Potential Climate Change Impacts on Native Bulrush Seeds (*Schoenoplectus spp.*) Relative to Invasive Common Reed (*Phragmites*) – Methods and Preliminary Results and Experience from the Wetland Ambassadors Program

SWS Fellowship Research - Final Report

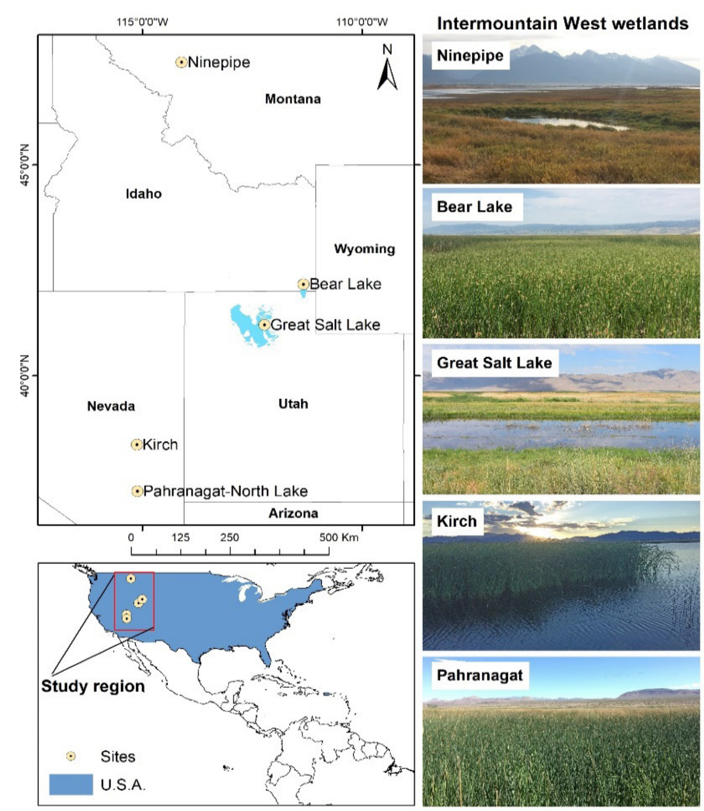
Tatiana Lobato de Magalhães[1], *Wetland Ecology Lab, Utah State University, Logan, UT*

INTRODUCTION

Through funding from the Society of Wetland Scientists' Wetland Ambassadors Graduate Research Fellowship[2], two experiments were conducted in the Wetland Ecology Lab at Utah State University and one field experiment (seeding trial) in Great Salt Lake wetlands during the summer of 2018. The experiments were focused on answering five questions: (1) How do changes in temperature and water potential impact native bulrush seed germination (Growth Chamber Experiments 1 and 2)? (2) How do bulrush germination rates correspond with *Phragmites* germination (Growth Chamber Experiments 1 and 2)? (3) How do changes in temperature and water potential impact the germination of native bulrush seeds sourced from different regions (Growth Chamber Experiment 2)? (4) How does bulrush seed germination vary with temperature and water potential in the field (Field Study)? (5) How do field germination rates correspond with germination under simulated climate change conditions in growth chambers (Growth Chamber Experiments 1 and 2 and Field Study)?

These experiments focused on two native bulrush species - *Schoenoplectus acutus* (Muhl. ex Bigelow) Á. Löve & D. Löve (hardstem bulrush) and *Schoenoplectus americanus* (Pers.) Volkart ex Schinz & R. Keller (threesquare bulrush) and one non-native species - *Phragmites australis* (Cav.) Trin. ex Steud. (common reed). The native bulrushes serve as critical food and nesting sources for migratory birds and are target species for Great Salt Lake wetland restoration (Evans and Martinson 2008; Marty and Kettenring 2017). Great Salt Lake wetlands are threatened by increasing demands on water upstream for development and agriculture and by the proliferation of invasive species (Long et al. 2017; Wurtsbaugh et al. 2017). One such invasive species that is particularly harmful to these wetlands is *Phragmites australis*. Restoring this ecosystem following *Phragmites* control is a high priority and often relies on seeding with bulrushes in an effort to return native vegetation to the area. *Phragmites* seeds have high rates of germination (Mauchamp et al. 2001; Kettenring and Whigham 2009). Recent research indicates that *Phragmites* germination rate more than doubles under increased temperature conditions (Martin 2017). As such, climate change may also intensify the expansion of the invasive *Phragmites* (Tougas-Tellier et al. 2015). Understanding how seed germination of *Phragmites* and *Schoenoplectus* spp. changes in response to changing temperature and water regimes could provide insights on current and future plant community dynamics in natural and restored wetlands. Another topic of interest was how seeds may vary within hardstem bulrush populations in response to temperature and water potential changes. A range of geographically different seed sources from five populations of *S. acutus* were collected and used in the experiments (Figure 1): Great Salt Lake (41.2061 N, -112.2131 W), Kirch Water Management

FIGURE 1. Study area showing location of *Schoenoplectus acutus* populations.



