Nebraska Water Resources Center
Annual Technical Report
FY 2008

Introduction

Dr. Kyle D. Hoagland has served as director of the University of Nebraska Water Center since 2000, with Michael Jess as associate director, and Lorrie Benson, J.D. as assistant director. Steve Ress and Tricia Liedle continue as communications specialist and program specialist, respectively. Now completing their first year in the Water Center, we also have Rachael Herpel as our water outreach specialist, Duane Mohlman as our data assistance coordinator and Patricia Jarecke as our administrative assistant.

The Water Center is currently housed as part of the School of Natural Resources, located in Hardin Hall (3310 Holdrege, Lincoln, NE 68583-0979). The campus-wide Water Resources Research Initiative (WRRI) completed into its fifth and final year. The annual Water Law, Policy, and Science conference, "Blue Gold: When Water Meets Money" was held on April 29-30, 2009, with featured outside speakers Ari Michelsen, Chris Goemans, James Boyd, Garth Taylor, Ellen Hanak, David Brookshire, Micael Hanemann, Noel Gollehon, and Anne MacKinnon.

A 40-Year History of the Water Center was completed and distributed widely (free). Along with the history book a "Nebraska Water Map" was produced involving eight federal, state, and private foundation partners, and also distributed free of charge. We've continued to assist with development of the UNL water portal (water.unl.edu) and we maintain the NIWR website (snr.unl.edu/niwr) through the Water Center. Along with these websites, we continue to focus on the Water Center’s home website (http://watercenter.unl.edu).

Research Program Introduction

In 2009, four research seed grants were chosen to receive funding through the USGS 104(b) program. Areas chosen for funding were: (1) potential linkages between nitrate reduction and uranium dissolution in groundwater; (2) microbial communities in hyper-alkaline Sandhills lakes; and (3) remedial technologies for chlorinated solvent-contaminated groundwater.

Several major water events were conducted and/or sponsored by the UNL Water Center this year, including the annual summer water tour following the "Republican River Basin" in south central Nebraska. The annual Water Colloquium took place in October. Also held was a Water Quantity Summit meeting.

The Water Sciences Laboratory continues as a core facility to assist water science faculty. Analyses and the number of faculty utilizing this cutting-edge analytical facility continued to grow. Once again, analyses were conducted for several other universities, state and federal agencies, as well as for private companies and individuals, but the focus remains on UNL faculty.

Most recently, UNL is in the process of forming a Global Water Institute, with an emphasis on agricultural water management, based primarily on private fund contributions.

Cooperative Agreement No. 07HQAG0004 Incorporating Remote Sensing Information into the US Drought Monitor

Basic Information

Title:	Cooperative Agreement No. 07HQAG0004 Incorporating Remote Sensing Information into the US Drought Monitor
Project Number:	2006NE163S
Start Date:	4/1/2007
End Date:	9/20/2010
Funding Source:	Supplemental
Congressional District:	1
Research Category:	Not Applicable
Focus Category:	None, None, None
Descriptors:	
Principal Investigators:	Mark D Svoboda

Publication

1. Nghiem, et al. (authors from JPL, USGS, NDMC, NOAA PSD, DFO, and others), “Pattern and Frequency of Soil Moisture Variability over the Continental United States,” manuscript in revision, 52 pp., 2009.
2. Nghiem, S. V., D. Balk, E. Rodriguez, G. Neumann, A. Sorichetta, C. Small, and C. D. Elvidge, “Observations of Urban and Suburban Environments with Global Satellite Scatterometer Data,” ISPRS Journal of Photogrammetry and Remote Sensing, doi:10.1016/j.isprsjprs.2009.01.004, 14 pp., in press, 2009.
3. Nghiem, S. V., and G. Neumann, “Remote Sensing of the Global Environment with Satellite Scatterometry,” keynote paper in Microwave Remote Sensing of the Atmosphere and Environment VI, ed A. Valinia, P. H. Hildebrand, and S. Uratsuka, Proc. of SPIE, Vol. 7154, 715402, doi:10.1117/12.804462, 11 pages, 2008.
4. Nghiem, S. V., “Satellite Remote Sensing of Soil Moisture for Drought Applications,” invited paper, National Integrated Drought Information System Knowledge Assessment Workshop – Contribution of Satellite Remote Sensing to Drought Monitoring, Boulder, Colorado, USA, 6-7 February 2008.
5. Nghiem, S. V., G. R. Brakenridge, and G. Neumann, “Drought, wetland, and Flood Monitoring with Satellite Scatterometer,” EOS Trans, AGU, 88(23), Jt. Assem. Suppl., Abst. U53B-05, May 2007.
6. Nghiem, S. V., G. R. Brakenridge, D. Cline, M. Dettinger, R. M. Dole, P. R. Houser, G. Neumann, E. G. Njoku, D. K. Perovich, K. Steffen, M. Sturm, J. Verdin, D. A. Wilhite, S. H. Yueh, and T. Zhang, “Global Observations of Land Surface Water with Satellite Active and Passive Microwave Sensors,” Satellite Observations of the Global Water Cycle, Irvine, California, 7-9 March 2007.
7. Brakenridge, G. R., S. V. Nghiem, E. Anderson, and R. Mic, “Orbital Microwave Measurement of River Discharge and Ice Status,” Water Resources Research, Vol. 43, W04405, doi:10.1029/2006WR005238, 2007.

INTRODUCTION AND PROBLEM

The National Drought Mitigation Center (NDMC) is a partner with the NASA's Jet Propulsion Laboratory (JPL), the U.S. Geological Survey's Center for Earth Resources Observation and Science (USGS/EROS), NOAA's Physical Science Division (PSD) and Climate Prediction Center (CPC) along with Dartmouth College in the project entitled "National Drought Monitoring System for Drought Early Warning Using Hydrologic and Ecologic Observations from NASA Satellite Data".

The objective of this project is to assimilate hydrologic and ecologic observations from NASA Earth satellite sensors, including the Advanced Microwave Scanning Radiometer - Earth Observing System (AMSR-E), the QuikSCAT/SeaWinds Scatterometer (QSCAT), and the Moderate Resolution Imaging Spectroradiometer (MODIS), into a national drought monitoring system, specifically the United States Drought Monitor (USDM), an existing national decision support tool used for drought monitoring and drought early warning. The lead Principal Investigator for the partnership is Son Nghiem from the Jet Propulsion Laboratory (JPL). The 3-year project is scheduled to last through September 30, 2010.

The NDMC team members include Mark Svoboda, Dr. Brian Wardlow, Dr. Tsegaye Tadesse, and Brian Fuchs at the University of Nebraska-Lincoln, who will work to establish and carry out the scientific program as proposed in the project plan. The NDMC tasks for Year 3 of this project are outlined in the following section.

The role of the NDMC is to serve as the lead integrator for incorporation of products derived from NASA satellite data (including ASMR, QuikSCAT, and MODIS vegetation index (VI) data) into an improved operational U.S. Drought Monitor (USDM) system. The NDMC is responsible for working with USDM authors to establish: 1) input data requirements and formats, 2) system requirements for the USDM to assimilate new remote sensing data, and 3) processing requirements to improve USDM outputs. The NDMC will also work with USDM authors and project partners to benchmark new USDM results against the results from current USDM approach, which uses non-NASA data inputs, to assess improvements. In addition, the NDMC will develop a centralized web location for USDM authors and project partners to access the NASA satellite data-derived products and the USDM deliverables produced using the new remote sensing data sets.

Several limitations in the current U.S. drought monitoring effort have been identified: (1) the coarse level of spatial detail at which analyses are performed and results delivered and (2) the lack of detailed, accurate, and objective data sources especially where current networks of weather stations are sparse in the public lands of the West. These represent the two largest impediments to early detection of drought and its impacts at the county or sub-county level, which is where key drought decision making takes place.

JPL has the lead in the development of drought monitoring products from AMSR-E and QSCAT. The role of USGS/EROS is the development of systems for production of time-series vegetation index (VI) imagery from MODIS data, and delivery of VI products to USDM authors and the drought community in general. The NDMC plays the role of lead integrator for an improved

operational USDM system. The NDMC is also responsible for ingesting NASA results from JPL and USGS into the existing USDM system for drought decision support, and performing benchmark analyses.

RESEARCH PROGRAM, OBJECTIVES AND METHODOLOGIES

NDMC will benchmark new results against the current approach using non-NASA data to assess improvement, and will distribute results to users via the NDMC Internet infrastructure. The Year 3 tasks include:

1. **Continue guidance to establish data and processing requirements for the remote sensing products generated by the project participants for integration into the operational USDM system.** As products developed using the initial set of requirements become available, the NDMC will work with the USDM authors to ensure they meet their operational needs. If needed, the initial requirements will be adjusted and/or modified for effective integration of the data into the USDM system.

2. **Develop a centralized web location for USDM authors and project participants to access the NASA satellite-derived products**. The NDMC-NASA Partnership website (URL: http://drought.unl.edu/nasa) developed and hosted by the NDMC for project-related information will be used as the central access point for the remote sensing-derived products generated for the advanced USDM prototype system. A 'Data' section will be added to the website and adapted according to the deliverables provided by the project participants. In addition, these data products will also be posted in the USDM Authors' Community within the National Integrated Drought Information System's (NIDIS) U.S. Drought Portal (www.drought.gov) for authors to visualize the information in an interactive map viewer. A demonstration of the advanced USDM system will be conducted once the feed is established and automated from CPC to NIDIS.

3. **Coordinate with USDM authors to implement remote sensing data product ingestion into an advanced USDM prototype environment.** The NDMC will work with USDM authors to describe the informational content of each project deliverable as it becomes available and assist them with the evaluation/integration of this information into the USDM development process.

4. **Benchmark existing and new USDM results to evaluate the improvements in the USDM map results produced using the advanced USDM prototype system.** The NDMC will work with the USDM authors to assess the enhancements provided by the remote sensing products in the development of the USDM maps. Each product will be evaluated independently in the improved USDM prototype by comparing the new USDM map results with those produced with the existing USDM process. The evaluation of the products will be dependent on them being delivered in a timely fashion in Year 3 to allow adequate time to investigate their utility and potential contribution within the USDM map

development process. Examples of the improvements made in the USDM maps with a specific remote sensing-based product will be documented.

5. **Participate in a demonstration of the improved USDM prototype and distribute the improved drought products over the Internet to users via the NDMC web site**. Once activities 1 through 4 are completed, the NDMC will coordinate with project participants and USDM authors to communicate the improved USDM prototype at professional meetings and in the peer-reviewed literature to demonstrate the utility of remote sensing-based products derived from NASA satellite observations. The improved USDM drought products and supporting information will be made available to the general public via the NDMC-NASA Partnership website.

6. **Initiate the implementation of the prototype approach operationally at the end of Year 3**. The implementation of such an approach will be dependent on the timely delivery of data products early in Year 3 in order to complete activities 1-5, which is required in advance of developing the operational phase of this project.

INFORMATION TRANSFER PROGRAM AND YEAR 2 PROGRESS

- JPL, USGS, NDMC, and NOAA PSD attended and presented project status and work progress, worked on research project plan, related NASA drought work and NIDIS, and planned on website, reports, meetings, and papers/publications. Meeting was led JPL and USGS and hosted by NOAA PSD in Boulder, Colorado, Sep 2008.

- JPL developed QSCAT soil moisture change products (SMC) covering the entire coterminous (continental) United States (CONUS) for drought monitoring. JPL packaged the data products with the format, resolution, and characteristics that can be ingested by NOAA PSD to produce drought monitoring prototypes, which are made available to the all drought monitoring team members.

- JPL implemented data processor to produce data and maps for drought monitoring over CONUS.

- JPL established automated data link to deliver data and maps to NOAA PSD on a daily basis.

- JPL worked with NOAA PSD to implement several color protocols for drought product prototypes.

- JPL worked with PSD to develop several formats of drought product prototypes including NetCDF, png, pdf, and kml format. The kml format has the capability to zoom in counties.

- JPL completed a case study in the Los Angeles area to verify the SMC results for two extreme cases using the zoom-in capability from the kml prototype made by NOAA PSD: (1) dry case on 14 January 2009 when downtown Los Angeles was hot at 86 F, there was high Santa Ana winds, and red flag warning was issued, and (b) wet case when downtown Los

Angeles was cool at 58 F, there was 1.04-in precipitation and onshore winds, and flash flood warning was issued. SMC correctly identified both the dry and wet conditions.

- JPL benchmark shows that the SMC products can resolve the county-level resolution accounting for the Nyquist resolution requirement versus the old drought monitoring resolution at the climate division resolution. The resolution at county level is a major goal of the National Integrated Drought Information System (NIDIS).

- JPL completed subcontracts to transfer funding supports to co-investigators for NASA. JPL also managed the subcontract progress and extended the subcontracts for NASA so that the work could be continued until NASA sends the yesr-3 funds.

- JPL analysis for the Lonoke, Arkansas, site demonstrated the close similarity of seasonal trends in active (QSCAT) and passive (AMSR-E) microwave signals to seasonal NDVI and lagged soil moisture. The microwave data also tracked well with instantaneous soil moisture data.

- JPL analysis of temperature and precipitation station data for Great Falls, Montana, revealed the detection of drought and heat wave spells in the seasonal time series of active (QSCAT) and passive (AMSR-E) microwave signals.

- JPL demonstrated that QSCAT detection of increased surface moisture in October 2004 in Arkansas and Louisiana coincided with lowering of drought severity rankings in the USDM.

- JPL demonstrated the similarity of QSCAT surface moisture patterns in the western U.S. in September 2004 to those produced by the NASA Land data Assimilation System (LDAS).

- JPL demonstrated that the microwave surface moisture patterns in California for the winters of 2005 (wet) and 2007 (dry) correctly mirrored conditions described by the USDM for the same periods.

- JPL demonstrated the potential for QSCAT to complement MODIS NDVI for drought monitoring in Kenya (where 3 million people were affected in 2000), especially when cloud cover is an issue.

- USGS performed validation of eMODIS historical time-series and expedited data utilizing comparison with standard MODIS Vegetation Index products.

- USGS collaborated with Dr. T. Miura in the development of an NDVI data translation algorithm designed to translate historical AVHRR NDVI so that it is comparable with current eMODIS NDVI.

- USGS applied T. Miura data translation algorithm to historical AVHRR (average time series) for input into calculation of PASG from eMODIS.

- USGS performed validation of eMODIS Vegetation Index derivative Percent of Average Seasonal Greenness (PASG) utilizing comparison with translated AVHRR-derived PASG products.

- USGS ran successful real-time test of automated drought processing chain based on near-real time weekly eMODIS composited input data over 48-states at a pixel resolution of 1000 m^2. Output products (PASG and Start of Season) were processed within 24 hours of satellite collection.

- USGS acquired and tested revised Start of Season code from Augustana College computer scientist to resolve calculation errors.

- USGS provided products on an ongoing weekly basis (e.g., 30-day precipitation, 7-day precipitation, AVHRR PASG and VegDRI) to be regularly loaded into the National Integrated Drought Information System (NIDIS) Map Viewer (http://www.drought.gov/) in preparation for providing NASA eMODIS-based drought products to the NIDIS Map Viewer and to the USDM authors.

- USGS provided NOAA PSD with MODIS-derived irrigation data (2002) at 250 m^2 resolution over the conterminous U.S. for use in evaluation of satellite-derived surface soil moisture products.

- USGS established requirements for an expedited MODIS delivery system (eMODIS) to replace the discontinued MODIS Direct Broadcast System at EROS.

- USGS documented the processing flow for VI products from AVHRR and MODIS inputs.

- USGS designed and coded the processing chain for automated VI metrics from eMODIS**.**

- USGS installed and tested an updated version of VI time-series smoothing and seasonal metrics code from Augustana College computer science department.

- USGS prepared a smoothed time-series NDVI database for 2005-2007 based on weekly Terra and Aqua eMODIS 1-km data as input to metrics calculation and cross-calibration with AVHRR.

- USGS calculated prototype eMODIS-based VI seasonal metrics (e.g., Percent of Average Seasonal Greenness) for 2005-2007.

