Contract No.: 170

Task Order # 10 – Service Agreement Between the Nebraska Department of Natural Resources and Board of Regents, University of Nebraska, Nebraska Water Center

Task: Estimation of Evapotranspiration from Riparian and Invasive Species Using Remote Sensing and in Situ Measurements in the Republican River Basin

Project Personnel

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Department of Natural Resources Project Liaisons

Nebraska Department of Natural Resources: Jennifer J. Schellpeper, Mike Thompson, Steve Gaul

Description of Work

This project is meant to coincide with the work being carried out in the Republican River Basin Riparian Management Study and Demonstration (RRBRMSD) which received funding from the Interrelated Water Managment Plan Program Fund. This project will be coordinated with the project sponsors and partners of the RRBRMSD.

The purpose of this project is to use a combination of techniques to develop reliable estimates of evapotranspiration (ET) from riparian zones and to determine varying water use rates for typical and invasive species in the Republican River Basin.

The impact of riparian vegetation on streamflow depletion has emerged as an issue in watershed management. Previous studies across the High Plains and the Arid West have produced widely varing impacts on surface and ground water due to riparian ET. The effect of riparian vegetation is a function of vegetation type, local microclimates, soil properties and landscape characteristics. The quantification of ET for a riparian zone must involve a combination of several experimental methods. Flux measurement techniques, such as Eddy Correlation System (ECS), provide means for estimating ET when the plant canopy is relatively homogeneous both in composition and height, and where the fetch is relatively large. Sap flow measurement techniques monitor transpiration for a sampling of individual trees. Soil and ground water monitoring is useful in determining hydrologic impacts and water balance conditions. Satellite remote sensing techniques provide estimates of ET that overcome some scale issues and provide quantification of large-area riparian zone ET. This research project will utilize the above techniques where applicable.

Eddy covariance systems or Bowen Ratio systems will be used to quantify latent heat and other energy balance components over the riparian zone. One of the issues with using ECS to measure latent heat flux over heterogeneous riparian zone is the uncertainties in defining the boundary layer in which the canopy is expected to be in equilibrium. The system can provide a total value for the latent heat flux (including evaporation and transpiration) that occur from the riparian zone. However, the total flux measured using this system may or may not be a representative of the riparian zone for which the water use is intended to be quantified due to uncertainties in boundary layer. Another difficulty is the height of the trees that may limit using this energy flux instrument. As the height of the flux instrument increases the fetch requirement in the boundary layer of the riparian zone increases significantly. When fetch is inadequate, water vapor captured by the ECS may or may not originate in the riparian zone. It is necessary that the flux measurements be accompanied with physiological and other measurements taken from riparian vegetation and soil profile. The supporting measurements will include sap flow measurements to quantify riparian transpiration per unit of time,

soil water status to determine depletion in soil water, plant (tree) leaf area index or green canopy area, and possibly other variables such as growth index.

The compensation heat-pulse method of measuring sap flow involves heating conductive woody tissue and measuring heat dissipation at two locations along the stem of the plant. Tree sap flow measurements will be made to quantify variations in transpiration as a function of atmospheric demand and water availability. Combining sap flow measurements with monitoring of other plant parameters on specific trees will allow assimilation of effects which would be difficult to quantify from flux measurements alone. An appropriate sampling strategy and scaling methods will be employed to estimate stand-level transpiration from individual plant sap flow measurements. This will enhance our ability to predict the physiological responses of the riparian zone to environmental conditions.

Remote sensing estimates of ET will build on those for the SEBAL and the METRIC™ models. Both models require parameterization of the energy balance and estimate surface energy fluxes based on spectral satellite measurements. The METRIC™ model originates from versions of SEBAL and has similar principles and foundation as SEBAL. The METRIC method has auto-calibration capabilities for each satellite image using ground-based calculation of alfalfa reference ET based on hourly weather data. We will quantify the spatial distribution and seasonal variation of ET from March through October for each year of the project. This period spans the pre-green-up and growing season to allow for characterizations in ET, and surface water and ground-water interactions. The LANDST Enhanced Thematic Mapper (ETM) which measures a panchromatic band with 15-m spatial resolution and a thermal IR channel with 60-m spatial resolution will be used for the project. The repeat coverage interval is 16 days. We will compare predictions of the SEBAL/METRIC model to measured daily and seasonal evapotranspiration using flux measurements. We will conduct ground-truth measurements at the sites to classify types of riparian vegetation at the sites. An essential component in estimating riparian ET is the determination of the area for various vegetation types or classes within the riparian zone. Therefore, in addition to ground measurements, high-resolution remote sensing measurements and aerial imagery will be necessary to spatially extrapolate tree and stand measurements with a step-wise scaling approach. The project will concentrate on corridor areas along perennial streams in each watershed.

Meetings

Within six months of the last signature on this task order, the Project Personnel will meet with the Department of Natural Resources Project Liaisons (DNR) to discuss Phase II of this study. The product of that discussion will be an attachment to this task order specifying project goals, methodology and work product/report deadlines.

The Project Personnel and DNR should plan on at least two meetings each year to discuss findings, adjustments and directions and to strategize changes for the next season's work.

