# RESTORATION OF CENTENNIAL WETLANDS, SHERWOOD PARK, ALBERTA:

# WEED COMMUNITY COMPOSITION AND MANAGEMENT

Final Report
**ER390**| Restoration of Natural System Practicum
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Cover photo: Constructed cell at Centennial Wetlands, Sherwood Park, Alberta; note the dense cover of scentless chamomile (*Tripleurospermum inodorum*), a noxious weed, at the site. Stakes associated with weed control trial plots monitored as part of this project are visible in the middle ground to the left. Photo by Brian Eaton.

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## Abstract

Centennial Wetlands is a wetland complex located in Sherwood Park, Alberta that consists of multiple natural and constructed cells incorporated into the municipal storm water management system. In 2012-2013, a new basin was constructed as part of this complex in compensation for a wetland that had been destroyed during development of a new transit and recycling facility nearby. As part of this construction, an extensive upland area was created between the new basin and a nearby remnant forest. Municipal environmental managers were interested in examining weed abundance and community composition, and potential non-chemical weed control methods, for the site. To this end, I established a total of 9 weed sampling and control plots in each of two areas at the site. These included 3 replicates in each area of control (no treatment), mow, and solarization, for a total of 18 plots. Sampling was down in all plots during establishment of the study (July 2015) to estimate overall plant community composition and weed abundance. Sampling was repeated in October 2015, and again in August 2016 to examine changes in weed abundance and community composition in response to treatments. Mean weed coverage was approximately 39% at project initiation, and seven weed species were present at the site. Weed cover was reduced by mowing in the first season, but had started to rebound by the end of the second growing season. Solarization was more effective at reducing weed cover, but I did not track response of the plant communities after removing the plastic sheeting used during the experiment. However, the effects of this approach are also expected to be transitory, based on other studies. I recommend that solarization be used to open space for planting and/or seeding native species, and for planting shrubs through the plastic to encourage strong establishment success and enhanced competitive ability. In addition, although not as effective at reducing weed populations, mowing could be combined with seeding and/or planting at sufficient densities to increase the likelihood of establishment of native species at the site. It may be necessary to protect these plantings/seedlings from local wildlife, as some species – such as Canada geese – can negatively affect young vegetation and prevent establishment. Overall, I recommend that municipal staff involved in this project pursue a more coordinated planning and implementation approach to ensure the Centennial Wetlands restoration project is cost-effective and successful.

## Introduction

Wetlands provide many ecological goods and services that are important to ecosystem function and/or are valued by humans, including flood mitigation, water purification, wildlife habitat, and recreational opportunities (Woodward and Wui 2001; Boyer and Polasky 2004; McLaughlin and Cohen 2013). Of inland (e.g. non-marine or coastal) habitats, wetlands are ranked as having the highest monetary value (de Groot et al. 2012), reflecting their critical role on the landscape and to humans. However, despite their importance ecologically and economically, wetland habitats have often been destroyed or severly degraded by urbanization, agriculture and other human activities (Turner et al. 1987; Bartzen et al. 2010).

In response to historic and ongoing wetland loss and degradation, Alberta implemented a new Wetland Policy (Alberta Environment and Sustainable Resource Development 2013) throughout the province on July 4, 2016, with similar policies implemented earlier by some municipalities (e.g. Strathcona County 2009b). Wetland mitigation, and outlined in these policies, is based on No Net Loss of wetland function: wetland services will be maintained across the landscape, despite the impacts of development. This approach dictates that management actions follow a tiered approach, with options to first: *avoid impacting wetlands*, then second: *minimize impacts* where avoidance is not possible, and third – as a last resort: *replace wetlands that are destroyed or degraded* when avoidance or minimization of impacts are not possible.

There are several challenges inherent in such mitigation approaches, such as assessing the value of lost wetlands, estimating equivalency, and determining compliance (Spieles 2005; Matthews and Endress 2008; Clare and Creed 2014), and mitigation programs are often unsuccessful in achieving their stated aim of replacing lost wetlands with similar habitat (Zedler and Callaway 1999; Bekessy et al. 2010; Burgin 2010). Restoring wetlands in any setting is a challenging task and may require an extended period of time (Moreno-Mateos et al. 2012) and incur significant monetary costs (Gutrich and Hitzhusen 2004). At the same time, isolated wetlands may provide hydrological services (e.g. water storage, water quality improvement) even if they are poor in other respects (e.g. biodiversity), and may be especially important in disturbed areas because this is where natural hydrological functions are likely to be most impaired (McLaughlin and Cohen 2013). In addition, restoration of mitigation wetlands and associated riparian and upland areas can improve other values such as wildlife habitat, biodiversity, ecological production, and may also serve as educational and recreational sites for urban populations (Chiesura 2004; Goddard et al. 2010; Gómez-Baggethun and Barton 2013; Standish et al. 2013).

## Restoration goals

This report concerns a mitigation wetland constructed in 2012-2013 in Sherwood Park, Alberta, as compensation for a wetland destroyed nearby during the construction of a new transit station and recycling facility (J. Thrasher-Haug, personal communication). This mitigation wetland was incorporated into an existing wetland complex called Centennial Wetlands, a series of natural and constructed wetland basins. Strathcona County, the municipality in which Sherwood Park is located, developed a series of objectives for the restoration of the Centennial Wetlands site. These included (a) improving the quality of water that was passing from the stormwater system and through the wetland complex to a recreation area to the north; (b) creating or improving wildlife habitat at the site to increase the diversity of urban wildlife in this area of Sherwood Park; and, (c) increase recreational and educational opportunities at the site. These goals support municipal policy to protect urban wetlands to provide multiple services (Policy SER-009-036 - Strathcona County 2009a, Strathcona County Utilities 2013).

My project focused on (1) weed control to support establishment of native plant species in the upland and riparian zones around the wetland; and, (2) developing guidance for enhancing habitat for urban wildlife at the site. Specific objectives were to (1) estimate weed abundance and community composition in the upland zone around the constructed cell; (2) test and demonstrate non-chemical weed control methods in the upland zone; (3) examine occurrence of wildlife species at the site; and, (4) provide information on specific approaches to enhancing wildlife habitat at the site to encourage and maintain urban wildlife diversity.

## Study area

Centennial Wetlands (UTM coordinates: 12N 347263E, 5936196N) is located in Sherwood Park, a suburban community of approximately 69,000 people (Strathcona County 2015) located just east of Edmonton, Alberta (Figure 1). This urban wetland complex is located in the northwest part of Sherwood Park, sandwiched between extensive suburban areas to the south and east, and industrial and recreational sites to the west and north. Development of the area is ongoing, with light industrial sites recently constructed immediately to the west of the wetlands, and construction of a new office/retail complex planned for the area directly adjacent to the site to the east (Figure 2).

