Drought, Climate Change, and Conservation

Vision, 14 September 2007

Goal: Understand and mitigate impacts of drought and elevated temperature on ecosystem function and biodiversity conservation.

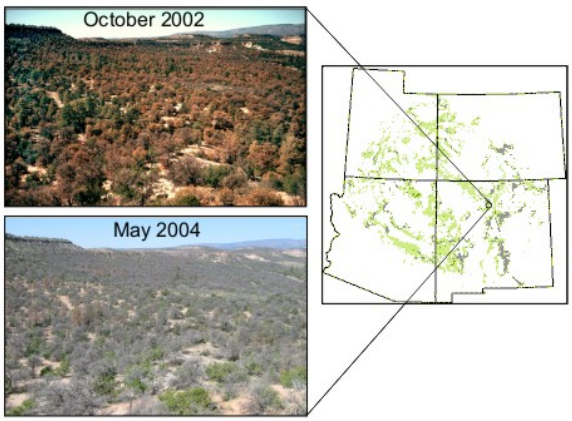

Figure 1. Widespread dieoff of piñon pine (Pinus edulis) at Bandelier National Monument in New Mexico. (photos by C. Allen)

The Problem: Extreme climatologic events, such as droughts, floods, and hurricanes, are projected to increase in frequency and intensity as global warming progresses, leading to unprecedented changes in ecosystem function and new challenges for conservation of biodiversity.

Drought Impacts: The Creekside Center for Earth Observation, in collaboration with other researchers, is engaged in studies and conservation planning to mitigate the impacts of climate-induced ecological changes associated with drought.. For example, the recent protracted drought in southwestern North America (2000-2005+) together with high temperatures caused subcontinental-scale tree mortality. Reduced soil moisture during the drought weakened natural defenses of piñon pine (*Pinus edulis*) and led to extensive outbreaks of the naturally occurring pathogen piñon bark beetle (*Ips confusus*), with more than 90% piñon mortality in many areas. This rapid, widespread mortality will alter ecosystem structure and function for decades.

Elements of Drought and Conservation:

- **Climate:** compile long-term temperature and precipitation records for pre-drought, drought, and post-drought periods at local and regional scales
- **Site characterization:** monitor ecosystem properties (soil moisture, canopy structure, etc.), community composition (overstory and understory), and population dynamics (tree demography, etc.)
- **Regional analysis:** quantify relations between climate, seasonal patterns of productivity (phenology), and dieoff using satellite remote sensing and geographic information system (GIS) analysis
- **Host-pathogen interactions:** analyze stand structure and climate influences on spatio-temporal dynamics of bark beetle outbreaks
- **Impacts of invasive species:** assess effects of invasive species on native biodiversity and evaluate mitigation options
- **Ecosystem simulation:** model future ecosystem structure and function (composition, productivity, hydrology, etc.) under different climate scenarios
- **Collaboration/coordination:** share data and analyses via the Drought Impacts on Regional Ecosystems Network (DIREnet)
- **Adaptive management:** develop and implement site-specific, science-based conservation plans
- **Education and outreach:** communicate with diverse audiences (public, researchers, resource managers, decision makers, etc.) through various media (web sites, briefing papers, presentations, brochures, etc.)

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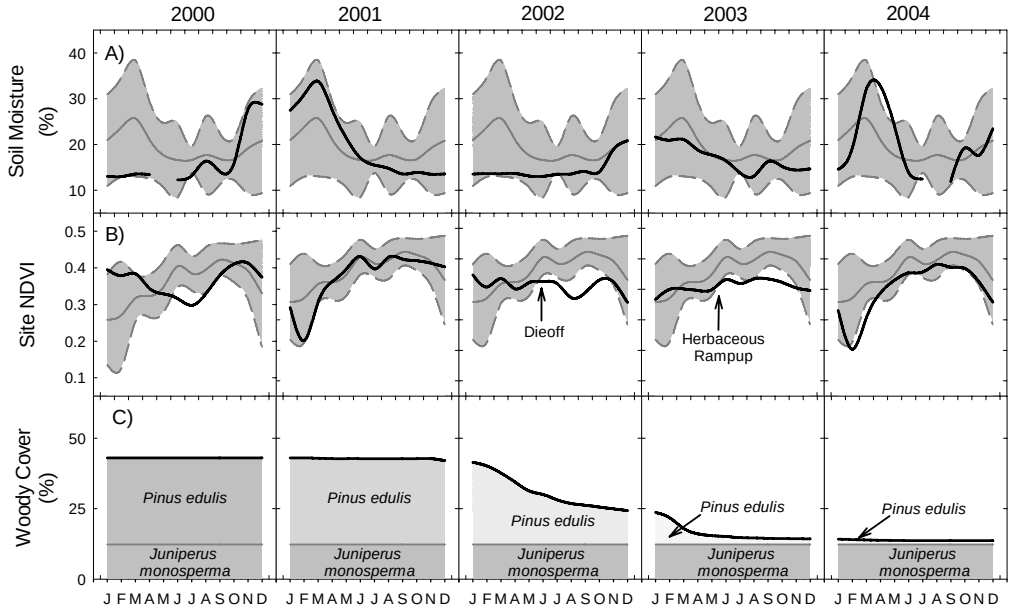

Figure 2. A) Soil moisture, B) remotely sensed Normalized Difference Vegetation Index (NDVI), and C) piñon pine mortality at Mesita del Buey, NM. For each plot, the metric of interest is illustrated with a solid dark line, and the 11-year pre-drought baseline mean (solid gray line) and 95% confidence interval (dashed gray lines and associated gray area) are displayed for reference.

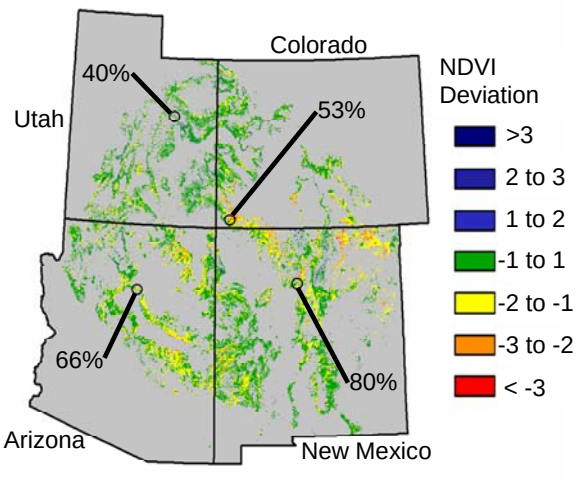

Figure 3. Map of NDVI deviation during the drought illustrates where mortality was greatest. Percent mortality is shown at four key study sites, including Mesita del Buey, NM. NDVI is a measure of green (photosynthetic) biomass.

Figure 4. Dieoff of the piñon canopy released resources to the herbaceous understory. Herbaceous plants green up more rapidly in response to precipitation than evergreen trees, resulting in a fundamental shift in the seasonal pattern (phenology) of ecosystem productivity. (photo by P. Rich)

Collaborators:

- Craig Allen, Bandelier National Monument
- David Breshears, University of Arizona
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Key Literature:

Breshears, D.D., N.S. Cobb, **P.M. Rich**, et al. 2005. Regional vegetation die-off in response to global-change type drought. *Proceedings of the National Academy of Sciences* 102(42):15144-15148.

Rich, P.M., D.D. Breshears, and A.B. White. 2007. Phenology of mixed woody-herbaceous ecosystems following extreme events: net changes from differential responses. *Ecology. Special Section on Phenology*. In Press.

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