1. Corresponding author contact: tatilobato@gmail.com. Note that the original report entitled *Wetland Ambassadors Graduate Research Fellowship Final Report – 2018* was reformatted along with minor edits for publication in this journal.

2. The SWS Wetland Ambassadors Graduate Research Fellowship allows graduate students to travel to another country and conduct groundbreaking wetland research with some of the world's top wetland research scientists.

Area (38.3642 N, -115.1223 W), Ninepipe Water Management Area (47.4399 N, -114.1007 W), Bear Lake (42.1724 N, -111.3227 W), and Pahranagat-North Lake (37.2596 N, -115.1098 W).

METHODS

In two experiments, bulrush and Phragmites seeds were placed in separate growth chambers (Conviron® Model A1000, Conviron, North Branch, Manitoba, Canada) set to one of four temperature regimes. Three replicates of > 100 seeds for each species and populations were placed in parafilm sealed germination boxes (11 x 11 x 4 cm) with 100 mL of distilled water and solutions of polyethylene glycol (PEG). Germination was recorded daily for four weeks (Figure 2). To simulate current and future predicted temperatures for the Great Salt Lake, maximum and minimum monthly average temperatures came from the global climate model (GCM) data of CMIP5 manually pulled from Worldclim (Hijmans et al. 2005). For Experiment 1, germination boxes of each species (S. acutus, S. americanus, and P. australis) were distributed among four temperature regimes (monthly average of daytime and nighttime temperatures): 23/10° C (present May in Great Salt Lake wetlands), 28/14° C (present June), 33/18° C (present July and also June 2070), and 36/20° C (July 2070), and each water potential (0, -0.15, -0.3, -0.6, and -1.2 MPa). In total, Experiment 1 had 216 sample units (60 treatments + 12 extra treatments of Ψ_0 MPa X 3 replicates X 100 seeds = 21,600 seeds) and 60 treatments (3 species X 4 temperature X 5 water potential). The experiment was run in two phases: phase 1 (installed on June 9, 2018, with the water potential 0, -0.15, and -0.3 MPa) and phase 2 (installed on July 3, 2018, with the water potential 0, -0.6, and -1.2 MPa). For Experiment 2, a range of geographically different seed sources (five populations of *S. acutus*; Figure 1) were used. Germination boxes of each population were distributed among the same four temperature regimes of Experiment 1, and each water potential (0, -0.6, and -1.2 MPa). In total, Experiment 2 had 180 sample units (60 treatment X 3 replicate X 100 seeds = 18,000 seeds) and 60 treatments (5 populations X 4 temperature X 3 water potential). The experiment was installed on July 5, 2018 and ran through August 2, 2018.

The field experiment (seeding trial) occurred in June and July 2018. Fifty seeds of the two bulrush species (*S. acutus* and *S. americanus*) were distributed among eight germination plots (~20 L, bag strainer) at two sites (Farmington Bay and Bear River Migratory Bird Refuge). Temperature sensors (iButtons model DS1922L) and soil water potential sensors (Watermark Sensors) were installed in each seed bag (Figure 3). Each of the temperature sensors was enclosed in an iButton case (model DS9107) to prevent water from damaging the sensor. The temperature was recorded every 2 hours and water potential every 4 hours. The experiment was initiated on June 18, 2018, and total germination was recorded after four weeks.

PRELIMINARY RESULTS

While final analysis of the study data is underway and will be reported later, there are some preliminary observations of note.

1. Seed germination in all species was affected by temperature and water potential changes.
2. Total germination in all species was reduced as the water potential decreased.
3. Total germination of S. americanus was lower than S. acutus and P. australis in all treatments.
4. In the 0 MPa treatments, the total germination of P. australis was the same for all temperature regimes.
5. There were no significant differences between seeds sourced from the different regions.
6. Field germination rates for both bulrush species was lower than germination under simulated climate change conditions in growth chambers. ■

FIGURE 2. Germinated seeds of hardstem bulrush, *Schoenoplectus acutus*.