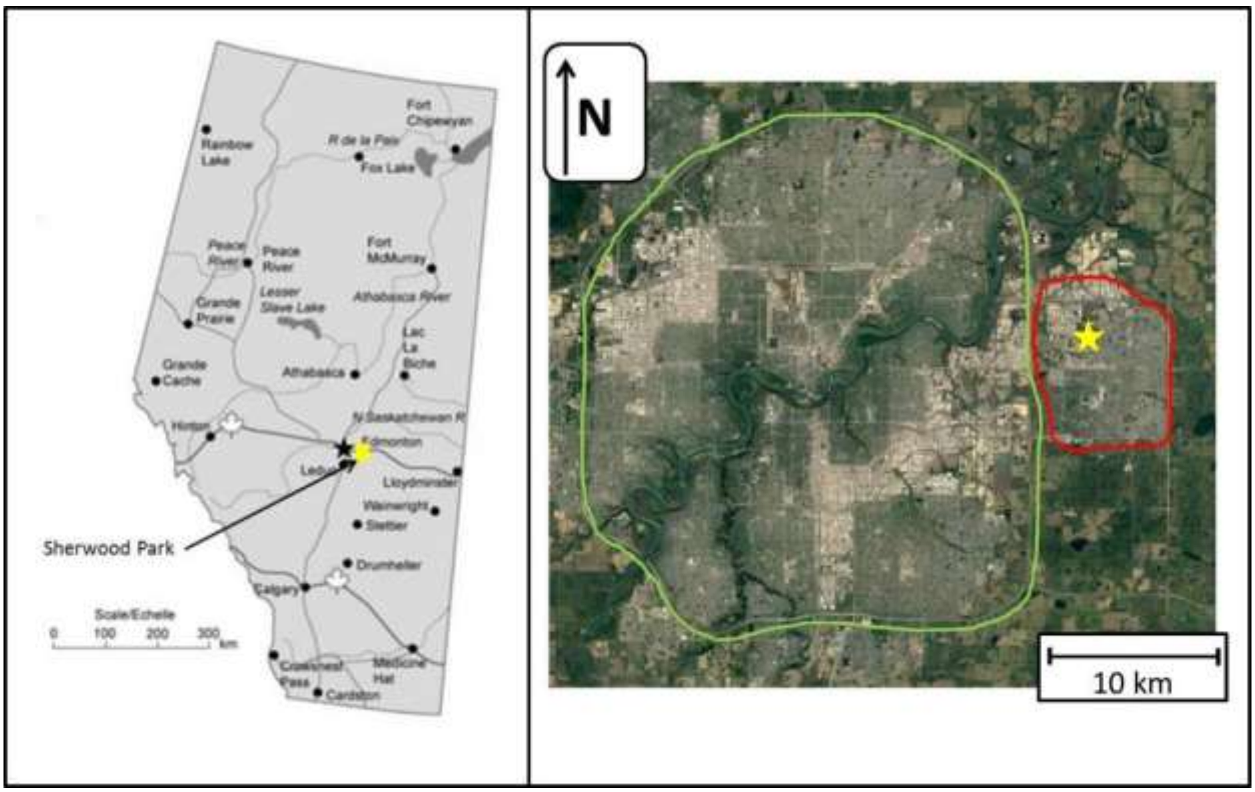


Figure 1. Left panel: Location of Sherwood Park, indicated by the yellow rectangle, within Alberta.

Right panel: location and size of Sherwood Park (outlined in red) relative to the Edmonton area (outlined in green); the yellow star indicates the approximate location of the study site within Sherwood Park. Image modified from Google Earth (version 7.1.7.2606).

Like many wetland complexes in Alberta's capital region, Centennial Wetlands is incorporated into a stormwater control system; the largely urban drainage basin for this particular complex is almost 1,300 ha in size. Water from this catchment flows into Centennial Wetlands from the south, and moves through a series of natural and constructed basins as it proceeds north. Two new basins were constructed at the Centennial Wetlands site in 2012-13 as compensation for wetlands lost to nearby development, under the principle of No Net Loss of wetlands within the urban and rural areas of Strathcona County (Strathcona County 2009). Of these, my project focused on the southern basin (Figure 2), which was an extension of a basin constructed in a formerly agricultural field around 2008 (Figure 3).

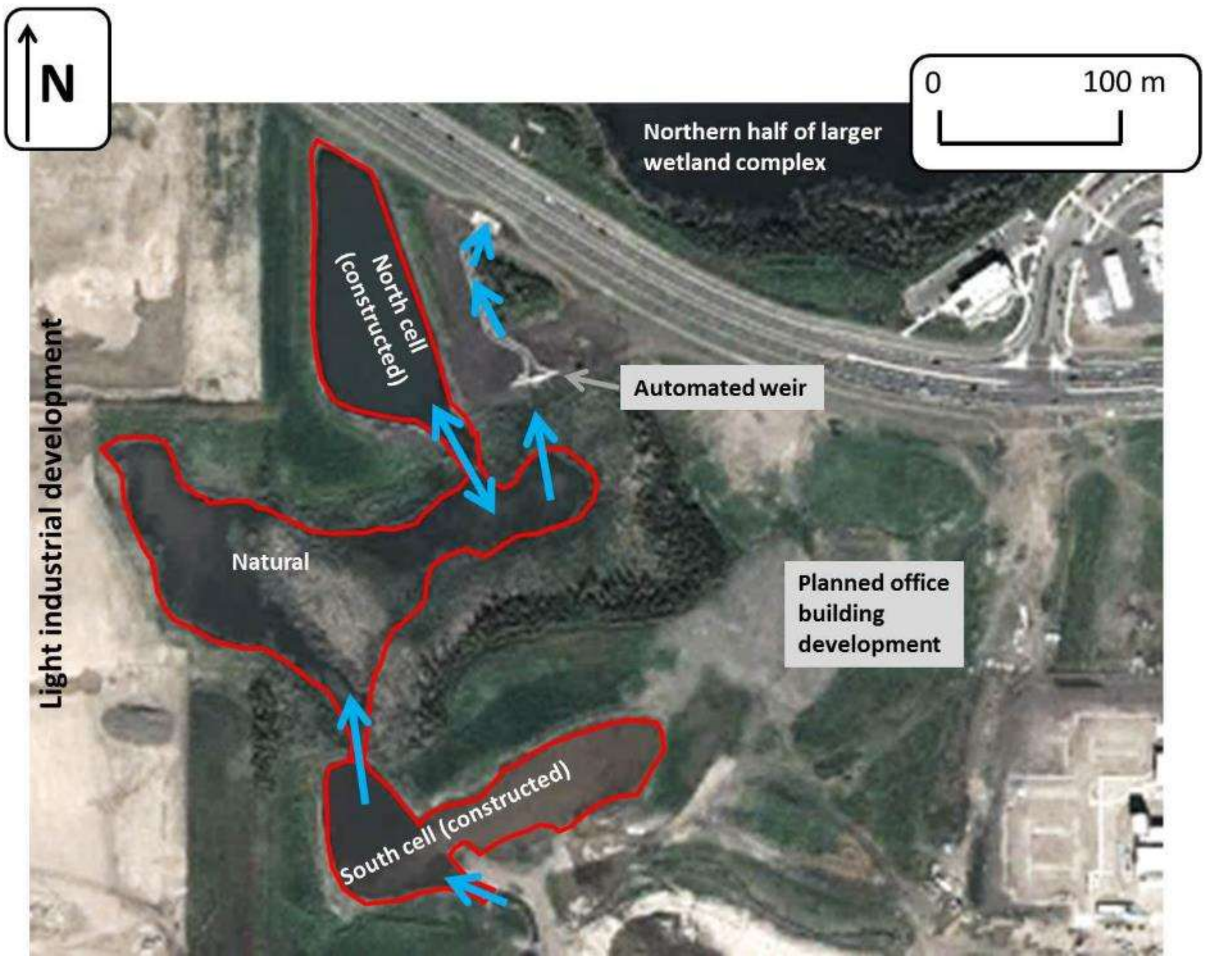


Figure 2. Layout of Centennial Wetlands, Sherwood Park, Alberta.

