Parameterization and Calibration

EES 4760/5760

Agent-Based and Individual-Based Computational Modeling

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Class #22: Wednesday, November 06 2024

Download new Wood Hoopoe model

- class_22_models.zip from the downloads page
- or https://ees4760.jgilligan.org/models/class_22/Sect20-5_WoodHoopoes_2ndEd.nlogo

Vocabulary:

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- **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

Theory-Development vs. Parameterization/Calibration

- **Theory Development:**
  - Develop different submodels for agent behavior & decision-making
  - Identify the submodels that best reproduce a range of observed patterns
- **Parameterization and Calibration:**
  - With a given submodel,
    - Decide which parameters to vary and which to leave fixed
    - Choose values for the fixed parameters
    - Find the values for the variable parameters that best reproduce observed patterns

Testing and Calibrating

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

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

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

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 but there are *distinct patterns*

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

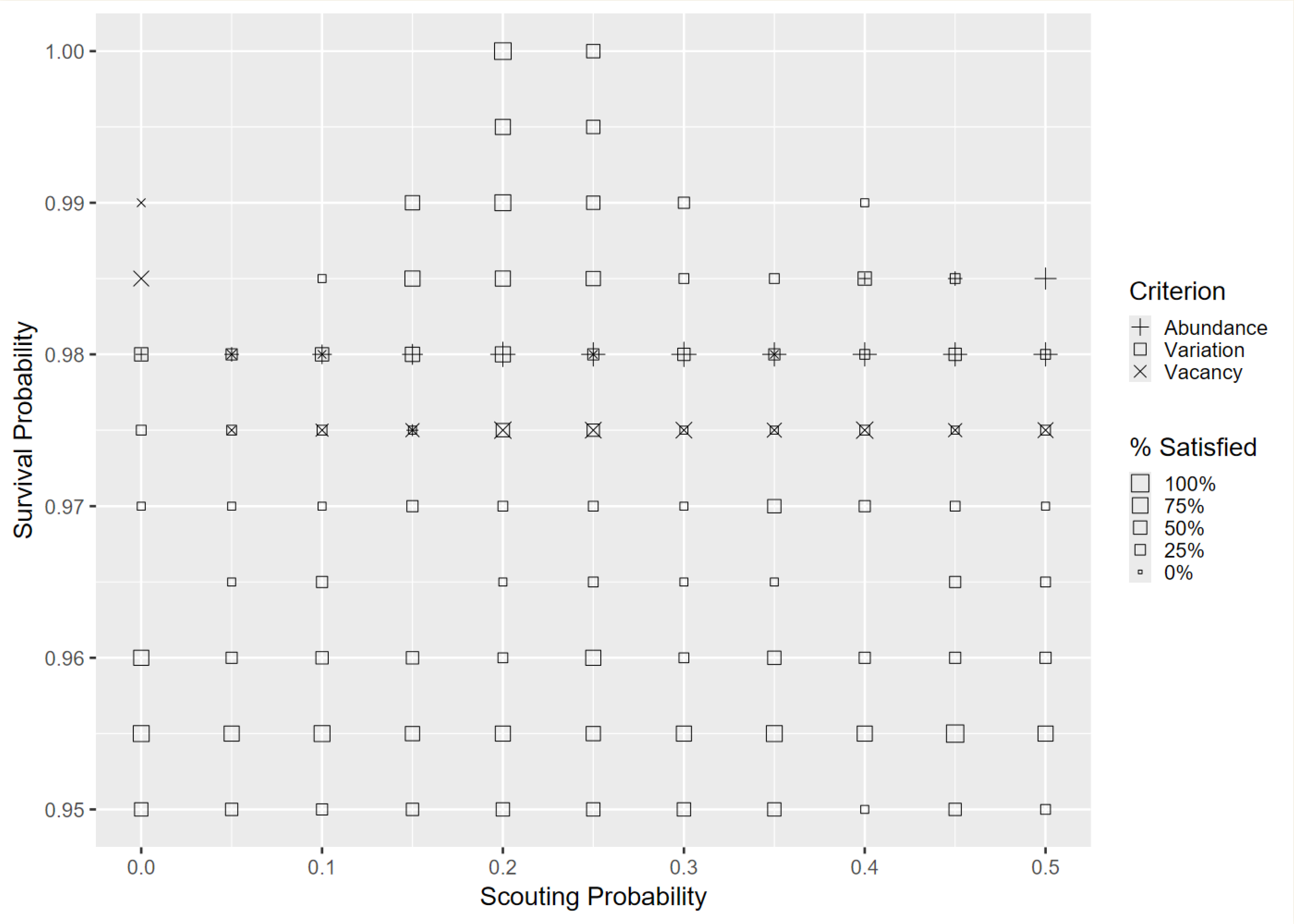
Example: Woodhoopoe Model

- 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.

