The Use of Remote Sensing, GIS and Multivariate Vegetation Analyses to Explain the Distribution of Riparian Forest Communities at Multiple Spatial Scales

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Overarching Question

► PNW Watersheds
  - History of timber harvest
  - Degradation
  - Hardwood/Shrub dominated
  - Riparian restoration needed

► Under what conditions should we restore conifer to stands currently dominated by hardwood in our effort to rehabilitate fish habitat?

► Case study: Cedar River Watershed
Analytical Framework

- **Remote Sensing (Macro Scale)**
  - Used to characterize the current range of riparian forest conditions

- **GIS (Meso Scale)**
  - Develop a model to identify sites suitable for conifer restoration in riparian areas

- **Multivariate Vegetation Analysis (Micro Scale)**
  - Identifies plant communities and landforms that support conifer restoration

Remote Sensing Research Objectives

- Test the use of remote sensing tools of analysis in classifying 5 riparian forest cover classes.

1. Deciduous
2. Early Seral Conifer
3. Mid Seral/Mature Conifer
4. Late Seral/Old Growth Conifer
5. Mixed Conifer/Deciduous

- Can stands be classified with overall accuracy $\geq 75\%$ when compared with field observations?
MASTER Data

Master Data (2001)
- High Resolution: 5 m
- Hyper-spectral: 50 bands
- Pixel contains spectral reflectance of features.

Plot 1: Observed as Deciduous
Plot 2: Observed as Mid Seral Conifer

Corrected Image & Max Like
Corrected Image & SAM
BR Image & Max Like
BR Image & SAM
Validation

► Evaluate the accuracy of classification against field observations.

► Producer Accuracy
Proportion of pixels correctly classified as X/# pixels observed to be X

** Small sample size. Not well represented

<table>
<thead>
<tr>
<th>ID</th>
<th>Producer</th>
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<tbody>
<tr>
<td>Decid</td>
<td>88%</td>
</tr>
<tr>
<td>Young</td>
<td>91%</td>
</tr>
<tr>
<td>Mid</td>
<td>86%</td>
</tr>
<tr>
<td>Old</td>
<td>43%**</td>
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</table>

GIS Analysis

► Classified riparian forest cover map brought into GIS.

► Base layer

► Perform spatial analysis
GIS Habitat Suitability Model

Develop a GIS model to conduct a salmon habitat suitability analysis.

Where are sites across the watershed that exhibit both:

1. High biological potential for fish: geomorphic context
2. Suitable for conifer restoration

Assumptions:
- confinement, gradient, old conifer
- 3 major factors

Layers in GIS Model:
1. Channel confinement (Lidar)
2. Channel gradient (Lidar)
3. Riparian forest cover
Decision Tree: Boolean logic for locating ideal restoration sites

- **Gradient**
  - Is gradient \( \leq 8\% \)
    - NO
    - YES

- **Constraint**
  - Is constraint \( \leq 10\% \)
    - NO
    - YES

- **Forest Cover**
  - Is it early seral?
    - NO
    - YES

**GIS Model Results**

- Model identifies a suite of potential sites.
- Need to examine micro scale landforms at sites.
Multivariate Vegetation Analysis

Objectives:
Identify sites with landforms supporting conifer.

1. Characterize the distribution of riparian plant communities.
2. Analyze community distribution relating to:
   - Alluvial landform

Phase 2: Alluvial Landform Classification

Field plots assigned to 4 landform classes:

1. 2 yr. Active Floodplain
2. 2-100 yr. floodplain
3. Terrace
4. Hillslope
GEE Statistical Analysis

- Similar to MANOVA
- Key variables tested: %Conifer, %HW, sapling density
- $H_0$ = No difference between conifer basal area across 4 landforms
- $Z > 3 \times \text{Std. Error} =$ Difference in means not due to chance.
- Reject $H_0$

<table>
<thead>
<tr>
<th>GEE RESULTS</th>
<th>Estimate</th>
<th>Robust Std. Error</th>
<th>Robust Z value</th>
<th>p value</th>
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<td>Landform 4</td>
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<td>0.33</td>
<td>5.10</td>
<td>.0001</td>
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</tbody>
</table>

Weighted Averaging Ordination

- Multivariate technique to understand the patterns in community data.
- Relationship between moisture gradient and species distribution.
- Assigned weighted values (1-10) (Reed 1989).
- Correlate landform to moisture gradient.
Indicator Species Analysis

- Classification Method
- Detects the value of a species in defining an environmental condition
- Condition = landform

<table>
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<th>Species Code</th>
<th>Landform Class</th>
<th>p value</th>
<th>Comment</th>
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</tbody>
</table>

Multi-Response Permutation Procedure

- Non-parametric classification procedure
- Tests $H_0$: No difference between plant assemblages across 4 landform groups

MRPP Results:
- $T$ Statistic: Between Group Agreement
  - Negative $T = strong separation (≤ -10.0)$
  - Result: $T = -17.8 (p = 0.00000)$

- $A$ Statistic: Within Group Agreement
  - Positive $A = strong homogeneity (≥ 0.1)$
  - Result: $A = 0.1$

Vegetation analysis establishes which landforms host plant communities that would support conifer restoration
Management Implications

Scientists can use this collective research as:
Methodology for addressing the question of watershed restoration.

1. Remote Sensing Classification:
   - baseline that characterizes the range of conditions

2. GIS Model:
   - identifies potential restoration sites
   - high biological potential for fish

3. Multivariate Vegetation Analysis:
   - Identifies landforms that support conifer retention.

Acknowledgements

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Dr. J.F. Franklin
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