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Nisutlin Delta National Wildlife Area

Invasive species monitoring and management

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Nisutlin Delta National Wildlife Area invasive species monitoring and management

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Acknowledgements

This report documents invasive species monitoring and management during July 2025.

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Abstract

The Nisutlin River Delta National Wildlife Area is a federally protected wilderness area located 10 kilometres east of the Village of Teslin, Yukon. The delta is an important area for migrating birds and provides important habitat for moose. Historic horse grazing and overwintering activity has likely led to the establishment of invasive species within the protected area. This study evaluates the presence of invasive species in the delta as well as management efforts to reduce the density of invasive species. Ground and aerial survey and management efforts were focused on a small area heavily impacted by horse overwintering activities. We evaluated species abundance for both invasive and native species and determined species density for invasive species within the impacted area. We determined that the presence of invasive species was significant directly within the area impacted by overwintering activities, but not significant in areas outside the impacted zone. We encountered six invasive species during monitoring and targeted three priority invasive species for removal. Our monitoring and management efforts highlight the need for early detection and rapid response in wilderness areas to effectively control and reduce the spread of invasive species. We recommend that prior to subsequent invasive control actions, management agencies first determine what level of management is acceptable and develop a long-term invasive species management plan for the Nisutlin Delta National Wildlife Area. Possible future management and control actions include monitoring of permanent plots, smothering of high-density areas, planting native species and herbicide applications.

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Introduction

The Nisutlin River Delta National Wildlife Area (NRDNWA) is located 10 kilometres northeast of the Village of Teslin, Yukon. This area is recognized for its important habitat for migratory birds that feed in the shallow waters during fall migration. It also holds significant value for moose habitat, supporting a moose density of 10-15 animals per square kilometre (Hoefs 1976). This area is culturally significant for Teslin Tlingit citizens for its high waterfowl and moose hunting potential. The Nisutlin River is a popular canoeing destination, and many recreational users camp along the delta.

The NRDNWA was established in 1995 under Chapter 10, Schedule A of the *Teslin Tlingit Umbrella Final Agreement.* National Wildlife Areas are a protected area established under the *Canada Wildlife Act* and are managed under the mandate of Environment and Climate Change Canada's (ECCC) Canadian Wildlife Service (CWS). While no formal co- management system currently exists for the NRDNWA, CWS coordinates and collaborates with the Teslin Tlingit Council, the Teslin Renewable Resources Council, and the Government of Yukon, Department of Environment for management of the protected area

The NRDNWA is dominated by herbaceous vegetation and shrubs such as horsetail (*Equisetum* spp.), bunchgrass (*Calamagrostis* spp.) and willow (*Salix* spp.) which provide high value, nutrient rich, grazing potential for herbivores. The earliest accounts of grazing in the delta date back to 1930 (Tim Dewhurst, Interview – RRC members 2007). Horses were typically overwintered on Nisutlin Delta, grazing from mid-October to early spring. The most recent grazing lease, held by a Yukon owned outfitting business, expired in 2024. During operation of this lease up to 30 horses were overwintered. Grazing was supplemented by alfalfa pellet feed, which was imported into the Yukon.

Biophysical surveys have noted invasive plant species in the NRDNWA since at least 1998 (Bennett 1998). We speculate these invasive species likely arrived through contaminated supplemental feed or feces from horses as they grazed in areas with established invasive species before being moved into the delta to overwinter. Documented impacts worldwide from the introduction of invasive species in other backcountry areas are vast, including changes in native species composition, changes in hydrology, and spread of plant pathogens (Pickering et al. 2010). The Government of Yukon does not have an Invasive Species Act, however early detection and rapid response is a best management practice undertaken by industry and government entities to limit the spread of invasive species. The purpose of our fieldwork in July 2025 was to delineate an area of impact from horse corral activities and to trial management actions within the corral area.

Study area

Corral area and grazing infrastructure

The site of the previous horse corral, cabins and invasive species infestation are located southwest of Colwell Bay (Figure 1). The cabin and corral sit at the edge of the esker, approximately 50 metres from the high-water wetlands of the delta. The corral area can be accessed in the summer through an established trail, starting at the west side of the delta, following a pine forest esker. In high water, it may be possible to access the corral using a boat from the east side of the delta, however the mud flats at the interface of the bay and forest area make travel by boat difficult. Based on established trails in the area, it appears horses regularly travelled from the corral area along the esker and radiated out from the corral area to graze in the delta.