- USGS converted all eMODIS products to appropriate format and scaling for use in the drought monitoring system, and wrote a script to enable eMODIS data to be ingested into VegDRI drought models.

- USGS established an ad-hoc U.S. AVHRR/MODIS data continuity working group with university and other agency partners to define steps for cross-calibration of the two VI time series, permitting their joint use in a single historical record.

- USGS performed comparisons between AVHRR and eMODIS NDVI (7-day composites) and NDVI-based metrics using samples based on phenological regions of the U.S.

- USGS presented project status and future plans at the annual U.S. Drought Monitor Forum in Portland, Oregon, in October 2007.

- USGS and NOAA organized a NIDIS Knowledge Assessment Workshop entitled "Contributions of Satellite Remote Sensing to Drought Monitoring" in February 2008 in Boulder, Colorado. A range of presentations was made covering precipitation and snow pack, vegetation, soil moisture and evapotranspiration. State climatologists chaired panels. USGS gave a presentation entitled "Using eMODIS Vegetation Indices for Operational Drought Monitoring", and JPL presented "Satellite Remote Sensing of Soil Moisture for Drought Applications".

- NDMC maintains an email list server to facilitate communication amongst all project participants (nasadrought@unl.edu) (ongoing).

- NDMC will continue to update and maintain a project web site (http://www.drought.unl.edu/nasa/index.html) for project communication and to facilitate the integration of NASA Earth Science data into the USDM (ongoing). Data and Deliverables section will also be set up on the NDMC-maintained NASA project page when ready.

- NDMC secured FTP site and established NASA Project web site at NDMC (Sep 08).

- NDMC staff (Wardlow and Tadesse) met with USGS EROS staff (Brown and Cali Jenkerson) to discuss the eMODIS products and coordination of the deliverables to the USDM authors. The discussions included an update on the development of the eMODIS system, product and system specifications, and deliverable requirements for the USDM authors. (Aug 08).

- NDMC staff (Svoboda, Hayes, Tadesse, Poulsen, and Wardlow) and EROS (at EROS) scheduled a meeting to discuss the initial products being generated from the eMODIS system. (May 09).

- NDMC presented VegDRI and enhanced DM/DSS mock-up at the NADM Forum (Oct 08) (Wardlow, Fuchs, and Svoboda).

- NDMC presented VegDRI at the US/Canada Bi-lateral GEO Workshop, Arlington, VA (Oct) (Wardlow).

- NDMC and USGS collaborated on prototyping remote sensing data requirements for drought decision support. (Dec 08).

- NDMC (Brian Wardlow) participated and presented on the NDMC remote sensing projects and activities at the NIDIS Knowledge Assessment Workshop entitled "Contributions of Satellite Remote Sensing to Drought Monitoring" in February 2008 in Boulder, Colorado.

- NDMC's attendance and presentation on NDMC activities/progress at NASA project meeting in Boulder, CO. Set up initial contacts and data formatting requirements for the National Integrated Drought Information System (NIDIS) Portal (drought.gov) for ingesting JPL/PSD products and data into the U.S. Drought Monitor author community w/in the portal. This will allow for weekly automation/integration into the Map Viewer tool for analysis and evaluation in enhancing the Drought Monitor. Contact established with NOAA National Climatic Data Center and their portal team. (Svoboda) (Sep 08).

- NDMC's presentation at the North American Drought Monitor Forum in Ottawa, Canada. Talked about NDMC research efforts w/ regards to U.S. and North American monitoring and its potential ties to the NIDIS, Global Earth Observation System of Systems (GEOSS), and the North American Drought Monitor, which lack sufficient observed observations and is ready to evaluate new remotely sensed data and derivative products (Oct 08).

- NDMC showed NOAA-PSD the shape file format access in U.S. Drought Monitor archive and presented U.S. Drought Monitor operational snow product resources to JPL (Oct 08).

- NDMC provided guidance/feedback on initial JPL and NOAA PDS derivative products involving the QuikSCAT Soil Moisture Change (SMC). Provided information on Drought Monitor ranking percentile criteria, color scheme, and U.S. Drought Monitor operational methods, color scheme, delta maps, and temporal production needs that will be applied to the SMC product (Oct 08/March-April 09).

- NOAA PSD acquired in-situ soil moisture data (mostly for the state of Nebraska) from High Plains Regional Climate Center in Lincoln; also acquired related sensor data for the same stations, including soil temperature, precipitation, air temperature, and soil type. Daily soil moisture observations and related variables (AWDN1) were acquired for 37 stations in Nebraska from High Plains Regional Climate Center (HPRCC). Starting dates of records vary, but earliest data begin in 2000. Soil types for each station and level were acquired separately.

- NOAA PSD also acquired other in-situ data sets from other agencies, with the idea that these data would be valuable in the near future. For example, we now have archived USGS data for 13 stations, mostly Wisconsin. In addition to the 13-station USGS data set, the Soil Climate Analysis Network (SCAN) data set consisting of 134 stations in the western United States was acquired. These data were provided by the US Department of Agriculture, Natural Resources Conservation Service (NRCS).

- NOAA PSD acquired pixilated soil moisture estimates from the QSCAT (active) and AMSR-E (passive) instruments. Data are provided by JPL. QSCAT SMC and AMSR-E data acquired for region corresponding to CONUS. QSCAT SMC data extends from January 2007

to present, with ongoing automatic updates. AMSR-E extends from June 2002 to present and can be easily updated.

- NOAA PSD processed data to facilitate comparison (common units and format, daily resolution, etc.). Make a standard daily station time series format. Provide customized data from these sources to members of project team at their request. Data sets have been processed. AWDN1 station data set is in local standard format. QSCAT SMC and MODIS NDVI are in NetCDF format. AMSR-E is in HDF source format. QSCAT SMC and AMSR-E files are available to project team members (updated occasionally or by request).

- NOAA PSD is in progress to compare and validate surface soil moisture observations with satellite-based measurements. This includes investigation into the area that a single surface-based observation can reliably represent, relationship with soil type, etc. This work is continued into in Year 3 of the project. Preliminary results were obtained for Nebraska stations versus MODIS NDVI.

- NOAA PSD started to develop an algorithm to relate surface soil-moisture as determined from satellite to depth-integrated soil moisture from ground-based observations. (1 November 2008). This work is continued into Year 3. Requisite data sets and comparison software have been partially developed.

- NOAA PSD coordinated with National Integrated Drought Information System (NIDIS) and the Western Water Assessment (WWA) on improving value of soil moisture measurements from an end user perspective. This is an ongoing collaboration with other drought team members.

- NOAA PSD is prepared to participate in using MODIS-based system results for surface water status (provided by Dartmouth Flood Observatory) to benchmark old and new USDM results to determine and quantify the improvements.

- NOAA PSD is taking the role of leading a demonstration of the improved USDM prototype. In this regard, SMC daily prototype is on line and demonstrated via distributed e-mail of 20 February 2009. Future products will be demonstrated as they are produced. Collaboration to improve prototypes continues.

- NOAA CPC (Climate Prediction Center) participated in discussions of drought forecast by telecon.

- DFO (Dartmouth Flood Observatory) has developed surface water status products, and used them as a metric for evaluating the system performance of the Drought Monitor. U.S. stream gaging stations, which also measure surface water, provide a critical input to the present drought assessment algorithms. Streamflow integrates the effects of temperature, precipitation, watershed geomorphology and geology, and antecedent conditions. The U.S. has been divided into 5348 hydrologic accounting units (watersheds) and the present array of gaging stations provide information on the status of moisture deficits or surpluses for many of these units, and including contributing units further upstream. However, many of these stations gage major rivers and their linked tributary systems, and data from these are not independent measurements of the local

contributing areas until the imported water from upstream watersheds is accounted for. This is not accomplished in the 7 day streamflow averages prepared by the USGS (used in the USDM) and presented in the form of percentiles for period of record: instead, as one moves downstream along all streams and rivers, the additional gaging station discharge percentile information applies to the entire upstream contributing areas instead of the local incremental contributing areas. Remote sensing offers, instead, the opportunity for discrete land parcel or catchment-unit measurements of existing surface water status. As well, there exist hundreds of U.S. ponds and reservoirs, including many small water bodies < 100 km^2, which are ungaged. Across much of the U.S, these water bodies are important to local agriculture, livestock, recreation, and other uses and their areal extents are also observable indicators of drought status. Increases in contributing watershed runoff to many reservoirs are accompanied by changes in reservoir water surface areas. If these areas can be consistently, frequently, and economically monitored, through time, then such data can provide significant enhancement and testing of map evaluations of regional drought conditions (such as the U.S. Drought Monitor, or USDM). DFO obtains such measurements to facilitate their incorporation into the USDM as an independent drought monitoring evaluator.

- DFO evaluated the capability of MODIS data to numerically estimate the surface water status of selected U.S. hydrologic accounting units. DFO began, as planned, by testing change detection/measurement approaches. It is clear that Band 2 of the two MODIS sensors very sensitively discriminates surface water changes at a spatial resolution of 250 m: the challenge is to design a processing methodology that, working around the abundant noise (changes in cloud cover and cloud shadows, terrain shadowing, seasonal changes in vegetation and illumination, atmospheric changes), can produce a weekly MODIS-based product covering all of the U.S. (excluding Alaska, Hawaii, and territories) and which can be directly compared to the USDM).\

- DFO developed several other methods for surface water classification and mapping. “Change detection” for water can proceed either by direct comparison of raster-based data or as Geographical Information System (GIS) water polygon-based comparison of mapped water. Mapping the water, in this case, makes use of standard remote sensing image classification procedures to discriminate water, then polygons are fit to the classified water areas, and then, within the GIS, map displays can show areas of expanded or decreased water area.

- DFO demonstrated the advantage of the GIS-based approach. It offers the possibility to retain the relatively fine spatial resolution of the two MODIS 250 m bands, by performing new data retrieval and water classification and mapping over discrete, 10 deg x 10 deg portions of CONUS. However, it also allows for easy combination of such detailed, regional displays into all-U.S. displays that can be directly compared to the USDM. This work is continued in Year 3 of the project.

- All participated in writing and presenting review and technical reports, and conference/journal papers.

How Water Resources Limit and/or Promote Residential Housing Developments in Douglas County

Basic Information

Title:	How Water Resources Limit and/or Promote Residential Housing Developments in Douglas County
Project Number:	2008NE164B
Start Date:	3/1/2008
End Date:	2/28/2010
Funding Source:	104B
Congressional District:	2
Research Category:	Social Sciences
Focus Category:	Economics, Floods, Management and Planning
Descriptors:	floodplains property values, dam construction lakeview amentities
Principal Investigators:	Steven Shultz

Publication

1. Shultz, S, and N. Schmitz, 2008.. Viewshed Analyses to Measure the Impact of Lake Views on Urban Residential Property Values. The Appraisal Journal: 76(3): 224-232.
2. How Water Resources Limit and/or promote Residential Housing Developments in Douglas County. 2008. Shultz and Schmitz. http://unorealestate.org/pdf/UNO_Water_Report.pdf

How Water Resources Limit and/or Promote Residential Housing Developments in Douglas County

Progress Report (Executive Summary) as of May, 10, 2009

Objectives:

This research quantifies the relationships between water resources and residential property values in the Greater Omaha metropolitan area by measuring the impact of:

1. 100-year floodplain designations on residential housing prices to evaluate potential economic benefits of flood mitigation projects.

2. Man-made lakes on nearby residential property prices to identify strategies to maximize public benefits.

3. Alternative types of open space/low impact development (LID) subdivision designs on residential property values. This will help both the public and private sector better understand and promote successful and profitable LID subdivisions.

These analyses are expected to be of interest to both policy makers and resource managers in their ongoing efforts to design and implement cost-effective flood mitigation and stormwater water management projects in Douglas County.

Approaches:

The methodological approach of this study relied on empirical real estate transaction data that was referenced within a geographical information system (GIS) in order to quantify site-specific relationships between water resources and property values. In particular, hedonic price models (also known as 'mass appraisal' models) were estimated along with comparisons of the sale prices of residential lots. Earlier phases of this research have already been accepted for publication in peer-reviewed professional journals.

Results 1: Floodplain Impacts and Residential Property Values

Hedonic price models indicate that homes within Douglas-Papio Creek floodplains100-year floodplains have sold for 3.9% less than otherwise similar but non-floodplain homes over the 1996 to 2007 time period. Based on these hedonic price impacts in conjunction with the estimated market value of all 1,123 Douglas-Papio floodplain homes, a hypothetical set of upstream flood mitigation projects which would remove all of these homes from the floodplain, would generate $5.3 million in increased property values.

Alternatively, potential flood mitigation benefits were also calculated based on the estimated cost of flood insurance premiums: $11.9 million for all Douglas-Papio floodplain homes versus $360,000 for only the homes designated to be in the newly revised floodplain in 2008 (based on 'grandfathered' non-floodplain insurance rates which are about 75% cheaper than typical 100-year floodplain rates).

These property valuation estimates related to floodplain status, could potentially be used by Douglas County for evaluating the economic feasibility of proposed flood mitigation projects in the Papio Creek Watershed. In particular, if it is known how proposed flood mitigation projects impact downstream floodplains (i.e. the number of homes removed from the 100-year floodplain), then either expected property value increases or avoided flood insurance could be considered as flood mitigation benefits. For example, depending on the likely effectiveness of a flood mitigation project, and the type of benefits deemed most appropriate for comparison, a range of possible economic benefits associated with future (hypothetical) Douglas-Papio Creek flood mitigation projects emerges: The low end of the range is $36,000 in benefits associated with a scenario of only 10% of homes being removed from the Douglas-Papio Creek floodplains, and considering only new insurance costs to homes placed in the floodplain in 2008-09. The high end of the range is $11.9 million based on avoided flood insurance when 100% of Douglas-Papio Creek residential properties are removed from the floodplain. This information could potentially be used in conjunction with results of hydrologic-based feasibility studies (by others) to evaluate the economic feasibility of proposed flood mitigation projects in Douglas and/or Washington County. However, two other key

property types should be included in such analyses: Commercial property which is likely more valuable than residential property within these floodplains, and undeveloped land which would likely increase in value if it is removed from the 100-year floodplain.

Results 2: Amenity Values Created by Lakes

Hedonic valuation models of residential housing sales along with comparative lot sale analyses have demonstrated that substantial increases in residential property values have resulted from the construction of four different man-made lakes in the Omaha area. Lake views increase housing values by between 7% and 18% at the four different lakes and has created $26.7 million in increased housing values. Both view and access premiums are paid by home and/or lot buyers and based on the analyses of lot sales at two lakes, most of these premiums appear to be captured by landowners and/or developers at the time the lakes are first constructed. It is also evident that increased levels of exclusivity increase the premiums that homebuyers are willing to pay for both lake views and access.

An analysis of 'Dam Site 13' (the most recently constructed Omaha lake and the first 'public-private lake construction partnership'), demonstrated that the private sector partner contributed $1.6 million to the cost of lake construction and in return, is *expected* to generate an additional $7.7 million from incrementally higher lot sale values associated with view and access premiums. This corresponds to a discounted rate of return of 437% or, 87% annually for five years. These are *preliminary* estimates of potential profit levels and continued research on this topic is warranted particularly since it is suspected that part of the lot values in this subdivision may be due to proximity to a school and/or a very high quality subdivision design.

It was concluded that future public-private lake construction partnerships should more closely evaluate whether contributions from private developers are sufficient in relation to the increased profit levels associated with lake views and/or access that they are likely to capture. Alternatively, the design of future lakes should have more public recreation and buffer areas that improve both access and lake water quality in order to guarantee the public fully captures lake amenity values that are created through the use of public funds.

Results 3: LID Subdivision Design and Property Values

A set of 14 different hedonic valuation models were estimated across 326 different subdivisions in the western and southwestern (suburban) portions of Douglas County in order to quantify how different types of open space characteristics, which are considered a proxy for alternative LID designs, impact residential property values. From this it was concluded that homeowners:

- Are willing to pay more for a home near open space if the open space is owned and/or managed by private versus a public entity.
- Prefer open space that is dominated by trees and mowed grasses over non-mowed areas, or open spaces with recreation (sports) facilities.
- Prefer open space with trails.
- Are willing to pay 1.1% more for clustered open space (LID) designs, and, 2.74% more for open (contiguous) open space (LID) designs than they would for conventional sub-division designs.

