Environment and Natural Resources Trust Fund
2009 Phase 2 Request for Proposals (RFP)

LCCMR ID: 091-D1

Project Title: Projecting Environmental Trajectories for Energy-Water-Habitat Planning

Total Project Budget: $ $194,000

Proposed Project Time Period for the Funding Requested: 2 years

Other Non-State Funds: $ $0.00

Priority: A3. Technical Assistance for Conserving Land

First Name: Peter **Last Name:** Reich

Sponsoring Organization: U of M

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St. Paul MN 55108

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Region:	County Name:	City / Township:
Statewide		Statewide

Summary: Combine detailed climatic records of Minnesota with present and past ecosystem boundaries to forecast future fine-scale flow of climate across the state and help plan human and natural resources.

Main Proposal: 1008-2-006-proposal-2-main.doc

Project Budget: 1008-2-006-budget-3-budget.xls

Qualifications: 1008-2-006-qualifications-4-manager.doc

Map: 1008-2-006-maps-5-map.doc

Letter of Resolution:

MAIN PROPOSAL

PROJECT TITLE: Projecting Environmental Trajectories for Energy-Water-Habitat Planning

I. PROJECT STATEMENT

Combine detailed climatic records of Minnesota with present and past ecosystem boundaries to forecast future fine-scale flow of climate across the state and help plan human and natural resources.

II. DESCRIPTION OF PROJECT RESULTS

Just as weather flows across the surface of the earth, so does climate—only much more slowly. We have developed new methods for understanding this flow, to start with the climatic changes of the 20th-century dust-bowl era and project them and their environmental effects forward into the foreseeable future. Because Minnesota encloses the triple junction of the three great ecosystems of North America—western prairie, northern coniferous forests, and eastern deciduous forests—conditions here are particularly sensitive to local changes and also relevant to the nation as a whole.

It is not advisable to plan future resource use without taking into account changes that are likely to occur in those resources. This project aims to provide such information on a broad scale, and relate it to the plants, animals, and waterways of Minnesota. Since the prototype mathematical algorithms have already been tested and demonstrated in a pilot program (see attached map), and the raw data are already available, this proposed project can produce an important result for a relatively limited expenditure.

Result 1: Data and software assembly, computer runs. Budget: $113,000.

We will use the millions of observations that are maintained in established databases of century-long climatological records, available across Minnesota and the bordering regions. From this vast collection of observations we will construct mathematical representations of prevailing conditions, interpolating to any point on the ground and at any time within the range of the data. This method will allow us to project moisture as well as temperature, which existing global-circulation models are not reliably able to do.

A pilot project has shown that such mathematical representations can change steadily and smoothly even as the flow of the climate on the ground changes abruptly. (See map, rapid trajectory change near the Wisconsin border at the end of the dust-bowl era.) That provides hope of anticipating abrupt changes in the future before they happen. We will use the mathematical flows to determine how regional conditions across Minnesota changed on a fine grid during the 20th century, and then make projections showing how they are expected to change in the foreseeable future. We will pay special attention to areas that could undergo abrupt change, as has happened in the past.

Deliverable	Completion Date
1. Data assembly, unification, database construction	11/30/2008
2. Software adaptation and automation of pilot programs	1/30/2009
3. Computer runs and production of working maps and tables	6/30/2009

Result 2: Analysis, documentation, and publication. Budget: $81,000.

Following from the previous result, we will use the working maps and tables to provide documentation on (1) areas having future potential for renewable bioenergy production, (2) future effects on energy consumption for heating, cooling, and other climate-induced consumption, (3) future supply of water to reservoirs or aquifers, (4) local trends in extreme rainfall events relevant to flood control, (5) ranges of locally threatened or endangered species, (6) changes that could promote invasive species, (7) areas of increased dangers of fire, insect damage, or other ecological change.

