ALBERTA'S
LIVING LABORATORY
PROJECT

Final Report 2018

Prepared for: Alberta Land Institute

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1) EXECUTIVE SUMMARY

This three-year, interdisciplinary research project informs both the science and economics of wetland restoration, using the Nose Creek Watershed in Rocky View County, Alberta, as an on-the-ground living laboratory.

Through extensive fieldwork and laboratory analysis, researchers at Western University are working to understand the recovery rates of individual wetland functions. The research team is currently undertaking a chronosequence (a time series) of soil samples from previously restored wetlands to date the soil and analyze rates of nutrient retention. The use of a Hydrologically Distributed Model (HDM) allowed researchers to map connections between wetlands and other large drainage features.

The economic side of the project involved the actual restoration of wetlands with the use of a market-based instrument known as a reverse auction. In a reverse auction, landowners submit bids to the restoration agent to communicate their willingness to accept compensation for wetland restoration on their property. The auction is complete, with four landowners in the study region submitting bids. In total, 13 basins totaling 47.27 acres were accepted for restoration. To date all of these basins have been restored (Table 3).

University of Alberta maintains ongoing communications with Rocky View County and private landowners. Furthermore, priority areas for restoration are being identified in the coming months to ensure that a second auction in Rocky View County remains a viable option for the City of Calgary. Additionally, this project has provided opportunities for future research and has created scientific and communications tools that can be adopted by municipalities throughout Alberta who may wish to prioritize wetlands for restoration or implement a reverse auction in their jurisdictions.

2) PROJECT ACCOMPLISHMENTS

Our proposal had outlined seven phases of work over the four years of funding for this project:

1) Understanding the historic, current, and future ecosystem function of wetlands in Nose Creek Watershed
2) Reverse Auction Coordination and Promotion
3) On-Site Assessments and Development of Restoration Plans
4) Reverse Auction Implementation
5) Restoration Activity and Construction
6) Monitoring and Evaluation
7) (Ongoing) Communications and Outreach

Phases 1, 3, and 6: Wetland Science

Purpose: To understand the historic, current, and future ecosystem functions of wetlands in the Nose Creek Watershed/On-site assessments and development of restoration plans

A Comprehensive Drained Wetland Inventory

The research team commissioned a flight to obtain LiDAR (light detection and ranging) data for the Nose Creek subwatershed. The LiDAR digital elevation model and optical imagery method created an existing wetland inventory. There are approximately 24,570 spatially located, existing wetlands in the Nose Creek watershed, totaling 12,166 ha (14% of the subwatershed).

Researchers used curvature analysis to develop an inventory of wetlands that have been drained with a ditch, which were the "restorable" wetlands that were targets for the auction. According to this inventory, there are 1,588 restorable wetlands in the Nose Creek watershed. This inventory was verified in July 2015, by observing a collection of sites from the roadside including intact wetlands, altered wetlands, and random non-wetland sites in Rocky View County.

Estimates of Total Wetland Loss

We estimated wetland loss using the existing and drained wetland inventory. Our results suggest that within the Nose Creek watershed there has been a historical loss of 72% of wetland number and 79% loss of wetland area. Of the wetland number loss, 7% of this loss is restorable (i.e., has a drainage ditch) and of the area loss, 10% of this is restorable (Figure 1). Detailed information on inventory calculations are in Waz and Creed (2017).

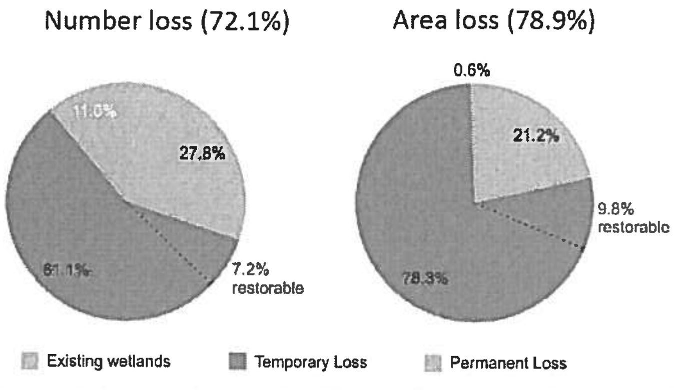

Figure 1: Wetland number and area loss in the Nose Creek watershed.

On-Site Assessment and Development of Restoration Plans

Current ABWRET-E wetland function: We used the ABWRET-E tool (Creed et al. 2018) to remotely assess the functions of all drained wetlands identified in the drained wetland inventory and all mapped existing wetlands within the Nose Creek watershed. Our results indicate that the ditch-drained wetlands identified in the drained wetland inventory in the Nose Creek had higher average function scores for all categories, except for ecological health, than existing wetlands (Figure 2).

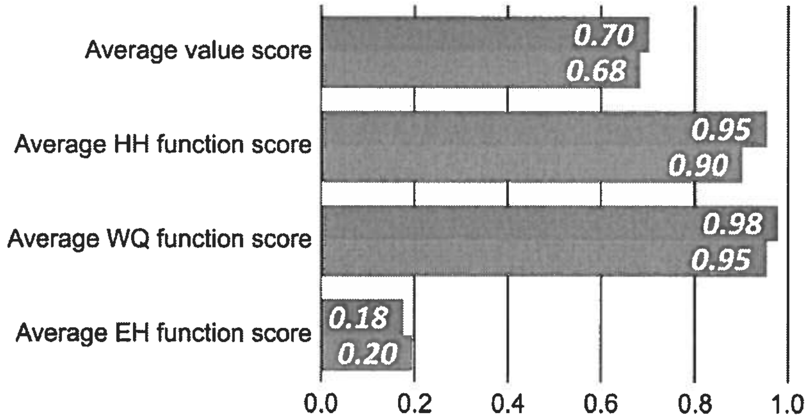

Figure 2: ABWRET-E scores for ditch drained wetlands identified in the drained wetland inventory (blue) and existing wetlands (orange)

ABWRET-E and ABWRET-A functions of wetlands restored: The research team assessed the function of drained wetlands that were restored as part of this project using the ABWRET-A tool in summer 2016. We compared the ABWRET-A results to the ABWRET-E results we computed for the restored wetlands to determine any differences that occur between the two standardized methodologies (Table 1). We calculated the functions for the restored wetlands in the Nose Creek using the ABWRET-Actual tool pre-restoration (Table 2).