These research results should be useful to both public planners and private developers in the design and implementation of open space and LID subdivision designs within residential subdivisions. In particular, price premiums associated with alternative open space or LID subdivision designs can now be compared to their implementation costs and relative effectiveness for stormwater management.

Where These Research Methodologies Have Already Been Peer Reviewed

Shultz, S. and N. Schmitz. 2008 (forthcoming). Augmenting Housing Sales Data to Improve Hedonic Estimates of Golf Course Frontage. ***Journal of Real Estate Research.***

Shultz, S, and N. Schmitz, 2008. Viewshed Analyses to Measure the Impact of Lake Views on Urban Residential Property Values. ***The Appraisal Journal*** **(Summer, 2008).**

Shultz, S. and P. Fridgen. 2001. "Floodplains and housing values: Implications for flood mitigation projects". ***Journal of the American Water Resources Association*** 37(3)

Shultz, S. and D. King. 2001. "The use of census data for hedonic price estimates of open space amenities and land uses". ***Journal of Real Estate and Finance Economics*** 22(1)

Suggested Follow-Up Research

The original study objectives specified in the contract between UNO, Douglas County, and the NU Water Center, are considered to have been met by this Final Project Report. However, the UNO research team plans to conduct follow-up research on the various suggested future research topics listed below (categorized by floodplain, lake amenities, and LID research themes). No additional funds are being requested from the sponsors for this continued research, and the resulting research results will be considered 'supplemental reports' and distributed to the Douglas County Board and the NU Water Center when they are completed (likely in the next 6 to 12 months).

Floodplain-Property Value Research

1) Conduct comparable sales based appraisal analyses.
2) Evaluate strategies to improve flood insurance cost estimates.
3) Conduct surveys of floodplain property owners.
4) Estimate the impact of floodplain status of commercial properties and for undeveloped land.
5) Determine total (residential, commercial and vacant) property values and related flood mitigation benefits in the Douglas-Papio floodplains

Lake-View Amenities

1) Conduct a hedonic analysis of sold lots at Standing Bear, and Zorinsky to better measure view and access values that were captured by developers
2) Continue to collect and monitor both lot and housing sales at Dam Site 13 to see if view and access premiums change over time
3) Conduct surveys of homebuyers at Dam Site 13 and nearby subdivisions to identify factors that may have influenced their purchase decisions and in particular, to assess the importance of lake views, access and other factors.

LID/Open Space Amenities

1) Replicate the open space hedonic price models using lot sales. This would potentially be more helpful for residential housing developers to identify different profit levels associated with different open space designs

2) Survey homebuyers to elicit their perceptions of and preferences for different open space amenities. This could potentially confirm many of the conclusions reached in this study based on observed property sales data

Fate of microcontaminants in streams augmented by wastewater treatment plant effluent use

Basic Information

Title:	Fate of microcontaminants in streams augmented by wastewater treatment plant effluent use
Project Number:	2008NE168B
Start Date:	3/1/2008
End Date:	5/31/2009
Funding Source:	104B
Congressional District:	1st district
Research Category:	Water Quality
Focus Category:	Toxic Substances, Surface Water, Water Quality
Descriptors:	
Principal Investigators:	Shannon Bartelt-Hunt, Daniel Davidson Snow

Publication

Final Report: Fate of Microcontaminants in Streams Augmented by Wastewater Treatment Plant Effluent

Shannon L. Bartelt-Hunt, *Assistant Professor, Department of Civil Engineering, 203B Peter Kiewit Institute, University of Nebraska-Lincoln, Omaha, NE 68182-0178*
Daniel D. Snow, *Director, Water Science Lab, Water Science Center, University of Nebraska-Lincoln, Lincoln, NE*

Project Objectives

This project was conducted over a 15 month period from March 1, 2008 to May 31, 2009. The objective of this project was to evaluate the fate and transport characteristics of selected WWTP microcontaminants and to determine if a passive sampling technology can be used in quantitatively assessment of contaminant fate in receiving waters. To achieve this objective, the following experiments were performed:

1) Laboratory Calibration Study: In March 2009, we conducted a laboratory calibration study of the POCIS samplers. Briefly, the POCIS samplers were exposed to DI water spiked with selected contaminants of interest for a 21 day exposure period. POCIS were placed in glass beakers containing 2L of DI water and spiked with the microcontaminants of interest. A positive control (spiked water with no POCIS) and a negative control (unspiked water with no POCIS) were also carried throughout the exposure period. Aqueous samples were obtained from each beaker at 0, 3, 7, 14 and 21 days and analyzed for the compounds of interest using LC/MS/MS. We are currently in the process of calculating contaminant uptake rates for each compound. These uptake rates can be used to quantify contaminants recovered from POCIS after field deployment.
2) Field Deployment: in May 2009, we deployed POCIS samplers in the field at two locations: at the WWTP at Hastings, Nebraska and at the Theresa St. WWTP in Lincoln, NE. Samplers were deployed in triplicate at four locations at each site: in the effluent prior to discharge, within the mixing zone just after discharge, approximately 500 ft downstream, and approximately 1500 feet downstream. The POCIS will be deployed in the field for a 21 day exposure period. At the conclusion of the exposure period, the POCIS will be collected and returned to the laboratory where they will be extracted and analyzed. Using this data, we intend to evaluate the persistence of selected pharmaceuticals originating from WWTP effluent. We will simulate contaminant fate in the receiving water body using a simple 1D model

Student Training

DelShawn Brown, a graduate student working on this project, will graduate with a M.S. in Environmental Engineering in August 2009.

Dissemination of Results

A manuscript will be prepared for publication in a peer-reviewed journal based on the results of this study. This manuscript will be submitted no later than October 2009.

Geographic trends in contamination of Nebraska s surface waters as indexed by sex steroids of common carp

Basic Information

Title:	Geographic trends in contamination of Nebraska s surface waters as indexed by sex steroids of common carp
Project Number:	2008NE169B
Start Date:	3/1/2008
End Date:	2/28/2009
Funding Source:	104B
Congressional District:	1 & 2
Research Category:	Biological Sciences
Focus Category:	Non Point Pollution, Ecology, Surface Water
Descriptors:	None
Principal Investigators:	Kevin Lee Pope, Alan S Kolok, Daniel Davidson Snow

Publication

Geographic trends in contamination of Nebraska's surface waters as indexed by sex steroids of common carp

FINAL REPORT
Submitted to University of Nebraska—Lincoln Water Center

9 April 2009

Dr. Kevin L. Pope
USGS – NCFWRU
University of Nebraska-Lincoln
424 Hardin Hall
Lincoln, NE 68583-0711

Dr. Alan S. Kolok
Department of Biology
University of Nebraska-Omaha
114H Allwine Hall
Omaha, NE 68182-0040

Dr. Dan D. Snow
Water Sciences Laboratory
203 Water Sciences Laboratory
University of Nebraska-Lincoln
Lincoln, Nebraska 68583

ABSTRACT

Endocrine disrupting compounds (EDCs) have been identified in the streams and rivers of Nebraska during the past few years. We initiated a multi-disciplinary assessment of geographic trends in the occurrence of EDCs in water bodies (all but one were lentic systems) throughout Nebraska. We used common carp sex steroids and carp gene expression profiles as indirect indicators of exposure to EDCs, and water samples from each reservoir were used to provide a "snapshot" of EDCs concentration. The specific objectives of this project were to document occurrence and concentrations of steroidogenic contaminants in water from water bodies throughout Nebraska and examine geographic variation in effects of sex steroids on adult common carp. We hypothesized that sex steroid profiles would vary considerably across the state, and would be associated with bioavailability of steroidogenic compounds within each reservoir. A primary goal of this project was to obtain preliminary data (geographical variation in concentrations of sex steroids in adult common carp) needed to assemble a grant proposal for a large, multiyear assessment on the occurrence and biological effects of steroidogenic compounds in lakes and reservoirs throughout the Midwest. Contrary to our *a priori*

expectations, we did not find a geographic trend in the occurrence of steriodogenic compounds. Further, endpoints from the two measures we used to assess biological effects of EDCs in water bodies across Nebraska (plasma sex steroid concentrations and hepatic vtg mRNA expression) did not agree. Thus, compelling evidence necessary to obtain a large, multiyear grant for assessment of geographic variation in sex steroids in aquatic systems is still lacking.

INTRODUCTION

Endocrine disrupting compounds (EDCs) have been identified in the streams and rivers of Nebraska during the past few years, most notably downstream from beef cattle feedlots (Soto et al. 2004; Kolok et al 2007) and local wastewater treatment plants (Kolok et al. 2007). Furthermore, feral and caged populations of fathead minnows living in these watersheds exhibited reproductive abnormalities and alterations in the expression of reproductively important genes (Soto et al. 2004; Kolok et al. 2007). The two studies published to date were restricted in their geographical scope, limiting our understanding of the geographic variation in occurrence and effect of EDCs in Nebraska. Indeed, a preliminary analysis of minnows caged in four different watersheds throughout Nebraska has documented pronounced defeminization of female minnows, indicating probable exposure to EDCs.

Although wastewater treatment plants and beef feedlots are often located adjacent to streams, evaluating the extent to which EDCs occur throughout the lakes and reservoirs of Nebraska is also important. A vast majority of anglers in Nebraska concentrate their fishing efforts on lakes and reservoirs, producing a large marginal economic value from recreation for these water bodies. Recruitment of fishes in Nebraska lakes and reservoirs is extremely variable, and in some reservoirs natural recruitment has been so limited that annual stockings of sportfish became necessary. It is possible, and has been suggested, that EDCs may be responsible for the limited recruitment of sportfish (Blazer 2002). The first step in determining whether fishes of Nebraska are being exposed to EDCs is implementation of a study to determine if geographical variation in EDCs occurrence and effect exist throughout the lakes and reservoirs of Nebraska.

There are many reasons to believe that geographical analysis of endocrine disruption of fish that reside in small, lacustrine environments may be particularly informative. First, lakes

and reservoirs serve as catchments for storm-water runoff, and EDCs that are in the runoff will likely enter these water bodies. Second, geographical variations in land use (e.g., urban housing, row-crop agriculture, pastureland, etc.) will profoundly influence the chemical composition of the runoff that enters a water body. Third, EDCs that enter these systems through time will accumulate in the sediments where they can ultimately be released by benthic-feeding fishes.

Common carp *Cyprinus carpio* is as an excellent environmental sentinel organism, especially in Nebraska because they are established in virtually every major lake and reservoir throughout the state. Further, common carp are benthic feeders that routinely roil the bottom sediments, exposing themselves to EDCs trapped within the sediments. Common carp have been used as the model organism in other studies. For example, studies of common carp in Lake Mead, Arizona-Nevada, documented differences in gonad size (gonadosomatic index) and rates of histopathological gonad abnormalities for males collected from different sections of the reservoir. These differences in reproductive physiology provide strong circumstantial evidence that male reproductive performance is hinder by the discharge of treated industrial and municipal effluents into this large reservoir (Bevans et al. 1996; Patiño et al. 2003).

We initiated a multi-disciplinary assessment of geographic trends in the occurrence of EDCs in lentic systems throughout Nebraska. We used common carp sex steroids and carp gene expression profiles as indirect indicators of exposure to EDCs, and water samples from each reservoir were used to provide a “snapshot” of EDCs concentration. The specific objectives of this project were to document occurrence and concentrations of steroidogenic contaminants in water from water bodies throughout Nebraska and examine geographic variation in effects of sex steroids on adult common carp. We hypothesized that sex steroid profiles would vary

considerably across the state, and would be associated with bioavailability of steroidogenic compounds within each reservoir.

METHODS

This study focused on the evaluation of techniques for assessing possible fish-contaminant interactions in 20 lakes and reservoirs in Nebraska. Water bodies were randomly selected within a stratified design based on type of water body (lake or reservoir) and geographic location within the state (Figure 1). Water samples and fish tissue were collected from each study site during July-August 2007 for assessment of steroidogenic compounds. We expected that temporal variation in concentration of sex steroids would be minimal during this period because of the reduced potential for run-off, thereby allowing for geographic assessment without the need to correct for expected seasonal differences in concentration of sex steroids.

Field procedures: Standard water-quality parameters (e.g., temperature, conductivity, turbidity, etc.) were measured at each water body. In addition, depth-integrated grab samples of water were collected using a Teflon bailer from three locations within each water body. Grab samples within each water body were homogenized and placed in pre-cleaned amber bottle and stored on ice. Samples were frozen as quickly as possible to minimize changes in steroid concentration after collection, and then samples were delivered to the UNL Water Sciences Laboratory, where they were analyzed for steroidogenic compounds.

Twenty common carp from each water body were captured using daytime electrofishing (pulsed DC) during July-August 2007. Adult common carp were anesthetized with MS-222 (0.1 g/L water) and blood was collected from the caudal vein of these fish using a heparinized syringe. Blood from each fish was transferred into pre-labeled 10-cc vacutainers and stored on

ice. After blood was collected, fish were euthanized, measured and weighed, and their sex verified by visual inspection of gonads. Gonads and liver were removed via dissection and weighed individually. A portion of the liver was excised and stored in liquid nitrogen. This process was repeated on randomly selected fish until we reached our target sample size of six male and six female fish, after which the remaining fish were released unharmed; in several cases, we processed all 20 fish without obtaining our target sample size. Liver and blood samples were transported to the Aquatic Toxicology Laboratory at UNO, where they were analyzed for plasma sex steroids and the hepatic mRNA expression of vitellogenin 1 (vtg), an estrogen-responsive gene.

Laboratory procedures: Steroidogenic compounds monitored in reservoir water included synthetic steroid growth promoters (trenbolone, melengestrol acetate, zeralonol) and natural steroid hormones (17β-estradiol, estrone, estriol, testosterone, androstenedione). Frozen grab samples were thawed immediately prior to analysis. . Samples were analyzed for natural and synthetic steroid hormones using on-line solid phase extraction (SPE) liquid chromatography-tandem mass spectrometry (LC/MS/MS). This highly sensitive method makes use of a commercial automated extraction system coupled to an LC/MS/MS and is similar to that described by Rodriguez-Mozaz et al.(2004) for analysis of ng/L concentrations of natural estrogens in water. Method development and validation is described elsewhere (Damon et al, in preparation).

Pure standards steroids were purchased from Sigma-Aldrich (St. Louis, MO) or Acros Chemicals, and Hayashi Pure Chemical Industries (Osaka, Japan). Deuterium-labeled steroid hormone analogues were obtained from Sigma Aldrich (St. Louis, MO) and used as internal standards. Calibration standards and samples were fortified with standard compounds

immediately prior to extraction and analysis using a Symbiosis Environ on-line solid phase extraction system (Spark Holland, Emmen, The Netherlands). The system was configured with an automatic cartridge exchanger, integrated stream switching valve, high pressure dispenser, gradient pump with control using SparkLink software. Twenty mL aqueous samples were extracted using Prospekt 2/Symbiosis 1.0 x 10mm Oasis HLB solid phase extraction cartridges. Each cartridge was eluted directly to a Waters 2695 HPLC and then to a Micromass Quattro Micro triple-quadrupole mass spectrometer in atmospheric pressure photoionization (APPI) mode. Detection and quantification of steroids utilized multiple reaction monitoring (MRM) with argon collision gas. A Thermo HyPurity C18 column (250 x 2 mm, 5 um, 50°C) was used for gradient separation at a flow rate of 0.35 ml/min. The gradient consisted of solvent A (0.1% formic acid water) and solvent B (0.1% formic acid methanol), with 0-3 min 50%B, 3-14 min 65% B, 14-20 min 95%B, with a return to initial solvent conditions for the last 10 minutes of the gradient (30 minutes total). Identification of target compounds was accomplished by comparing the retention times for the respective MRM transition in a sample to that of a standard analyzed under the same conditions. Retention times were considered to match if they were within ±5% of the standards. Recovery, measured through analysis of 10 portions of 25mL reagent water fortified at 5 ng/L, averaged between 62% for estrone and 121% for progesterone.