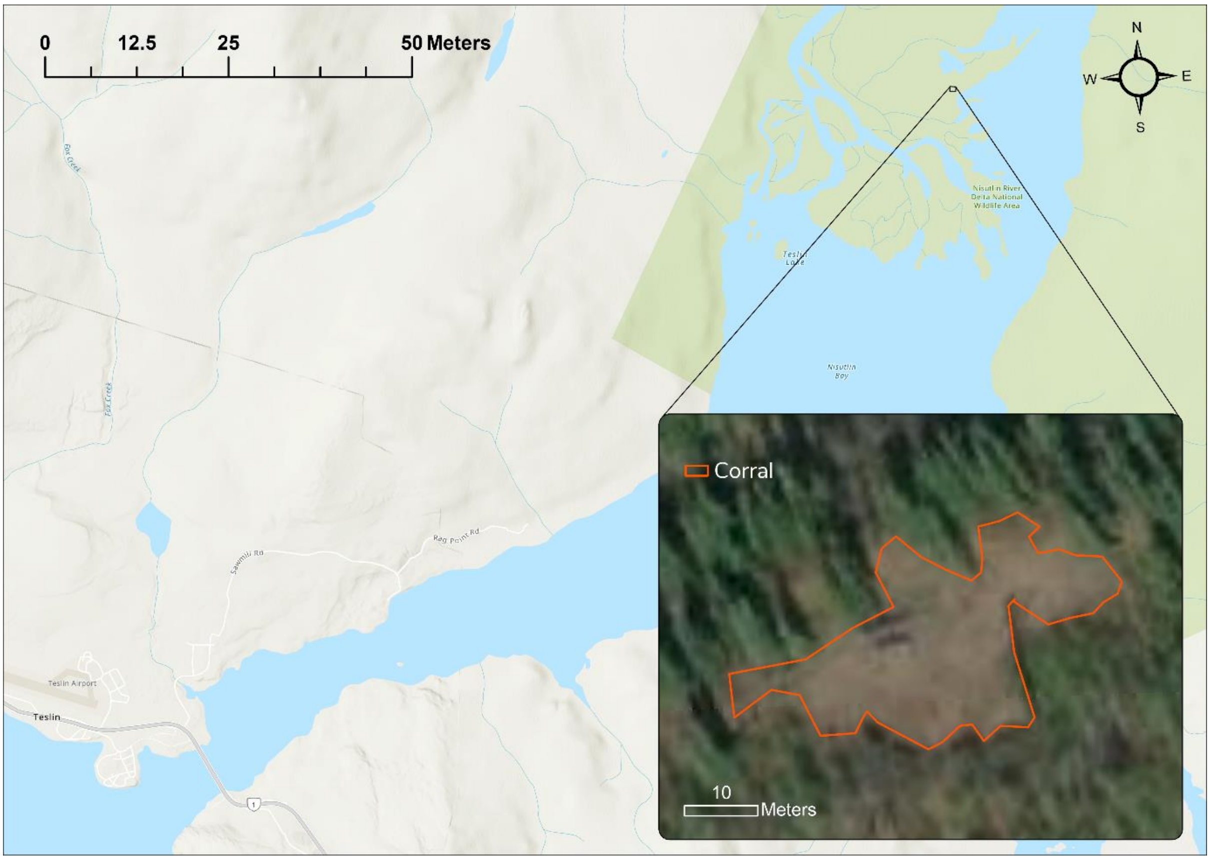


Figure 1. Map of study area (latitude 60.237034, longitude -132.546546).

To facilitate overwintering of horses, a corral, two log cabins and an outhouse were established to monitor the horses during past grazing activities. In 2017, a separate cabin on skids and feed storage outbuilding were brought to the site. The original log cabins and corral have since collapsed or been partially deconstructed. The newer cabin on skids remains at the site and appears to be used frequently. The feed storage outbuilding has been blown over by wind, and partially damaged. We did not observe any other pieces of equipment or infrastructure during this survey work.

Figure 2. Oblique photo of the corral facing west. The line of coniferous trees facing upwards shows the esker and the trail we took from the river.

Area of infestation

Invasive species are heavily concentrated in the historic corral area, directly adjacent to the cabins and outbuildings. Based on empty feed bags found on site, this area appears to be where horses were fed supplemental feed. Within the centre of the corral area there is a manure pile, indicating horses spent concentrated time feeding and resting here. Within the manure pile we encountered empty cans, broken glass and other detritus, indicating the pile may have been used to dispose of garbage on site.

Figure 3. Aerial overview of the corral area showing the historical cabins and outbuildings as well as the newly placed cabin and collapsed feed storage shed. The esker trail can be viewed as the prominent trail at top of the photograph, and the Nisutlin Delta was accessed by horses from the faint trail on the bottom left of the photo.

