

Parameterization and Calibration of Models

EES 4760/5760

Agent-Based & Individual-Based Computational Modeling

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Download Models and Data

- Zip File: https://ees4760.jgilligan.org/models/class_22_models.zip
 - Containing:
 - Wood Hoopoe NetLogo model: [Sect20-5_WoodHoopoes.nlogo](#)
 - R Scripts to analyze behaviorspace output:
 - [process_bs.R](#)
 - [analyze_woodhoopoe.R](#)
 - Behaviorspace output:
 - [Sect20-5_WoodHoopoes Calibration-table.csv](#)
 - [Sect20-5_WoodHoopoes Calibration2-table.csv](#)

Vocabulary:

- **Parameterization:**
 - For many modelers, this means choosing values for parameters.
 - More parameters = more uncertainty (bad)
 - Value parsimony
 - For ABMs, it's different:
 - Many submodels
 - Parameterize and test submodels separately
- **Calibration**
 - A special kind of parameterization
 - Adjust a few important parameters to reproduce patterns observed in real system

Testing and Calibrating

- Test program: Has it been implemented correctly?
- Test submodels: Are they doing what you think they are doing?
- Verification: Is the model doing what it's supposed to do?
 - Reproduce patterns, data, observations.
- Understanding: What's going on? Why?
- Validation: Can we find new (independent, secondary) patterns in the model that we can test against new observations?

Theoretical Models

- No data to calibrate from
- “Guesstimate” parameter values from what you do know.
- Perform sensitivity analysis to see how important it is to “get parameters right”

Challenge

- Model and system are complex
 - We don't know exactly what model is "supposed to do"
- Any pattern in the output could be a *bug* or a *feature*
- Brute-force analysis does not work (you can't try every possible value of each parameter)
- **We need a plan!**

Master plan for analysis

Controlled Simulation Experiments

- Controlled = simplify
 - If I kill all individuals, population should be 0
 - If I double mortality rate, population should decrease

First experiments

- Explain your model to others
- Ask others to look at your model and code
- Graphical, numerical output of entities and state variables
 - Monitors, graphs, print output, save output to a file
 - Use NetLogo inspect feature (right click on a patch or turtle)
- A step button to execute one step at a time
- See what happens

Test submodels separately

- Create a separate testing model
- Make a controlled environment for your submodel
- For research: Document your testing, keep notes and files

Patterns

- Low-level debugging (one line of code at a time) is too slow
- To speed things up, focus on **patterns**
- Analysis means:
 - Tuning parameters,
 - Turning submodels on and off
 - Observe how patterns change.
- Examples:
 - Population after 48 days
 - Total biomass
 - Variance of turtle size
 - Spatial patterns: are turtles bunched up or spread out?
 - etc.

Categorical vs. Best Fit

- Best-fit: Numerical data, minimize difference.
 - Best when many real world systems always have same values.
- Categorical:
 - True/False, or ranges of values
 - Best when real-world system has a lot of variation

Don't panic!

- Finding good patterns to use is **hard**.
- You might need to test many patterns
- You will need multiple patterns
- It is hard work, but it can be fun
- Just as with real experiments, it is important to think creatively.