Plasma sex steroid concentrations and hepatic vtg mRNA expression was evaluated for five males from each field site. Fish were chosen for analysis based on their body mass, GSI and HSI, and outliers were removed from consideration. Analysis was conducted on individuals chosen randomly from the remaining pool of fish from each field site.

Plasma estradiol and testosterone concentrations were measured by radioimmunoassay (RIA) according. Plasma estradiol/testosterone ratios were determined by dividing plasma estradiol concentrations by plasma testosterone concentrations

Hepatic vtg mRNA expression analysis was conducted using previously published protocols (Kolok et al. 2007). Hepatic mRNA expression was determined using a Bio-Rad MyiQ Real-Time Polymerase Chain Reaction Detection System managed by Optical System Software version 1.0. Data were quantified by the standard curve method using series diluted cDNA samples as a standard. The expression of each gene was normalized by the expression of L8 mRNA, a "housekeeping" gene, and expressed in relative terms.

Statistical analysis: A single factor analysis of variance (ANOVA, Statview 5.0) was used to test for differences in body mass, organ indices, plasma estradiol/testosterone ratios and hepatic mRNA expression among water bodies. Newman-Kuels multiple comparison tests were used to separate water bodies when a significant difference existed. Statistical significance was set at $\alpha = 0.05$.

RESULTS

Steroid hormones in water

Except for a trace of androsterone in one sample at 0.006 μg/L, no steroid hormones were detected in water samples above the 0.005 μg/L detection limit (Table 1). Thus, no geographic trend could be determined with respect to steroid hormone concentrations across the environmental conditions sampled.

Plasma sex steroids

Significant differences ($P < 0.0001$) in plasma estradiol/testosterone ratios were detected (Figure 2). Specifically, male common carp collected from Lake Zorinski had significantly higher estradiol/testosterone ratios than male carp collected from any other site. In addition, male common carp collected from Lake Ericson had significantly higher estradiol/testosterone ratios than male carp collected from Bluestem, Calamus, Enders, Johnson, Medicine Creek, Pawnee, Red Willow, Stagecoach and Standing Bear.

Hepatic vtg mRNA expression

There were no significant differences in the hepatic mRNA expression of male carp collected from any of the field sites. Furthermore, the vast majority of males collected had vtg mRNA expression below detectable levels.

DISCUSSION

Except for a trace of androsterone in one sample, we detected no steroid hormones in water samples collected from the 18 water bodies across Nebraska. The lack of detectable levels of steroid hormones in water samples is consistent with other studies of surface water systems, as they typically occur in extremely low concentrations (<0.001 μg/L), if at all. Nonetheless, we did detect differences in plasma sex steroid concentrations in male common carp from these water bodies. The plasma sex steroid concentrations in male common carp suggests that biological exposure to EDCs differs among water bodies throughout Nebraska. Contrary to the plasma sex steroid endpoint, however, we detected no systematic differences in hepatic vtg mRNA expression and male common carp from these water bodies. Expression of hepatic vtg

mRNA in male common carp provides evidence that biological exposure to EDCs by common carp, if any, has not caused feminization of the individuals assessed. Thus, we were unable to assess geographic trends because the reproductive toxicity indicators were not in agreement. The lack of detectable levels of steroid hormones in water samples collected for this study implies either that other types of contaminants (pesticides, metals, etc.) are responsible for any endocrine disrupting effects to indigenous populations of fish in Nebraska or that these contaminants do not occur in the dissolved phase. Further, the dynamics of wild fish populations adds additional complexity for our understanding of these results. For example, a difference in age of common carp within and among water bodies is likely positively correlated with period of exposure to EDCs, which is an important factor for biological responses to EDCs.

A primary goal of this project was to obtain preliminary data (geographical variation in concentrations of sex steroids in adult common carp) needed to assemble a grant proposal for a large, multiyear assessment on the occurrence and biological effects of steroidogenic compounds in lakes and reservoirs throughout the Midwest. Contrary to our *a priori* expectations, we did not find a geographic trend in the occurrence of steriodogenic compounds. Further, endpoints from the two measures we used to assess biological effects of EDCs in water bodies across Nebraska (plasma sex steroid concentrations and hepatic vtg mRNA expression) did not agree. Thus, compelling evidence necessary to obtain a large, multiyear grant for assessment of geographic variation in sex steroids in aquatic systems is still lacking.

ACKNOWLEDGEMENTS

We thank Marlo Sellin, Teyona Damon, Nathan Gosch, Carla Knight, Christopher Lewis, Alexis Maple, Dustin Martin, Mark Pegg, Derek Tomes and Jason Weigel for assistance in the

field and laboratory. Funding for this project was provided by the U.S. Geological Survey through their 104b project; these funds were awarded and administered by University of Nebraska—Lincoln Water Center.

REFERENCES

Bevans, H. E., S. L. Goodbred, J. F. Miesner, S. A. Watkins, T. S. Gross, N. D. Denslow, and T. Schoeb. 1996. Synthetic organic compounds and carp endocrinology and histology in Las Vegas Wash and Las Vegas and Calville Bays of Lake Mead, Nevada, 1992 and 1995. Water Resources Investigative Report 96-4266, U.S. Geological Survey National Water Quality Assessment Program.

Blazer, V.S. 2002. Histopathological assessment of gonadal tissue in wild fishes. Fish Physiology and Biochemistry 26:85-101.

Kolok, A.S., D. D. Snow, S. Kohno, M. K. Sellin and L.J. Guillette Jr. 2007. Occurrence and biological effect of exogenous steroids in the Elkhorn River, Nebraska. Science of the Total Environment 388: 104-115.

Patiño, R., S. L. Goodbred, R. Draugelis-Dale, C. E. Barry, J. S. Foott, M. R. Wainscott, T. S. Gross, and K. J. Covay. 2003. Morphometric and histopathological parameters of gonadal development in adult common carp from contaminated and reference sites in Lake Mead, Nevada. Journal of Aquatic Animal Health 15:55-68.

Rodriguez-Mozaz, S. M.J. Lopez de Alda, Damia Barcelo. 2004. Picogram per Liter Level Determination of Estrogens in Natural Waters and Waterworks by a Fully Automated On-Line Solid-Phase Extraction-Liquid Chromatography-Electrospray Tandem Mass Spectrometry Method. Anal. Chem. 76: 6998-7006.

Sellin, M.K. and A.S. Kolok. 2006. Cadmium exposures during early development: do they lead to reproductive impairment in fathead minnows? Environmental Toxicology and Chemistry. 25: 2957-2963.

Soto, A. M., J. M. Calabro, N. V. Prechtl, A. Y. Yau, E .F. Orlando, A. Daxenbarger, A. S. Kolok, L. J. Guillette, Jr., B. le Bizec, I. G. Lange and C. Sonnenschein. 2004. Androgenic and estrogenic activity in cattle feedlot effluent receiving water bodies of eastern Nebraska, USA. Environmental Health Perspectives 112: 346-352.

Table 1. Results of the LC/MS/MS analysis for steroid hormones in the water samples collected during summer 2008. Concentrations are in μg/L.

Water Body	4-Androstenedione	Androsterone	17a-Trenbolone	17b-Trenbolone	a-Zearalenol	b-Zearalenol	a-Zearalanol	Estriol	Estrone	Ethynyl Estradiol	Melengestrol Acetate	Progesterone	17b-estradiol	Testosterone
Zorinski	<0.005	0.006	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Ericson	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Willow Creek	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Spalding	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Merritt	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Elkhorn River	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Conestoga	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Eagle Scout	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Red Fox	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Blue Stem	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Calamus	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Enders	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Johnson	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Medicine Creek	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Pawnee	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Red Willow	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Stage Coach	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Standing Bear	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005

Figure 1. Geographic location (latitude and longitude) of the 18 Nebraska water bodies assessed for steroidogenic compounds and their influences on sex steroids of common carp.

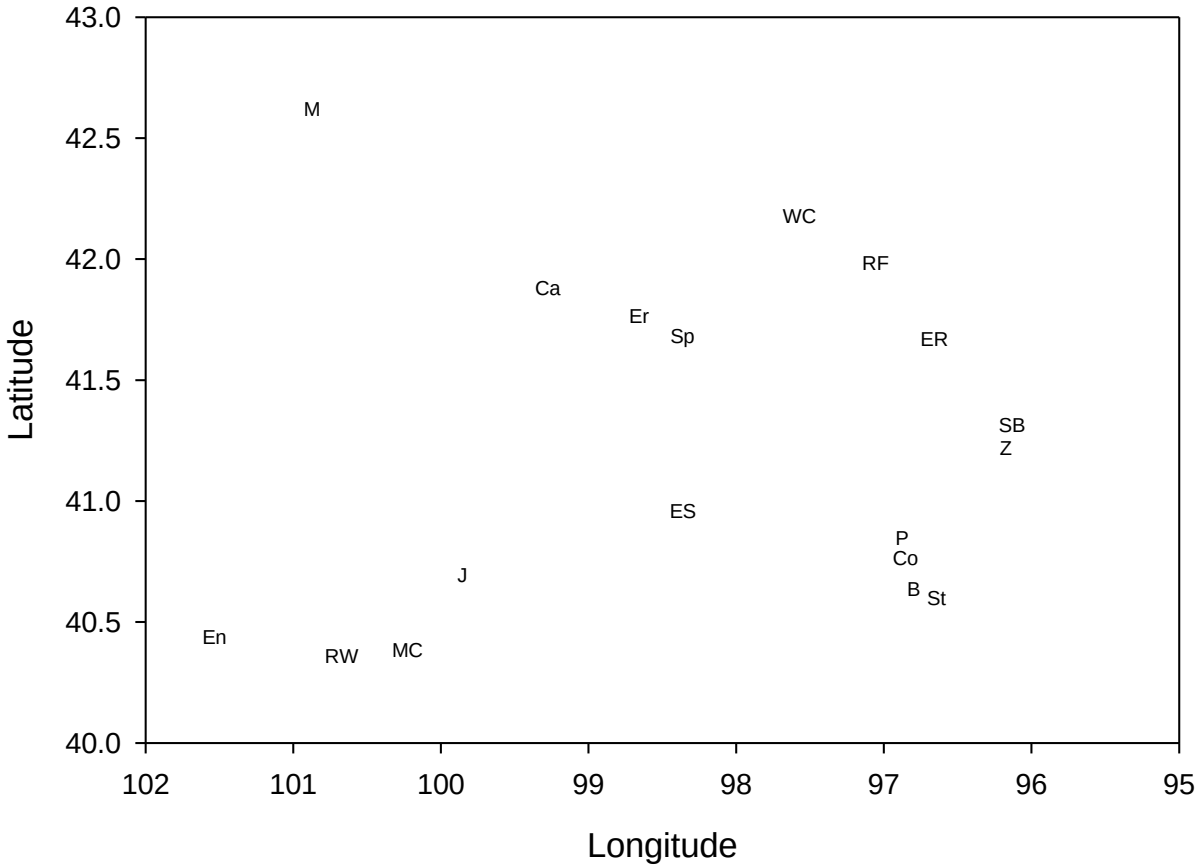
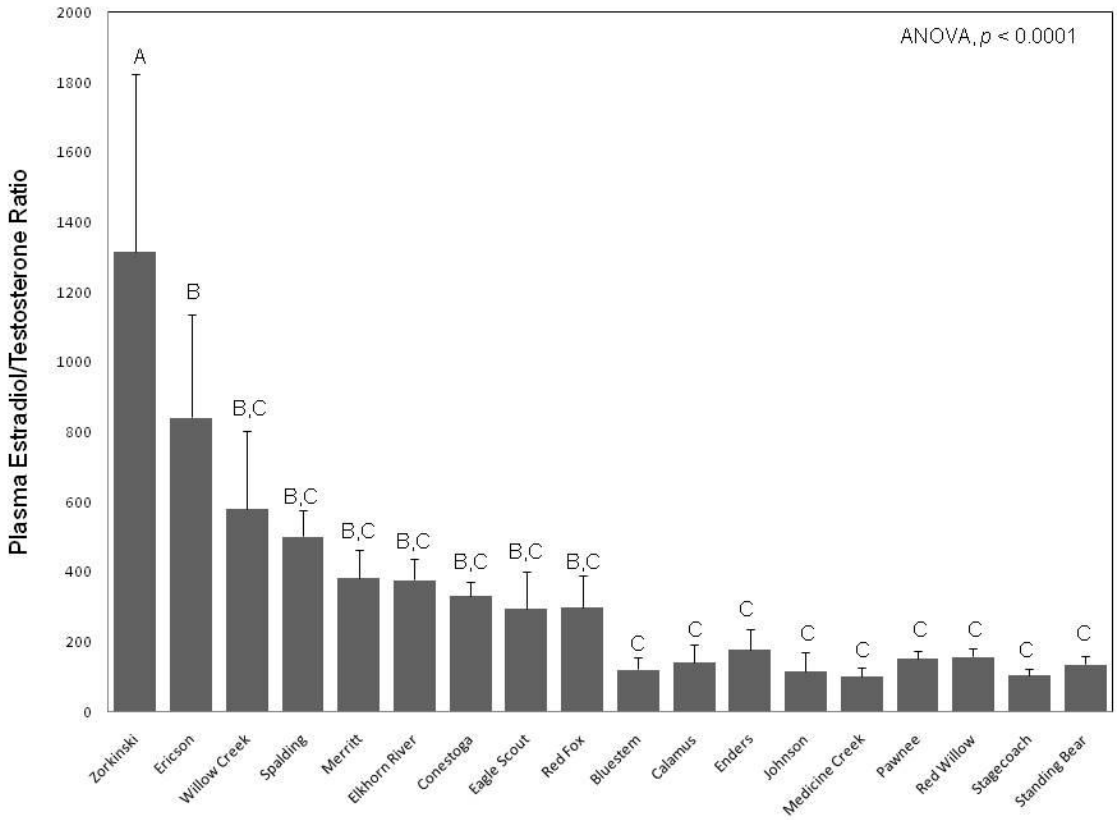


Figure 2. Plasma estradiol/testosterone ratios among males collected from 18 field sites throughout the state of Nebraska. Capital letters indicate significant differences between groups.



Satellite-based Energy Balance to Assess Riparian Water Use

Basic Information

Title:	Satellite-based Energy Balance to Assess Riparian Water Use
Project Number:	2008NE171B
Start Date:	3/1/2008
End Date:	2/28/2009
Funding Source:	104B
Congressional District:	
Research Category:	Climate and Hydrologic Processes
Focus Category:	Water Quantity, Invasive Species, Water Use
Descriptors:	None
Principal Investigators:	Ayse Irmak, Gary W. Hergert, Sunil Narumalani, Donald C. Rundquist, Gary L Stone

Publication

SATELLITE-BASED ENERGY BALANCE TO ASSESS RIPARIAN WATER USE

USGS 104B Final Report

Principal investigator: Ayse Irmak, Asst. Prof. of School of Natural Resources and Civil Engineering. Center for Advanced Land Management Information Technologies (CALMIT). University of Nebraska-Lincoln (UNL). airmak2@unl.edu

Co-PIs: Donald Rundquist, Prof., Sunil Narumalani, Prof., CALMIT, UNL. Gary Hergert, Prof., Agronomy-Horticulture; Gary Stone, Extension Educator. UNL Panhandle Research and Extension Center. UNL.

Collaborator: Robert Wilson, Prof., UNL Panhandle Research and Extension Center.

Project Description

Our goal is to improve our ability to estimate riparian ET by utilizing satellite and air-bone remote sensing data on major watersheds in the North Platte River. A physically surface energy balance model, METRIC (Mapping Evapotranspiration at high Resolution using Internalized Calibration), was used to calculate ET from satellite remote sensing. Specific objectives of the proposal are:

1. Quantify daily and seasonal distributions of ET over riparian systems at selected watersheds along the North Platte River Basin in Nebraska.

   Expected outcome: The major outcome of this work would be quantitative surface energy balance algorithm for land estimates of ET for riparian systems.

2. Comparison of water use and water availability on riparian species by utilizing ET maps with existing air-bone based riparian species distribution map.

   Expected Outcome: The riparian species distribution map was used to identify location of species precisely. This map will be integrated into METRIC ET maps to quantify amount of ET flux from each riparian species.