Table 1: ABWRET-Actual (A) v. ABWRET-Estimated (E) and Discrepancies

Restored Wetland ID	ABWRET - A	ABWRET - E	Difference
4	C	C	None
4	C	C	None
1	C	C	None
1	B	C	-1
2	D	C	1
2	D	C	1
3	C	C	None
3	D	C	1
3	C	C	None
3	C	C	None
3	D	C	1
3	D	C	1

Table 2. ABWRET-A Assessment Results

Function (ABWRET-A Raw Score)	1	2	3	4	5	6	7	8	9	10	11	12
Surface Water Storage (WS)	6.52	5.32	3.31	5.81	3.83	3.13	3.86	4.20	5.71	5.65	5.79	6.63
Stream Flow Support (SFS)	0.00	0.00	2.64	0.00	3.51	3.49	2.74	2.96	0.00	0.00	0.00	0.00
Streamwater Cooling (WC)	0.00	0.00	1.31	0.00	2.31	2.56	0.81	0.95	0.00	0.00	0.00	0.00
Sediment & Toxicant Retention & Stabilization (SR)	10.00	10.00	4.14	10.00	4.36	4.02	4.22	4.37	10.00	10.00	10.00	10.00
Phosphorus Retention (PR)	10.00	10.00	3.52	10.00	4.18	4.20	3.96	4.13	10.00	10.00	10.00	10.00
Nitrate Removal & Retention (NR)	10.00	10.00	4.53	10.00	4.96	4.38	5.19	5.45	10.00	10.00	10.00	10.00
Organic Nutrient Export (OE)	0.00	0.00	3.08	0.00	5.02	4.61	3.91	3.77	0.00	0.00	0.00	0.00
Fish Habitat (FH)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Aquatic Invertebrate Habitat (INV)	5.53	4.81	5.23	4.69	7.04	5.03	4.86	5.82	4.83	6.51	4.84	4.94
Amphibian Habitat (AM)	2.69	2.46	2.61	2.31	3.52	2.54	2.49	2.99	2.46	3.32	2.39	2.48
Waterbird Habitat (WB)	5.34	3.90	4.06	4.98	5.16	4.07	3.99	4.48	4.18	5.22	5.09	5.14
Songbird, Raptor, & Mammal Habitat (SBM)	2.68	2.41	2.78	2.11	4.16	3.02	2.92	3.44	2.69	3.72	2.31	2.26
Pollinator & Native Plant Habitat (PH)	3.38	2.36	2.93	2.77	4.22	3.15	3.23	3.54	2.82	3.37	2.88	2.19
Human Use & Recognition (HU)	2.01	1.64	1.96	1.48	1.59	1.46	1.40	1.68	2.92	2.77	1.70	1.72
Function (ABWRET-A Normalized Score)												
Surface Water Storage (WS)	0.91	0.70	0.35	0.79	0.44	0.32	0.45	0.50	0.77	0.76	0.78	0.93
Stream Flow Support (SFS)	0.00	0.00	0.43	0.00	0.57	0.57	0.45	0.48	0.00	0.00	0.00	0.00
Streamwater Cooling (WC)	0.00	0.00	0.19	0.00	0.34	0.37	0.12	0.14	0.00	0.00	0.00	0.00
Sediment & Toxicant Retention & Stabilization (SR)	1.00	1.00	0.25	1.00	0.27	0.23	0.26	0.28	1.00	1.00	1.00	1.00
Phosphorus Retention (PR)	1.00	1.00	0.22	1.00	0.30	0.30	0.27	0.29	1.00	1.00	1.00	1.00
Nitrate Removal & Retention (NR)	1.00	1.00	0.15	1.00	0.22	0.13	0.26	0.30	1.00	1.00	1.00	1.00
Organic Nutrient Export (OE)	0.00	0.00	0.47	0.00	0.77	0.71	0.60	0.58	0.00	0.00	0.00	0.00
Fish Habitat (FH)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Aquatic Invertebrate Habitat (INV)	0.57	0.47	0.53	0.46	0.76	0.50	0.48	0.60	0.47	0.69	0.48	0.49
Amphibian Habitat (AM)	0.34	0.31	0.33	0.28	0.48	0.32	0.31	0.39	0.30	0.45	0.29	0.31
Waterbird Habitat (WB)	0.42	0.24	0.26	0.38	0.40	0.27	0.26	0.32	0.28	0.41	0.39	0.40
Songbird, Raptor, & Mammal Habitat (SBM)	0.21	0.15	0.22	0.10	0.48	0.27	0.25	0.35	0.21	0.40	0.14	0.13
Pollinator & Native Plant Habitat (PH)	0.29	0.11	0.21	0.18	0.44	0.25	0.26	0.32	0.19	0.29	0.20	0.08
Human Use & Recognition (HU)	0.19	0.12	0.18	0.09	0.11	0.08	0.07	0.13	0.37	0.34	0.13	0.13
Normalized Score (ABWRET-A) Based on Wetlands in RWVAU												
Normalized Hydrological Health (HH)	0.91	0.70	0.43	0.79	0.57	0.57	0.45	0.50	0.77	0.76	0.78	0.93
Normalized Water Quality (WQ)	1.00	1.00	0.47	1.00	0.77	0.71	0.60	0.58	1.00	1.00	1.00	1.00
Normalized Ecological Health (EH)	0.57	0.47	0.53	0.46	0.76	0.50	0.48	0.60	0.47	0.69	0.48	0.49
Normalized Human Use (HU)	0.19	0.12	0.18	0.09	0.11	0.08	0.07	0.13	0.37	0.34	0.13	0.13
RWVAU #	16	13	13	16	13	13	13	13	13	13	16	16
Normalized Value Score (ABWRET_a)	0.76	0.66	0.45	0.68	0.64	0.54	0.46	0.52	0.71	0.77	0.69	0.74
Value Category (a, b, c, d)	c	d	d	d	d	d	d	d	d	c	d	c
Abundance Factor	0	1	1	0	1	1	1	1	1	1	0	0
Final Score (A, B, C, D)	C	C	D	D	C	C	D	D	C	B	D	C
Note that one restored basin could not be scored using the ABWRET protocol as it was considered too impacted at the time of the assessment.												