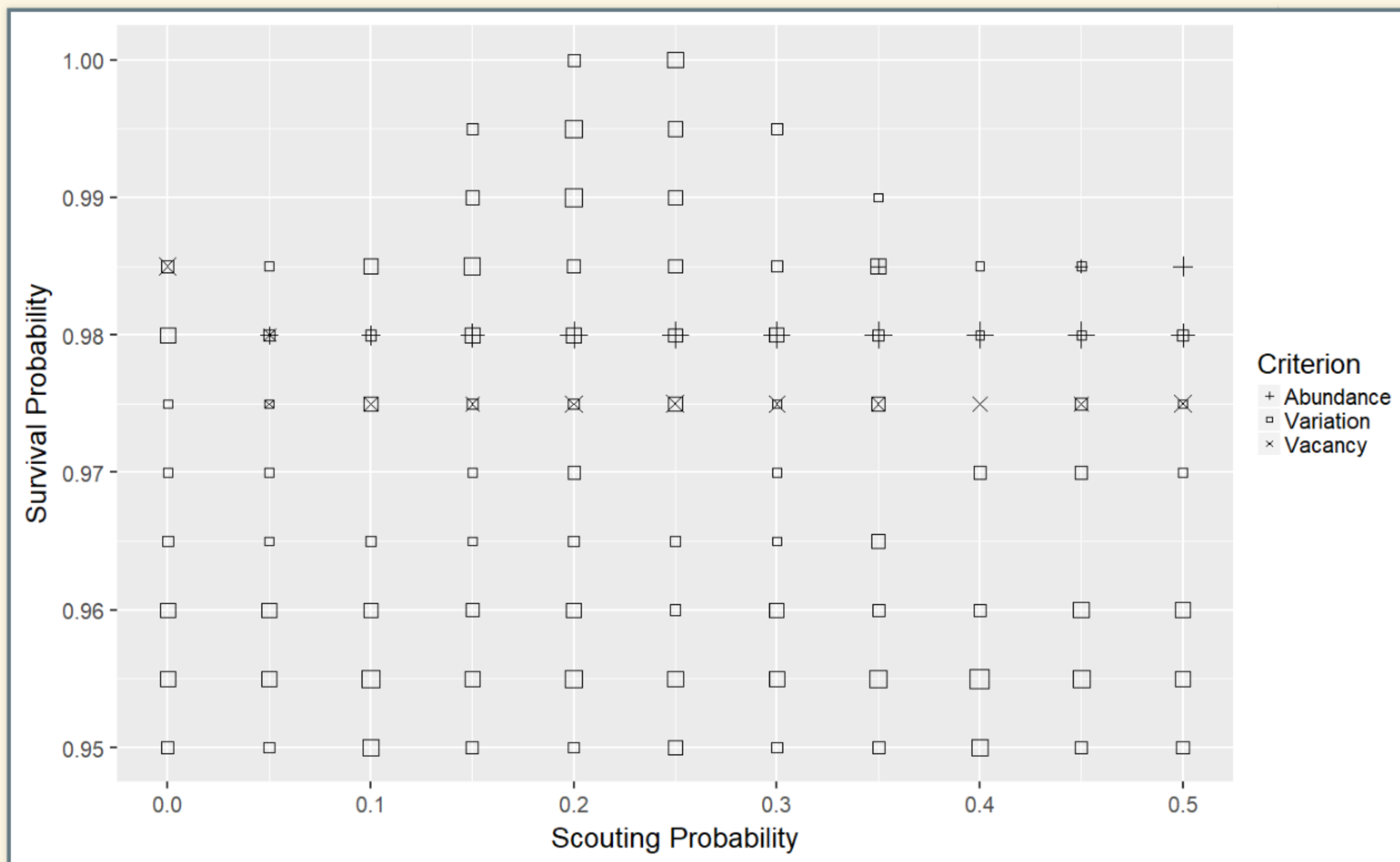
Example: Woodhoopoe Model

- Use “random scouting” submodel
- Parameters:
 - Survival probability (mortality)
 - Scouting probability (*can't be directly measured in real world*)
- Calibration Criteria
 - Variation in real groups, so *we're not trying to reproduce a specific value.*
 - Categorical calibration
 - Three patterns from field observations:
 1. **Abundance:** Total population in range 115–135 (25 patches)
 2. **Variation** Standard deviation of population from one year to next in range 10–15
 3. **Vacancy** On average, 15–30% of patches missing one or both alphas.