This report describes the procedures used processing satellite images for year 2005 for Landsat Path 33 Row 31. The final product includes actual evapotranspiration (ET) as well as fraction of evapotranspiration in relation to a reference alfalfa crop. Individual ETrF images were generated from Landsat 5 and Landsat 7 satellite imagery using the METRIC model. This model was developed by the University of Idaho for use in Erdas Imagine® image processing software (Leica Geosystems Geospatial Imaging, LLC). Each satellite image for 2005 was processed on a pixel by pixel basis using METRIC to estimate ETrF (evapotranspiration in relation to a reference alfalfa crop) and actual evapotranspiration.

Meteorological Data: Weather data were acquired from the High Plains Regional Climate Center's (HPRCC) Automated Weather Data Network (AWDN) (Table 1). The AWDN stations record hourly data for air temperature, humidity, soil temperature, wind speed and direction, solar radiation, and precipitation. Reference ET (ETr) values were calculated using the ASCE-EWRI (2005) standardized Penman-Monteith equation for alfalfa reference.

Hourly precipitation and ETr data were summed together to create daily, 24-hour values. Data from the Scottsbluff, NE station were used for the generation of intermediate and final METRIC products from the individual images. The rest of the stations were used to create an interpolated (Inverse Weighted Distance) map of reference ET for the project area to be used with the monthly and seasonal ET maps.

Table 1. AWDN station coordinates and characteristics.

Station	Latitude	Longitude	Elevation (m)
Alliance-North, NE	42.18	102.92	1213
Alliance-West, NE	42.02	103.13	1213
Arapahoe Prairie, NE	41.48	101.85	1097
Arthur, NE	41.65	101.52	1097
Gordon, NE	42.73	102.17	1109
Gudmundsen, NE	42.07	101.43	1049
Mitchell Farms, NE	41.93	103.70	1098
Scottsbluff, NE	41.88	103.67	1208
Sidney, NE	41.22	103.02	1317
Sterling, CO	40.47	103.02	1200
Torrington, WY	42.03	104.18	1216

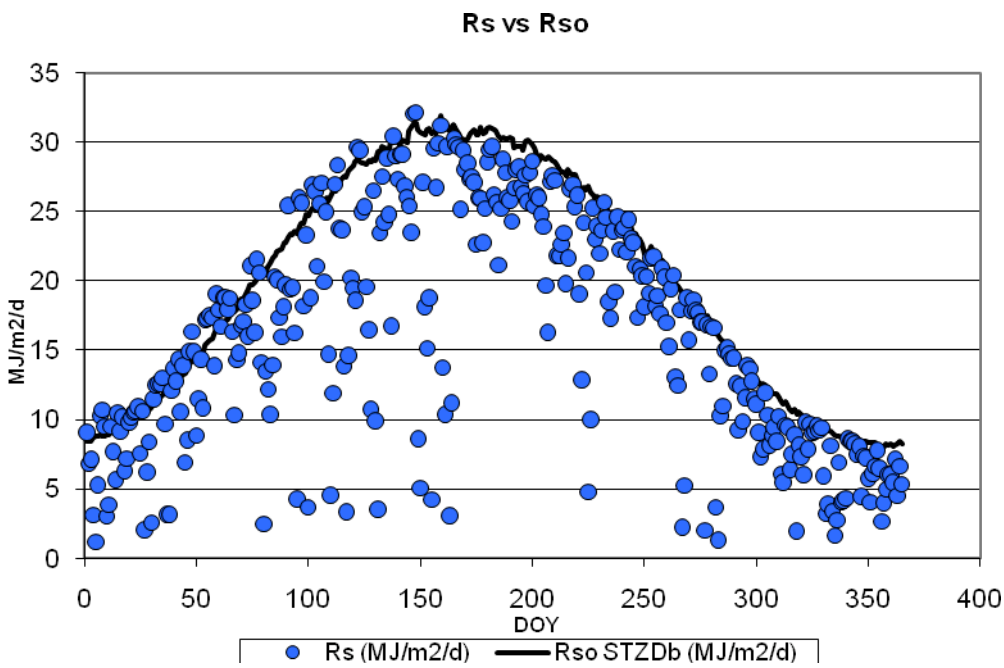


Figure 1. Observed solar radiation (MJ/m^2) and calculated clear sky solar radiation (MJ/m^2) in 2005 at Scottsbluff, NE.

Daily Soil Water Balance Model: A daily water balance model based on Allen et al. (1998) was employed to estimate residual evaporation from the hot pixel (Fig. 2). The satellite overpass times were acquired from the image meta data files to estimate zenith angle of the sun, instantaneous values of wind speed at 200 m, air humidity, and ETr.

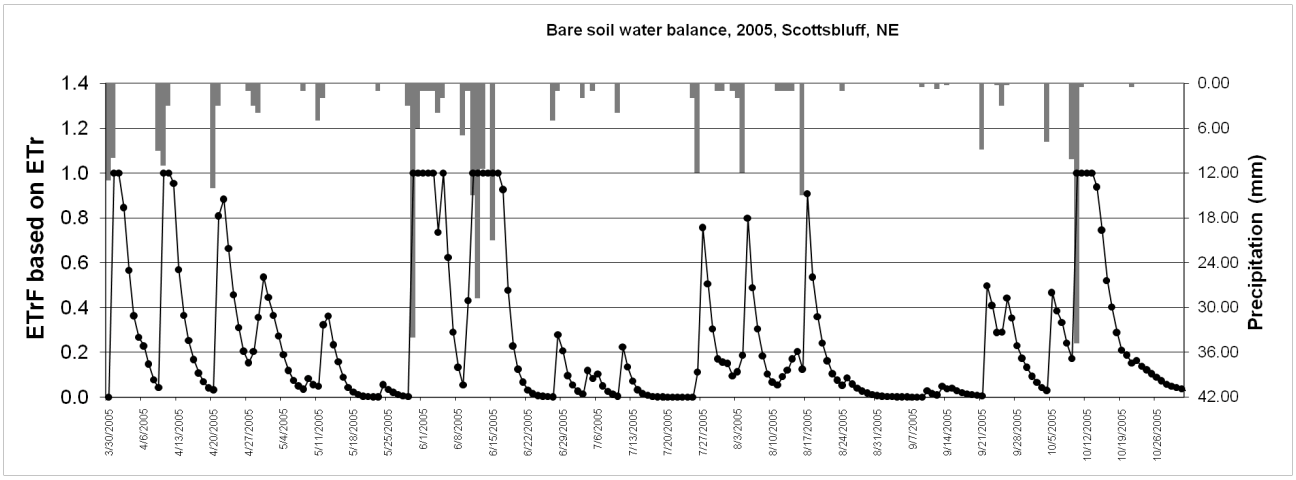


Figure 2. Soil water balance for bare soil calculated from meteorological data from Scottsbluff, NE 2005. Soil water balance is used to determine ETrF for hot pixel selection.

Satellite Imagery: A total of 10 Landsat images were purchased for 2005 of the Nebraska Panhandle region. Table 3 lists the dates of the imagery. Landsat images were ordered for path 33, row 31 as systematic terrain-corrected (Level 1T), 30 meter spatial resolution, with nearest neighbor resampling method. The thermal band was resampled by USGS to 30 meters. UTM zone 13, NAD 1983 was the projection and datum used.

Table 3. Landsat imagery of Nebraska Panhandle acquired for 2005.

Date	Satellite	Path	Row
13 April 2005	Landsat 5	33	31
15 May 2005	Landsat 5	33	31
31 May 2005	Landsat 5	33	31
02 July 2005	Landsat 5	33	31
10 July 2005	Landsat 7	33	31
19 August 2005	Landsat 5	33	31
28 August 2005	Landsat 5	32	31
20 September 2005	Landsat 5	33	31
14 October 2005	Landsat 7	33	31
23 November 2005	Landsat 5	33	31

Seasonal Actual ET (from May 01 through september 30) for riperian species

Figure 3 shows the riparian species on flight #3 on NE Panhandle. This map was integrated with seasonal ET maps obtained with METRIC model (see fig. 1.5. on Appendix A). Figure 4 through 8 show seasonal actual ET (from may 01 through september 30) for each riperian species. The y axis on each figure (histogram) shows number of landsat pixels for each riparian species while x axis shows corresponding actual ET values in mm. For instance, the seasonal water use (from May 01 through september 30) of saltcedar ranged from as low as 350 mm to as high as 961 mm depending on the density and age of saltcedar tree. On average, the water use of saltcedar was 680 mm. The details of METRIC ET processing were explained in Appendix A.

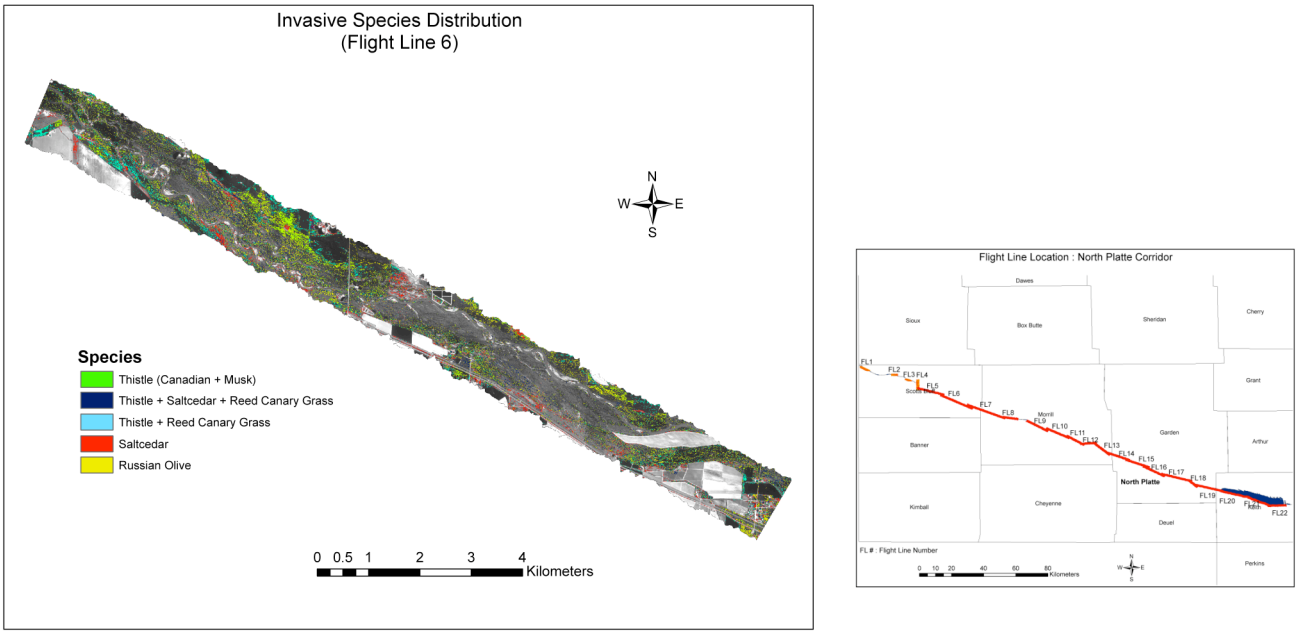


Figure 3. Invasive species distribution in 2005 for flight line #3 on Path 33, Row 31.

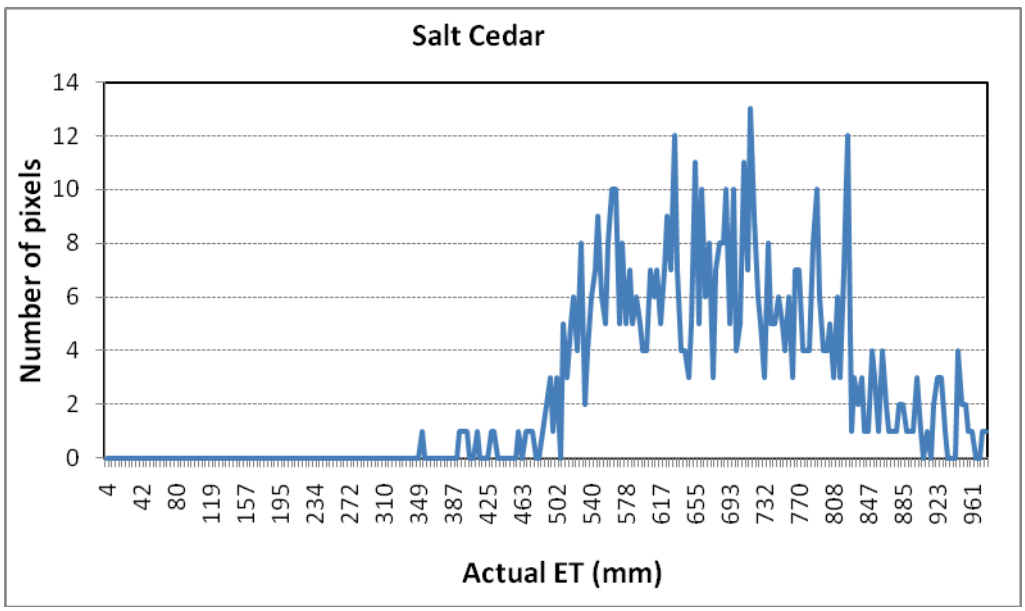


Figure 4. Histogram of seasonal ET (from May 01 through September 30) in 2005 for salt cedar.

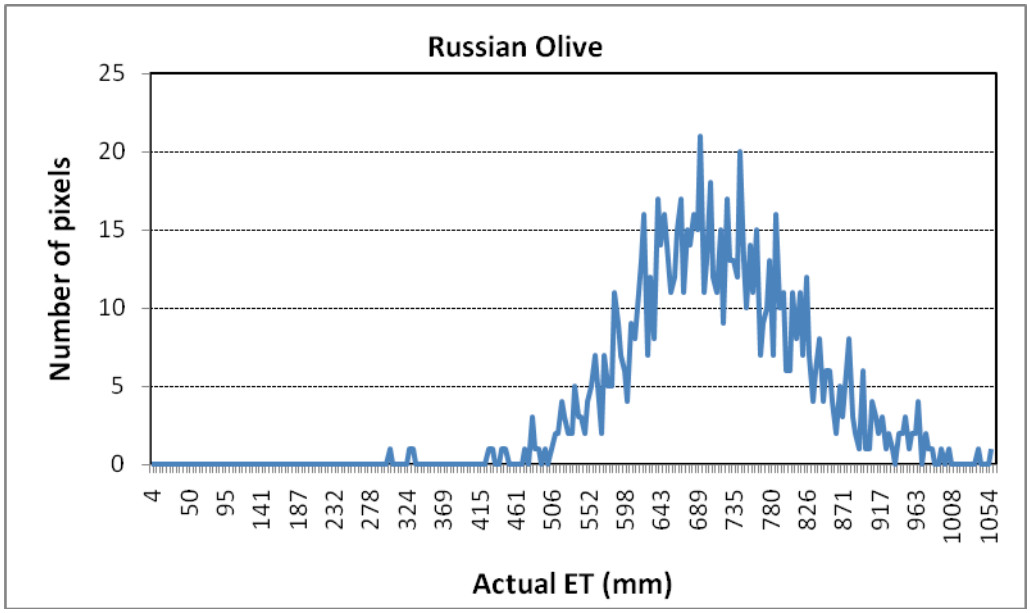


Figure 5. Histogram of seasonal ET (from May 01 through September 30) in 2005 for Russian olive.