Monitoring and Evaluation

Wetland depletion arrests the ability of landscapes to provide ecosystem services: to attenuate floods; retain and process nutrients; sequester carbon; and to provide habitat. It is largely unknown how quickly these ecosystem services recover post-restoration or what relationship exists between time since wetland restoration and the rate of carbon sequestration/nutrient accumulation.

Given the short project duration, gaining meaningful insights into the return of ecosystem functions in the restored wetlands as part of this project was unlikely. Therefore, we sampled wetlands that were previously restored by Ducks Unlimited Canada (DUC) to examine the rate of recovery of ecosystem functions in wetlands that varied in the number of years since restoration, from zero (Drained) to 23 years restored. The restored wetlands that were sampled were located in the Camrose area, located in the Parkland Natural Region as there were no previously restored wetlands in the Nose Creek watershed (Figure 1). Criteria for selection of the restored wetlands were as follows: (1) age since restoration; (2) located on property owned by DUC; (3) restored using a ditch plug; and (4) accessible. In total, 30 wetlands were sampled in 2016, including: three drained; 3 intact; and 24 restored wetlands (Figure 3).

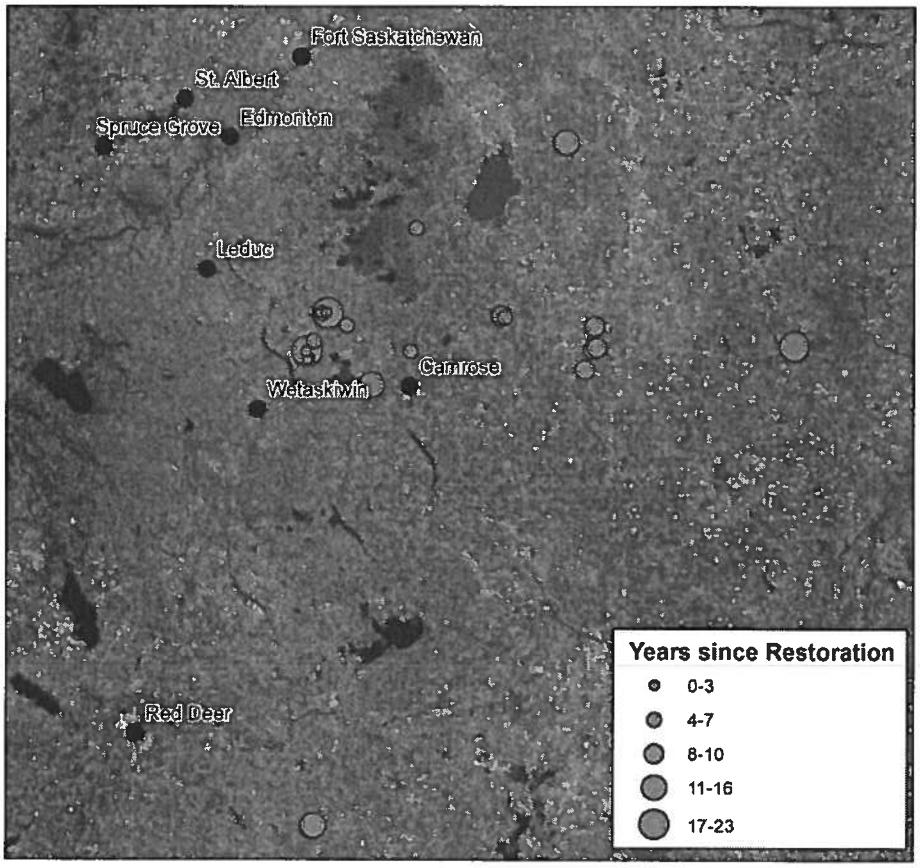

Figure 3: Wetland chronosequence sampling sites in the Parkland Natural Region of Alberta. The age since restoration is as of 2016.

Carbon and phosphorus sequestration: Sampling for carbon and phosphorus involved taking soil cores from each of the thirty wetlands in the sample. These soil cores have undergone isotope analysis at the University of Manitoba in order to determine their age. Researchers at Western University are currently processing this data to determine nutrient retention rates. Soil samples from drained wetlands collected during the 2016 field season will be necessary to develop baseline conditions of carbon and phosphorus storage and to determine accumulation rates pre-restoration. Results of the chronosequence will provide information about the potential use of restored wetlands to store greenhouse gases (i.e., CO_2) and nutrients (phosphorus). A better understanding of the potential of restorable wetlands is highly valuable, as it provides evidence-based insight for development of landowner's wetland restoration contracts.

Vegetation recovery patterns in restored wetlands: Researchers are determining the success of wetland restoration and ecosystem process recovery by evaluating vegetation recovery patterns and plant functional traits within restored wetlands. Detailed vegetation surveys were conducted at each of the 30 wetlands during July and August of 2016 and 2017, corresponding to the peak-growing season for the Central Parkland sub-region of Alberta. This regional wetland plant diversity study will help to inform the restorative and management directives that have been and are currently being developed as part of the implementation of Alberta's Wetland Policy (2013).