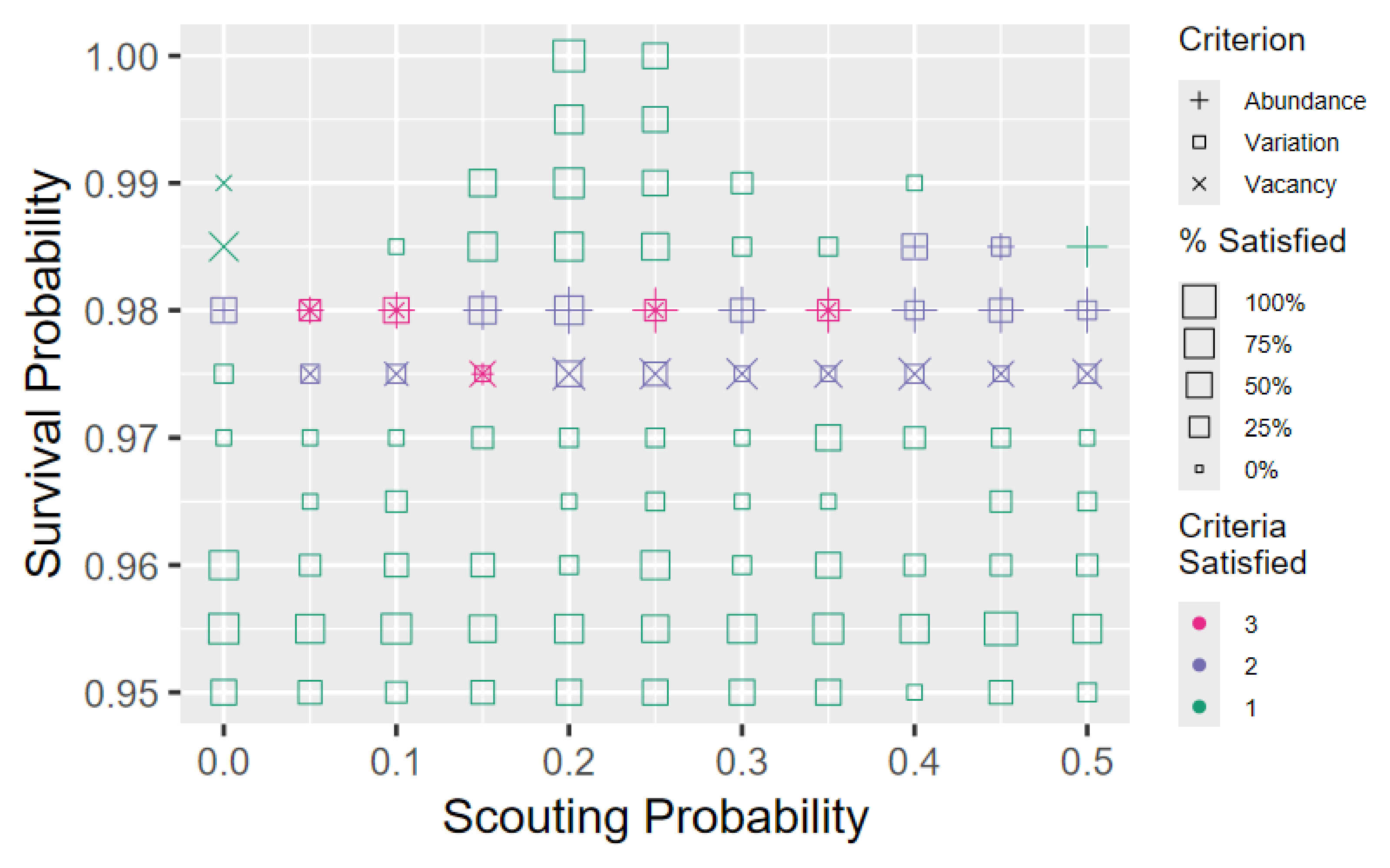
https://ees4760.jgilligan.org/models/class_22/Sect20-5_WoodHoopoes_2ndEd.nlogo

