

Trust Fund 2008 Work Program

Date of Report: 3/4/08
Date of Next Status Report: 1/15/09
Date of Work program Approval:
Project Completion Date: 6/30/10

I. PROJECT TITLE: Future of Energy and Minnesota's Water Resources

Project Manager: Dr. Sangwon Suh
Affiliation: University of Minnesota
Mailing Address: 1390 Eckles Ave.
City / State / Zip : Saint Paul, MN 55108
Telephone Number: (612) 624-5307
E-mail Address: sangwon@umn.edu
Fax Number: (612) 624-3005
Web Page address: <http://www.bbe.umn.edu/staff/suh.html>

Location: Saint Paul, MN

Total Trust Fund Project Budget:	Trust Fund Appropriation:	\$ 270,000
	Minus Amount Spent:	\$ 0
	Equal Balance:	\$ 270,000

Legal Citation: M.L. 2008, Chap. [], Sec. [], Subd. 4(a)

Appropriation Language: \$270,000 is from the trust fund to the Board of Regents of the University of Minnesota to spatially model water demand in Minnesota under differing energy production scenarios and develop a Web-based tool for comparing policy scenarios impacts on water resources in the state.

II. PROJECT SUMMARY AND RESULTS:

Minnesota's water resources are poised to undergo significant changes in the coming decades. There is an urgent need to integrate an analysis of demands on Minnesota's water resources with scenarios of future energy production. We propose to develop an integrated spatial model that will analyze the future of MN's water budget with particular attention to changes in water demand under different scenarios. Key trends that will be incorporated into the scenarios include (1) biofuel production (considering water needs for irrigation of the biofuel feedstock as well as for processing); (2) changes in the electricity grid mix considering Minnesota's Renewable Energy Standards; (3) demographic changes; and (4) climate change. Scenarios of water demand will be combined with GIS mapping and water balance techniques, which will deliver spatially and temporally explicit water budget projections for each scenario. Our findings will allow us to better understand the

interactions between agricultural policy, energy policy, demographic changes and Minnesota's water budget, so that policymakers can be better informed about how their decisions affect water resources. We will present our findings through a series of maps depicting Minnesota's spatial water budget under a variety of future scenarios. These maps will be made available to the public through an online tool and a series of seminars.

III. PROGRESS SUMMARY AS OF (date): 250 word limit.

IV. OUTLINE OF PROJECT RESULTS:

Result 1: Current spatial water budget in map form

Description: *We will produce GIS map layers of current water demand and water supply in Minnesota. These maps will be combined to generate a map of Minnesota's water budget, and to identify potentially water-scarce regions and the supply and withdrawal factors that contribute to this water scarcity.*

Summary Budget Information for Result 1:

Trust Fund Budget:	\$ 76,714
Amount Spent:	\$ 0
Balance:	\$ 76,714

Deliverable	Completion Date	Budget	Status
1. <i>Background document summarizing current knowledge on groundwater resources and withdrawals</i>	9/30/08	\$ 12,679	
2. <i>List of key factors regulating water supply And demand</i>	1/31/09	\$ 35,737	
3. <i>GIS layers of current water demand and supply, and map of current state water budget</i>	6/30/09	\$ 28,298	

Completion Date: 6/30/09

Result Status as of 1/15/09:

Result Status as of 6/30/09:

Result Status as of 1/15/10:

Result Status as of 6/30/10:

Final Report Summary:

Result 2: Maps of future state water budgets under different scenarios

Description: *We will model scenarios of water demand and water supply under dynamic combinations of ethanol production trends, agricultural land use change, demographic growth, and climate change. By overlaying a map of water demand under different scenarios with a map of water supply under these scenarios, we will generate a spatial water budget for the state, which will reveal areas of potential water scarcity.*

Summary Budget Information for Result 2: Trust Fund Budget: \$ 108,891
Amount Spent: \$ 0
Balance: \$ 108,891

Deliverable	Completion Date	Budget	Status
1. Description of modeled scenarios and GIS layers for water supply and demand in all scenarios	6/30/09	\$ 59,735	
2. Maps for each scenario depicting future water budget	12/31/09	\$ 49,156	

Completion Date: 12/31/09

Result Status as of 1/15/09:

Result Status as of 6/30/09:

Result Status as of 1/15/10:

Result Status as of 6/30/10:

Final Report Summary:

Result 3: Interpretation and dissemination of research results

Description: *We will derive policy implications from the analysis, which will be released in a format useful to planners and local citizens. To disseminate this information around the state, we will create an online tool that will embed the modeling results in an interactive website, searchable by future scenario and by location. We will also conduct seminars at various locations around the state to inform local citizens and policymakers about the results of our analysis.*

Summary Budget Information for Result 3: Trust Fund Budget: \$ 84,394
Amount Spent: \$ 0
Balance: \$ 84,394

Deliverable	Completion Date	Budget	Status
1. Policy recommendations Informed by research results	3/31/10	\$ 33,538	
2. Seminars and online Information tool	6/30/10	\$ 50,856	

Completion Date: 6/30/10

Result Status as of 1/15/09:

Result Status as of 6/30/09:

Result Status as of 1/15/10:

Result Status as of 6/30/10:

Final Report Summary:

V. TOTAL TRUST FUND PROJECT BUDGET:

Staff or Contract Services: \$266,700

Equipment: \$3,300

Other: \$ (be specific)

TOTAL TRUST FUND PROJECT BUDGET: \$ 270,000

Explanation of Capital Expenditures Greater Than \$3,500: N/A

VI. OTHER FUNDS & PARTNERS:

A. Project Partners: Anne Kapuscinski, Peter Reich (both faculty, co-PI's of University of Minnesota Ecosystem Science and Sustainability Initiative)

B. Other Funds Proposed to be Spent during the Project Period: *The faculty P.I.'s will spend time on this project that is not paid for by LCCMR.*

C. Past Spending: *The Sustainability Initiative has been funded through a \$900,000 Bush Foundation grant that expires in the fall of 2008. This grant is being used to conduct a participant scenario development process, which will provide critical input to our water model. The water balance modeling will also receive input from a project under P.I. Suh to explore the impacts of climate change on state*

water resources, with funding from the University of Minnesota Agricultural Experiment Station.

D. Time: 7/1/08 – 6/30/10

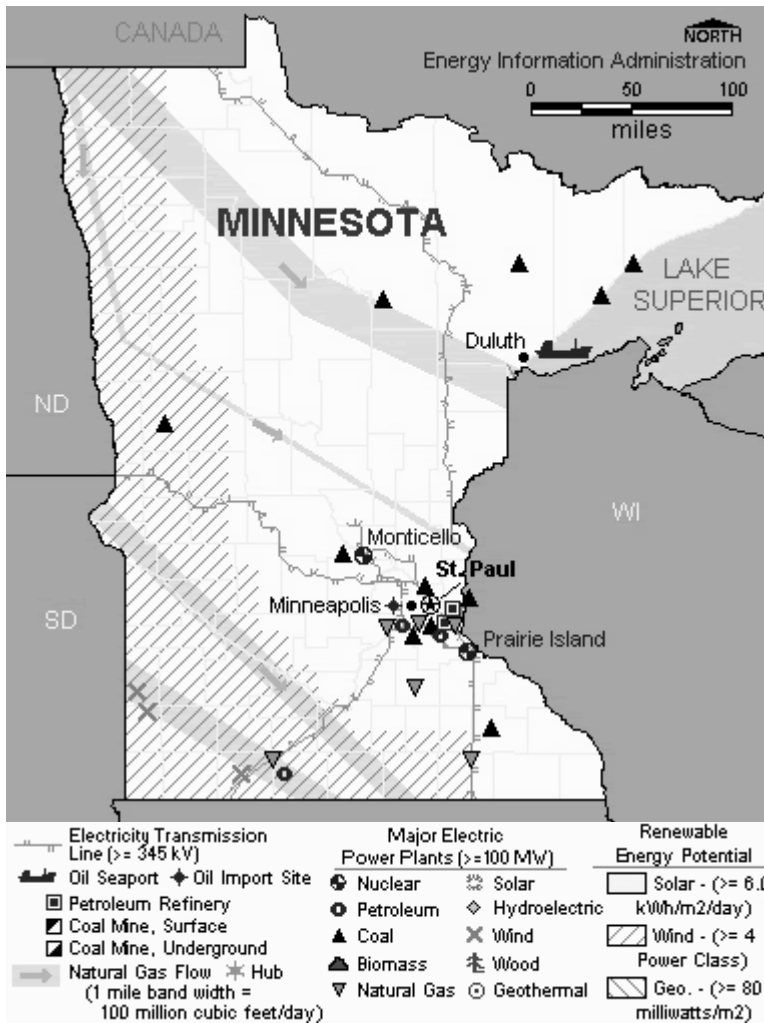
VII. DISSEMINATION: *The dissemination of research results is built into the project timeline and budget, as described above.*

VIII. REPORTING REQUIREMENTS:

Periodic work program progress reports will be submitted not later than 1/15/09, 6/30/09, 1/15/10, and 6/30/10. A final work program report and associated products will be submitted between June 30 and August 1, 2010 as requested by the LCCMR.