Deliverable	Completion Date
1. Correlation with ecological, physical, and local conditions	11/30/2010
2. Web-based time-lapse video files of results across Minnesota	1/15/2011
3. Analysis and reporting	6/30/2011

III. PROJECT STRATEGY AND TIMELINE

A. Project Partners. ***Peter Reich*** is project manager. In addition: (1) ***Clarence Lehman*** (Ecology) will provide software expertise to carry out the computer computations, data processing, and geographic mapping, working with graduate assistants. (2) ***Richard McGehee*** (Mathematics) will provide numerical and topological expertise to interpret the multi-dimensional surfaces associated with the project, and to guide its mathematical applications. (3) ***Lee Frelich*** (Forest Ecology) will lend his expertise on the plant communities of Minnesota and how they are responding to present-day change in their conditions. (4) ***Mark Seeley*** (Climatology) will apply his expertise with long-term climatic trends in the region to guide and interpret project results. He will also open a powerful conduit for public awareness of the project and its results. Public understanding and public involvement is a key to successful adaptation in a democracy, and Dr. Seeley will be providing one of those keys. (5) ***Donald Wyse*** (Agronomy) will contribute his expertise on agricultural systems, including parameters related to their maintenance and long-term susainability. He will provide essential connections to industry, relating bioenergy production to agribusiness realities. (6) ***Jeannine Cavender-Bares*** (Ecology) will relate the physiological tolerances of species to their climatic distributions to predict range shifts and risks of invasive species. (7) We will also employ undergraduate and/or graduate assistants.

B. Project Impact. This project has a broad scope, covering all four areas in the LCCMR 2009 Phase-2 Funding Priorities by providing information important for planning the future of land, habitat, water, invasive species, and renewable bioenergy. In particular, the project will provide information on (1) the future supply of water to our natural and artificial watersheds, (2) locations of lands suitable for future grassland, woodland, and potentially wetland bioenergy, (3) locations of lands suitable for food crops in the future, (4) conditions that affect invasive species, (5) the fate of carbon sequestration in Minnesota's vast peatland complexes, (6) future spatial boundaries of our state's ecosystems, (7) validation of other climate models, and (8) other various conditions involving human, animal, and ecosystem health. The project also aims to increase awareness of the effects of global environmental change and thereby encourage actions that could ultimately help prevent or reverse some of its effects.

Our goal is to provide information for planners to adapt to climate changes before they actually occur, including adaptive management of the next-generation bioenergy industry. For example, increased inter-annual variability in rainfall will favor certain mixed species over single species, and will favor grassland biofuels over woodland ones. The techniques will apply to the entire state of Minnesota, but they will also be able to be adapted by all other states of the union to later form a nation-wide assessment of the topics considered here locally.

Our results will be particularly useful in helping agronomists correctly place large bioenergy plantations on the landscape, for then they will help ameliorate the very processes that are causing environmental change now. Our research indicates that low-input, high-diversity bioenergy crops can not only reduce fossil fuel consumption now, but also can absorb fossil carbon dumped into the atmosphere in the past (Tilman, Hill, Lehman 2006). Moreover, when bioenergy crops of the future are combined with emerging technologies for carbon capture and storage (Olabisi, Reich, et al, 2008), they hold a greater promise still. They can conceivably form the basis of a second industrial revolution that could undo the greenhouse effects of the first by transferring fossil carbon on a vast scale from the biosphere back to the crust of the earth.

C. Time. This is proposed as a two-year project. Its first year will involve data assembly, algorithm validation, analysis, and preparation of preliminary maps and tables. It second year will correlate the results with ecological, hydrological, physical, and social aspects. Included in the second year are any additional computer operations necessary, culminating in final reports and public presentations.

D. Long-Term Strategy. This project can be part of Minnesota's share of no less a goal than learning to manage the earth for perpetual habitability. Such a strategy is related to a major new graduate program recently funded by the University of Minnesota entitled "Whole Earth Dynamics — The Whole and its Parts under Global Change," initiated by three of the sponsors of the present proposal.