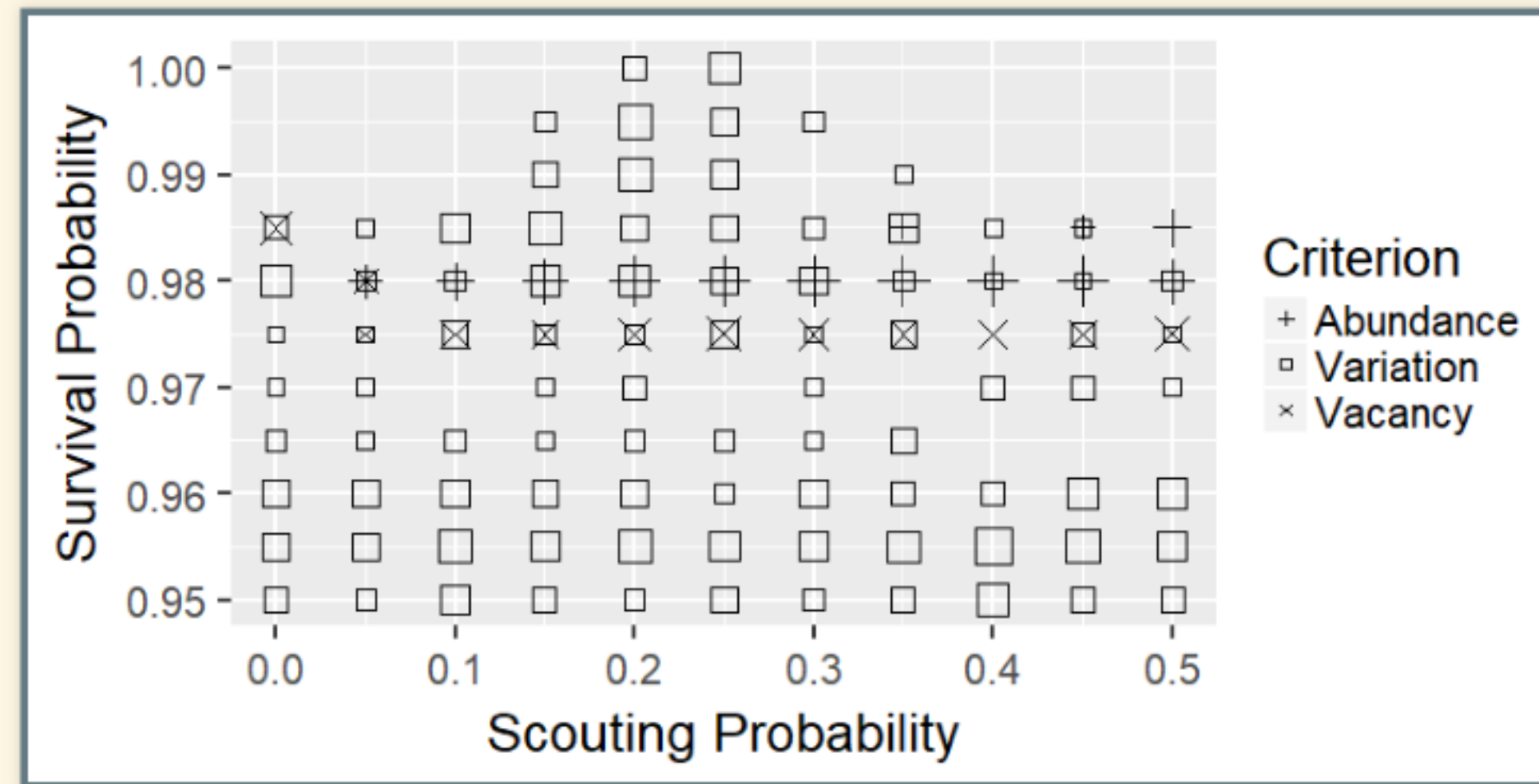
https://ees4760.jgilligan.org/models/class_23/Sect20-5_WoodHoopoes.nlogo