The wetland basins are outlined in red, and blue arrows show the direction of water flow through the wetland complex. Image modified from Google Earth (version 7.1.2.2041).


Figure 3. Series of images showing the changes that have occurred at the study site since 2002. The area was initially predominated by agriculture [upper left image], and there is little evidence of a wetland. By 2008 [upper right image] part of the south cell has been constructed and linked to the natural wetland in the upper left of the image. In 2012, construction of the second part of the south cell is underway [lower left image]; this portion of the cell has been completed 2014 [lower right image]. Image modified from Google Earth (version 7.1.2.2041).

## Project Plan

This project was conceived to address a number of questions around upland habitat restoration and wildlife habitat enhancement. One of the initial goals was to plan and execute a controlled burn of the stand of dead and dying trees to the north of the focal site. This stand of trees had been impacted by a flood event in the wetland complex in 2008, followed by extensive mortality within the stand (Figure 4). As a result, more than half of the previously treed area was converted to snags and abundant downed woody debris (Figure 5). While this material provides habitat for many smaller wildlife species, including cavity nesters, invertebrates, and small mammals, this level of fuel loading represents a potential fire hazard.


Figure 4. A time sequence showing the original extent of the forest around the Centennial Wetlands (2002), the flooding of the riparian zone (2008), and the loss of a significant portion of forest following the flooding (2016).

The green line outlines the extent of standing trees in each image. Images modified from Google Earth, version 7.1.2.2041.

Figure 5. Snags and downed woody material along wetland margin at Centennial Wetlands, Sherwood Park, Alberta.

These trees were killed during a flooding event in 2008. Photo by Brian Eaton, March 29, 2014.

Because of the fire hazard associated with the fuel load near the restored site, especially given its proximity to existing and planned buildings and infrastructure, we (myself and Kiley Marchuk, an Environmental Analyst for Strathcona County) met with the county fire marshal at the study site on June 15, 2016 to discuss the possibility of a controlled burn to at least part of the site. This would not only reduce the fuel load, but also rejuvenate the site and provide opportunities for educational signage and outreach events related to natural fire cycles and their importance to ecology in the region. However, after surveying the site, the marshal concluded that the risk of a controlled burn was too great, and would not allow us to proceed with that part of the project. We also considered trying to chip and remove the material, but it was decided that this would be too costly. Therefore, I abandoned the idea of using fire to restore the treed area at Centennial Wetlands and instead, at the request of Strathcona County Environmental Planning staff, I focused on weed control and wildlife habitat aspects of the restoration project.

Specific objectives related to the revised project focus were to:

(1) estimate weed abundance and community composition in the upland zone around the constructed cell;
(2) test and demonstrate non-chemical weed control methods in the upland zone;
(3) examine occurrence of wildlife species at the site; and,
(4) provide information on specific approaches to enhancing wildlife habitat at the site to encourage and maintain urban wildlife diversity.

Here I cover the first two objectives of the project; the wildlife information will be conveyed during the presentation related to the practicum.

## Methods

### Weed abundance and community composition (Objective 1)

In order to estimate the abundance of weedy species in the upland zone around the focal wetland basin, a total of 18 sampling plots were distributed in two Sampling Areas (9 plots in each) at the site. These areas were placed within the upland zone that had been contoured using earth-moving equipment during construction of the wetland basin, as these disturbed areas had been colonized by a variety of plants, including weedy species. The objective was twofold: (1) to use a standardized approach to sampling the plant community to determine composition and relative abundance as a baseline with which to compare changes in response to control methods, and (2) to establish plots to trial and demonstration physical control methods.

Plant sampling plots were distributed by established rectangular grids at each Sampling Area; these grids were adjusted to fit into an area of similar aspect and slope. The grid for Area 1 was 40 m x 24 m and located on a sloped area at the eastern end of the wetland basin; the grid for Area 2 was 64 m x 14 m and located on the relatively flat area to the north of the basin. Each grid was divided into 2 m x 2 m cells, and sequential numbers were assigned to each cell. A random numbers table, generated using Microsoft Excel, was used to randomly distribute 9 plots within each grid: 3 control plots, 3 mow plots, and 3 solarize plots (details on these are provided below); see Figure 6. The corners for each plot were marked with wooden stakes and/or stake flags, and labeled (Figure 7). No two plots could be adjacent to each other, nor touching at the corners.

Initial plot sampling was done using a 2 m x 2 m plot frame constructed from PVC pipe (Figure 7). This was placed on each plot so that the corners of the frame aligned with the corner markers, and the relative canopy cover of each plant species - not just weedy species - was visually estimated, as was percentage of plot area covered by bare soil and plant litter (e.g. dead plant material, etc.). All cover estimates were done by the same person (Kiley Marchuk, who has a background in environmental monitoring and plant identification) throughout the project. Cover estimates were made to the nearest 5%; where a species covered less than 5%

of the plot, they were classified as <5% (i.e. were abundant enough to occur in one or more small patches, but not enough to reach 5% of total plot area), or Trace (typically one to a few individual plants). Initial plot establishment and cover estimates were done on July 22, 2015, providing a baseline dataset.


Figure 6. Approximate distribution of weed control trial plots.

The label for each plot type is centred on the plot location; there are 3 replicates of each plot type in each Area. Plot types: Control = no treatment; Mow = mowed to ground level; Solar = solarisation - mowed to ground level and covered with black plastic. Image modified from Google Earth, version 7.1.7.2606; image dated September 29, 2015.


Figure 7. Setting up the weed control and treatment plots.

Left panel: A PVC plot frame (2 m x 2 m) in use while setting up a plant sampling plot. Note the flags used to mark three of the plot corners, and the wooden stake used to mark the fourth. Right panel: close-up of wooden stake showing labelling for Area 2, Solarization plot 1.

### Weed control and demonstration trials (Objective 2)

One of the main concerns related to the restoration of the study wetland was weed control, as the site was heavily disturbed during construction, with no native cover, and therefore vulnerable to colonization by weedy species from an adjacent snow dump area (J. Thrasher-Haug, personal communication), or via wind, water, or animal dispersal from nearby urban areas (Ehrenfeld 2008). Strathcona County expressed reluctance to use chemical weed control, unless absolutely necessary, so I tested two different physical control methods which I thought could be used at the relatively small scale of the Centennial Wetlands site. These methods included mowing and solarisation; three replicates of each plot type, as well as control plots in which no weed control was practiced, were established in each of the Sampling Areas described in the previous section (Table 1). Mowing consisted of using a whipper-snipper and pruners to clear the vegetation down to the surface of the ground, and then raking all the plant material out of the plot (Figure 8). Solarization was done by removing the vegetation in the same way as for the mowed plots, covering the cleared area with thick black plastic sheeting, and sealing the edges of the plastic into a trench around the plot.

