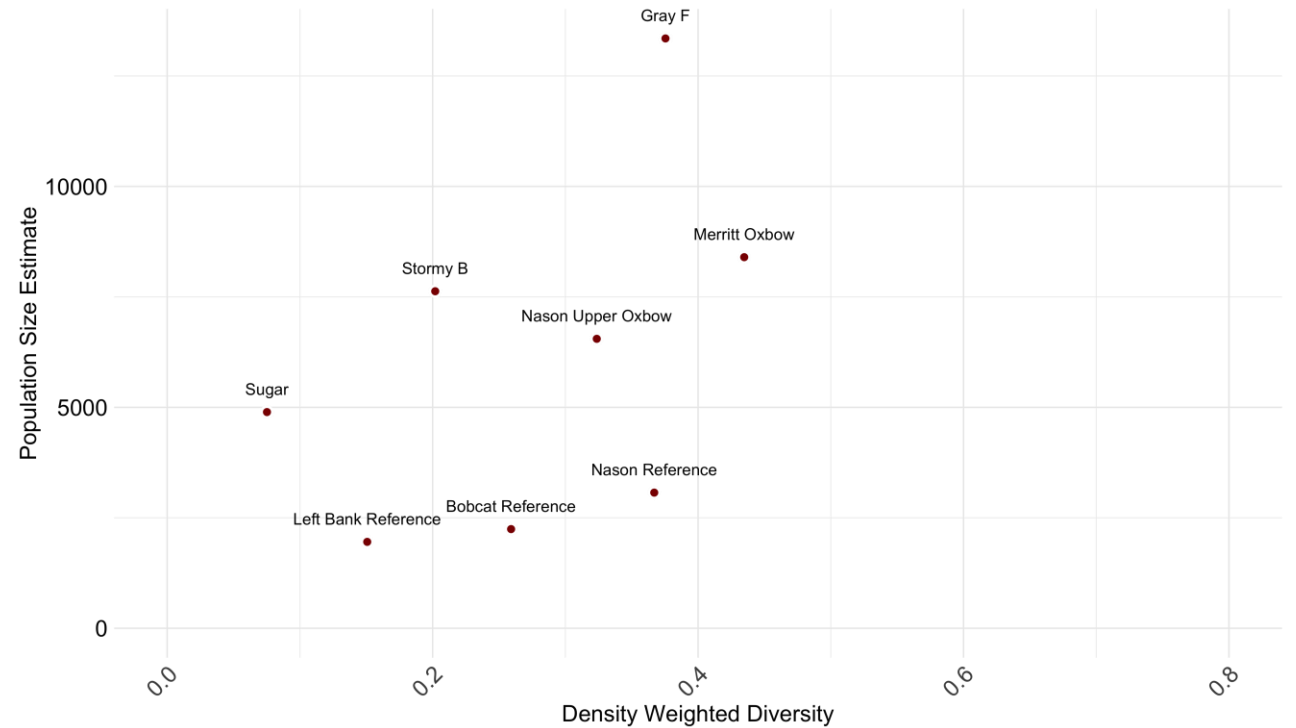


Workflow Density Weighted Habitat Diversity



Density Weighted Diversity (GLMM)

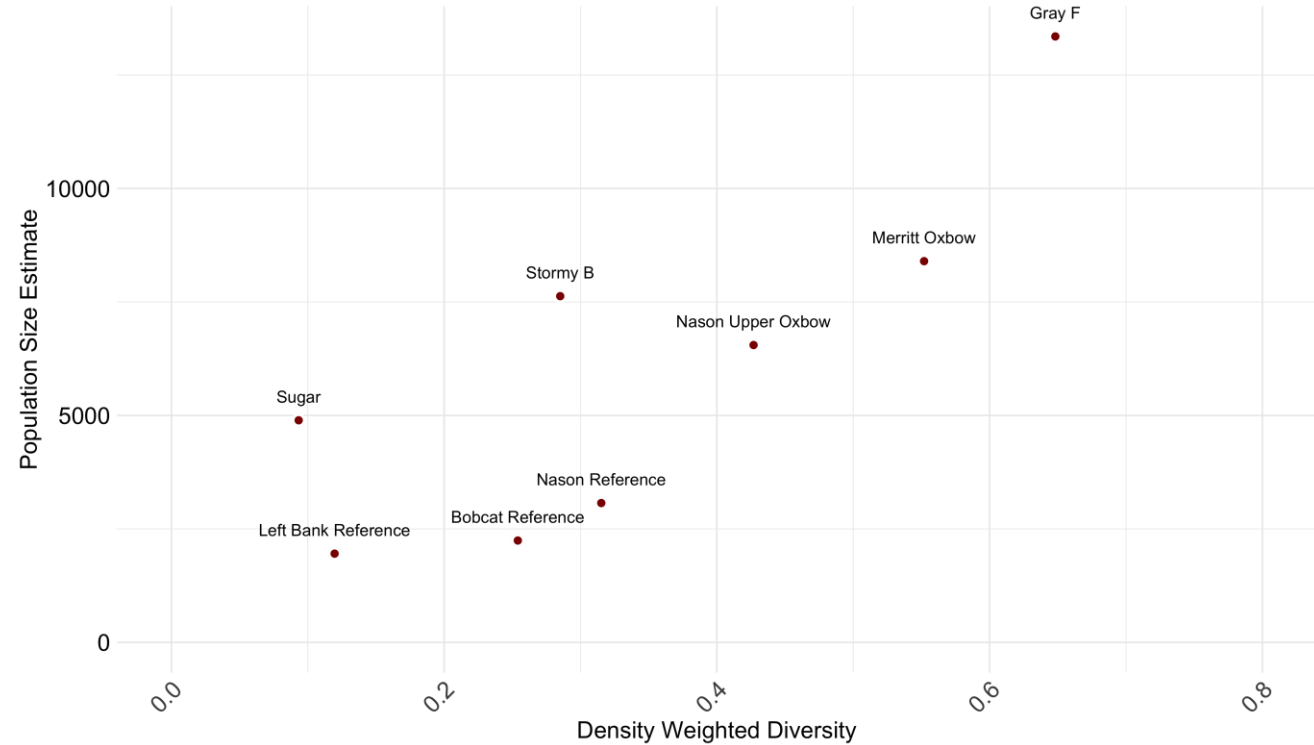
- Density weighted diversity can be used as predictor for reach population size.
 - Higher density weighted diversity correlates with higher population sizes.



Density Weighted Diversity (Decision Tree)

- Restored reaches show higher density weighted diversity compared to reference reaches.

➤ Suggests that restoring floodplain conditions is increasing juvenile population



Recapitulation

Field study 2023: random & non-random samples



Simulations: Are non-random samples representative of floodplain Chinook density on floodplains?



Field study 2024: non-random samples



Simulations to estimate habitat diversity for each floodplain



Does **weighted habitat diversity** predict abundance at the population scale?

Conclusions

- Floodplain restoration effects were detected at both **reach** and **population** scales.
- Consistent results across **multiple models** strengthen the conclusions.
- The method is **applicable to short-term data**, unlike many studies that require long-term monitoring.
- **Management implication:** Creating diverse floodplain habitat



Thank you!

- HCP Tributary Committees
- Salmon Recovery Funding Board / WA State RCO
- US Forest Service, PNW Research Station
- Chelan County Natural Resources Department
- Local Partners
- Field Crew

