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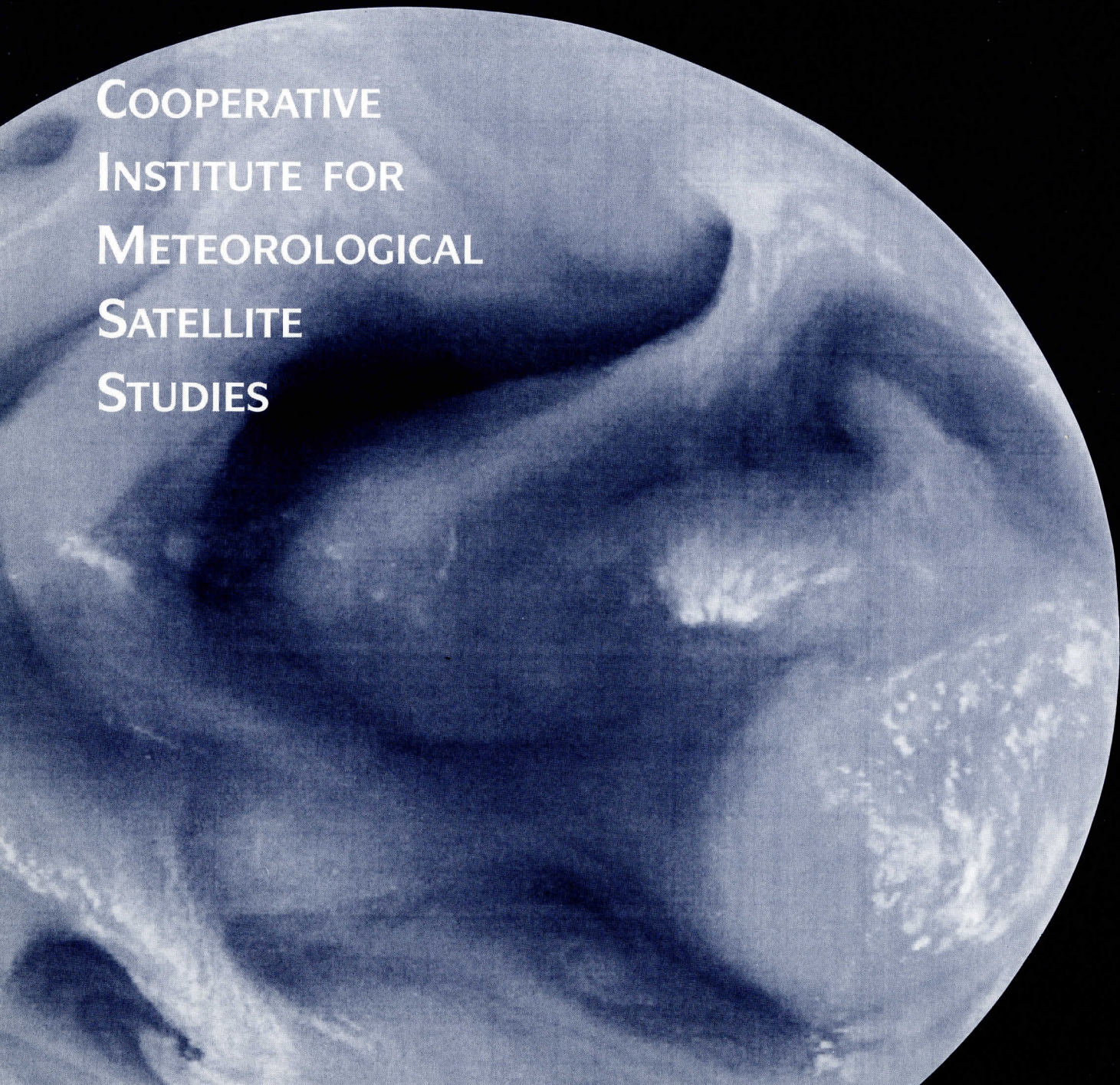
**Upper Midwest RESAC
Midwest Center for Natural Resource Management**

**Final Report
NASA Grant NAG13-99008**

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A REPORT from the

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**Upper Midwest RESAC
Midwest Center for Natural Resource Management**

**Final Report
NASA Grant NAG13-99008**

for the period of
3 March 1999 through 2 March 2003

Submitted to
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Executive summary

The goal of the Midwest Center for Natural Resource Management was to provide information and tools for agriculture, water resources, and forestry managers.

We developed a decision support system for agricultural managers called the Precision Agricultural-Landscape Modeling System (PALMS). PALMS simulates the flow of heat, moisture, and mass in the atmosphere-plant-soil system. Interactions among topography, soil type, tillage, and crops are all considered simultaneously. Comparisons with field data showed that soil moisture is well simulated. Runoff is routed correctly, collecting in runoff channels and depressions where observed. The crop model component produces variability in yield and maturity dates across the field, but hybrid-specific behavior needs improvement. PALMS is being beta-tested by two companies during 2003. PALMS development fostered 8 new partnerships and leveraged over \$800,000 in grants.

In the area of water resources, we completed several observational and modeling studies of the climate and hydrology of the Upper Midwest. Our primary modeling tools were the Integrated Biosphere Simulator and Hydrologic Routing Algorithm. Model results were extensively compared with observations of soil moisture, snow depth, river discharge, and evapotranspiration. We focused on identifying and understanding observed variations in lake hydrology throughout the region. For example, we discovered that the seasonal cycle of Great Lakes water levels has been undergoing significant changes over the past 50-140 years, and that some of the observed changes agree with what has been predicted to occur as a result of regional warming. We recently completed a 10-year energy budget analysis of lake evaporation in northern Wisconsin that provided many new insights into the mechanisms that lead to variations in evaporation rate on a wide variety of time scales.

Forestry research had two main projects. In the first, we studied the carbon (C) sequestration potential of different land use types in southwestern Wisconsin. Of five tree species plantations studied, Norway spruce sequesters the most C over a 40-year rotation and Red Oak the least. An economic analysis showed that Red Pine and White Pine plantations were the most cost effective for C sequestration. In the second project, we adapted a global biosphere model to simulate growth and yield in forest mixes specific to the Upper Midwest and in the boreal forest. We adapted the Integrated Biosphere Model to include species-specific growth and allocation relationships. We added a peat residue layer to improve soil temperature for boreal forests, and introduced a fire disturbance algorithm to allow the model to be used to study carbon cycling.

Remote sensing research produced a method by which coarse-resolution remotely-sensed surface energy fluxes can be disaggregated into fine-resolution fluxes, using a combination of GOES and AVHRR (coarse), with LandSat and a surface model (fine). We are testing the method, DisALEXI, against fluxes observed at the Oklahoma Mesonet site.

Introduction

Two groups in the Upper Midwest proposed to create research centers under NASA's Regional Earth Science Applications Center (RESAC) program. As the goals of the proposed Midwest Center for Natural Resource Management were very similar to those of the proposed Upper Great Lakes (UGL) RESAC, the RESAC program administrators suggested that the two centers, MCNRM and UGL be combined into a single Upper Midwest RESAC. The MCNRM emphasized the development of process-based modeling to create tools for natural resource managers, while the UGL emphasized remote sensing products. This report outlines the goals, strategies, and results of the Midwest Center for Natural Resource Management, one of the two components of the Upper Midwest RESAC. Although much of the work outlined was done independently by researchers of the MCNRM group, collaborations with the UGL group resulted in exchange of knowledge and skills, and notable outreach vehicles, such as the website and Whitepaper (discussed in further detail below). The term "we", when used below, refers to the MCNRM.

Statement of the Issues

The Upper Midwest region (Wisconsin, Minnesota, Michigan, Northern Illinois and Northern Indiana) is a diverse region in physiography, environment, and vegetation. Major natural ecosystems include prairies in the south, northern hardwood and cold-temperate conifer forests in the central and northern part of the region, transitional boreal forests in the far north, and aquatic communities scattered throughout. Prairies have largely been replaced by a wide variety of intensive agricultural crops, including corn and soybean, and specialty crops such as cranberry, fruits, vegetables, ginseng and others. The region's extensive use change has resulted in one of the highest concentrations of croplands on the planet, producing a mosaic of grasslands, forests, croplands, pasture, urban areas, and water bodies. The Upper Midwest region also exhibits extreme year-to-year variability in precipitation, which exerts a significant control on ecosystem processes and natural resource availability. These diverse ecological and environmental conditions contribute to a similar diversity in the economic base, which relies heavily on agriculture, forest products, recreation and tourism, manufacturing, and mining.

Farmers, foresters, and resource managers face increasing societal pressure to simultaneously meet food, water, fiber, and recreation demands for the rapidly growing human population, and manage natural and cultivated ecosystems on a sustainable basis. Despite dramatic improvements in scientists' understanding of environmental and human change effects on ecosystems, the advances in knowledge are not being incorporated into resource management policy and practice. Significant opportunities to promote more efficient and sustainable resource management are being missed, because scientific research is not being translated into information that can be directly applied at the level of the local resource managers.

Project Strategy

The goal of the proposed Midwest Center for Natural Resource Management (MCNRM) was to close the gap between current scientific knowledge and management of forests and agricultural lands by developing integrated, science-based management models that have both economic and environmental ramifications.

Before designing specific products, we approached several groups who had natural resource management concerns (one approached us). Five groups agreed to be partners. Their role was to suggest specific products that they would find useful, provide any data and expertise that would assist our producing useful products, and evaluate the products as they were developed. The Wisconsin Department of Natural Resources agreed to partner with the forestry and agriculture work. Champion International Paper and the US Forest Service were forestry partners. The Cooperative Institute for Meteorological Satellite Studies was a partner in the area of remote sensing. Case, Inc. agreed to partner with the agriculture work.

After our partners listed specific products that they had great interest in, we identified three main paths for creating those products: data collection, process-based modeling, and remote sensing product generation.

In forestry, one issue was the ability of forests to sequester carbon. Since some basic research had to be done to identify the ability of different species to sequester carbon, this became a data collection and analysis project. Results from the data analysis could then be used to build carbon sequestration into models.

Forestry growth and yield, water resources, and precision agriculture needed a process-based modeling approach. We used one main process-based model as the basis for various products: the Integrated Biosphere Simulator (IBIS). This model was robust, provided most components of the water-energy-mass exchange in the air-canopy-soil system, and was already familiar to several of the researchers.

