Idaho Water Resources Research Institute
Annual Technical Report
FY 2017

Introduction

The Idaho Water Resources Research Institute (IWRRI) was established in 1963 by the University of Idaho, Board of Regents, and is administered through the University of Idaho. The IWRRI mission is to support and promote the investigation of Idaho's interdisciplinary issues related to water use and to aid in developing solutions to Idaho's water problems through inter- institutional research, education and information transfer. To accomplish this mission, IWRRI draws on expertise within the Idaho university system to (1) develop meaningful solutions for Idaho water problems through basic and applied, interdisciplinary research; (2) provide high-quality natural resource education and educational support; and (3) transfer technologies and information developed from research activities to agencies, organizations, and individuals involved in water use, management, and protection. IWRRI has administered over 950 water resources research projects over its history, with the vast majority of these projects undertaken in partnership with federal, state and local agencies that are stewards of Idaho's water resources. IWRRI's delivery of sound, unbiased water resource research has earned it the trust and support of water users and managers across Idaho and academic recognition of researchers across the nation.

Research Program Introduction

The Idaho Water Resources Research Institutes research program is comprised of the following objectives: (1) To work with state and federal agencies and non−government organizations to identify water research needs of the state and region; (2) To promote water−related research relevant to state and regional needs; (3) To stimulate, coordinate, and provide leadership for water resources research within Idaho universities and collaborate with sister institutions in adjoining states; (4) To cooperate with and assist state and federal agencies and non−governmental organizations for the benefit of the citizens of Idaho and the region; and (5) To develop funding for needed research and encourage cooperation with other research organizations.

The Idaho Water Resources Research Institute was able to support four new research projects during the 2017 104B project year on the vulnerability of Idaho's dairy industry to long-term drought, influence of sulfur form on metal mobility and water quality in a mining-impacted lateral lake of the Coeur d'Alene River, estimating the bulk exchange of water and solutes between fringing wetlands and lakes to estimate the role of wetlands in water quality, and development of the on-line Idaho Waters Digital Library.

Influence of Sulfur Form on Metal Mobility and Water Quality in a Mining-Impacted Lateral Lake of the Coeur d’Alene River

Basic Information

Title:	Influence of Sulfur Form on Metal Mobility and Water Quality in a Mining-Impacted Lateral Lake of the Coeur d’Alene River
Project Number:	2017ID212B
Start Date:	3/1/2017
End Date:	2/28/2018
Funding Source:	104B
Congressional District:	ID-01
Research Category:	Water Quality
Focus Categories:	Geochemical Processes, Water Quality, Wetlands
Descriptors:	None
Principal Investigators:	Jeff Langman, James Moberly

Publication

1. Langman, J.B., Moberly, J.G., 20xx, Formation and Stability of Nanophase Metal Particles in Mining-Impacted Lacustrine Sediments, Journal of Applied Geochemistry. (in process)

Influence of Sulfur Form on Metal Mobility and Water Quality in a Mining-Impacted Lateral Lake of the Coeur d'Alene River

Title:	Influence of Sulfur Form on Metal Mobility and Water Quality in a Mining-Impacted Lateral Lake of the Coeur d'Alene River
Project Number:	
Start Date:	3/1/2017
End Date:	2/28/2018
Funding Source:	104b
Congressional District:	ID-1
Research Category:	Water Quality
Focus Category:	GEOCHE, WQL, WL
Descriptors:	porewater, sulfur intermediary form, ligand competition, metal mobility, mining impacts, seasonal solute flux
Principal Investigators:	Jeff Langman, James Moberly

Publications

There are no current publications. The following publication is in development:
Langman, J.B., Moberly, J.G., 20xx, Formation and Stability of Nanophase Metal Particles in Mining-Impacted Lacustrine Sediments, Journal of Applied Geochemistry.

The broader goal of the study was to evaluate the seasonal flux of sulfur forms that can scavenge or release metal(loid)s in the benthic environment of a mining-impacted lake of northern Idaho. The deposition of metal-contaminated sediments in the lateral lakes of the lower Coeur d'Alene River Basin (Basin) provided a mix of metal-sulfide and metal-carbonate forms that react to the seasonal flux of environmental and biological conditions, which can remobilize metals such as iron, lead, manganese, and zinc. A strong reducing environment can produce conditions for the scavenging of metals by reduced sulfur forms while more oxidized sulfur forms can allow for release of the metal into porewater where it may be transported to surface water. This mineral dissolution and metal release process consists of crystal disintegration through microbial-catalyzed oxidation/reduction and hydrolysis and transport of hydrophilic species such as sulfate or the pH-driven solubility of metals. The balance of sulfur speciation and complexation is environmentally controlled, but the complexity of organic-rich benthic environments with strong seasonality greatly impacts metal mobility.

From April through November 2017, water samples and sediment cores were collected monthly from a lateral lake (Thompson) in the lower Basin. Upper- and lower-layer porewater was centrifuged from the sediments, and along with lake water, concentrations of cations and anions and water isotope values were determined to evaluate the seasonal release of metals into the porewater environment. Additionally, filtered and unfiltered porewater and lake water were measured for particle size distribution, ζ potential, polydispersivity, and mobility to examine the form and potential transport of metals released into solution. To pair with the release of metals into the porewater and lake water, sediment samples collected throughout the year from different depths were analyzed using X-ray absorption spectroscopy (XAS) to evaluate sulfur oxidation states and associated iron-manganese relations at the 06B1-1 beamline (SXRMB) at the Canadian Light Source, Saskatchewan, Canada.

Preliminary results of the study indicate changes in pH, conductivity, and water isotopes (δ^2H and δ^{18}O) of bottom-layer, lake water (Figs. 1 and 2) that appear to correspond to seasonal flux of temperature and likely source waters. Metal concentrations in upper-layer porewater (Figs. 3 and 4) indicate strong seasonal flux with the largest concentrations of lead and manganese in June and July. Correspondingly, the largest zeta potential and mobility of nanoparticles in filtered porewater from the upper layer (Figs. 5 and 6) were in the June and July samples. It is expected that sulfur oxidation states will correspond with metal release and resulting seasonal concentrations indicative of scavenging or retention by the sulfur forms in the benthic sediments.

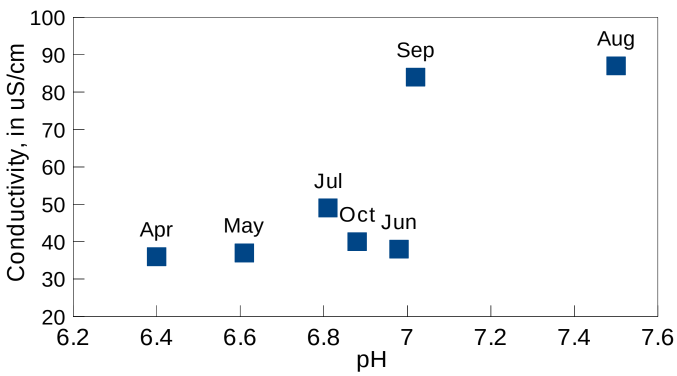

Figure 1. Conductivity vs. pH of bottom-layer, lake water.

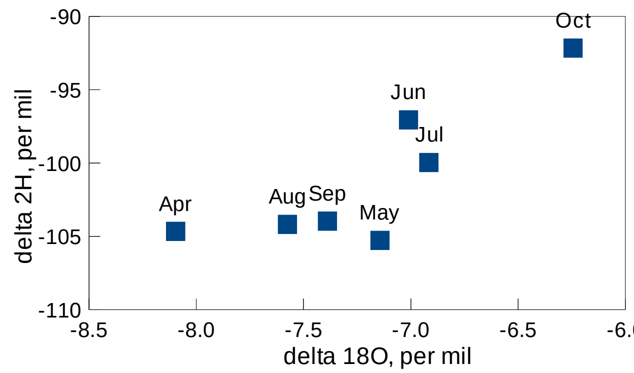

Figure 2. δ^2H vs. δ^{18}O of bottom-layer, lake water.

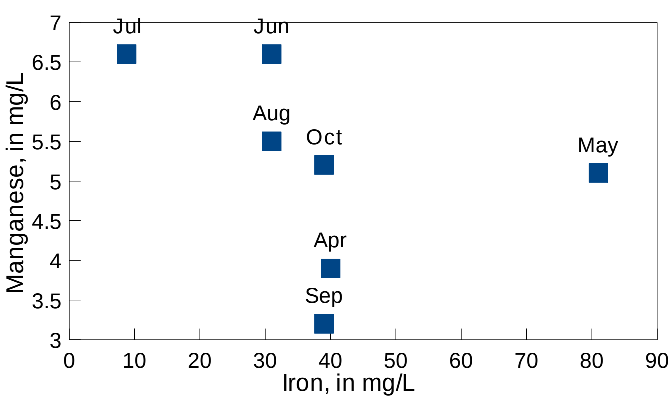

Figure 3. Manganese vs. iron in upper sediment porewater.