Table 1. Study design for weed control trials (see text for details on plot size, distribution, and treatment).

| **Treatment type** | **Area 1** | **Area 2** |
|---|---|---|
| Control | 3 plots | 3 plots |
| Mowed | 3 plots | 3 plots |
| Solarization | 3 plots | 3 plots |

Figure 8. Tools used to remove plant material on the mow and solarisation plots.
The cordless whipper-snipper was an essential tool in making this process efficient.

Weed control trial plots were checked periodically over the course of the project (Table 2). Note that mow plots were initially treated (mowed) in July 2015 and were treated again in late August 2015 to mimic mowing schedules typically used by Strathcona County on their municipal properties. In early October 2015 we did plant surveys on the control and mow plots again, but due to time constraints we did not fully uncover and assess all the solarization plots. In late March 2016 all plots were examined, including each solarization plot, and a photo was taken of each plot. Solarization plots were re-covered for future assessment after another growing season; it was necessary to repair the plastic on these plots periodically, as animals would walk on them and puncture the plastic, allowing plants to grow out of the holes (Figure 9). Final assessments were done on all plots on August 25, 2016, providing information on weed responses to control methods after two full growing seasons.

Table 2. Schedule for treating and monitoring weed control trials.

| Date | Activity |
|---|---|
| **2015** | |
| July 22 | • Establish control and treatment plots<br>• Record cover by species (pre-treatment) |
| July 25 | • Mow and solarize |
| August 23 | • Treat mow plots again<br>• Repair plastic on solarisation plots |
| October 9 | • Record cover by species for control and mow plots (did not do solarization plots) |
| **2016** | |
| March 28 | • Survey solarization plots and cover again |
| May 31 | • Repair plastic on solarisation plots |
| August 25 | • Final assessment of plant cover by species for all plots |


Figure 9. Repairing solarization plots.
A – an undamaged solarization plot; B – footprints showing where an animal (likely a coyote) walked across the plastic covering the solarization plot, causing a small hole (circled in red); C – weeds growing out of a hole punctured in the solarization plastic; D – a solarization plot after it has been repaired using duct tape (to add strength) covered by Tuck tape (the red tape) because it sticks to the plastic better.

## Results

### *Weed abundance and community composition (Objective 1)*

Cover estimates were made for all plant species found in plots at the study site. Because we estimated cover the nearest 5%, and used two categories for species that had less than 5% cover (<5% and trace), coverage estimates did not total 100% for each plot. Therefore, before analysis I assigned a value of 2.5% for all species that had been categorized as "<5%", and a value of 0.1% to all those categories as "Trace". The total coverage for each plot was then calculated by summing the estimated coverage for each species, and the coverage for each species was then normalized to the estimated total coverage.

Initial cover estimates (e.g. before any treatments) were combined across all plots to provide a baseline understanding of the plant community at the restoration site. Note that some planting had been done by Strathcona County in the riparian zone of the constructed wetland, but that I avoided those areas when setting out my cover plots to get a picture of the plant community that had established on its own in the nearby upland zone, and to avoid impacting planted areas during the mowing and solarization treatments.

Weeds in Alberta are are officially classed as prohibited noxious (weeds found in few locations such that eradication could be possible), or noxious (weeds considered too widely distributed to eradicate, though local authorities may conduct control programs if they feel these species may have significant ecological or economic impact within their municipality) (Province of Alberta 2010). The “common” category is not a regulatory designation, and includes those that interfere with agriculture systems but not to the extent that noxious or prohibited noxious weeds do, or they are too prevalent to control (Brenda Nachtegaele, personal communication).

Initial plot surveys identified a total of 28 species across all 18 plots (Table 3). Six of these species were weeds, accounting for an average 39% of the plot area, with scentless chamomile and Canada thistle forming the bulk of the weedy coverage overall (Figure 10). There was considerable variation across the individual plots, with some supporting very few weeds, and others approaching 90% weedy cover (Figure 11). Overall, the area around the restored wetland was dominated by extensive stands of scentless chamomile (Figure 12).

Table 3. Plant species found in the initial survey, July 22, 2015; n=18.
See Appendix A, Table A-1 for scientific names for each species.

| Common name* | Coverage | Common name* | Coverage |
|---|---|---|---|
| Scentless chamomile | >20% | Goldenrod | >1% |
| Purple prairie clover | 10 - 20% | Reed grass | >1% |
| Canada thistle | 10 - 20% | Timothy | >1% |
| Golden bean | 10 - 20% | Green needle grass | >1% |
| Leaf litter/dead grass | 5 - 10% | Smooth brome | >1% |
| Bare ground | 5 - 10% | Western dock | >1% |
| Nodding thistle | 1 - 5% | Northern bedstraw | >1% |
| Wheat | 1 - 5% | Dragonhead mint | >1% |
| Grass species | 1 - 5% | Chickweed | >1% |
| White sweet clover | 1 - 5% | Tickle grass | >1% |
| Perennial sow thistle | 1 - 5% | Yellow sweet clover | >1% |
| Foxtail barley | 1 - 5% | Field bindweed | >1% |
| Dandelion | >1% | Canola | >1% |
| Common plantain | >1% | Saskatoon | >1% |
| Bird's foot trefoil | >1% | Hemp nettle | >1% |
| Golden dock | >1% | | |

* Weed status: no shading = not designated as a weed; green = common weed; orange = noxious; pink = prohibited noxious. See text for details on definition of weed status.

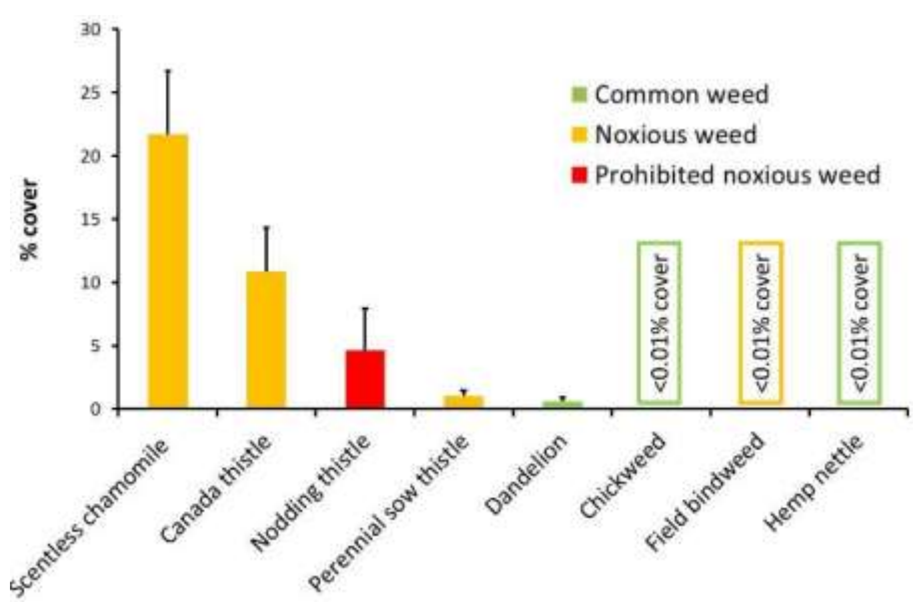


Figure 10. Average cover by weed species at the time of plot establishment (July 22, 2015) across all 18 plots.