For the surface flux disaggregation product, a combination of remote sensing data used with a process-based model would provide the best utility. We selected the Atmosphere-Land EXchange Inverse (ALEXI) model as the process-based model, and a combination of GOES, AVHRR, and LandSat TM for remote sensing data sources.

Our pathways for getting the information and products to stakeholders were the Upper Midwest RESAC web site and Whitepaper (both found at <http://resac.gis.umn.edu>), public conferences, "open houses", workshops, and some of the more common scientific venues: professional meetings, scientific journal publications, and colloquia. Our partners also proved effective in generating interest in our products as they described to others their involvement in the various projects.

Partnerships

As mentioned in the previous section, the five original partners were the Wisconsin Department of Natural Resources (forestry and agriculture), Champion International Paper (forestry), the US Forest Service (forestry), the Cooperative Institute

for Meteorological Satellite Studies (CIMSS; remote sensing), and Case, Inc. (agriculture).

The forestry partners were brought into the project through Stith T. Gower's relationships (Department of Forest Ecology and Management) with them on previous projects. Their initial involvement was primarily to provide data and access to research sites. During the project, the USFS provided data and access to sites at the Chequamegon National Forest and the Wisconsin DNR provided data and access to research plots at the Coulee Experimental Forest. The partnership with Champion was short lived, as the contact there soon was transferred to a position outside of research and development. His replacement was not interested in continuing the relationship.

Partnerships in water resources did not exist at the time of the proposal. But through repeated contacts with certain groups at meetings, several new, informal relationships were developed. In particular, representatives from the Great Lakes Carriers' Association and International Joint Commission (stakeholders in Great Lakes shipping and regulation) have expressed great interest in the Great Lakes water level studies and possible future collaboration. Our main water resources researcher now resides at Lake Superior State University and has several new relationships there.

In agriculture, the partnership with the DNR was very informal, and consisted of data sharing. The partnership with Case took several interesting turns before and during the project. Before RESAC was announced, a research-oriented person at Case, Steve Faivre, approached John Norman, interested in working on some sort of joint research project. In the proposal to RESAC, there was to be a partnership through Case with Pioneer. Between the proposal preparation and the beginning of the project, the support at Pioneer for the relationship between Case and Pioneer dissolved. Case stayed on as a partner, while Pioneer did not. Case provided monetary support (\$15,000 per year for three years), and some personnel support through their consulting group AFS Services. Our main contact was Mark Stelford.

About midway into the RESAC project Case Inc. was purchased by New Holland of Europe and they disbanded their entire Advanced Farming Systems group and fired over 50 employees. This interfered with joint efforts between our group and the few Case personnel who were left. We concentrated on model development independently, as our contact was given assignments that took him to the Dakotas and Canada for most of the year. Our contact, Mark Stelford, eventually left Case Inc. (now Case New Holland - CNH) and started his own consulting business. This ended our association with Case. Steve Faivre also left Case and joined Deere and Co. and was impressed enough with what we were doing to begin a collaboration with us in 2001 that continues today. Deere and EarthIT (a company started by one of John Norman's graduate students, also working closely with Deere) are now our main partners. These two companies are officially beta testing PALMS in 2003.

Several new partnerships were born from interest in our PALMS work. John Baker of the USDA/NRCS Soil and Water Research Unit contacted us to work on a project to determine the effects of in-field variability on the energy, carbon dioxide and water fluxes that he measures on two research sites. We are intensely involved in the Wisconsin Buffer Initiative and with UW Platteville's Pioneer Prairie Farm, to model the effectiveness of buffers in keeping sediment and nutrients out of surface waters. We are

also in partnership with Bill Stangle of Soil Solutions Consulting on a project that will quantify the amount of phosphorus leaving agricultural lands in Wisconsin. The previous two projects also include the Wisconsin Discovery Farm Program, a program to collect scientific data and test the practicality and effectiveness of best management practices on real working farms.

Our partnership with the Cooperative Institute for Meteorological Satellite Studies (CIMSS) has continued to be strong throughout the entire project. Satellite data, expertise and advice were given freely and regularly during the project. Preliminary DisALEXI products are available to CIMSS personnel as they are produced. A new partner attracted by the research in this area is the Oklahoma Mesonet group, which maintains about 90 flux measurement sites in Oklahoma.

Research Accomplishments

Water Resources

In the area of water resources, we have completed a number of observational and modeling studies of the regional climate and hydrology of the Upper Midwest. Our primary modeling tools have been the Integrated Biosphere Simulator (IBIS; Kucharik et al., 2000) and Hydrologic Routing Algorithm (HYDRA). Results from these models have been extensively compared with observations of soil moisture, snow depth, river discharge, and evapotranspiration throughout the Upper Midwest (Lenters et al., 2000). We have found that the models provide a reasonably good simulation of the regional land surface water balance and are well-suited for examining the effects of climate and land use change on the large-scale hydrology of the Upper Great Lakes region.

Prior to examining such effects, however, we have focused much of our attention on identifying and understanding observed variations in lake hydrology throughout the region (Benson et al., 2000; Lenters 2001; Lenters 2003). This has provided a valuable historical context for understanding the impacts of past climate variations on the water balance of the Great Lakes and their surrounding watersheds. For example, we discovered that the seasonal cycle of Great Lakes water levels has been undergoing significant changes over the past 50-140 years, and that some of the observed changes are in line with what has been predicted to occur as a result of regional warming. These include changes in the seasonal timing of runoff and associated advances in the annual rising and falling of lake levels. The observations also imply increases in basin-wide evapotranspiration for the Lake Superior watershed (and other Great Lakes basins). The results of these observational studies will be used as a springboard for future applications of the IBIS and HYDRA models, which are well-suited for understanding the fundamental mechanisms for these historical variations in lake level, as well as predicting future changes.

We have also recently completed a 10-year study of the effects of climate variability on lake evaporation, and will be submitting the results to the *Journal of Hydrology* within the next few months. The project represents a comprehensive energy

budget analysis of lake evaporation in northern Wisconsin and has provided many new insights into the mechanisms which lead to variations in evaporation rate on a wide variety of timescales. The study is ongoing, and as more years are added to the study, we expect to gain a significantly better understanding of the effects of long-term climate change on lake evaporation. This has extremely important water resource implications for the Upper Midwest, since evaporation plays a significant role in the availability of surface and groundwater resources.

Forestry

Forestry research had two main projects. In the first, we studied the carbon (C) sequestration potential of different land use types in southwestern Wisconsin. Plots of single-species trees were sampled at the Coulee Experimental Forest for the amount of carbon stored in aboveground biomass, forest floor litter, and soil. Two agricultural sites were also sampled, with the corn field considered to be the control. Of five tree species studied - Norway Spruce, White Pine, Red Pine, European Larch, and Red Oak - Norway spruce sequesters the most C over a 40-year rotation and Red Oak the least. An economic analysis of the cost of sequestering carbon considered land purchase or rental price, property taxes, costs of land preparation, seedlings, and planting labor, sale of pulp or timber, and amount of carbon stored. Results of the economic analysis showed that Red Pine and White Pine plantations were the most cost effective for C sequestration and Red Oak the least cost effective. When longer rotations were considered, the cost effectiveness of Red Oak became similar to other species.

In the second forestry project, we adapted the Integrated Biosphere Simulator (IBIS) to simulate growth and yield in forest mixes specific to the Upper Midwest and in the boreal forest. Forest-IBIS includes species-specific growth, stress, and allocation relationships. We added a peat residue layer to improve soil temperature for boreal forests, a moss plant functional type to close the biomass-carbon budget, and introduced a fire disturbance algorithm to allow the model to be used to study carbon cycling. Results from the model are being compared to observations from several sites.

Comparisons between observed and simulated transpiration and leaf area index (LAI) at the Northern Old Black Spruce (NOBS) site show that Forest-IBIS recovers too quickly for intermediate and catastrophic fires. To correct for this, we introduced a 30-year transition period over which the woody carbon removed from the tree is slowly transformed into woody litter. Comparisons of net ecosystem exchange (NEE) and soil temperature at NOBS indicate that the peat layer increases the soil temperature agreement, but that the thermal conductivity of the peat needs to change with its water content in order for NEE to match. Comparisons of NEE at the Chequamegon Ecosystem-Atmosphere Study Site show a good match, as peat is not present. Comparisons are being done with data from an independent data set from Harvard Forest.

Agriculture

We developed a decision support system for agricultural managers called the Precision Agricultural-Landscape Modeling System (PALMS). PALMS is adapted from

IBIS, but includes a routing algorithm for runoff, effects on runoff and infiltration from tillage, roughness, soil crusting, and crop-specific algorithms, such as corn grain and silage moisture. PALMS simulates the flow of heat, moisture, and mass in the atmosphere-plant-soil system on 5m x 5m to 20m x 20m grid cells within a single agricultural field. Interactions among topography, soil type, tillage, and crops are all considered simultaneously, so that the variability of the soil and landscape result in sub-field-scale variability in soil moisture, soil temperature, crop maturity, and yield. Comparisons with field data showed that soil moisture is well simulated. Runoff is routed correctly, collecting in runoff channels and depressions where observed. The crop model component produces variability in yield and maturity dates across the field, but hybrid-specific behavior needs improvement. PALMS is currently licensed through the Wisconsin Alumni Research Foundation for beta-testing by two companies, Deere and Co., and EarthIT.

As PALMS requires an extensive data set for each farm field, we contributed to research being conducted by others on data collection techniques. We assisted in collection of topography, soil electrical conductivity, soil moisture profiles, and soil texture profiles on several fields. These data are combined to produce the 3-d soil texture map required for PALMS. A protocol is currently being written to describe the steps needed to produce the 3-d map. We contributed to work on soil penetrometers to quickly measure soil texture, moisture, color, and structure, without pulling cores or digging pits. We also assisted in the development of a Simple Inverse Yield Model (SIYM), which uses a corn yield map and weather data to determine the soil's water holding capacity in different parts of a field. This water holding capacity map can then be used to build the 3-d soil texture map.