IX. RESEARCH PROJECTS:

Attachment A: Budget Detail for 2008 Projects - Summary and a Budget page for each partner (if applicable)											
Project Title: <i>The Future of Energy and Minnesota's Water Resources</i>											
Project Manager Name: <i>Sangwon Suh</i>											
Trust Fund Appropriation: \$ 270,000											
1) See list of non-eligible expenses, do not include any of these items in your budget sheet											
2) Remove any budget item lines not applicable											
2008 Trust Fund Budget	<u>Result 1 Budget:</u>	Amount Spent (date)	Balance (date)	<u>Result 2 Budget:</u>	Amount Spent (date)	Balance (date)	<u>Result 3 Budget:</u>	Amount Spent (date)	Balance (date)	TOTAL BUDGET	TOTAL BALANCE
	<i>Current spatial water budget in map form</i>			<i>Maps of future state water budgets under different scenarios</i>			<i>Interpretation and dissemination of research results</i>				
BUDGET ITEM			0			0	0		0	0	0
PERSONNEL: wages and benefits (2 graduate students, 1 postdoctoral researcher, 1 month faculty salary)	76,714		76,714	108,891		108,891	81,094		81,094	266,699	266,699
Equipment / Tools (<i>website design and software for developing interactive online tool</i>)			0			0	2,300		2,300	2,300	2,300
Travel expenses in Minnesota			0			0	1,000		1,000	1,000	1,000
Other (<i>Describe the activity and cost be specific</i>)			0			0			0	0	0
COLUMN TOTAL	\$76,714	\$0	\$76,714	\$108,891	\$0	\$108,891	\$84,394	\$0	\$84,394	\$269,999	\$269,999



Map of Minnesota's electrical plants (courtesy DOE-EIA). Water for cooling during electricity generation is the largest part of the state's water demand.

The Future of Energy and Minnesota's Water Resources

Peer Review Proposal to the LCCMR, 2008

Submitted by:

Sangwon Suh
Anne Kapuscinski
Peter Reich
Laura Schmitt Olabisi
Yiwen Chiu
Kris Johnson

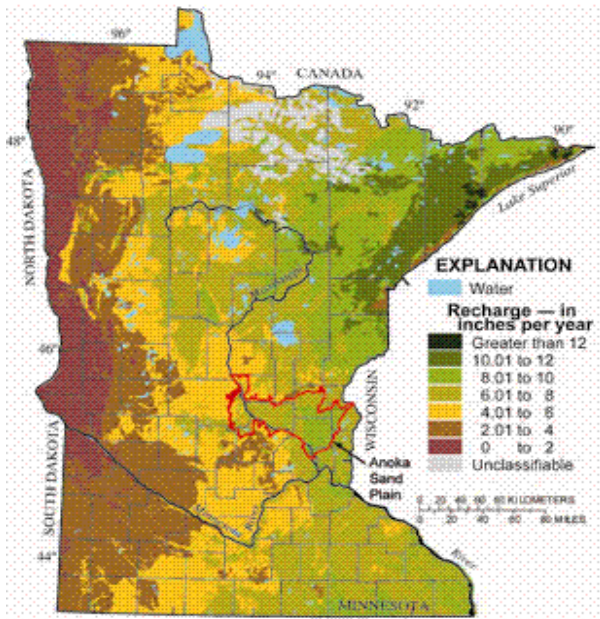
University of Minnesota

I. Abstract

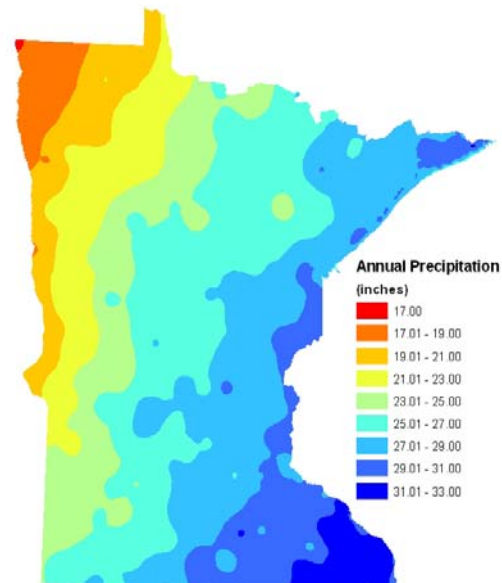
Minnesota's water resources are poised to undergo significant changes in the coming decades. There is an urgent need to integrate an analysis of demands on Minnesota's water resources with scenarios of future energy production. We propose to develop an integrated spatial model that will analyze the future of MN's water budget with particular attention to changes in water demand under different scenarios. Key trends that will be incorporated into the scenarios include (1) biofuel production (considering water needs for irrigation of the biofuel feedstock as well as for processing); (2) changes in the electricity grid mix considering Minnesota's Renewable Energy Standards; (3) demographic changes; and (4) climate change. Scenarios of water demand will be combined with GIS mapping and water balance techniques, which will deliver spatially and temporally explicit water budget projections for each scenario. Our findings will allow us to better understand the interactions between agricultural policy, energy policy, demographic changes and Minnesota's water budget, so that policymakers can be better informed about how their decisions affect water resources. We will present our findings through a series of maps depicting Minnesota's spatial water budget under a variety of future scenarios. These maps will be made available to the public through an online tool and a series of seminars.

II. Background and Hypothesis

Minnesota's water resources are critical to the state's economy, ecology and culture. There is a common perception that Minnesota is a water-rich state, but in fact the state's water resources are highly heterogeneous. Rates of groundwater recharge, precipitation, and evapotranspiration, which determine the amount of water available for human and ecosystem use, vary considerably throughout the state (Figure 1).



1a. Groundwater recharge in Minnesota in in./yr. (Delin & Falteisek 2007)



1b. Precipitation in Minnesota in in./yr. (map prepared by Yiwen Chiu)

Several major changes likely to occur or already occurring in Minnesota that will impact the water budget will also be spatially heterogeneous. These include demographic change, climate change, biofuel development, and electricity production. There is a need to develop a tool for evaluating the impacts these changes will have on water resources, so that water use planning may become more integrated and holistic with a focus on sustainability, as recommended in the Minnesota Statewide Conservation and Preservation Plan and previous documents (Otterson et al. 2002).

Recent Minnesota legislation establishing a goal of 80% greenhouse gas reduction by 2050 will prompt shifts in the fuel mix for electricity production and transportation use, with consequences for water demand. Water for cooling in electrical production is currently the largest part of the state's water demand, but that could change if Minnesota makes a major switch to wind-generated or solar electricity, or to electricity fueled with biomass (Figure 2). These changes could have the effect of reducing water demand for electricity production, or of shifting water demand to rural areas where biomass crops would be grown for electrical generation.

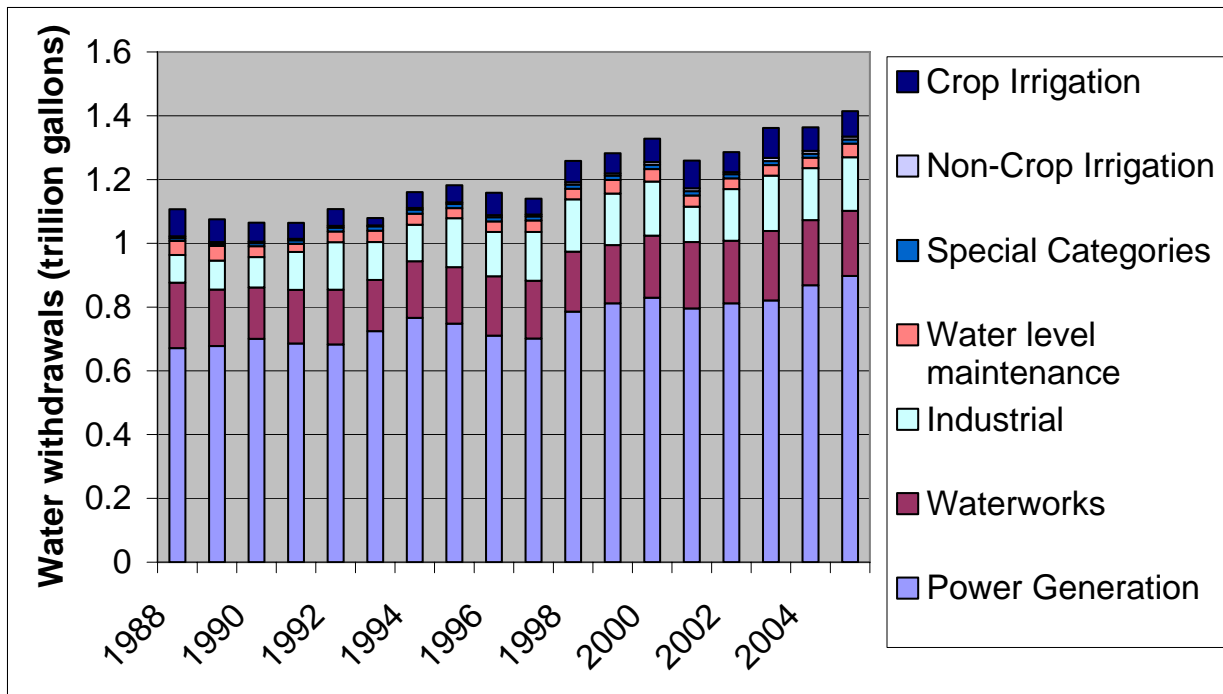


Figure 2. Water use by category in Minnesota, 1988-2005 (from MNDNR water permit records)