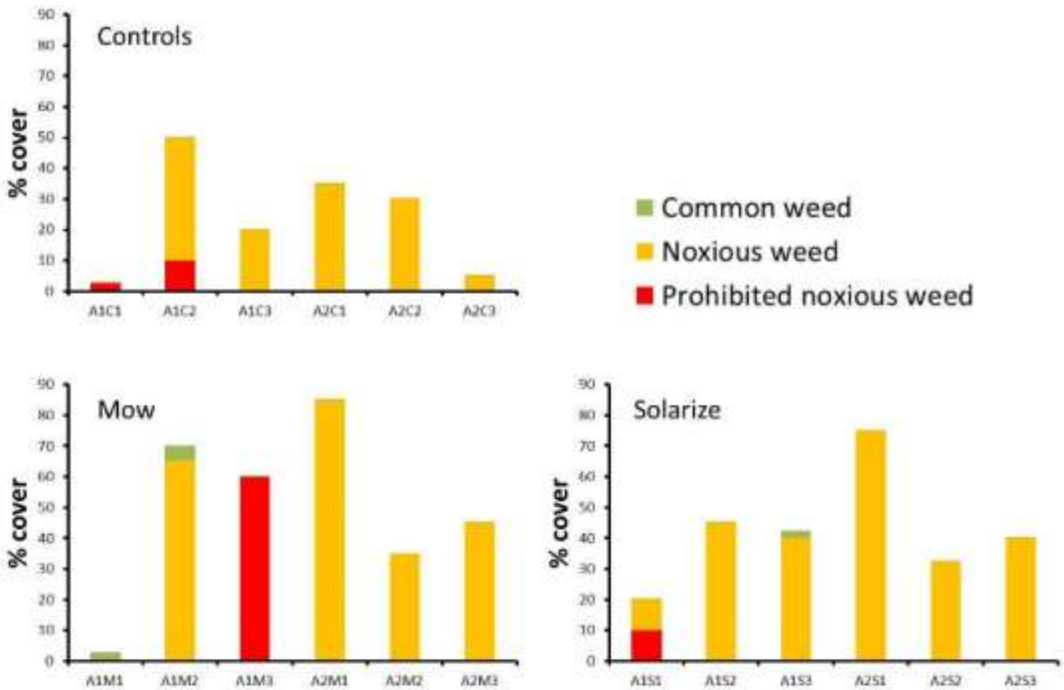


Figure 11. Total cover by weed species at the time of plot establishment (July 22, 2015) in individual plots.
Code for x-axis: first two characters refer to the Area in which the plot was located: A1 = Area 1, A2 = Area 2; last two characters refer to the treatment type (C = control, M = mow, S = solarize) and the replicate (1, 2, or 3).

### *Weed control and demonstration trials (Objective 2)*

Over the 13 months of the weed control trials, there were substantial changes in the percent of the plots covered by different classes of weed species (Figure 13). In general, solarization did a good job of reducing weed populations, and weeds only grew in these plots when the plastic sheet was punctured. Mow plots reduced overall weed populations in the first growing season, but they were starting to rebound by the end of the second growing season (fall of 2016). Noxious weed coverage in the control plots increased during the project, but common weeds were scarce in these plots, likely because they were largely outcompeted by the more aggressive noxious species. Nodding thistle, the only prohibited noxious species found at the site, essentially disappeared from the site in all plots by the end of the study.

Figure 12.  This view is looking east toward the Area 1 weed plot, and number of which are indicated by the white arrows.  The white flowers are scentless chamomile, the dominant weed species in the area.

This image also shows that the wetland is not far from the urban areas of Sherwood Park; the local fire station is clearly visible to the upper right of image (the brown building).  My wife is visible in the middle ground, in the left of the image, and provides a sense of scale.

Note that although this project started with 18 vegetation plots, three plots were destroyed by county staff mowing the overall site to try to control weed populations.  One control plot was lost in Area 2 before the October 9, 2015 plot assessment, and two more (one mow plot in each Area) were destroyed before the final plot surveys on August 25, 2016.  Ironically, the first incident was part of a much larger event in which a member of the county summer work force inadvertently mowed down approximately $10,000 worth of plants installed in the riparian zone of the constructed wetland basin.

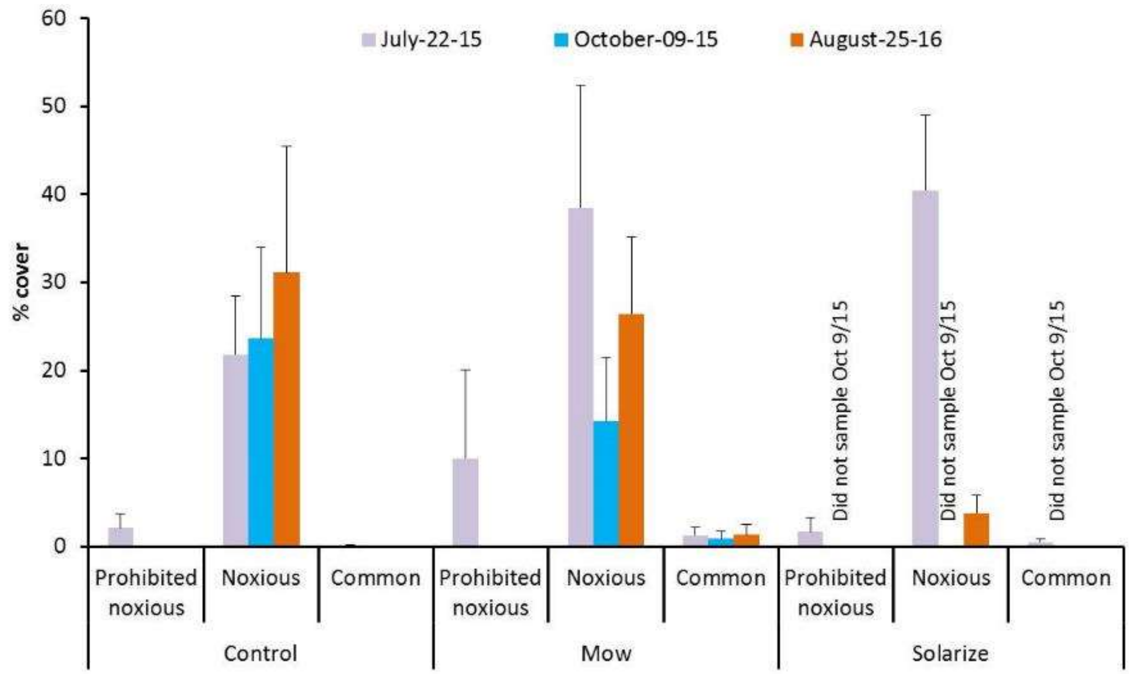


Figure 13. Changes in mean coverage by different classes of weed species in the control and treatment plots over time. Bars represent Standard Errors.

Examining the data on an individual plot basis shows that there was substantial variation in weed coverage across plots (Figure 14), with coverage in the initial survey ranging from very low in a few plots to over 80% in others. Control plots that started with relatively high weed coverage tended to stay high over the study. A similar effect was seen with mow plots that started with high weed coverage; in this case weed coverage dropped with mowing, but had started to rebound by the end of the second growing season (Figure 14). Solarization plots were covered until the end of the study, so they only supported a few plants that grew through holes in the plastic covering; it would be interesting to go back and reassess those plots in the summer of 2017 to see what species established after the plastic sheeting was removed.