Monitoring of invasive species

Target species

We identified four target species to monitor and undertake management action. Invasive species selection was based on observations of the species from previous monitoring work in the NRDNWA in the summer of 2024.

Black bindweed (*Fallopia convolvulus*)

Black bindweed is an annual, climbing herb with thin, deep roots. The stem trails on the ground or twines around other plants. Each plant can produce up to 30,000 seeds. Black bindweed can cover bare ground quickly and spread rapidly, potentially preventing the establishment of native species (Klein 2011). It is listed as a noxious weed in Alaska, Manitoba and Saskatchewan Invasives Species Acts. It is likely black bindweed was introduced through contaminated feed.

Narrowleaf hawksbeard (*Crepis tectorum*)

Narrowleaf hawksbeard is an annual plant that grows in a single, sometimes branched stem from a small taproot. It grows up to 60 centimetres and has dandelion-like yellow flowers. Each plant produces more than 49,000 seeds and can spread a long distance from established disturbed areas into gravelly natural areas such as river bars or lakeshores (Yukon Invasive Species Council a [date unknown]). Narrowleaf hawksbeard is listed as a noxious weed in Alaska, Alberta, Manitoba and Saskatchewan.

Scentless chamomile (*Tripleurospermum inodorum*)

Scentless chamomile is a broadleaved plant with dill like, finely divided leaves and large white daisy like flowers. It can grow as an annual, biennial (one year in vegetative state, one year in reproductive state) or short-lived perennial (multiple reproductive years) (Yukon Invasive Species Council b [date unavailable]). It prefers moist, disturbed areas, such as roadsides, croplands and rangelands. Scentless chamomile is considered a noxious weed under the *British Columbia Weed Control Act*, with regulated management actions. It is likely scentless chamomile was introduced from supplemental feed bags such as alfalfa pellets, or contaminated hay.

Smooth brome (*Bromus inermis*)

Smooth brome is a perennial grass that varies in height from 0.5-1.2 metres. The plant has deep rooted rhizomes and erect stems. It reproduces both vegetatively and by seed, creating dense populations that can dominate sites, inhibit natural succession and alter soil conditions (DiTomaso et al. 2013). Smooth brome prefers sunny areas and disturbed sites such as roadside and pastures. Smooth brome is an important agricultural plant and the primary forage grass for most hay production in the Yukon and Northern BC (Yukon Invasive Species Council c [date unavailable]). It is likely smooth brome was introduced into the NRDNWA through supplementary feeding of hay for horses.

Delineation of area of impact

Desktop delineation

Prior to surveying we undertook a heads-up digitization exercise to delineate the corral and infrastructure present at the site. Our aim for this digitization exercise was to determine the necessary survey intensity and management resources needed for fieldwork, based on the area of potential impact from supplementary feeding activities. We digitized in ArcGIS Pro, using a satellite imagery hybrid reference layer, with world imagery dated May 16, 2015 (**Figure 4**). The imagery showed a cleared area in the forest and two dark buildings. Based on previous site visits, we were confident this was the corral area and previously erected cabins. We drew a polygon around the visible cleared area.

We then drew a 30-metre buffer around the digitized corral. We chose 30 metres as a buffer size to align with Government of Yukon's riparian setback recommendation for working near water guidance (Yukon Government 2021). Within the polygon we used the "generate tessellation" tool to generate a hexagonal grid over the buffered area, setting the cell size at 5 metres squared.

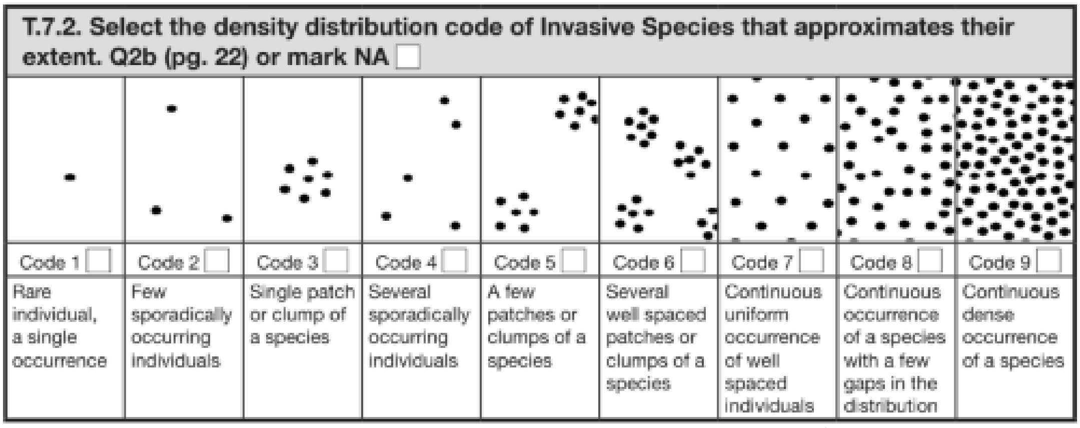
Figure 4. Desktop delineation showing hexagonal grid and 30 metre buffer, heads up digitized polygon of area of impact based on 2015 satellite imagery, and randomly selected permanent sample plots.