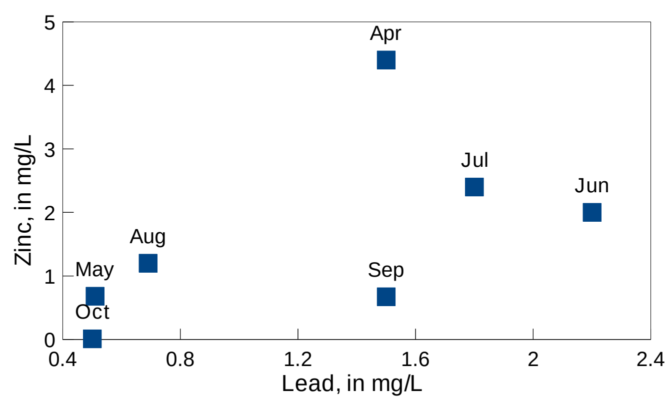

Figure 4. Zinc vs. lead in upper sediment porewater.

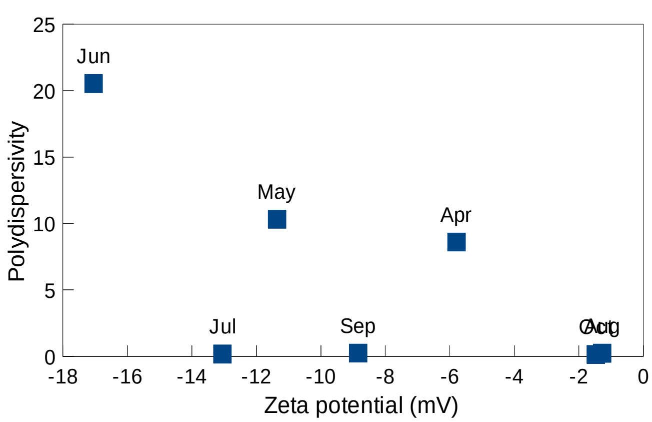

Figure 5. Polydispersivity vs. ζ potential in upper porewater.

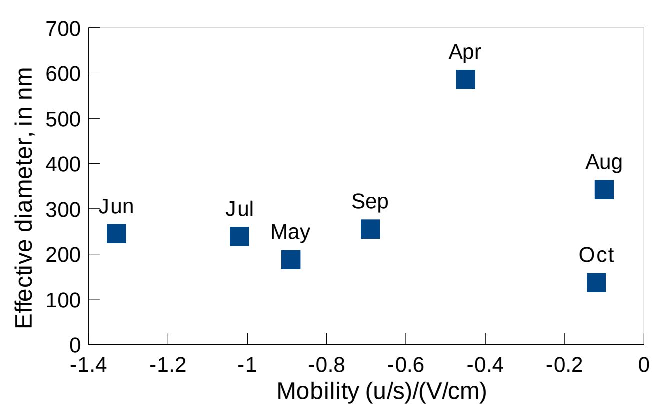

Figure 6. Effective diameter vs. mobility in upper porewater.

Estimating the bulk exchange of water and solutes between fringing wetlands and lakes to estimate the role of wetlands in water quality

Basic Information

Title:	Estimating the bulk exchange of water and solutes between fringing wetlands and lakes to estimate the role of wetlands in water quality
Project Number:	2017ID215B
Start Date:	3/1/2017
End Date:	5/31/2018
Funding Source:	104B
Congressional District:	ID-01
Research Category:	Water Quality
Focus Categories:	Water Quality, Nutrients, Wetlands
Descriptors:	None
Principal Investigators:	Frank Wilhelm

Publications

There are no publications.

Project 2017ID215B was granted an extension by USGS to 5/31/18 due to delay in project start date due to funding lag. This report will be updated upon submittal of final project report to IWRRI by project PI.

Idaho Dairy Industry Vulnerability to Long-term Drought

Basic Information

Title:	Idaho Dairy Industry Vulnerability to Long-term Drought
Project Number:	2017ID216B
Start Date:	3/1/2017
End Date:	2/28/2018
Funding Source:	104B
Congressional District:	ID-ALL
Research Category:	Social Sciences
Focus Categories:	Drought, Water Supply, Management and Planning
Descriptors:	None
Principal Investigators:	Barbara Cosens, Mark David Solomon

Publications

There are no publications.

Barbara Cosens, Mark Solomon, Alycia Bean
104B Final Report
Idaho Dairy Industry Vulnerability Assessment

I. Problem

The dairy industry in Idaho has grown tenfold since the late 1980s. Along with the growth of the dairy industry is the commodity increase in milk production - the largest agricultural sector in Idaho with a 2016 value of $2.36 billion (National Agricultural Statistical Service (NASS)). Idaho ranks first in the U.S. for production of certified organic hay, and is the second largest U.S. producer of alfalfa hay. Alfalfa makes up more than 80% of Idaho's total hay production, with over 4 million tons harvested per year (ID State Department of Agriculture).

While alfalfa is a profitable crop and needed to support the growing dairy industry, it is a very water intensive crop at an average of 46 inches of water per growing season (Shewmaker, Allen, & Neibling, 2011) compared to the 21 – 23 inches for barley, potatoes and soybeans (FAO, 2015). Water in alfalfa country in southern Idaho is already over allocated. In fact, in a good water year, there is not enough water for all needs in the Magic Valley. Junior water users in the prior appropriation hierarchy of 'first in time, first in line' have already (2015) agreed to cut their use by ~13% so senior water rights holders can have their water rights fulfilled.

Climate change is anticipated to increase surface and air temperature in the semi-arid region of southern Idaho; average annual temperatures in the northwest are projected to increase between 2°C and 5°C (Abatzoglou, Rupp, & Mote, 2014). With an increase in temperature comes an increase in evapotranspiration (ET), meaning even more thirsty alfalfa crops. Water deficiency can impact the productivity of perennials beyond stress conditions (Curtis et al., 2014). The estimated ET of alfalfa in southern Idaho is 36 inches (Shewmaker et al., 2011). Projected warming may result in an increase of ET of alfalfa. As an example, an ET for alfalfa of 55 inches per year has been recorded in California (Hanson, 2015).

II. Research Objectives

In order to better understand the potential vulnerability of the dairy industry in Idaho to long-term drought, we wanted to geo-locate the owners of water right permits from the Idaho Department of Water Resources (IDWR) in the Magic Valley's six counties of Cassia, Gooding, Jerome, Lincoln, Minidoka, and Twin Falls along the Snake River and above the Eastern Snake Plain Aquifer. Then these data were to be overlaid with ArcMap GIS layers for analysis with the National Agricultural Statistics Service (NASS) cropland data layer (2016) for alfalfa owners to determine the source (ground or surface water) of water right and the priority date of the water right used to grow alfalfa. These data would provide a more holistic picture to determine current and future water needs for the dairy industry in southern Idaho.

III. Methodology

USDA National Agricultural Statistics Service (NASS) Cropscape Cropland Data Layer query was identified for alfalfa crops at the 30x30 pixel level from the agricultural census information at the county level. The area of interest of the Magic Valley was defined then exported as a shape file. The statistics retrieved included: "value", "category", "pixel counts", and "acreage" of the total 44 crops reported in the Magic Valley. Alfalfa crops were selected and exported for a projection using UTM Zones, Albers Conic and degrees latitude and longitude for ArcMap's GIS data layer.

As required by federal law, the NASS survey data used to provide census information for the area of interest is confidential so that no individual producer may be identified. Growers reporting alfalfa production as seen in the crop data layer can be overlaid with water rights information to identify alfalfa producers at the same place of use (POU) or point of diversion (POD) as a correlating water right. Since there is not an actual reporting of alfalfa crops by any one water right holder on the public information site, the assumption that a particular right is for an alfalfa crop is recorded as such if one or more of the following are true:

The IDWR permitted right is of the type of Water Use category for POUs:

- a. “Irrigation”
- b. “Irrigation from storage”
- c. “Irrigation storage”

AND

1. The water right overlaps with a National Agricultural Statistics Service (NASS) Cropland Data Layer (CDL) pixel (30m x 30m scale) for the category “alfalfa”.

OR

2. The IDWR permitted right is within 100 meters (creating a 200m diameter from the POD) of a NASS reported alfalfa crop (based on the most recent CDL which is 2016).

Water Use categories (99 total for IDWR) are only reported for permitted Places of Use. Points of Diversion have been given the 100-meter buffer to help eliminate overlap with adjacent POD water rights and may include one or more Cropland Data Layer pixels of alfalfa. To clarify the mapping processing tool, the buffering on 100-meter distance from a POD creates a 100m radius and a 200m diameter from the POD. The information garnered from the attribute tables in ArcGIS for different layers for water rights including points of use (POU) and points of diversion (POD) headers in the tables, converted to excel and shared on Dropbox were:

> OBJECTID, Water Right, Basin Number, Sequence Number, Split Suffix, Status, Priority Date, Owner, Overall Max, Source, Source Quality, Tributary O, Tributary 1, Water Distribution, Diversion N, Diversion T, Data Source, Metal Tag Number, Water Right ID, Point of Diversion, Water Right Report, Water Right affiliated documents, Water Rights Map, Spatial Data.

There are 50 types of POUs and 319 sources of PODs. There are 2,013 owner names for POUs, but 2,617 water rights. There are 2,030 POD owners with an average diversion rate of 30.68 (max of 5,470) cfs per acre.