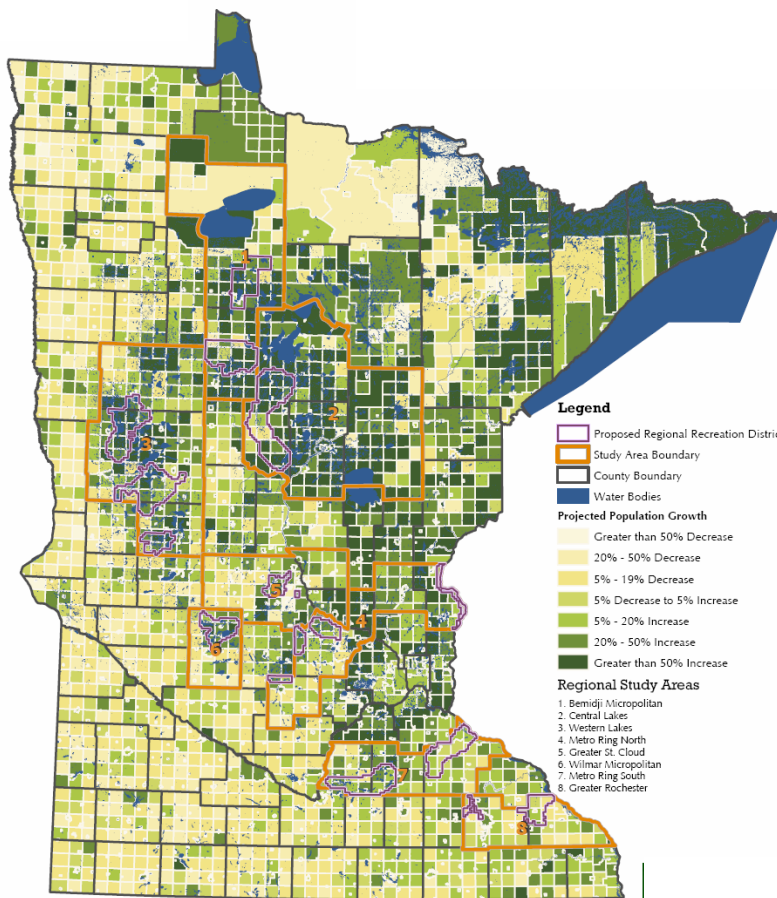
Water for ethanol production is currently a very small portion of overall water use in Minnesota, but if ethanol production expands, water demands could exceed supply in some regions of the state. Under the ethanol blending mandates in place, Minnesota will need to produce (or import) 564,000,000 gallons of ethanol annually by 2013, according to the state Department of Agriculture. Economic incentives could drive this production number even higher. This corresponds to 2.3 billion gallons of water needed for processing, assuming the ethanol is made from corn grain, and 3.4 billion gallons of water for processing cellulosic ethanol using enzymatic methods (Keeney & Muller 2006). There are some technological options for reducing these water requirements by up to 20%, but these innovations are associated with a higher capital cost (Aden 2007). If irrigation needed for corn production is factored into

ethanol water requirements, Minnesota's water demand for ethanol production climbs to 443 billion gallons by 2013 (Schnoor et al. 2007). Currently, only a small percentage of Minnesota corn land is irrigated, but this could change if corn expands onto marginal lands. Around the United States, most dedicated energy crops for biofuel production are not irrigated. However, irrigation may be necessary if these crops are planted over a large landscape. Miscanthus, for example, requires more water than corn (McIsaac et al. 2007).

Considered as part of the 1.4 trillion gallon state water use budget, water demand for biofuel production may not be significant. However, for certain localities ethanol production may be enough to overwhelm local groundwater resources when combined with other competing industrial and municipal uses. This is a serious possibility, given the fact that most current and proposed ethanol plants are located in relatively water-poor regions of the state, particularly southwest and south-central Minnesota. Plans to construct a corn-based ethanol plant near Pipestone were stopped in 2005 because of concerns over water supply (Gordon 2005).

Mixed prairie grasses, another option being considered for ethanol feedstock in Minnesota, may have less severe impacts on local water resources, but it is important to test this hypothesis with a model (Tilman et al. 2006). All biofuel options involve some degree of land cover change, which impacts the hydrology of local systems (Reed et al. 2006).

Population growth in Minnesota is slowing overall, but like other trends it will occur in a



spatially heterogeneous manner. The Central Lakes and greater Metro region will experience population growth, while many rural areas of the state may lose population (Figure 3). Municipal water use per capita has increased in Minnesota since the 1950's, implying that the efficiency of water use by people and households in urban areas is not improving (Figure 4). This trend is opposite the pattern seen in most parts of the United States, where water consumption rates are not growing as fast as the population (USDOE 2006). Minnesota's increasing water consumption, combined with spatial patterns of population growth, may lead to significantly more stress on water resources (VanBuren & Wells 2007).

Figure 3. Map of expected population growth between 2005 and 2030
Source: MN State Demographer's Office. Map prepared by Mike Wieteki.

Climate change is projected to increase overall precipitation in Minnesota, with a disproportionate amount of this increase occurring during the late fall and early winter (Donner & Kucharik 2003, CWP 2005). This may not be an unqualified boon for the state's water resources, however, as more of this precipitation is expected to occur during heavy rains and storm events, potentially increasing rates of drought and flooding (Seeley, 2007). Additionally, evapotranspiration is expected to increase in the upper Midwest, which may negate the precipitation water gains (Jackson et al. 2001). Other researchers working on a global scale have found that the effects of shifting precipitation patterns due to climate change will be dwarfed in most regions by increased water demand (Vörösmarty et al. 2000). Our modeling approach will help determine which of these dynamics will dominate in Minnesota.

Hypothesis: Due to the heterogeneity of Minnesota's water resources and water demand, **some regions of the state will experience water scarcity in the future.** The severity and extent of this scarcity will depend on the particular patterns of water use and water availability that will develop in Minnesota in response to biofuel production, demographic change, agricultural growth, and climate change.

III. Description of methodology

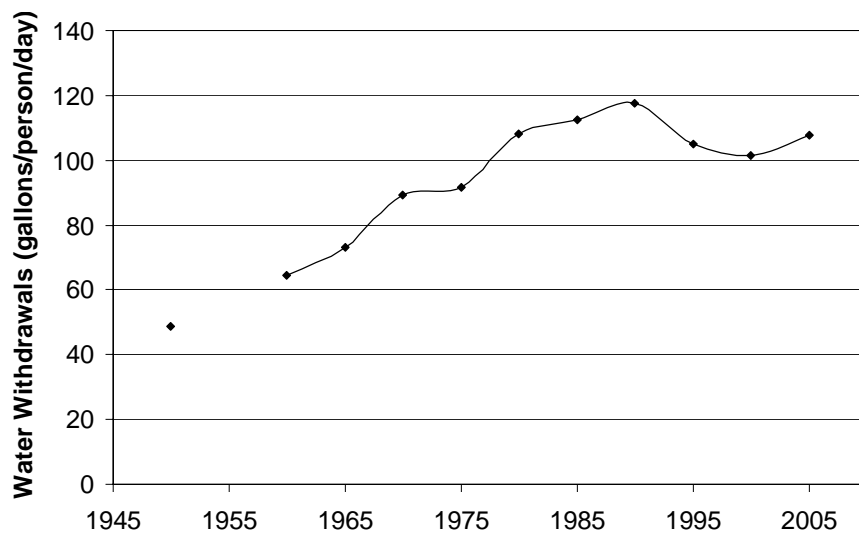


Figure 4. Municipal water use per capita in Minnesota, 1950-2005

Our approach is a unique combination of water balance modeling, scenario development, and GIS mapping. The scenario development process will quantify spatial changes in water demand, while the water balance approach will quantify water supply. We will create a baseline map of water demand under a

'Business as Usual' scenario, using spatial patterns of point-source water withdrawals from aquifers and surface water made available through the Department of Natural Resources permitting database. Water withdrawals will be projected up to the year 2030 using spatial trend analysis, incorporating the dependence of water use on other spatial variables, for example, population density, crop type and precipitation rates. New water withdrawal locations will be added to the point source map as urban areas and cropland expand, and existing water withdrawal locations will increase or decrease their withdrawals in response to population growth, precipitation rates, agricultural crop type, water scarcity, etc. (Rosegrant et al. 2002). Feedbacks among these different dynamics will also be considered through an iterative modeling

approach. This basic technique of mapping water demand has been utilized on a global scale (Simonovic 2002, Cai & Rosegrant 2002).

Scenarios of water demand under different combinations of ethanol production, agricultural land use change, demographic growth, and climate change will be modeled using the same methodology. These maps of water demand pertaining to different scenarios will be compared with maps of available water generated using the water balance approach. We will also be working closely with the Water Resources Sustainability project run by P.I.'s Nieber, Kanivetsky, Mulla, Wilson, and Shmagin, which is in the process of quantifying groundwater resources in Minnesota. This project will provide another input to our spatial analysis of water supply, which will be projected up to the year 2030. By combining a map of water demand under different scenarios with a map of water supply under these scenarios, we will generate a spatial water budget for the state, which will reveal areas of potential water scarcity.

Water Balance Approach

A traditional water balance approach treats a given area as an individual system and determines its stock dynamics by computing the associated in-and-out flows (Duan et al. 1996). However, this approach does not necessarily provide spatial information on water distribution and availability. Therefore, geographical information system (GIS) tools will be used in this study to develop a detailed water balance regulated by a suite of environmental criteria at a resolution of one square mile.

