

**Utah Center for Water Resources Research
Annual Technical Report
FY 2011**

Introduction

The Utah Center for Water Resources Research (UCWRR) is located at Utah State University (USU), the Land Grant University in Utah, as part of the Utah Water Research Laboratory (UWRL). It is one of 54 state water institutes that were authorized by the Water Resources Research Act of 1964. Its mission is related to stewardship of water quantity and quality through collaboration with government and the private sector.

The UCWRR facilitates water research, outreach, design, and testing elements within a university environment that supports student education and citizen training. The UCWRR actively assists the Utah Department of Environmental Quality (UDEQ), the Utah Department of Natural Resources (UDNR), the State Engineers Office, all 12 local health departments, and several large water management agencies and purveyors in the state with specific water resources problems. In FY 11, the UWRL expended a total of almost \$9 million in water research support. USGS Section 104 funds administered through the UCWRR accounted for approximately three percent of this total. These funds were used for research addressing water and wastewater management problems, outreach, information dissemination, strategic planning, water resources, and environmental quality issues in the State of Utah. Two research projects were funded in FY11 with funds from a 104-h grant, and two projects were funded from the 104-b program. These projects are respectively entitled, (1) "Drought Index Information System Development for NIDIS," (2) "Estimating Crop Water Use with Remote Sensing: Development of Guidelines and Specifications," (3) "Analyzing the Spread of *Phragmites australis* over Short Time-scales Using Spatial and Genetic Tools," and (4) "Reducing the Dangers of Low-Head Dams in Utah" These projects dealt with the following water management issues: (1) developing a capability to evaluate and implement drought indices on a spatial basis for inclusion in a National Integrated Drought Information System (NIDIS) pilot study creating a drought early warning system for the Upper Colorado River Basin; (2) developing a framework for estimating crop water use using remote sensing through a standardized approach, thus providing guidelines and specifications for applying certain evapotranspiration (ET) models and producing ET products that are acceptable to the USGS WaterSmart program and the scientific and user community; (3) assessing changes in wetland vegetation over time using high resolution imagery in several spectral bands obtained by application of low-cost unmanned aerial vehicles, as well as genetic sampling, to determine the relative contribution of seeds vs. rhizomes in the spread of invasive *Phragmites* patches in a Utah wetland over one year under flooded vs. unflooded conditions; and (4) establishing a classification system for low head dams based on the dangers created at various flow conditions and identifying a potential simple solution to eliminate the drowning hazards presented by such dams. The projects all involved collaboration of local, state, and federal water resources agency personnel.

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USGS Section 104 funds were used to establish a data server to support the publication of drought index information for the NIDIS Upper Colorado River Basin (UCRB) pilot drought early warning system which aims to enhance access to drought related data and enable custom drought index calculation. A HydroServer using the CUAHSI HydroServer software stack on virtual servers hosted at the Utah Water Research Laboratory (UWRL) data center has been developed to publish drought index values as well as input data used in drought index calculations, with web services for the data sources necessary for drought index calculation. Procedures to aggregate the input data to the time and space scales chosen for drought index calculation have also been developed, and automated data and metadata harvesters that periodically scan and harvest new data from the input databases have been created to ensure that the data available on the drought server are kept up to date.

Irrigated agriculture is the largest consumptive water user in the western United States. Estimates of crop water use can be improved through more accurate evapotranspiration (ET) estimates. A research project supported with Section 104 funds this year is in the initial stages of developing a framework for estimating crop water use using remote sensing through a standardized approach that will provide guidelines and specifications to be followed in order to apply certain models and produce ET products that are acceptable to the USGS WaterSmart program and the scientific and user community. This research includes reviewing and testing candidate remote sensing – based ET models to establish model performance and determining the uncertainty associated with the application of these models. A set of study sites will be selected from within the 17 western United States representing different climatic regions, and a variety of spatial and point datasets will be utilized. This work will benefit many hydrological modeling and water resources management applications.

The Bear River Migratory Bird Refuge (BRMBR) in northern Utah provides critical habitat to migratory birds, but its habitat value is compromised by an invasive grass species, *Phragmites australis*, that actively displaces native vegetation and alters wetland nutrient cycling. USGS 104b funds were used to assess the ability of unmanned aerial vehicles (UAVs) and pattern recognition algorithms to detect fine-scale changes in the geographic distribution of *Phragmites* and other wetland species cover over the course of a year under different environmental conditions. Inexpensive unmanned aerial vehicles (UAVs) were used to acquire georeferenced, multi-spectral, high resolution (appx. 25 cm) imagery (mosaicked and georectified) of the BRMBR in the summers of 2010 and 2011. A previously developed multi-class relevance vector machine (MCRVM) was applied to analyze the imagery and identify the areas and rates at which *Phragmites* is invading the BRMBR and which species were being displaced. These new technologies make it possible to detect and quantify the rate of spread of *Phragmites* in large wetland areas at very high spatial resolution within the span of a single growing season and with an overall classification accuracy of 95% (as compared to the 85% current industry standard for classification algorithms). Intensive genetic sampling also occurred at the sites monitored by the UAVs to evaluate changes in genet richness, assess the spread of *Phragmites* by seeds vs. rhizomes under flooded and unflooded conditions, and evaluate the extent of clonal spread in the same patch between years. The ability to accurately assess changes in wetland vegetation over time will be beneficial for both ecological research and natural resources management.

Low-head dams are small structures that have water continually flowing over their crest that are used to impound water for a variety of municipal industrial, and recreational needs. At certain flow conditions, these structures can create strong currents called rollers that rotate in an upstream direction, creating a serious

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drowning hazard for individuals who venture too close and become trapped in the unrelenting cycle. The final project utilizing USGS Section 104 funds is establishing a classification system for these low-head dams based on the dangers created at various flow levels. This system will help recreational water users and dam owners assess hazards and act appropriately in terms of safety and liability. The project also aims to identify at least one simple solution, that when added to a low-head dam will effectively break up the upstream directed current, thereby eliminating the dangers created by the rollers and allowing individuals swept over low-head dams to continue downstream rather than become trapped by the current. Establishing an easy to use and understand hazard classification system for these structures and finding a simple way to reduce the strength of the roller could save many lives in the future.

These projects involved collaborative partnerships with various local, state, and federal agencies throughout the state.

USGS Grant No. G10AP00039 Drought Index Information System for NIDIS

Basic Information

Title:	USGS Grant No. G10AP00039 Drought Index Information System for NIDIS
Project Number:	2008UT134S
Start Date:	1/1/2010
End Date:	12/31/2012
Funding Source:	Supplemental
Congressional District:	UT 1
Research Category:	Climate and Hydrologic Processes
Focus Category:	Drought, None, None
Descriptors:	
Principal Investigators:	David Gavin Tarboton, Jeffery S. Horsburgh

Publications

There are no publications.

Drought Index Information System Development for NIDIS

Investigators

David G. Tarboton
Jeffery S. Horsburgh
Graduate Student: Jeanny Miles
Programmer: Stephanie Madsen

Duration

1/1/2010-12/31-2011

Project Description:

The National Integrated Drought Information System (NIDIS) pilot study is focused on the creation of a drought early warning system for the Upper Colorado River Basin. Utah State University has a project that is part of this study for development of a capability for evaluation and implementation of drought indices on a spatial basis. This involves the creation of a geographic database that is linked to historical time-series and real-time hydroclimatic data available over the web. To facilitate this we are establishing a NIDIS drought index server using the capability of and technology from the Consortium of Universities for the Advancement of Hydrologic Science, Inc. (CUAHSI) Hydrologic Information System (HIS). The CUAHSI HIS is an internet based system that supports the sharing of hydrologic data. It consists of databases connected using the Internet through web services as well as software for data discovery, access and publication. The NIDIS HIS server will support the storage of drought index values and supporting input data, the sharing of this data on the web using WaterOneFlow web services and the WaterML data transmission format. The server will include map presentation services for the display of map based drought index information. The CUAHSI HIS uses a desktop application, HydroDesktop, for client-based data access. This is extendible through plug-in capability. We will develop a drought index plug-in to HydroDesktop that will support access to drought index values and supporting information published on the NIDIS server as well as the capability to compute and display custom drought index products.

Accomplishments (1/1/2010-5/1/2010):

This project started January 1/2010 and is still at an early stage of development. The first year of the project primarily involves system development that comprises (1) setting up a NIDIS HIS server, (2) establishing the system, procedures and agreements for gaining access to and publishing NIDIS drought information, and (3) developing the HydroDesktop plugin to support the calculation and display of custom drought index products.

To date a HIS Server has been established as a virtual machine within the Utah Water Research Laboratory data server cluster. Five sets of web services have been identified as required to support the calculation of drought indices, namely:

- SNOTEL
- StreamFlow
- Soil Moisture
- Precipitation
- Reservoir Levels

We have developed a web service to publish SNOTEL data in the WaterML data transmission format and work is under way for the other data sets.

Work Plan (5/1/2010-12/31/2011):

Following establishing the NIDIS drought HIS Server using CUAHSI HIS functionality, our ongoing work will involve the following:

- Establishing procedures for ingesting data into the Observations Data Model (ODM) relational database used by HIS from its primary source and format, drawing upon ODM loader and potentially SQL Server Integration Services capabilities. Primary data sources may be web or ftp sources, or National Weather Service (NWS) Standard Hydrometeorological Exchange Format (SHEF) data streams. Specifically we anticipate obtaining the NRCS SWSI and supporting information in SHEF format.
- Setting up WaterOneFlow Web services for both calculated drought index values and the data inputs used to generate them.
- Setting up map display and visualization services.

Work will also include development of a HydroDesktop plugin that supports user customizable calculation of drought indices based on data available through the NIDIS drought HIS Server.

The HydroDesktop client and drought index plugin will support the following functionality.

- Access to drought index calculation inputs
- Access to published drought index values
- Ability to flexibly work with drought index relevant information to compute and evaluate different custom drought index products and related measures

In the second year of the project we will conduct training workshops on NIDIS HIS in Utah, Wyoming and Colorado. We also plan to iteratively refine and enhance the NIDIS HIS Server and HydroDesktop plugin based on feedback from users.

USGS Grant No. G10AP00039 Drought Index Information System for NIDIS

Basic Information

Title:	USGS Grant No. G10AP00039 Drought Index Information System for NIDIS
Project Number:	2010UT134S
Start Date:	1/1/2010
End Date:	12/31/2012
Funding Source:	Supplemental
Congressional District:	
Research Category:	Climate and Hydrologic Processes
Focus Category:	Drought, None, None
Descriptors:	
Principal Investigators:	David Gavin Tarboton

Publications

There are no publications.

Progress Report: USGS Grant No. G10AP00039 Drought Index

Information System for NIDIS

David Tarboton

Jeff Horsburgh

May, 2012

Project Description

Utah State University has established a data server to support the publication of drought index information for the NIDIS Upper Colorado River Basin (UCRB) pilot drought early warning system. The goals are to enhance access to drought related data and enable custom drought index calculation. The approach has been to first establish a foundation of primary hydrologic information related to drought in the UCRB pilot available through the Consortium of Universities for the Advancement of Hydrologic Science Inc. (CUAHSI) Hydrologic Information System (HIS), then aggregate this data at time and space scales most relevant for drought index calculation and publish it using HIS so that local customized drought index evaluation is enabled.

The CUAHSI HIS is a federated system for sharing hydrologic data. It comprises multiple data servers, referred to as HydroServers, that publish data in a standard XML format called Water Markup Language (WaterML), using web services referred to as WaterOneFlow web services. HydroServers can also publish geospatial data using Open Geospatial Consortium (OGC) web map feature and coverage services and have a web interface for data access. HydroServers use a Microsoft Windows Server operating system and ESRI ArcGIS Server platform to publish data from Microsoft SQL databases and ArcGIS server files. Time series data is stored in SQL Server databases using the Observations Data Model (ODM). HIS also includes a centralized metadata catalog that indexes data from registered HydroServers and a data access client referred to as HydroDesktop.