Previous USDA National Agricultural Statistics Service (NASS) and Idaho Department of Water Resources (IDWR) public water right data were used to find Magic Valley growers reporting alfalfa production. These data were then examined for combined water rights to delineate priority dates. The priority date may be the same for the same owner, and the parcel of land the water right is used to irrigate may be the same, but the water right type (POU or POD) would be different and therefore, the water right permit number would be different as well.

Metadata for the processes for ArcMap and GIS layer creation were written and recorded in the metadata report located on the shared IWRRI Dropbox folder. A model builder flow chart in ArcMap can relay this information visually and is stored in the geodatabase .mxd file. The accessible excel files include the priority date, owner, water right source, and the total acreage of that water right.

POD Processing Steps:
-Select only POD in Area
-Buffer 100m
-Clip CDL by buffered POD
-Convert raster to polygon
-Calculate area in acres
-Spatial Join POD attributes
-Dissolve by date, source, owner

POU Processing Steps:
-Select only POD in Area
-Select only water use irrigation
-Clip CDL by buffered POU
-Convert raster to polygon
-Calculate area in acres
-Spatial Join POU attributes and CDL features
-Dissolve by date, source, owner

IV. Principal Findings

Based on the ArcMap, GIS layers created for visual analysis of the following: 1) Area of interest 2) NASS Cropland Data Layer 3) Irrigation Organizations 4) Alfalfa Reported 5) Dams 6) POU water permits 7) POD water permits and 8) Water Districts, and the attribute tables for each containing pertinent information to the water right type, priority date, and owner, a vulnerability assessment was made.

For Place of Use water right owners there were 30 rights (priorities dated 1969-2016), 12 from groundwater and 18 surface water rights. For Point of Diversion water right owners there were 92 rights (priorities dated 1969-2016) 63 of which were surface water, the remaining 29 ground water rights.

For illustrative purposes, the GIS layers were set to “play” sequentially on every decade for the previous 9 years to see which water rights would be affected by a more senior water call. The spatial distribution of these temporal data may be viewed in a multitude of ways by IWRRI staff, and once uploaded to the website, by stakeholders interested in specific locations, owners (individuals, organizations or even private trusts) priority date or sources. The use of the model builder processing tool can allow for easy updates to data sources (i.e. NASS cropland data cover) as it becomes available.

V. Significance

There is evidence that the dairy industry in Idaho is vulnerable to long-term drought. According to NASS, the cropland data layer changes between years show that 29 crops changed to alfalfa from 2015 to 2016 in the Magic Valley for a total of 373,164 acres converted. However, examination of the available years of information shows a drop in alfalfa crops in 2011 (264,774 acres), with a gradual increasing trend since (NASS).

There is an increase in temperature and evapotranspiration (ET). Irrigated crops have a higher sensitivity to increase in temperatures (Lobell et al. 2006). Similarly, alfalfa farms are particularly sensitive to soil moisture content and cannot recover below a certain threshold (Allen et al., 2004). This has implications for irrigated agriculture and could undermine crop value (Schlenker et al., 2007).

Drought may occur with greater frequency and magnitude given the current warming trends (Hamlet and Lettenmaier, 2007; Pagano and Garen, 2005). Since 2000, Idaho has declared drought nearly 150 times (IDWR, 2017) and almost every year (save 06, 09, 11).
In 2015 all of Idaho was in a drought (Idaho State Drought Monitor Report). Water rights may be impacted as a result (Heyhoe et al., 2004). Additionally, there is a decline in natural water storage such as snow pack and aquifer levels (Mote, et al., 2018). If junior users in the Magic Valley are already curtailed in non-drought years, additional water supplies or more efficient water uses will need to be explored to sustain growth. Additionally, the use of model builder in ArcMap and StoryMap to document work flow for queries to determine results in a given data set may be manipulated by future users to look more closely at different components of this research project. This provides real-time, reliable data that is of significance for interactive stakeholder engagement and decision making.

VI. Figures

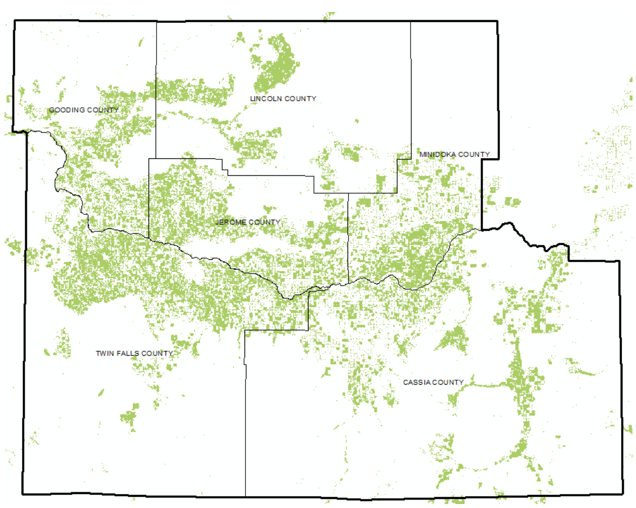

Figure 1. National Agricultural Statistical Service Cropland Data cover for alfalfa (2016) in the area of the Magic Valley.

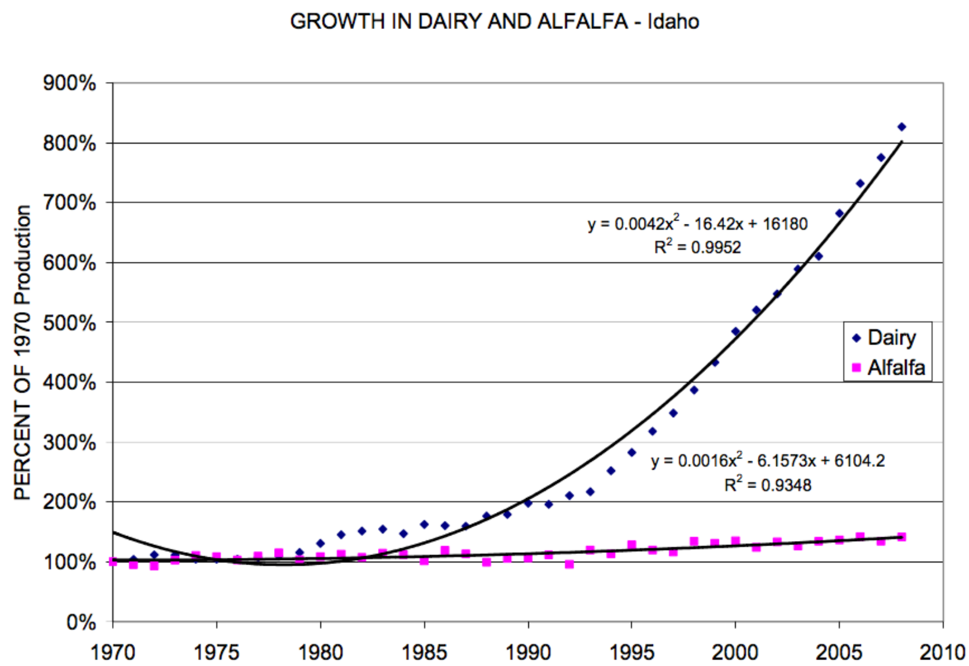

Figure 2. Idaho Dairy and Alfalfa Production. Dan Putnam, Forage Extension Agronomist, UC Davis titled "Envisioning the Future for Alfalfa and Forage Crops in the West - Is it really as bad as it looks?"

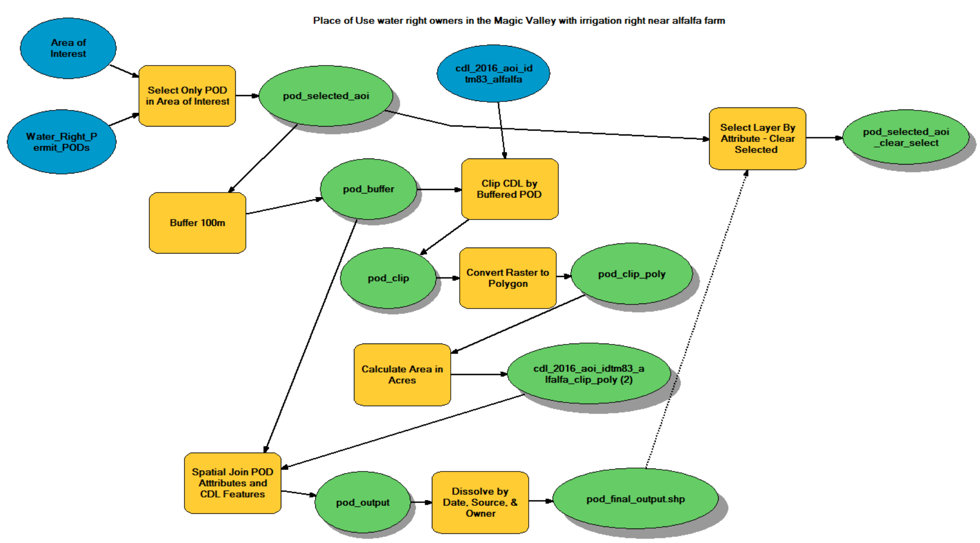

Figure 3. Processes for POD water rights query in Model Builder, ArcGIS.