Behaviorspace Experiment

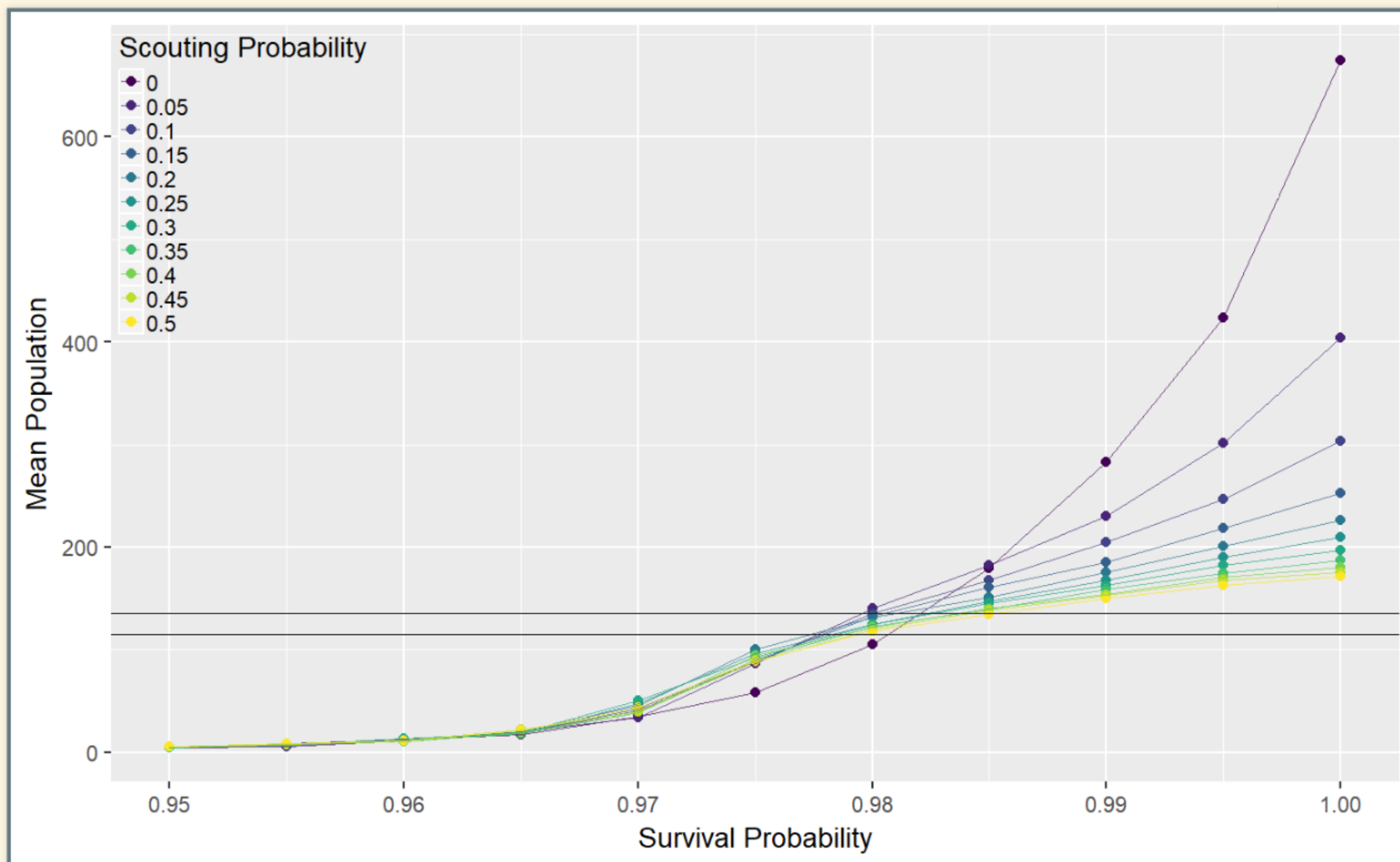
- Monitor `count turtles` and `count patches with [(count turtles-here with [is-alpha?]) < 2]`
- Run for 22 years (264 ticks)
- Vary `scout.prob` from 0.0–0.5 by 0.05
- Vary `survival.prob` from 0.95–1.00 by 0.005
- 121 combinations
- Analyze behaviorspace output file:
 - Throw away first two years (warm-up)
 - Look at month 11 (November, just before breeding)



