Aquatic Ecosystems and Terrestrial Landscapes are Linked
“Eventually, all things merge into one, and a river runs through it”
-- Norman Maclean
What does Landscape Ecology Have to Offer?

Five General Principles
Patch Context Matters

Source: Pahl-Wostl 1998
Patches Differ in Quality

Source: Hughes 1998
Patch Boundaries Affect Flows

Connectivity is Critical

Flow Regime
- Magnitude
- Frequency
- Duration
- Timing
- Rate of Change

Water Quality
Energy Sources
Physical Habitat
Biotic Interactions

Ecological Integrity

Source: Poff et al. 1997
Scale Matters

Source: Townsend and Hildrew 1994
PRBO Conservation Science

Restoration: Re-establishing Connections and Processes
Sacramento River Riparian Restoration
Study Design

Restored

Remnant/Reference
Black-headed Grosbeak Response to Restoration

\[ \log(\text{Black-headed Grosbeak abundance + 0.06667}) \]

Source: Gardali et al. 2006 *Restoration Ecology*
Black-headed Grosbeak Habitat Models

<table>
<thead>
<tr>
<th>MODEL</th>
<th>AIC</th>
<th>delta-AIC</th>
<th>AIC-w</th>
</tr>
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<tbody>
<tr>
<td>percent riparian 2km, # tree species</td>
<td>475.616</td>
<td>0</td>
<td>0.622</td>
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<tr>
<td>percent riparian 2km, willow</td>
<td>478.695</td>
<td>3.079</td>
<td>0.133</td>
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What are the Goals of Restoration?
The Dilemma of Restoring At-Risk Species
Conservation Reliant Species

- Guam kingfisher
- Attwater's prairie chicken
- Hawaiian gallinule
- Kirtland's warbler
- Brown pelican
- Peregrine falcon

- Occurs only in captivity
- Maintained by captive releases
- Continuous management required
- Periodic management required
- Maintains populations under existing regulations
- Adapted to human environments
Conservation Reliant Species

- **Guam kingfisher**
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- Adapted to human environments
- Maintained populations under existing regulations
- Periodic management required
- Continuous management required
- Maintained by captive releases
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Continuous management required to maintain populations under existing regulations. Periodic management is also required. Some species, like the Guam kingfisher, occur only in captivity.
The Endangered Species Act

delisting → endangerment → listing

recovery → delisting

management actions → X → recovery plan
How Many Threatened and Endangered Species are Conservation Reliant?

Source: J.M. Scott et al., unpublished

**Bar Graph**

- **Invertebrates**: 84%
- **Vertebrates**: 80%
- **Plants**: 83%

**Y-axis**: Percentage of listed species that are conservation reliant

**X-axis**: Categories (Invertebrates, Vertebrates, Plants)

Source: J.M. Scott et al., unpublished
Time Scales and Restoration Goals
Restoration often has past (historic) systems as a goal, but also needs to consider future conditions.
Climate Change is the Elephant in the Room
Hotspots of Change in Species Richness

Wilson’s Warbler

Oak Titmouse

Source: PRBO, Stralberg et al., 2009. PLoS ONE
“No-analog” Future Bird Assemblages

Many areas will contain assemblages that we have not seen before --- and that the species have not experienced before.

Projected Distribution: Black-headed Grosbeak

Source: D. Stralberg et al., PRBO, unpublished
Tidal Marsh Response to Sea Level Rise

Sea Level Rise -> Elevation (Tidal Inundation) -> Sedimentation

Elevation (Tidal Inundation) -> Salinity

Salinity -> Plant Species Distributions and Biomass

Plant Species Distributions and Biomass -> Bird Species Distributions

Bird Species Distributions

Carbon Dioxide

Temperature

Precipitation
Song Sparrow Population Trends, Suisun Marsh

Percent Change

Year

Source: Nur and Wood, PRBO, unpublished
Projected Elevation Changes: Suisun Marsh

Source: Stralberg et al. PRBO, in progress
**GOALS**

- Resistance
- Resilience
- Response

**STRATEGIES**

- enhance connectivity
- promote redundancy and buffers
- reduce landscape synchrony
- realign disrupted conditions
- expect surprises
- identify and protect refugia

Source: Millar et al. 2007 *Ecological Applications*
What are the Goals of Restoration?
Implementing Adaptive Management

1. Problem
2. Reassess Problem
3. Communicate & Assess
   - Analyze, Synthesize, Evaluate
   - Data Collection & Management
4. Evaluate & Select Conservation Measures:
   - Research, Pilot, Full-Scale
5. Design & Implement CMs
6. Design & Implement Monitoring
7. Knowledge Base
8. Goals/Objectives
9. Models
10. Expected Outcomes
    - Performance Metrics
11. Revise Objectives
12. Refine KB, models, re-evaluate
13. Refine actions, re-evaluate
14. Evaluate, Synthesize, Evaluate
“Sometimes, if you stand on the bottom rail of a bridge and lean over to watch the river slipping slowly away beneath you, you will suddenly know everything there is to be known.”

- Winnie-the-pooh (A.A. Milne)
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