Determining extent of spread

To determine the extent outside of the delineated corral area we systematically walked the perimeter of the corral and noted if invasives species were present in each hexagon cell at the edge of the corral polygon. If an invasive species was encountered, the surveyor would then move to the adjacent hexagon cell, continuing to move outwards from cell to cell until no invasive species were detected. The surveyor would then return to the edge of the corral and continue to work outwards around the perimeter of the corral.

Determining density of invasive species

We recorded density of invasives species while determining the extent of spread outside of the corral. If surveyors encountered an invasive species, they recorded the species name as well as a density distribution code for each species occurring inside of the grid cell. We followed the invasive species density distribution code developed by the BC Ministry of Forests (Invasive Plant Program 2023; **Figure 5**). Due to time constraints, individual grid cells within the delineated corral area were not surveyed. Upon visual inspection of the corral, we determined that within the corral area there was a coverage of at least Code 7, a continuous uniform occurrence of well-spaced individuals, especially for smooth brome. Survey results were spatially analyzed to generate a heat map using ArcGIS Pro.



T.7.2. Select the density distribution code of Invasive Species that approximates their extent. Q2b (pg. 22) or mark NA ☐

Code 1 ☐	Code 2 ☐	Code 3 ☐	Code 4 ☐	Code 5 ☐	Code 6 ☐	Code 7 ☐	Code 8 ☐	Code 9 ☐
Rare individual, a single occurrence	Few sporadically occurring individuals	Single patch or clump of a species	Several sporadically occurring individuals	A few patches or clumps of a species	Several well spaced patches or clumps of a species	Continuous uniform occurrence of well spaced individuals	Continuous occurrence of a species with a few gaps in the distribution	Continuous dense occurrence of a species

Figure 5. Invasive species distribution code used to determine density of invasive species outside of the corral area.

Unmanned aerial vehicle mapping

We used an unmanned aerial vehicle (UAV) to map the corral and explore methods of estimating invasive species population using red, green, blue (RGB) orthomosaics. We also used the UAV to capture several oblique photos of the area. Permitting for UAV usage within NRDNWA was obtained by Erica Wall with Environment and Climate Change Canada.

We collected imagery with a DJI Mavic Air 2 using the built-in camera and sensor. Five ground control points (GCPs) were evenly distributed throughout the corral. We completed the flights on July 21, 2025, in the late afternoon.

We planned flights using DroneDeploy with the intention of using it for automated flights. However, DroneDeploy did not function as planned in the field, and we had to capture images manually. Two mapping flights were completed in addition to a general reconnaissance flight for other photos. The vegetation detection flight was loosely based off Gallmann et al. (2022), wherein the altitude was set at 19 metres with an overlap of approximately 90 per cent. For the corral mapping flight, we flew at an altitude of 50 metres and aimed for an overlap of 80-85 per cent. We flew at approximately 2-4 metres/second for both flights. Exposure and f-stop were set to default and controlled by the UAV camera.

Processing was completed by Nigel McNeil with the Technology, Innovations, and Mapping Unit, Government of Yukon, Department of Environment. Products were created using DJI Terra. The outputs consist of a RGB orthomosaic and a digital surface model. Both orthomosaics have gaps, resulting in empty pixels in the highly vegetated areas (**Figure 6**), and the 19 metre ortho having artifacts around dense vegetation (**Figure 7**).

Figure 6. Blank pixels on the 19 metre ortho.

Figure 7. Artifacts around a clump of vegetation on the 19 metre ortho.

We estimated the cover of scentless chamomile by creating polygons following the perceived outlines of the flowerheads and calculating the sum of the shape area. Polygons were created using the Editor tool in ArcGIS Pro (Figure 8).

Figure 8. Manually delineating scentless chamomile from the 19 metre orthomosaic.