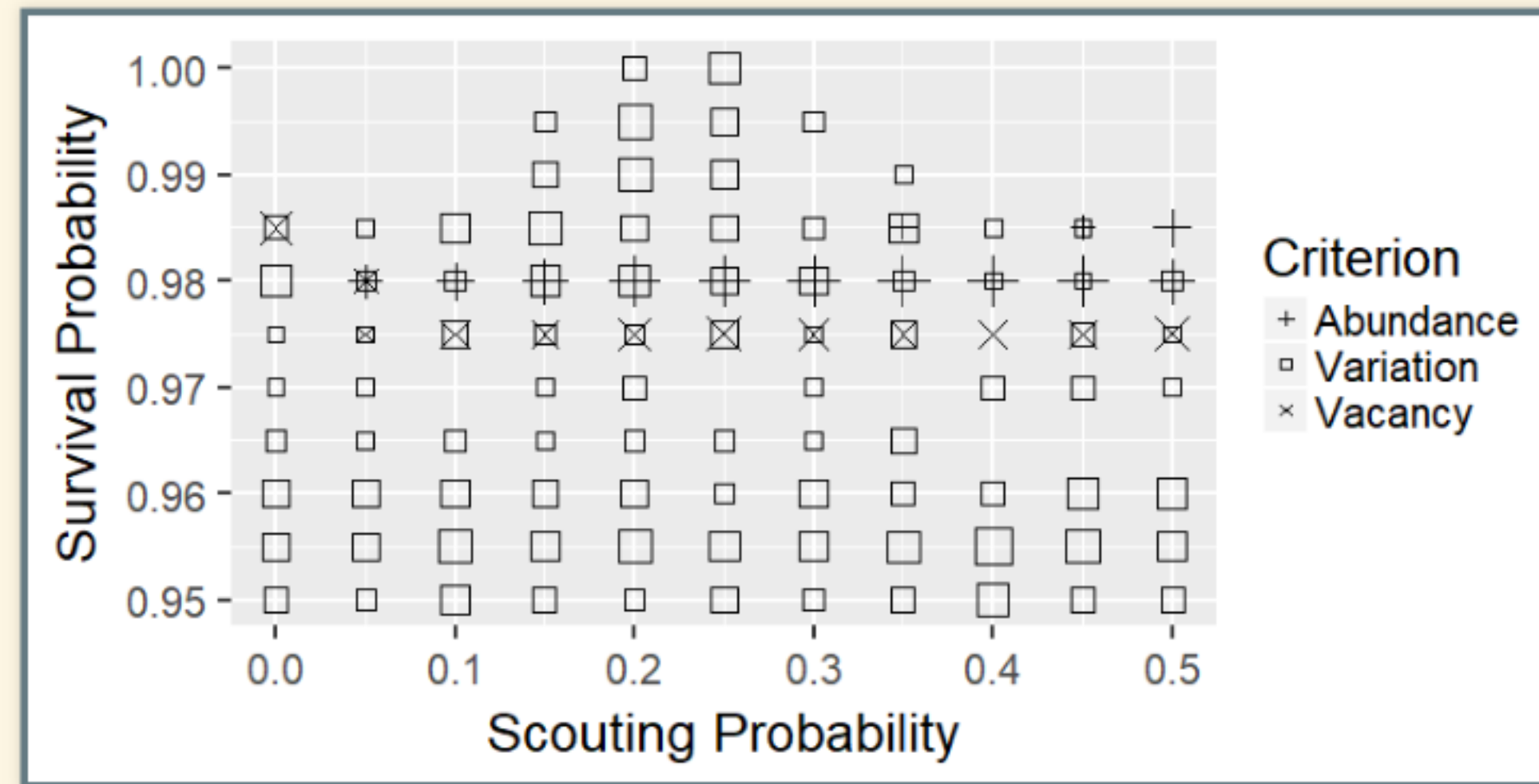
Interpreting results



- A few combinations reproduce all three patterns.
- Abundance pattern only for `survival.prob = 0.975–0.985`
- Vacancy pattern only for `survival.prob = 0.975–0.990`