Water resources will be divided into major "stocks", identified as atmosphere, land surface, and aquifers. Minnesota will be considered as a system composed of interconnected networks of water stocks and flows. For example, groundwater and surface water are linked through the groundwater recharge factor, which has been calculated by the USGS. A GIS model will be employed to carry out the variable computations and to represent the water stock and flow networks (Ludwig & Mauser 2000, Huff et al. 2002). Some of the required map layers will be collected from USGS and MN DNR web-based data banks, while other layers will be generated from raw datasets collected/posted by various sources, including the USDA Forest Service, NOAA, and NASA. By linking these layers with hydrological algorithms (i.e. storage flux (ΔS) = input (I) – output (O)), the water balance can be determined spatially (Singh & Woolhiser 2002), allowing the user to visualize the distribution and dynamics of both groundwater and surface water (Figure 5).

Scenario Development

The Sustainability Initiative at the University of Minnesota researches strategies to achieve benefits for human societies and natural ecosystems over the long term. Two of the P.I.'s for this proposed project (Kapuscinski and Reich) are also co-P.I.'s of the Sustainability Initiative. By July 2008, the Initiative will have completed a scenario analysis of potential pathways towards the state's 80% by 2050 greenhouse gas (GHG) reduction goal, comparing the possibilities and tradeoffs associated with different GHG reduction strategies. Many of these strategies, such as shifts in electricity production, will have effects on the water resource. At the same time, the Sustainability Initiative, working with the Minnesota Regional Sustainable Development Partnerships, is conducting workshops around the state with groups of stakeholders from government, business, and the private sector to envision potential futures for Minnesota.

These efforts will serve as input to the scenario development portion of this project. Laura Schmitt Olabisi, who will serve as the postdoctoral coordinator for the proposed project, is contributing quantitative analysis to the scenario development workshops and will interface with the workshop participants extensively. These workshops are designed to elicit residents' visions of multiple plausible future conditions for their region, many of which affect the water resource. For example, residents in the northwestern counties have developed a scenario of agricultural land being given over to cellulosic biofuel feedstock production, which will impact irrigation rates. Residents in the southeastern portion of the state have developed scenarios of local food production and population expansion, which will affect municipal water withdrawals and the type of crops grown. These parameters will be quantified and entered into the model scenarios.

We will also conduct an extensive literature review to inform the scenario development, and we will leverage the efforts of two of our P.I.'s (Suh and Kapuscinski) who are working on scenario development for the Statewide Conservation and Preservation Plan commissioned by the LCCMR.

Our initial list of parameters to be included in the model scenarios include:

- Land devoted to biofuel crops, location and type of crops
- Location of biofuel plants and technology used by these plants
- Location and fuel source of electricity generation plants
- Rate and location of demographic expansion
- Efficiency of water use by type of user
- Climate change (maximum and minimum predicted temperature changes and shifts in rainfall)
- Regulatory constraints on water withdrawals and water movement
- Economic responses to water scarcity
- Water conservation technology, such as rainwater harvesting and surface impoundment

These variables will be entered into a dynamic spatial model that will calculate their values annually through an iterative process such as a yearly 'do-loop'. This will allow us to incorporate multiple variable effects and feedback loops. For example, if a given location becomes water-scarce, the subsequent yearly iteration would reflect increasing economic pressure to conserve water, and efficiency of water use would therefore increase. Drivers of water consumption at the federal or global level, such as biofuel subsidies, will be modeled exogeneously (for example, through the 'biofuel expansion' scenarios).

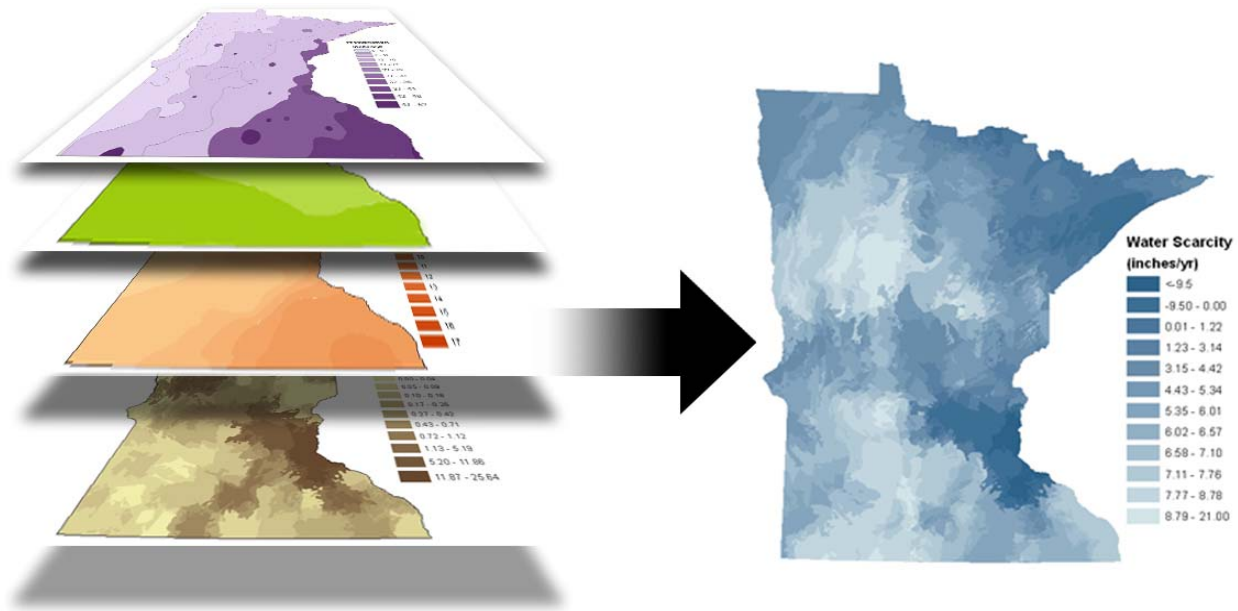


Figure 5. Water balance is computed by combining map layers that contain background data and information. The final map product represents the water balance under a given scenario.

Modeling Uncertainty

Combining complex trends in a dynamic analysis necessarily introduces uncertainty into the modeling procedure. The strength of our approach lies in its incorporation of a broad range of potential scenarios, which in itself tests the robustness of the model output by varying the input parameters and the nature of the interactions between model variables. We are not seeking to deliver a ‘prediction’ of water demand, but to define the parameters of water availability under a variety of plausible scenarios, in order to guide policy discussion and planning. For example, if a region of the state is projected to become water-scarce by 2030 under all or nearly all of the modeled scenarios, it is much more likely that that region will in fact face serious water challenges, because the model result is robust through a wide range of input parameter values and interaction terms. Policymakers and local citizens should carefully monitor and regulate water use in these areas, and water-intensive industries should not be located there.

Overall Workflow

The analysis will be performed in the following order:

- (1) Literature review/interviews/data mining
 - Establish contacts and review existing studies
- (2) Identification of key parameters of water supply and demand.
 - Precipitation rate, evapotranspiration rate, run-off rate, water withdrawal rate per capita, water withdrawal rate per gallon of ethanol production, etc.
- (3) Assign these parameters to each geographical unit
 - GIS layers for each parameter.

- Water balance using these layers will show the current state of the water budget for each geographical unit
- (4) Scenario development
- Scenarios will specify the possible future of these parameters for each geographical unit
 - This will be converted into a GIS layer for each scenario.
- (5) GIS mapping and water balancing
- This will result in spatially explicit water budget maps for each scenario.
- (6) Interpretation of the results
- Derive policy implications.
 - Perform sensitivity analysis as needed.
- (7) Dissemination of the results
- Seminars and on-line information tool.

IV. Description of the results and/or products (deliverables) to be produced from the proposed research

The final deliverables of the project include **data and maps** depicting the results of the state water budget analysis under different scenarios. We will also **identify potentially water-scarce regions**, and identify the factors that contribute to this water scarcity. This information will be used to derive **policy implications** from the analysis, which will be released in a format useful to planners and local citizens.

Finally, to disseminate this information around the state, we will create an **online tool** that will embed the modeling results in an interactive website, searchable by future scenario and by location. We will also **conduct seminars** at various locations around the state to inform local citizens and policymakers about the results of our analysis. The Sustainability Initiative's affiliation with the Minnesota Regional Sustainable Development Partnerships gives our team access to a network of local citizens and leaders around the state that would be a potential audience for the dissemination of results.

V. Timetable for completing the proposed research. (milestones and dates)

TASKS	2008-2009											
	1	2	3	4	5	6	7	8	9	10	11	12
I. Review Literature and Compile Data												
Consult relevant literature and policy proposals; draw on Sustainability Initiative and Statewide Plan scenarios												
II. Identify Key Parameters												
Create GIS layers representing key independent variables												
III. Assign Parameters to Geographical Units												
Create maps of water supply and demand; combine to generate present spatial water budget												
IV. Develop Scenarios												
Describe scenarios holistically; project independent variable layers into future; generate maps of water supply and demand under each scenario												
TASKS	2009-2010											
	13	14	15	16	17	18	19	20	21	22	23	24
V. Conduct GIS and Water Balance Analysis												
Combine water demand and water supply maps for each scenario to generate spatial water budget												
VI. Interpret Results												
Test model results using data and expert panel; generate policy recommendations												
VII. Disseminate Results												
Create online tool; conduct policy seminars around state												

VI. Deliverable products correlated to the timetable and budget

Deliverables and budget for each task:

- (1) Literature review/interview/data mining—\$12,679
 - Background document
- (2) Identification of key parameters of water supply and demand—\$35,837
 - A list of key parameters
- (3) Assign these parameters to each geographical unit—\$28,398
 - GIS layers for water supply and demand
 - A map showing the current state of water budget
- (4) Scenario development—\$59,835
 - Descriptions of all scenarios
 - GIS layers for water supply and demand for all scenarios
- (5) GIS mapping and water balancing—\$49,156
 - Maps for each scenario showing potential future water budget.
- (6) Interpretation of the results—\$33,638
 - Policy discussion.
- (7) Dissemination of the results—\$50,856
 - Seminars and on-line information tool.