Species abundance

We determined species presence and abundance for both invasive and native species through per cent cover measurement. We used the hexagonal grid to randomly select 11 plots within the corral polygon, and 11 plots within the buffer area outside the corral area. In the field we established an additional two permanent plots inside of the corral on top of the manure pile to capture the exceptionally high density of invasive species. We established an additional plot outside of the corral, as one of the randomly selected plots based off desktop delineation was inside of the corral. Plots were permanently marked using a 12-inch metal stake and ButterSoft aluminum tree tag. We recorded sub metre accuracy latitude and longitude for each plot using an Arrow 100 Submeter GNSS Receiver.

We recorded per cent cover using a 1 metre squared hoop quadrat (Figure 9). Within each quadrat, we recorded species presence and total percent cover. All vascular plants were recorded at the species level. Where possible, cryptogrammic species were recorded at the species level but recorded at genus level if the surveyor was unsure of the species epithet.

Data were analyzed using two-way analysis of variance to determine if a difference in species abundance occurred between corral plots and control plots. Control plots were those which were established outside the direct impacts of horse overwintering.

Figure 9. Permanent plot established in the manure pile.

Invasive species removal

Hand pulling and tilling

Due to limited resources for this project and proximity of standing water to the corral area, we determined that herbicide application would not be feasible at this stage of the project. We chose hand pulling as the primary control method. Our hand pulling efforts were contained to the open corral area, as this area had the greatest density of invasive species. We started at the edge of the open area, pulling all broadleaf invasive species seen. We then worked towards the centre of the corral where the manure pile was located. We determined working from areas of low to high concentration may help to limit the spread of future invasives outwards from the corral area (Eppinga et al. 2021). When pulling we endeavoured to pull the entire plant, attempting to remove as much of the root material as possible. Most plants pulled were in flower at this time; however, we did not observe any plants that had already gone to seed.

We bagged all narrowleaf hawksbeard that was pulled into black garbage bags, removing the bags from the site and disposing them in designated trash facilities. We did this to reduce the potential of narrowleaf hawksbeard going to seed once it was pulled (Yukon Invasive Species Council a [date unknown]). All other target species were pulled and left to die on the soil surface. We did not hand pull any smooth brome, as hand pulling of smooth brome has limited efficacy due to rhizome reproduction if root matter if left in the soil (DiTomaso et al. 2013). Due to the observed extent of smooth brome inside the corral area and spread of smooth brome along the trails connecting the corral area to other natural areas, we determined hand pulling would not be a feasible approach and would not significantly alter the existing smooth brome population within the NRDNWA.

After completing hand pulling of all broadleaf invasive species from the manure pile area, we simulated tilling of the area by using hand shovels to dig up and turn over the top layer (10-30 centimetres) of manure and soil. By simulating mechanized tilling, we were able to dig up and sever root material, desiccating any remaining vegetative matter. By disturbing the soil, we exposed potential seedlings that may germinate throughout the remainder of the growing season, which would then be killed by frost before reaching a reproductive stage (Bajwa et al 2015).

Figure 10. Waste pile of hand pulled Scentless Chamomile within the manure pile. This pile was left on site and covered with a poly woven tarp to facilitate smothering.

Smothering

After completion of simulated tilling, we used waterproof woven poly tarps to cover the disturbed area. Covering the surface of the ground with dark, opaque material that is impermeable to sunlight will block sunlight and air, killing the plants by preventing photosynthesis (Plumb [date unknown]). Our area of focus for smothering was directly over the manure pile, as this area had the highest concentration of invasive species. Tarps were secured into the ground with 12-inch metal stakes. We overlapped each tarp along one edge with its adjacent tarp to prevent them from coming undone and to ensure continuous coverage. We then placed firewood and logs that were present in the area on the edges of all the tarps to prevent sunlight from penetrating through the edges of the tarps (**Figure 11**). The tarps will remain over the ground throughout the winter and past next year's germination stage. We acknowledge that smothering this area will also potentially kill any native species that are under the tarps, however given the high density of invasive species in this area, we feel the benefit of potentially reducing the population of invasive species outweighs the risk of killing native plants.

Figure 11. Manure pile area covered by poly woven tarps to facilitate smothering of invasive species. The size of covered area is approximately 275 metres squared.

Monitoring results

Species detection from imagery

The 50-metre flight sufficiently captured the monitoring area, including the edges of the corral (**Figure 12**). Conditions were adequate for capturing imagery. Shadows were minimal despite flying late in the day. Photos were slightly overexposed, resulting in sun glare on the lighter objects, including the GCPs and bleached woody debris. However, GCPs can still clearly be identified and there are no heavy shadows obscuring significant areas. The 19-metre flight did not capture the entire corral clearing, but we were able to capture the manure pile, which contained the high concentration of invasives (**Figure 13**).