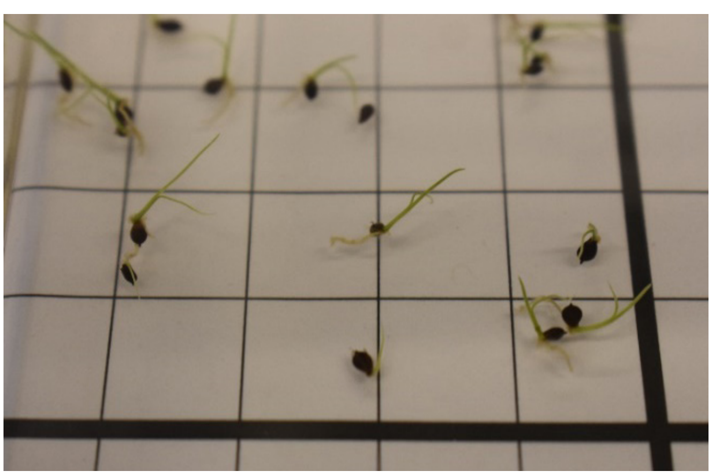


FIGURE 3. Soil water potential sensors and seed bags in the field.

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My Experiences as a Wetland Ambassador

I am currently a Ph.D. candidate in Biological Sciences at the Autonomous University of Queretaro, Mexico. I completed my Master's degree in the field of Plant Sciences at Santa Catarina State University, Brazil in 2013. My research interests are broad, but they focus on biodiversity, ecology, genetics, and conservation of freshwater ecosystems. I have been working on large-scale spatial patterns of aquatic plants, combining community and population approaches. I have conducted graduate research mainly on central Mexico highland sites, where temporary wetlands are part of the landscape and are geographically isolated. The title of my Wetland Ambassadors fellowship project was "Potential climate change impacts on native seeds relative to invasive *Phragmites*: implications for Great Salt Lake wetland restoration".

I carried out my SWS Wetland Ambassadors fellowship at the Wetland Ecology Lab at Utah State University, Logan, U.S.A, under the mentorship of Dr. Karin Kettenring. Being a Wetland Ambassador this summer helped me to reach my goal to become an innovator in the field of wetland science. I achieved my previous aims for joining this program specifically to: (1) improve my scientific skills for high-level research, (2) meet future research collaborators, and (3) publish scientific papers. I was also involved in other projects of the Wetland Ecology Lab, including with some restoration projects, insect surveys, and rhizome collections (Figure 4). With these activities I had the opportunity to learn new techniques, to meet interesting people working in Dr. Kettenring's Lab, and to visit wetlands along Utah Lake and Clear Lake, and at Salt Creek Waterfowl Management Area (WMA), Bear River Bird Refuge, and Farmington Bay WMA.

The following are some outputs from this experience:

- Webinar: Dr. Karin Kettenring and I presented the experiment results in an SWS webinar (December 13th 2018), entitled "Potential climate change impacts on native seeds relative to invasive *Phragmites*: implications for Great Salt Lake wetland restoration."
- Scientific paper: Dr. Karin Kettenring, Emily Martin (a graduate student at Utah State University), and I are working on a publication using the data from my experiments in the Wetland Ecology Lab.

- Conference: The Biological Sciences graduate program at Autonomous University of Querétaro (the Ph.D. program in which I am enrolled) invited me to present a talk to graduate students about my experience in Utah.

Researching in Dr. Karin Kettenring's Lab broadened my experience and knowledge of wetland science and restoration. This experience gave me the opportunity to learn new techniques for wetland restoration, data analysis, and new tools for field data collection. I will take advantage of the new knowledge acquired, and apply it in the developing world, thereby advancing the science by practicing it in places where wetland conservation is less established. Also, conducting a project in another country in a new (to me) wetland type increased my understanding of the ecology and diversity patterns in these environments. In this Fellowship program, I had the opportunity to strengthen my multi-disciplinary research approaches, which will allow me to do projects better in the future.

I seek opportunities for promoting the SWS specifically by increasing international awareness of it. Also, I am looking for ways to contribute to the Society's goals on these points: (1) promote discussions about wetlands in forums and blogs, (2) encourage integration of different branches of wetland science and practice, and (3) enhance exchange of ideas and data through an SWS webinar.

Finally, I thank the Society of Wetland Scientists for this unique opportunity. ■

FIGURE 4. Working on an aquatic insect survey (the author, Jack Trice, Emily Leonard, and Emily Martin), bulrush rhizome collections (Karin Kettenring and the author), and wetland restoration projects (Emily Martin, Amanda Mast, Dave England).