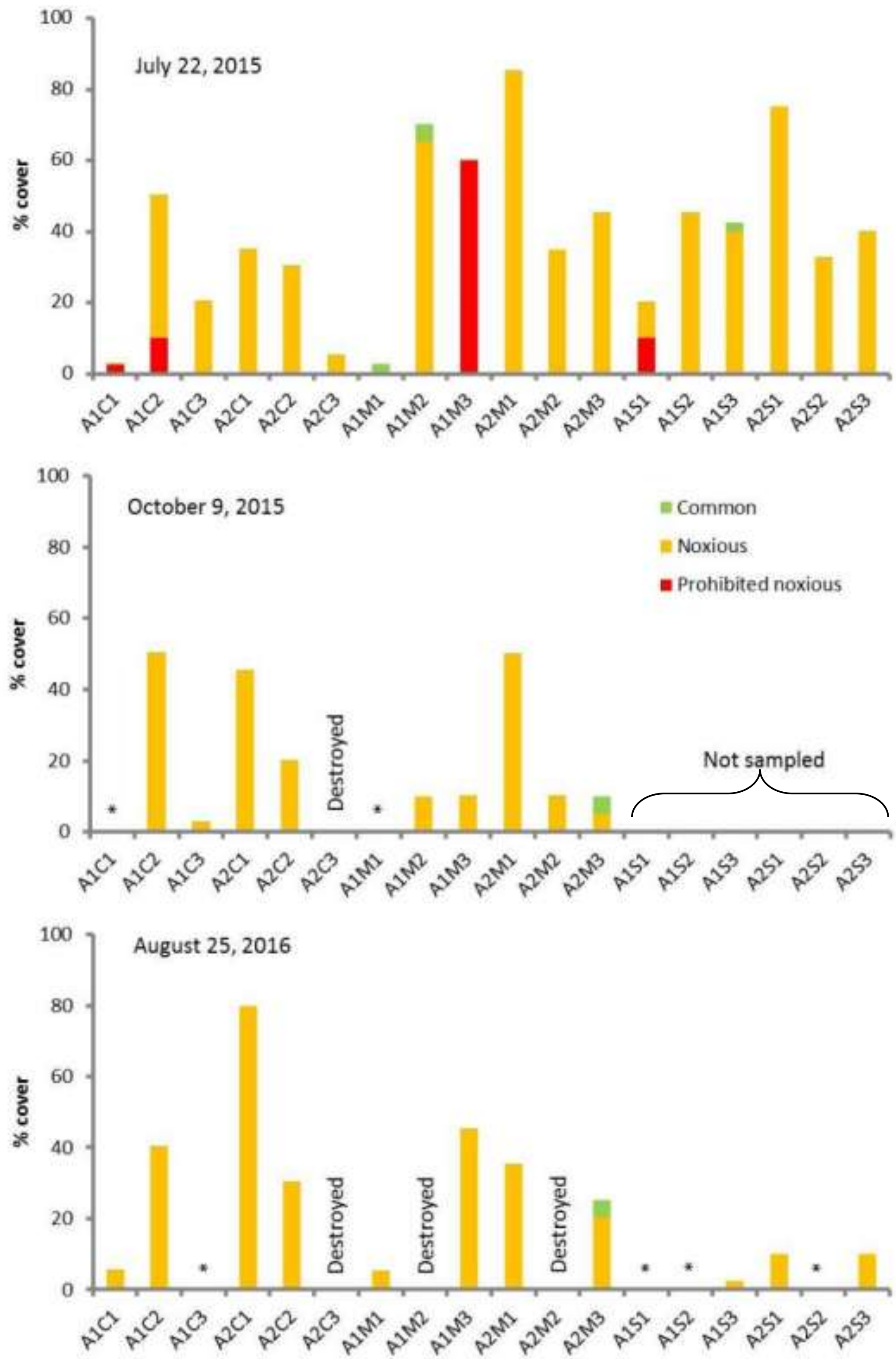


Figure 14. Comparison of weedy cover for individual plots over the course of the project. Note: * indicates total weedy cover less than 0.5%.

In addition to information on weed species, I collected cover estimates for all other plant species encountered during the project. There were noticeable differences in the appearance of the three plot types after treatment (Figure 15). Overall, total diversity decreased during the study (Table 4), suggesting there were changes at the site that affected all plot types. By examining individual treatments, we can gain information on how the overall plant community responded to changes in site conditions, or to the treatments themselves. Diversity in control plots remained similar during the project time period, though the community composition - particularly in terms of species that occurred as only one or a few individuals in the plots (e.g., <1% cover) – did change over time (Table 5). In general, the dominant species remained dominant in the control plots, though reed grass did increase substantially during the study period (Table 5).

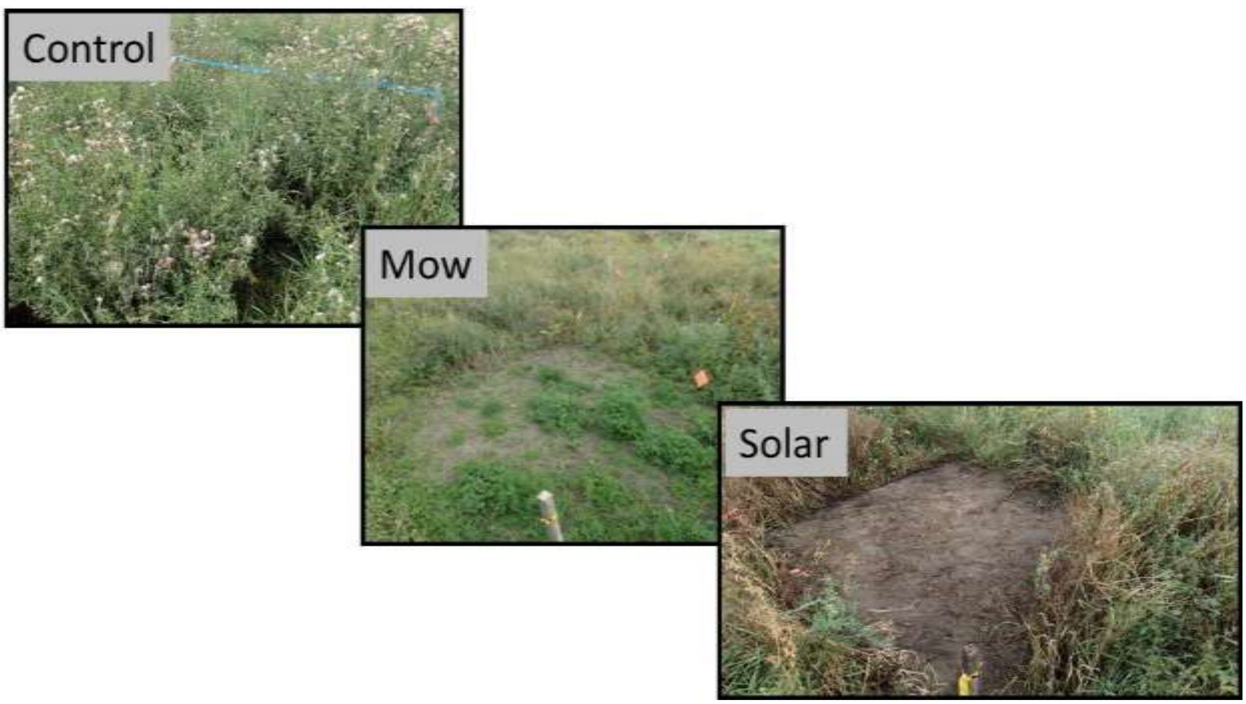


Figure 15. Examples of the appearance of plant communities in control, mow and solarization plots after treatment.