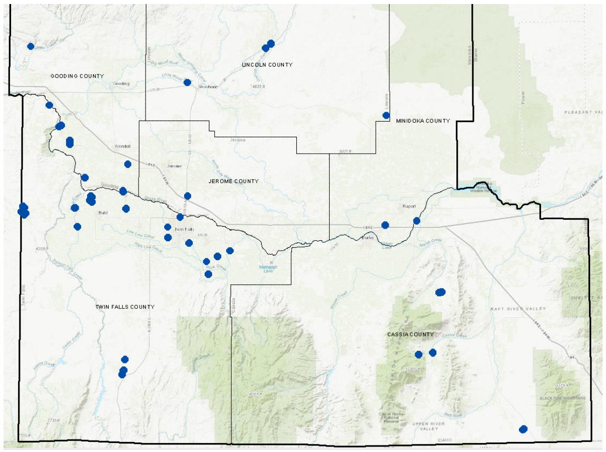

Figure 4. Area of Interest and POD permits cumulatively reported from 1969 – 1999

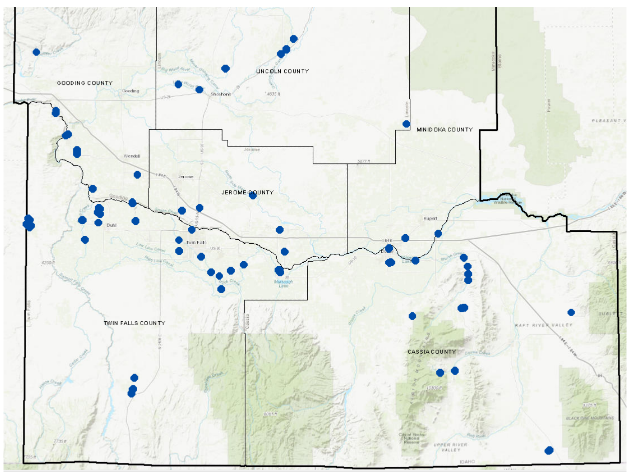

Figure 5. Area of Interest and POD permits cumulatively reported from 1969 – 2009

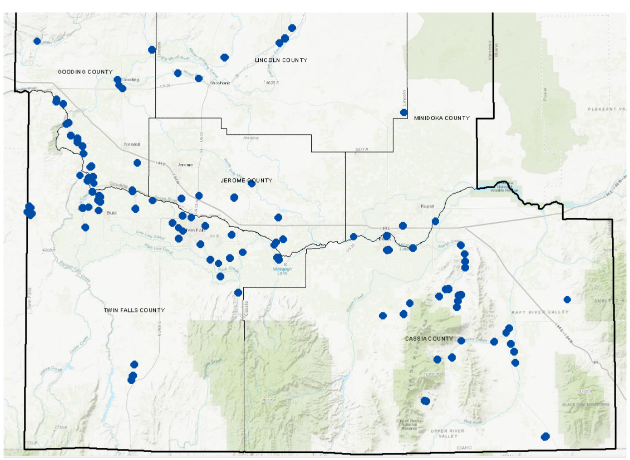

Figure 6. Area of Interest and POD permits cumulatively reported from 1969 – 2016

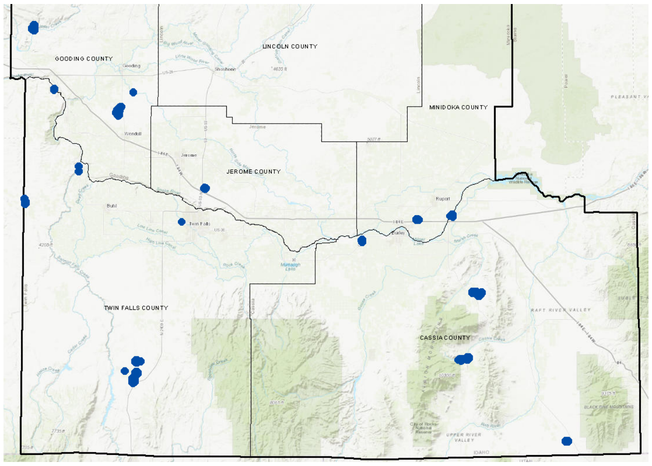

Figure 7. Area of Interest and POU permits cumulatively reported from 1969 – 1999

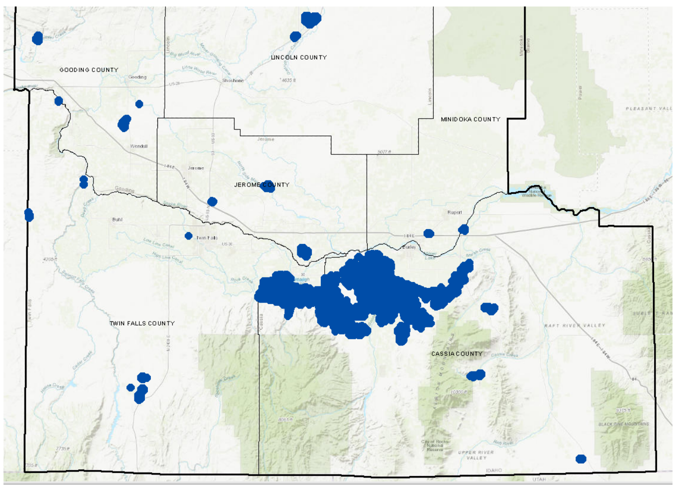

Figure 8. Area of Interest and POU permits cumulatively reported from 1969 – 2009

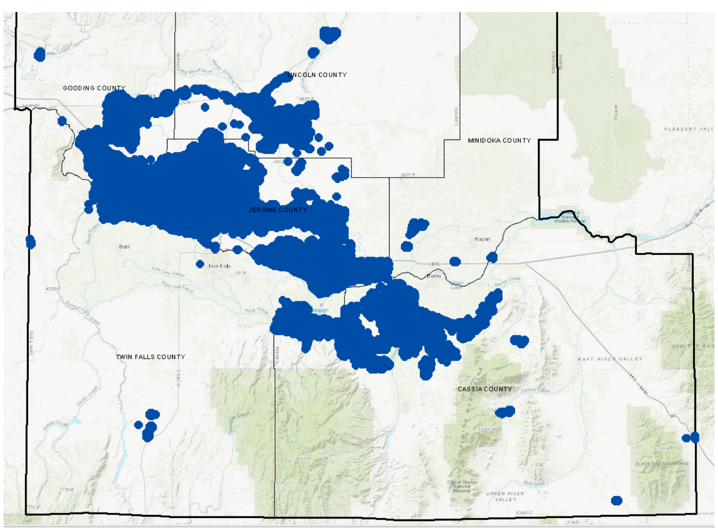

Figure 9. Area of Interest and POU permits cumulatively reported from 1969 – 2016

VII. References

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Information Transfer Program Introduction

The Idaho Water Resources Research Institutes Outreach and Information Transfer program is designed to engage public involvement in water resource research and programs, and to facilitate transfer of water resource research to water users, managers and stakeholders. During the 2017 Program Year, 104B program and state funds were used to support these program objectives and to specifically support drought and climate change vulnerability assessment and planning, conferences and symposia.

Idaho Drought Planning

Basic Information

Title:	Idaho Drought Planning
Project Number:	2016ID209B
Start Date:	3/1/2016
End Date:	6/1/2017
Funding Source:	104B
Congressional District:	ID-01
Research Category:	Climate and Hydrologic Processes
Focus Categories:	Drought, Management and Planning, Law, Institutions, and Policy
Descriptors:	None
Principal Investigators:	Mark David Solomon

Publications

There are no publications.

No single state or federal agency in Idaho is tasked with comprehensive drought planning outside of its specific mission, nor is there an assemblage of agencies with drought planning as their objective. In 2015, IWRRI was asked by state and federal agencies to spark creation of a comprehensive Idaho drought plan. As a respected, impartial and trusted statewide water resource research institution, IWRRI was and is uniquely positioned to facilitate comprehensive Idaho drought planning as part of IWRRI's information transfer and outreach mission.

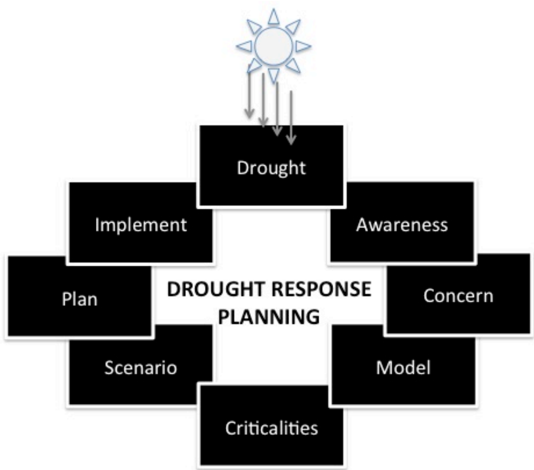
IWRRI conducted one-on-one meetings with representatives of state agencies, federal agencies, agricultural water users, energy companies, NGOs, cites, counties, and other critical stakeholders to secure willingness of entities to engage in comprehensive drought planning. IWRRI secured agreement to participate from key entities, including: USGS Idaho Water Science Center, US Bureau of Reclamation Upper Snake River Area Office, U.S. Forest Service, Natural Resources Conservation Service, Coeur d'Alene Tribe, Idaho Department of Water Resources, Idaho Department of Lands, Idaho Department of Agriculture, Idaho Water Users Association, Idaho Groundwater Association, Idaho Power Company, Idaho Rivers United, and Idaho Conservation League, as well as UI faculty in appropriate disciplines (climate change, hydrology, economics, urban planning, water resources management). Plenary session presentations were made to the Idaho Water Users Association Annual Water Law Symposium and the Idaho Association of Counties Annual Mid-Winter Conference.