Accomplishments

For the NIDIS project, we have established the <http://drought.usu.edu> HydroServer using the CUAHSI HydroServer software stack on virtual servers hosted at the Utah Water Research Laboratory (UWRL) data center. The drought HydroServer was developed as a platform to publish drought index values as well as the input data used in drought index calculations. Primary input data required for drought index calculation include streamflow, precipitation, reservoir storages, snow water equivalent, and soil moisture. Before this project began, only streamflow from the USGS National Water Information System (NWIS) was available as a standard WaterOneFlow web service. We have set up the following web services to provide access to the data needed for the computation of drought indices.

Level 0 original agency data:

- SNOTEL 6 standard variables (all SNOTEL Sites):
http://drought.usu.edu/snotel/cuahsi_1_1.asm?WSDL. This is a flow through data service to provide access to data for the six standard variables available at all SNOTEL sites. Metadata describing the sites and variables is stored on the drought server, but data requests retrieve the latest data directly from the NRCS. Current data is retrieved from NRCS data published in directories

under <http://www.wcc.nrcs.usda.gov/ftpref/data/snow/snotel/cards/>, with sites from <http://www.wcc.nrcs.usda.gov/nwcc/sitelist.jsp>.

- USBR storage and elevation data (only for Upper Colorado Basin): http://drought.usu.edu/usbrreservoirs/cuahsi_1_1.asmx?WSDL
- USGS NWIS Streamflow data (all NWIS sites provided by SDSC): <http://river.sdsc.edu/wateroneflow/NWIS/DailyValues.asmx?WSDL>

The first two services above we set up for this project, but they do also serve to provide general access to SNOTEL and USBR reservoir data. The last was developed by SDSC as part of the CUAHSI HIS project.

Level 1 harvested agency data (Upper Colorado River Basin only plus a buffer):

- SNOTEL Snow Water Equivalent: http://drought.usu.edu/SNOTEL_L1/cuahsi_1_1.asmx?WSDL
- USBR Reservoir Storage: http://drought.usu.edu/USBR_L1/cuahsi_1_1.asmx?WSDL
- USGS Streamflow: http://drought.usu.edu/NWIS_L1/cuahsi_1_1.asmx?WSDL
- NCDC Precipitation: http://drought.usu.edu/NCDC_L1/cuahsi_1_1.asmx?WSDL. This is a hold and serve data service to provide access to NCDC precipitation data within a 50 mile buffer around the Upper Colorado River basin watershed. NCDC data is obtained from <http://www.ncdc.noaa.gov/oa/climate/ghcn-daily/>. In the last year this service was reprogrammed to use this data source due to NCDC's phasing out of its 3200 Daily data and initial WaterML services.

This is data either from the level 0 web services or directly from an agency source, and which is stored on the USU drought server for efficient access for our calculations.

Level 2 time OR space aggregated data (Upper Colorado River Basin only plus a buffer):

SNODAS Snow Water Equivalent

- For HUC 8 - http://drought.usu.edu/SNODAS_HUC8/cuahsi_1_1.asmx?WSDL
- For HUC 10 - http://drought.usu.edu/SNODAS_HUC10/cuahsi_1_1.asmx?WSDL
- For HUC 12 - http://drought.usu.edu/SNODAS_HUC12/cuahsi_1_1.asmx?WSDL

All of the following are in the summary database and web service at:

http://drought.usu.edu/NIDISTimeSeries/cuahsi_1_1.asmx?WSDL

- Time aggregated USGS streamflow values
- Time aggregated USBR reservoir storage values
- Time aggregated NCDC precipitation values
- Time aggregated NRCS SNOTEL snow water equivalent values

In addition to the above observational data web services, we have also published the following GIS datasets as OGC map services on the NIDIS HydroServer.

- UCRB Study Area
- NIDIS Monitoring Sites
- USGS HUCS
- UCRB Major Rivers
- ESRI Street Base Map

These underlie the HydroServer map application (<http://drought.usu.edu/nidismap/>) that provides map based display of drought information over the UCRB pilot (Figure 1).

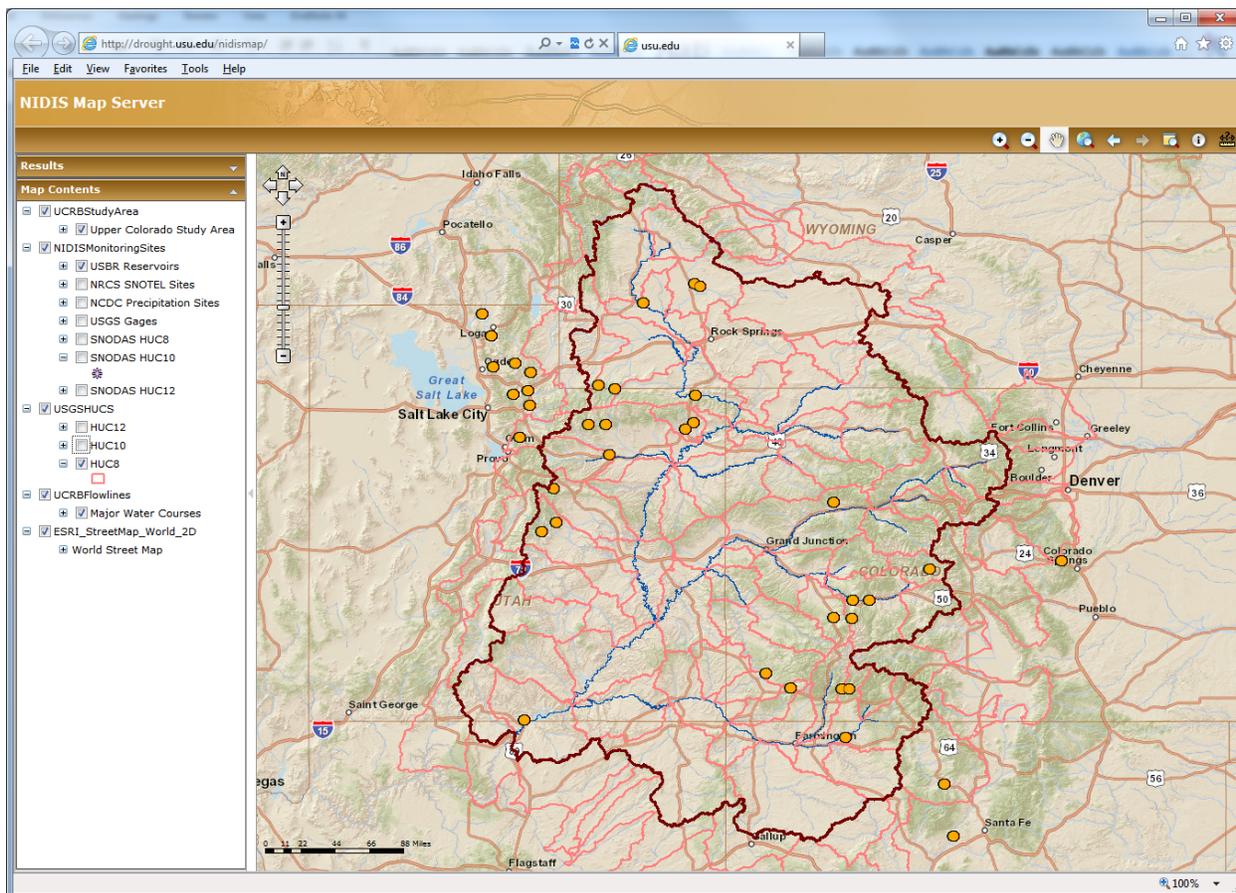


Figure 1. NIDIS Map Server

Work Plan

The funding for this project is close to completion.

The following level 3 time and space aggregated data (Upper Colorado River basin only at HUC 10 scale) are in the process of being loaded into the summary database and web service at:

http://drought.usu.edu/NIDISTimeSeries/cuahsi_1_1.asmx?WSDL

- Time and space aggregated USGS streamflow values
- Time and space aggregated USBR reservoir storage values
- Time and space aggregated NCDC precipitation values
- Time and space aggregated SNODAS HUC 10 snow water equivalent values

These level 3 data products will then be used to calculate percentiles and publish drought indices. Once published these drought indices (and their supporting data) will be available on the drought HydroServer as well as accessible through the HydroDesktop client. We plan to develop a use case example that demonstrates how to use HydroDesktop to retrieve the data and compute custom drought indices using the analytic capability that HydroDesktop has through its linkage to the R analysis environment.

Reducing the Dangers of Low Head Dams in Utah

Basic Information

Title:	Reducing the Dangers of Low Head Dams in Utah
Project Number:	2011UT154B
Start Date:	3/1/2011
End Date:	2/29/2012
Funding Source:	104B
Congressional District:	UT1
Research Category:	Engineering
Focus Category:	Surface Water, Recreation, Methods
Descriptors:	None
Principal Investigators:	Michael C. Johnson, Steven L. Barfuss

Publications

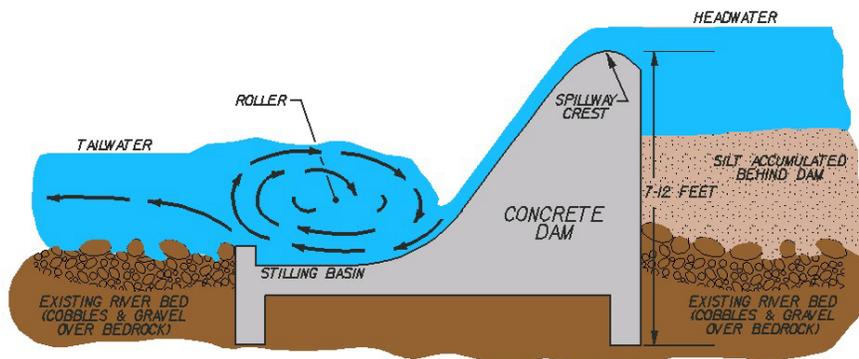
There are no publications.

REDUCING THE DANGERS OF LOW-HEAD DAMS IN UTAH

Michael C. Johnson, Principal Investigator, Riley Olsen, Research Assistant

Introduction and Problem

Low-head dams are small structures, usually no taller than 5 to 10 feet, that are designed to have water continually flowing over their crest. They are used for many purposes, including the impoundment of small volumes of water for use by municipalities, industry, and recreational users; water quality improvement; and simply to house and protect utility lines at river crossings. At certain flow conditions, these structures can create serious drowning hazards due to a current created at the downstream face of the dam, as depicted in Figure 1 below. This current, commonly referred to as a roller or hydraulic, features a counterintuitive upstream directed surface velocity. This roller can be strong enough to trap debris, such as trash and tree branches, near the face of the dam for prolonged periods of time. Fooled by the calm appearance of the cascading water often present, many recreational water users have ventured too close to these structures and found themselves caught in the strong current, often struggling to the point of exhaustion, and many times drowning before being rescued or ejected from the unrelenting cycle.



<http://www.overmywaders.com/index.php?belowthemillpond>

Figure 1 – An ogee crested low-head dam featuring a dangerous roller

Objectives

One of the main objectives of this research is to establish a classification system for low-head dams based on the dangers created at various flow conditions. It is hoped that this classification system will utilize parameters that are easily measured and obtained in the field, such as

upstream and downstream water depth. This classification system will help recreational water users and dam owners assess hazards and act appropriately in terms of safety and liability.

Another objective of this study is to identify at least one simple solution, that when added to a low-head dam, will effectively eliminate the dangers presented by the roller by breaking up the upstream directed current. By breaking up the dangerous hydraulic, individuals that are swept over a low-head dam will be flushed over the structure and continue on downstream with little chance of being trapped by a current.

Research Methodology

This research is being performed using primarily computational fluid dynamics (CFD) software to model flow over low-head dams at various flow conditions. The numerical solutions obtained from the CFD simulations will be analyzed and compared through careful examination of upstream directed surface velocities. Easily measured parameters, such as upstream and downstream water depth, will then be compared and correlated to the upstream velocities. The objective is to identify a relationship that accurately relates the current strength to these observed parameters.