Remote Sensing

Remote sensing research produced a method by which coarse-resolution remotely-sensed surface energy fluxes can be disaggregated into fine-resolution fluxes, using a combination of GOES and AVHRR (coarse), with Landsat and a surface model (fine). GOES imagery is used to compute insolation, while GOES sounder and AVHRR are used to compute the large-scale fluxes with ALEXI. Landsat TM visible, near IR, and thermal bands are used to break up the large 5km pixels into 30m pixels. DisALEXI is the process that breaks up the large pixels into small pixels, constraining the sum of the fluxes over the 30m pixels to agree with that over the 5km pixel containing them. The greatest challenge in the process is to radiometrically correct the imagery so that radiances of the same locations agree among the various sources. DisALEXI is being tested against fluxes observed at the Oklahoma Mesonet site.

Products and Services

Most details of the products are described in the Research Accomplishments section, above. Journal references can be found in the Publications section. Here is a summary:

Water Resources

- Studies of the climatology and hydrologic balance in the Upper Midwest, published in several journals.
- Analyses of the historical lake levels of the Great Lakes, published in two studies in the Journal of Great Lakes Research.
- A 10-year study of the effects of climate variability on lake evaporation on a lake in northern Wisconsin, to be submitted to Journal of Hydrology.

Forestry

- Biological and economic feasibility of afforestation to sequester carbon: a case study, submitted to Journal of Environmental Quality.
- Forest-IBIS, still being compared to field data, available from co-investigator Stith T. Gower.

Agriculture

- PALMS: the Precision Agricultural-Landscape Modeling System, available under licensing from the Wisconsin Alumni Research Foundation. Currently being beta-tested by two companies.
- SIYM: a Simple Inverse Yield Model, published in the Soil Science Society of America Journal.

Remote Sensing

- DisALEXI: Disaggregated Atmosphere Land Exchange model Inverse, still under field data comparison, available from co-investigator John Norman.

Outreach

Our pathways for getting the information and products to the stakeholders were the Upper Midwest RESAC web site (<http://resac.gis.umn.edu>), brochure, and Whitepaper (http://resac.gis.umn.edu/news/resac_whitepaper.pdf), public meetings/forums, the popular press, "open houses", workshops, professional meetings, scientific journal publications, and colloquia.

The web site, the brochure, and the Whitepaper were results of the combined efforts of the entire Upper Midwest RESAC. The web site was very useful in providing a place to put summaries of our work, and post material that had been presented at other outreach venues. The Whitepaper served in part to focus our RESAC's sight on the big picture. It provided a description of our vision and goals that helped guide our collective efforts on all of our individual projects, as well as informing others about our RESAC. The brochure provided an attractive 1-page summary of the material in the Whitepaper.

Presentations at conferences, professional meetings, public forums, etc. were very effective in reaching stakeholders. Being able to describe the project in person allowed us to convey our excitement in the projects. And since the presentations were usually

attended by individuals interested in the subject to begin with, the outreach tended to be very effective.

Papers in scientific journals tend to be a slower method of outreach, due to the rigor of the entire process. But a paper published in a scientific journal is the best way to convey the details to fellow scientists. These papers are also a valuable follow-up to oral presentations. One can refer interested persons to the paper for an in-depth description.

Each of the outreach venues proved to be effective in its own way. And the results of outreach and education efforts appeared to be cumulative. The more times a person or group heard about the product, the more they were interested in learning more about it. Our partners also proved effective in generating interest in our products. It seemed that if someone heard about it from a second party before hearing about it directly from us, they were more interested in it.

We are already seeing the benefits of our outreach efforts. Our outreach has raised awareness of the water resource studies being undertaken as part of the Upper Midwest RESAC, particularly in the area of Great Lakes water levels. For example, we now maintain a regular presence at the annual meeting of the International Association for Great Lakes Research and are regularly invited to participate in meetings and public forums related to climate change and water resource issues in the Great Lakes region.

Our four workshops and many presentations of PALMS have generated quite a bit of excitement in various groups. A person who attended one of the PALMS workshops was prompted to be part of our project to quantify phosphorus losses from agricultural lands (new partner Bill Stangel of Soil Solutions Consulting). The University of Wisconsin - Madison's College of Agriculture and Life Sciences (CALS) holds an Alumni University every summer. A presentation of PALMS generated many positive remarks by the attendees, and subsequent thanks from the CALS Alumni University organizers. A presentation to the CALS Board of Visitors (an advisory board consisting of members of agricultural industry and advocacy groups) generated so many positive comments that now work is underway to produce an Outreach Package. This package will describe the goals of the Wisconsin Buffer Initiative by way of PALMS simulations of the effects of different management methods on a dairy farm in Wisconsin.

Our work on DisALEXI resulted in a partnership with a group that maintains the Oklahoma Mesonet. We use their flux measurements to compare to DisALEXI fluxes, while they use DisALEXI comparisons to judge the quality of the flux measurements they obtain from different flux tower instrument configurations (they have 10 "super" sites with research-grade instruments and 79 sites with less expensive instrument packages). The fact that the Oklahoma Mesonet also has an out-of-state user of their data helps justify the existence of the network.

Overall, we found that in-person presentations of information proved more effective than more passive methods, such as the web site and papers in journals, and that outreach is a continuous, and cumulative process.

A list containing all of the outreach, sorted by date can be found in Appendix A.

Sustainability

Efforts to build sustainability for our projects were continuous. We pursued opportunities for collaboration, applied for grants, and formed new partnerships. Below are some highlights.

New funding

- USDA/NRCS - The Impact of Soil Spatial Variation on Field-scale Measurements of Crop Water Use and Carbon Balance: \$24k
- USDA/CSREES - Quantifying Phosphorus Losses from Agricultural Fields: \$548k
- UW Platteville - Topographic and Electrical Conductivity Survey: \$4.6k
- John Deere & Co.- High Resolution Mapping of Soil Landscapes: \$50k
- Wisconsin Buffer Initiative - Proposed Work Plan for the Technical Subcommittee on Monitoring and Modeling of the WBI Advisory Committee: \$200k

New partnerships/collaborations

- USDA/NRCS Soil and Water Management Research Unit, St. Paul, MN
- John Deere & Co.
- Discovery Farm Program, WI
- Wisconsin Integrated Cropping Systems Trials
- Wisconsin Buffer Initiative
- Lake Superior State University
- EarthIT
- Soil Solutions Consulting
- Oklahoma Mesonet

Conclusions

We have learned quite a bit about developing earth science applications in the four years of RESAC. First and foremost, we have found that one should always be on the lookout for new opportunities. Partnerships can dissolve in the blink of an eye, and that having a backup plan for that essential partner is a must. If one is always searching for new collaborations and partners, chances are that one can find some person or group to replace that missing partner. And if one catches them early enough, a potential competitor can be a collaborator.

A second lesson learned is that one should always keep up the outreach efforts. Stakeholders can be quite skeptical of new things that come along. The more times the stakeholder hears about a project, and the longer that project exists, the more credibility one has with that person or group. And sometimes, large benefits come from getting the word out to groups one wouldn't normally consider; outreach opportunities should not be passed by.

And third, we have found that it is essential to find out what one's colleagues in different departments and universities are doing. Earth science is such an interdisciplinary subject, that one is bound to have only a small amount of the skills needed. Look to colleagues for this skill. Most are willing to share what they know gladly, and may benefit from something you know as well.

Publications

Papers in Refereed Journals:

Lenters, J.D., 2003: Trends in the Lake Superior water budget since 1948: A weakening seasonal cycle. *J. Great Lakes Res.*, *accepted*.

Morgan, C.L.S., J. Norman, and B. Lowery, 2003: Estimating Plant-Available Water Across a Field with an Inverse Yield Model. *Soil Sci. Soc. Amer. J.*, 67:620-629.

— Norman, J., M. Anderson, W. Kustas, A. French, J. Mecikalski, G. Diak, T. Schmugge, and B. Tanner, 2002: Remote Sensing of Surface Fluxes at 10-m Pixel Resolutions. *Water Resour. Res.*, *accepted*.

— Diak, G., J. Mecikalski, M. Anderson, J. Norman, W. Kustas, R. Torn, and R. DeWolf, 2002: Estimating Land-Surface Energy Budgets from Space: Review and Current Efforts at the University of Wisconsin--Madison and USDA/ARS. *Bull. Am. Meteor. Soc.*, *accepted*.

D. Barger and S.T. Gower, 2002: Biological and economic feasibility of afforestation to sequester carbon: a case study. *J. Environ. Quality*, *submitted*.

Donner, S. D., M. T. Coe, J. D. Lenters, T. E. Twine, and J. A. Foley, 2002: Modeling the impact of hydrological changes on nitrate transport in the Mississippi River Basin from 1955 to 1994. *Glob. Biogeo. Cycles*, 16(3), 10.1029/2001GB001396.

Jacobs, J.M., D.A. Myers, M.C. Anderson & G.R. Diak, 2001: GOES surface insolation to estimate wetlands evapotranspiration. *J. Hydrology*, *submitted*.

Lenters, J. D., 2001: Long-term trends in the seasonal cycle of Great Lakes water levels. *J. Great Lakes Res.*, 27(3), 342-353.

Lenters, J. D., M. T. Coe, and J. A. Foley, 2000: Surface water balance of the continental United States, 1963–1995: Regional evaluation of a terrestrial biosphere model and the NCEP/NCAR reanalysis. *J. Geophys. Res.*, 105, 22,393–22,425.

Benson, B. J., J. D. Lenters, J. J. Magnuson, M. Stubbs, T. K. Kratz, P. J. Dillon, R. E. Hecky, and R. C. Lathrop, 2000: Regional coherence of climatic and lake thermal variables of four lake districts in the Upper Great Lakes Region of North America. *Freshwater Biology*, 43, 517–527.

Kucharik, C. J., J. A. Foley, C. Delire, V. A. Fisher, M. T. Coe, J. D. Lenters, C. Young Molling, N. Ramankutty, J. M. Norman, and S. T. Gower, 2000. Testing the performance of a Dynamic Global Ecosystem Model: Water balance, carbon balance, and vegetation structure, *Glob. Biog. Cyc.*, 14(3), 795-825.

Rooney, D., and B. Lowery, 2000: A profile cone penetrometer for mapping soil horizons. *Soil Sci. Soc. Amer. J.*, 64: 2136-2139. The cover of this issue features images from Daniel Rooney's soil video penetrometer.

