Climate change/land use change scenarios for assessing threats to ecosystem services on California rangelands

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Ecosystem services provided by rangelands

- Food, fiber and fuel
- Wildlife habitat
- Water
- Carbon sequestration
- Adaptation to climate change
- Open space, cultural values
Integrated Threats to Rangelands

- In California 20,000 acres of rangelands are lost every year
- Privately owned
- Cattle ranching: low profits
- Low levels of protection

Land conversion and climate change lead to loss of grazing land, water availability, and altered species distribution
Rangeland Coalition Focus Area Map (TNC, 2007)

http://www.carangeland.org/focusarea.html

Dark blue: Critical Conservation Areas

(Privately-owned rangelands that have high biodiversity value and require conservation action in the next 2-10 years.)
Project Goals

• Six spatially-explicit climate change/land use change scenarios from years 2000 – 2100 consistent with three IPCC emission scenarios and two global climate models –

  B1 (sustainability)
  1. PCM (warm, wet future)
  2. GFDL CM 2.1 (hot, dry future)

  A1B (wealth and technology)
  1. CSIRO Mark 3.5 GCM (warm, wet future)
  2. MIROC 3.2 (medres) (hot, dry future)

  A2 (population pressures)
  1. PCM (warm, wet future)
  2. GFDL CM 2.1 (hot, dry future)

• Assess potential threats to rangeland ecosystem services
  1. wildlife habitat
  2. water availability (Lorraine Flint and Alan Flint, USGS)
  3. carbon sequestration
3. An economic analysis of scenarios to quantify economic costs and benefits (Frank Casey, USGS)

4. A web-based visualization tool, and

5. An outreach program that will target the Rangeland Coalition network to communicate how results can be applied to conservation and land management decisions. (Pelayo Alvarez, Defenders of Wildlife)
Why IPCC emission scenarios?

- Climate scenarios and land use scenarios need to be logically consistent to form the basis for integrated assessments and long-term policies (Bierwagen et al. 2010).

- Existing land-use land-cover (LULC) change modeling and downscaled global climate models based on the same scenarios – **A1B, A2, B1**
  - USGS LULC change scenarios
  - USGS ensemble projections of climate and hydrology for California (Lorraine Flint and Alan Flint, USGS)
National Assessment of Ecosystem Carbon Sequestration and Greenhouse Gas Fluxes


- Three LULC change scenarios for each EPA Level III ecoregion (Ben Sleeter, USGS)
- FORE-SCE model: maps of LULC change by scenario/year (Terry Sohl et al., USGS)
- GEMS biogeochemical model: annual total ecosystem carbon change per LULC class (S. Liu et al., USGS)
Rancher’s Focus Group, January 2012, Davis CA

Key Concerns about ranching future:

• Limited availability of grazing land for lease
• Fragmentation of grazing land
• Forage quality and quantity
• High start-up investment
Scenario Narratives for CA Rangelands
– Alternative conservation plans

**A1B** (wealth and technology)
- Development – low density
- Agriculture – high value perennial crops
- Conservation – mixed-use emphasis
- 500,000 acres protected by 2100, near urban centers

**A2** (population pressures)
- Development – low density
- Agriculture – intensive, less innovation
- Conservation – low priority
- No active conservation planning

**B1** (sustainability)
- Development – high density
- Agriculture – moderate
- Conservation – biodiversity high priority
- 1,000,000 acres protected by 2100, in high biodiversity areas
Integrated Scenarios

Three IPCC scenarios (A1B, A2, B1)
Two climate models (warm, wet or hot, dry)

Land use/land cover change +

Climate/hydrology decadal change

Maps by scenario/year to 2100 at ~250 meter resolution

California Rangeland Conservation Coalition Focus Area

EPA Level III Eco-regions: Central Valley and Chaparral and Oak Woodlands
Land-use land-cover change 2006 to 2100; B1, A2, A1B
Land use-land cover/Climate/Hydrological Change

- Precipitation
- Minimum Winter Temp.
- Maximum Summer Temp.
- Climatic Water Deficit
- Potential Evapotranspiration
- Decadal averages 2010 – 2100, 250 meters

Ecosystem Services Change (water, carbon, habitat)

- Basin Characterization Model
- Runoff, Recharge, Stream Discharge
  2010, 2040, 2070, 2100

- Change to Priority Conservation Areas (TNC, 2007)
  Decadal change 2010 – 2100

- GEMS biogeochemical model
- Total Ecosystem Carbon
  2006 – 2050

FORE-SCE LULC Change Model
Annual maps of land use change 2006-2100, 250 meters
Landscape-level analysis

- Land use/climate change for conservation scenarios
- Water-wildlife hotspots
LULC change in B1 conservation areas

