Restoration, Resilience, and the Provision of Forest Ecosystem Services

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Southwestern Ponderosa Pine Forests

- Covers much of the mountains and high mesas of the Colorado Plateau
- Have been subject to extensive anthropogenic impacts since the mid-late 1800s
  - Suppression of surface fires (a natural disturbance regime)
  - Old-growth logging
  - Grazing
  - Climate change
Declining Forest Resilience
Historical Conditions

- Open, park-like spaces
- 50 - 150 mature trees per hectare
- Diverse, productive understory
- High-frequency, low-severity surface fires

Figure courtesy ERI, NAU
Current Conditions

- Few forest openings
- Upwards of 2,500 trees or more per hectare
- Decreased understory productivity and biodiversity
- Low-frequency, high-severity crown fires

Figure courtesy ERI, NAU
SW Forest Restoration

- Mechanical thinning
- Controlled burning
- Wildlife reintroduction

Figure courtesy ERI, NAU
Declining Ecosystem Services

- Resilient Forest
- Current Conditions
- Persistent Shrubland

Quantity & Quality of Forest Ecosystem Services
# Regional Forest Ecosystem Services

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<tr>
<th>Provisioning Service</th>
<th>Regulating Service</th>
<th>Cultural Service</th>
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<tr>
<td>Timber/biomass materials</td>
<td>Wildfire prevention</td>
<td>Recreation opportunities</td>
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<td>Game and fish resources</td>
<td>Erosion prevention</td>
<td>Real estate/amenity value</td>
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<td>Grazing resources</td>
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<td>Water resources</td>
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## Regional Forest Ecosystem Services

### Provisioning Service
- Timber/biomass materials
- Game and fish resources
- Grazing resources
- Water resources

### Regulating Service
- Wildfire prevention
- Erosion prevention
- Carbon sequestration

### Cultural Service
- Recreation opportunities
- Real estate/amenity value
## Economic Contributions of Ecosystem Services

<table>
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<tr>
<th>Ecosystem Service</th>
<th>Economic Contributions (per year)</th>
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<tr>
<td>Timber/biomass</td>
<td>$357,000</td>
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<tr>
<td>Game and fish</td>
<td>$1,268,000</td>
</tr>
<tr>
<td>Grazing resources</td>
<td>$151,000</td>
</tr>
<tr>
<td>Wildfire prevention</td>
<td>$3,500/hectare</td>
</tr>
<tr>
<td>Recreation opportunity</td>
<td>$5,325,000</td>
</tr>
<tr>
<td>Real estate value</td>
<td>Up to ~$37,000 per house</td>
</tr>
</tbody>
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From (Winter and Watson, 2005), (Kim and Wells, 2005), and (Mason et al., 2006)
Timber Resources

- Much of the regional timber industry has been dismantled due to Federal land policies.
- Aspects of national forest management policies result in an inconsistent timber supply for commercial wood processors.
- There exists a “surplus” of timber supply in the form of thinned wood, forest restoration by-products.
Wildfire Insurance

- Rodeo-Chediski and Haymen fires of 2002 (Graham, 2003; Snider et al., 2003):
  - Burned **245,000 hectares** of forest
  - Forced the evacuation of **13,000** people
  - Caused nearly **$300 million** in property damage, suppression costs, and rehabilitation expenditure

- A wildfire within 1.75 miles of a house can decrease property value by **$14,744**; a second wildfire causes an additional decrease of **$34,453** (Mueller et al., 2008)
Carbon Sequestration

- Restoration **stabilizes** forest carbon sequestration.
- Untreated forests have **exceeded** “carbon carrying capacity”.
- Restoration produces a **net gain in carbon sequestration** relative to expected value of wildfire emissions.

- Losses to wildfire:
  - In 2002, forest fires in western US released ~24 Tg of CO2 equivalent.
  - Loss of carbon continues to accrue into the future due to high rates of tree mortality.

- Permanent losses due to **change of vegetation-type**.
Cost of basic-level treatment: ~$2,000/hectare

Economic return on avoided wildfire damage: ~$3,500/hectare
Socioeconomic Determinants of Restoration Scale

- Funding
- Corroborative industry and markets
  - Restoration by-products
  - Carbon credits for forests
- Public support
Forest Restoration is an Investment in Natural Capital

- Natural capital, like financial or manufactured capital, _produces economic flows_ (ecosystem services).

- When improperly managed, natural capital, also like other forms of capital, can _cause negative economic consequences_ (catastrophic forest fires).
4 Forest Restoration Initiative

Coconino National Forest
Kaibab National Forest
Apache-Sitgreaves National Forest
Tonto National Forest

From (Kim and Wu, In Review)
Future Directions

Figures produced using InVEST
Without properly-scaled ecological restoration...

...forest ecosystem services will go up in smoke!

Photo courtesy Michael Petriello
Thank You!