Figure 12. Orthomosaic of the corral taken at 50 metres altitude.

Figure 13. Orthomosaic of the corral taken at 19 metres altitude.

We did not adjust the flower detection methodology to accommodate the limitations of the UAV we were using; therefore, the resulting imagery is not sufficient to detect most of our target species. The study in which we based our flight used a drone with higher resolution camera and sensor.

The vegetation detection flight did not cover the entire corral. We determined the risk of collision from flying at such a low attitude outweighed any potential gains of vegetation detection. An automated flight would have been ill-advised due to this same reason. Our ground sampling distance (~2.08 millimetre /pixel) was slightly higher than that of flights by Gallmann et al. (2022; ~1.5 millimetre/pixel).

Scentless chamomile was the only species to appear distinctly in the imagery and be distinguishable enough to manually delineate the flowerheads (**Figure 14**). The smooth brome is also apparent, but the extent of its presence on the edges of the corral clearing becomes uncertain with the decreased frequency of the chamomile and an increase in other vegetative cover. It is also impossible to distinguish individual stalks.


Figure 14. Scentless chamomile at 19 metres above ground.

Species abundance

Total species abundance for plots within the corral was significantly greater (p= 0.000551) than plots outside of the corral (Figure 15). Apart from smooth brome, all targeted invasive species were only encountered within the corral. The difference in abundance of invasives within the corral versus outside the corral was significant (p=0.00393). The difference in species abundance between native and invasive species within the corral was also significant (p=0.04559). However, the difference in abundance of native species inside the corral versus outside the corral was not statistically significant (p=0.07173). This suggests invasive species are concentrated in areas of disturbance, and when encountered they occupy a larger per cent of total cover than native species. A full species list for all plots can be found in Appendix 1.

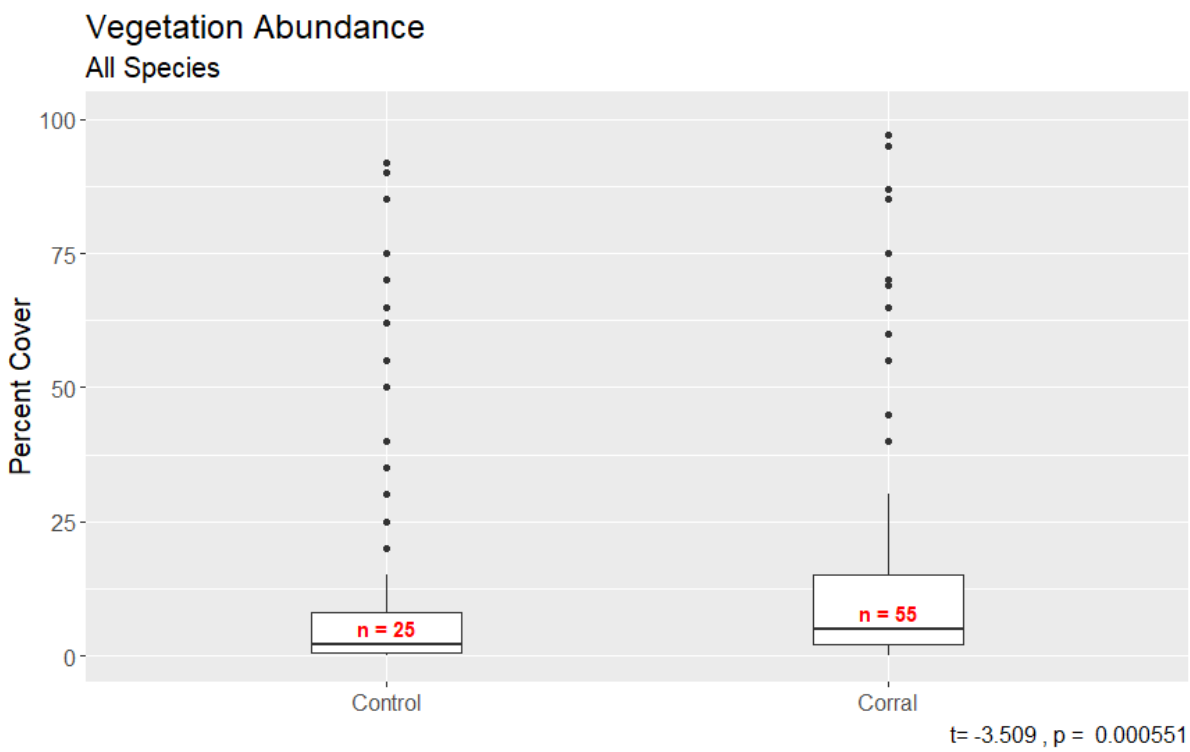


Figure 15. Per cent cover for all species within and outside the corral. Species abundance was significantly greater within the corral.