Summer maximum temperature by scenario, B1 conservation areas
Water-wildlife hotspots for dry scenarios (draft)
Case Study of Six Watersheds:

North:
Upper Stony
Lower Butte

Central:
Lower Cosumnes
Alameda Creek

South:
Upper Tule
Estrella

Changes in:
- Wildlife habitat
- Carbon
- Runoff, recharge, streamflow
Change in Total Ecosystem Carbon - Upper Stony Watershed

Grassland

Combined Forest

Habitat Change - Upper Stony Watershed

- Developed
- Agriculture
- Hay/Pasture
- Grassland
- Herbaceous Wetland
- Woody Wetland
- Shrubland
- Forest
Change in Total Ecosystem Carbon – Consumnes Mokelumne Watershed

Grassland

Megagrams of Carbon

A1B | A2 | B1
---|---|---
2006 | 800000 | 1000000 | 1200000
2050 | 1400000 | 1600000 | 1800000

Combined Forest

Megagrams of Carbon

A1B | A2 | B1
---|---|---
2006 | 600000 | 800000 | 1000000
2060 | 1200000 | 1400000 | 1600000

Habitat Change – Consumnes Mokelumne Watershed

A1B

A2

B1

Acres

Year

2006 to 2100
Change in Total Ecosystem Carbon – Alameda Creek Watershed

### Grassland

- **Y-axis:** Megagrams of Carbon
- **X-axis:** Climate Scenario
- **Graphs:**
  - A1B
  - B1
  - A2
- **Year:** 2006, 2050

### Combined Forest

- **Y-axis:** Megagrams of Carbon
- **X-axis:** Climate Scenario
- **Graphs:**
  - A1B
  - A2
  - B1
- **Year:** 2006, 2050

Habitat Change – Alameda Creek Watershed

- **Legend:**
  - Developed
  - Agriculture
  - Hay/Pasture
  - Grassland
  - Herbaceous Wetland
  - Woody Wetland
  - Shrubland
  - Forest
- **Year Range:** 2006 to 2100
- **A1B**
- **A2**
- **B1**
Soil storage affected by soil porosity and soil depth –
New soil thickness dataset – SSURGO county-level soil surveys (L. Flint, USGS)
Upper Stony Watershed

Recharge/Runoff

Streamflow

Baseline discharge, millions of m³

Climate Scenario

Historic  | CSIRO A1B  | MIROC A1B  | GFDL A2 | GFDL B1 | PCM A2 | PCM B1
---------|------------|------------|---------|---------|--------|--------
2003-2006 | 2037-2040  | 2067-2070  | 2096-2099 |
Consumnes Mokelumne Watershed

Recharge/Runoff

Streamflow

Historic | CSIRO A1B | MIROC A1B | GFDL A2 | GFDL B1 | PCM A2 | PCM B1
---|---|---|---|---|---|---
2003-2006 | 1.5 | 0.5 | 1 | 1.5 | 0.5 | 1
2037-2040 | 0.5 | 1 | 1.5 | 0.5 | 1 | 1.5
2067-2070 | 1 | 1.5 | 0.5 | 1 | 1.5 | 0.5
2096-2099 | 1.5 | 0.5 | 1 | 1.5 | 0.5 | 1

Basin discharge, millions of m³

Historic | CSIRO A1B | MIROC A1B | GFDL A2 | GFDL B1 | PCM A2 | PCM B1
---|---|---|---|---|---|---
2003-2006 | 5,000 | 4,000 | 3,000 | 2,000 | 1,000 | 0
2037-2040 | 4,000 | 3,000 | 2,000 | 1,000 | 0 | 0
2067-2070 | 3,000 | 2,000 | 1,000 | 0 | 0 | 0
2096-2099 | 2,000 | 1,000 | 0 | 0 | 0 | 0
• Potential for C sequestration decreases with area and rate of grassland conversion
• The ratio of recharge to runoff decreases with increasing urbanization (Alameda, Cosumnes)
• Amount of change depends on current soil storage capacity, more change if urbanization on deep soils
• In non-urbanized watersheds, ratio of recharge to runoff can increase in dry years (Upper Stony)
• Has implications on water resource planning – water supply and habitat and need to plan for extreme events
Outreach

a) Key messages:
   • Inform stakeholders of impacts of climate change and land use change to rangeland ecosystem services
   • Decision-making tool for prioritization of climate change mitigation strategies (i.e. restoration sites, conservation easements)
   • Raise awareness about the importance of rangelands in providing ecosystem services

b) Targets
   • Ranches and land managers
   • Government agencies
   • Non-profits: Ag and conservation organizations
   • Others: researchers, planners, legislators, general public
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