Each wetland that was sampled was delineated using common field indicators of wetland habitat such as:

- Vegetation: hydrophytic species cover more than 50% of the dominant plant species (>20%) in the plot.
- Soils: thick organic layer (>30cm), gleying and/or mottling within 30cm, oxidized rhizospheres, etc.
- Hydrology: presence of surface water, sediment deposits, watermarks, presence of shells, etc.

Vegetation sampling was conducted to capture heterogeneity across the hydrologic gradient of wetlands as represented by different vegetation zones (riparian, wet meadow, emergent, and open water). Quadrats were sampled within each vegetation zone based on species-area accumulation curves. Plants were identified to the species level, and percent cover was estimated using a cover class system to minimize observer bias. In addition, relevé sampling (random walk through) was conducted in each wetland to identify rare species or species otherwise not recorded through quadrat sampling.

All species were identified based on the flora of Alberta, nativity, and wetland indicator status. Vegetation measures based on species richness, diversity, and community composition were calculated to determine the variability in these natural wetlands.

Our results indicate that restored wetlands resemble natural wetlands on agricultural landscapes within 3-5 years of restoration (Figure 4). However, restored wetlands maintained significantly lower species richness and a distinct community composition compared to wetlands located within natural reserves (Cooking Lake-Blackfoot Provincial Recreation Area). Early establishment of non-native species during recovery, dispersal limitation, and depauperated native seed bank were probable barriers to complete recovery.

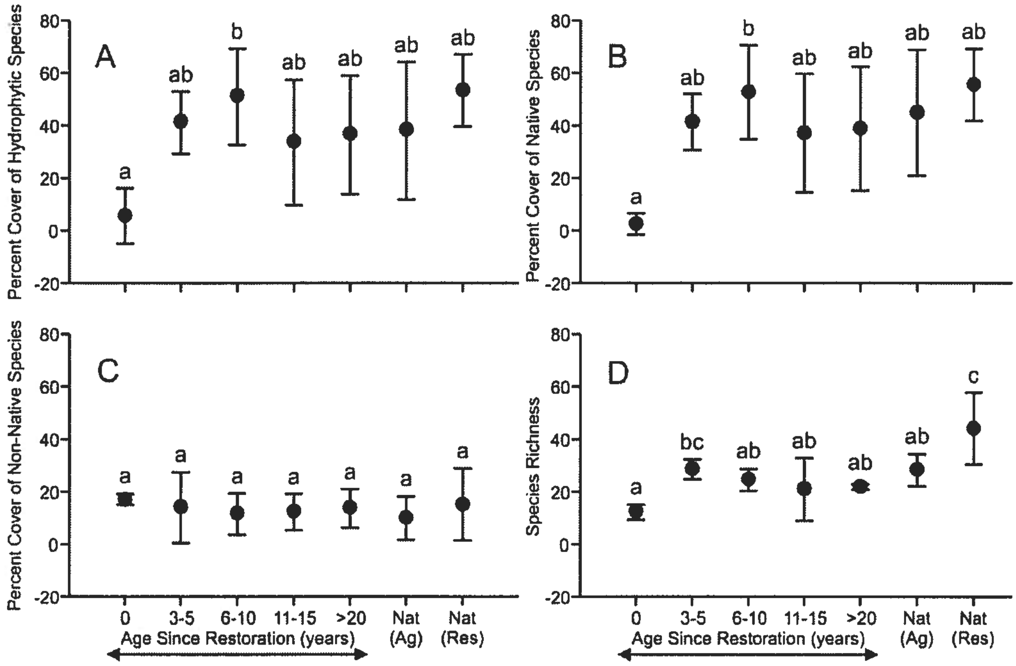

Figure 4: Mean ± SD (A) percent cover of hydrophytes, (B) percent cover of native species, (C) percent cover of non-native species, and (D) species richness across a chronosequence of restored wetlands. Age 0 represents drained wetlands, Nat (Ag) represents natural wetlands on agricultural landscape, and Nat (Res) represents wetlands located within a natural reserve. Different letters indicate significant differences.

Wetland restoration and watershed hydrologic resilience: A hydrologically distributed model that examines and maps surface and subsurface connections between wetlands and other larger drainage features (e.g., rivers, lakes) has been developed for the Nose Creek watershed. This grid-free model is able to efficiently take into account the geometry of small-scale potholes and satisfy the governing equation and mass balance in the entire basin (see Ameli and Creed 2017 for more information). Therefore, this model can efficiently determine the source, destination, age, and travel time of the water (solute) particles among wetlands and the catchment outlet. Additionally, it can establish the hydrological connectivity between wetlands and allow us to gain understanding of the changes in hydrology that occur due to the restoration and/or drainage of wetlands on the landscape. Further, the model allows for the simulation of connections between wetlands and other hydrologic features during various wetness conditions.

We calibrated and applied this model to the Nose Creek watershed to examine changes in hydrology with wetland drainage and whether the restoration location of wetlands within the watershed disproportionately promotes watershed resilience to floods and droughts. Our results found that increases in peakflow and decreases in baseflow, especially as the area of wetland removal surpasses 50% of historical wetland extent. We found that wetlands within 100 meters of the major stream network (Nose Creek and West Nose Creek) play a disproportionately important role in attenuating peakflow, while location is not important for baseflow.

We also applied the model during a simulation of the major flood event that occurred in the City of Calgary in June 2013. Our results reveal that if all 1,500 drained wetlands were restored in the Nose Creek watershed, they could have reduced the total volume of flow originating from the Nose Creek watershed by 1.5×10^6 cubic metres during the week of the flood. This volume of water is equal to 16% of total flow discharged toward the City of Calgary from the Nose Creek watershed during the week of the flood.

Phases 2 and 4: Reverse Auction

Reverse Auction Coordination and Promotion

Communication strategy: In fall 2014 and winter 2015, the research team spent a significant amount of time developing and planning communications materials for advertising the reverse auction.