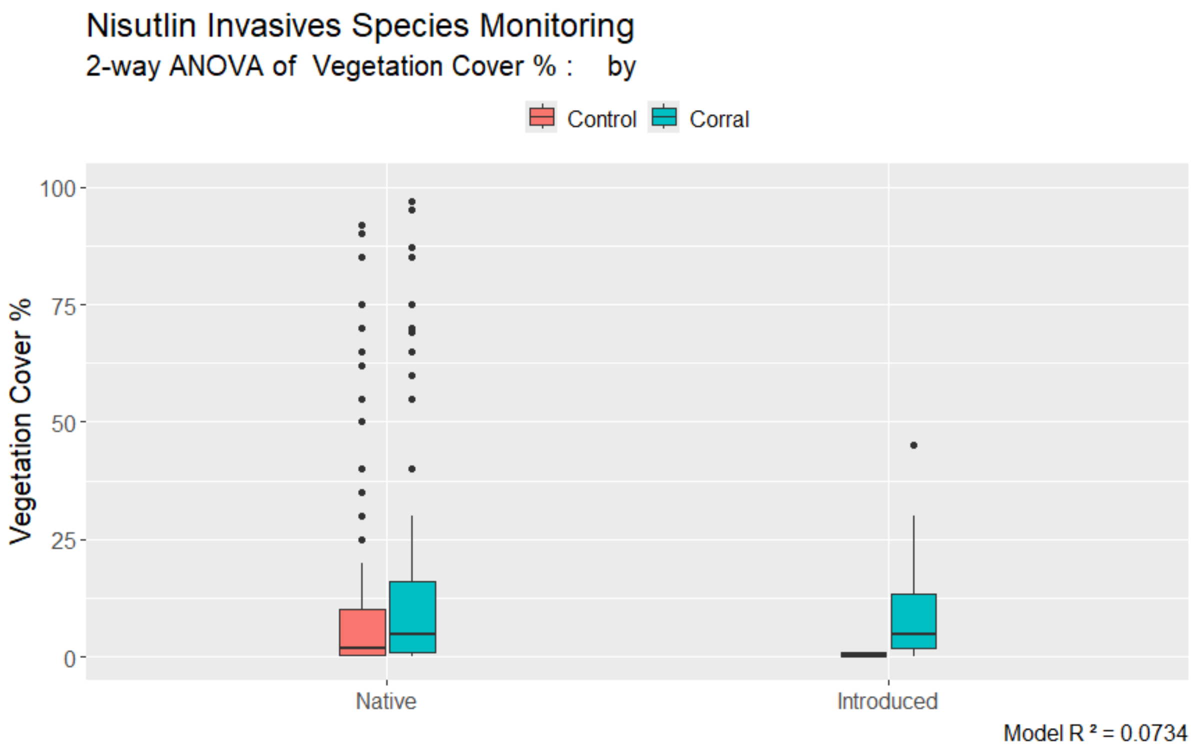


Figure 16. Vegetation cover of native versus introduced species within and outside the corral area. The cover of native species within the corral area was not significantly different than outside the corral area.

Invasive grass species were the most common species stratum within the corral. Smooth brome (*Bromus inermis*) was the most common invasive species encountered during surveys, occurring 11 times with an average percent cover of 12.45 per cent and highest per cent cover of 45 per cent. Kentucky bluegrass (*Poa pratensis* ssp. *pratensis*) occurred eight times, with an average percent cover of 10.87 per cent and highest per cent cover of 30 per cent. Narrowleaf hawksbeard (*Crepis tectorum*) occurred 3 times, with an average percent cover of 3.33 per cent, and highest percent cover of 5 per cent. Dandelion (*Taraxacum officinale*) occurred once, with a percent cover of 0.25 per cent. Scentless chamomile occurred once with a percent cover of 1 per cent. We note that the scentless chamomile's occurrence was clustered into a small area within the corral and randomized percent cover surveys within the corral may not accurately represent its overall abundance. Black bindweed (*Fallopia convolvulus*) was not encountered during surveys and was not visually found during mechanical control. Horse dung was present in plots both inside and outside the corral area, occurring eight times and representing an average of 7.76 per cent of total cover.