Behaviorspace Experiment

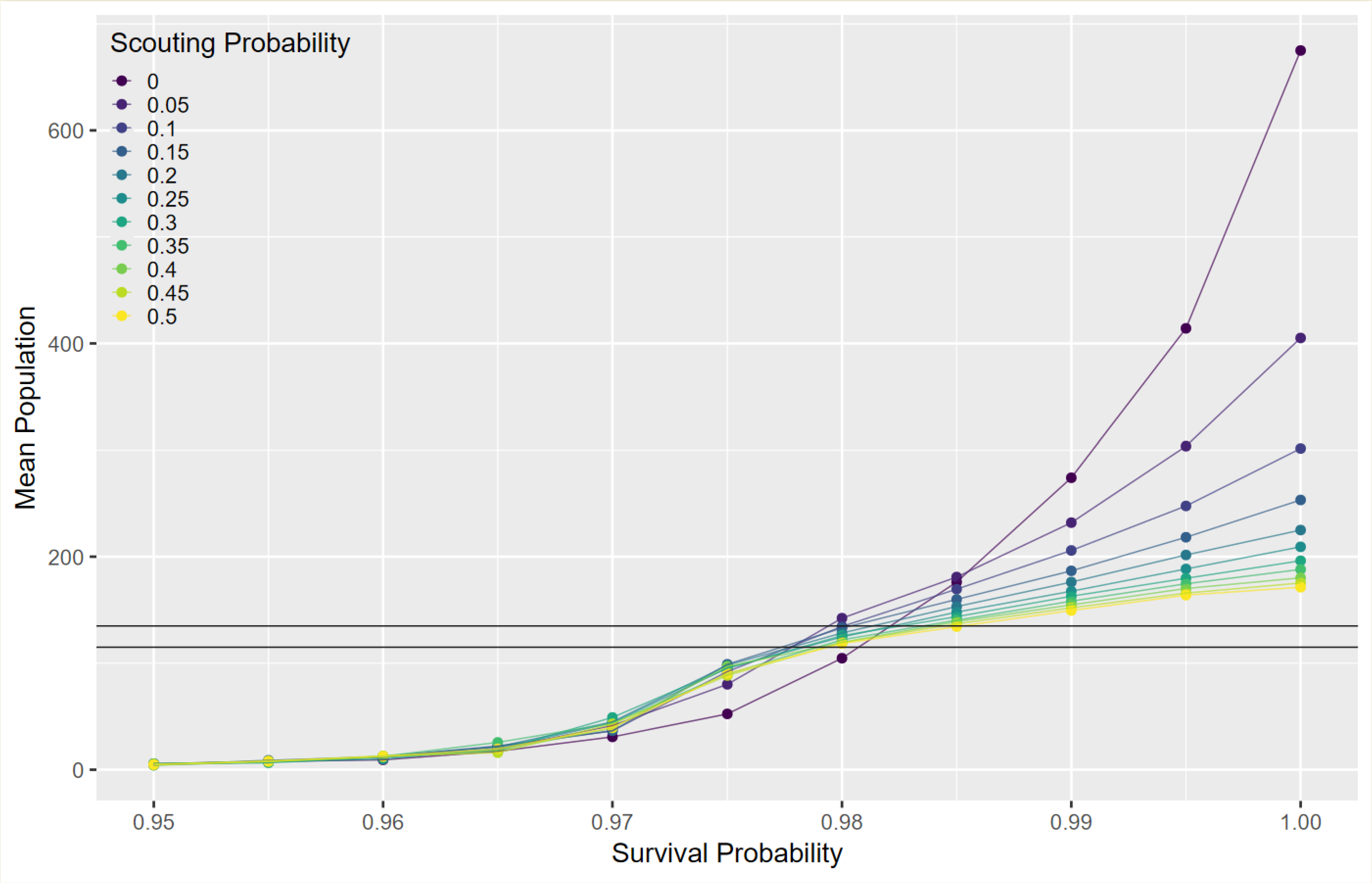
- Monitor
  - `count turtles` and
  - `count patches with [(count turtles-here with [is-alpha?]) < 2]`
- Run for 22 years (264 ticks)
- Vary `scout.prob` from 0.0–0.5 by 0.05
- Vary `survival.prob` from 0.95–1.00 by 0.005
- 121 combinations
- Analyze behaviorspace output file:
  - Throw away first two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