Project Budget

IV. TOTAL PROJECT REQUEST BUDGET

BUDGET ITEM *(See list of Eligible & Non-Eligible Costs, p. 17)*	**AMOUNT**	**% FTE**
Personnel: Academic salary and benefits [Lehman $74384 for software development and computational tasks, 33% FTE; Frelich $12421 for ecosystem analysis and model comparisons, 8.3% FTE; Reich $14195, for project management and scientific direction, 4.2% FTE]	$ 101,000	15%
Personnel: Civil Service salary and benefits (GIS specialists)	$ 8,000	8%
Personnel: Graduate Student salary and benefits	$ 82,000	100%
Acquisition (Including Easements):	N/A	
Restoration:	N/A	
Other: Specialized papers and inks for maps and charts	$ 1,000	
Other: Travel to present project results	$ 2,000	
TOTAL PROJECT BUDGET REQUEST TO LCCMR	$ 194,000	

V. OTHER FUNDS

SOURCE OF FUNDS	**AMOUNT**	**Status**
Remaining $ From Previous Trust Fund Appropriation (if applicable):	$ -	
Other Non-State $ Being Leveraged During Project Period:	$ -	
Other State $ Being Spent During Project Period:	N/A	
In-kind Services During Project Period:	N/A	
Past Spending:	$ -	

Curriculum Project Manager Qualifications and Organization Description

Project Manager: Professor Peter B. Reich
Regents Professor, Distinguished McKnight University Professor, and F.B. Hubachek, Sr., Professor of Tree Physiology and Forest Ecology
Department of Forest Resources, University of Minnesota, St. Paul, MN 55108
E-mail: preich@umn.edu; Phone: 612-624-4270; FAX 612-625-5212

Professional Appointments and Preparation
F.B. Hubachek, Sr., Professor, Dept of Forest Resources, U. Minnesota, 1991-
Assistant/Associate Professor, Dept of Forestry, U. Wisconsin-Madison, 1985-1991
Post-doc (1985) and Ph.D. (1983) Cornell University;
M.S. (1977) University of Missouri;
B.A. (1974) Goddard College

Honors, Professional Recognition and Service (Selected)
Invited speaker > 120 symposium, conferences, and seminars; e.g., Harvard; Duke; Penn State; Princeton; Stanford; Texas A&M; Cornell; Michigan State; Washington
Institute for Scientific Information (ISI) Science Citation Index, List of Top 20 Ecologists and Environmental Scientists in the World, 2002 –
Advisor to numerous Federal science and policy agencies
Member of numerous editorial review boards and NSF panels

