Proposed EPA Region 7 RARE Project/ Contact Information

Project Title: A Multi-Model Ecosystem Simulator for Predicting the Effects of Multiple Stressors on Great Plains Ecosystems

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ORD ♠in-place♠ funding vehicle: Student services contract (post doctoral level)

Proposed Study Area: 50,000 km^2 area in Flint Hills region of eastern Kansas (Figure 1)

U.S. EPA RARE funding request: FY2004 = $50,000 (Develop landscape GIS databases)
FY2005 = $50,000 (Conduct model-base risk assessments)

Background

ORD proposes to develop spatially-explicit databases and modeling tools to assist Region 7 in conducting environmental risk assessments. This work will focus on the 50,000 km^2 Flint Hills region in eastern Kansas, an economically and ecologically important mosaic of agricultural grasslands, native prairie and urban environments (Figure 1). ORD will develop process-based models to assess the effects of multiple, interacting stressors (fire, grazing, invasion of woody species, climate change, and contaminants) on agricultural and prairie ecosystems. The models will be used to assess impacts on plant productivity and diversity, and stream discharge and water quality. By characterizing spatial and temporal dynamics of biomass production, this work potentially can be linked to regional fire and air quality models. Biomass burning is used extensively in the Flint Hills to manage agricultural grasslands and native prairie, but may contribute to regional episodes of ozone and particulate matter pollution. The work proposed here will establish a foundation for comprehensive risk assessments that consider both the ecological and air quality impacts of biomass burning.

ORD's Western Ecology Division is currently developing a multi-model ecosystem simulator to accomplish these goals. The simulator consists of a set of linked, spatially-explicit models that mechanistically simulate long-term changes in ecosystem dynamics as a result of natural and anthropogenic stressors. The models include a biogeochemistry model (GEM; Rastetter et al. 1991, McKane et al. 1997) connected with a hydrology model (TOPMODEL; Stieglitz et al. 1997, 2003) to predict fate and effects of water, nutrients and contaminants in terrestrial ecosystems and associated surface waters. Resulting changes in nitrogen and carbon cycles will influence plant species composition, which will be simulated using plant community models (e.g., MEL; Rastetter et al. 1992). Wildlife population changes that result from habitat alterations can potentially be predicted by overlaying a spatially-explicit population model (PATCH; Schumaker et al. 2004). Taken together, these models will establish a new methodology for conducting integrated risk assessments that is spatially explicit and designed for use in real settings. It will track conditions of concern over timeframes (days to centuries) that are ecologically relevant, and will provide the tools for assessing inter-related impacts on terrestrial and aquatic ecosystems. The outputs will include computer-generated visualizations of predicted changes that can provide risk assessors and

managers with user-friendly tools for use in environmental decision-making.

Approach

ORD will collaborate with Kansas State University and Region 7 to assess the cumulative spatial and temporal effects of multiple, interacting stressors on the Flint Hills ecosystem. This model-based assessment will initially focus on the ecological effects of fire, grazing, invasion of woody plant species, climate change, and contaminants. The ecosystem simulator described above will be used to forecast and diagnose risks to grassland productivity and diversity, and stream discharge and water quality. Although this work will also establish a foundation for conducting wildlife risk assessments, the model linkages (GEM-MEL-PATCH) and wildlife data needed for that will be developed under subsequent research. The following approach will be used to accomplish our present goals.

FY2005

1. Use existing information for the Flint Hills region to construct the GIS data layers needed to implement the ecosystem simulator. Data sources include the Natural Resources Conservation Service, Konza Prairie Biological Station, Kansas Gap Analysis Program, U.S. Weather Service, National Center for Atmospheric Research, and county agricultural extension offices. An ArcInfo GIS database will be assembled with the following information for each pixel (30 x 30 m) within the 50,000 km^2 study area.
    a. Digital elevation model: latitude, longitude and elevation.
    b. Vegetation characteristics: land use, cover type, species composition, and biomass.
    c. Soil physical and chemical properties: soil depth, bulk density, texture, carbon, nitrogen, phosphorus.
    d. Climate data: daily minimum and maximum temperature, precipitation and solar radiation.
2. Conduct an initial test of ORD's ecosystem simulator for the 3,500 hectare Konza Prairie Biological Station. This data rich Long Term Ecological Research site will be used to establish key parameter values for the GEM, TOPMODEL, and MEL models. Model performance will be verified against Konza Prairie's long-term data on plant biomass production, and stream discharge and water quality in response to fire, grazing and climate.

FY2006

1. Apply the ecosystem simulator to the entire Flint Hills region.
    a. Conduct initial simulations to test the simulator's accuracy against regional data for plant biomass production and accumulation, stream discharge and water quality.
    b. Use the simulator to assess spatial and temporal ecosystem responses to various stressor scenarios, including fire, grazing, invasion of woody species, climate change, etc.
2. Work with Region 7 to develop a detailed proposal for linking regional biomass, fire, and air quality models. The goal will be to identify the simplest modeling strategy for effectively predicting the impact of biomass burning on regional air quality.

Expected Results

1. ORD will produce a website with links to the GIS databases, component models and stressor scenarios used to implement the ecosystem simulator for the Konza Prairie and Flint Hills region. The website will provide instructions and examples that demonstrate the use of the simulator for conducting risk assessments. The website will serve as the primary technology transfer tool for delivering the models and simulation output to Region 7 and other clients. ORD will update the website as refinements and additions are made.
2. ORD will produce several peer-reviewed research articles describing the application of the ecosystem simulator to the Konza Prairie and Flint Hills region (coauthors will include ecologists and modelers at Kansas State University, Georgia Institute of Technology and Marine Biological Laboratory). The articles will summarize model-based assessments of the effects of multiple, interacting stressors (fire, grazing, invasion of woody species, climate change, and contaminants) on grassland productivity and diversity, and stream discharge and water quality. These assessments will demonstrate the relative importance of natural and anthropogenic stressors and how interactions between the two can affect ecosystem structure and function. The articles will be the primary means for disseminating information to the scientific community, and will contribute to transfer of technology to policymakers and stakeholders.

Literature Cited

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Figure 1. Proposed RARE project study area (50,000 km^2) in the Flint Hills region of eastern Kansas.