Diak, G.R., Bland W.L., Mecikalski J.R., Anderson M.C., 2000: Satellite-based estimates of longwave radiation for agricultural applications. *Agricultural And Forest Meteorology* (103)4, 349-355.

Chapters in books:

Morgan, C.L.S, J.M. Norman, C.C. Molling, K. McSweeney, and B. Lowery, 2003: Evaluating soil data from several sources using a landscape model. In *Scaling Methods in Soil Physics*, Pachepsky, Radcliffe, and Selim, eds. CRC Press, Boca Raton, 243-260.

Papers in Proceedings:

Rodgers, C., J. Mecikalski, C. Molling, J. Norman, C. Kucharik, and C. Morgan, 2000: Spatially distributed hydrologic-biophysical modeling: Applications in precision agriculture. Preprints, 24th Conf. on Agricultural and Forest Meteorology, Amer. Meteor. Soc., Boston, MA, pp.86-87.

Stelford, M, S. Faivre, J. Norman, C. Molling and G. Diak, 2001: Becoming a low-cost producer of the future: opportunities for using equipment logistics. Proceedings of the 2001 Wisconsin Fertilizer, Aglime and Pest Management Conference, January 16-18, 2001, Madison, WI. pp206-212.

Molling, C., F. Wayne, J. Norman, J. Mecikalski, M. Stelford, 2001: A computer demonstration of a precision agricultural landscape modeling (PALM) system. Proceedings of the 2001 Wisconsin Fertilizer, Aglime and Pest Management Conference, January 16-18, 2001, Madison, WI. pp240-243.

Morgan, C., C. Molling, J Norman, and B. Lowery, 2002: Evaluating Soil Property Information on a Landscape. Proceedings of the 2002 Wisconsin Fertilizer, Aglime and Pest Management Conference, January 15-17, 2002, Madison, WI. pp64-69.

Customer Feedback

As an example of the value of RESAC to our agricultural stakeholders, Appendix B contains several letters of support that were written for a USDA grant proposal.

Our water resources researcher received quite a few comments on his work. Here are some excerpts from emails:

"I recently read some of your work on MSN regarding water levels on the Lake. I know levels are way down. My question is-at what point does the use of water by the major cities on the Lake affect the Lake level. How many homes, businesses,etc. can be added at Milwaukee, Chicago,etc., before it has an effect on the level. Everyone I talk to says

it is the weather! Please let me know your thoughts, or where I can learn more."

Paul E. Fowler
Black Wolf Wildlife Association
Black Wolf Point Farm

"I am a student at the University of Wisconsin-Madison doing a story on the low water levels of the Great Lakes. I recently read an article Great Lakes 'seasons' may reflect a warming trend that included you as a scientist doing research on this issue. I was wondering if I could meet with you sometime next week to discuss this issue. Please let me know what time works best for you."

Julianna Whiteside

"I would just like to say thank-you for sending me a copy of your article [in Great Lakes Research Journal]. I just finished my annotated bibliography and I wrote a lot about your article. Your article was well written, and one doesn't have to be an expert on the subject in order to understand your research. Thank a lot for sending it to me, it really contributed to my project."

Lindsay Swanson

"Thank you very much for your excellent comments and suggestions for rewrites on the Great Lakes article. I shared all of your comments with the editor and author--they very much appreciated your insights. The manuscript will be appearing in print in the September issue of National Geographic magazine. May I send you a complementary copy? To which address shall I send to? Many thanks for all of your help--it was very much appreciated."

Nora Gallagher

" I am planning a research project on the impact of global warming on Canadian commercial navigation in the Great Lakes. A search on the world-wide web indicates that you have conducted research on the impact of global warming on the Great Lakes. Your extremely valuable research is referred to in several press reports. I was wondering if you could direct me to papers of yours in this area."

Frank Millerd, Department of Economics
Wilfrid Laurier University

Appendix A - List of Outreach

September 24, 1999 International Joint Commission 1999 Great Lakes Water Quality Public Forum
John Lenters, Christine Molling: summary of RESAC activities and implications for GL water quality.

February 8, 2000 Dane County Agribusiness Delegation 2000 Annual Meeting, about 40 attendees.
Chris Kucharik discussed soil carbon,: how it has changed in WI since European settlement, how it can be replenished, why you want to replenish it.

March 23, 2000 Verona School.
Tom Gower talked to 80-100 4th and 5th graders at Verona Elementary School, Verona Wisconsin.
Presentation titled "monitoring the health of terrestrial ecosystems from space". Students were introduced to the major terrestrial ecosystems of the world, some of the pressing environmental problems threatening the health of each ecosystem, and how remote sensing can be used to monitor the health of terrestrial ecosystems.

March 29, 2000 UW-Madison
John Lenters gave a talk entitled "Impacts of Global Warming: Present and Future" and participated in a panel discussion on global warming
The forum was sponsored by the WisPIRG group here on campus (Wisconsin Student Public Interest Research Group). Attendance: roughly 30 people.

March 2000
The paper entitled "Satellite Estimates of Solar and Longwave Radiation for Agricultural Applications" by Diak, Bland, Mecikalski, and Anderson was accepted for publication by Agricultural and Forest Meteorology.

April, 2000
John Lenters submitted to *Geophysical Research Letters* an article entitled "Long Term Trends in the Seasonality of Great Lakes Water Levels"

May 2, 2000
John Norman gave a 50-minute Web lecture on "The Good Earth: Soil Science" for about 12 middle school teachers. This will also be used to train teachers for years to come.
The WEB address of the presentation is <http://www.ssec.wisc.edu/outreach/GET-WISE/ProfNrnm.html>

May 14-17, 2000
Tom Gower, Kruger National Park, South Africa
Science Steering Committee for Global Change and terrestrial Ecology (GCTE)
15 scientists comprising the science steering committee for GCTE
Science agenda for YR 2000/01 was discussed. Programmatic areas of non-linear ecosystem response, role of terrestrial ecosystems in sequestering carbon, and how GCTE will fit into International Geosphere Biosphere Programme.

May 24, 2000
John Lenters Press release explaining results found in *Geophysical Research Letters* submitted article entitled "Long Term Trends in the Seasonality of Great Lakes Water Levels", two talks presented at International Association of Great Lakes Research (annual meeting) Cornwall, Ontario: one about Great Lakes water level research, the other about IBIS modeling activities and RESAC partnerships - approximate audience sizes: 100, 20, respectively

May 24, 2000 - A news piece highlighting John Lenters' above work on the Great Lakes has hit the UW web site (www.wisc.edu). Or you can find the news bit at <http://www.news.wisc.edu/thisweek/view.msml?id=5008>

Week of May 24, 2000

Dan Rooney gave a talk entitled "Imaging the Color characteristics of the Soil Environment" at the ASPRS Conference, Washington, DC. Presentation to 40 and a published proceedings paper titled the same.

June 13, 2000

John Lenters' Great Lakes research (see April /May 24) was featured on CNN's web site news: <http://www.cnn.com/2000/NATURE/06/13/great.lakes.enn/>

More related items:

- responded to reporters questions regarding Great Lakes water level research (first 3 weeks of June)
- gave an 8-minute interview for WEMU radio (segment called "Issues of the Environment") in Michigan (June 28); also regarding Great Lakes research
- agreed to lead Great Lakes climate change workshop for high school students at the Global Climate Change Environment Conference (in Milwaukee, WI; Nov. 14, 2000).

June 30, 2000

The Wisconsin Milk Board's Web site <http://www.wislink.org/> links to SSEC weather imagery on its front page and has a whole SSEC section in Weather Resources. SSEC links there include the Upper Midwest Regional Earth Science Applications Center.

July 1, 2000

Published:

Diak George R., Bland William L., Mecikalski John R., Anderson Martha C., Satellite-based estimates of longwave radiation for agricultural applications, *Agricultural And Forest Meteorology* (103)4 (2000) pp. 349-355

July 9, 2000

Dan Rooney presented his tip and sleeve and video penetrometer research at the ASAE conference in Milwaukee, WI – Workshop on Remote Sensing in Agriculture

July 17, 2000

Dan Rooney gave a presentation about Soil Imaging Penetrometer - Pi Cone at USDA-NRCS State office, Champaign, IL to 15 soil scientists and administrators. Gave field demonstrations of these penetrometers to 10 State soil scientists at various locations

July 20, 2000

John Lenters spoke with reporter from the Toronto Star on numerous occasions about Great Lakes water level research. Story was scheduled to run on July 20.

July 24-28, 2000

John Lenters provided research results and Great Lakes water level data to an elementary school science teacher in Superior, CO.

July 24-28, 2000

John Norman presented "Satellite Estimates of Evapotranspiration on the 100-m Pixel Scale" at the IEEE Geoscience and Remote Sensing Society in Honolulu, Hawaii.

August 15, 2000

Dan Rooney presented his work with the tip and sleeve and video penetrometer to members of the Soil Science Society of America and editors of the SSSA Journal.

August 15, 2000

John Norman presented "Spatially Distributed Hydrologic-Biophysical Modeling: Applications in Precision Agriculture" at the AMS Agricultural and Forest Meteorology Conference in Davis, CA.

August 19, 2000

Christine Molling had a demonstration at the University of Wisconsin - Madison's Campus Open House. The demo consisted of a small version of PALM (our precision farming program) for which guests could modify weather and planting date before running to get yield on a 20x20m farm plot. Also gave away bookmarks describing some of the agricultural work that the Upper Midwest RESAC is doing. 20-25 attendees, 5-7 of which were campus faculty/staff/students, rest general public (all ages).

August 23, 2000

John Lenters contacted via email Julie Archambault, Administrative/Research Assistant Federation of Canadian Municipalities and provided information regarding Great Lakes water level research and location of submitted journal article.

August 28, 2000

Initial meeting with our new outreach person: Dick Wolkowski. Discussed outreach opportunities in future: Wisconsin Fertilizer, Agricultural Lime, and Pest Management Conference in January, 2001; Wisconsin Farm Progress Days in 2002; Ed Liegel, agricultural consultant.

September 8, 2000

John Norman gave a seminar at Northern Illinois University in the Dept. of Geography on Models and Measurements in Site Specific Agriculture.