Table 4. Presence of plant species in the weed trial plots, by sampling date.

| Common name* | July 22, 2015 | October 9, 2015 | August 25, 2016 |
|---|---|---|---|
| Alsike clover | | | X |
| Bird's foot trefoil | X | X | |
| Buckwheat | | | X |
| Canada thistle | X | X | X |
| Canola | X | | |
| Chickweed | X | X | |
| Clover species | | X | |
| Common plantain | X | X | X |
| Dandelion | X | X | X |
| Dragonhead mint | X | | X |
| Fescue species | | X | |
| Field bindweed | X | | |
| Fowl bluegrass | | | X |
| Foxtail barley | X | X | |
| Golden bean | X | | X |
| Golden dock | X | | |
| Goldenrod | X | X | X |
| Grass species | X | X | X |
| Green needle grass | X | X | |
| Hemp nettle | X | | |
| Nodding thistle | X | | |
| Northern bedstraw | X | X | X |
| Perennial sow thistle | X | X | X |
| Purple prairie clover | X | X | X |
| Reed grass | X | X | X |
| Richardson's geranium | | X | |
| Saskatoon | X | | |
| Scentless chamomile | X | X | X |
| Smartweed | | X | |
| Smooth brome | X | | |
| Tickle grass | X | | |
| Timothy | X | X | X |
| Western dock | X | X | X |
| Wheat | X | X | X |
| White cockle | | | X |
| White sweet clover | X | X | |
| Wild strawberry | | | X |
| Yellow sweet clover | X | | |
| Yellow toad flax | | | X |
| **Total number of species** | **29** | **22** | **21** |

* Weed status: no shading = not designated as a weed; green = common weed; orange = noxious; pink = prohibited noxious. See text for details on definition of weed status.

Table 5. Changes in vegetation community in control plots over time.

| Common name* | July 22, 2015 | October 15, 2015 | August 25, 2016 |
|---|---|---|---|
| Purple prairie clover | >20% | 1 - 5% | >20% |
| Scentless chamomile | 10 - 20% | 5 - 10% | 1 - 5% |
| Golden bean | 10 - 20% | | 1 - 5% |
| Bare ground | 10 - 20% | 10 - 20% | 5 - 10% |
| Leaf litter / dead grass | 5 - 10% | 10 - 20% | |
| Wheat species | 5 - 10% | 5 - 10% | 10 - 20% |
| Canada thistle | 1 - 5% | 10 - 20% | >20% |
| Nodding thistle | 1 - 5% | | |
| Foxtail barley | 1 - 5% | <1% | |
| Grass species | 1 - 5% | 5 - 10% | 5 - 10% |
| Common plantain | <1% | <1% | <1% |
| Perennial sow thistle | <1% | <1% | 1 - 5% |
| Bird's foot trefoil | <1% | 10 - 20% | |
| Goldenrod | <1% | <1% | <1% |
| Green needle grass | <1% | <1% | |
| Reed grass | <1% | 10 - 20% | 10 - 20% |
| Western dock | <1% | <1% | 1 - 5% |
| Dandelion | <1% | <1% | <1% |
| Timothy | <1% | <1% | <1% |
| Chickweed | <1% | | |
| Golden dock | <1% | | |
| Tickle grass | <1% | | |
| White sweet clover | <1% | <1% | |
| Hemp nettle | <1% | | |
| Smooth brome | <1% | | |
| Alsike clover | | | <1% |
| Buckwheat | | | <1% |
| Clover species | | 1 - 5% | |
| Dragonhead mint | | | 1 - 5% |
| Northern bedstraw | | <1% | <1% |
| Richard's geranium | | <1% | |
| White cockle | | | <1% |
| Wild fowl bluegrass | | | <1% |
| Wild strawberry | | | <1% |
| Yellow toad flax | | | <1% |
| **Total number of species** | **25** | **21** | **22** |

* Weed status: no shading = not designated as a weed; green = common weed; orange = noxious; pink = prohibited noxious. See text for details on definition of weed status.

In contrast to the control plots, diversity in the mow plots dropped during the project, with a 35% decrease in the number of species over the 13 months these plots were sampled (Table 6). Again, there was a shift in the composition of the plant community, with some species disappearing and others establishing in the plots. There were substantial reductions in some weed species (e.g. scentless chamomile and nodding thistle), as well as increases in species such as purple prairie clover and golden bean (Table 6), which are considered desirable species in a restoration context (Kiley Marchuk, personal communication).

The solarization plots supported few plants, and those that did grow under the plastic sheeting were typically linked to other individuals who supported them via root systems or rhizomes (Figure 15). Other individuals took advantage of rents in the plastic to grow with little immediate competition (Figure 15). Species diversity was low across all the solarization plots.

Figure 15. Plants growing in solarization plots.
Left panel: plants growing under plastic sheeting; right panel: weeds growing from holes in plastic sheeting.

Table 6. Changes in vegetation community in mow plots over time.

| Common name* | July 22, 2015 | October 15, 2015 | August 25, 2016 |
|---|---|---|---|
| Scentless chamomile | >20% | 5 - 10% | 5 - 10% |
| Canada thistle | 10 - 20% | 5 - 10% | 10 - 20% |
| Purple prairie clover | 10 - 20% | | >20% |
| Nodding thistle | 10 - 20% | | |
| Grass species | 5 - 10% | >20% | >20% |
| Wheat species | 5 - 10% | | 1 - 5% |
| Leaf litter / dead grass | 5 - 10% | 5 - 10% | |
| Golden bean | 1 - 5% | | 5 - 10% |
| Bare ground | 1 - 5% | >20% | |
| White sweet clover | 1 - 5% | | |
| Dandelion | 1 - 5% | <1% | 1 - 5% |
| Golden dock | <1% | | |
| Common plantain | <1% | <1% | <1% |
| Foxtail barley | <1% | | |
| Reed grass | <1% | | 5 - 10% |
| Smooth brome | <1% | | |
| Perennial sow thistle | <1% | | 1 - 5% |
| Bird's foot trefoil | <1% | <1% | |
| Dragonhead mint | <1% | | |
| Northern bedstraw | <1% | | |
| Timothy | <1% | | <1% |
| Canola | <1% | | |
| Field bindweed | <1% | | |
| Western dock | <1% | | <1% |
| Yellow sweet clover | <1% | | |
| Alsike clover | | | 1 - 5% |
| Chickweed | | <1% | |
| Clover species | | 5 - 10% | |
| Fescue species | | <1% | |
| Goldenrod | | <1% | <1% |
| Smartweed | | <1% | |
| Fowl bluegrass | | | <1% |
| Yellow toad flax | | | <1% |
| **Total number of species** | **25** | **14** | **16** |

* Weed status: no shading = not designated as a weed; green = common weed; orange = noxious; pink = prohibited noxious. See text for details on definition of weed status.