VII. Budget requirements to conduct the proposed research including identifying any state and non-state in-kind and/or leveraged funds provided to support the research.

Staff or Contract Services:

\$ 7,700 for one month salary and fringe for P.I. Suh x 2 years	= \$ 15,400
\$60,000 for one postdoctoral researcher x 2 years	= 120,000
\$65,750 for two graduate students x 2 years	= 131,500
Subtotal	266,900

Equipment:

\$3500 second year for travel and supplies for developing/ disseminating policy interface	= \$ 3,500
Subtotal	3,500

Total Budget: \$270,400

Other Funds being Leveraged

The faculty P.I.'s will spend time on this project that is not paid for by LCCMR. The Sustainability Initiative has been funded through a \$900,000 Bush Foundation grant that expires in the fall of 2008. This grant is being used to conduct our GHG reduction scenario analysis, and the participant scenario visioning, which will provide critical input to our water model. The water balance modeling will also receive input from a project under P.I. Suh to explore the

impacts of climate change on state water resources, with funding from the University of Minnesota Agricultural Experiment Station.

References Cited

- Aden, A., 2007. Water Usage for Current and Future Ethanol Production. *Southwest Hydrology* Sept/Oct 2007: 22-23.
- Cai, X., and M. Rosegrant, 2002. Global Water Demand and Supply Projections Part 1: A Modeling Approach. *Water International* 27(2):159-169.
- Center for Watershed Protection, 2005. Issue Paper “B”: Precipitation Frequency Analysis and Use. Joint report issued by CWP and Emmons & Olivier Resources, Saint Paul.
- Delin, G.N., and J.D. Falteisek, 2007. Ground-Water Recharge in Minnesota. U.S. Geological Survey Fact Sheet 2007–3002, U.S. Department of the Interior.
- Donner, S., and C. Kucharik, 2003. Evaluating the impacts of land management and climate variability on crop production and nitrate export across the Upper Mississippi Basin. *Global Biogeochemical Cycles* 17: 1085.
- Duan, Q. Y., J. C. Schaake, and V. I. Koren, 1996. FIFE 1987 water budget analysis. *Journal of Geophysical Research* 101(D3): 7197-7208.
- Gordon, G., 2005. “Water supply can't meet thirst for new industry.” *Star Tribune* 12/26/05.
- Huff, D. D., W. W. Hargrove, R. Graham, N. Nikolov, and M. L. Tharp, 2002. A GIS/Simulation Framework for Assessing Change in Water Yield over Large Spatial Scales. *Environmental Management* 29(2): 164-181.
- Jackson, R. B., S. R. Carpenter, C. N. Dahm, D. M. McKnight, R. J. Naiman, S. L. Postel, and S. W. Running, 2001. Water in a Changing World. *Issues in Ecology* 9:1-16.
- Keeney, D., and M. Muller, 2006. Water Use by Ethanol Plants: Potential Challenges. Institute for Agriculture and Trade Policy. IATP, Minneapolis.
- Ludwig, R., and W. Mauser, 2000. Modelling catchment hydrology within a GIS based SVAT-model framework. *Hydrology and Earth System Sciences* 4(2): 239-249.
- McIsaac, G., M. David, and C. Mitchell, 2007. Biomass Crop Effects on Soil Nitrogen and Water Fluxes. Presentation at 4th annual Special Research Initiative Symposium on Biomass Energy. January 11, University of Illinois.
- Otterson, P., G. Sabel, and M. Tietz, 2002. Charting a Course for the Future: Report of the State Water Program Reorganization Project. Report prepared by Minnesota Planning with EQB Water Resources Committee, Saint Paul.
- Reed, P.M., R.P. Brooks, K.J. Davis, D.R. DeWalle, K.A. Dressler, C.J. Duffy, H. Lin, D.A. Miler, R.G. Najjar, K.M. Salvage, T. Wagener, B. Yarnal, 2006. Bridging river basin scales and processes to assess human climate impacts and the terrestrial hydrologic system, *Water Resour. Res.*, 42, W07418, doi:10.1029/2005WR004153.
- Rosegrant, M.W., X. Cai, and S. A. Cline, 2002. World Water and Food to 2025: Dealing with Scarcity. Presentation at 2002 International Symposium for the World Food Prize, Des Moines, October 24-25.
- Schnoor, J.L., O. C. Doering III, D. Entekhtabi, E. A. Hiler, T. L. Hullar, G. D. Tilman, W. S. Logan, N. Huddleston, and M. J. Stoeber, 2007. Water Implications of Biofuels Production in the United States. Report of the National Academy of Sciences, NAS, Washington D.C.
- Seeley, M., 2007. Climate Change in Minnesota: Measurement Evidence, Consequence, and Implications. Presentation in the Water Resources Science Seminar series. November 2, University of Minnesota.

- Simonovic, S., 2002. World water dynamics: global modeling of water resources. *Journal of Environmental Management* 66: 249-267.
- Singh, V. P., and D. A. Woolhiser, 2002. Mathematical Modeling of Watershed Hydrology. *Journal of Hydrologic Engineering* 7(4): 270-292.
- Tilman, D., J. Hill and C. Lehman, 2006. Carbon-Negative Biofuels from Low-Input High-Diversity Grassland Biomass. *Science* 314: 1598-1600.
- United States Department of Energy, 2006. Energy Demands on Water Resources: Report to Congress on the Interdependency of Energy and Water. Report of the USDOE to House and Senate Subcommittees on Energy and Water Development Appropriations, Washington D.C.
- VanBuren, P., and J. Wells, 2007. Use of Minnesota's Renewable Water Resources: Moving Towards Sustainability. St. Paul, Environmental Quality Board.
- Vörösmarty, C. J., P. Green, J. Salisbury, and R. B. Lammers, 2000. Global Water Resources: Vulnerability from Climate Change and Population Growth. *Science* 289: 284-288.

VIII. Identification and background of principal investigators and cooperators who will carry out the proposed research

Biographical sketch - SANGWON SUH

102 Kaufert Lab., 2004 Folwell Ave., Saint Paul, MN 55108

Tel. 612-624-5307 Fax. 612-625-6286 e-mail: sangwon@umn.edu

(a) Education and Training

Ajou University (S. Korea) Environmental and Engineering B.S. 1998

Ajou University (S. Korea) Environmental and Urban Systems Eng. M.S. 2000

Leiden University (Netherlands) Environmental Science and Engineering Ph.D. 2004

Carnegie Mellon University, Industrial Ecology Postdoctoral Research Associate 2005

(b) Professional Experience

08/05 – present Assistant Professor, Dept. Bioproducts and Biosystems Engineering, College of Food, Agriculture and Natural Resources Science, University of Minnesota.

08/04 – present Associate Fellow, Institute of Environmental Sciences (CML), Leiden University, the Netherlands (Dept. Industrial Ecology)

08/04 – 07/05 Postdoctoral Research Associate, Civil and Environmental Engineering, Carnegie Mellon University (supported by BE: MUSES program)

01/02 – 06/04 Research Scientist, Dept. Industrial Ecology, Institute of Environmental Sciences (CML), Leiden University, the Netherlands

(c) Publications (For the last five years, > 30 journal articles and 2 books)

5 most closely related to the proposed project

Hawkins, T., C. Hendrickson, C. Higgins, H. S. Matthews, S. Suh, **2007**: A Mixed-Unit Input-Output Model for Environmental Life-Cycle Assessment and Material Flow Analysis, *Environmental Science and Technology*, 41 (3), 1024-1031.

Suh, S., **2006**: Are Services Better for Climate Change? *Environmental Science and Technology*, 40 (21), 6555 – 6560.

Suh, S., Huppes, H., **2005**: Methods in Life Cycle Inventory (LCI) of a product, *Journal of Cleaner Production*, 13 (7), 687 – 697.

Suh, S., M. Lenzen, G. Treloar, H. Hondo, A. Horvath, G. Huppes, O. Joliet, U. Klann, W. Krewitt, Y. Moriguchi, J. Munksgaard, G. Norris, **2004**: System Boundary Selection for Life Cycle Inventories, *Environmental Science & Technology*. 38 (3), 657 – 664.

Suh, S., **2004**: Functions, commodities and environmental impacts in an ecological economic model, *Ecological Economics*, 48 (4), 451 – 467.

5 other significant publications

Huppes, G., A. de Koning, S. Suh, R. Heijungs, L. van Oers, P. Nielsen, J.B. Guinée, **2006**: Environmental impacts of consumption in the European Union using detailed input-output analysis, *Journal of Industrial Ecology*, 10 (3), 129 – 146.