September 16, 2000

Published:

Lenters, J.D., M.T. Coe, and J.A. Foley (2000). Surface water balance of the continental United States, 1963-1995: Regional evaluation of a terrestrial biosphere model and the NCEP/NCAR reanalysis. *Journal of Geophysical Research (Atmospheres)* 105 (D17), 22,393-22,425.

September 19, 2000

Dan Rooney gave a presentation on Subsurface Mapping to employees of STS in Chicago Illinois. STS (stsltd.com) is currently mapping bare soil hyperspectral and crop imagery to find the best places to spread paper sludge.

September, 2000

John Lenters initiated contact with the NOAA Great Lakes Environmental Research Laboratory (Ann Arbor, MI) and the U.S. Geological Survey (Lansing, MI) to generate collaboration and outreach on Great Lakes water resource issues.

October 4, 2000

John Norman, Dick Wolkowski, and Christine Molling met with Ed Liegel, an agricultural consultant in Spring Green, WI. We discussed the ag applications of RESAC and asked if he'd be interested in becoming a RESAC partner. He was and said he'd give us names of other consultants who could comment on the usability of PALM.

October 5, 2000

George Diak was interviewed by a journalist from the Madison Capitol Times. He spoke about the RESAC project and some of his other projects.

October 12-13, 2000

Combined Upper Midwest RESAC meeting at East Lansing, MI. In attendance were 3 guests from the Great Lakes Environmental Research Laboratory, 1 guest from the USGS,

October 25, 2000

Submitted abstract "proposal" to conduct a workshop on Distributed GIS and Mobile Mapping Methods in Agriculture at the Wisconsin Land Information Association's Conference in February, 2001.

November 3-5, 2000

John Lenters participated in a workshop on the future of Lake Superior research. The meeting was held in Two Harbors, MN. Lenters presented a poster on the Upper Midwest RESAC.

November 4, 2000

Christine Molling was interviewed via email by a UW journalism student (for a class assignment) regarding the relationship between weather and agriculture in Wisconsin.

November 7, 2000

Dan Rooney gave a presentation at the SSSA Meeting entitled "Mapping Subsurface Strata using a Soil Imaging Penetrometer." Audience size approximately 50 people.

November 10, 2000

Christine Molling was interviewed by a UW student (for a class assignment) regarding the use of GIS in precision agriculture modeling.

November 13, 2000

John Lenters spoke via e-mail with Bob Bakhtiari of the Wisconsin Radio network regarding questions on climate change effects in the Great Lakes region.

November 14, 2000

John Lenters gave a presentation at the Wisconsin High School Environment Conference in Milwaukee, WI. The talk was titled "Global Warming: Impact on the Great Lakes Region" and was given to roughly 80-100 middle and high school students.

Mid-November, 2000

Christopher Kucharik gave a talk at the International Crane Foundation entitled: "Assessing the impact of Prairie Restoration on C sequestration across southern Wisconsin." This led to an interview with a reporter from the Sauk Prairie Eagle newspaper (circulation of 2300), who then wrote an article for their Agriculture section of the Nov 30, 2000 issue of the paper. The article was entitled: "Examining the influence of prairie restoration on soil organic matter in southern Wisconsin: Land conservation, carbon sequestration, and potential economic impacts".

November 19-22, 2000

John Lenters spoke via e-mail with Brian Philips, a professor at Lakehead University (Thunder Bay, ON), and answered questions regarding Great Lakes water level variations. Also sent Great Lakes water level data for use in an undergraduate thesis project.

December 13, 2000

Richard Wolkowski gave a talk to the Minnesota Crop Production Retailers in Minneapolis, MN regarding sub-field variability of soil conditions.

December 16, 2000

John Lenters presented a poster at the Fall AGU meeting in San Francisco,

CA. The poster title was: "Thermodynamic Analysis of an Ice-covered Lake in Northern Wisconsin from Pre-freeze to Post-thaw"

December, 2000

The cover of the Soil Science Society of America Journal (distribution 10,000 subscribers) features images from Daniel Rooney's soil video penetrometer.

January 9, 2001

John Lenters spoke with the operations manager of the Centre for Earth Observation Science at the University of Manitoba via e-mail. Answered questions about the Upper Midwest RESAC and discussed their interests in establishing a monitoring program for large lakes

January 17, 2001

Several talks given at the Wisconsin Fertilizer, Agrilime, and Pest Management Conference:
Mark Stelford, John Norman, Christine Molling, George Diak: Becoming a low-cost producer of the future: Opportunities for using equipment logistics.
Daniel Rooney, John Norman, Mark Stelford: Mapping soils with a multi-sensor penetrometer.
Christine Molling, John Norman, Cristine Morgan, Rick Wayne, John Mecikalski, Mark Stelford: Computer demonstration of a Precision Agricultural-Landscape Modeling (PALM) system.
Audience (from 30-150 for each talk) consisted of farmers, agricultural consultants, agribusiness, Extension, etc.

January 26, 2001

John Lenters presented the keynote address at the 2001 Winter Expo of the Lake Michigan Water Analysts (LMWA) group in Kenosha, Wisconsin. Audience was approximately 60-80 people with interests in water quality issues in the Lake Michigan region. Presentation was entitled "Global warming: Impact on the Great Lakes region"

January 29, 2001

John Lenters spoke via e-mail with a contract writer for Environment Canada. Reviewed a draft story on seasonal trends in Great Lakes water levels and answered related questions.

January 30-Feb 1, 2001

Christopher Kucharik presented a poster at NASA EOS Investigator's Working Group Meeting: Ft. Lauderdale, Florida. Audience size about 100: modeling to remote sensing.
C. Kucharik, C. Molling, J. Norman, K. Brye, S. Donner, and J. Foley
Application of Global Ecosystem Modeling Tools to Agriculture: Continental-Scale Food Production to Precision Farming.

February 7, 2001

John Lenters spoke with a reporter at the Appleton Post Crescent. Answered questions about Great Lakes water levels and an upcoming conference on climate change.

February 17, 2001

John Lenters gave a presentation at the Wisconsin Interfaith Conference on Climate Change and Global Warming in Green Bay, Wisconsin. The talk was given to roughly 80-100 people (mostly the general public), and the title was "Global Warming: Impact on the Great Lakes Region".

February 19, 2001

John Lenters gave a seminar at Lake Superior State University (Sault Ste. Marie, Michigan) to roughly 30-40 students and faculty. The title of the talk was "Global Warming: Impact on the Great Lakes Region".

March 1, 2001

Christine Molling and Dan Rooney each gave talks at the Wisconsin Land Information Association Conference in La Crosse, WI. Christine Molling talked about the precision ag model (PALM) and Dan Rooney talked about soil penetrometers. About 25 in audience.

March 3 and 6, 2001

Christine Molling, John Norman, and George Diak gave two PALM workshops to a total of about eight agricultural consultants, dealers, and other ag industry personnel. Attendees learned to use PALM and explored ways of using PALM for decision-making in an ag environment. Attendees also suggested new applications for software such as PALM.

March 12, 2001

Christine Molling sent a copy of WLIA presentation (3/1/01) to Dr. Henry Lin of UW Steven's Point. One of his students who was unable to attend was interested in learning more about PALM.

March 15, 2001

Christine Molling discussed with Jeff Timmons the possibility of using PALMS for water resources work being done in Polk county. Jeff heard the PALMS presentation at WLIA (3/1/01) and introduced himself after the talk.

March 21, 2001

Christine Molling spoke with Jeff Timmons again to discuss how to begin to collaborate. Timmons wishes to use PALMS on a farm in Polk County on which he will conduct a phosphorus runoff study this season. Timmons stated he would send orthophotos, soil maps, and background info to Molling. Molling said she would send latest PALMS distribution CD with test data to Timmons.

March 30, 2001

John Lenters attended EPA workshop on "Climate change and Great Lakes water levels" in Chicago, Illinois. Spoke with stakeholders in Great Lakes shipping and regulation. Distributed copies of RESAC brochure and recent paper on Great Lakes water levels.

April, 2001

Lenters provided assistance to 2 graduate students requesting advice on lake evaporation, solar radiation, and other lake energy fluxes; used for student thesis research projects.

May 23, 2001

Combined Upper Midwest RESAC Open House in St. Paul, MN at University of Minnesota. Posters showing results of all projects were available for viewing. People who worked on the projects talked about the work to visitors. About 35 people from 13 different agencies attended the Open House. At least three attendees requested additional information.

May 24, 2001

Upper Midwest RESAC members presented a response to the MN DNR's request for a joint research program to investigate the potential effects of changing climate on the ecosystem, infrastructure, and economy of Minnesota.

June, 2001

Lenters presented a paper at the annual meeting of the International Association of Great Lakes Research in Green Bay, Wisconsin. Presentation was entitled "Why is the seasonal cycle of Great Lakes water levels changing?"

June 22, 2001

Kucharik spoke at Midwest Renewable Energy Fair in Amherst, Wisconsin entitled "Land Conservation, Carbon Sequestration, and Potential Economic Impacts in Wisconsin"

June 27, 2001

Some applications of PALMS were shown during UW's Agronomy Field Days in conjunction with the Midwest Hay Producer's Hay Expo at the Arlington Agricultural Research Station, Arlington, WI. About 60 people saw the short presentation.

August 8, 2001

John Norman and Christine Molling gave two hands-on workshops of PALMS at the UW Extension's Crop Diagnostic Training Center New Technology Workshop. Each of the two workshops was attended by approximately 14 consultants and dealers in the agribusiness sector. Participants were able to run the software on computers and discuss results.

August 9, 2001

Christopher Kucharik submitted a paper entitled "IBIS yield and Nitrate Loss Predictions for Wisconsin Maize Receiving Varied N-Fertilizer" to Journal of Environmental Quality.

August 12-14, 2001

John Norman attended the ZONES research conference with Ron Schuler to learn about the activities of a million dollar research program on precision farming funded by the North Central Soybean Association. In particular, the modeling program of Bill Bachelor.

August, 2001

George Diak and co-authors submitted the paper "GOES surface insolation to estimate wetlands evapotranspiration" by J.M. Jacobs, D.A. Myers, M.C. Anderson & G.R. Diak to Journal of Hydrology

September 4, 2001

Christine Molling wrote an assessment of the current state and the future of precision agriculture modeling in the US. A grad student in Norway asked for this information after seeing the PALMS material on the RESAC web site.