1.00
0.99
0.98
0.97
0.96
0.95
Survival Probability
0.0
0.1
0.2
0.3
0.4
0.5
Scouting Probability
Criterion
Abundance
Variation
Vacancy
% Satisfied
100%
75%
50%
25%
0%

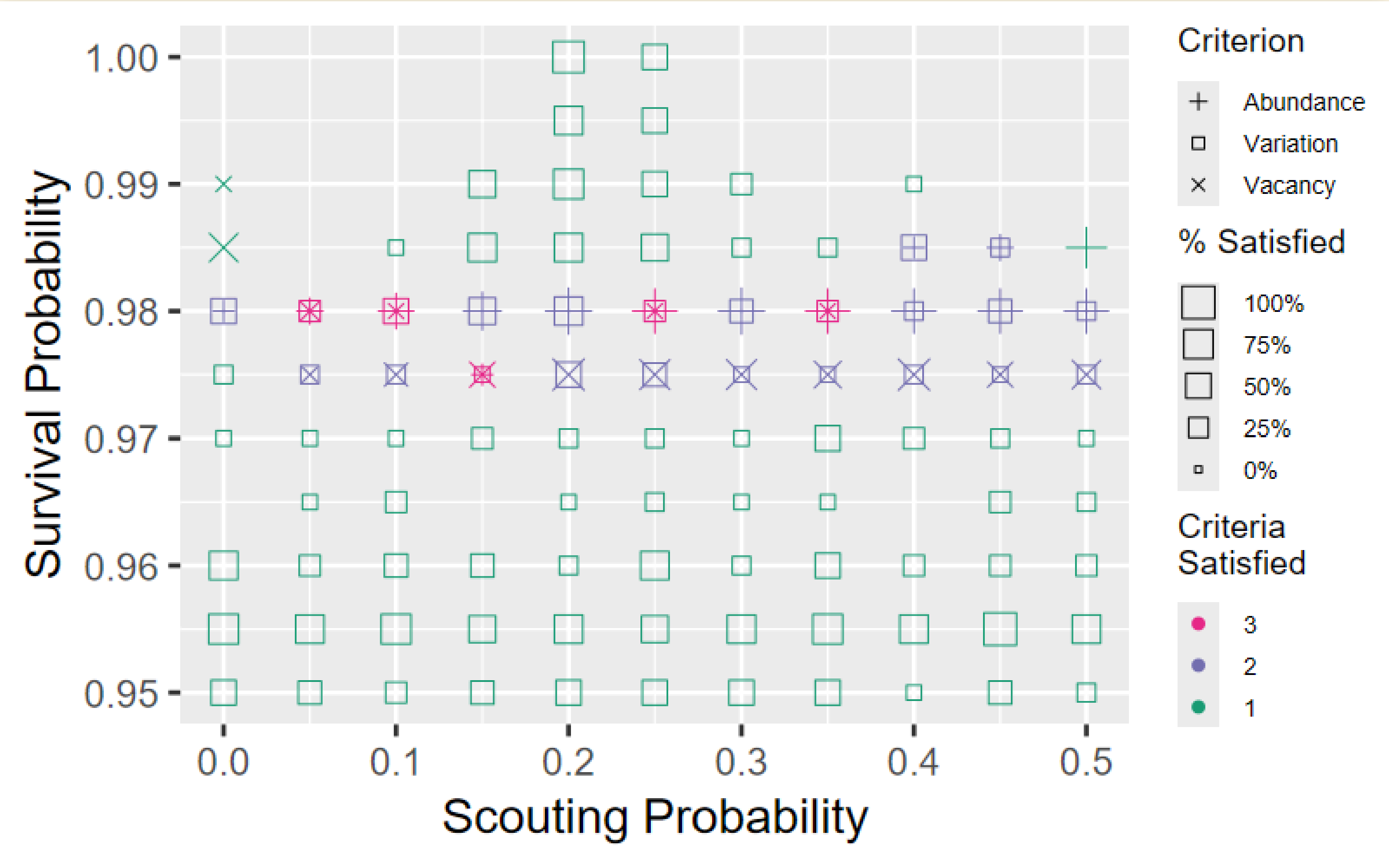
Interpreting results



- 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

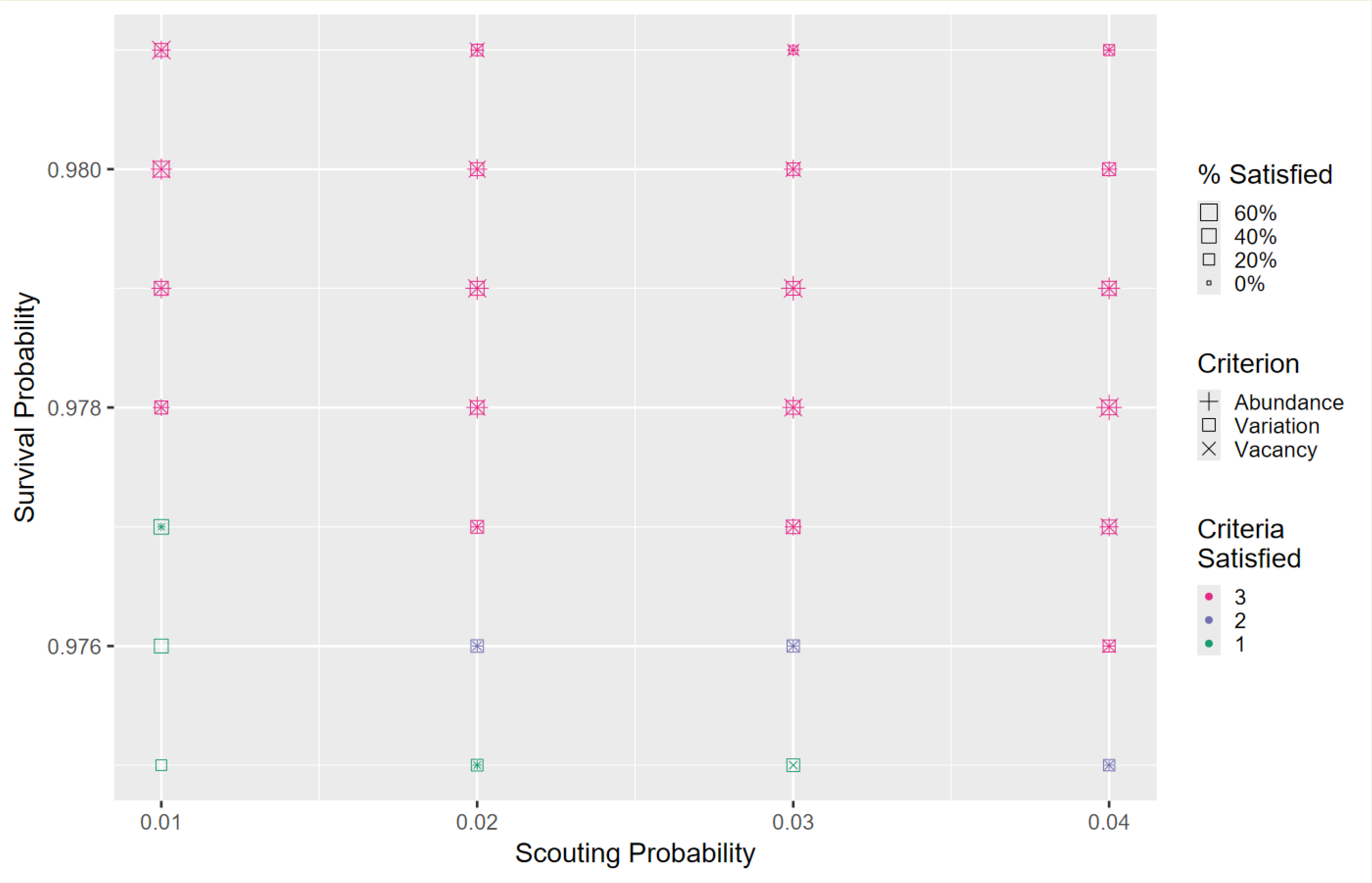

Scouting Probability
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5
Mean Population
600
400
200
0
0.95
0.96
0.97
0.98
0.99
1.00
Survival Probability

Next steps



- Explore region near `survival.prob` ~ 0.975–0.985 and `scout.prob` ~ 0.01–0.40
- Try changing scouting submodel.

Detailed Calibration



Satisfying All Three Criteria