Once this relationship has been successfully identified, the next step will be to experiment with several possible additions to the dams, again using CFD models. These mitigation options will be evaluated based on their effectiveness at reducing the upstream directed portion of the roller, by again looking at surface velocities downstream of the dam.

In order to verify the accuracy of the numerical results obtained through the CFD program, physical models of several of the simulations will be built and tested at the Utah Water Research Laboratory. This will be done utilizing a gravity fed rectangular laboratory flume (6 ft x 30 ft x 4 ft deep). The physical models will be set up so that water depths at specified distances upstream and downstream of the dam match, as closely as possible, those at the same distances in the corresponding CFD models. Once these water surface elevations are achieved, a flow meter will be used to measure the flow rate. This flow rate, as well as photos and video, will be compared to the numerically obtained flow rate and CFD animations to verify that the physical

process is being accurately reproduced by the CFD model. Also, a scaled human shaped model will be constructed and inserted into the physical model to test the roller's ability to trap a victim.

Results

Because this research is currently underway, no conclusions have been made yet, although several CFD models and corresponding physical models have been tested and analyzed. The upstream water depth (h_u), downstream water depth (h_d), and flow rate (Q) of one of these pairs of tests are shown in Table 1 below, along with the percent differences in these parameters.

Table 1 – Comparison of CFD and Physical Model Measure Results

	H_u (ft)	H_d (ft)	Q (cfs)
CFD Model	2.25	1.27	2.27
Physical Model	2.25	1.250	2.19
Percent Difference	0	1.57	3.52

Other pairs of tests have shown similar results to those in Table 1, with percent differences in parameters ranging from about 1 to 5 percent. Because of the small percent differences in upstream and downstream water depth, as well as flow rate, it has been determined that the CFD setup and software is an appropriate and effective tool to utilize for this research.

Conclusion

Because the dangerous flow conditions that can be present at low-head dams have claimed so many lives in the past, it is a worthwhile task to study these structures more closely than has yet been done. By establishing an easy to use and understand classification system of the hazards at these structures, as well as finding a simple way of reducing the strength of the roller, many lives can be spared from this senseless end.

Analyzing the Spread of *Phragmites Australis* Over Short Time Scales Using Spatial and Genetic Tools

Basic Information

Title:	Analyzing the Spread of <i>Phragmites Australis</i> Over Short Time Scales Using Spatial and Genetic Tools
Project Number:	2011UT156B
Start Date:	3/1/2011
End Date:	2/29/2012
Funding Source:	104B
Congressional District:	UT1
Research Category:	Ecological Processes
Focus Category:	Surface Water, Invasive Species, Wetlands
Descriptors:	None
Principal Investigators:	Karin Kettenring, Shannon Clemens, Austin Jensen, Mac McKee, David Rosenberg

Publications

There are no publications.

Analyzing the Spread of *Phragmites australis* over Short Time-Scales Using Spatial and Genetic Tools

Problem Description

Accurately assessing changes in wetland vegetation over time is important for both natural resource management and ecological research. A fundamental question in ecology is what drives the distribution of plant species; addressing this question implies that we are able to accurately determine where certain species occur and how their occurrence changes over time. At the same time, natural resource managers need to be able to determine where desirable native plant species occur and how management activities drive changes in vegetation. One of the biggest challenges for natural resource managers is whether they can accurately track changes in invasive plant species, either their expansion or their retraction, in response to control efforts. Many currently available remote sensing strategies do not operate at a fine enough resolution to be useful for these ecological and management purposes. For example, satellite imagery lacks sufficient resolution in both space and time to provide decision-relevant information to wetlands managers. Imagery obtained from the use of conventional aircraft platforms is too expensive for many wetlands management applications. In contrast, high-resolution imagery can be obtained from the application of unmanned aerial vehicles at very low cost in several different spectral bands. This technology will be explored in this project.

One of the most problematic invasive species in wetlands in North America is *Phragmites australis* (Galatowitsch et al. 1999). This aggressive grass species was introduced from Europe more than one hundred years ago and actively displaces native vegetation (Marks et al. 1994). The consequences of *Phragmites* invasion include a loss of flora and fauna and alternations to wetland nutrient cycling (Marks et al. 1994; Meyerson et al. 1999; Meyerson et al. 2000; Windham and Ehrenfeld 2003). In northern Utah, *Phragmites* has invaded many of the brackish wetlands of the Great Salt Lake (Kettenring, pers. obs.). These wetlands provide critical habitat to migratory birds on the Pacific flyway but their habitat value is compromised by the *Phragmites* invasion. Managers need tools to document the occurrence and expansion of *Phragmites* to know where to target control efforts and to know what native plants are being replaced by *Phragmites*. Similarly, to assess the success of control efforts, rates of retraction are also needed. New technologies developed by the Utah Water Research Laboratory for acquiring remotely sensed data and for quantifying the distribution of vegetative types over a large area may provide important and cost-effective tools for estimating the spread of invasive species. These tools were used last year to determine the distribution and rate of spread of *Phragmites* in a 12-square mile area of the Bear River Migratory Bird Refuge, located on the north side of the Great Salt Lake, and they showed extremely promising results. However, the protocols and analytic methods for using this new technology require additional work for use in a wetland setting.

Thus, this research will address the following question: **Are UAVs and pattern detection algorithms able to detect fine-scale changes in *Phragmites* and other wetlands species over the course of a year and from one year to the next? Can this technology be used to calculate**

rates of *Phragmites* expansion over one year under varying environmental conditions? Similarly, can this technology be used to determine what native plant species *Phragmites* is replacing as it invades?

Phragmites can spread by both seeds and rhizomes (underground stems). However, the contribution of seeds versus rhizomes to *Phragmites* spread is just beginning to be understood (Bart and Hartman 2002, 2003; League et al. 2006; McCormick et al. 2010). One important piece of information that has not been assessed is how much spread within existing stands of *Phragmites* is by seed versus rhizomes. To complement efforts to assess fine-scale changes in *Phragmites* cover, genetic techniques will be used to determine the relative contribution of seeds versus rhizomes in *Phragmites* spread. To address this research need, we ask the following question: **What is the relative importance of spread by seed versus rhizomes in the expansion of *Phragmites* patches over the course of one year and from one year to the next?**

Study Area

The research is being conducted at the Bear River Migratory Bird Refuge (BRMBR) which is located on the northeast shore of the Great Salt Lake, Utah, at the terminus of the Bear River. The Refuge, managed by the U.S. Fish and Wildlife Service as part of the National Wildlife Refuge System, comprises over 115 square miles of marsh, open water, uplands, and alkali mudflats and is one of the largest wetland complexes along the Great Salt Lake. With this location and size, the Refuge provides critical wetlands wildlife habitat and resting grounds for migratory birds along the Pacific Flyway. It is one of the most important habitat areas for migratory birds in North America.

BRMBR managers use an engineered system of dikes, canals, radial gates, weirs, and other water control structures to regulate water flows into and out of 23 wetland units in the marsh and open water areas. Together, these units cover an area of approximately 43 square miles and comprise and allow for a diverse mix of wetland habitats such as open water, native vegetation, invasive vegetation, and mixtures of native and invasive vegetation within a very small geographic area. BRMBR managers are very concerned about the spread of invasive vegetation such as *Phragmites* within Refuge wetland units. They would like to quantify the current extent of the *Phragmites* invasion plus better understand how *Phragmites* is invading over time. Managers are also very interested to deploy cheap yet effective technology that can better help them monitor and quantify the response of *Phragmites* and other species, both invasive and native, to their ongoing vegetation management activities.

Scope of Work

To address our research questions we are addressing the following four project objectives:

1. To assess the ability of unmanned aerial vehicles (UAVs) and pattern recognition algorithms to detect fine-scale changes in the geographic distribution of *Phragmites* and other wetlands species cover over the course of a year and from one year to the next.

2. To determine rates of expansion of *Phragmites* over one year, and from one year to the next, under different environmental conditions.
3. To determine what native species *Phragmites* is replacing during its invasion.
4. To determine the relative importance of spread by seed versus spread by rhizomes in the expansion of *Phragmites* patches over one year, and from one year to the next, under different environmental conditions.

Methods

DNA Analyses: Field

We identified 20 *Phragmites* patches (which were being monitored by the UAV flights) to sample intensively for assessment of spread by seeds versus rhizomes. We targeted 10 patches in flooded wetland areas (Units 3A and 2D) and 10 patches in unflooded areas (Units 3C and 3D) at the Bear River Migratory Bird Refuge to test our hypothesis that *Phragmites* spreads predominantly by rhizome under flooded conditions but by seeds under unflooded conditions. Protocols for intensive and reduced sampling were carried out during the summers of 2010 and 2011.

2010 patches – intensive sampling: Our sampling scheme in 2010 for each of 20 *Phragmites* patches is shown in Figure 1. Our approach was to collect leaves every 0.5 m along each of two 25m transects. The first transect, innermost to the patch, followed the edge of the densest part of the patch. The second transect followed the edge of the patch at 25-50% of maximum stem density. We also sampled any “stragglers” that were on the invasion front of the patch that were at <10% of maximum stem density. The very dense sampling scheme used in this initial phase of the project was intended to allow us to optimize our sampling strategy in future efforts to maximize the number of patches tested without losing significant information on genet richness. We evaluated all leaves from this 2010 dense sampling scheme for four patches: 3A01, 2D10, 3D11, and 3C20.

2010 patches – reduced sampling: Based on our results from the intensive sampling, we determined that we could process a subset of the leaves initially collected and still get the same information on genet richness. Thus, for the other 16 patches sampled in 2010, we did not process the innermost transect samples, and then only processed 1 of every 3 samples in the middle transect, and all of the “stragglers”. Thus, for the middle transect, we processed samples every 1.5m rather than every 0.5m. This sampling strategy allowed us to get information on additional patches without extending the budget.

2010 vs. 2011 patches – reduced sampling: In 2011, we resampled six of our patches (3A01, 3A03, 3D11, 3D13, 3C18, and 3C20), to evaluate changes in genet richness / mode of reproduction and the extent of clonal spread in the same patch between years. We used the reduced sampling scheme in 2011, as described above for 2010, except we also sampled every

1.5m along the innermost transect. We show these inner transect genets in the figures but exclude them for calculations of genet richness so that richness values are directly comparable with 2010 samples. Due to extremely high snowpack in the winter of 2010-2011, all patches were in flooded units in 2011.