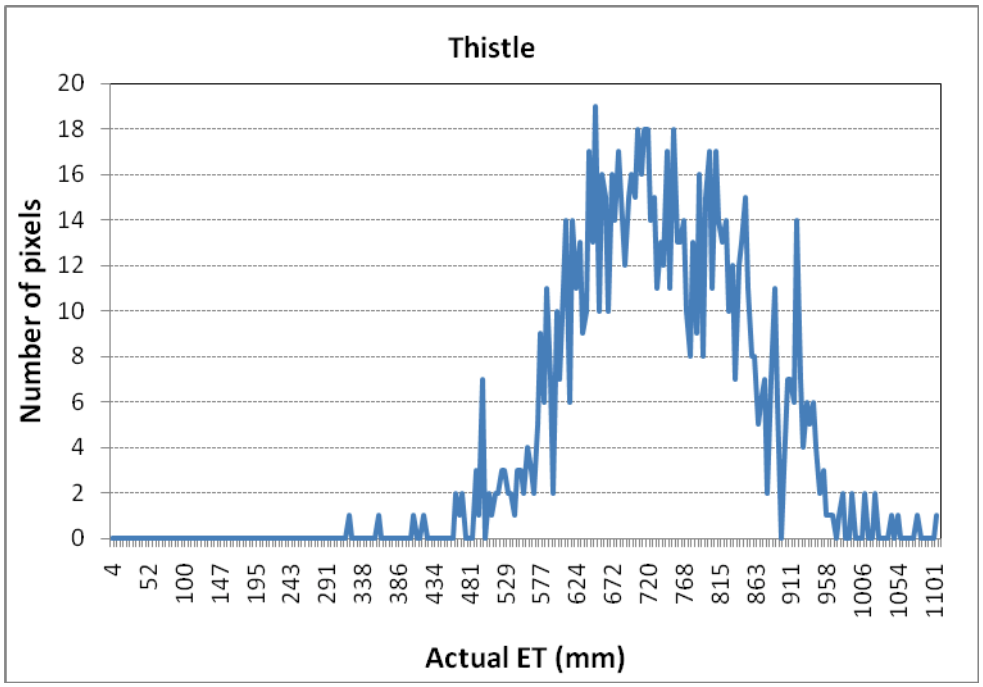


Figure 6. Histogram of seasonal ET in 2005 for Thistle.

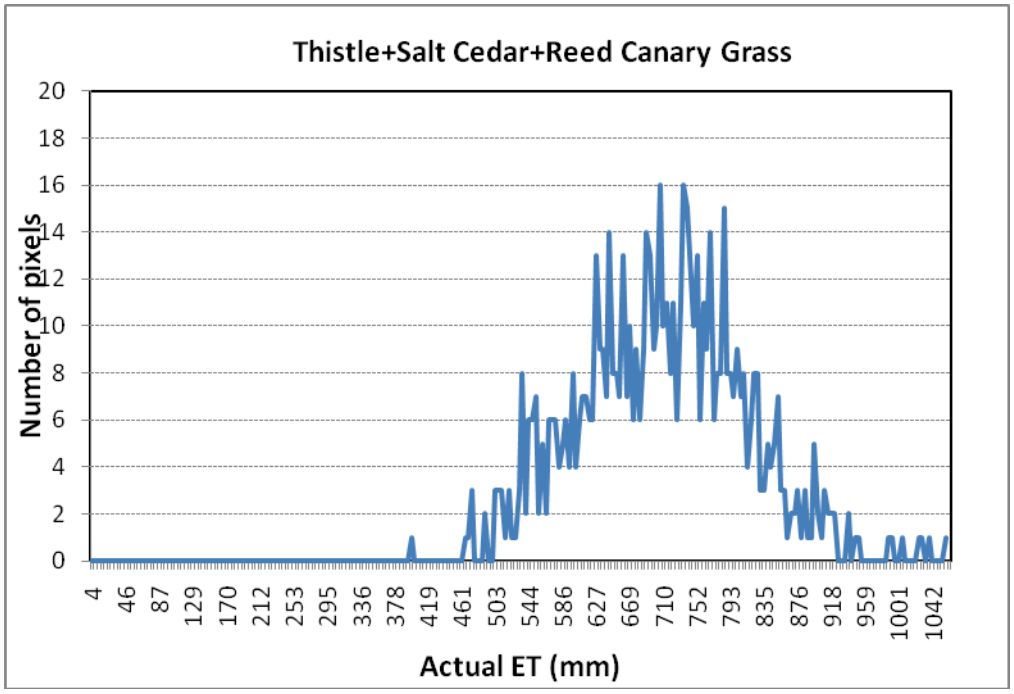


Figure 7. Histogram of seasonal ET in 2005 for land use class of thistle + salt cedar +reed canary grass.

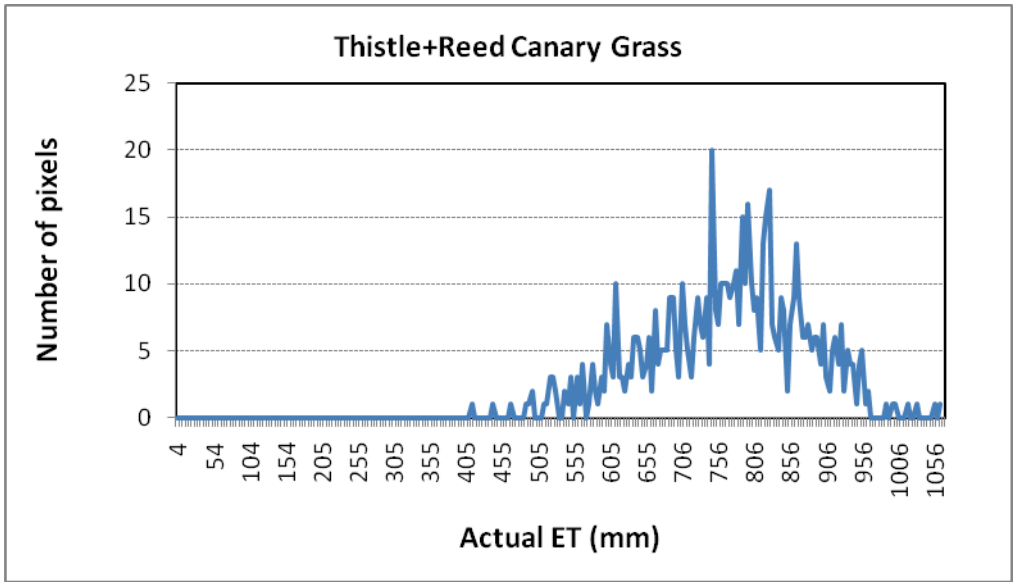


Figure 8. Histogram of seasonal ET in 2005 for thistle+ reed canary grass.

APPENDIX A:

Gap-filling of Landsat 7 ETM+: On 31 May 2003, image data from the ETM+ sensor onboard the Landsat 7 satellite began exhibiting "striping" artifacts (USGS, 2008). It was determined that the problem was a result of the failure of the Scan Line Corrector (SLC) which compensates for the forward motion of the satellite. The post-SLC failure images of Landsat 7 are termed as SLC-off images. Due to the SLC failure, about 22% of the scene area is missing in SLC-off images. Processing of SLC-off images requires replacing the missing data. Various approaches are used for filling the missing data. Some of these approaches use data from the previously acquired images to replace the missing pixels. However, this approach is not very useful for agricultural applications due to temporal dynamics. Because Landsat 7 was still able to acquire imagery, the USGS developed new image products to fix the striping problem by combining two separate dates or by interpolation to fill in the data gaps.

We carried out our own correction to the scan line correction for Landsat7 datasets by using convolution filtering (nearest neighborhood method) with a 5X5 pixels majority function (Singh et al., 2008). In our application, we have used the approach of gap filling utilizing same time images with spectral information from the neighboring pixels. For this, the convolution filtering algorithm with majority function has been used to replace the missing data. The majority function is preferred due to our overall objective of estimating ET from the agricultural fields. This technique works perfectly for the inner missing lines. However, the missing pixels at the edges of the image scene are not well represented due to large gaps. Hence, it is advisable to subset the images leaving the outer edges.

Thermal shift in Landsat 5 Imagery: Inspection of Landsat 5 L1T NLAPS images, ordered through the AmericaView Project, indicates a systematic vertical downward shift of 30 to 90 m in the resampled band 6 (thermal band). Band 6 was resampled during the L1T process from the original 120 m to 30 m. The shift problem seems to occur for both cubic convolution and nearest neighbor resampling schemes. This shift has been evident in Landsat 5 images for p33r31 and p32r31 from 1997, 2002, and 2005. A shift of band 6 was not obvious in Landsat 7 images that were ordered. We have concluded that manually shifting the thermal band north 60 meters (2 pixels) rectified the problem.

Preparation of Digital Elevation Model and Land Use Map: The Digital Elevation Model (DEM) was obtained from the EROS Data Center Seamless Data Distribution System. The DEM was downloaded as 1 arc second and reprojected to NAD 83 GRS 1980 UTM 13 using cubic convolution.

METRIC does not require a land cover map but is recommend in order to improve the parameterization and estimation of the surface roughness parameter (Allen et al., 2007). The land use maps are a composite of (1) the 1991-1993 Nebraska Gap Analysis Program (GAP), (2) the 1997, 2001, or 2005 Nebraska Cooperative Hydrology Study (COHYST), and (3) the 2001 National Land Cover Dataset (NLCD). Three land use maps were created for the Nebraska Panhandle: 1997, 2001, and 2005. These maps correspond to the years the COHYST land use maps were generated. The land use maps were reprojected into NAD 83 GRS 1980 UTM 13 using nearest neighbor resampling.

Processing Individual ETrF Images and Managing Cloud Cover in Imagery

ETrF (relative ET fraction) cannot be directly estimated for cloud covered land surfaces. Even thin cirrus clouds can lower the values in the satellite thermal band and cause large errors in the calculation of sensible heat fluxes. Therefore, it is essential that all satellite imagery be checked for cloud cover and shadows, and be masked out. A suggestion made by Allen and Burnett (2009) involves the use of daily MODIS 250 m, NDVI products to provide information on the development of vegetation during the cloud cover period. This method was applied to cloud cover areas for image dates of May 15th, May 31st, and July 2nd.

MODIS/Terra Surface Reflectance Daily L2G Global 250m SIN Grid V005 data were ordered from the NASA Warehouse Inventory Search Tool (WIST) website. Only MODIS dates within 5 days of the Landsat date were

considered. Cloud-free MODIS images (23 April, 18 May, 28 May, 06 July) in 2005 were run through the MODIS Reprojection Tool (MRT) software provided by the USGS LP DAAC. The data were reprojected to UTM zone 13, NAD83, using nearest neighbor resampling. The files were output as HDFEOS format. Reprojected MODIS files were then imported into ERDAS Imagine where the data was converted to reflectance and NDVI was calculated. Figure 1.3 shows ETrf for individual Landsat dates by utilizing data from Landsat and MODIS.

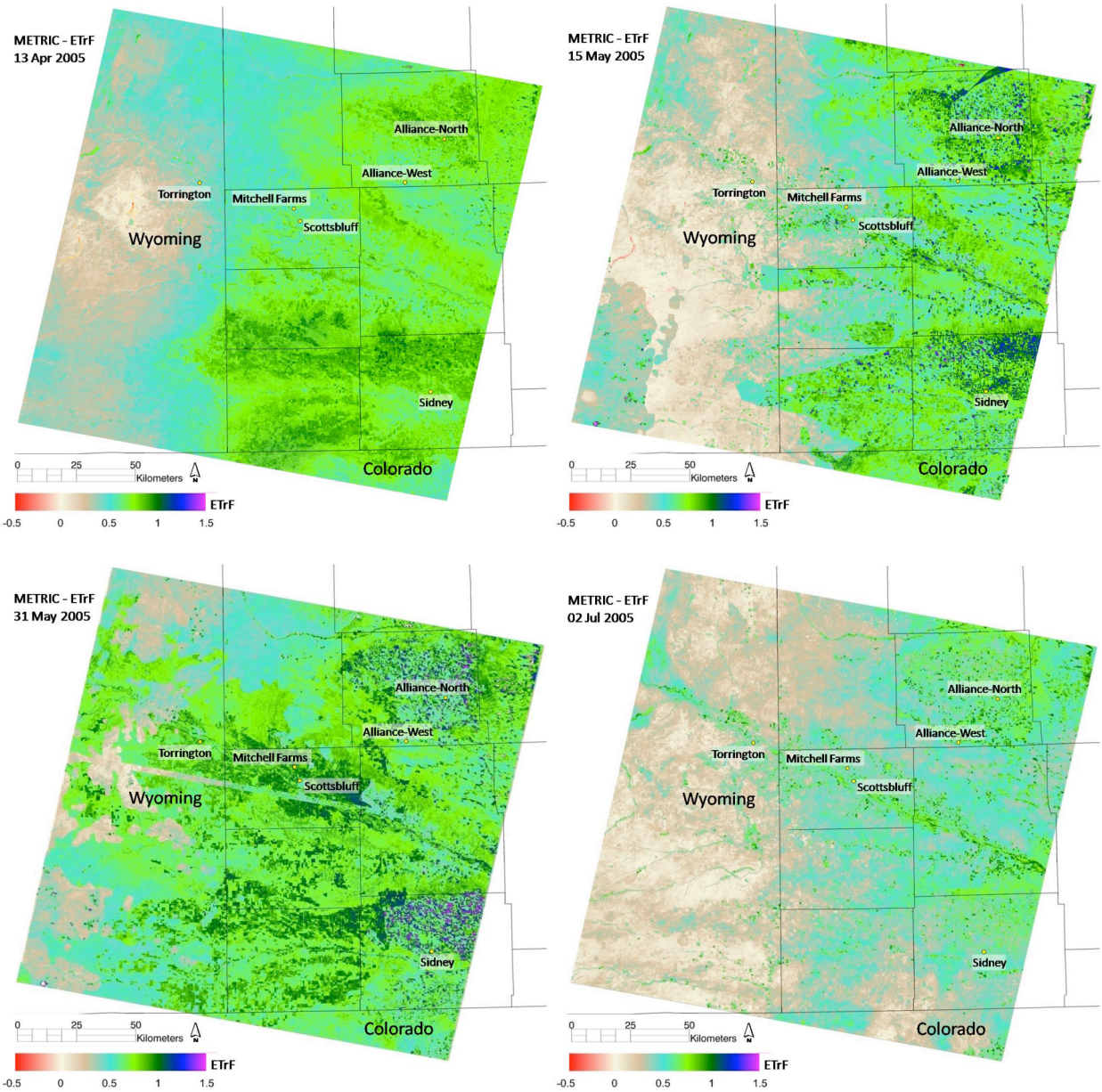


Figure 1.3. Calculated ETrf (reference ET faction) for individual Landsat dates in 2005 path 33, row 31.

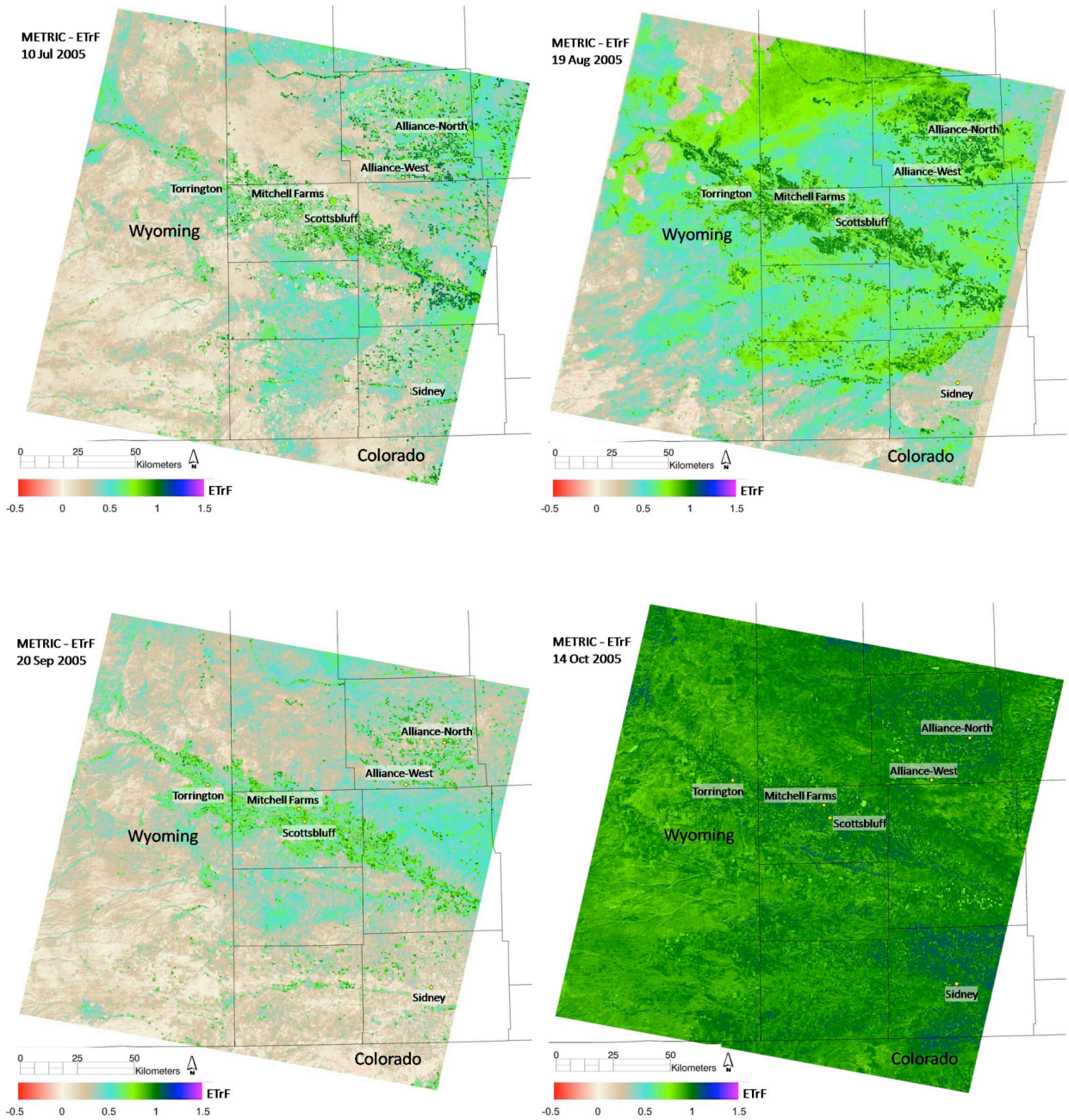


Figure 1.3. Continued. Calculated ETrf for individual Landsat dates in 2005 path 33, row 31.