- Branding and logo: The research team worked with Gillian Harvey of Part Deux Creative to develop a consistent brand and logo for the project, including the project name, "Alberta's Living Laboratory Project."
- Messaging and tag lines: The research team also worked with Gillian Harvey to develop standard messaging across the project materials, including "tag lines" that include key information about the project.
- Website: A website was created specifically for the reverse auction component of this research at www.RestoreOurWetlands.ca. The website is aimed to help landowners understand what the project is about and how they can become involved. The website includes interactive graphics about "What is a Wetland" and "What is a Reverse Auction." There are also downloadable files available about the project.
- Print materials: Print materials including brochures, Frequently Asked Questions, images of the roll-up banners brought to events, and materials for the engagement of kids were created.

Local auction advertising: Since February 2015, the research team has been engaged in broader communications with the Rocky View County public. In addition to having materials and events that focused on recruitment for participation in the auction, our campaign also communicated the import values and functions that wetlands provide to human communities. A list of the main outreach activities that our team undertook as part of the auction promotion are listed below:

- Project launch: An official launch event was held on March 10, 2015, at Golden Rod Hall in Rocky View County. The list of invitees included local Rocky View County employees and representatives as well as approximately 50 local community leaders as identified by the Agricultural Services staff at Rocky View County. The project launch included a dinner for all attendees. The agenda included a presentation by the project team and a mock "reverse auction," in which attendees submitted bids to receive real money.
- Agri-view newsletters: Rocky View County releases a newsletter for all agricultural landowners in the county four times per year, called "Agri-View." The research team has had an article about the project in three consecutive issues of the newsletter and has received positive feedback from community members about the articles.
- Farm tour: Rocky View County holds an annual farm tour in July. The research team attended the farm tour on July 24, 2015 and presented to those attending the tour, approximately 150 participants. The team also had an information booth at the dinner that was held after the event.
- News articles: Local and Alberta-based media have written news articles about the project, including:
    - Edmonton Journal, "University of Alberta project will use market mechanisms to restore wetlands," March 10, 2015
    - Alberta Beef Magazine, "Tools to restore wetlands," May 2015
    - Alberta Farmer Express, "What's it worth? New project aims to nail down the value of wetlands," June 24, 2015
    - The Morinville news, "Restoring wetlands through market-based solutions" September, 2017
    - The Ag Review [Rocky View County] "Wetland restoration success" September 2017
    - The Pincher Creek Voice "Restoring Wetlands through market-based solutions" September 2017

After identifying landowners with drained wetlands on their property, the research team targeted advertising specifically to those landowners within the study area that could potentially participate in the auction. This targeted communication included:

- Information mail out: The research team sent letters and project brochures to 255 potential participants in July 2015. The letter explained the project and what the research team was hoping to achieve in terms of paying landowners to restore wetlands.
- Phone campaign: The research team was able to obtain phone numbers for most potential participants from staff at Rocky View County. Members of the

project team made phone calls to 124 landowners that had received the information mail outs.

- Focus group: Dr. Boxall held a focus group session on August 24, 2015. Five landowners who lived in Rocky View County but outside of the watershed were invited to provide feedback on contract structure, payment schedules and management practices with regards to wetland restoration.
- Information sessions: The research team held information sessions for potential reverse auction participants on September 15, 2015 and on October 21, 2015 in Airdrie. These sessions were well-attended and provided landowners an opportunity to view maps with the researchers and discuss some of the specific concerns they had about participating.

The research team identified five landowners in the study region who were interested in submitting bids into the auction. The restoration agent, Ducks Unlimited Canada (DUC), along with Dr. Shari Clare of Fiera Biological, visited each landowner and inspected prospective basins. DUC staff followed up with a formal land survey to show each landowner the extent of the restored wetland boundaries post-restoration. These boundaries were mapped on an aerial photograph and were provided to each landowner. At both the initial visit, as well as the subsequent formal survey, restoration issues, such as required engineered structures to prevent flooding or the presence of oil and gas infrastructure were identified for each basin and were also mapped on the aerial photographs. These maps were then sent to the reverse auction team (Dr. Peter Boxall and MSc. Student Anna Kauffman).

Boxall and Kauffman visited all five landowners who expressed interest in participating in the auction to discuss the auction and the restoration work that would occur on each drained wetland on the landowners property. Each landowner was presented with a copy of the contract that would be used to secure the basin once a bid was submitted and accepted. The contract is virtually the same as the current contract used by DUC. Contract provisions included a ten-year term, with no limit on grazing or haying of the restored wetland. The pricing method was uniform as each winning bidder received equal payments per acre. DUC will make payments with 50% of the payment made up front, and 50% of the payment distributed over ten years paid at 1.6% interest. Landowners and University of Alberta researchers had in-depth discussions of various issues, including the contract term, the extent of the restoration, the need for subsequent follow-up visits by DUC for monitoring, and a timeline of bid submission and restoration. The team also discussed with each landowner various factors that could be considered in determining the dollar value of bids including, but not limited to: potential costs associated with herbicides for weed control, fencing to keep livestock away from the restoration work, and various opportunity costs associated with the land (e.g. cropping areas, stocking rates, etc.). At no time did the team tell the landowners who the other potential bidders were, nor did they discuss actual bid prices during the visits.

Four of the five potential bidders submitted. In total, 14 basins were bid into the auction (see Table 1). One of the 14 basins required an engineered water structure, which would be costly to restore. In discussions with the City of Calgary, it was decided that all bids (excluding the one requiring an engineered structure) would be accepted. Thus, 13 basins totaling 47.27 acres (19.13 hectares) were selected for restoration (Table 3).

Table 3. A summary of accepted basins in the Nose Creek reverse auction - April 2016.

Bidder ID	*Size of Basin (acres)*
1	2.12
1	0.54
2	0.4
2	1.19
3	0.7
3	8.26
3	5.54
3	4.37
3	2.54
3	1.37
3	4.68
4	11.05
4	4.51
4[1]	4.16
Total of all bids	**51.43**
Total of accepted bids	**47.27**

[1] This basin would require an engineered structure that would involve high restoration costs, so the bid for this basin was not accepted in the auction.