The planning process agreed to examines acute criticalities in the context of chronic water scarcity, identifying vulnerabilities at the sub-basin and larger scale with a thirty-year planning horizon (2046) at ten-year time steps. The term "criticality" is used here to mean geo-located system vulnerabilities that if exposed to drought conditions have the inherent potential to create out-sized effects in their sub-basin or beyond. Criticalities may take many forms including infrastructure capacity, hydrologic function, ecologic function, public health, water rights, water quality, regulatory rules, etc. Generally, chronic water scarcity induces system adaptation over time. Acute criticalities induced by water scarcity may, however, precipitate system chaos. As such, the five-part planning process described below is designed to report anticipated chronic conditions and to plan responses to identified acute criticalities:

1) Climate Change Effects Modeling: Climate change will be modeled using data and modeling provided by the UI Applied Climate Science Lab, who will also apply the results to modeling of changes in wildfire frequency, intensity and distribution. UI and IWRRI scientists will lead application of climate change and wildfire modeling outputs to hydrograph modeling. Existing modeling performed by project collaborators will be collected, vetted and included as appropriate to minimize duplication of efforts and speed the process.
2) Update 2001 Idaho Drought Plan: The results of climate change effects modeling will be used to update the 2001 Idaho Drought Plan. This first phase planning product will provide agency managers and water users information to appropriately plan for and manage Idaho's water resources for short-term drought while the long-term drought plan is developed and implemented over time.
3) Criticalities: Criticalities will be identified and prioritized in a stakeholder-driven process of iterative workshops distributed across the major river basins of the state (i.e. Bear Lake, upper Snake, mid-Snake, Boise, Weiser/Payette, Salmon, Clearwater, Panhandle). Scoping workshops will be held to elicit stakeholder identification of potential criticalities and to engage a diverse set of stakeholders in the planning process. Analysis of modeling outputs will expand or delete the list of potential criticalities. A second set of workshops will bring the analysis back to the stakeholders for verification followed by prioritization by the steering committee.
4) Scenario Planning: Stakeholders affected by high-priority criticalities will be invited to participate in facilitated scenario response planning workshops, supported by researchers

with expertise in the nature of the particular criticality. The purpose of the scenario planning is twofold: to role play likely responses to triggering of a criticality, and to identify where actions need to be taken to fill a data or framework gap to preclude undesired scenario responses. Where possible, given time and resource restraints of the planning process, researchers will be engaged to fill the identified gaps. Where not possible, gaps will be prioritized and assembled into a follow-on proposal for funding when sources are available.

5) Report: Results of the process will be assembled into a draft report and taken to stakeholders as per step 2. Following incorporation of feedback and comments from stakeholders and the steering committee, a second phase plan for addressing the highest priority Idaho drought criticalities will be completed and incorporated into the updated Idaho Drought Plan.



Initial steps to develop funding for the multi-year planning process are underway with drought-specific funding programs administered by the Federal Emergency Management Agency and U.S. Bureau of Reclamation identified for proposal development by IWRRI and submission by the State of Idaho. IWRRI is trialing a proof-of-concept project as part of its 2017 104B supported research in the Magic Valley area of the East Snake Plain in southern Idaho. The project is examining the potential vulnerability of the Idaho dairy industry to water right administration under a long-term drought scenario.

Stakeholder Engagement, Outreach and Education

Basic Information

Title:	Stakeholder Engagement, Outreach and Education
Project Number:	2016ID210B
Start Date:	3/1/2016
End Date:	6/1/2017
Funding Source:	104B
Congressional District:	ID-01
Research Category:	Not Applicable
Focus Categories:	Education, None, None
Descriptors:	None
Principal Investigators:	Mark David Solomon, Brant G Miller, Julie Scanlin, Jerry Long

Publications

1. Squires, A., Jennewein, J., Engels, M., Miller, B., & Eitel, K. B. (Fall 2016). Integrating Watershed Science in High School Classrooms: The Confluence Project Approach. CLEARING, 14-17.
2. Squires, A., Jennewein, J., Engels, M., Miller, B., & Eitel, K. B. (Fall 2016). Integrating Watershed Science in High School Classrooms: The Confluence Project Approach. CLEARING, 14-17.

Bringing Water Resources Education to the K-12 Classroom

IWRRI provides support for place-based and traditional watershed education programs for K-12 students. The Confluence Project (TCP) engages teachers and students in place and project-based curricular approaches. TCP is a watershed and climate science curricular approach that is infused with Indigenous knowledge, providing K-12 teachers with a model to take back to their classrooms. TCP uses a series of field experiences that help students better understand issues related to water as a critical resource. In 2016, TCP expanded to southeastern Idaho reaching approximately 300 Idaho students.

In the Treasure Valley (Boise area), students used TCP provided equipment with the TCP curriculum to conduct a study on a local water quality issue. Several groups chose to measure water quality before and after the use of natural filters like native grasses and wetlands. Some groups chose to look at topics surrounding snow science and impacts on water quality such as cloud seeding and the use of ice melt. Other groups looked at the impacts of large-scale monocultures and the differences in water quality as it compares to other forms of land use like permaculture. Students also used the equipment to examine the downstream impacts of water pollution on macro-invertebrates. Students worked with mentors from Boise State University to collect and analyze data, create a research poster, and presented their research posters at TCP's science night on May 12th at Vision Charter School. The equipment used to collect data and do research aligned with the Confluence Project curriculum and enabled students to better understand the broader topic of water quality as it specifically relates to agriculture, snow science, and stream and river science.

In southeastern Idaho, approximately 60 Environmental Science students at Teton High School participated in this year's TCP program. During the week of Feb 6th, TCP personnel traveled to Driggs, Idaho to provide teacher support before and during the Snow Science field experience. This support included scouting field locations, meeting with partner organization, arranging gear, teaching in class pre-field experience lessons, facilitating the field experience, and managing field data. Grand Targhee Ski Resort supported this field experience with staff from their Nature center securing snow shoes for the students, providing on-site classroom space, and selecting appropriate field sampling locations. During the field experience students dug a total of 10 snow pits to ground level (>2 m of snow in places) and collected data on the snow water equivalent in each layer of the snow pack. In addition, they got a basic introduction to avalanche safety and background on changing snow pack conditions in the NW as a result of climate change. As part of the post lesson the students compared their field data with data collected at the Grand Targhee's SNOTEL site in order to better understand how water forecasts are generated. Feedback from the students was very positive, with many indicating that this was their first introduction to snow science (and snowshoes) and that they greatly appreciated gaining an understanding of how a snow pack changes over time.

The Idaho Water Resources Research Seminar Series

Beyond supporting K-12 education, IWRRI provided a state-wide water resources seminar series during the Fall semester of 2016, delivered via a compressed video system to Boise, Moscow, Pocatello, Idaho Falls and Coeur d'Alene. During project year 2016, IWRRI increased its seminar and professional outreach activities in Northern Idaho via its new Lake Social Ecological Systems (LaSES) lab at UI-Coeur d'Alene, hosting world-renowned limnologist Jorg Imberger for a series of public lectures and workshops associated with the grand opening of the lab.

The Idaho Travel Grant Program

During Project Year 2015, travel support was provided to faculty and researchers at the University of Idaho. Support was additionally provided for the Interim Director to attend the 2016 Annual National Institutes of Water Resources meeting and for stakeholder engagement meetings across Idaho.

Additional Activities

In 2016, IWRRI sponsored or provided support for several public water resources conferences and symposiums including: the Spokane River Forum, attended by over 500 people over three days; the Idaho Environmental Education Association (IdEEA) annual conference attended by 200 K-12 educators; the Idaho Water Users Association Annual Conference; and the Boise River Enhancement Network's annual Boise River Bash. Interim Director Solomon provided plenary session presentations to the Spokane River Forum, the Idaho Water Users Association Water Law Symposium, the annual Idaho Water Quality Workshop, the Idaho Association of Counties, the Our Gem (Coeur d'Alene Lake) Symposium, and the Idaho Chapter of the American Water Resources Association. IWRRI continues its support of the Idaho State Chapter of the American Water Resources Association by recruiting members and providing sponsorship and publicity for several of its events. Interim Director Solomon is on the ad hoc steering committee planning the Fall 2017 Idaho's Changing Climate Summit.

Development of the Idaho Waters Digital Library, Phase Two

Basic Information

Title:	Development of the Idaho Waters Digital Library, Phase Two
Project Number:	2017ID214B
Start Date:	3/1/2017
End Date:	2/28/2018
Funding Source:	104B
Congressional District:	ID-01
Research Category:	Social Sciences
Focus Categories:	Education, None, None
Descriptors:	None
Principal Investigators:	Evan Williamson, Devin Becker, Jodi Haire

Publications

There are no publications.

