Low-Cost Rangeland Restoration for Ecosystem services

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ACES/Ecosystem Markets 2012
Current Research at UC Davis

Spatial methods for low-cost rangeland restoration

- Novel USDA-funded restoration research based on spatially-explicit ecological theories, pattern/process

- Motivated by stakeholder concerns over cost-benefit uncertainty of rangeland restoration
  - Difficult and expensive, often little economic benefit to landowners
  - Concerns with taking land out of production
Current Research at UC Davis

**Spatial methods for low-cost rangeland restoration**

- Also motivated by concern over ecosystem services
  - Rangelands provide valuable ES
  - Biodiversity, forage, runoff reduction, C sequestration
  - Rangelands degraded via exotic species, over-grazing, etc.
Current Research at UC Davis

Spatial methods for low-cost rangeland restoration

Goals

1. Quantify effects of restoration efforts on processes and ecosystem services in cost:benefit framework
2. Test novel, cost-effective methods of targeted restoration based on spatial theories of vegetation dynamics and precision agriculture
3. Apply results to inform restoration efforts
Perennial Native CA Grasses

- 300+ species of native CA grasses
- Vast reduction in past 200 years, replaced by exotic annuals
- Grasslands cover approx 25% of the state (open grassland, oak woodland or savanna) Barry et al. 2006
- Only 2% of CA grasslands contain native perennials (USDA, ARS)
- Degradation of grasslands, loss of valuable ecosystem services

Native grass seedlings, CA
Processes and Ecosystem Services

Native grasses influence ecological processes that in turn enhance ecosystem services with associated benefits for people.

<table>
<thead>
<tr>
<th>Process</th>
<th>Ecosystem Service</th>
<th>Benefit</th>
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<tbody>
<tr>
<td>Increased infiltration</td>
<td>Reduced runoff</td>
<td>Water storage, increased production</td>
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<td>Nutrient cycling</td>
<td>Higher N retention with native grasses vs. annual, exotic communities</td>
<td>Forage and beef production</td>
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<td></td>
<td><em>(Eviner and Chapin 2001)</em></td>
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<td></td>
<td>Addition of perennial native grasses should increase C uptake and net gains in soil C</td>
<td>Soil carbon sequestration</td>
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<td></td>
<td><em>(Potthoff et al. 2005; Kroeger et al. 2009)</em></td>
<td></td>
</tr>
<tr>
<td>Plant diversity</td>
<td>Wildlife habitat</td>
<td>Species existence values, aesthetic enjoyment, recreation, cultural</td>
</tr>
</tbody>
</table>
Food, Fiber and Food Production

• Forage production in grasslands and oak savannas critical for CA livestock industry

• 34 million grazed acres of CA rangeland (Stewart et al. 2003)

• Native perennial grasses should increase forage value
  (Dyer 2002; Bartolome 2007; Malmstrom et al. 2009)
  – Longer green period extends the foraging season

• More research needed
  – Analysis of forage impacts from perennial grass restoration*
  – Nutrient analyses of perennial grasses versus nonnative annuals*
  – Animal preference trials
Carbon

• Loss of native grasses estimated to cause soil C losses of 7.1–21.2 tons/ac in top 50 cm of soil (Koteen 2005, 2007)

• Higher stocks of carbon in soils of native perennial grass community (Koteen at al 2011)

• At 2012 price of $10 / ton CO$_2$, sequestering 7.1–21.2 tons C/ac through native grass addition could generate $71-212$/ac over decades required for uptake.
If 5% of grasslands in Butte, Glenn, Shasta and Tehama counties were restored, soil C would increase by an estimated 288-865 thousand tons (1.06-3.17 million tons CO$_2$) (Kroeger et al. 2009)
Wildlife Habitat

• Grasslands provide habitat for 90% of rare California spp. (Alvarez 2011)