The next step involved DUC, who was contracted by the City of Calgary to perform the actual restoration work, contacting each successful bidder to formally sign the contract and book a date for the restoration work to proceed. All landowners have had their wetlands restored as of November 2017.

With the reverse auction completed, Boxall and Kauffman have completed the following research pieces:

- The drained inventory was used to develop estimates of the actual physical supply of drained basins that could have been associated with bids. This will allow us to determine what percentage of the drained lands actually were secured in the auction. When merged with land ownership information, these data will also allow the construction of an estimate of the participation rate of potential bidders in the auction. Among 66 bidders targeted for participation in our auction, 4 landowners participated. This indicates a 6% participation rate in our auction.

- Kauffman interviewed successful bidders in both the Nose Creek and Wintering Hills auctions. She also interviewed eligible bidders who did not participate in either of the two auctions. The information collected from these interviews will help determine: how landowners formulate bids; why they did not participate in the auctions, and; what they think of auctions as a method to secure wetland areas for restoration in future securement programs.
- Kauffman used phone communication records from the Assiniboine River Auction (conducted in 2010) and the Rocky View County Auction to highlight key themes of consideration for non-participation in wetland restoration.
- Kauffman interviewed six non-participant landowners in Rocky View County in order to qualify landowner's barriers to participation in the auction. Results indicate that landowners perceive a high cost of participation in the form of nuisance costs. Landowners are averse to contracts as they are unwilling to give up property rights. Finally, landowners do not believe that they have a restorable wetland on their property.

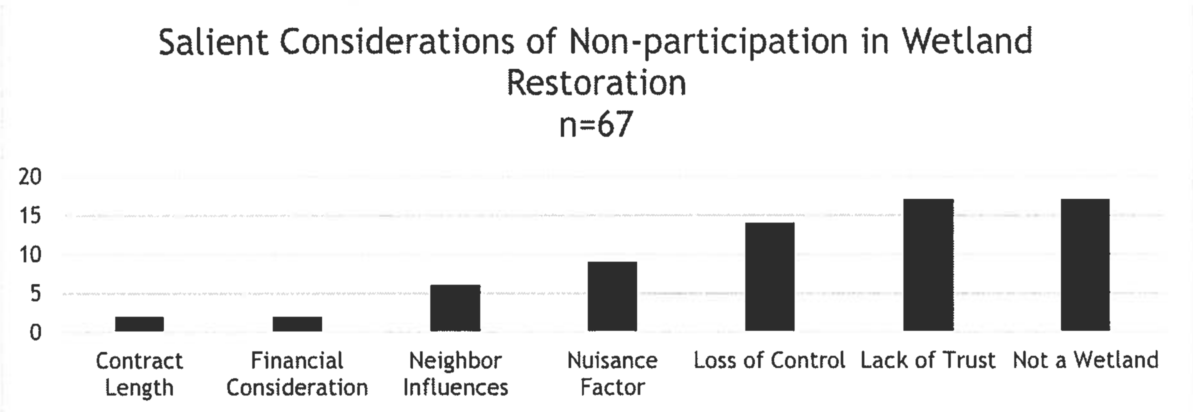

Figure 1 Word query summary for communications records showing the highest response, as "I do not have a wetland on my property." Lack of trust, loss of property rights, and nuisance factors are also important.

- Kauffman and Boxall investigated the bid amounts in the auction and benchmarked these bids against opportunity costs (the foregone benefit) in order to determine opportunistic bidding behavior. We compared these estimates with estimates from two other auctions: the Assiniboine River Watershed (2010) and the Wheatland County Auction (2015). Results show that bidders did not seek high degrees of information rent in comparison to the other auctions that were of similar design.

Phase 5: Restoration Activity and Construction

Wetland restoration was conducted by Ducks Unlimited Canada. Restoration began in fall 2016 and was completed in October 2017. Peter Boxall, Anna Kauffman, and the project manager Hawley Campbell attended one of the restoration sites in person to learn more about the process and take photos of the work.

Phase 7: Ongoing Communications and Outreach

We have hosted a number of events and meetings to encourage landowner participation in our project including those listed above in the reverse auction section. Members of our research team have also presented about this project at events held by project partners or other organizations, including:

- Alberta Innovates - Bio Solutions Impact Innovation 2015 (May 2015)
- Rocky View County Agricultural Service Board (May 2015)
- Alberta Beef Producers - Environment Committee (May 2015)
- Bow River Basin Committee - Legislation and Policy Subcommittee (June 2015)
- Alberta Association of Conservation Offsets (September 2015)
- Alberta Land Institute – Community Advisory Board (October 2015)
- Association of Alberta Agricultural Fieldmen's In-Service Training (December 2015)
- Agri-Environmental Partnership of Alberta (December 2015)
- Battle River Watershed (March 2016)
- Land Use 2016 - Alberta Land Institute Conference (May 2016)
- Watershed Resiliency and Restoration Program South Showcase, Lethbridge, AB (April 2017)
- Wetland Ecological Services Workshop, Ottawa, ON (February 2017)
- Technical Advisory Committee meeting (April 2017)
- Canadian Agricultural Economics Society Annual Meeting (June 2017)
- Agri-Food Policy Conference- Canadian Agricultural Economics Society (January 2018)
- Technical Advisory Committee meeting (February 2018)
- Alberta Innovates - Bio Solutions Workshop on MBIs (November 2018)

Outputs

In addition, numerous presentations about the project have been made at professional conferences (see below).

Listing of Papers arising from this initiative presented at professional conferences:

2018

Serran JN, Creed IF, Lobb DA, Badiou P. 2018. Are nutrients being stored or going downstream? The carbon and phosphorus retention of restored, drained, and intact wetlands on agricultural landscapes. American Geophysical Union Fall Meeting, December 10-14, Washington DC.