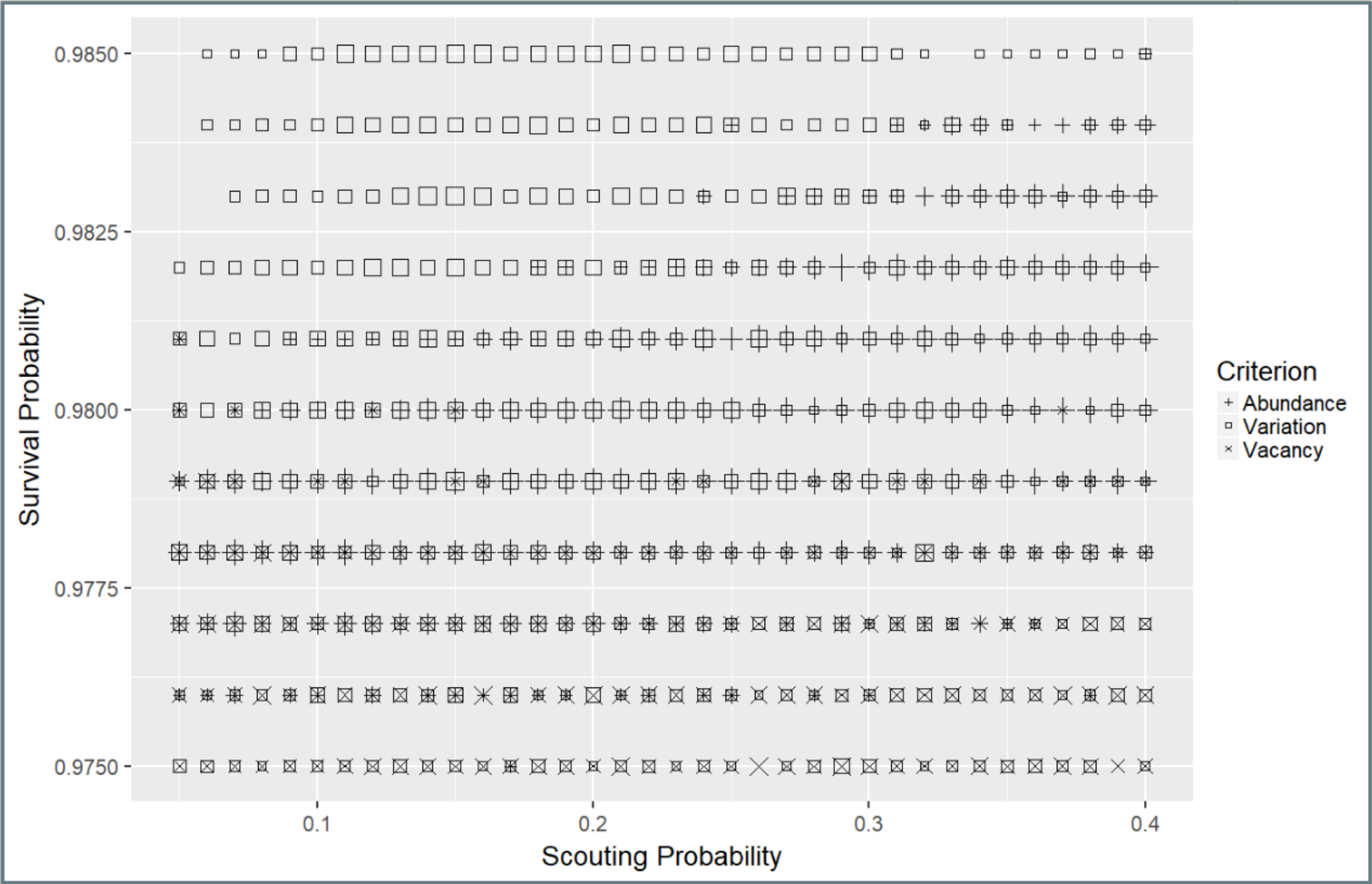


Next steps



- Explore region near `survival.prob` ~ 0.975 – 0.985 and `scout.prob` ~ 0.05 – 0.40
- Try changing scouting submodel.

Detailed Calibration



Satisfying All Three Criteria