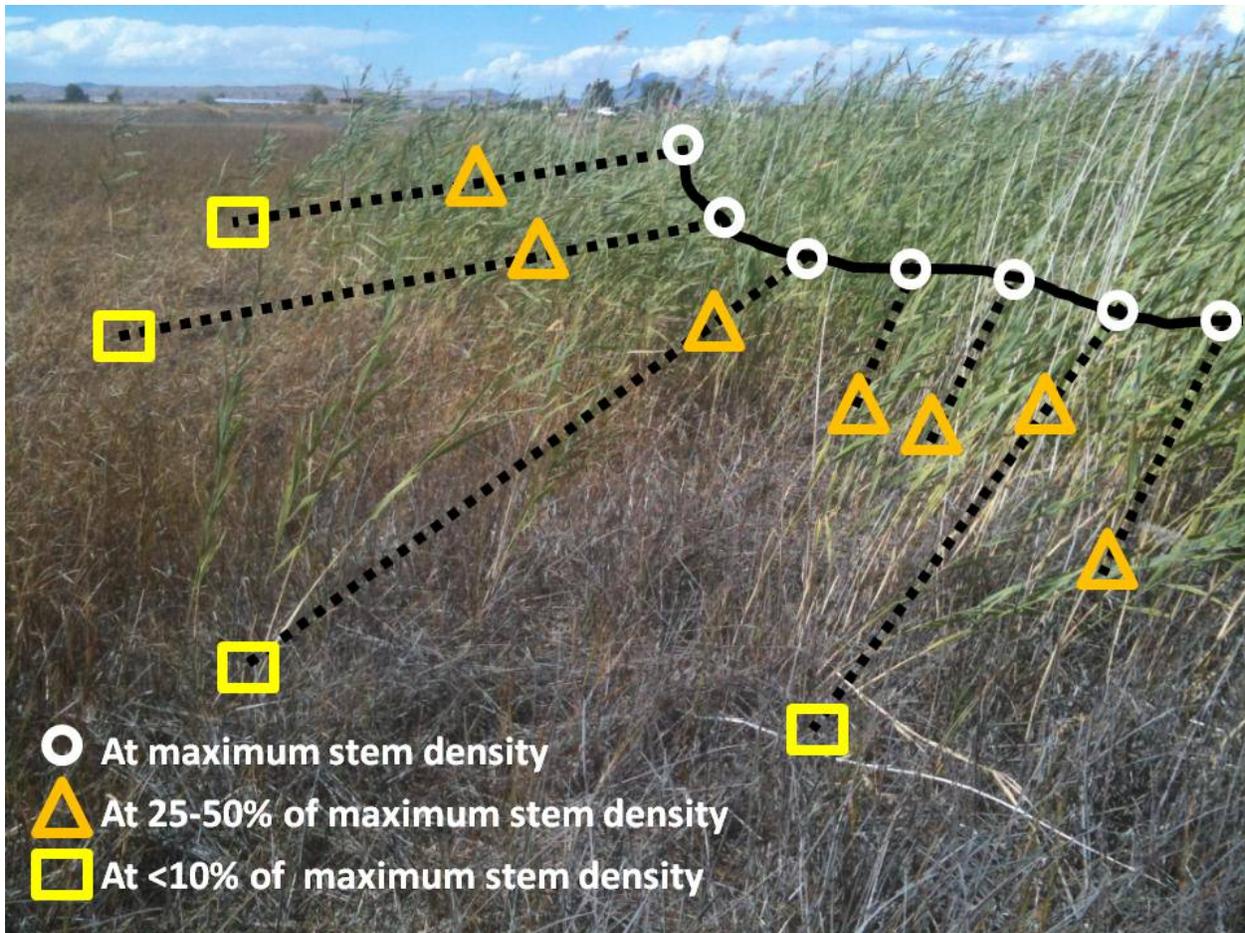


Figure 1. Sampling scheme for *Phragmites* leaf collection for genet diversity assessment in 2010 in 20 *Phragmites* patches. The inner (white circles) and middle (orange triangles) transects were 25m long and samples were initially collected every 0.5m (although we did not run all these samples for 16 of these patches – see methods). The yellow squares represent “stragglers” – stems that formed the invading edge of *Phragmites* patches. In 2011, in six patches, we used a similar sampling scheme except samples were collected every 1.5m for the inner and middle transects.

DNA Analyses: Lab

Leaf samples collected in the field were preserved by placing in paper envelopes submerged in a silica gel desiccant and were transported to the laboratory. In the laboratory, DNA was extracted from the leaf tissues using a Qiagen DNeasy 96 Plant Kit. Variation in individual DNA samples was characterized using a molecular marker system known as “amplified fragment length polymorphism” analysis, or AFLPs. This technique uses a combination of restriction enzymes and polymerase chain reaction (PCR) to identify mutation sites differing among DNA samples,

and allows the identification of genetically unique individuals. Using this technique we analyzed data from 110 variable sites (loci) in the *Phragmites* genome. This set of loci gave us ample statistical power to discern genetically distinct individuals (genets) that arose from different seeds, and also allowed us to identify multiple stems (ramets) that arose originally from the same seed but have spread vegetatively through rhizomes. Thus, we were able to determine relative spread by seed versus rhizome in each patch under flooded vs. unflooded conditions.

Remote Sensing with UAVs

The Utah Water Research Laboratory (UWRL) and the Center for Self-Organizing Intelligent Systems (CSOIS) at Utah State University (USU) have developed unmanned aerial vehicles (UAVs) for use in water-related research activities. The UAV platform, named “AggieAir,” has the capability of carrying multiple cameras that capture imagery in the visual and near-infrared bands at a spatial resolution of 2.5 to 25 cm, depending on the altitude of flight. For more information on AggieAir, refer to <http://aggieair.usu.edu/>.

The AggieAir UAVs were used during the field seasons in both 2010 and 2011 to acquire georeferenced multi-spectral imagery of the BRMBR. The imagery was then analyzed by state-of-the-art pattern recognition algorithms to determine whether wetlands species cover, including *Phragmites*, can be accurately quantified through remote sensing methods using the limited sensors that can be deployed by the UAVs. Change detection analyses were performed to assess whether the imagery acquired by the UAVs could be used to identify the areas and rates at which *Phragmites* is invading the BRMBR and which species were being displaced. Finally, correlations were sought between the DNA data and the classifications available from the analyses of the aerial imagery provided by the UAV flights.

Results and Discussion

2010 patches – intensive DNA sampling: Of the 470 samples analyzed in the four intensively sampled patches, we detected 16 unique genets (Table 1). While three of the patches were genetically quite uniform, one of the patches (3D11) had remarkably high genetic diversity (=genet richness) (Table 1; Figure 5B). Most of the unique genets in this patch comprised clones of small spatial extent, and these unique genets were clustered together spatially, suggesting an episode of seed establishment. At the same time, there were two very large clones running the length of that patch. In patch 2D10, the only other patch with more than a single genet, we found that the genets were generally cohesive, and not scattered throughout the patch (Figures 2e), suggesting that rhizome expansion was important in the spread of this patch.

2010 patches – reduced sampling: Of the 765 samples analyzed in the 20 patches in 2010 with the less intensive sampling, we detected 71 unique genets. Genet richness varied widely among the patches (0.01 to 0.30; Table 2; Figures 2-5) and there did not seem to be a strong relationship between genet richness and water level (flooded vs. unflooded; Figure 6). These findings indicate that there are likely factors other than water levels influencing genet richness within patches, such as historical disturbances.

Table 1. Summary of genet data for the four patches that were intensively sampled in 2010.

Plot	Water level treatment	# samples	# unique genets	Genet richness
3A01	flooded	119	1	0.01
2D10	flooded	119	4	0.03
3D11	unflooded	120	10	0.08
3C20	unflooded	112	1	0.01
Total		470	16	

Table 2. Summary of genet data for all 20 patches sampled with the reduced sampling scheme (for 3A01, 2D10, 3D11, and 3C20 we excluded samples to mimic the same sampling scheme of the other 16 patches). For the patches that we sampled in both 2010 and 2011 (3A01, 3A03, 3D11, 3D13, 3C18, and 3C20), we present both sets for comparison purposes, with 2011 sampled patches denoted with “-2011” in their patch name.

Patch name	Water level	# samples	# genets	Genet richness
3A01	flooded	39	1	0.03
3A01-2011	flooded	40	1	0.03
3A02	flooded	40	2	0.05
3A03	flooded	45	1	0.02
3A03-2011	flooded	35	1	0.03
3A04	flooded	41	3	0.07
3A05	flooded	47	1	0.02
2D06	flooded	40	5	0.13
2D07	flooded	37	9	0.24
2D08	flooded	42	4	0.10
2D09	flooded	40	3	0.08
2D10	flooded	41	3	0.07
3D11	unflooded	39	10	0.26
3D11-2011	flooded	35	15	0.43
3D12	unflooded	44	2	0.05
3D13	unflooded	32	6	0.19
3D13-2011	flooded	20	4	0.20
3D14	unflooded	32	3	0.09
3D15	unflooded	38	2	0.05
3C16	unflooded	35	9	0.26
3C17	unflooded	34	2	0.06
3C18	unflooded	35	2	0.06
3C18-2011	flooded	32	2	0.06
3C19	unflooded	32	4	0.13
3C20	unflooded	32	1	0.03
3C20-2011	flooded	32	1	0.03
Total (2010)		765	71*	
Total (2011)		194	24*	

*Note that two genets were repeated across two patches in 2010 and across one patch in 2011; these repeats are reflected in the summation of the number genets found each year.

For patches with higher levels of genet richness, we saw two emerging patterns. For patches such as 2D07 and 2D06 the genet diversity was spread throughout the patch (Figures 2a and b). On the other hand, 3D11 appeared to have most of the genet diversity isolated in one area within the patch (Figure 5A).

We had four patches that were each composed entirely of one genet suggesting that the only means of patch expansion was by rhizomes. These findings are interesting in light of recent findings that emphasize the importance of seed reproduction in *Phragmites* spread at broader spatial scales in northern Utah (Kettenring & Mock, In revision).

We had four instances where we found identical genets among patches (Table 3). In three of these cases, the patches were neighboring each other; the stems sampled could still be attached to the same rhizome, or these could be instances of rhizomes breaking off and dispersing short distances. In the fourth situation, the patches were in different wetland units a few hundred meters apart. However, given the rarity of this case, we cannot rule out a sampling / laboratory error without follow-up analyses.

2010 vs. 2011 patches – reduced sampling: When we compared genet richness within the same patch across two years, in general, we found no to little differences (Patches 3A01, 3A03, 3D13, 3C18, and 3C20; Table 2). The one exception to this pattern was patch 3D11 that increased genet richness from 0.26 to 0.43 between 2010 and 2011. Given recent evidence that higher levels of patch genet richness leads to increased seed reproduction because of increased opportunities for cross-pollination in Chesapeake Bay *Phragmites* patches (Kettenring et al. 2010; Kettenring et al. 2011), these findings are not too surprising. What is surprising is that we did not see more instances of increased genet richness between our two sample years given that we had a number of patches with multiple genotypes.

Table 3. Genets found in two patches.

Genet name	Patch name (# occurrences)	Patch name (# occurrences)
DD	2D09-2011 (1)	3A02-2011 (35)
XX	3C19 (11)	3C20 (112); 3C20-2011 (49)
YY	2D08 (1)	2D09 (37)
CCC	3C20-2011 (1)	3C19 (9)