Monthly and Seasonal ET Maps

Individual maps of ETrF generated from METRIC were interpolated using a spline model. Figure 1.4. shows monthly ET for path 33, row 31 in 2005. The spline model requires two images each in the preceding and subsequent months of the month to be interpolated. Because only one image was available for the month of April, a new ETrF image was created for April 23rd from MODIS 250m NDVI data. The methods used were the same as the cloud filling method using MODIS 250m NDVI data. Monthly ET maps were summed to obtain total seasonal ET for the study area (fig. 1.5.).

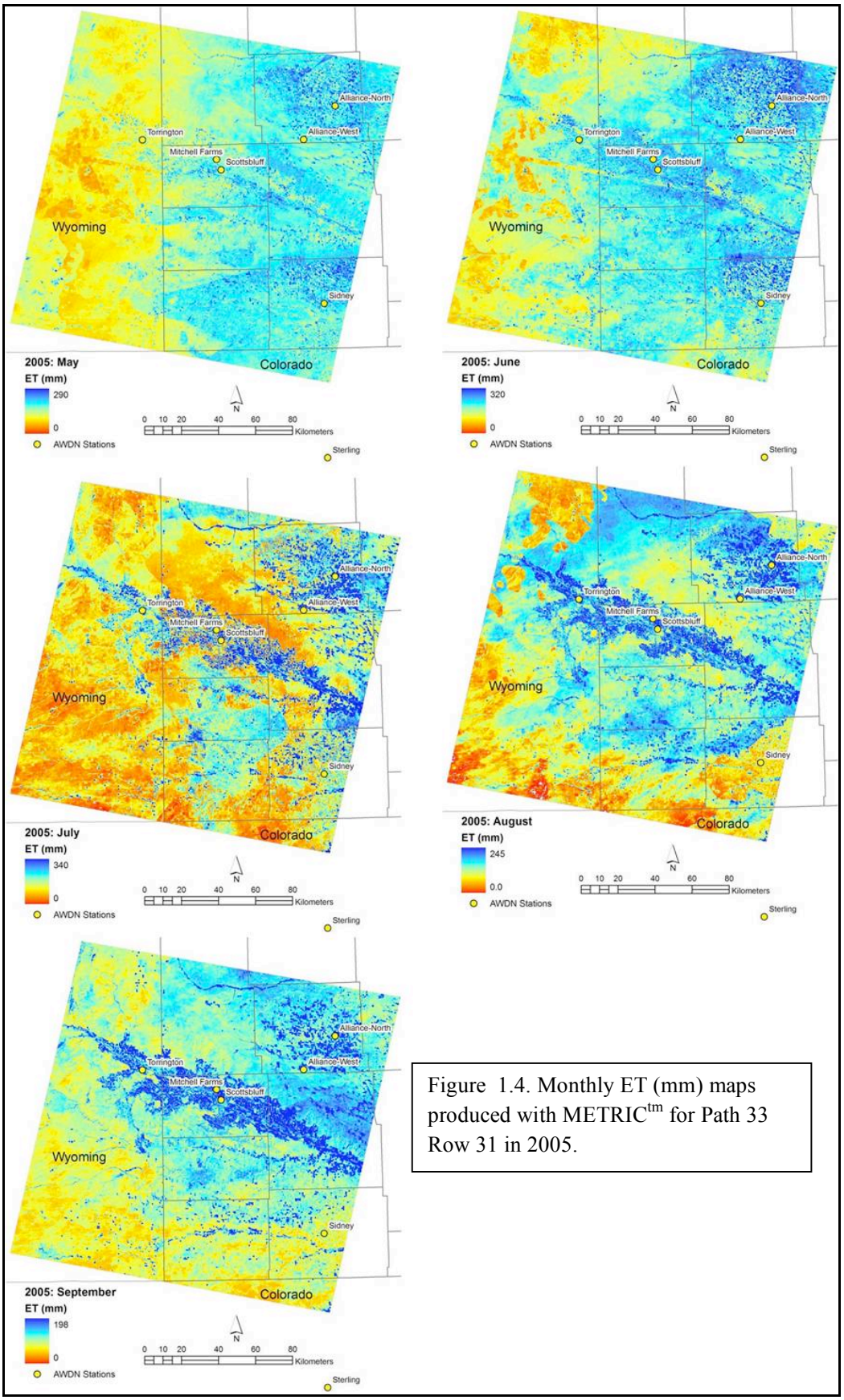


Figure 1.4. Monthly ET (mm) maps produced with METRIC^{tm} for Path 33 Row 31 in 2005.

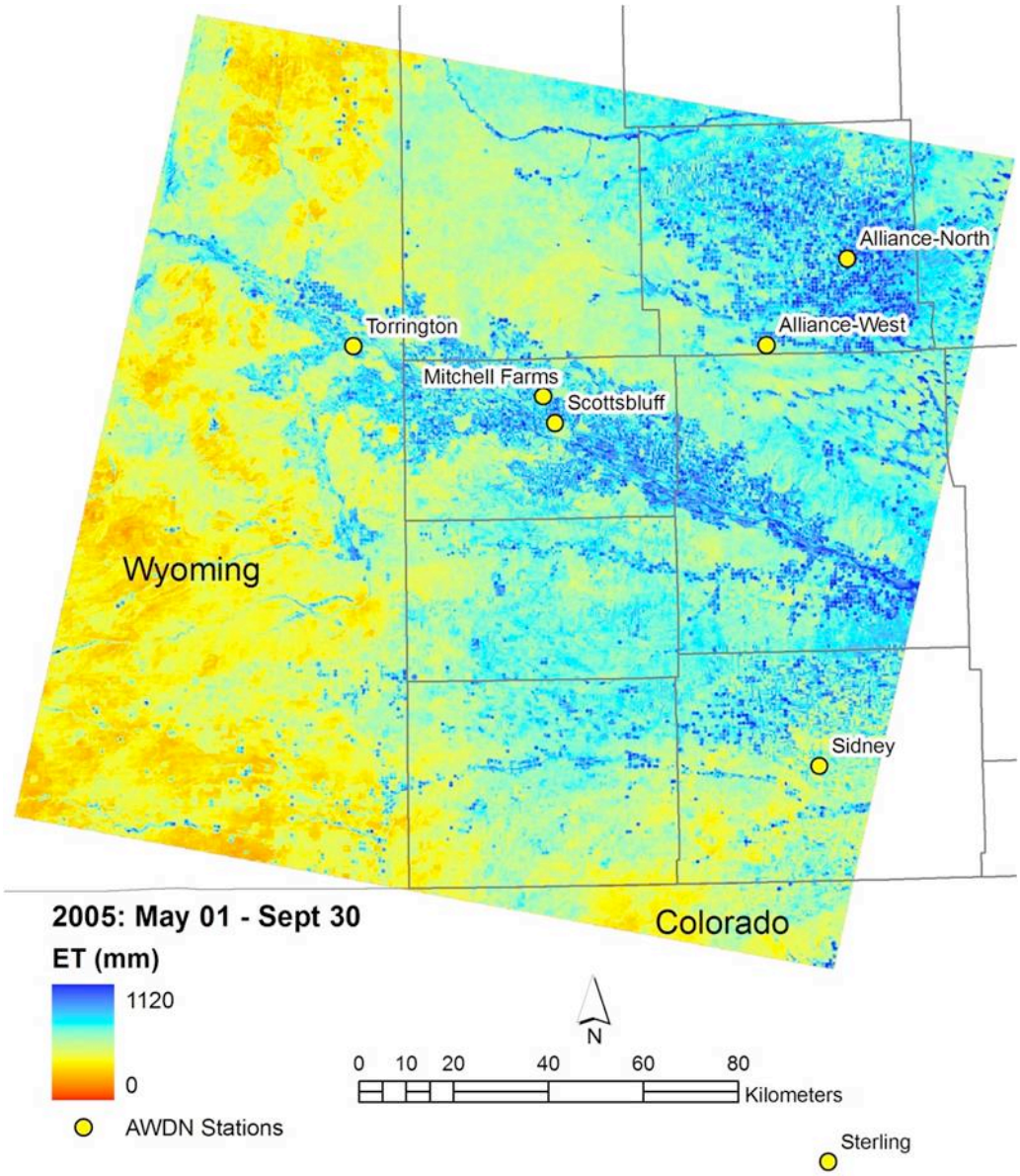


Figure 1.5. Seasonal ET (mm) map from May 01 through September 30 in 2005 for Path 33 Row 31.

Award No. G09AP00031 Standards of Practice for Adaptive Management

Basic Information

Title:	Award No. G09AP00031 Standards of Practice for Adaptive Management
Project Number:	2008NE198S
Start Date:	1/15/2009
End Date:	9/15/2009
Funding Source:	Supplemental
Congressional District:	2
Research Category:	Biological Sciences
Focus Category:	Hydrology, Models, Methods
Descriptors:	Adaptive Management
Principal Investigators:	Kyle D. Hoagland, Kyle D. Hoagland

Publication

Project Narrative
Applied Research and Training Proposal:
Standards of Practice for Adaptive Management

Introduction and Rationale for Project

The challenge facing most recovery and restoration projects, nationwide, is that law or policy are being requiring not just to retrieve threatened and endangered species and their ecosystems from the brink of collapse but to use Adaptive Environmental Assessment and Management (AEAM or AM) in doing so. Much like the airline story of Peoples Express (boom then bust) – the planes were ordered, the tickets issued before sufficient flight crews had been adequately trained and familiarized with Peoples Express' new concept of running an airline. Eventually, decline in quality of service and loss of public confidence to meet flight schedules doomed the company.

The same calamity could befall the nation's ecological recovery and restoration efforts and Adaptive Management as well. Scientists, engineers, manager and policy makers need adequate training in proven practices and grounding in a rather dramatic departure from conventional resource science and management concepts if AM guided ecological recovery and restoration efforts are to succeed.

More specifically, the Corps of Engineers operations and management of Missouri River is under a Section 7 jeopardy opinion issued by the US Fish and Wildlife Service (2005) that specifies targets for habitat recovery and the process (Adaptive Management) that is to be used in achieving recovery.

The Missouri: An Endangered River. The Missouri River is a large and complex floodplain ecosystem that covers ~1/6th of the US continental land surface. The River's floodplain ecosystem is severely degraded, one of the nation's most ecologically endangered rivers. The Missouri River ecosystem is in jeopardy because impoundments and channel training devices have altered its river regime. The river's hydrodynamics have been distorted and the consequences include the loss of

- Natural flood pulse
- Natural low flows
- Stream meanders
- Riparian vegetation
- Variations in temperature fluctuation
- Cut and fill alluviation

Nearly 3 million acres of the river's floodplain habitat has been changed. Sediment transport since installation of the dams has been dramatically reduced. Much of the river has been dammed (75 total) and channelized. The frequency and amplitude of the River's peak flows has been sharply reduced. Cropland expansion and impoundments have eliminated floodplain vegetation. Reproduction of cottonwoods, a vitally important ecological species, has largely ceased in un-impounded and channelized reaches. Reproduction of benthic vertebrates has been reduced by ~70%. Of the 67 native species living in the mainstem, 51 are now listed as rare, uncommon, and/or decreasing across all or parts of their ranges.

Objectives of Applied Research and Training Project:

The states, tribes, federal agencies, business communities and people of the Missouri River Basin have embarked on an unprecedented joint venture in habitat recovery and sustainable restoration of the most endangered river in the nation. New authorizes have been issued requiring an overhaul in every aspect of river management. New requirements for citizen engagement, changes in operating schedules, management of combined river channel and floodplain, a new ecosystem restoration plan, opportunities for river-community revitalization, discussions among states and tribes for reconfiguring the Pick-Sloan Plan of 1944 and a new, more prominent roll of science in helping to lead not just follow river-related decision making.

The River and its basin communities are poised for change. What is needed process that provides the flywheels that entrain and focus the performance of these various activities. Adaptive Management is designed to address the ecological and management puzzles of the recovery and restoration. And has proven capable of effectively linking with the other river-related activities identified above. However, to accomplish such tasks and avoid the calamity that befell Peoples Express; considerable energies must be devoted to a) researching the emerging standards of practice, b) determining the competencies requisite to the challenges faced, c) developing training modules and conducting workshops and a short course for the engineers, scientists and managers involved in the MOR Recovery program.

The purpose of this proposal is two fold:

1. *Training* -- Provide training opportunities for the engineers and scientists involved in the MOR Recovery Program

a. One 5-day short course the week of February 23-27th, 2009.

2. *Applied Research* -- Determine the standards of practice and competencies needed buy engineers, scientists and managers to implement Adaptive Management for the MOR Recovery Program

Products from Applied Research and Training Project

The two project purposes will yield two sets of products:

1. *Training Activities:* The second set of products will flow out of the first, taking the shape of training modules to be delivered at either the workshops in late October or the short course in mid-January or both. A very tentative list of training modules likely to be developed include:
    - Institutional and Policy Considerations -- that both frame and constrain the practice of Adaptive Management.
    - AM, NEPA, ESA and the Courts – Over 60 federal court cases involving Adaptive Management in relationship to the National Environmental Policy Act and the Endangered Species Act have been decided. This record of decision provides valuable guidance for implementing agencies.
    - Adaptive Governance – top down and bottom up approaches engaging science and democratic processes in platforms fitting to the temporal and spatial scales of the challenges faced.
    - Water Resource Engineering for Ecological Recovery and Restoration -- For the most part engineering solutions to water resources problems have attempted to provide "fail-safe" solutions to multidimensional problems that defy optimization. Ecological recovery requires a new set of tools that are "safe-fail" and optimize the whole instead of individual parts, or functions (navigation, flood control, etc).
    - Justifying Composite Solutions to Wicked Problems – Complex problems are irreducible. They involved multiple, interacting functions that do not readily lend themselves to cost-benefit analyses. Further, constituencies are demanding greater transparency in decision-making, which requires functionally disaggregated and relational approaches

(compositives) to the development of decision packages.