Ameli AA, Creed IF. 2018. Managing wetlands to promote hydrologic resilience against flood and drought in human-altered watersheds. American Geophysical Union Fall Meeting, December 10-14, Washington DC

Creed IF. 2018 Concentration-Transit Length: A new relationship linking hydrology and biogeochemistry for science-based management of wetland-dominated landscapes. American Geophysical Union Fall Meeting, December 10-14, Washington, DC.

Creed IF. 2018. Connectivity Matters: A portfolio of hydrologic connections are needed to protect vulnerable waters and sustain watershed functions. North American Congress for Conservation Biology. July 21-26, Toronto, ON.

2017

Ameli AA, Creed IF. 2017. Quantifying surface and groundwater hydrologic connectivity of geographically isolated wetlands to surface water systems in a prairie pothole landscape. American Water Resources Association Spring Specialty Conference, April 30-May 3, Snowbird, UT.

Creed IF, Ameli AA. 2017. Cumulative effects of wetland drainage on watershed-scale subsurface hydrologic connectivity. American Geophysical Union Fall Meeting, December 11-15, New Orleans, LA.

Creed IF, Ameli AA, DeVries B, Zaffaroni M, Zamberletti P, Accatino F. 2017. Connectivity matters: Portfolios of hydrologic connections among geographically isolated wetlands and to rivers are important determinants of watershed functions. Society for Freshwater Science, Annual Meeting, June 4-8, 2017. Raleigh, NC.

Creed IF, Ameli AA. 2017. Prioritizing geographically isolated wetland management strategies to reduce the risk of eutrophication of Lake Winnipeg. American Water Resources Association Spring Specialty Conference, April 30-May 3, Snowbird, UT.

Creed IF. 2017. Connectivity matters: Portfolios of hydrologic connections of wetlands to streams are important determinants of wetland functions. Association for the Sciences of Limnology and Oceanography Aquatic Sciences Meeting, Mountains to the Sea, February 28-March 3, Honolulu, Hawaii.

Creed IF, Ameli AA. 2017. Management of hydro-biogeochemical connectivity of geographically isolated wetlands to reduce the risk of eutrophication of Lake Winnipeg, European Geosciences Union, General Assembly, April 23-28, Vienna, Austria.

Kauffman, A. 2017. An Analysis of Reverse Auctions for Drained Wetland Basin Securement. Student paper presented at the 2017 Canadian Agricultural Economics Society Meeting. June 18-21, Montréal, QC.

Zaffaroni M, Zamberletti P, Creed IF, Accatino F, De Michele C. 2017. No wetland is an island: Quantifying the contribution of individual wetlands to the resilience of species-at-risk on a prairie pothole landscape. Association for the Sciences of Limnology and

Oceanography Aquatic Sciences Meeting, Mountains to the Sea, February 28-March 3. Honolulu, Hawaii. (poster)

Zamberletti P, Zaffaroni M, Accatino F, Creed IF, De Michele C. 2017. "Keystone" wetlands for maintenance of vulnerable species in landscapes with different wetland network configurations. Association for the Sciences of Limnology and Oceanography Aquatic Sciences Meeting, Mountains to the Sea, February 28-March 3. Honolulu, Hawaii.

2016

Ameli AA, Creed IF. 2016. Efficiency of Best Management Practices in agricultural landscapes, International Association of Great Lakes Research Meeting, June 6-10, Guelph, ON.

Ameli AA, Creed IF. 2016. Mapping hydrologic connectivity of geographically isolated wetlands, European Geophysical Union General Assembly, April 17-22, Vienna, Austria.

Ameli AA, Creed IF. 2016. Hydrologic connectivity of geographically isolated wetlands to surface water systems. American Geophysical Union Fall Meeting, December 12-16, San Francisco, CA

Creed IF, Laurent KL, Serran JN. 2016. Scientific advances to inform market-based instruments for improved ecosystem services. United Nations Association in Canada Toronto Branch Earth Day 2016: Reflections on COP21: A call to think globally and act locally. April 23. Toronto, ON.

Creed IF. 2016. Wetland restoration can help us fast track the return of watershed ecosystem services. Land Use 2016: Regional Planning for Ecosystem Goods and Services. May 4-5. Edmonton, Alberta.

Creed IF. 2016. Wetland restoration can help us fast track the return of watershed ecosystem services. 10th INTECOL International Wetlands Conference: Hotspots of Biodiversity and Ecosystem services under Global Changes. September 19-24. Changshu, China.

Salaria S, Creed IF. 2016. Quantifying hydrologic connectivity and its influence on plant diversity in the Prairie Pothole Region of Alberta. International Association of Great Lakes Research Meeting, June 6-10, Guelph, ON. (poster)

Serran JN, Creed IF. 2016. Restoring wetlands through market based instruments. World Wetland Day, February 2, Waterloo, ON. (poster)

Waz A, Creed IF. 2016. Automating the identification of drained wetlands in the Prairie Pothole Region. World Wetland Day, February 2, Waterloo, ON. (poster)

Waz A, Creed IF. 2016. Automating the identification of drained wetlands. Symposium on Sustainable Agricultural Systems in the Great Lakes. April 14, London, ON. (poster)

Waz A, Creed IF. 2016. Automating the identification of drained wetlands. International Association of Great Lakes Research Meeting, June 6-10, Guelph, ON. (poster)

2015

Waz A, Creed IF. 2015. Identifying Drained Wetlands and their Anticipated Functions in the Prairie Pothole Region. Canadian Network for Aquatic Ecosystem Services Annual Meeting, April 29-30, Sault Ste. Marie, ON.

Listing of Publications:

Ameli AA, & Creed IF. Wetland restoration location matters in the promotion of watershed resilience to floods and droughts. Submitted to the Journal of American Water Resources Association.

Ameli AA, Creed IF. Groundwaters at risk: Wetland loss reduces sources, lengthens pathways, and decelerates rejuvenation of groundwater resources. Submitted to the Journal of American Water Resources Association.

Ameli AA, & Creed IF. 2017. Quantifying hydrologic connectivity of wetlands to surface water systems. Hydrology & Earth System Sciences, 21(3).