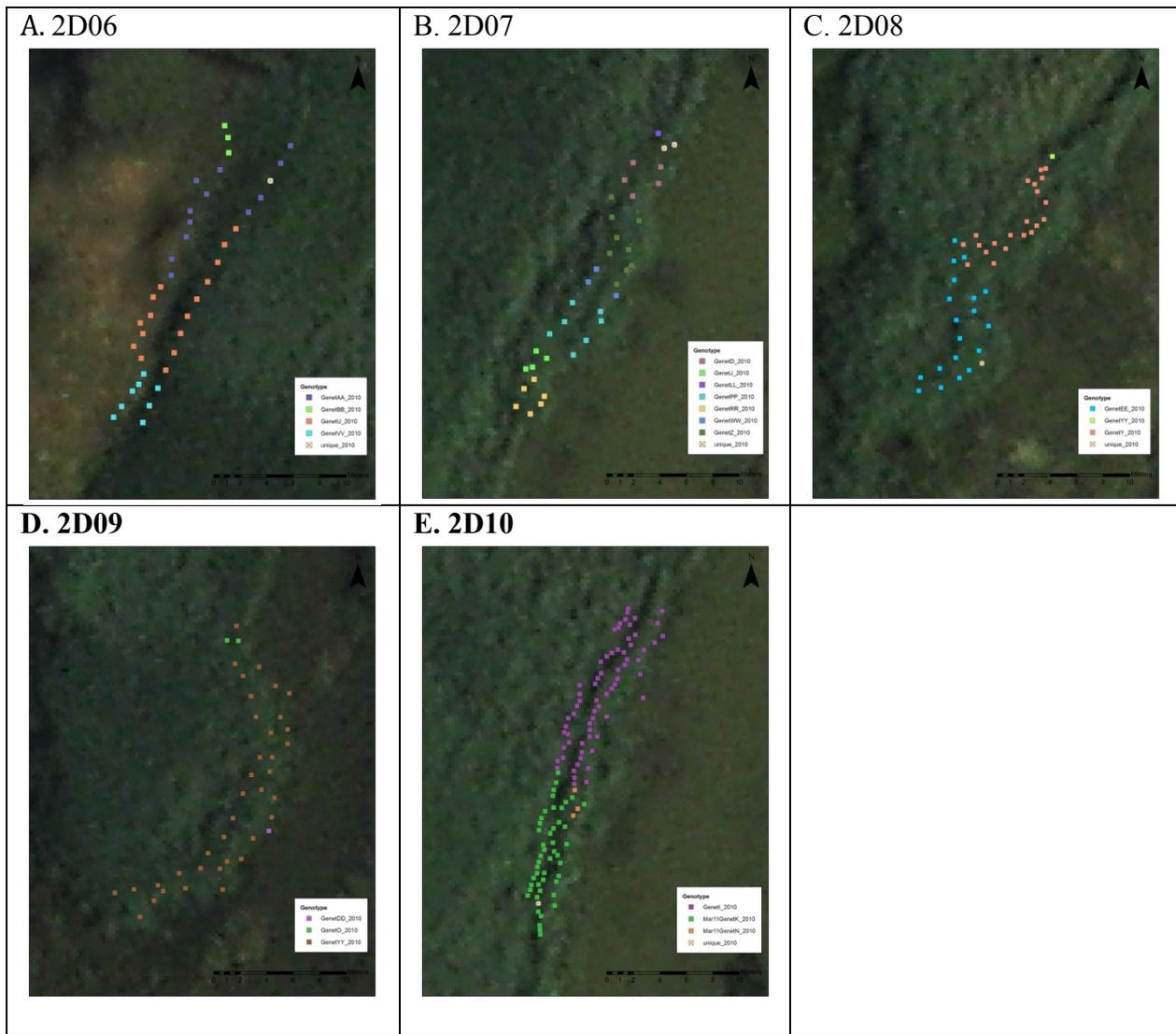


Figure 2. The distribution of different clones within five *Phragmites* patches in Unit 2D at Bear River Migratory Bird Refuge. Samples that were genetically identical share a common color. Samples that were genetically unique are denoted with an “x” in a circle.

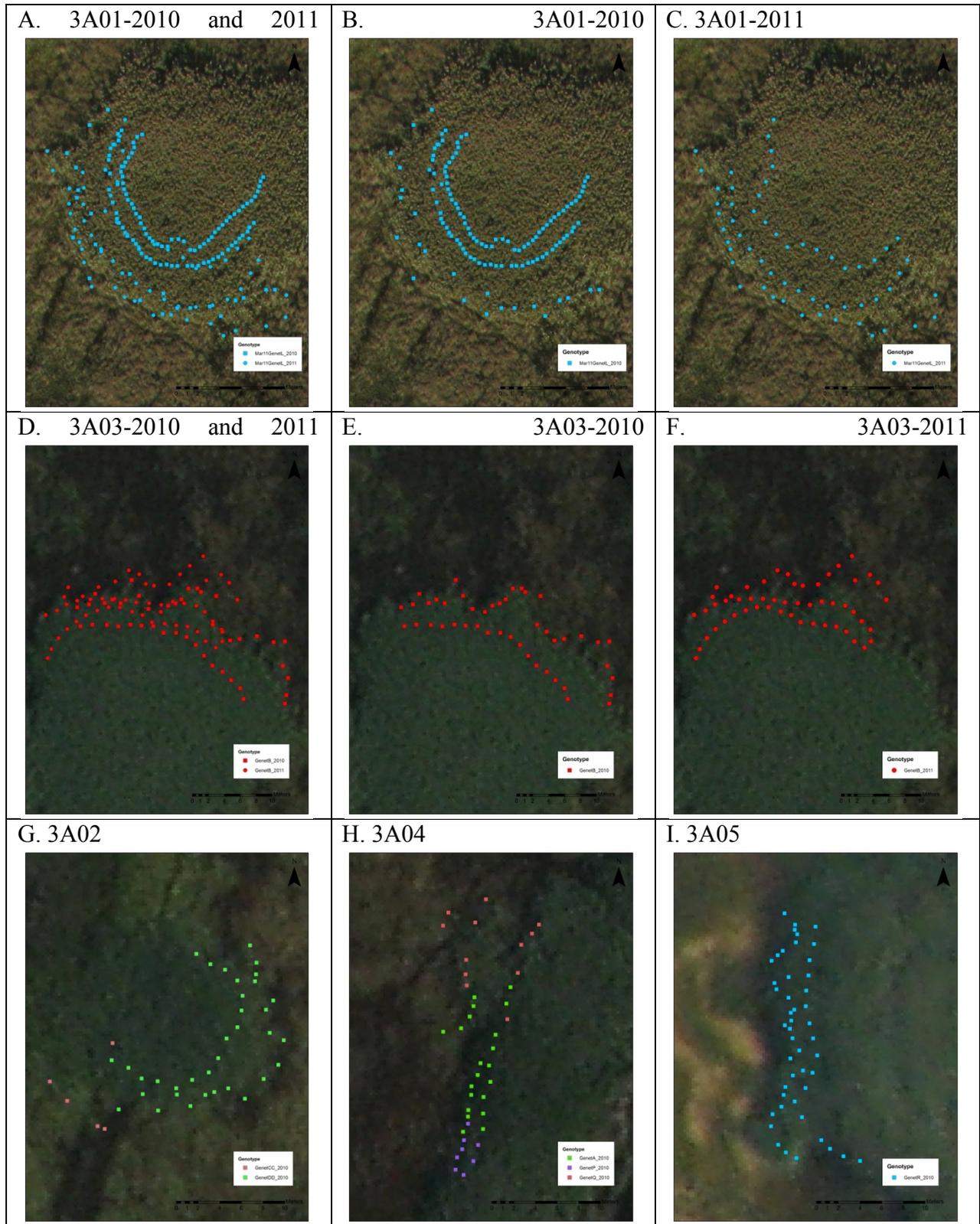


Figure 3. The distribution of different clones within five *Phragmites* patches in Unit 3A at Bear River Migratory Bird Refuge. Samples that were genetically identical share a common color. Samples that were genetically unique are denoted with an “x” in a circle.

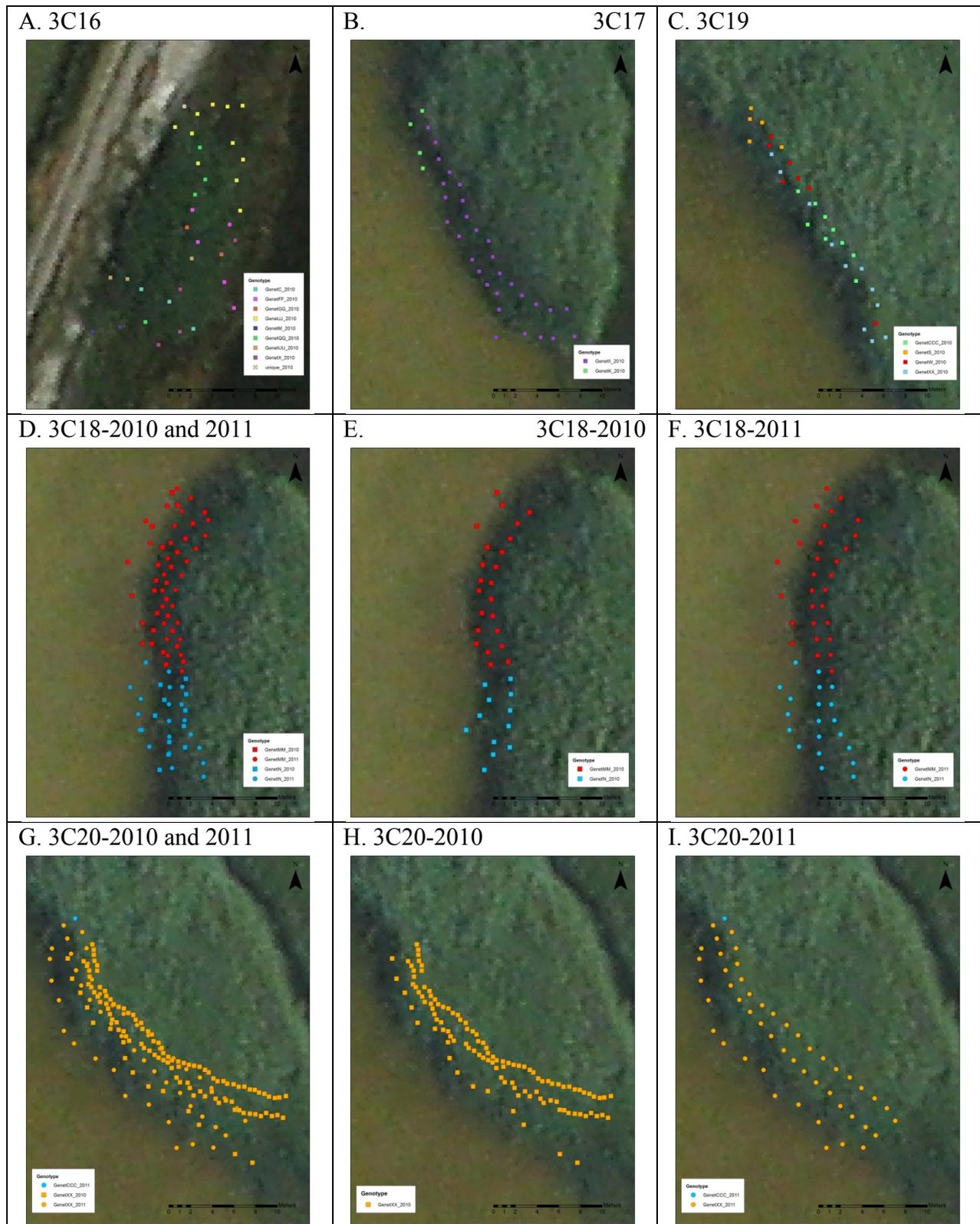


Figure 4. The distribution of different clones within five *Phragmites* patches in Unit 3A at Bear River Migratory Bird Refuge. Samples that were genetically identical share a common color. Samples that were genetically unique are denoted with an “x” in a circle.