Suh, S., **2005**: Developing Sectoral Environmental Database for Input-Output Analysis: Comprehensive Environmental Data Archive of the U.S., *Economic Systems Research*, 17 (4), 449 – 469

Suh, S., **2005**: Theory of Materials and Energy Flow Analysis in Ecology and Economics, *Ecological Modeling*, 189 251 – 269.

Guinée, J.B., M. Gorrée, R. Heijungs, G. Huppes, R. Kleijn, A. de Koning, L. van Oers, A. Wegener Sleswijk, S. Suh, H.A. Udo de Haes, H. de Bruijn, R. van Duin, M.A.J. Huijbregts, **2002**:

Handbook on Life Cycle Assessment. Operational Guide to the ISO Standards. Kluwer Academic Publisher, Dordrecht, The Netherlands.
Heijungs, R., Suh, S., 2002: *The Computational Structure of Life Cycle Assessment*, Springer, Dordrecht, the Netherlands.

(d) Synergistic Activities

Associate Editor, International Journal of Life Cycle Assessment (LCA)

Since 2003, Sangwon Suh is serving as an associate editor of the *International Journal of Life Cycle Assessment*, the only journal wholly dedicated to the advancement of science and practice of LCA.

United Nations' Environmental Program / Life Cycle Initiative activities

UNEP's life cycle initiative is currently the largest international organization on LCA since TC207 of ISO. The initiative aims at harmonizing LCA methods and data, building capacity for developing world and disseminating life-cycle thinking. Sangwon Suh is among a dozen appointed members of TF3 and TF5, which are responsible for LCI methodological consistency and LCA capacity building, respectively.

Developing public LCA databases

Sangwon Suh has developed CEDA/MIET databases ver. 1.0, 2.0 and 3.0 from 2000 to 2005. CEDA/MIET is a Life Cycle Inventory (LCI) database for the U.S. that utilizes a comprehensive list of environmental statistics and the U.S. input-output table. It contains information on 1344 environmental interventions generated by 500 industry sectors and around 100 different Life Cycle Impact Assessment (LCIA) methods. The latest version of the database has been adopted by a number of commercial/non-commercial LCA software packages including SimaPRO 6 and CMLCA and is being used by thousands of LCA practitioners world-wide.

Services in professional organizations and committees

Sangwon Suh is active in various professional organizations and committees. Listed here are a selection of them that are relevant for the current proposal: Advisory Committee Member of the Eco-Industrial Development Council (EIDC) (2006 – present); an LCA Steering Committee Member of SETAC-Europe (2003 – 2006); an LCA Advisory Group Member of SETAC-North America (2005 – present); Award Committee Member of the International Society for Industrial Ecology (2007 – present); Technical Committee Member of the International Input-Output Association, Istanbul Conference (2007); Chair of the Input-Output Working Group, SETAC-Europe (2003 – 2006).

Invited speaker

Sangwon Suh has been invited by universities and conference organizers as a keynote or a seminar speaker nationally and internationally. Selected invited speaks: International Eco-Industrial Development Conference in Seoul, South Korea (2006); International Material Flow Analysis Workshop in Tokyo, Japan (2005); Yale University (2005); Carnegie Mellon University (2004); NATO Advanced Science workshop, Hungary (2004); Waseda University, Japan (2003); Institute of Advanced Technology (IST), Portugal (2003); Ecole Polytechnique Fédérale de Lausanne (EPFL), Switzerland (2002); Norwegian Technical University in Trondheim (2003); University of Tokyo, Japan (2002).

Biographical sketch- Peter B. Reich

Department of Forest Resources

1530 Cleveland Avenue North, University of Minnesota, St. Paul, MN 55108

Phone: 612-624-4270; FAX 612-625-5212; E-mail preich@umn.edu

Education

Ph.D. (1983) Environmental Biology and Plant Ecology, Cornell University, Ithaca, NY

M.S. (1977) Forest Ecology, University of Missouri, Columbia, MO

B.A. (1974) Writing and Physics, Goddard College, Plainfield, VT

Professional Experience

Regent Professor, University of Minnesota, St. Paul, MN, 2007 -

F.B. Hubachek, Sr., Professor, Dept Forest Resources, U. Minnesota, St. Paul, MN, 1991-

Assistant /Associate Professor, Dept Forestry, U. Wisconsin, Madison, WI, 1985-1991.

5 publications relevant to this project:

Dijkstra, F.A., J.B. West, S.E. Hobbie, P.B. Reich. 2007. Dissolved inorganic and organic N leaching from a grassland field experiment: interactive effects of plant species richness, atmospheric [CO₂] and N fertilization. Ecology (in press)

Hale, C., L.E. Frelich, P.B. Reich, J. Pastor. 2005. Effects of European earthworm invasion on soil characteristics in northern hardwood forests of Minnesota, USA. Ecosystems 8:911-927.

Reich, P.B., J. Knops, D. Tilman, J. Craine, D. Ellsworth, M. Tjoelker, T. Lee, S. Naeem, D. Wedin, D. Bahauddin, G. Hendrey, S Jose. K. Wrage, J Goth, W. Bengston. 2001. Plant diversity enhances ecosystem responses to elevated CO₂ and nitrogen deposition. Nature 410:809-812.

Reich, P.B., D.A. Peterson, K. Wrage, D. Wedin. 2001. Fire and vegetation effects on productivity and nitrogen cycling across a forest-grassland continuum. Ecology 82:1703-1719.

Tilman D, PB Reich & JMH Knops. 2006. Biodiversity and ecosystem stability in a decade-long grassland experiment. Nature 441:629-632.

5 other peer-reviewed publications (out of >280 in total)

Reich PB, MG Tjoelker, JL Machado J Oleksyn. 2006. Universal Scaling of Respiratory Metabolism, Size, and Nitrogen in Plants. Nature 439: 457-461.

Reich, PB, SE Hobbie, T Lee, DS Ellsworth, JB West, and others. 2006. Nitrogen limitation constrains sustainability of ecosystem response to CO₂. Nature 440:922-925.

Reich, PB, D Tilman, S Naeem, D Ellsworth, J Knops, J Craine, D Wedin, J Trost. 2004. Species and functional diversity independently influence biomass accumulation and its response to CO₂ and N. Proc Nat Acad Sci USA 101:10101-10106.

Withington JM, PB Reich, J Oleksyn, DM Eissenstat. 2006. Comparisons of structure and lifespan in roots and leaves among temperate trees. Ecological Monographs 76:381-397.

Wright I, PB Reich, M Westoby, and GLOPNET researchers. 2004. The worldwide leaf economics spectrum. Nature 428:821-827.

Synergistic Activities, Honors, Recognition, and Service (selected recent)

- Institute for Scientific Information (ISI) Science Citation Index, List of Top 20 Ecologists and Environmental Scientists in the World, 2002 – present (Current rank #6)
- National Institute on Climate Change Research, Midwestern Regional Panel, 2006-07

- National Science Foundation, Biocomplexity and the Environment Program, Coupled Biogeochemical Cycles Panel member, 2004
- NSF, Ecological and Evolutionary Physiology Panel Member, 1994-97
- Editorial Review Board (or equivalent): *Oecologia* (2006-08), *Tree Physiol.* (1993-95, 2004-) *Trees* (1991-97), *Can Journal Forest Research* (1992-98), *Ecology/Ecological Monographs* (1995-99)

Collaborators/graduate and postdoctoral advisees:

Collaborators (past 4 years) Ackerly D (UC Berkeley), Anderson L (Ohio Wesleyan); Baruch Z (U. Simón Bolívar, Venezuela); Bolstad P (Minnesota), Bongers F (Wageningen U., Netherlands); Bouma T (Netherlands Inst. of Ecol); Bulaj B (Agric. Univ., Poznan, Poland); Cavender-Bares J (Minnesota); Chapin F (U Alaska); Chadwick O (UC-Santa Barbara); Chorover J (U. Arizona); Chung H (U. Michigan), Cornelissen J. (Vrije U., Netherlands); Craine J (Dartmouth); Daszkiewicz P (Museum National D'Historie Naturelle, France); Davis M (Macalester); Dickie I (Landcare Research, NZ); Diemer M (Univ. Zurich, Switzerland); Dijkstra F (UC-Santa Cruz), Dovciak (U. Washington), Eissenstat D (Penn State); Elkin A (Penn State); Ellsworth D (Michigan), Falster D (Macquarie U., Australia), Fargione J (Purdue U.), Flexas F (U. de Illes Balears, Spain); Frelich (Minnesota), Garnier E (C.N.R.S., France); Groom P (Curtin U. Australia); Gulias J (U. de Illes Balears, Spain); Hale C (Minnesota); Hikosaka, K. (Tohoku University, Japan), Hobbie, S (U. Minnesota); Jagodzinski A. (Inst. Dendrol., Poland); Johnson (N. Arizona), Karolewski, P. (Inst. Dendrol., Poland); Kloeppe, B (Georgia), Knops J (Nebraska), Lamont B (Curtin U, Australia); Lee T (U. Wisconsin-Eau Claire); Lee W. (Landcare Research, NZ); Lusk C. (Macquarie U., Australia); Machado J (Swarthmore); Medlyn B (U. New South Wales, Australia), Midgley J (U. Cape Town, S. Africa); Modrzyński, J. (Agric. Univ., Poznan, Poland); Naeem S (Columbia), Navas M-L. (C.N.R.S., France); Niinemets Ü. (U. Tartu, Estonia); Oleksyn J (U. Minnesota); Olesinski, J. (Agric. Univ., Poznan, Poland); Ollinger (U. N. Hampshire), Osada N (U. Tokyo, Japan); Pastor J (Minnesota-Duluth), Poorter H (Utrecht U., Netherlands); Palik P (USFS-Grand Rapids), Poot P (U. Western Australia); Prior L. (Charles Darwin U., Australia); Roumet C. (C.N.R.S., France); Russelle M (ARS, Minnesota); Thomas S (U. Toronto, Canada); Tilman D (Minnesota), Tjoelker M (Texas A&M Univ.); Veneklaas E (U. Western Australia); Villar R (U. de Córdoba, Spain); Turanska, E. (Inst. Dendrol., Poland) Walters M (Michigan State); Warton D (U. New South Wales, Australia), Wedin D (Nebraska), West J (Utah), Westoby, M. (Macquarie U., Australia); Withington, J.M. (Penn State); Wright, I. (Macquarie U. Australia); Wright, J. (Duke University); Wright J. (Smithsonian Tropical Research Institute); Zak, D (Michigan), Zytowski, R. (Inst. Dendrol., Poland).