Idaho Waters Digital Library

The Idaho Waters Digital Library (IWDL) provides open digital access to unique information resources about Idaho watersheds (https://www.lib.uidaho.edu/digital/iwdl/). Phase one of the project, funded in FY2012, enabled University of Idaho Library Digital Initiatives to digitize and make available more than 400 documents, and to create an interactive web portal. The majority of these documents are Idaho Water Resources Research Institute (IWRRI) reports for sponsored research throughout the state. Phase two of the project (FY2017) sought to digitize and add the remaining IWRRI print materials from 1980 to 2012 to the online database. The addition of over 230 reports and related data significantly increases the value of the repository as an aggregated resource for researchers and other users. In addition to new digitization, phase two included quality control and enhancement of existing metadata and digital objects, digital preservation activities, a complete web portal redesign, and improvements to discoverability of IWDL materials.

Introduction

Since its initiation under the 1964 Water Resources Research Act, IWRRI has supported research across Idaho, in collaboration with multidisciplinary specialists, public, and private partners. Historically IWRRI advanced research to support water resource planning for the economic and environmental needs in the state (Sowards and Lacabanne, 2017). IWRRI contracted analytical and modeling research to address current issues, and the ensuing research technical completion reports were available directly to water resource practitioners. Many of these unique research publications existed in print copies only, making them difficult to discover and access, and limiting the availability to researchers and the public. In 2008 Jodi Haire laid the foundation of the IWDL as a graduate project, digitizing documents and using the CONTENTdm digital asset management system to host the new digital collection. Funding from the United States Geological Survey and administered by IWRRI in FY2012 (Project 2011 ID175B) enabled University of Idaho Library Digital Initiatives to further develop the IWDL collection.

IWDL now serves as a central repository to facilitate research on Idaho watersheds, enabling better discovery, access, and dissemination, while ensuring digital preservation of unique materials. Documents in the digital collection range in date from 1897 to 2016, and represent critical subject areas such as mine wastes, water policy, hydroelectric power, hydrogeologic modeling, and aquifer management. The collection is well-used, averaging over 300 documents views per month in 2016. The value of this resource was recognized by selection for inclusion in the Western Waters Digital Library, which aggregates "digital collections of significant primary and secondary resources on water in the Western United States" (http://westernwaters.org/).

At the start of Phase Two, more than 200 IWRRI documents from 1980 to 2012 remained in storage, the majority of which existed only in paper format. The main goal was to digitize and process these remaining items to complete the online availability of IWRRI print documents. Supplementing the digitization effort, Digital Initiatives planned 1) quality control and enhancement of existing collection metadata and objects, 2) infrastructure improvements to the repository database, web platform, and digital archive, and 3) a complete redesign of the collection web portal to improve access and sustainability.

Phase Two Project Outcomes

Over the period of the project, a graduate research assistant from UI Water Resources worked on the goals of completing document digitization and metadata enhancement. Her experience in water resources was a valuable asset for unraveling puzzles in the physical archive and creating quality metadata and descriptions to enhance discovery. Following established procedures and best practices, the RA and Digitization Lab staff selected the best quality physical reports, used a document scanner to create preservation quality TIFFs, and processed the resulting digital files. For public access, PDF files with optical character recognition transcripts were created for each document. Quality control checks were implemented at every step of the process. Archival digital files were transferred to the Library's dark archive storage. Additionally, the RA discovered and processed more than 80 born-digital documents ranging from 1998 to 2012. The RA created quality metadata descriptions for all new documents, following a collection specific template designed to be interoperable with Dublin Core Metadata Initiative, including information such as geolocation, subjects, publication series, authors, contributors, and abstract.

After completing the new digitization and description work, the RA reviewed the existing collection materials, providing quality control on the database metadata, digital objects, and web interface. The metadata for each entry was crosschecked with the document for accuracy and completeness. Entries were updated to current citation standards and were brought to a consistent format. Digitized items that were found to be of poor quality, were re-scanned from original paper reports and replaced. Issues with corrupted metadata or missing records were remediated. Once the complete metadata and objects were reviewed, archival master packages were created, preparing the assets for ongoing digital preservation and enabling a smooth migration to new digital repository platforms in the future.

Building from the enhanced metadata, the Digital Initiatives team worked on web site redevelopment, focusing on incorporating principles of responsive design, accessibility, and search engine optimization into the framework. Working with a variety of open source components and Jekyll static site generator, they created a modular project used to build the public web portal (https://github.com/uidaholib/iwdl_source). Incorporating recent developments in machine readable semantic markup, the item pages expose document metadata for better ingest by external search engines and aggregators (Pekala, 2018). Furthermore, the project produces portable data formats, such as GeoJSON and CSV, that are consumed by the web site visualizations and are provided for download for other applications.

The enhanced use of metadata and structured markup in the IWDL portal will increase the findability of resources in the collection, connecting with more researchers. Improvements to the web interface ensure quality usability, better document representation, and more sustainable ongoing maintenance. The framework, metadata driven markup, visualization features, and modular components developed for IWDL will be put to use in other collections going forward. Phase Two development has helped solidify the IWDL, providing a wealth of content and technical enhancements that add value for researchers, scholars, and other stakeholders, supporting ongoing research and understanding of the region while preserving an era of previous work and research investment.

References

Pekala, S. (2018). Microdata in the IR: A Low-Barrier Approach to Enhancing Discovery of Institutional Repository Materials in Google. Code4lib, 39. Available from: http://journal.code4lib.org/articles/13191

Sowards, A. M., & Lacabanne, B. M. (2017). Instituting water research: the Water Resources Research Act (1964) and the Idaho Water Resources Research Institute. *Water History*, *9*(3), 295-316.

Idaho Outreach and Engagement Project FY2017

Basic Information

Title:	Idaho Outreach and Engagement Project FY2017
Project Number:	2017ID217B
Start Date:	3/1/2017
End Date:	2/28/2018
Funding Source:	104B
Congressional District:	ID-ALL
Research Category:	Not Applicable
Focus Categories:	Education, None, None
Descriptors:	None
Principal Investigators:	Mark David Solomon, John Abatzoglou

Publications

There are no publications.

The Idaho Water Resources Research Institutes Outreach and Information Transfer program is designed to engage public involvement in water resource research and programs, and to facilitate transfer of water resource research to water users, managers and stakeholders. During the 2017 Program Year, 104B program and state funds were used to support these program objectives and to specifically support drought and climate change vulnerability assessment and planning, conferences and symposia.

1) Drought and Climate Change Vulnerability and Planning

Drought planning in a changing climate presents a number of challenges with respect to watershed management, water allocations, and ecosystem impacts. This is additionally complicated by the challenges in identifying a commonly accepted definition of what constitutes drought under non-changing climatic conditions. Conceptually, drought is defined as when water demands exceed supplies, acknowledging that this varies substantially amongst competitors for water and at different scales and time periods. Locally, drought can be defined statistically as a period of unusual dryness ignoring the role of humans and land-use changes modifying the demand side of the equation.

At the request of stakeholders across Idaho, IWRRI supported drought and climate change research and education efforts through a multi-pronged approach in this 104B project year including: planning the dairy vulnerability research described in a previous section of this report; sponsorship of the first statewide business oriented climate change summit; continuing the success of the statewide summit by organizing and planning mini-summits at the sub-basin level; and projecting climate and drought for the two sub-basins selected for the first mini-summits described in detail below.

a) Safeguarding Idaho’s Economy in a Changing Climate

Researcher: Mark Solomon, IWRRI Associate Director

IWRRI played a key role in organizing and implementing Idaho’s first climate change summit, held simultaneously in four locations across the state over two days. Planning for the summit began with an ambitious primary goal: To explore market-based solutions for safeguarding Idaho’s economy, health, landscape, and lifestyle. The Summit attracted 575 participants statewide, engaging Idahoans from almost every business sector to share their experiences with changes in climate and develop tangible and implementable solutions. During the two days, Summit participants gathered in person at four locations: Boise State University, University of Idaho, Idaho State University, and Henry’s Fork Foundation. The Summit was supported by 53 sponsors, 92 speakers and panelists, 27 exhibitors, 48 facilitators, and 34 volunteers. In addition to the primary goal described above, other goals of the Summit included:

1. Explore economic opportunities and efficiencies as well as risks, and build upon innovative ideas
2. Showcase successes of Idaho businesses in adapting to or mitigating unpredictability from a changing climate
3. Reveal and promote optimism and innovation
4. Build new collaborations, commitments, and ongoing forums

5. Provide resources and references for short and long-term actions and small and large-scale innovations.

Presentations and breakout sessions at Safeguarding Idaho's Economy in a Changing Climate generated dozens of compelling solutions for Idaho. Participants expressed strong interest in beginning work on these solutions. On January 9, 2018, the Summit steering committee met to develop recommendations for post-Summit next steps based on participant input. During the four-hour workshop, committee members reviewed the values and vision underpinning the Summit, participant survey results, and the challenge areas and solutions generated at the breakout sessions. From that review, the committee members identified four key strategic opportunities to implement in the near future:

1. Risk Analysis: Produce an Idaho economic risk analysis and solutions roadmap.
2. Local Workshops: Support workshops in local communities to foster dialogue and incubate solutions.
3. Working Groups: Promote solutions-focused, industry-specific, and cross-sector project teams to work on climate-related initiatives.
4. Support Other Efforts: Explore opportunities to add business perspective to the Northwest Climate Conference (NWCC) in Boise, October 2018.