## Discussion and Recommendations

Weed populations in the upland zone around the restored wetland basin were abundant at this beginning of this project (mean of 39% of the plot areas). This is not an uncommon occurrence for sites that have been recently disturbed, as this site was during the construction of the nearby wetland basin (Lake and Leishman 2004; Hierro et al. 2006). Invasive or nonnative species, such as weeds, can have a substantial negative impact on local ecosystems, reducing cover of native species, altering ecological cycles, and affecting habitats for other organisms (McKinney 2002; Goddard et al. 2010; Vilà et al. 2011). Therefore, it may be necessary to control invasive weeds in the first few years of a restoration project, until native vegetation can colonize the site or be actively planted and become established. For example, Kettenring and Adams 2011 suggested that establishing native vegetation is likely to be most successful in the long term if control of invasive plants is followed by replanting of desired species.

In this project I showed that mowing reduced weed populations initially, but that these populations had started to rebound by the end of the second growing season. Overall, the weed control trials showed that solarization was able to reduce the population of weeds, and other potential plant competitors, to almost zero cover when the plastic sheeting used to cover the ground was maintained. However, I was not able to determine how the plant community recovered from solarization because I did not uncover the plots during the study period, which was an oversight on my part. I can return to the site in the future to do post-treatment assessments on the solarization plots, but I do not have these data at present.

The pattern of transitory reduction in weed populations with mechanical treatments is common. Several studies have shown that solarization is very effective at reducing weed abundance in the short term (Horowitz et al. 1983; Marushia and Allen 2011), but that this effect only lasts one or two years before abundance increases again (Wilson et al. 2004; Holl et al. 2014). Mowing is often even less effective than solarization (Marushia and Allen 2011), and may even cause increases in some exotic plant species (Prevéy et al. 2014); it is, in rare cases, effective in control weedy plant species and promoting native species populations (Wilson and Clark 2001).

Based on the findings from this project, I recommend that weed control at the Centennial Wetland site use solarization to create openings in which native plants can establish (Labbrecht and D'Amore 2010), by natural colonization or – preferably – via active seeding or planting. I would suggest planting shrub seedlings through solarization material (e.g. black plastic) to give the seedlings a chance to establish with reduced competition, and allowing them to reach a size at which they can shade-out or out-compete invasive weeds. This approach can be used to establish shrub communities in islands or bands in the upland near the wetland basin, which may facilitate the establishment of trees and shrubs in these areas by acting as wind breaks and trapping wind-borne seeds (Harvey 2000; Holl 2002).

A complementary approach would be to use mowing to reduce invasive plant populations, followed by actively seeding and/or planting appropriate native species in the target area to prevent establishment of populations of weedy and/or exotic plant species (Zedler and Kercher 2005; Reid et al. 2009; Kettenring and Galatowitsch 2011). Some of the native species that still occur in the region and that might be appropriate for restoration planting include plains rough fescue (*Festuca scabrella*), beaked hazelnut (*Corylus cornuta*), bunchberry (*Cornus canadensis*), wild lily-of-the valley (*Maianthemum canadense*), wild sarsaparilla (*Aralia nudicaulis*), trembling aspen (*Populus tremuloides*), Saskatoon (*Amelanchier alnifolia*), prickly rose (*Rosa acicularis*), balsam poplar (*Populus balsamifera*), and white spruce (*Picea glauca*). Wetlands in the region often harbour common cattail (*Typha latifolia*), sedges (*Carex spp*.) or bulrushes (*Scirpus spp*.), willows (*Salix spp*.), common Labrador tea (*Ledum groenlandicum*), black (*Picea mariana*) and white spruce (Natural Regions Committee 2006), and these species may be useful in creating riparian zones around the constructed basin at the study site.

Protection of restoration plantings is important, especially in areas where local wildlife populations are reasonably abundant. For example, numerous Canada geese (*Branta canadensis*) were seen at the restoration wetland (Brian Eaton, personal observation), and grazing by this species is known to negatively impact the biomass and community composition of young wetland plant shoots and riparian vegetation (Evers et al. 1998; Handa and Jefferies 2000). In fact, this was one of the major factors in the loss of initial riparian plantings at the study site (Kiley Marchuk, personal communication). White-tailed deer (*Odocoileus virginianus*), a species also known to inhabit the study area periodically, may browse down restoration plantings (Opperman and Merenlender 2000). Beaver (*Castor canadensis*) can remove everything from shrubs to saplings to mature trees; wire screens or other repellents can be used to control their impact on individual plants (Colleen and Gibson 2001).

It is important that groups involved in the restoration of Centennial Wetlands take an optimized, coordinated approach to the project. Lack of communication has already resulted in the loss of $10,000 worth of restoration plantings, and there is a general lack of coordination amongst the various municipal agencies concerned with the site. I suggest that, before going forward with additional restoration activities, an effort should be made for the various agencies to meet to develop and implement a cost-effective restoration for Centennial Wetlands based on appropriate restoration and site management techniques, and drawing on the scientific and restoration literature and local experts to inform the path forward.

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## Appendix A.

Table A-1. Scientific names for plant species found in the weed control plots.

| **Common name*** | **Scientific name** |
|---|---|
| Alsike clover | *Trifolium hybridum* |
| Bird's foot trefoil | *Lotus corniculatus* |
| Buckwheat | *Fagopyrum esculentum* |
| Canada thistle | *Cirsium arvense* |
| Canola | *Brassica napus* |
| Chickweed | *Stellaria spp.* |
| Clover species | *Trifolium spp.* |
| Common plantain | *Plantago major* |
| Dandelion | *Taraxacum spp.* |
| Dragonhead mint | *Dracocephalum parviflorum* |
| Fescue species | *Festuca spp.* |
| Field bindweed | *Convolvulus arvensis* |
| Fowl bluegrass | *Poa palustris* |
| Foxtail barley | *Hordeum jubatum* |
| Golden bean | *Thermopsis rhombifolia* |
| Golden dock | *Rumex maritimus* |
| Goldenrod | *Solidago spp.* |
| Grass species | *Poa spp.* |
| Green needle grass | *Stipa viridula* |
| Hemp nettle | *Galeopsis tetrahit* |
| Nodding thistle | *Carduus nutans* |
| Northern bedstraw | *Galium boreale* |
| Perennial sow thistle | *Sonchus arvensis* |
| Purple prairie clover | *Dalea purpurea* |
| Reed grass | *Calamagrostis inexpansa* |
| Richardson's geranium | *Geranium richardsonii* |
| Saskatoon | *Amelanchier alnifolia* |
| Scentless chamomile | *Tripleurospermum inodorum* |
| Smartweed | *Polygonum spp.* |
| Smooth brome | *Bromus inermis* |
| Tickle grass | *Agrostis scabra* |
| Timothy | *Phleum pratense* |
| Western dock | *Rumex occidentalis* |
| Wheat | *Tricticum aestivum* |
| White cockle | *Silene latifolia* |
| White sweet clover | *Melilotus albus* |
| Wild strawberry | *Fragaria virginiata* |
| Yellow sweet clover | *Melilotus officinalis* |
| Yellow toad flax | *Linaria vulgaris* |
| **Total number of species** | |

* Weed status: no shading = not designated as a weed; green = common weed; orange = noxious; pink = prohibited noxious. See text for details on definition of weed status.