Graduate student advisee (current institution): D Ellsworth (Michigan), E Kruger (Wisconsin), M Walters (Michigan State), D Vanderklein (Montclair State), L Ko (USDA SWC), J Volin (Florida Atlantic), M Tjoelker (Texas A&M), D Peterson (USFS-Wenatchee), K Wrage (none), J Machado (Swarthmore), M Norris (Minnesota), M Tobin (Florida Atlantic), S Friedman (Michigan State), M Cornett (Nature Conservancy, Minnesota), D Carlson (Minnesota DNR), K Chapman (Applied Ecological Services), M Dovciak (U. Washington), T Lee (Wisconsin-Eau Claire), R Rich (Minnesota), S Weyenberg (National Park Service), K Knight (Minnesota), A Pierce (Minnesota DNR), C Hale (UM-Duluth), B Pelc (Minnesota)

Postdoctoral Advisees (current institution/company): J Oleksyn (Minnesota; Polish Academy of Science), M Walters (Michigan State), M. Tjoelker (Texas A&M), L Frelich (Minnesota), S Jose (Florida), F Dykstra (Minnesota), I Dickie (Landcare NZ), S Schnitzer (Wisconsin-Milwaukee), R Montgomery (Minnesota), C Adair (Minnesota), S Boyden (Minnesota)

MS Advisor: T Hinckley (Washington); PhD Advisor: J Lassoie (Cornell); Postdoctoral Advisor: R Amundson (unaffiliated)

Education

Swarthmore College, Biology, B.A. 1976
Weyerhaeuser Company, Aquaculture Research Technician, 1976-77
Oregon State University, Fisheries, M.S 1980 (Minor in Water Resources)
Oregon State University, Fisheries, Ph.D. 1984

Professional Experiences (all at University of Minnesota)

Founding Fellow, Institute on the Environment 2007-
Founding Director, Institute for Social, Economic, and Ecological Sustainability (ISEES) 1996-
Professor, Dept. Fisheries, Wildlife and Conservation Biology 1994-
Associate /Assistant Professor, Dept. Fisheries and Wildlife 1989-1994/1984-1989
Sea Grant Extension Specialist (Aquaculture and Biotechnology) 1984-

Five Most Relevant Publications

Kapuscinski, A.R., K. Hayes and S. Li, eds. 2007. *Environmental Risk Assessment of Genetically Modified Organisms, Vol. 3: Methodologies for Transgenic Fish*, CABI Publishers. 304 pp.
Brister, D. J. and A. R. Kapuscinski. 2007. A life-cycle framework to identify effects of aquaculture on environmental, economic and social sustainability goals. Working Paper for FAO Expert Workshop on Guidelines for Aquaculture Certification. Fortazela, Brazil, July 31-August 3, 2007
National Research Council (*Kapuscinski chapter chair*). 2004. Biological Confinement of Genetically Engineered Organisms. National Academy Press, Washington, D.C. 255 p.
<http://books.nap.edu/catalog/10880.html>
National Research Council (*Kapuscinski section chair*). 2004. *Atlantic Salmon in Maine*. National Academy Press, Washington, D.C. 275 p.
Miller, L.M., T Close and AR Kapuscinski. 2004. Lower fitness of hatchery and hybrid rainbow trout compared to naturalized populations in Lake Superior tributaries. *Molec. Ecology* 13:3379-3388.

Five Other Significant Publications:

Kapuscinski, A.R. 2005. Current scientific understanding of environmental biosafety of transgenic fish and shellfish. *Scientific and Technical Review* 24(1): 309-322.
www.oie.int/eng/publicat/RT/2401/A_R240127.htm
Senanan, W. A. R. Kapuscinski, U. Na-Nakorn and L. M. Miller. 2004. Genetic implications of hybrid catfish farming (*Clarias macrocephalus* x *C. gariepinus*) in central Thailand. *Aquaculture* 235: 167-184.
Miller, L.M., T Close and AR Kapuscinski. 2004. Lower fitness of hatchery and hybrid rainbow trout compared to naturalized populations in Lake Superior tributaries. *Molec. Ecology* 13:3379-3388.
Kapuscinski, A.R., et al. 2003. Making Safety First a Reality for Biotechnology Products. *Nature Biotechnology* 21(6): 599-601. Link at <<http://fwcb.cfans.umn.edu/isees/>>
Ardren, W. R. and A. R. Kapuscinski. 2003. Demographic and genetic estimates of effective population size (Ne) reveals genetic compensation in steelhead trout. *Molecular Ecology* 12: 35-49.

Synergistic Activities

Co-Director, University of Minnesota Sustainability Initiative – interdisciplinary research on scenarios for Minnesota’s environment in 2050; new undergraduate minor in Sustainability Studies (teach course on climate change mitigation); and public education programs.

Book Series Co-Editor (refereed), *Environmental Risk Assessment of Genetically Modified Organisms* CABI Publishers (Vols. 1-3 in print, Vol. 4 in review) 2003-

Consultative Group on International Agriculture Research (CGIAR) — WorldFish Center Board of Trustees (2003-07) and Chair Science Advisory Board (2007-)

Scientific Advisory Panels to 11 other Agencies — Global Environment Facility- Scientific and Technical Advisory Panel, UN-FAO, UN-WHO, UNEP, OECD, Great Lakes Fishery Commission; USDA, FDA, National Research Council, U.S. Congress OTA, Bonneville Power Administration. 1992 –

National Academy of Science committees – Chair, Research on ecological effects of GEOs on wildlife and habitats (2007-); **Member**: Atlantic Salmon of Maine (2001-2004), Bioconfinement of GEOs (2002-2004) and Salmon and Society in the Pacific Northwest (1992-1995)

Collaborators and Co-Editors (last 4 yrs, including co-author, superscripts –see affiliations at end)

Ira Adelman (UMN), William Ardren³, Paul Barten (U of MA), Devin Bartley (FAO), Deborah Brister (UMN), John Carlson (Penn State), Michael Clegg (UC Irvine), Tracey Close (MN DNR), Vir Chopra (Nat'l Academy Ag. Sci., India), Genya Dana (UMN), Robert Devlin (DFO, Canada), Raymond Duvall (UMN), William Eldridge¹⁶, Norm Ellstrand (UC Riverside), Ian Fleming (Memorial U.), Robert Goodman (U of WI), Mart Gross (U. of Toronto), Stu Hann (Boeing), Keith Hayes (CSIRO), Allen Isaacman (UMN), Lewis Incze (U. So. ME), Larry Jacobs (UMN), Brian Johnson (English Nature), Charles Johnson (Dupont-retired), Jean Kinsey (UMN), T. Kent Kirk (U WI), Ron Krall (Glaxo Smith Kline), G.M. LaVina (World Resources Instit.), Sifa Li (Shanghai Fisheries University), Thomas Lumpkin (Asian Vegetable R&D Center), David Magnus (Stanford), Daniel Magraw (CIEL), Margaret Mellon(UCS), Loren Miller³, William Muir (Purdue), Kristen Nelson (UMN), Barbara Neis (Memorial U.), Eugene Nester (U. of WA), Patrick O'Brien (ChevronTexaco), Nora Olembo (Kenya IPR Office), John Peloquin (American Protein Corp.), Gabrielle Persley (Doyle Foundation, UK), Emily Pullins²³, Peter Reich (UMN), Vern Ruttan (UMN), Nils Ryman (Stockholm U.), Wansuk Senanan¹¹, Peter Smouse (Rutgers), Allison Snow (Ohio State U), Jennifer Specker (U of RI), Mariam Sticklen (MI State U), Robert Stickney (Texas A&M U), John Sutinen (U of RI), Paul Turner (Yale)

Graduate Advisor: J.E. Lannan (MS and PhD), Oregon State University (deceased)

Thesis Advisor (28 total, 23graduated) and Postgraduate-Scholar Sponsor (6 in last five years)