IWRRI is also taking the lead on implementing the local workshop strategy, beginning with development of down-scaled climate projections for the targeted locations (see Section b, below) and is on the planning committee for the NWCC.

b) Projections of climate and drought for selected sub-basins in Idaho
Researchers: John Abatzoglou and Abigail Lute, UI Department of Geography

<u>Introduction</u>
We projected changes in drought related metrics through 2050 using an ensemble of downscaled climate scenarios and modeled output of surface hydrology and vegetation dynamics for a set of sub-basins in Idaho. For each basin we aggregated available gridded datasets of climate, hydrology, and vegetation produced from a common set of 10 climate models using the same protocols. Projected changes in average conditions as well as the frequency of occurrence of drought severity were calculated across a host of variables listed in the table below. These variables were calculated for a modeled historical climate period (1971-2000), for a modeled future time period (2021-2050), and compared with observational data for the period 1979-2017.

<u>Datasets and Methods</u>
Data were extracted from the Integrated Scenarios of Future Northwest Environment website (https://climate.northwestknowledge.net/IntegratedScenarios/). These data consist of paired climate, hydrologic, and vegetation scenarios run over the western US from a USGS project funded several years ago that PI Abatzoglou was a part of. Climate scenarios from 10 climate models that participated in the Fifth Model Intercomparison Project (CMIP5) which credibly simulated climate of the broader northwestern US (Rupp et al., 2013) were selected (Table 1). These data were statistically downscaled using the Multivariate Adapted Analogs (MACA, Abatzoglou and Brown, 2012) approach and the gridded climate data of Livneh et al., (2013) to produce daily data at ~6-km resolution over the US and Canadian portion of the Columbia River

Basin. These data were used to force the Variable Infiltration Capacity (VIC) model, which simulates macroscale hydrological processes, and the MC-2 model, which simulates vegetation dynamics.

Model Name	Model Agency
bcc-csm1-1-m	Beijing Climate Center, China Meteorological Administration
CanESM2	Canadian Centre for Climate Modeling and Analysis
CCSM4	National Center of Atmospheric Research, USA
CNRM-CM5	National Centre of Meteorological Research, France
CSIRO-Mk3-6-0	Commonwealth Scientific and Industrial Research Organization/Queensland Climate Change Centre of Excellence, Australia
HadGEM2-CC	Met Office Hadley Center, UK
HadGEM2-ES	Met Office Hadley Center, UK
IPSL-CM5A-MR	Institut Pierre Simon Laplace, France
MIROC5	Atmosphere and Ocean Research Institute (The University of Tokyo), National Institute for Environmental Studies, and Japan Agency for Marine-Earth Science and Technology
NorESM1-M	Norwegian Climate Center, Norway

Table 1. Names and modeling group for the 10 climate models used from the Integrated Scenarios project. Further details are available at http://climate.nkn.uidaho.edu/.

We focused on outputs and the monthly and longer timescales for evaluating drought. For most variables and drought measures of interest, we aggregated data across the watershed by taking the average of all pixels delineated by the watershed. Variables of monthly temperature, precipitation, and reference evapotranspiration (Penman-Monteith, reference grass surface) were acquired from MACA, and further used to calculate the Palmer Drought Severity Index (PDSI) which is a normalized measure of soil moisture. We explicitly used data from 1981-2010 for calibrating PDSI. Variables of monthly soil moisture (total column soil moisture), snow water equivalent (SWE), and runoff (baseflow plus surface flow) were acquired from VIC output. Finally, we acquired the annual fraction of vegetation burned in fire from the MC-2 model. The MC-2 model was run using both active fire suppression and without active fire suppression. For the purposes of this exercise and due to the geographic location of the watersheds, we examined only fire activity with suppression.

Variable	Metric (abbr)	Data Source	Drought Conditions
Heat	June-August temperature (T)	MACA	Highest 20%
Precipitation	Water-year precipitation (P)	MACA	Lowest 20%
Water Demand	Annual reference evapotranspiration (ETo)	MACA	Highest 20%
Flows	Water-year runoff (Q) June-September runoff (Qs)	VIC	Lowest 20%
Snowpack	April 1 snow water equivalent (SWE)	VIC	Lowest 20%
Wildfire	Burned area (BA)	MC2	Highest 20%
Soil Moisture	June-September soil moisture (SM)	VIC	Lowest 20%

Table 2: Variables related to drought stress, the metrics used to evaluate them, the associated data layers, and the drought condition classifiication examined in this work.

For the eight variables listed in Table 2, projected changes were examined from a 1971-2000 baseline. Modeled changes were examined for the 30-year period from 2021-2050 for two climate/emission scenarios, one considers continued utilization of carbon-based fuels and limited climate policy (RCP8.5) and another scenario considers enactment of moderate climate policies to curtail greenhouse gas emissions and increase sequestration of carbon (RCP4.5).

Three quantities were calculated for each watershed and variable: (1) change in the average value, (2) change in the average value in the top 20% of drought years, and (3) change in the frequency of conditions that have historically been regarded as *drought-tending*. The second measure asks about the magnitude of change in conditions for the most drought-like 20% of years in the future versus the most drought-like 20% of years historically, with drought-like conditions defined based on the variable of interest. For example, for precipitation this would compare precipitation between the driest 20% of future years to the driest 20% of historical years. For temperature, this would compare the hottest 20% of future temperatures to the hottest 20% of historical temperatures. The third quantity asks how much more frequent historical drought-like conditions may be in the future. We note that there is no strict definition of drought, but suggest that focusing on a quantity like the most extreme 20%, or an event that historically occurred “1-in-5 years” provides some tractability with audiences and is not too constrained from a data perspective to tackle. For example, while there are statistical approaches to estimate a 1-in-100 year drought, the uncertainty behind such estimates are quite large.

Metrics were calculated separately for each hydrologic basin by aggregating all data at their native resolution resulting in a single time series for each basin. In addition to summarizing the average changes for the metrics above, we created .csv files of all annual data from each model.

Results

We provide tables of the statistics for each of the nine measures here. Measures presented are averaged over the 10-models, while the actual data are provided for each model individually in the csv files. We summarize data separately for each of the 5 hydrologic units of interest.

a. Heat (June-August Temperature)

	RCP4.5			RCP8.5		
Basin	ΔT (C)	ΔTdrought (C)	Drought conditions	ΔT (C)	ΔTdrought (C)	Drought conditions
CDA Lake	2.3	2.5	84%	2.6	3.0	90%
St Joe	2.3	2.6	84%	2.6	3.0	89%
Upper CDA	2.3	2.5	84%	2.6	3.0	91%
S. Fork CDA	2.3	2.5	84%	2.6	3.0	89%
Big Wood	2.3	2.5	85%	2.6	3.0	88%

- Warming of 2.3-2.6C in summer mean temperature by the 2021-2050 period
- Slightly greater rates of warming projected for the hottest 20% of years
- Nearly all years projected to be above the 80th percentile for the 1971-2000 period

b. Precipitation (Water-year totals)

	RCP4.5			RCP8.5		
Basin	ΔP (mm, %)	ΔPdrought (mm, %)	Drought conditions	ΔP (mm, %)	ΔPdrought (mm, %)	Drought conditions
CDA Lake	21mm (2%)	8mm (1%)	16%	35mm (4%)	32mm (5%)	13%
St Joe	24mm (2%)	5mm (1%)	16%	48mm (4%)	44mm (5%)	14%
Upper CDA	32mm (3%)	14mm (2%)	15%	47mm (4%)	43mm (5%)	14%
S. Fork CDA	27mm (2%)	9mm (1%)	16%	46mm (4%)	43mm (5%)	14%

Big Wood	18mm (4%)	-17mm (-4%)	22%	37mm (7%)	4mm (1%)	18%

- 2 to 7% increase in annual precipitation by the 2021-2050 period
- Changes in dry year precipitation are smaller than changes in average year precipitation for RCP4.5, and about the same for RCP8.5
- Historical dry years to become slightly less common in most basins by 2021-2050

c. *Water demand (Mean Annual reference evapotranspiration)*

	RCP4.5			RCP8.5		
Basin	ΔETo (mm, %)	ΔETo drought (mm, %)	Drought conditions	ΔETo (mm, %)	ΔETo drought (mm, %)	Drought conditions
CDA Lake	101mm (11%)	107mm (11%)	84%	115mm (13%)	130mm (13%)	89%
St Joe	105mm (12%)	108mm (12%)	85%	120mm (14%)	134mm (15%)	90%
Upper CDA	105mm (13%)	110mm (12%)	86%	121mm (15%)	135mm (15%)	90%
S. Fork CDA	107mm (13%)	111mm (12%)	86%	123mm (15%)	138mm (15%)	90%
Big Wood	119mm (12%)	121mm (12%)	85%	133mm (14%)	145mm (14%)	87%