- New Class of Surprises – Restoration and recovery programs face new challenges as the foreshocks of Climate Change (Katrina, 1993 Mississippi River Flood, year-round fire seasons in the western US, sudden collapse syndrome for plants and animals, habitat alternation on biome level). The question is how can recovery programs and communities respond effectively to this new age of climate challenges.
- Science Reasoning and Modes of Inquiry – New challenges require new responses. Conventional science is not delivering the methods and results that are responsive to the needs of managers and policy makers scrambling to make sense and take action in very complex social and ecological systems. Adaptive Management offers science for society; a way of establishing a meaningful dialogue between nature and society to recover lost connections and mutually beneficial relationships.
- Primary Principles, Practices and Tools –A popular misconception of AM is that it was developed in response to the EIS process when in fact it was designed in Europe with a whole new set of concepts and approaches in mind. Many of these original ideas and concepts need to be emphasized anew and their relevance demonstrated.

The team of researchers involved in the study will reconfigure the training modules listed above substantially based on the knowledge and understanding they bring to the project and what the applied research component of this project will reveal to each of them and to the team as a whole. They include:

- Brad Karkainen
- Kent Loftin
- Chad Smith (RA)
- Kathy Hiltsley (logistics)
- Steve Light

The methods and approaches of conveying various concepts, experiential understandings and new ways of working will be given serious thought as the training

modules are developed. Lessons learned from previous experience will be applied to increase communication and student comprehension.

2. *Project Product:* The first product produce a manual of standards of practice for Adaptive Management. In the process of developing the final product the team will address 4 questions listed below, the results of which will drawn from teaching of the training modules
    - What must recovery/restoration projects across the nation do to stay out of trouble with the courts, congress, policy, constituencies, etc.? (Where are projects/programs stumbling and why? Develop examples)
    - What are the "standards of practice" gleaned from primarily from peer reviewed literature, federal policy, independent scientific peer reviews of projects, GAO and NRC reports, demanded of AM programs? Examples of where these standards are being met.
    - What are the core competencies — principles, practices, tools and processes -- that the AM-based recovery program are/will be measured by?
    - How our approach to "management guidance" must change so that responses are equal the unprecedented speed, scale and complexity of the challenges we will face?

Information Transfer Program Introduction

The University of Nebraska-Lincoln (UNL) Water Center maintains and expands upon a tradition of ambitious and proactive information transfer programming utilizing USGS and other public and private funding sources. This program is designed to complement the full range of research, extension and outreach programming that the UNL Water Center is engaged in. The UNL Water Center is easily in the top five of the more than 50 Water Resources Research Institutes nationwide in terms of comprehensive, diverse and up-to-date information transfer programming. The UNL Water Center combines experienced and dedicated research, extension and teaching faculty and staff, the latest technologies and techniques, and a comprehensive, needs-based programming itinerary to provide a wide-range of science-based information to a broad clientele. Information transfer needs are constantly being reassessed.

Information transfer supports a variety of research, engagement and education programming sponsored or co-sponsored by the Water Center, the Water Resources Research Initiative, UNL's Office of Research, School of Natural Resources, UNL Extension and the University of Nebraska's Institute of Agriculture and Natural Resources.

Mediums include print, electronic, broadcast and web-based, along with conferences, symposiums, seminars, colloquiums, tours, trade shows and other public events. Information is published in the form of newsletters, brochures, fact sheets, press releases, proceedings, research briefs, Internet web sites, public and commercial radio and television coverage, videotape/DVD, books and others.

Water Center Educational Materials/Information Transfer Plan

Basic Information

Title:	Water Center Educational Materials/Information Transfer Plan
Project Number:	2006NE130B
Start Date:	3/1/2006
End Date:	2/28/2009
Funding Source:	104B
Congressional District:	1
Research Category:	Not Applicable
Focus Category:	Education, None, None
Descriptors:	
Principal Investigators:	Kyle D. Hoagland, Steven W. Ress

Publication

1. Newsletters: The Water Current newsletter is in its 38th year of continuous publication. The 16-20-page newsletter is published quarterly in full-color in a magazine-style format. It has a free subscriber-based distribution of approximately 3,000 copies per issue, more than 95 percent of which represent requested subscriptions. An annual reader survey is published each spring. Water-related research, extension, education and outreach faculty and key staff are featured in each issue. Guest columns and commentaries are published on a regular basis. An information-based column by the UNL Water Center s director is published in each issue. Special, theme-oriented issues are published occasionally. Past themes have centered on the U.S. Army Corps of Engineers work in the Missouri River basin, Nebraska s irrigation districts and companies, and drought-related topics. Virtual copies of the newsletter online in PDF form at http://watercenter.unl.edu. The UNL Water Center is also a primary contributor of water-related news and feature articles in the quarterly UNL School of Natural Resources Resource Links newsletter.
2. Water Center informational brochures: All full color. Updated and produced annually. These include, but are not limited to, the mission and programming of the UNL Water Center, Water Resources Research Initiative (WRRI), Great Plains CESU, UNL Water Sciences Laboratory and other units or programs affiliated with the Water Center.
3. Water Center Pocket Resources Directory: A color, accordion-fold pocket brochure listing key NU, federal, state and local water resource agencies and points of contact for the public. Fourth edition published this year.
4. Water Center fact sheets: Used to inform and to promote both general themes, such as the Water Center itself, or to announce specific programs, seminars, courses, etc. All produced in full color.
5. A range of publications produced outside the UNL Water Center, particularly fact sheets, research project results and other print materials from USGS, Nebraska Department of Environmental Quality, U.S. Environmental Protection Agency, U.S. Army Corps of Engineers, local Natural Resources Districts and University of Nebraska-Lincoln Extension, are available through the Water Center and School of Natural Resources web sites.
6. News Releases: The Water Center produces about 40 press releases annually which focus on research results or significant progress, extension programs, educational opportunities, public tours, seminars, lectures and symposiums and other matters of public impact involving the Water Center, Water Resources Research Initiative or School of Natural Resources. Conferences, seminars, tours,

collections of waste pesticides, pesticide container recycling and other activities are similarly announced using press releases. The releases support a wide variety of UNL water-related research and outreach that cross departmental and academic disciplines. The Water Center is well known as a willing and reliable source among local and state reporters specializing in covering water and natural resources-related news. Calls from journalists looking for University of Nebraska sources for fast and reliable information on water and natural resource topics are common and frequent. The Water Center makes wide use of electronic and broadcast journalism sources, as well as the more traditional print (newspaper) sources.

7. History of the UNL Water Center 1964-2008: A first-ever popular chronology and history of the UNL Water Center. Details its history and evolution since the center was first established in 1964. The book published in the spring of 2008. Full color, soft cover, 91 pages. Available free to the public.
8. Water Center Pocket Resources Directory: A color, accordion-fold pocket brochure listing key NU, federal, state and local water resource agencies and points of contact for the public. Reprinted in January 2009.

2008 USGS Report
Information Transfer Program:

UNL Water Center,
School of Natural Resources
University of Nebraska-Lincoln

Newsletter:

The *Water Current* newsletter is in its 40th year of continuous publication. The 16 to 20-page full-color newsletter publishes quarterly in magazine format. It has a free subscriber-based distribution of approximately 2,700 copies per issue, more than 95 percent of which represent requested subscriptions. It is also available online in pdf format.

An annual reader survey is published each spring. Water-related research, engagement, education and outreach faculty and key staff are featured in each issue. Guest columns and articles are encouraged from faculty, students and constituents. A director's column is published in each issue. Liberal use is made of color photographs and graphics.

Other Print Resources (all distributed free of charge):

Brochures and pamphlets: All full color. Updated and produced regularly. These include, but are not limited to, the mission and programming of the UNL Water Center, Water Resources Research Initiative (WRRI), Great Plains Cooperative Ecosystems Studies Unit, UNL Water Sciences Laboratory, Tern and Plover Partnership, and other units or programs affiliated with the Water Center.

Water Center Pocket Resources Directory: A color, accordion-fold pocket brochure listing key NU, federal, state and local water resource agencies and points of contact for the public. Reprinted in January 2009.

Water Center fact sheets: Used to inform and to promote both general themes, such as the Water Center itself, or to announce specific programs, seminars, courses, etc. All produced in full color. Several variants, designed around specific audiences, both internal and external.

History of the UNL Water Center 1964-2008: A first-ever popular chronology and history of the UNL Water Center. Details its history and evolution since the center was first established in 1964. The book published in the spring of 2008. Full color, soft cover, 91 pages. Available free to the public.

A range of publications produced outside the UNL Water Center, particularly fact sheets, research project results and other print materials from USGS, Nebraska Department of

Environmental Quality, U.S. Environmental Protection Agency, U.S. Army Corps of Engineers, local Natural Resources Districts and University of Nebraska-Lincoln Extension, are available through Water Center and School of Natural Resources web sites.

News Releases:

The Water Center produces about 30 press releases annually focusing on research results or significant progress, extension programs, educational opportunities, public tours, seminars, lectures, symposiums and other matters of public impact involving the Water Center, Water Resources Research Initiative and other natural resource-focused UNL departments and offices. Conferences, seminars, tours, collections of waste pesticides, pesticide container recycling and other activities are similarly announced.

The releases support a wide variety of UNL water-related research and outreach that cross departmental and academic disciplines.
The press releases are naturally focused on public impact of UNL-sponsored research and programming.

The Water Center coordinates public media requests for information and interviews with appropriate sources on any water-related topic of interest to media and devotes significant attention to cultivating long-term relationships with members of the working media. The Water Center has a well-developed reputation as a willing and reliable "source" among local and state reporters specializing in water and natural resources news. Media calls are frequent and routine and water-related faculty and staff are accustomed to fielding questions from the media. The Water Center makes wide use of electronic and broadcast journalism sources, as well as the more traditional print (newspaper) sources.

Electronic Resources:

Print materials produced by the UNL Water Center, and other information, are available online at http://watercenter.unl.edu . The Water Center co-sponsors, designs and maintains the following related Internet web sites utilizing a dedicated, fulltime webmaster/IT specialist:

UNL Water (new this year – cooperative UNL site for water information):
http://water.unl.edu/home

UNL Water Center:
http://watercenter.unl.edu/

Water Sciences Laboratory (WSL):
http://waterscience.unl.edu

Great Plains Cooperative Eco-Systems Studies Unit (CESU):
http://greatplains.cesu.unl.edu/

Water Law, Policy and Science Conference:
http://snr.unl.edu/waterconference/

Water Resources Research Initiative (WRRI):
http://wrri.unl.edu/

These sites are vigorously scrutinized, maintained and updated. UNL Water Center faculty and staff are currently engaged in discussions to bring all UNL water-related web sites and web-based information under the umbrella of a portal site to help make public access to UNL water information easier and more complete.

Conferences, Seminars, Tours and Retreats:

Water Law, Policy and Science Conference: Conducted each Spring. Co-sponsored by the Water Center, Water Resources Research Initiative, College of Law, School of Natural Resources and various other UNL entities. The conference explores pertinent current issues related to emerging state and regional water and environmental law, policy and research. Nationally and internationally known speakers are invited to present. Now in its fifth consecutive year. It attracts 150 to 200 attendees annually. News releases, brochures, a printed program, radio spots and web-based information are produced in support of this event. Media are encouraged to attend and given full access to speakers.

Water and Natural Resources Seminars: A longstanding series of 12 to 14 free weekly public lectures from January to April each year. Co-sponsored by the School of Natural Resources, Institute of Agriculture and Natural Resources and other UNL entities. The series may be taken for graduate or undergraduate student credit, or as free public lectures. Individual lectures attract an audience of 60-100, as well as approximately 10 registered students. News releases, mailings, brochures, posters and web-based information are produced in support of this long-standing series.

Summer Water and Natural Resources Tour. Co-sponsored by the Kearney Area Chamber of Commerce, Nebraska Association of Resources Districts, Nebraska Public Power District, Central Nebraska Public Power and Irrigation District and others. The annual tour is conducted over three to five days each summer and is used to educate and inform on current water and natural resource issues effecting Nebraska. Typically limited to 50 participants. Attendees often include state legislators and congressional staff. News releases, mailings and a brochure are produced in support of this event. This year's tour was held in Nebraska Republican River basin, with plans to travel to Northern California's Sacramento-San Joaquin River Bay-Delta in June 2009.

Fall Research Colloquium. Held in conjunction with UNL's School of Natural Resource Sciences. Brings water and natural resource faculty, staff and students together to share in research results/significant progress.

Faculty/Staff Retreats: Another vehicle to present completed and/or significant progress research activity to colleagues, take time for interdisciplinary brainstorming to develop research programming and secure funding and to foster an increased sense of collegiality among professionals dispersed throughout the state.

Educational Displays:

The Water Center makes frequent public displays in association with conferences, symposiums, agricultural trade shows, educational open houses and water and environmental education festivals.

In addition, Water Center staff makes presentations and have seats on steering committees for annual educational and informational festivals such as "Earth Wellness Festival," "Husker Harvest Days" (one of the largest commercial agricultural expos in the country), "Gateway Farm Expo" and others. UNL Water Center staff chaired the first major revamping of UNL Extension presence at Husker Harvest Days in nearly 30 years in September 2008. More than 50,000 toured UNL exhibits during the three-day run of the show, ranking it among the event's top-10 most visited attractions.

Promotional Items:

Custom promotional items are distributed at nearly every Water Center event. These include fishing lures, umbrellas, golf balls, key chains, pencils, lanyards, book bags, etc. They are designed and procured for general distribution and for student recruitment.

Support for the UNL Pesticide Education Office:

The Water Center handles press relations and publicity for federal-restricted use pesticide educational programming conducted by the UNL Pesticide Education Office within UNL's Department of Agronomy and Horticulture. This unit was once part of the UNL Water Center. These efforts include publicity for very successful statewide plastic pesticide container recycling and waste pesticide collection programs that are closely linked to groundwater quality issues.

Primary Information Dissemination Clientele:

U.S. Department of Agriculture
U.S. Environmental Protection Agency
U.S. Geological Survey
U.S. Bureau of Reclamation
U.S. Army Corps of Engineers
U.S. Bureau of Land Management
Nebraska Department of Natural Resources
Nebraska Department of Agriculture
Nebraska Department of Health and Human Services System
Nebraska Department of Environmental Quality

Nebraska Environmental Trust Fund
Nebraska Association of Resources Districts (and 23 individual NRDs)
Nebraska Congressional delegation
Nebraska State Senators
Public and private power and irrigation districts
The Audubon Society
The Nature Conservancy
Nebraska Alliance for Environmental Education
Nebraska Earth Science Education Network
Other state Water Resources Research Institutes
University and College researchers and educators
NU students
Public and parochial science teachers
Farmers
Surface and groundwater irrigators
Private citizens

Cooperating Entities:

In addition to primary support from the USGS, the following agencies and entities have helped fund information dissemination (communications) activities by the UNL Water Center during the past year.

U.S. Environmental Protection Agency
U.S. Department of Agriculture
Nebraska Department of Environmental Quality
Nebraska Research Initiative
Nebraska Game and Parks Commission
National Water Research Institute
Nebraska Water Conference Council
Nebraska Public Power District
Central Nebraska Public Power and Irrigation District
Farm Credit Services of America
Kearney Area Chamber of Commerce
Nebraska Association of Resources Districts
UNL Institute of Agriculture and Natural Resources
UNL Agricultural Research Division
UNL College of Agricultural Sciences and Natural Resources
UNL School of Natural Resources
UNL Water Resources Research Initiative

Information Transfer Plan/Water Education

Basic Information

Title:	Information Transfer Plan/Water Education
Project Number:	2008NE173B
Start Date:	3/1/2008
End Date:	2/28/2009
Funding Source:	104B
Congressional District:	1
Research Category:	Not Applicable
Focus Category:	Education, None, None
Descriptors:	None
Principal Investigators:	Kyle D. Hoagland, Steven W. Ress

Publication

NE2008173B

See the NE2006130B report
(ongoing grant continued for NE2006130B)

USGS Summer Intern Program

None.

Student Support					
Category	**Section 104 Base Grant**	**Section 104 NCGP Award**	**NIWR-USGS Internship**	**Supplemental Awards**	**Total**
Undergraduate	2	0	0	0	2
Masters	2	0	0	0	2
Ph.D.	0	0	0	1	1
Post-Doc.	0	0	0	0	0
Total	4	0	0	1	5

Notable Awards and Achievements

Publications from Prior Years