Mark Gross¹ (Ph.D.1995) Gwen M. White² (Ph.D. 1996, Pew Scholarship for Integrated Training in Conservation and Development) Loren Miller³ (Ph.D.1996, M.S. 1992) Susan Solarz^{4*} (Ph.D. 1998, Knauss Marine Policy Fellow) William Ardren⁵ (Ph.D. 1999) Lori Pommerenke^{6**} (Ph.D. 2000, AAAS Fellow) Dennis Kelso^{7*} (Ph.D. 2000) Astrid Scholz^{8*} (Ph.D. 2001) Tsegaye Nega^{9**} (Ph.D. 2002) Karen G. Mumford¹⁰ (Ph.D. 2002) Wansuk Senanan¹¹ (Ph.D. 2002, M.S. 1997) Kelly Paulson (Ph.D. expected 2008, NSF Grad. Fellowship) Anne Cooper (Ph.D. expected 2008, Fulbright Fellow 2002-03, M.S. 2004) Deborah Brister^{**} (M.S. 2002, Ph.D. in progress), Genya Dana* (Ph.D. expected 2009, NSF-IGERT trainee), Leah Sharpe (Ph.D. expected 2009, NSF-IGERT trainee), David M. Nelson¹² (M.S. 1998, Knauss Marine Policy Fellow) Dimuth DeSilva¹³ (M.S. 1989) He Ling¹⁴ (MS 1990) Jeff Mittelmark¹⁵ (M.S. 1993) William Eldridge¹⁶ (M.S. 2000) Carolyn Carr¹⁷ (M.S. 2000), Chris Sneddon^{18**} Teri Allendorf^{6**} (AAAS Fellow) Paul Elkan^{19**} Paul Phifer^{5**} (AAAS Fellow) Sara Tjossem²⁰ (Post-doc) David Faust²¹ (Post-doc) Blake Ratner²² (Post-doc) Emily Pullins²³ (Post-doc), Tim Patronski²⁴ (MS 2005), David Caroffino²⁵ (MS 2006) Kris Johnson²¹ (Research Associate), Laura Schmitt-Olabisi²¹ (Post-Doc)

Affiliations of Advisees:* co-advisor, **ISEES Graduate Scholar In-Residence (≥1 years since 1996), ¹disability leave, ²Indiana Dept. Natural Resources, ³St Cloud State U., ⁴American U., ⁵US FWS, ⁶US AID, ⁷UC Santa Cruz, ⁸Eco-Trust (Oregon), ⁹Carleton College, ¹⁰Emory U., ¹¹Burapha U. (Thailand), ¹²NOAA, ¹³Sanifo-Aventis, ¹⁴biotechnology company (MD), ¹⁵Northern Water Gardens (founding President), ¹⁶U. of Washington, ¹⁷Conservation Consultancy (MN), ¹⁸Dartmouth College, ¹⁹Wildlife Conservation Int'l, ²⁰Columbia U., ²¹U. of Mn., ²²WorldFish Center, USDA ²³Biotechnology Regulatory Service, ²⁴US Fish and Wildlife Service, ²⁵Purdue U. (PhD program)

Laura Schmitt Olabisi, Ph.D.

Ecosystem Science and Sustainability Initiative, University of Minnesota
200 Hodson Hall, 1980 Folwell Ave, St Paul, MN 55108, schm2105@umn.edu, 612-626-2747

Professional Preparation

- Brown University, B.S, Environmental Science, 1999
- State University of New York College of Environmental Science and Forestry, Ph.D., Systems Ecology, 2006
- University of Minnesota, Postdoctoral appointment, 2007-present

Appointments

- 2007–present** University of Minnesota, Research Associate, Ecosystem Science and Sustainability Initiative
- 2001–2006** State University of New York College of Environmental Science and Forestry, Teaching Assistant
- 2004** National Science Foundation GK-12 Graduate Fellow
- 1998–99** Brown University, Student Coordinator, Department of Environmental Studies
- 1998** Harvard University Research Forest, Summer Intern, Soil Warming Project

Publications

Schmitt, L. (Published online 5/22/07). Developing and Applying a Soil Erosion Model in a Data-Poor Context to an Island in the Rural Philippines. *Environment, Development and Sustainability*.

Schmitt, L. and A. Guzman (2007). Development Confusion: Free Trade, Colonial Legacy, and the Philippine ‘Puzzle’, in C. Hall and G. LeClerc (eds.) Making World Development Work: Scientific Alternatives to Neoclassical Economic Theory, University of New Mexico Press, Albuquerque, NM.

Submitted: Schmitt Olabisi, L. Testing the Effectiveness of the Medium-Term Philippine Development Plan for Reducing Poverty and Protecting the Environment on Negros Island, Philippines. *Ecological Economics*.

Submitted: Schmitt Olabisi, L. and A. Guzman. Migration in the Philippines: Causes and Patterns. *Sustainability: Science, Practice and Policy*.

Synergistic Activities

Presentations

“Water, Water Everywhere? The Future of Water Use in Minnesota.” Water Resources Group Seminar series presentation, University of Minnesota, September 21, 2007.

“The Root Causes of Migration in the Philippines.” Auburn University Urban-Rural Interface Conference, Atlanta, April 10, 2007 (with Aileen Guzman).

Educational/Community Service

- Currently organizing interdisciplinary research group for postdoctoral researchers and advanced graduate students at the University of Minnesota.
- Consulted with Heifer Foundation Philippines on a development project in Dauin, Negros Oriental (2004).
- Organized sustainable agriculture workshops for rural residents in Bato, Negros Oriental, Philippines (2004).

Honors and Awards

- NSF GK-12 Fellow, 2004
- Doctoral Tuition Scholarship and Teaching Assistantship, SUNY-ESF, 2001-2004
- *Cum laude* graduate of Brown University, 1999
- Inducted into Sigma Xi Scientific Research Society, 1999

Collaborators

- Aileen Guzman, State University of New York College of Environmental Science and Forestry

Thesis Advisors and Post-doctoral Sponsors

- Dr. Anne Kapucinski, University of Minnesota
- Dr. Peter Reich, University of Minnesota
- Dr. Sangwon Suh, University of Minnesota
- Dr. Charles Hall, SUNY College of Environmental Science and Forestry
- Prof. Myrna Hall, SUNY College of Environmental Science and Forestry
- Dr. John McPeak, Syracuse University
- Dr. John Gowdy, Rensselaer Polytechnic Institute
- Dr. David Pimentel, Cornell University

Yiwen Chiu

Water Resources Science, Doctoral Program, University of Minnesota
Rm. 112, 1390 Eckles Avenue , St Paul, MN 55108, chiux030@umn.edu

Professional Preparation

- National Taiwan University, B.S, Forestry, 1996
- University of Minnesota, M.S, Water Resources Science, 2006
- University of Minnesota, Doctoral Program, 2006-present

Appointments

2006– University of Minnesota, Research Assistant, Dept. of Bioproducts and Biosystem
present Engineering
2005 University of Minnesota, Research Assistant, Ecosystem Science and Sustainability Initiative
2004-2005 University of Minnesota, Research Assistant, Dept. of Forestry
2000-2004 National Taipei University of Technology, Assistant Researcher & Executive
Coordinator, Water Environment Research Center

Publications

Textbook

Lin, J. Y., Y. W. Chiu, Introduction to Ecological Engineering Methods. Ming-Wen Books, Taipei, Taiwan (2003).

Invited Lectures

Chiu, Y. W., Graduate Seminar: Environmental Planning – Revolution by Ecological Sound Practices. Dept. of Geography, National Changhua University of Education (2003).

Chiu, Y. W., How can community participate in ecological sound development? Ecological Engineering Community Workshop. Nanzone, Touyuan (2003).

Chiu, Y. W., J. Y. Lin, International Experiences in Ecological Engineering Methods. Ecological Conservation Training Workshop for Hydrological Engineers. Nantou, Taiwan (2003).

Chiu, Y. W., J. Y. Lin, The Trend of Ecological Engineering Methods. Ecological Conservation Training Workshop for Hydrological Engineers. Nantou, Taiwan (2002).

Chiu, Y. W., J. Y. Lin, The role of ecological engineering methods in public construction and development. The Workshop in Public Construction, Local Culture and Landscape. Construction and Planning Administration, Ministry of Interior (2002).

Chiu, Y. W., J. Y. Lin, Adopting Ecological Engineering Methods for Erosion Control. County Workshop in Promoting Soil Protection and Erosion Control. Hsin-Chu County Government, Taiwan (2002).

Chiu, Y. W., J. Y. Lin, International Experiences in Conducting Ecological Engineering. Ecological Conservation Training Workshop for Hydrological Engineers. Nantou, Taiwan (2001).

Synergistic Activities

Presentations

Chiu, Y. W., S. Suh, Decision Support System for Reservoir Watershed Management. Poster Section, ISIE 2007 Conference, Toronto, Canada (2007).

Chiu, Y. W., J. Y. Lin, The Development of Ecological Engineering Methods in Taiwan: The Case of The Formosan Salmon Habitat Enhancement. American Ecological Engineering Society 2002 Meeting. Burlington, Vermont. USA (2002).

Chiu, Y. W., J. Y. Lin,, The Application of Ecological Working Methods in Taiwan River Reconstruction. The 3rd International Conference on Watershed Management. Taipei, Taiwan (2001).

Lin, J. Y., Y. W. Chiu, A Decision Support System for Reservoir Watershed Management in Taiwan. The 7th International Workshop on Drinking Water Quality Management and Treatment Technology. Taipei, Taiwan (2000).

Honors and Awards

- Travel Grant, Water Resources Science, University of Minnesota, 2007
- Tuition Scholarship, Water Resources Science, University of Minnesota, 2004

Thesis Advisors

- Dr. Sangwon Suh, University of Minnesota
- Dr. John Nieber, University of Minnesota