September 26, 2001

Dan Rooney's penetrometer work was featured in an article called "A Worm's-Eye View" in MIT's Technology Review: <http://www.techreview.com/web/baker/baker092601.asp>.

Recently published:

Lenters, J.D., 2001: Long-term Trends in the Seasonal Cycle of Great Lakes Water Levels. Journal of Great Lakes Research, 27(3):342-353.

November 5, 2001

Lenters attended a public consultation meeting (Sault Ste. Marie, ON) sponsored by the International Joint Commission to discuss the recently initiated Upper Great Lakes Plan of Study (a review of the Lake Superior outflow regulation operations). Was asked to present an overview of recently published long-term trends in the seasonality of Great Lakes water levels.

November 14-15, 2001

Wes Jarrell of the Discovery Farms and I were invited to present two 1.5 hour talks at the Professional Dairy Producers of Wisconsin Environmental Summit in Green Bay, WI. Wes had 45 minutes and I had 45 minutes, and we presented the talk two times; 30 persons the first time and 45 persons the second time. The title of my talk was "Applying Site-Specific Research in Crop Production and Environmental Protection to Farm Management". Wes talked about the Phosphorus Index and linked his work to simulations we had done with PALMS so the two talks were coordinated.

November 27 – December 6, 2001

Demonstration of PALMS at the Area Soil and Water Management Meetings

Eight Locations: Edgerton, Eau Claire, Sparta, Marshfield, Juneau, Kiel, Shawano, and Dodgeville, Wisconsin. Dr. Wolkowski presented a demonstration of the PALMS model at the annual Area Soil and Water Management meetings. The audience consisted of 484 Certified Crop Advisers, Fertilizer Dealers, Vocational Technical College Instructors, County Agents, Government Agency personnel, and others. His presentation began with a Power Point discussion of the purpose and potential of the PALMS model, followed by a live demonstration. Soil water content and infiltration ration were shown for the Arlington field in June, 2000 during a particularly wet part of the season.

December 6, 2001

John Norman and Christine Molling traveled with Wes Jerrel to conduct a site visit of the first farm chosen in the Discovery Farm Program (<http://www.discoveryfarms.org>). The farm located in Buffalo County, WI is in the driftless area. The Bragger farm contains two drainage basins that will be studied intensely. These basins both contain intermittent waterways and springs that feed permanent streams. The two streams have continuously recording sampling gages installed by the USGS (<http://water.usgs.gov/wi/nwis/current?type=flow> see streams 053793305 and 053793306). Norman and Molling will take part in the study of this Discovery Farm by running model simulations on selected fields and comparing simulated runoff to stream gage data.

December 20, 2001

Lenters submitted an abstract to the International Association of Great Lakes Research annual meeting (Winnipeg, June 2002) to present an analysis of seasonal trends in the Lake Superior water budget.

January 2, 2002

The following solicited paper "Characterizing Soil Properties on a Landscape Using Data Sources at Several Scales" by Morgan, Norman, Molling, McSweeney, and Lowery was submitted to be published in Scaling Methods in Soil Physics, Radcliffe, Selim, and Pachetsky, Eds, ASA/CSSA/SSSA, Madison, WI.

January 4-5, 2002

Christine Molling discussed upcoming talk (see Jan 16, 2002 entry) with George Gallepp and Katie Weber of UW's College of Agriculture and Life Sciences. Gallepp and Weber are writing press releases featuring this talk and other selected talks to be given at the WFAPM conference. See http://www.cals.wisc.edu/media/news/01_02/new_tools.html

January 9, 2002

Tom Gower attended and spoke at a meeting with StoraEnso to discuss research project to examine C life cycles from cradle to grave e.g. budgeting carbon uptake and emissions through he life cycle of the tree, product, waste, including mean residence time in landfill. The meeting went very well and they will likely fund a research project - this is a direct result of our research activities in the NASA project. Likely collaborators will be CanFor (a very large private timber company in Canada), Time-Warner (e.g. Time magazine) and Home Depot.

January 15, 2002

D. Barger and S.T. Gower submitted a journal article to Journal of Environmental Quality: "Biological and economic feasibility of afforestation to sequester carbon: a case study."

January 16, 2002

Christine Molling presented "Evaluating Soil Property Information on a Landscape" at the Wisconsin Fertilizer, Aglime, and Pest Management Conference. Audience consisted of approximately 50 growers, consultants and ag sector business persons. See <http://www.news.wisc.edu/view.html?get=6998>

January 17, 2002

John Lenters gave a presentation to the local chapter of the Sierra Club at Lake Superior State University (Sault Ste. Marie, MI). His talk was entitled "Global Warming: Impact on the Great Lakes Region." There were about 34 people in attendance (including students, faculty, and local community members).

January 24, 2002

Christine Molling recorded two 3-minute radio spots to be featured on UW's College of Agriculture and Life Sciences radio show, called "Ag Facts." Host Jeanie Geurink asked questions about new modeling techniques (PALMS) that will help farmers make decisions about the management of their farm fields. This show is distributed to radio stations across the state of WI. Errors occurred in the taping, so the spots were re-recorded on 2/12/2002.

February 2, 2002

Barry Jacobson of Soil & Water Engineering Technology, Inc in Gainesville, FL requested information from Christine Molling about PALMS. He is interested in using the model with a variable rate nitrogen product from Cargill. Molling sent him a ppt presentation reviewing the main points of the model.

February 8, 2002

Christine Molling was invited to give a 15min overview of PALMS to the members of the Wisconsin Integrated Cropping Systems Trials (WICST) team. The talk emphasized ways in which this model could be a valuable research tool for the goals of WICST. Ron Doetch, Programs Manager of Quality Traders, Inc. (www.qtraders.com) asked for a copy of the presentation. He felt that PALMS would be useful in their predictions of grain quality.

February 22, 2002

Christine Molling was asked to review a chapter for a book entitled "Precision farming - A global perspective" to be published by Hayworth Food Products Press, New York. The editor of the book, Ancha Srinivasan, gave a manuscript entitled "The Role of Precision Agriculture in Decision-Support and On-Farm Experimentation" to Molling to review.

February 26, 2002

Robert Caldwell of the University of Nebraska asked Christine Molling about the runoff formulation of PALMS. Molling sent him some information.

February 28, 2002

Tom Gower attended a meeting in New York concerning carbon cycling and forest carbon shadows. This meeting was hosted by Stora Enso. Other interested corporations included Time-Life and Home Depot. Tony Janetos with World Resources Institute, formerly from NASA Land Cover-Land Use Change Program, was a NGO representative.

March, 2002

The UW College of Agriculture and Life Sciences 2002-2003 Science Report contained an article on PALMS by George Gallepp. The article entitled "Physics in a Corn Field" mentioning the collaboration among Soil Science, Space Science and Engineering Center, and Institute for sustainability and the Global Environment researchers.

March, 2002

John Lenters exchanged e-mail with two University of Wisconsin students who had questions about Great Lakes water levels. Also forwarded electronic copies of a recent publication on seasonal changes in Great Lakes water levels.

March, 2002

John Lenters participated in a student-organized Native American Pow Wow: "Honoring the Water" (at Lake Superior State University). Gave a 15-minute presentation on global warming impacts on water resources, and participated in a panel discussion.

March, 2002

Cristine Morgan's SIYM paper "Estimating Plant-Available Water Across a Field with an Inverse Yield Model" by Cristine L.S. Morgan, John M. Norman, and Birl Lowery, was accepted pending minor revision

by Soil Science Society of America Journal. This was jointly supported by RESAC and USDA NRI grant with Birl Lowery.

March 1, 2002

Christine Molling and Cristine Morgan visited John Baker, of the USDA's ARS office in St. Paul to discuss surveying two fields on which he has flux towers. Baker is hiring John Norman's (UW Soils Dept.) group to conduct topographic and electrical conductivity surveys on his fields, run PALMS to assess spatial differences in evapotranspiration on the fields, and help to assess the impact of these spatial differences on the fluxes measured.

March 5, 2002

Molling and Norman met with Josh Posner of UW's WICST to discuss ways in which running PALMS on the cropping trails may add valuable information to the analysis of trials data.

March 18, 2002

Molling and Norman visited the UW Platteville's Pioneer Prairie Farm. Jay Weber, the project manager, plans to hire John Norman's group to do topographic surveys of fields, and electrical conductivity surveys of selected drainage basins on the farm.

March 20, 2002

Sabine Grunwald, of the University of Florida invited John Norman to give a PALMS demonstration at the ASA-CSSA-SSSA Annual Meeting in November.

March 20, 2001

John Norman delivered a seminar in the Global Sustainability Lecture Series sponsored by the Center for Sustainability and a Global Environment (SAGE) entitled "Applying Site-Specific Research in Crop Production and Environmental Protection to Farm Management".

April 6, 2002

George Diak, John Norman, and Christine Molling met with Mark Stelford of Case New Holland to discuss further collaboration on the issue of compaction. We discussed several issues that relate to making COMPAC, written by a researcher from USDA/ARS, to work within the PALMS framework.

April 8-15, 2002

Christine Molling and a Dept of Soils graduate student conducted topographic and soil conductivity surveys at the UW Platteville Pioneer Prairie Farm. This information will be used as part of the research done at the farm under the Wisconsin Agricultural Stewardship Initiative. Whole-farm systems are being studied under WASI in order to establish the effects of management practices on the economics, environmental impacts, and productivity on Wisconsin farms.

April 24-25, 2002

Christine Molling and a Dept of Soils graduate student conducted topographic and soil conductivity surveys at the University of Minnesota's Rosemount Research Farm. This data will be used in a collaboration between UW and John Baker of the USDA/ARS to determine the effects of in-field variability on flux tower data.

April 30, 2002

Christine Molling met with a graduate student in Geographic Information Engineering who was hired for the summer to interface PALMS with ArcGIS, one of the more popular GIS software packages. The goal is to make PALMS more approachable to users, by joining PALMS with visualization and geographic analysis software that they may already be familiar with.

May, 2002

John Lenters offered consultation to Nora Gallagher of National Geographic magazine for an article regarding Great Lakes water levels.

