ECOLOGICAL SAMPLING: NEW METHODOLOGIES TO DEFINE THE STRATA BOUNDARY POSITIONS AND SAMPLE EFFORT ALLOCATION USING INFORMATION ON SPECIES DISTRIBUTION AND ECOLOGICAL VARIABLES.

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Main question: Species, how many and where?

Problem: Often based on practical and convenient sampling issues

Intuitive: Best design is based on species distributions
New Idea:

Do not predefine and fix the number of strata, boundary positions or sampling effort allocation, create an adaptive strategy based on species distributions and other variables.

Assumption:

Best design is based on species distributions.
Create 30 by 30 grid sampling area

Species → Boundary → Sample

Strata boundary positions
Number of strata
Allocation sampling effort

Neyman Allocation

X200
All possible boundary combinations
X 10
EFFECT BOUNDARY POSITION: PRECISION

Uniform distribution

Exponential distribution
EFFECT BOUNDARY POSITION:
ACCURACY

Uniform distribution

Exponential distribution
EFFECT NUMBER OF SAMPLES & NUMBER OF SPECIES

Effect sampling intensity

Effect number of species
**EFFECT NUMBER OF STRATA**

The table below shows the percentage of plots sampled at different positions for various distributions:

<table>
<thead>
<tr>
<th>% plots sampled</th>
<th>linear distribution</th>
<th></th>
<th>half normal distribution</th>
<th></th>
<th>exponential distribution</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5%</td>
<td>15%</td>
<td>25%</td>
<td>5%</td>
<td>15%</td>
<td>25%</td>
</tr>
<tr>
<td># species</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100</td>
<td>2%</td>
<td>0%</td>
<td>-1%</td>
<td>-1%</td>
<td>1%</td>
<td>0%</td>
</tr>
<tr>
<td>300</td>
<td>2%</td>
<td>1%</td>
<td>1%</td>
<td>2%</td>
<td>2%</td>
<td>2%</td>
</tr>
<tr>
<td>500</td>
<td>3%</td>
<td>1%</td>
<td>1%</td>
<td>4%</td>
<td>2%</td>
<td>2%</td>
</tr>
</tbody>
</table>

- **linear distribution**
  - % position boundary 0: 5%, 15%, 25%
- **half normal distribution**
  - % position boundary 0: 5%, 15%, 25%
- **exponential distribution**
  - % position boundary 0: 5%, 15%, 25%

The minimum N variance average = 1500

boundary_1 = 23
boundary_2 = 53
- Local minima
- Linear relation between boundary position and allocation effort
- Results Neyman allocation

\[ n_h = n \times \frac{(N_h \times \sigma_h)}{\sum_i (N_i \times \sigma_i)} \]
New Idea:

Do not predefine and fix the number of strata, boundary positions or sampling effort allocation and create an adaptive strategy based on species distributions or other variables.

Assumption:

Best design is based on species distributions.
Sampling using Halton sequence

- More balanced than using uniform distribution
- Spatially balanced in n-dimensions
- Random seed to obtain stochastic model

![Uniform distribution vs Halton Sequence](image)

Balanced in n-dimensions
Is there a reason to increase sampling intensity in a region over other another region? → unequal selection probability
Method

- Based on geographical location

- Based on ecological variables: e.g. Type of habitat

- Based on practical variables: e.g. Distance to road

- Based on prior information: e.g. Field knowledge scientist

<table>
<thead>
<tr>
<th>h.x</th>
<th>h.y</th>
<th>h.reject</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.23</td>
<td>0.84</td>
<td>0.53</td>
</tr>
<tr>
<td>0.63</td>
<td>0.62</td>
<td>0.85</td>
</tr>
<tr>
<td>0.74</td>
<td>0.98</td>
<td>0.02</td>
</tr>
</tbody>
</table>
FUTURE WORK

Problems:

- How to define probabilities rejection sampling?
- Optimal sample size (over time)?
- Reliability ecological interpretation results?

Practical

- Create easily accessible package for ecologists
- **Implementation in GIS**
- Testing method in the field