- Water demand increases 11-15% in average and drought years by the 2021-2050 period, with little contrast from basin to basin
- Slightly greater increases in water demand are projected for RCP8.5 than RCP4.5
- 84-90% of years projected to be above the 80th percentile for the 1971-2000 period.

d. *Runoff (Water-year total)*

	RCP4.5			RCP8.5		
Basin	ΔQ (mm, %)	ΔQdrought (mm, %)	Drought conditions	ΔQ (mm, %)	ΔQdrought (mm, %)	Drought conditions

CDA Lake	-11mm (-3%)	-13mm (-6%)	25%	-4mm (-1%)	-2mm (-1%)	20%
St Joe	-34mm (-6%)	-39mm (-9%)	30%	-20mm (-3%)	-21mm (-5%)	27%
Upper CDA	-43mm (-7%)	-48mm (-11%)	33%	-33mm (-6%)	-32mm (-7%)	30%
S. Fork CDA	-44mm (-7%)	-50mm (-10%)	33%	-31mm (-5%)	-33mm (-7%)	29%
Big Wood	-3mm (-2%)	-11mm (-12%)	29%	+5mm (+4%)	-3mm (-3%)	23%

- Small reductions in mean annual runoff projected for most basins
- Larger declines in drought year runoff than mean runoff and increased frequency of drought conditions projected
- Declines in runoff are less severe in the more severe climate scenario (RCP8.5), likely due to slightly more precipitation modeled under those scenarios

e. *Runoff (Summer, June-September total)*

	RCP4.5			RCP8.5		
Basin	ΔQs (mm)	ΔQs drought (mm)	Drought conditions	ΔQs (mm)	ΔQs drought (mm)	Drought conditions
CDA Lake	-14mm (-17%)	-8mm (-12%)	46%	-14mm (-16%)	-8mm (-13%)	46%
St Joe	-75mm (-28%)	-42mm (-27%)	51%	-77mm (-29%)	-41mm (-27%)	53%
Upper CDA	-68mm (-29%)	-33mm (-25%)	54%	-71mm (-30%)	-35mm (-26%)	53%
S. Fork CDA	-79mm (-28%)	-44mm (-28%)	52%	-83mm (-30%)	-45mm (-28%)	54%
Big Wood	-13mm (-18%)	-10mm (-30%)	41%	-11mm (-15%)	-8mm (-25%)	34%

- Mean summer runoff to decline by 15-30% by 2021-2050
- Percent reductions in drought year runoff are similar to those for mean year runoff, except in the Big Wood Basin

- Drought conditions projected to occur every second or third year in the future

f. April snow water equivalent

	RCP4.5			RCP8.5		
Basin	ΔSWE (mm, %)	ΔSWE drought (mm, %)	Drought conditions	ΔSWE (mm, %)	ΔSWE drought (mm, %)	Drought conditions
CDA Lake	-80mm (-57%)	-31mm (-68%)	66%	-85mm (-61%)	-33mm (-73%)	68%
St Joe	-133mm (-27%)	-112mm (-36%)	53%	-148mm (-30%)	-127mm (-40%)	55%
Upper CDA	-163mm (-32%)	-154mm (-51%)	59%	-182mm (-36%)	-171mm (-57%)	61%
S. Fork CDA	-151mm (-29%)	-130mm (-41%)	57%	-168mm (-32%)	-148mm (-46%)	58%
Big Wood	-20mm (-10%)	-23mm (-17%)	30%	-13mm (-6%)	-13mm (-10%)	28%

- Northern basins to lose one to two thirds of April snowpack, with smaller declines of 6-10% for the Big Wood
- Larger relative declines projected for dry years than average years
- Historic droughts projected to occur more often than not in the Northern basins

g. Soil moisture (June-September average)

	RCP4.5			RCP8.5		
Basin	ΔSM (mm, %)	ΔSM drought (mm, %)	Drought conditions	ΔSM (mm, %)	ΔSM drought (mm, %)	Drought conditions
CDA Lake	-33mm (-7%)	-32mm (-9%)	43%	-30mm (-7%)	-30mm (-8%)	41%
St Joe	-64mm (-9%)	-69mm (-12%)	53%	-65mm (-10%)	-70mm (-12%)	52%
Upper CDA	-77mm (-10%)	-89mm (-14%)	51%	-79mm (-11%)	-90mm (-14%)	50%

S. Fork CDA	-73mm (-10%)	-85mm (-13%)	52%	-74mm (-10%)	-87mm (-13%)	50%
Big Wood	-12mm (-4%)	-22mm (-9%)	35%	-7mm (-2%)	-12mm (-5%)	31%

- Soil moisture reductions of 2-11% projected for mean years
- Larger declines projected for dry year soil moisture than average year soil moisture
- Drought year conditions projected to occur once every second or third year

*h. Burned Area **

	RCP4.5			RCP8.5		
Basin	ΔBA (%, %)	ΔBA drought (%, %)	Drought conditions	ΔBA (%, %)	ΔBA drought (%, %)	Drought conditions
CDA Lake	+1.3% (118%)	+1.0% (32%)	59%	+1.5% (130%)	+0.9% (30%)	70%
St Joe	+1.3% (101%)	+1.3% (48%)	78%	+1.3% (106%)	+1.2% (42%)	82%
Upper CDA	+2.0% (339%)	+2.7% (204%)	94%	+2.1% (356%)	+2.7% (200%)	96%
S. Fork CDA	+1.5% (143%)	+1.7% (78%)	90%	+1.5% (143%)	+1.5% (69%)	92%
Big Wood	+1.0% (90%)	+1.5% (67%)	66%	+1.1% (100%)	+1.7% (74%)	76%

* In table above, first values in each cell indicate the absolute change in the percent of annual burned area. For example, the the St. Joe watershed, an extra 1.3% of the watershed burns per year, which is about a doubling of the historical baseline. The second values, in parentheses, indicate the percent change in the percent of annual burned area.

- Annual burned area is projected to double to quadruple by 2021-2050
- Greatest increases in burned area by far are projected for the Upper CDA basin
- Roughly 60-95% of years are expected to exhibit drought conditions in the future

<u>Conclusion</u>

Projected changes in key drought related metrics across five Idaho watersheds revealed some substantial shifts in climate, hydrology, and fire regimes by the 2021-2050 time period. In general, the watersheds are projected to become significantly warmer, experience nominal increases in annual precipitation, with lower spring snowpack and consequently lower summer streamflow, decreased soil moisture, and increased annual burned area. While projections for the Northern basins are broadly similar, the Big Wood basin is projected to have smaller reductions in April 1st SWE and summer soil moisture, likely due to its higher elevation where snowpack is less sensitivity to warming over the next few decades. In general, RCP8.5 projections were slightly hotter and wetter than RCP4.5 projections. Consequently, impacts strongly tied to temperature (e.g. water demand) were projected to become more severe under the more severe scenario, whereas impacts closely related to precipitation (e.g. annual runoff) were projected to be similar or less severe.

Future drought years are expected to be substantially warmer (2.5-3.0C), and to be characterized by higher ET and burned area, and lower SWE, annual and summer runoff, and soil moisture than historic drought years. Hot years, high water demand years, and high fire years that historically occurred 1 in 5 years are expected to occur nearly every year in the future in most basins. Years with low streamflow, snowpack and soil moisture are expected to occur more frequently in the future as well. On the other hand, low precipitation years are expected to occur slightly less frequently.

References

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Rupp, D. E., J. T. Abatzoglou, K. C. Hegewisch, and P. W. Mote (2013), Evaluation of CMIP5 20th century climate simulations for the Pacific Northwest USA, J. Geophys. Res. Atmos., 118, 10,884–10,906, doi:10.1002/jgrd.50843.

c) Other Outreach and Engagement Efforts

In 2017, IWRRI sponsored or provided financial support for public water resources conferences and symposiums including the Spokane River Forum and the Our Gem (Coeur d'Alene Lake) Symposium, attended by over 500 people over three days, and the Climate Summit described previously. IWRRI Director Kolok and Associate Director Solomon provided plenary session presentations to the Spokane River Forum, American Water Resources Association Annual Meeting, Idaho's Changing Climate Summit, and numerous local stakeholder meetings. IWRRI continues its support of the Idaho State Chapter of the American Water Resources Association by recruiting members and providing sponsorship and publicity for several of its events. IWRRI sponsored and provided the Idaho Water Resources Research Seminar Series during the Fall semester of 2017, delivered via a compressed video system to Boise, Moscow, Pocatello, Idaho Falls and Coeur d'Alene.

USGS Summer Intern Program

None.

Notable Awards and Achievements

Publications from Prior Years

1. 2016ID202B ("Seasonal Flux of Environmental Conditions and Metal Solutes in the Shallow Groundwater Environment of the Mining-Impacted Upper Coeur d'Alene River Basin") - Articles in Refereed Scientific Journals - Langman, J.B., Moberly, J.G. 2018. Weathering of a mined quartz-carbonate, galena-sphalerite ore and release and transport of nanophase zinc carbonate in circumneutral drainage, Journal of Geochemical Exploration 188, 185–193.