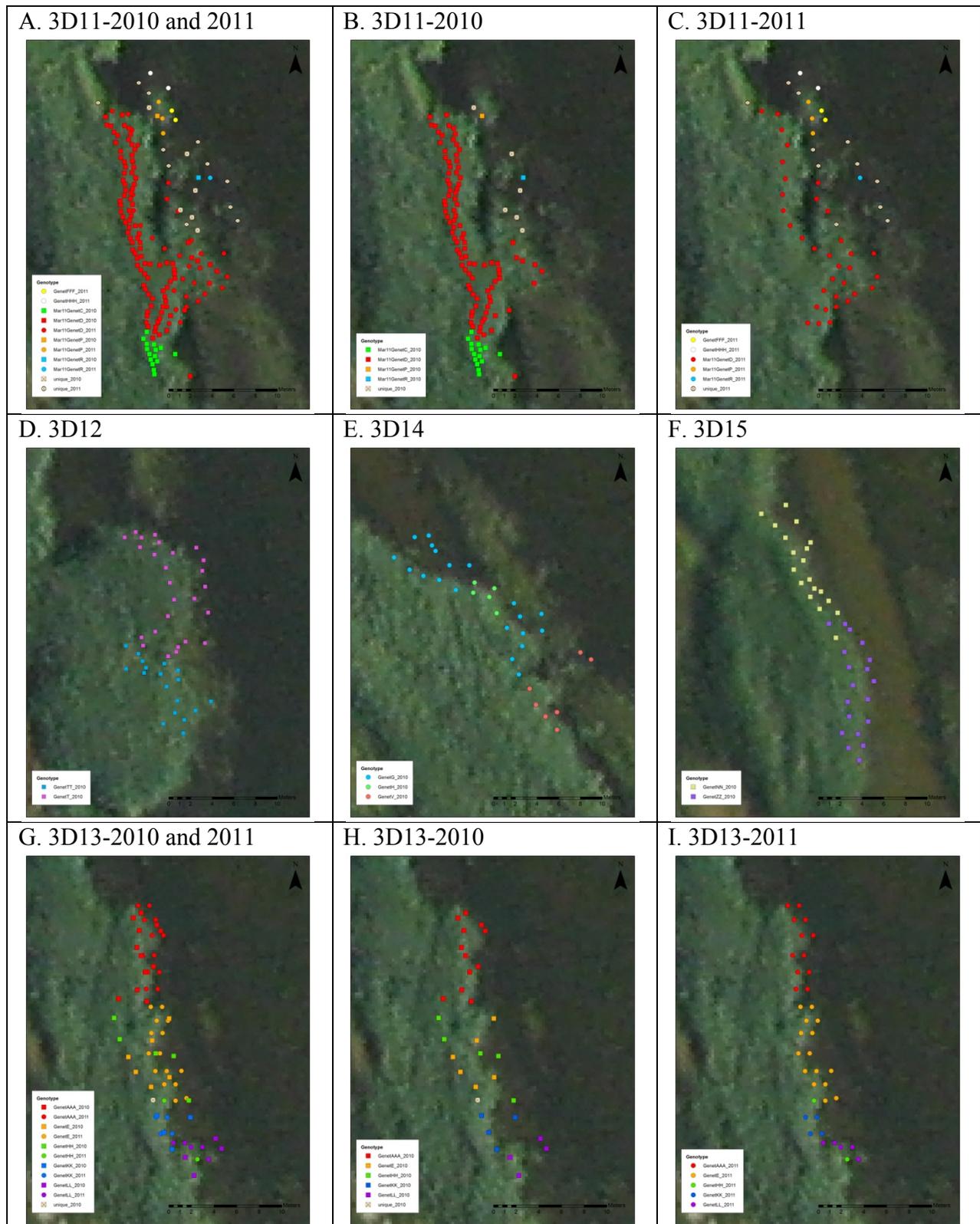


Figure 5. The distribution of different clones within five *Phragmites* patches in Unit 3A at Bear River Migratory Bird Refuge. Samples that were genetically identical share a common color. Samples that were genetically unique are denoted with an “x” in a circle.

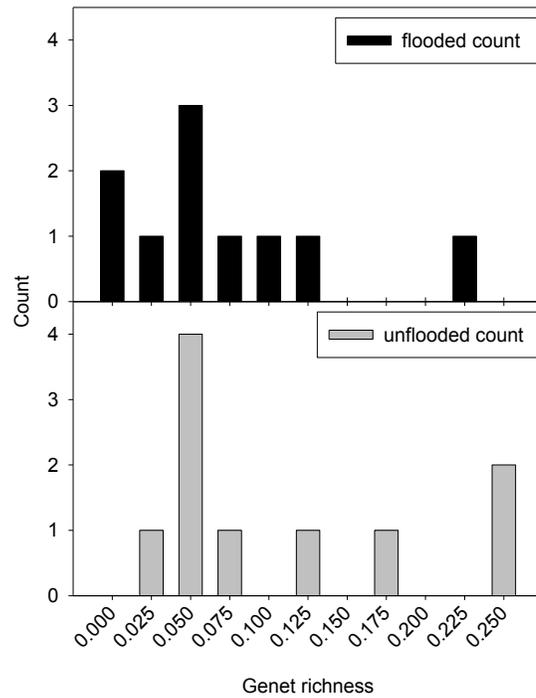
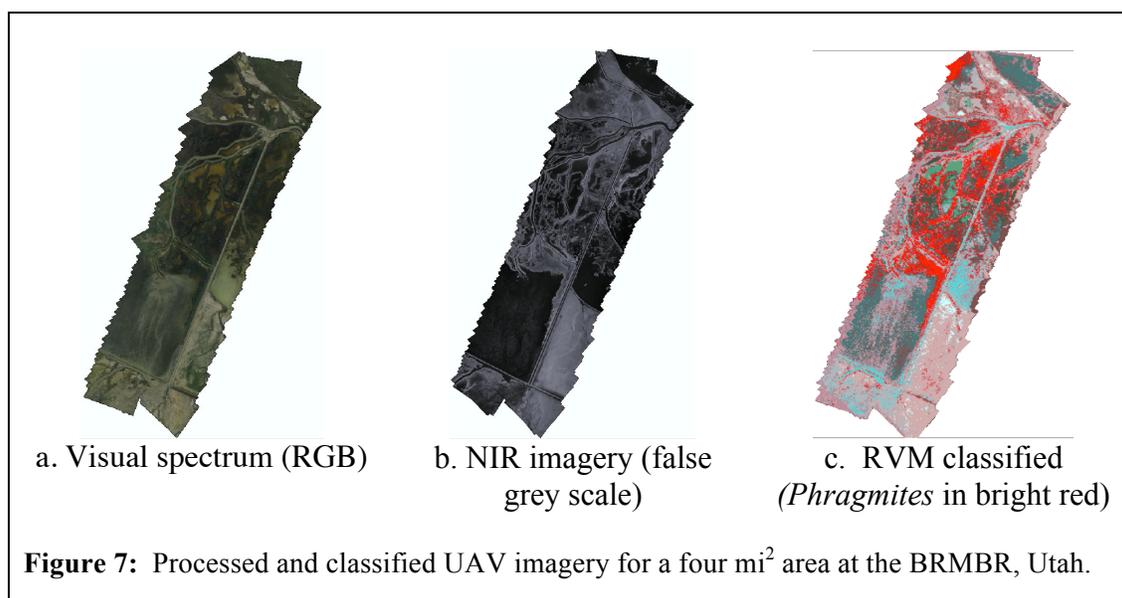


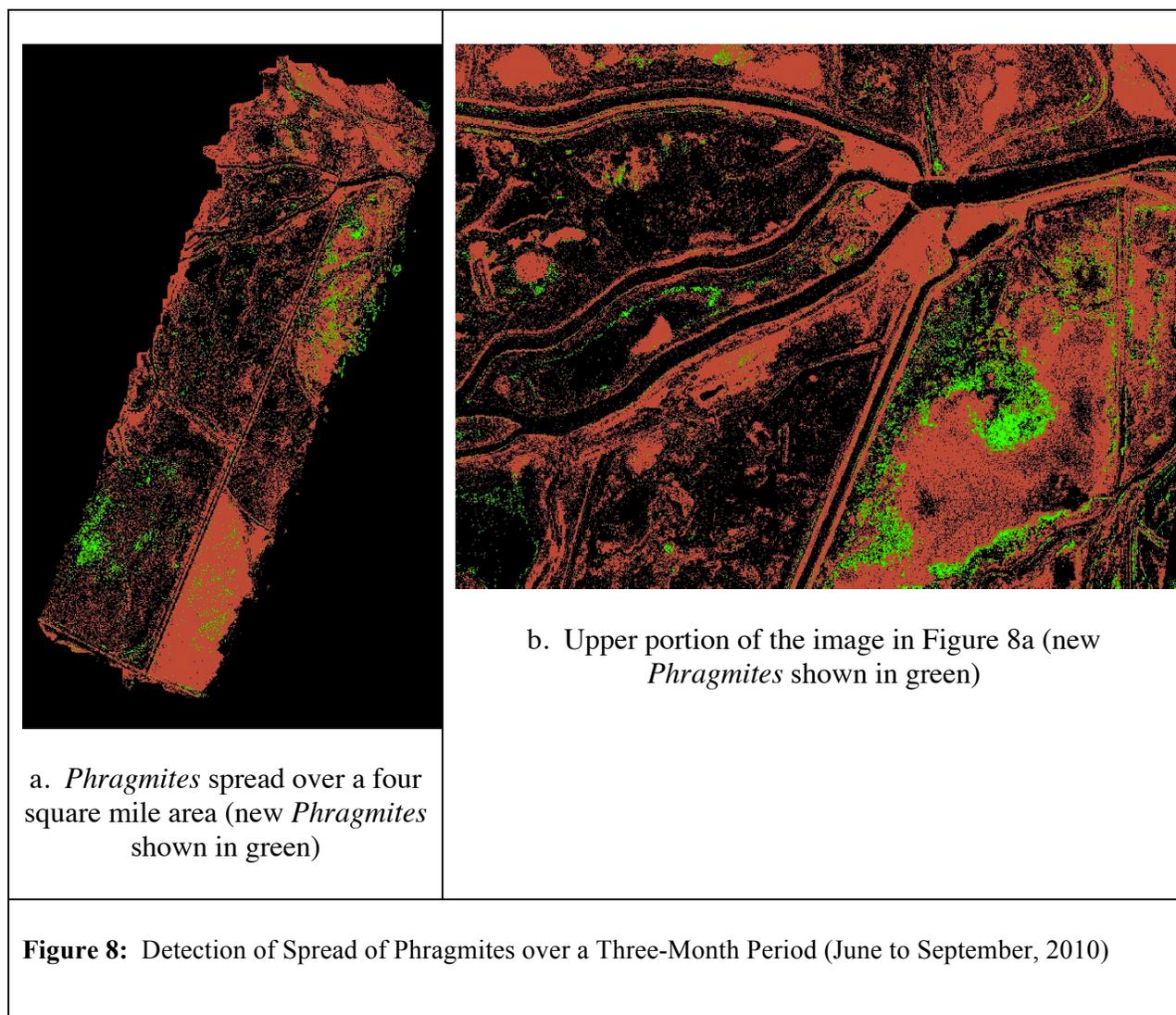
Figure 6. The distribution of genet richness for the 10 patches in flooded wetland units and the 10 patches in unflooded wetland units in 2010.

UAV Remote Sensing Results: In the work done in 2010, aerial imagery in the red, green, blue, and near-infrared spectra was obtained for approximately 50 square miles of the BRMBR and was used to produce a high-resolution base map of the entire area wherein *Phragmites* is a problem. These data were used in combination with on-ground field inspections to identify specific areas or patches, totaling approximately 12 square miles, where UAVs were used to conduct aerial sampling at three other points in time. The imagery that was acquired was used to identify the distribution of *Phragmites* within that 12-square-mile area and to measure the spread of *Phragmites* throughout year. Each of these four high-elevation UAV flights (i.e., one 50 square mile flight and three flights of 12 square miles, each) produced mosaiced and georectified images that have a resolution of approximately 25 cm (see Figures 7a and 7b for an example of the visual spectrum and near-infrared imagery, respectively, acquired from a single flight in June, 2010). A multi-class relevance vector machine (MCRVM) was then developed and trained to identify ground cover types, including *Phragmites*. Figure 7c illustrates one such classification for a single flight (developed from the red/green/blue and near-infrared imagery taken for a four square mile area flown in June, 2010). The classification success rate for *Phragmites* was 95 percent.



In 2011, four more flights were conducted over the same 12-square mile area to acquire imagery in the visual and near-infrared spectra. The images were mosaicked and georectified, and their reflectance values adjusted for measured field sunlight conditions. Classification analyses were conducted using the MCRVM learning machine to identify ground cover types. When classified images such as that illustrated in Figure 7c are available through time, comparisons were conducted to identify areas of *Phragmites* expansion or contraction. Figures 8a and 8b show changes in the patterns of ground cover between flights conducted in June and September of 2010, with the green color representing expansion of *Phragmites* during the three-month time period. The area shown is the same as that illustrated in Figure 7, with spatial resolution of 25 cm. Classification accuracy for *Phragmites* was 95 percent.

The DNA data were used to train a multi-class relevance vector machine to identify different *Phragmites* genotypes. MCRVM classification using only spectral data produced a classification accuracy of around 60 percent, but when spectral data from the UAV images were combined with DNA information, the accuracy of classification of *Phragmites* improved to approximately 98 percent accuracy. These results are promising but preliminary at this time. Additional analyses are currently being conducted.