Waz A. & Creed IF. 2017. Automated techniques to identify lost and restorable wetlands in the Prairie Pothole Region. Wetlands. 37:1079-1091.

Zamberletti P, Zaffaroni M, Accatino F, Creed IF, De Michele C. Connectivity among wetlands matters for vulnerable amphibian populations in wetlandscapes. Ecological Modelling. 384:119-127.

Salaria S, Howard R, Clare S, Creed IF. In press. Incomplete recovery of plant diversity in restored prairie wetlands on agricultural landscapes. Restoration Ecology.

Zaffaroni M, Zamberletti P, Accatino F, Creed IF, De Michele C. Safeguarding wetlands and their connections within wetlandscapes to improve biodiversity outcomes. Submitted to the Journal of American Water Resources Association.

3) LESSONS LEARNED

There are many things that we learned as part of this project that could help inform both future wetland restoration research projects and on-the-ground wetland restoration.

1. *Provincial government participation is essential:* Wetland restoration work cannot happen without some level of provincial oversight. Numerous policies, regulations, and legislation are activated when wetland restoration is contemplated and executed.

2. *From a regulatory perspective, it is easier to drain a wetland than it is to restore a wetland:* Clarity regarding regulatory requirements and processing is lacking in the Government's new policy. We were told often that certain legislation and directives were coming with regards to wetland restoration, but were not in place when our project was being conducted. When restoring a wetland, we were unsure as to whether a Water Act approval was required, whether monitoring was required (and if so, who would be responsible and who would pay for the monitoring) and what was eligible for restoration. Partially drained wetlands were not eligible, according to the province, and neither were illegally drained wetlands. The South Saskatchewan Basin Closure Order also created additional confusion and uncertainty.

3. *Municipal government participation is key, but negotiating multiple municipal interests can be complex:* For this project, the City of Calgary was trying to restore wetlands as part of their compensation plan. The Municipal Government Act of Alberta states that municipalities are not to take interest in land that is outside their municipality. The wetlands that we restored were outside of the City of Calgary limits, so it was unclear as to whether this constitutes an interest in lands outside of their jurisdiction.

4. *Functional partnerships are crucial:* It takes numerous organizations and people to effectively restore a wetland. The key players are regulators (provincial and municipal), project coordinators and partners, land owners, and the restoration entity (the organization who carries out the restoration work). Wetlands are covered under numerous policies and frameworks (e.g., Wetland Policy, Water for Life Action Plan, Land-Use Framework) and often these agencies take interest in the process.

5. *Access to landowners is difficult without dedicated staff, trust, and good communication:* The recruitment of landowners to participate in the reverse auction requires effort. We hosted several information sessions, in person meetings, and on-site visits and surveys of each wetland. We also developed a dedicated project website, Twitter, and comprehensive communications plan. Recruitment of landowners also requires trust. Many landowners expressed reservation over the government dictating how they should manage their land. We had protracted discussions between our team and the Government of Alberta which resulted in delays to restoration work which fed skepticism. Several land owners also expressed a distrust and an unwillingness to work with DUC. Establishing connections with local organizations or the municipalities are key in gaining this trust. The Agricultural Service Officers in Rockyview County were pivotal in identifying potential farmers to participate.

6. *Dedicated staff are required for the administration of restoration programs*

7. *For many landowners, it's not just about the money.* Some landowners declined to participate in on first contact. Many landowners declined to participate after several conversations and after reviewing communication materials. Some landowners were not interested, the land was rented and would be too complicated, or felt like their site was unsuitable for restoration.

8. *We need more bulldozers and shovels:* More restoration agents would allow for an expanded scope of research with different approaches to wetland restoration.

4) PERSONNEL

This research project has contributed to student learning and the training of highly qualified personnel.

During the three-year research program, our research team included the following personnel:

Dr. Peter Boxall, Co-Principal Investigator

Dr. Irena Creed, Co-Principal Investigator

Dr. Shari Clare, Co-Investigator

Dr. Vic Adamowicz, ALI Research Director

Stacey O'Malley, Research Program Manager, University of Alberta (January - June 2016)

Hawley Campbell, Research Program Manager, University of Alberta (August 2016 - August 2017)

Anna Kauffman, Research Program Manager, University of Alberta (August 2017 - August 2018)

Jacqueline Serran, Field Technician/Program Manager (January 2015 - present)

Kaitlyn Cyr, MSc Student, University of Alberta (January - August 2016)

Anna Kauffman, MSc Student, University of Alberta

Anna Waz, MSc Student, Western University (September 2014 - August 2016)

Renee Howard, Summer Student then MSc student, Western University (September 2016 - August 2018)

Saloni Salaria, MSc Student, Western University (September 2015 - August 2017)

Sara Belontz, Summer Student and Research Assistant, Western University (May 2015 - April 2017)

Phillip Brewster, Summer Student, Western University (May - August 2015)

Michael Dallosch, Summer Student, Western University (May - August 2015)

Sergio Dominguez, Research Assistant (October 2017 - April 2018)

Colin Johnson, Research Assistant (May - November 2018)

5) BUDGET

Contributions from this grant have allowed our research team to fulfill our obligations to our grant funders. Please see Table 4 for the specifics of our expenditures to date.

6) REFERENCES

Ameli AA, & Creed IF. 2017. Quantifying hydrologic connectivity of wetlands to surface water systems. Hydrology & Earth System Sciences, 21(3).

Creed IF, Aldred DA, Serran JN, Accatino F. 2018. Maintaining the portfolio of wetland functions on landscapes: A rapid evaluation tool for estimated wetland functions and values. In: Dorney J, Savage R, Tiner R, Adamus P (eds). Wetland

and Stream Rapid Assessments: Development, Validation, and Application. Elsevier Publishing.

Waz A. & Creed IF. 2017. Automated techniques to identify lost and restorable wetlands in the Prairie Pothole Region. Wetlands. 37:1079-1091.