May 22-24, 2002

John Lenters presented a paper at the Lake Superior State-of-the-Lake conference in Houghton, MI. Title: "Long-term variations in the Lake Superior water budget"

June, 2002

George Diak had an in-depth discussion with Robert Reining of an agency that consults for NASA/NOAA on future satellite instrumentation. His organization, MITRE, is a not-for-profit national resource that provides systems engineering, research and development, and information technology support to the government. It operates federally funded research and development centers for the DOD, the FAA, and the IRS, with principal locations in Bedford, Massachusetts, and Northern Virginia (www.mitre.org). They discussed our RESAC and ALEXI remote sensing efforts and how products might be improved with if future if future operational satellites have high-spectral resolution instrumentation.

June 2-6, 2002

John Lenters presented a paper at the annual meeting of the International Association of Great Lakes Research in Winnipeg, Manitoba (June 2-6). Title: "An observational analysis of long-term trends in the Lake Superior water budget"

June 19, 2002

Christine Molling attended a meeting of the Wisconsin Integrated Cropping Systems Trials. The meeting was held to introduce the current participants to some of the people who may be involved in the next funding period. Molling briefly related the role of modeling systems to investigate the hydrologic (surface water and soil moisture) and environmental (nutrient leaching/runoff, soil carbon) impacts of the cropping trials.

June 27, 2002

Christine Molling presented two (identical) sessions at the UW College of Agriculture and Life Sciences Alumni University. A powerpoint presentation informed the participants about PALMS. Then participants were able to view season-long animations of PALMS output, which showed ponding, soil moisture, and crop growth in response to rain. About 30 alumni attended, ranging in age from around 45 to 80. Presentation and animations available on the RESAC website from the page <http://emily.soils.wisc.edu/RESAC/agric/calsalum.html>

June 28, 2002

John Norman gave a presentation at the Wisconsin Buffers Initiative meeting. The meeting was held to plan the agenda for a future workshop. The goal of the workshop will be to design a plan to scientifically establish the role of vegetative buffers in reducing runoff and sediment/nutrient transport; maintaining streambank stability; providing refugia for wildlife, plants, weeds, pests, and diseases; etc. Research findings will be used by the Wisconsin DNR to write regulations regarding the creation and maintenance of buffers. John Norman's talk introduced PALMS and highlighted ways in which such a modeling system can investigate the effects of buffer placement, width, and vegetation type. Preliminary examples were given.

July 22, 2002

Christine Molling ran three years of PALMS simulations on Arlington, WI soils for Dr. Philip Barak of the Soils Dept. Dr. Barak seeks to use drainage information from PALMS to help determine why phosphorus accumulates at certain levels in the soil.

July 29, 2002

Christine Molling, along with co-author J. Norman submitted the following invited abstract to be presented at the 2002 ASA/SSSA/CSSA Annual Meeting's Soil-Landscape Modeling Symposium: 3-D Simulations of Heat and Water Flow in Landscapes with Heterogeneous Soils.

August 27, 2002

Christine Molling spoke with Franta Majs of the University of Minnesota regarding how we use the EM38 electrical conductivity meter to do continuously geolocated surveys of soil by mounting a differential GPS on the sled that hold the EM38.

August 29, 2002

Christine Molling gave a talk entitled 'The Precision Agricultural-Landscape Modeling System: IBIS adapted to very small scales' at the Center for Sustainability and the Global Environment's IBIS workshop.

September, 2002

George Diak, along with co-authors J. Mecikalski, M. Anderson, J Norman, W. Kustas, R. Torn, and R. DeWolf submitted the following paper to the Bulletin of the American Meteorological Society: 'Estimating Land-Surface Energy Budgets from Space: Review and Current Efforts at the University of Wisconsin--Madison and USDA/ARS.'

September, 2002

George Diak, along with co-authors J. Mecikalski, M. Anderson, J Norman, R. Torn, R. DeWolf and W. Kustas submitted the following extended abstract to be presented at the next American Meteorological Society's 2003 Conference on Satellite Meteorology and Oceanography: 'Estimating the Land-Surface Radiant, Turbulent, and Conductive Energy Budgets Using Satellite systems and complementary Synoptic Data.'

September, 2002

John Lenters responded to an e-mail request from a professor at Wilfrid Laurier University (Waterloo, Ontario) to provide copies of publications, a description of current research, and a bibliographic database of publications on climate change impacts on the Great Lakes. The reference material is to be used in a recently initiated a study of the impacts of global warming on commercial navigation.

September, 2002

John Lenters submitted a paper entitled 'Trends in the Lake Superior water budget since 1948: A weakening seasonal cycle.' Paper was submitted to the Journal of Great Lakes for a special issue devoted to current Lake Superior research.

September 13, 2002

Christine Molling met with Dick Wolkowski to give him a quick lesson on using the hand-held gps. Dick wishes to give a lesson on GPS technology, mapping, and navigation to a group of Boy Scouts, and have the Scouts use the GPS to navigate to a target.

October, 2002

John Norman along with co-authors M. Anderson, W. Kustas, A. French, J. Mecikalski, G. Diak, T. Schmutge, and B. Tanner submitted the following paper to Water Resources Research: 'Remote Sensing of Surface Fluxes at 10-m Pixel Resolutions.'

October, 2002

http://www.cals.wisc.edu/media/news/10_02/P_loss_study.html is a news release featuring the study "Quantifying Phosphorus losses from Agricultural Fields." This study was recently funded by the USDA CSREES. The work to be done in this study is a direct result of work done under RESAC.

November 8, 2002

John Lenters exchanged e-mail with Reg Gilbert (senior coordinator with Great Lakes United) regarding the effects of climate change on the Great Lakes. Journal reprints and other supplementary materials were mailed to Mr. Gilbert.

November 11, 2002

Christine Molling presented the talk "3-D Simulations of Heat and Water Flow in Landscapes with Heterogeneous Soils" at the American Society of Agronomy - Soil Science Society of America - Crop

Science Society of America 2002 annual conference. Audience consisted of approximately 90 persons from academia and federal service/research institutions. Two persons requested copies of the presentation.

November 12, 2002

John Lenters gave a presentation to the Sault Naturalists Club in Sault Ste. Marie, Ontario. His talk was entitled "Global Warming: Impact on the Great Lakes Region." There were about 25 people in attendance (mostly from the local community).

December 11, 2002

Christine Molling presented an overview of PALMS to the Cooperative Institute for Meteorological Satellite Studies at UW Madison's space Science and Engineering Center. About 20 persons attended.

December 13, 2002

John Lenters submitted two abstracts to the International Association of Great Lakes Research annual meeting (Chicago, IL; June 2003) entitled, "Effects of climate variability on lake evaporation as determined from a 10-year energy budget study of Sparkling Lake (northern Wisconsin)" and "Understanding the origin of long-term trends in the seasonality of Great Lakes water levels: A synthesis of recent studies."

January 8, 2003

John Norman was invited to present a 3 hour workshop program at the Fifth Crop Modeling Workshop entitled "Crop Modeling for Environment-Specific Management" on PALMS. It was 1:00 pm to 4:00 pm Wednesday Jan. 8, 2003. The workshop was run by Dr. Robert Caldwell at the University of Nebraska, Lincoln, NE. The schedule can be viewed at <http://cropmodelingworkshop.unl.edu/Schedule2003.htm>

February, 2003

John Lenters served as the senior thesis advisor for an undergraduate student majoring in Environmental Science at Lake Superior State University. The title of the student's thesis was "Lake Ontario water budget from 1916 to 1999: Shifts in the seasonal cycle"

February, 2003

John Lenters participated in revisions of the initial draft of a book chapter (with co-authors John Magnuson, Barb Benson, and Dale Robertson) entitled "Climate variability and change." The chapter discusses the effects of climate variability and change on lakes in the Upper Midwest and will appear in the book "Long Term Ecological Research of North Temperate Lakes: Dynamics of Lakes in the Landscape."

Appendix B - Letters of Support

March 13, 2002

Professor Norman
Department of Soil Science
University of Wisconsin - Madison
263 Soils Building
1525 Observatory Drive
Madison, WI 53706

Dear Professor Norman:

I am writing this letter of support for the implementation of the PALMS program on our operation here in western Wisconsin. We hope that by using this model, when combined with the information collected by the Discovery Farms Program (water monitoring data, application rates/methods, economic data, yield data, etc.) we can help you develop an accurate model.

We became involved in the Discovery Farms Program because we are looking for methods to farm in an environmentally friendly manner, while maintaining or improving our farm's profitability. Our family believes that we must be pro-active in regards to adopting best management practices that protect the environment, but we are concerned about their affects on our ability to farm. We farm in a very difficult region of Wisconsin. We live in the driftless region of Wisconsin and our farm is surrounded by steep hills. The topography is common in this part of Wisconsin, in southeastern Minnesota and in eastern Iowa. The water from our land drains into streams that feed into the Mississippi River.

Dr. Norman, if we do not find methods to raise livestock in an environmentally sound manner, this part of the state will become a real environmental hazard. I believe this because as our neighbors quit dairy farming, they become cash croppers. The only way to make money cash cropping is to plant corn and soybeans (for the government payments), which increase the erosion and causes deep gullies. We believe that we need to maintain hay in our rotation and in order to have a profitable outlet for our hay, we need cattle. Since our farm has adopted no-tillage as the sole method for planting, we surface apply manure from both cattle and poultry. Proposed rules and regulations may require us to begin incorporating manure, which we believe will increase our soil erosion rates and may deliver more nutrients to the stream.

Two years ago the DNR proposed non-point rules that would have required a 300 foot buffer area around streams (including intermittent streams). Within this 300-foot area, we would have been required to farm to one-third tolerable soil loss levels (about 1.5 tons/acre). This rule would have eliminated 200 acres of our farm for crop production. This is out of the 285 tillable acres that we own in this valley (over 70%). That would have made it impossible for us to continue farming. The sad thing is that no one can tell us if we are negatively impacting the streams in our area the way we are farming now.

In summary, we believe that without pro-active programs like the Discovery Farms Program that takes research projects like PALMS out on real farms, the future of agriculture is in question. We are excited to work with you and the researchers from the university on this project. If there is anything that I can do to assist you, please feel free to call me anytime.