Conclusions

We found highly variable genet richness across the 20 patches we sampled in 2010 and within patches between 2010 and 2011. We did not find any obvious relationship between genet richness and flooding condition within or between years. We suggest future research evaluate additional factors that may drive these varied patterns in genet richness. In addition, it is important to see if genet richness necessarily translates to increased seed reproduction, as was found in the Chesapeake Bay, or if there are other factors driving sexual reproduction in Utah *Phragmites* populations.

The use of small UAVs to acquire remotely sensed data pertinent to wetland land cover, and the analyses of those data with advanced learning machines that are developed from the mathematics advanced by statistical learning theory provide a powerful set of tools for quickly and inexpensively acquiring aerial imagery, accurately identifying ground cover types at high spatial

(and temporal) resolution, detecting changes through time in the ground cover classes, and, potentially, correlating the information from DNA analyses with the aerial imagery in ways that allow higher accuracy in identification of *Phragmites* genotypes over large areas.

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USGS Award No. G11AP20229 Estimating Crop Water Use with Remote Sensing: Development of Guidelines and Specifications

Basic Information

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Publications

There are no publications.

Estimating Crop Water Use with Remote Sensing: Development of Guidelines and Specifications

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1. Introduction

Irrigated agriculture is the largest consumptive water user in the western United States. Improved estimates of crop water use through evapotranspiration (ET) estimates are important because of the diminishing water resources and competition for water in the 17 western states. Several programs have been established by states and federal government agencies to help monitor water resource in the western US including programs such as WaterSmart by the US Bureau of Reclamation. The key element in estimating crop water use is ET estimates. Also, knowledge of ET is useful for many applications including hydrological modeling and water resources management.

As indicated by the USGS, the aim of this work is to solve the water balance at the 12 digit HUC watersheds scale and eventually the 8 digit HUC level.

2. Problem and Research Objective

Estimating crop water requirements that are acceptable by the community of users and water agencies in the western states, as well as by the USGS WaterSmart, for reporting purposes is a challenging problem. A wide range of ET models is available in the literature, providing different approaches and estimates. The application of some of these models, in particular the remote-sensing based models, can be considered subjective because some of them rely mostly on modeler perception, experience, and understanding.

The main research objective is to develop a framework for estimating crop water use using remote sensing through a standardized approach. This framework will provide guidelines and specifications that would need to be followed by different states in order to apply certain models and produce ET products that are acceptable to the USGS WaterSmart program and the scientific and user community. To achieve the main objective the following activities will be followed:

1. Review currently available ET models
2. Select candidate models
3. Review cropland data base and report on its accuracy, availability, and ease of use.
4. Review and investigate the use of thermal and multispectral band imagery from multiple sensors
5. Perform sensitivity analysis of remote sensing ET models to input error from using gridded forcing weather data.

3. Methodology

An important aspect of this research work will be the selection, review and testing of candidate remote sensing-based ET models. This will allow the establishment of model performance over a wide range of agricultural crops and eventually different surface types outside of the irrigated areas. The models will be tested over irrigated cropland sites selected based on the availability, quality, and suitability of ground-based verification data. Considering the need for gridded weather forcing data over areas where there were limited or no such data, the uncertainty associated with the application of these models will be investigated. Forcing data will include, for example, those that are available in the North America Land Data Assimilation System (NLDAS).

3.1. Candidate models

Based on a preliminary review, candidate ET models have been selected. These models provide a broad range of the current practices in this arena and are presently accepted by the scientific community and the users. The selection was based on different criteria but with a particular attention on those models focused on cropland types of surfaces. The following were identified:

- Thermal Remote Sensing based models, which include all those that use the radiometric surface temperature obtained from different sensors as an input for estimating the surface energy balance components. Several models are being considered:
 - The Two Source Energy Balance (TSEB) Model by Norman et al. (1995), including its recent improvements and modification ALEXI -DisAlexi method (references). This model was introduced by the group at the - USDA-ARS hydrology and remote sensing lab.
 - SEBAL developed by Bastiaanssen et al. (1998), and METRIC by Allen et al. (2007)
 - SEBI – SEBS, S-SEBI, SEBS models (Su, Roerink, Menenti)
 - SSEB simplified surface energy balance developed by a group from the USGS (Gabriel Senay)
- Hybrid ET Approach
 - SEBAL and TSEB have been coupled with the reflectance-based crop coefficient method with a recently developed hybrid approach that couples the surface energy balance approach with water balance model. (Neale et al. 2012 submitted, Geli et al. 2012 in review, Geli, 2012).
- Crop coefficient-based approach
 - Traditional crop coefficient and reference ET approach supported by accurate crop layers obtained from the classification of satellite imagery. This is an approach used by the US Bureau of Reclamation through their LCRAS system
 - Hybrid ET- Utah State University (Neale, Geli) that uses the reflectance-based crop coefficient approach (Neale et al., 1989)
 - ET framework developed by Melton et al. - (NASA)
- Penman-Monteith approach
 - MODIS ET Algorithm, which uses Penman-Monteith equation and incorporates spatial data from MODIS to estimate ET (Mu et al. 2007)

- Approach developed by Henk de Bruin that uses the Penman-Monteith and satellite-based input data
- Priestly-Taylor approach
 - Evapotranspiration Priestly-Taylor Jet Propulsion Lab (PT-JPL) by Fisher et al. (2012).

3.2. The study sites

A set of study sites will be selected to test and evaluate the candidate models. These sites will be from within the 17 western United States with the interest in representing different climatic regions. Initially, the suggested sites include:

- The Palo Verde Irrigation District, California
 - The data for this site was collected by the remote sensing services lab at USU and the Alliance of Universities – Central State University through a project funded by the USBR. The data spans about 3.5 years from 2006 to 2009. It includes flux measurements, irrigation canal and drainage flows, and airborne and satellite images. The main crops are alfalfa and cotton crops. Data are also available for Tamarisk forests in the riparian zone of the Colorado River.
- Maricopa, Arizona. Data collected by the USDA-ARS, which includes cotton, small grain, and alfalfa crops
- Wyoming, Upper Colorado River Basin. Data available through a project funded by the Wyoming Dept. of Water Resources that includes eddy covariance flux tower data over different fields and crops
- Northern Utah. Flux and airborne/satellite remote sensing multispectral and thermal imagery collected within the Bear River Canal Company.
- Lower Colorado River basin – CRIT project. No ground-based flux tower data are available here, but the system has an extensive water measurement program and will be used to corroborate the seasonal ET estimates.

3.3. Remote sensing, weather and spatial datasets

Spatial and point datasets that will be used were identified considering different technical aspects including

- Thermal and multispectral imagery from Landsat TM, MODIS, and GOES
- Cropland Data Layer, produced annually by USDA, and its vector Common Land Units database of parcel boundaries
- Hourly weather data from weather station networks from the different states
- Spatial reference ET and other gridded weather forcing data including, for example, air temperature, wind speed, vapor pressure, and solar radiation

The USGS is currently testing a new algorithm that will eventually provide atmospherically corrected thermal and multispectral Landsat satellite imagery. We propose to use such a product in testing the models as a way of standardizing the calibration of imagery. This will ensure the quality of the data, guarantee a single source of data, and remove the associated uncertainty that arises from using atmospheric

calibration by individual users that apply different atmospheric correction models and/or methods.

4. Principal findings and significance

The project is presently in its first year. A report is in preparation summarizing the remote sensing based models being examined and their characteristics as well as advantages and disadvantages. The datasets for testing of the models are being gathered and prepared. The model developers are being contacted to request their participation in the comparison effort, and some of the research groups will be visited this summer.

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Information Transfer Program Introduction

The individual research projects documented in the Research Project section of this report have information and outreach components integrated within them. These include research findings published in the technical literature and findings and water management models and tools provided on the web pages of the Utah Center for Water Resources Research (UCWRR) and individual water agencies. Beyond this, Information Transfer and Outreach activities through the UCWRR, the Utah Water Research Laboratory (UWRL), and Utah State University (USU) have had an impact on the technical and economic development of the State of Utah. As part of the UCWRR outreach activities supported by USGS 104 funds, there continues to be a vigorous dialogue and experimentation with regard to the efficiency and effectiveness of outreach activities of the UCWRR. Faculty are engaged in regular meetings with State of Utah water resources agencies, including the Department of Environmental Quality (DEQ), the Department of Natural Resources (DNR), the State Engineer's Office, and numerous municipal water supply and irrigation companies to provide assistance in source water protection, on-site training, non-point source pollution management, technology transfer, development of source water protection plans (SWPPs), and efficient management of large water systems within the context of water-related issues in Utah. UCWRR staff, through the facilities at the UWRL, provides short courses both on- and off-site within the State of Utah, regionally, and internationally. Generally offered from one to five days in duration, short courses are tailored to meet the needs of the requestor.

Principal Outreach Publications

Principal outreach items include our two newsletters, “The Water bLog” (<http://uwrl.usu.edu/partnerships/ucwrr/newsletter/index.html>), which highlights research projects and their findings, and “The Utah WaTCH” (<http://uwrl.usu.edu/partnerships/training/utahwatch.html>), which addresses on-site and wastewater issues; and reports such as the Mineral Lease Report (<http://uwrl.usu.edu/documents/index.html>), which is submitted to the Utah Office of the Legislative Fiscal Analyst. Other publications from the UCWRR and UWRL appear regularly as technically-reviewed project reports, professional journal articles, other publications and presentations, theses and dissertation papers presented at conferences and meetings, and project completion reports to other funding agencies.

Information Transfer in Support of the Utah Center for Water Resources Research (UCWRR)

Basic Information

Title:	Information Transfer in Support of the Utah Center for Water Resources Research (UCWRR)
Project Number:	2011UT159B
Start Date:	3/1/2011
End Date:	2/29/2012
Funding Source:	104B
Congressional District:	UT1
Research Category:	Not Applicable
Focus Category:	Education, None, None
Descriptors:	None
Principal Investigators:	R. Ivonne Harris

Publications

There are no publications.

Information Transfer in Support of the Utah Center for Water Resources Research (UCWRR)

Problem

The Water Resources Research Act of 1964 established the Utah Center for Water Resources Research (UCWRR). The Center is housed at Utah State University in Logan, Utah. The general purposes of the UCWRR are to foster interdepartmental research and educational programs in water resources; administer the State Water Research Institute Program funded through the U.S. Geological Survey at Utah State University for the State of Utah; and provide university-wide coordination of water resources research.

Objectives

The center plays a vital role in the dissemination of information. Utah is home to approximately 50,000 miles of rivers and streams and 7,800 lakes. This water is an essential resource for the economic, social, and cultural well being of the State of Utah. As one of 54 water research centers, the UCWRR works to "*make sure that tomorrow has enough clean water.*"

A major component of the information transfer and outreach requirements of the UCWRR is the development of appropriate vehicles for dissemination of information produced by research projects conducted at the Center. This project provides on-going updates of the UCWRR web page, with information transfer specifically identified as the key objective. This project is in the process of disseminating semi-annual newsletters for the Utah Center that feature research projects and their findings, water-related activities in the state, and on-going work by researchers affiliated with the Center.

Methods

Web Pages

A vital objective in the dissemination of information for the UCWRR was the development of an up-to-date web page. The UCWRR web pages have been developed to make information available, thus creating a tool wherein interested parties can find solutions to water problems. The design of the web pages is developed with Adobe "Dreamweaver" software and CSS. Pictures are taken from the various on-going projects and added to the web pages. The address for the UCWRR is <http://uwrl.usu.edu/partnerships/ucwrr/>. Figures 1 and 2 are pictures of two of the pages. The web pages are works-in-progress and the pages are periodically updated.

1. The "Homepage" explains the center's purpose.
2. The "About Us" gives an overview of the center and its affiliations.
3. The "People" page gives an overview of the governing body of the center as well as key contact staff.

4. The “Research and Publications” page guides you to the various projects and reports. This page is updated periodically.
5. “The Water bLog” page provides access to current and past issues of the Center’s newsletter (described in the next section).
6. The “Contact” page has the center’s address and mode of contact.