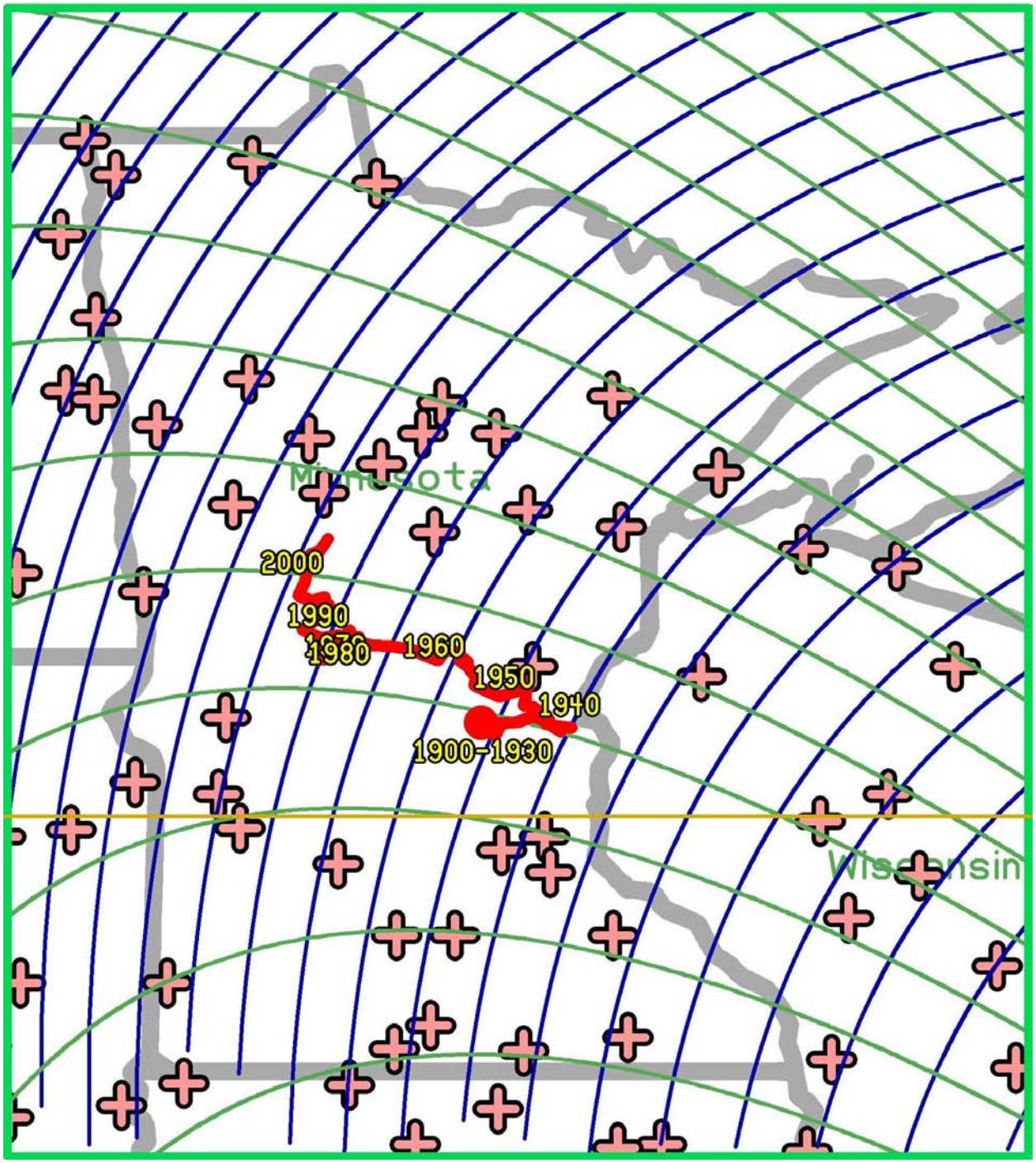
Areas of Expertise
Global environmental change and Terrestrial Ecosystems, including climate, biodiversity, ozone pollution, wildfire, elevated CO2, N pollution, land use change, and exotic invasion; Carbon cycling; Plant physiology, production; Ecosystem ecology, soil fertility and biogeochemistry. Systems studied: forests, woodlands, grasslands, agricultural row crops.

Project Management Experience
Lead PI or co-PI on forest and grassland science projects (total funding, >$18 million 2000- present, from federal [NSF, DOE, USDA, NASA], state, and private sources.

Peer-reviewed publications:
> 290 scientific articles and book chapters, including > 15 in high profile general journals (Nature, Science, etc.) as well as >250 in specialized technical journals

Project Management Qualifications for this Project
Background in global environmental change science, ecosystem ecology and plant physiology, including carbon cycling and plant productivity. Extensive experience successfully leading science projects and managing large research teams.

Organization Description
The University of Minnesota is both the state land-grant university, with a strong tradition of education and public service, and the state's primary research university



Map. Locations of the USHCN climatic stations used in the pilot project to prove the concepts and methods. Crosses show the locations of the long-term weather stations used. (Many additional stations will be used in the actual project.) The red line is the 20th-century trajectory of North America's triple ecotone—where the prairies, hardwoods, and softwoods all meet in Minnesota. During the dust-bowl years this meeting point moved a few miles per year toward Wisconsin. When the rains returned it abruptly turned about-face and headed for the Dakotas, continuing for three decades before stalling and hovering north and west of where it began the century. In the 1980s it abruptly headed north toward Itasca—a consequence of the warming of Minnesota. As climatic points like this move, so move the environments of Minnesota. If this point continues on its path for 70 more years, Minnesota will be reduced to a prairie state, without its native pines and forests. (*Vertical curves: moisture isoclines. Horizontal curves: temperature isoclines. Horizontal brown line: 45th parallel*.)