Sincerely



Joe Bragger

DISCOVERY F A R M S

Soil Science 1525 Observatory Dr., University of Wisconsin, Madison
Madison, WI 53706

Office: 608-263-7092 Fax: 608-262-2633

March 13, 2002

Dr. John Norman
Department of Soil Science
University of Wisconsin
Madison, WI 53706

Dear John:

As Senior Scientist of the Discovery Farms Program, I am very pleased to offer you our full and enthusiastic cooperation in the further development and landscape-scale testing of PALMS.

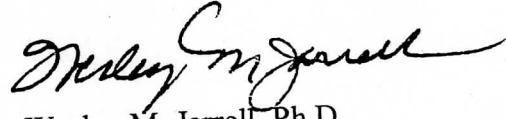
The PALMS fits perfectly into our desire to link the best of basic science approaches with the solution of immediate, practical problems. In many cases, we don't understand enough about effects of basic soils, geology, forest land, and farm management on water, sediment, and ion movement across the landscape to make confident decisions about changes in management. PALMS will let us take this giant step forward in demonstrating the scientific and the agronomic impacts of a wide variety of decisions, without having to directly monitor every possibility in the field.

I see this as the ultimate benefit of "adaptive management" types of approaches. We can look at the basic properties and dynamics of the system, describe these with the model and field analyses, then project what will change as we make management changes. We can link the farmer's costs of these changes – including money, time, opportunity costs – with the benefits to the environment that should come about because of these changes. Finally, we should be able to project into the future and design new management systems that may best enhance the environment and provide the least cost, or the highest financial benefit, to the farmer.

Although we have a number of tools available to us now, none appear able to meet these types of demands as well as PALMS. I am especially excited about incorporating our findings on the Bragger Farm into the Phosphorus Index, and taking these insights related to testing the PI to many other locations around the state. There is no question that the results of this study will be rapidly disseminated and adapted to other areas of the state and indeed the Upper Midwest region. Iowa and Minnesota are facing many similar challenges with their PI, and we are collaborating with them to make the best use of our limited resources in testing and refining the PI.

We look forward to supporting this project fully, because we expect the results to enhance both our basic understanding of landscape processes in agriculture, and our immediate ability to manage these processes for environmental and financial sustainability on the farm.

Sincerely,



Wesley M. Jarrell, Ph.D.
Senior Scientist

DISCOVERY



FARMS

40195 Winsand Drive PO Box 429
Pigeon Falls, WI 54760 - 0429
Office: 715 - 983 - 2257 Fax: 715 - 983 - 2138

March 13, 2002

Professor John Norman
Department of Soil Science
263 Soils Building
1525 Observatory Drive
Madison, WI 53706

Dear John:

It is a pleasure to write this letter of support for funding the implementation and calibration of the Precision Agricultural-Landscape Modeling System (PALMS) on the Bragger Discovery Farm.

I am sure there are many in the research community who do not know that Wisconsin has implemented an on-farm systems research program under the direction and leadership of the University, the Department of Natural Resources (DNR), the Department of Agricultural, Trade and Consumer Protection (DATCP) and the Natural Resources Conservation Service (NRCS). *"The mission of the Discovery Farms Program is to determine the impacts of production agriculture on the environment, while learning the economic and environmental ramifications of adopting best management practices on a diverse group of Wisconsin farms. Through these studies, we will provide information and improve communications on environmental and economic issues between producers, consumers, the research community, policy makers and agency personnel"*. Our program is designed to take recommendations and methods from researchers and implement and evaluate their effects on the environment and farm profitability, on a wide variety of operating farms located on various settings throughout Wisconsin.

The Bragger operation is an excellent farm to test PALMS and to determine how operations in Wisconsin are going to farm within the guidelines of the phosphorus based nutrient management standard. This farm lies in the driftless region of Wisconsin (unglaciated). They farm on very steep topography, which means that this farm has many fields with D, E and F slopes in production. Because of the topography, the Braggers have implemented a 100% no-till program (including alfalfa establishment). This type of topography also means that a great deal of their land base is not farmable (slopes that are too steep or have shallow soils). Non-tillable land is mostly wooded, with some acreage put into the conservation reserve program (CRP). For example, the home farm consists of 575 acres, of which only about 285 acres are tillable. When you take rented land into consideration, this farm has about 850 tillable acres consisting mostly of alfalfa, corn and soybeans.

The Braggers milk about 180 dairy cows, run a small cow-calf herd (about 40 cow/calf pairs), have a beef feedlot to finish the bull calves from both operations and run a pullet barn for a local broiler operation.

Their farm sits at the headwaters of Traverse Creek, which empties into the Trempealeau River about 30 miles north of where it enters the Mississippi River. Traverse Creek is a Class 1 trout stream and the Braggers have worked hard over the past years trying to implement production practices that will protect this stream and enhance water quality. The stream begins in two valleys that surround the operation and come together about one half mile east of the buildings. The streams are fed by very active springs and almost every field has either a waterway leading to the stream or empties directly into the stream. Though we are studying the entire farming system, the focus of your project is the north watershed that contains approximately 427 acres.

Let me explain how I see your work fitting into the Discovery Farms objectives for the Bragger operation. The focus of this systems research project is to determine the effectiveness of the phosphorus index, evaluate the methods to reduce soil loss to tolerable levels and look at nutrient losses based on different manure application methods. Your program can help us predict how the land will react to different production practices based on several conditions that exist on the landscape. By implementing your model, we can predict where on the land we should be concentrating our efforts to protect the environment. We can also use your model and combine it with yield information, economic information, and monitoring data to determine how best to use the land in an economically profitable and environmental sound manner.

PALMS will save us a great deal of time and money by accurately calculating the effects of different management decisions instead of implementing each of them and evaluating what happens on the land. We hope to help you calibrate your model so that we are confident that it accurately predicts how different management decisions will affect yields, economics and environmental losses. The development and calibration of this model represents a great leap forward for producers and agricultural consultants. We could evaluate how a field reacts to differing production practices and work with growers to implement safe practices with some level of confidence that these practices will be economical.

The Discovery Farms Program is anxious to begin working with you on this project. Once we have properly calibrated PALMS, we can begin working with the other 13 systems research projects. Each of these Discovery Farms needs to develop and implement a phosphorus based nutrient management plan that relies on the phosphorus index within the next three years. They also need to reduce soil loss to tolerable levels and are concerned about nutrient losses. The question of nutrient losses from agricultural fields could greatly affect the future of Wisconsin agriculture if total maximum daily load rules are developed by our DNR.

In summary, I believe that the PALMS model offers us a unique opportunity to predict how fields will react to different management practices. We need a model like PALMS so that we can work with producers on the implementation of best management practices to enhance environmental quality and ensure economically profitable agriculture. I am committed to working with you and our producers to calibrate this model and work toward the implementation of it throughout Wisconsin. If there is anything else I can do to assist you on this project, please feel free to contact me at anytime.

Sincerely,



Dennis R. Frame

Co - Director Discovery Farms Program
University of Wisconsin - Extension

SOIL SOLUTIONS CONSULTING

601 Atlas Avenue · Suite C · Madison, WI 53714 · (608) 224-1704 · fax (608) 224-1705

March 3, 2002
Dr. John Norman
University of Wisconsin
Dept. of Soil Science
1525 Observatory Dr.
Madison WI 53706

Dear Dr. Norman,


I am glad to hear you are continuing the development of the PALM model. Applications like PALM are not currently available to the private or public agricultural resource management service providers. Through your workshop and demonstrations of the software, I can see several components of this system dramatically improving how we implement management changes with farm clients related to soil conservation and nutrient management. Integrating a model such as PALM into a commercially available platform (such as ESRI/Arcview/ArcInfo) will provide a life for the model beyond the initial funding of the project. If PALM were in that format today, I would be utilizing it on several nutrient management projects involving our farm clients.

I am willing to assist your research group in any way possible to bring this project to the farms of my clients in Wisconsin for further testing and development. As an independent crop consultant, I work with multiple grain and livestock farms implementing BMP's designed to balance the economic and environmental sensitivities of the farm. The tools currently available to identify critical sites across the landscape have very real limitations that I feel will not meet the future needs of surface water protection. The runoff component of your model appears to have considerable potential to improve upon the current tools available to identify critical phosphorus (and soil) delivery sites.

The Bragger farm certainly increases the size and scope of the project, providing a diverse watershed for verification of this model. I feel collaborating on a real farm watershed outside the experimental farm environment will improve the ability of the model to reflect the needs of farmers and service providers like myself. As I have mentioned before, we can provide additional willing cooperators as the need arises.

Finally, I would like to applaud you and your collaborators for 'thinking outside the box' on this project. This model has the potential to be a very effective applied tool. I look forward to working with you on the site and the outreach components of this project.

Sincerely,


Bill Stangel



United States Department of Agriculture
Research, Education, and Economics
Agricultural Research Service

March 6, 2002

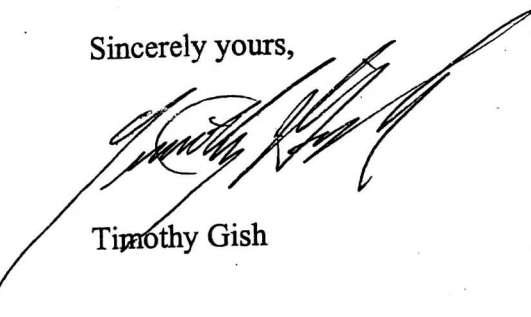
Dr. John M. Norman
Department of Soil Science
University of Wisconsin
1525 Observatory Drive
Madison, WI 53706

Dear Dr. Norman:

I look forward to collaborating with you and your research group on precision-agriculture. We have four adjacent watersheds that are heavily monitored with state of the art sub-surface, surface, atmospheric instrumentation. We are interested in linking spatial data on topography, soil type distribution, yield; and space-time data on soil moisture, nutrients, crop stress conditions and climate to precision-agriculture. Although in it's infancy, we have several years of data and feel that this would be an ideal opportunity for you to evaluate your Precision Agricultural-Landscape Modeling System (PALMS) while at the same time providing us with greater insight into the complex processes that occur on agricultural landscapes. From our discussions we have the necessary input information that PALMS requires and we would be pleased to share this with you. We have collected phosphorus measurements along with runoff intense soil moisture profiles, yield and are interested in comparing these measurements with your model.

The combination of our measurements and your model offer the possibility of a useful and synergistic collaboration that could be valuable for both of us.

Sincerely yours,



Timothy Gish



Soil Scientist
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