Climate change consequences, adaptations, and responses for maintaining grassland ecosystem function and biodiversity

OVERVIEW

Cascading climate change effects on grasslands and corresponding management actions will have large consequences for global carbon storage and climate feedbacks. These changes will have far-reaching implications for economic and cultural needs of human societies provided by grasslands, and for endemic and often imperiled grassland biodiversity. Studying the interplay of these exigencies and identifying solutions that balance these needs is critical for practical grassland conservation.

IMPORTANCE

Grasslands are estimated to cover 25-40% of all land surface and currently store ~1/3rd of the carbon stocks of Earth's terrestrial ecosystems. Grasslands perform many critical ecosystem services (e.g. soil formation, erosion control, pollination, recreation), support imperiled and iconic biodiversity, and are poised to play a crucial role in climate feedbacks. Moreover, grasslands remain the source of a large component of the species we harvest, the production location for much of our food and clothing, and support more than one billion people's livelihoods. Unlike forests, the majority of grassland stored carbon is belowground, making it less vulnerable to immediate loss in fires or insect herbivore outbreaks. Grassland management (e.g. livestock stocking rates, burning, conversion to agriculture, restoration activities) has a large potential to alter carbon cycles and pools. Recent global estimates suggest that improvements in grazing management could sequester an additional 150-700 million tons of CO_2 /year, while biodiversity restoration efforts could sequester 2.3-7.3 billion tons of CO_2 /year. More work is needed to identify the effects of grassland management on carbon storage, especially in a larger framework that considers the needs of wildlife and human use. Additionally, management strategies need to reflect dynamic conditions, as climate change is already altering grassland systems.

The effects of climate change in grasslands are accelerated as a result of grasslands' annual biomass production cycle. Earlier springs and increases in pCO_2 are generating earlier plant green-up and an overall increase in primary production. With shorter-lived grassland plants, greater rates of plant species turnover are expected, as plants respond competitively to changing conditions. Current global shifts from grass-dominated systems to shrublands reduce habitat for remaining grassland endemic taxa. Elevated pCO_2 additionally decreases plant nutrient densities, either through a simple dilution effect with greater biomass production, or through less nutrient transfer into plant tissues as plants reduce the time when their stomata are open. Extreme weather, including increases in heat waves, droughts and wildfires, and extreme rainfall events are additional challenges expected to have both rapid and long-term effects on grassland biodiversity and ecosystem function. Documenting the direct and indirect effects of these alterations to grassland plants will help advise management strategies in accounting for these increasingly rapid changes.

Increasingly, the repercussions of climate change are having negative impacts on the organisms that depend on grassland systems. Changes in plant communities include both woody encroachment and the spread of invasive grasses which continue to expand and outcompete native grassland plants. While poorly documented, recent work on grassland invertebrates suggests some populations may be declining as fast at 1-2%/year. Grassland bird abundances are plummeting, with the number of individual grassland birds in the US declining by more than half in the past 50 years. The reduction in nutrients (per bite of plant tissue) with increasing pCO_2 is a major challenge to grassland herbivores—which already consume low quality food—with the potential to reduce native herbivore abundances, from tiny gall wasps to elephants. These changes additionally stress livestock populations, which may require larger areas to obtain sufficient nutrition. Linking management actions and restoration activities to biodiversity data—all in the context of climate change—is critical for the protection and recovery of grassland endemic taxa.

POTENTIAL RESEARCH THEMES

We seek a postdoctoral fellow to advance understanding of linkages between climate change and grassland management, restoration, and biodiversity outcomes. Fellowship proposals should identify key research questions relating to grasslands and climate change that will be addressed through the fellowship with the support of Smithsonian programs. The postdoc may take advantage of the Smithsonian's existing grassland research program, sites, and infrastructure in eastern Montana and/or develop synthesis projects with continental to global grassland scopes with support from broad Smithsonian collaborations. The proposed research should inform grassland management and conservation strategies and seek to understand climate change effects and/or mitigation measures.

PROGRAMS AND ASSETS

Smithsonian's Great Plains Science Program is comprised of staff scientists, fellows, and interns based out of Montana, USA. The program is further supported by DC-area based Smithsonian research teams within the Smithsonian's National Zoo and Conservation Biology Institute and a thriving external collaboration network including universities, non-government organizations, federal, state, and tribal agencies, and community groups. The program has access to lab facilities in Bozeman, MT and field housing near Malta, MT through partnerships, and owns field and lab equipment across locations. Team advisors include experts in the use of remotely sensed and long-term satellite data to quantify changes in grassland systems. Data from either Montana field sites or grasslands more broadly may be available, or able to be developed on (but is not limited to), the following responses in front of a backdrop of climate change: above-ground plant biomass, effects of herbivores on plants and animals, bison restoration, microclimate refugia, grasshopper densities and control, grassland bird community composition, and livestock stocking rates.

ADVISORS

The fellow will work with scientists from the Great Plains Science Program (GPSP), the Conservation Ecology Center (CEC), and the Smithsonian Migratory Bird Center (SMBC) including Ellen Welti (GPSP, CEC), Hila Shamon (GPSP, CEC), Andy Boyce (GPSP, SMBC), Andrew Jakes (GPSC), Qiongyu Huang (CEC), and Kristina Anderson-Teixeira (CEC). The fellow will join a diverse collaboration network including interns, graduate students, local community leaders, and lead scientists and will have the opportunity to participate in outreach activities to stakeholders, training opportunities, and scientific conferences.