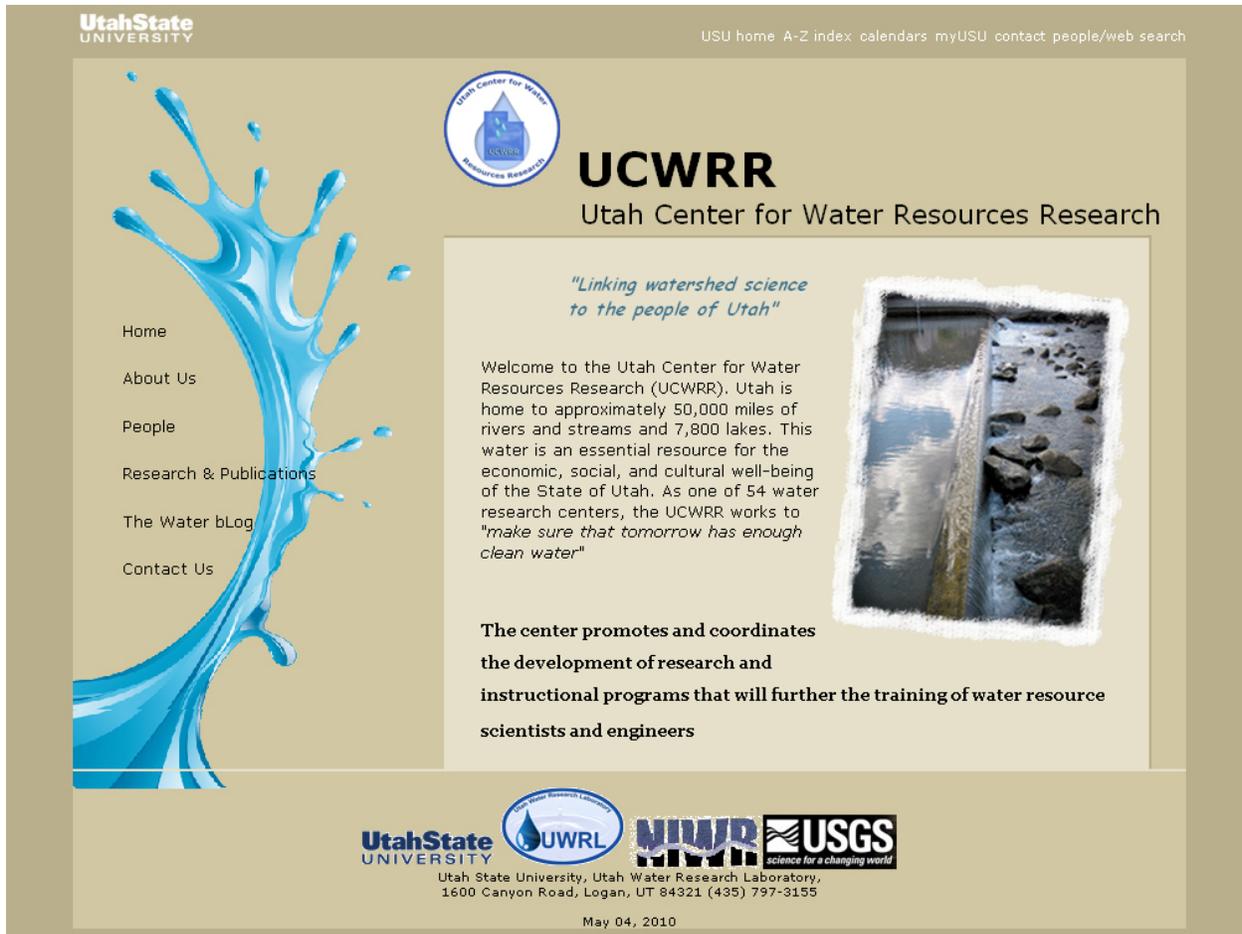


Figure 1. Home page for the UCWRR.



Figure 2. Research and Publications page for the UCWRR.

Newsletter

A semi-annual newsletter *The Water bLog* continues to be published. *The Water blog* is disseminated electronically at the UCWRR web site and through e-mail. The newsletter is e-mailed to approximately 350 readers. The main purpose of the newsletter is to highlight research projects and their findings. These will be of great interest and value to the State of Utah, as well as nationally and internationally.

A recent copy of the newsletter was sent out May 2012. One of the research projects featured in the newsletter is “Phytoremediation at Hill Air Force Base” where UCWRR researchers are evaluating the ability of hybrid poplar trees to take up and volatilize chlorinated solvents from contaminated groundwater at a Hill Air Force Base (AFB), Utah phytoremediation treatability pilot test site. One of the benefits to the State of Utah is that this will determine whether phytoremediation is a cost-effective approach to protecting public health and the environment of Utah.

Monitoring the growth and health of the trees and quantifying the uptake and removal of PCE and TCE from the site will allow for estimates of the total mass of PCE and TCE removed from the site and will demonstrate the effectiveness of the trees in removing target contaminants.



Tree Core Sampling



Soil Surface Volatilization Sampling

Another research project featured in the May 2012 Newsletter is “Fish Movement Through Lined Culverts” where UCWRR researchers are investigating a more fish-friendly alternative to traditional slip-lining techniques in culvert rehabilitation that uses baffles to increase the fish passage rates of native endangered fish.

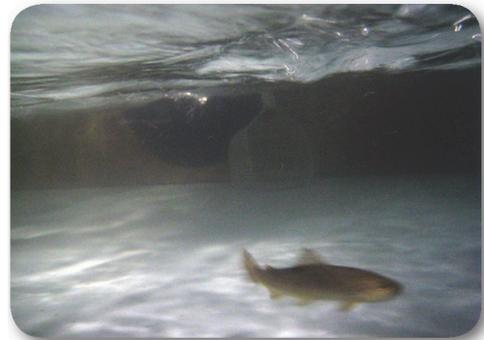
Many culverts in Utah and around the United States have reached the end of their useful life and are in need of repair or replacement. Two common concerns associated with culvert installation are whether it allows for aquatic life to migrate and whether it can pass the design flow.

UCWRR researchers recently partnered with the Utah Department of Transportation to evaluate the ability of fish to successfully pass through a 60-ft-long 2-ft-diameter, smooth-wall culvert liner with and without baffles installed. Wild brown trout (not endangered in Utah) were used as a surrogate for endangered Bonneville Cutthroat Trout. One of the benefits to the state is that culvert rehabilitation using baffled slip-liners provides significant cost savings over culvert replacement, and many of Utah’s culverts could be rehabilitated without threatening the passage of endangered fish such as Bonneville Cutthroat Trout.

Additional testing will continue to examine the interaction between fish and rehabilitated culverts and will aid in the advancement of fish-friendly culverts.



Baffled Slip-liner



Brown trout after culvert passage

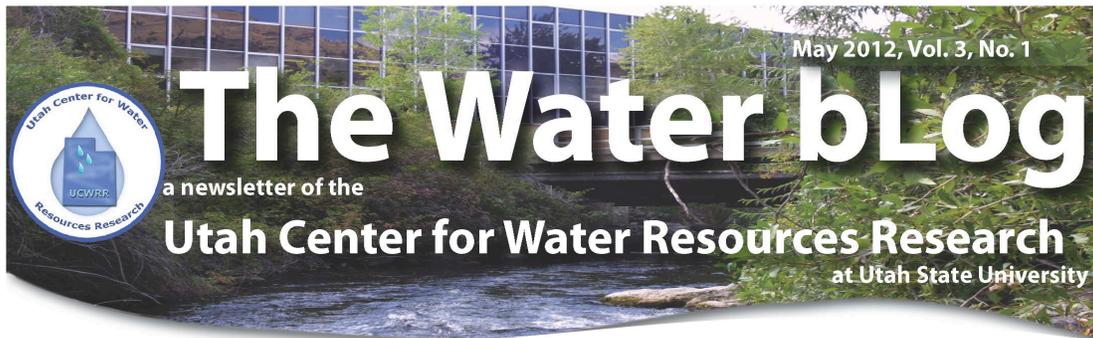
In the “News” section of the May 2012 newsletter we were delighted to report that distinguished alumna and former NASA astronaut Mary Cleave returned to Logan for a visit in early April as part of Utah State University’s Research Week.

Mary Cleave became a NASA astronaut in May 1980, at the age of 33, and worked in several other posts as an engineer for NASA on the ground before completing two space flights.



Mary Cleave visiting with UCWRR Research Engineer Austin Jensen about AggieAir

Figure 3 shows the first page of *The Water blog*’s May 2012 issue. For an electronic copy of current or past newsletters, please go to <<http://uwrl.usu.edu/partnerships/ucwrr/newsletter/>>.



Welcome!

The Water bLog is the semi-annual newsletter of the Utah Center for Water Resources Research (UCWRR), housed at the Utah Water Research Laboratory. The center supports the development of applied research related to water resources problems in Utah and promotes instructional programs that will further the training of water resource scientists and engineers. Each issue of The Water bLog reports on a small selection of the current or recently completed research projects conducted at the center. More information is available online at:

<http://uwrl.usu.edu/partnerships/ucwrr/>

INSIDE:

Research Highlight:

- ▶ **Phytoremediation at Hill Air Force Base**
- ▶ **Fish Movement Through Lined Culverts**

In the News:

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- ◆ Engineering Excellence
- ◆ Distinguished Visitor
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UtahStateUniversity

Message from the Director



Mac McKee, Director

Water-related research is what we do at the UCWRR, but the most satisfying aspect of our research is seeing the impact it has on real communities, real water problems, real people.

From our active sensor development program that allows us to monitor the spread of a single invasive wetland plant species or identify a particular salinity ion in a river to the development models to guide

the operation of complex water supply systems, we are making a real difference in the practical problems of water and natural resources management.

This issue of the Water bLog features research projects that evaluate the ability of hybrid poplar trees to take up and volatilize chlorinated solvents from shallow contaminated groundwater and investigate the effectiveness of baffled slip liners as a potentially fish-friendly alternative to culvert rehabilitation. These projects represent only a tiny fraction of the active research at the UCWRR aimed at finding practical solutions to natural resources challenges throughout the state. ■



RESEARCH HIGHLIGHT

Phytoremediation at Hill Air Force Base

UCWRR researchers are evaluating the ability of hybrid poplar trees to take up and volatilize chlorinated solvents from contaminated groundwater at a Hill Air Force Base (AFB), Utah phytoremediation treatability pilot test site.

Chlorinated solvents and other organic chemicals have contaminated soil and shallow groundwater at many locations in the State of Utah including many communities surrounding Hill Air Force Base (AFB). Phytoremediation uses plants to reduce, contain, or degrade these contaminants.

UCWRR researchers are using a phytoremediation treatability pilot test (PTPT) site to evaluate the potential of hybrid poplar trees to take up and volatilize tetrachloroethylene (PCE) and trichloroethylene (TCE) from groundwater near



Tree core sampling

The Water bLog May 2012, Vol. 3, No. 1

Figure 3. *The Water bLog*, the Newsletter for the UCWRR.

Data Base

Another concern the UCWRR has is making available electronic copies of research projects and reports. These are being converted to PDF format and have been added to a database to make them available on-line. This is a work in progress and some of the publications can be found in our website at <http://uwrl.usu.edu/publications>.

USGS Summer Intern Program

None.

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

Notable Awards and Achievements

Publications from Prior Years

1. 2008UT105B ("Low-Level Outlet Works Air Vent Sizing Requirements for Small to Medium Size Dams") - Articles in Refereed Scientific Journals - Tullis, B. P. and J. Larchar. 2011. "Determining Air Demand for Small- to Medium-Sized Embankment Dam Low-Level Outlet Works." Journal of Irrigation and Drainage Engineering, American Society of Civil Engineers, DOI: 10.1061/(ASCE)IR.1943-4774.0000345. December 2011, pp. 793-800.