Work Products

This project will provide datasets of evapotranspiration and the annual water balance for a range of conditions in the riparian areas along the Republican River. Project Personnel will provide water use for different land surfaces, calibrated and tested remote sensing ET methodology, and predicted ET maps across space and time. Some specific deliverables will include:

- Map of surface energy fluxes including ET across three watersheds in Lower, Middle and Upper Republican Natural Resources Districts (NRDs) for different spatial and temporal (i.e. daily, seasonal and annual) scales.
- Map of riparian vegetation classification across three watersheds by utilizing high-resolution remote sensing measurements and ground truth observations.
- Field measurements to analyze the performance of the SEBAL/METRIC procedure in predicting ET and consumptive use at a local scale.
- A dataset to determine the practical applicability of ECS to measure riparian zone ET by using a combination of flux measurements, riparian vegetation physiological characteristics, and remote sensing ET techniques.
- Comparison of water use and water availability on riparian vegetation and adjacent treated research area by measuring ET rates by utilizing a combination of techniques.
- Information on the feasibility, accuracy, practical applicability, challenges, advantages, and disadvantages of using techniques in quantifying riparian zone ET.
- Data for planners and decisionmakers to develop water management policies.
- Extension and education materials to inform and communicate results to stakeholders.
- Results shared with other colleagues and institutions.
- Reports

1. Brief status reports shall be provided quarterly by the Project Personnel to DNR. The status reports will be of sufficient detail to allow monitoring of progress. The report shall consist of one paper copy and one electronic copy.

2. Annual reports of all data acquired during the growing season, shall be provided to the DNR by Project Personnel by December 31 of each year, or at a time as otherwise mutually agreed upon. This annual report shall also contain suggestions and cost estimates on improving the study for the upcoming growing season. The report shall consist of one paper copy and one electronic copy.

3. A comprehensive draft final report shall be provided by Project Personnel to the DNR at a time mutually agreed upon. The report shall consist of one paper copy and one electronic copy.

4. A final report shall be provided by Project Personnel to the DNR at a time mutually agreed upon. Comments from the DNR on the draft report shall be addressed in the final report. The report shall consist of one paper copy and one electronic copy and shall contain at a minimum:

    - A summary of the data collection procedures.
    - An evaluation of data from each site and summary conclusions that include discussion of how accurate the data are, i.e., results of quality assurance and quality control analysis, etc.; and discussion on

whether the data is representative of lands within the immediate study site area.

Budget: A detailed budget is attached for expenses that will be incurred in completing the task. The project is expected to require five years for completion but it is understood that funding is only certain through June 2007 which represents a certain project budget of $209,440 and the potential for full funding of $1,045,478.

Schedule: Work on this task order will commence in February 2007 and is expect to continue through December 2011. Continuation of the project beyond June 2007 will be contingent on future funding.

Phase I (Fiscal Year 2006-2007)
During Phase I, the study sites will be selected; Phase II project goals, methodology and work product/deadlines will be determined; necessary personnel will be retained; necessary equipment may be purchased; and miscellaneous and indirect costs may be incurred. The total of these costs will not exceed $209,440

Phase II
Phase II of the study will be determined once the Project Personnel have met and produced the attachment as described above in the "Meetings" section.

Ann Bleed — 3/27/07

Ann Bleed, Director and Task Order Coordinator — Date

Kyle D. Hoagland — 3/19/07

Kyle Hoagland, Director Water Center and Project Manager — Date

Personnel:						
UNL Faculty for Remote Sensing	$13,000	$27,295	$28,114	$28,957	$29,826	$127,192
ET Flux Research Assistant	$20,000	$46,350	$47,741	$49,173	$50,648	$213,911
Benefits (@ 30%)	$9,900	$22,094	$22,756	$23,439	$24,142	$102,331
Total Personnel	$42,900	$95,739	$98,611	$101,569	$104,616	$443,434
Project to Remotely Map Species Distribution		$37,000	$37,000			
Equipment:						
ET Flux Systems	$75,000	$75,000	$75,000	$10,000	$10,000	$245,000
Soil Moisture Measurement Systems	$15,000	$15,000	$15,000	$1,500	$1,500	$48,000
Data Logging Equipment	$12,000					
Sap Flow Measurement Equipment	$12,000					
ET Weather Stations	$12,000					
Anemometers	$4,500					
Total Equipment	$130,500	$90,000	$90,000	$11,500	$11,500	$333,500
Miscellaneous						
Remote Sensing Imagery	$10,000	$10,000	$10,000	$10,000	$10,000	$50,000
Materials & Supplies	$3,000	$3,500	$4,500	$4,500	$4,500	$20,000
Travel	$4,000	$4,500	$5,000	$5,000	$5,000	$23,500
Publication		$1,500	$1,500	$1,500	$1,500	$6,000
Total Direct Costs:	$190,400	$242,239	$246,611	$134,069	$137,116	$950,434
Indirect Costs at 10%:	$19,040	$24,224	$24,661	$13,407	$13,712	$95,044
Total Cost	$209,440	$266,463	$271,272	$147,476	$150,828	$1,045,478