• Native grasses enhance wildlife habitat
  – A diverse array of mammals, amphibians, reptiles, birds
  – Forage, cover, burrowing and nesting sites
  – Direct value for people (hunting, wildlife viewing)
  – Passive uses (e.g. existence values, Kroeger et al. 2009)
Water cycling

• Deep native grass roots increase infiltration
  (CNGA, Mondeshka et al. 1988; Van Noordwijk et al. 1991)

• Little if any actual rate data from CA

• Additional research needed to understand perennial grass effects on infiltration
Recreation and Culture

• Annual grasslands at extreme risk of fire in summer and fall

• Longer green period of native grasses reduces risk and spread of catastrophic wildfires and associated costs

• E.g. reduced flash point fires along highways (Young and Claassen 2008)
Pest Control

• Research has shown that more diverse plant communities are often more resistant to weed invasion
  – Basic mechanism

• Native grasses may compete strongly with functionally similar weeds (e.g., yellow starthistle; Young and Claassen 2008)
Insect Habitat and Pollination Services

Native grasses enhance insect habitat

• California oatgrass (*Danthonia californica*)
  – Eaten by caterpillars of skipper butterflies (Robinson et al. 2007; plants.usda.gov)
  – Important component of habitat for other vulnerable and endangered butterflies (Chappell 2006, Collins 2006)

• Hedgerows with native grasses benefit pollinators (Morandin 2011) and birds (White et al. 2012)
Restoration Effects on Ecosystem Services

• We quantify effects of past restoration efforts on ecological processes and ES in cost:benefit framework

• In paired restored (native) and unrestored (exotic annual) grasslands, we measure:
  – Native and exotic plant diversity
  – Forage quality, production and utilization
  – Soil C and N
  – Infiltration
  – Seed bank composition
  – Arthropod diversity (above and below-ground)

• Translate differences into ecosystem services (benefits)

• Compare restoration costs to benefits
Restoration Effects on Ecosystem Services
Strip-seeding: Cost-effective Restoration

• Goal: test novel, cost-effective methods of restoration based on spatial theories of vegetation dynamics and precision ag

• Strip-seeding: plant some fraction of total field area to concentrate effort, increase establishment, and reduce cost
  – Targeted restoration to minimize cost:benefit ratios

• Manage seeded and unseeded areas to facilitate spread of natives

• Cost:benefit analysis

• Primary site near UC-Davis, others being established at land preserves and wildlife refuges
Dispersal and Establishment of Native Grasses

Measurements at strip edges, interior
- Native seed banks
- Plant production, diversity
- Arthropods
- Soil moisture
- Soil C and N
Grassland Restoration Costs

- The costs associated with re-seeding native species include:
  - Seedbed prep and weed control
  - Seed purchase and actual seeding (planting)
  - Follow-up management (weed control, mowing)
Grassland Restoration Costs

- Re-seeding native grass species varies by species, location and size of tract.

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<tr>
<th>Location</th>
<th>Acres</th>
<th>Cost</th>
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<tbody>
<tr>
<td>Cotton Wood Slough</td>
<td>17 acres</td>
<td>$4200/acre yr 1 $880/acre yr2</td>
</tr>
<tr>
<td>Fort Hunter Liggertt</td>
<td></td>
<td>$500/acre - $2000/acre</td>
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<tr>
<td>UC Russell Ranch</td>
<td>380 acres</td>
<td>$292/acre/yr</td>
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<tr>
<td>Bufferlands</td>
<td>10 acres</td>
<td>$540/acre</td>
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Source: Kroeger 2009, Andrew Faulks, Steve Scott- personal communication,
Summary

• Native California grasses enhance the provision of many valuable ecosystem services.
• An ES perspective emphasizes the social and economic benefits of restoration and implies a role for PES.
• Ongoing research seeks to quantify restoration effects on ES to inform payment-for-ecosystem service markets.
• Additional research to reduce restoration cost (strip-seeding)
Thank-You!

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