Density of invasive species

The highest density of invasive species was observed directly on the manure pile within the corral. This is likely a result of invasive species seeds germinating and persisting in the nutrient rich soil enriched by the horse manure (Pickering et al. 2010). Density of all invasive species decreased radiating outwards from the manure pile and was negligible once the habitat transitioned to tree or shrub dominated areas. Observations of invasive species radiating outside of the area of impact is shown in **Figure 17**. Only one invasive species, smooth brome, had a significant presence outside the corral and was also observed occurring along the esker horse trail. However, a detailed survey outside of the corral area was not undertaken during this survey and other invasive species may occur outside of the area of impact.

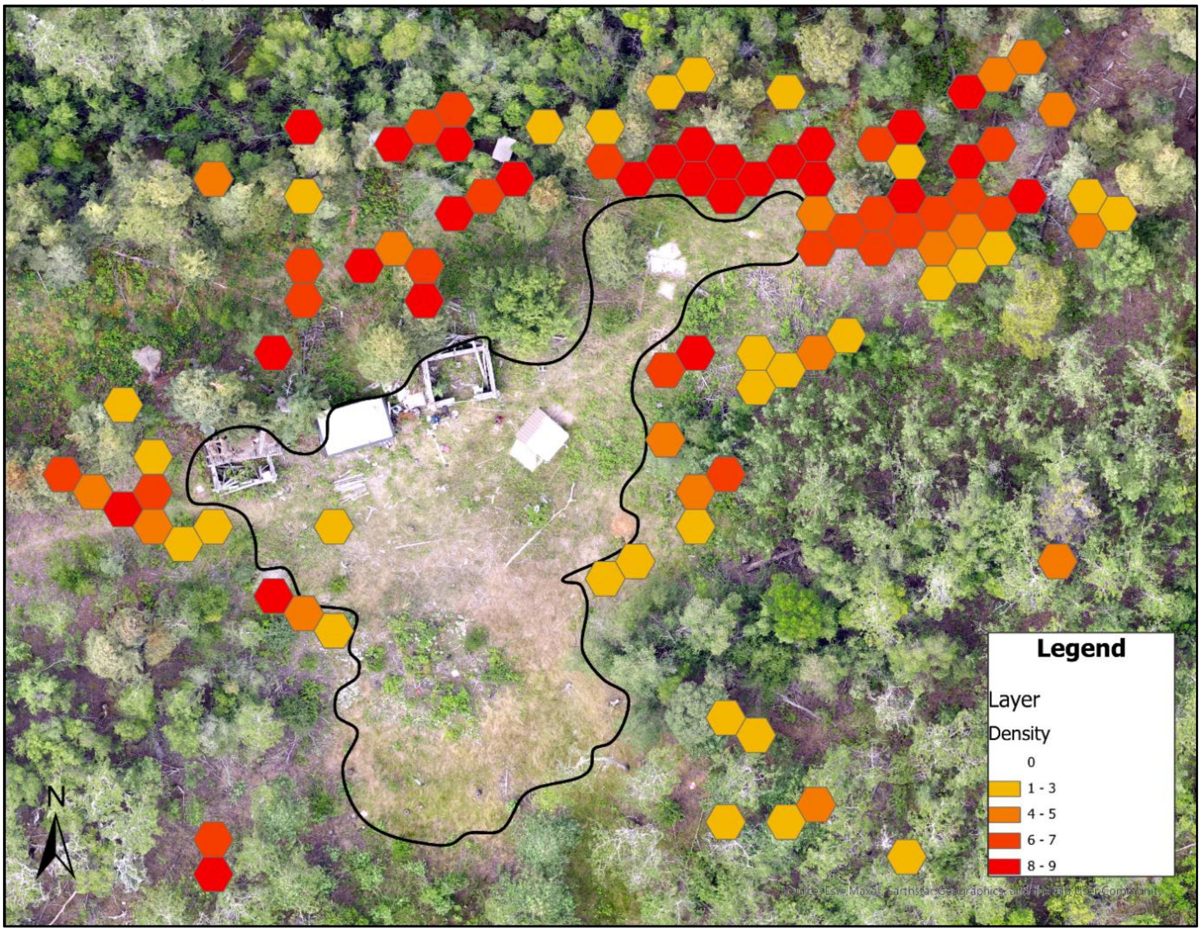


Figure 17. Density of target invasive species outside of the area of impact. Smooth brome (*Bromus inermis*) was the most commonly found species. Refer to **Figure 5** for density code explanations.

Determining population from imagery

The total area of scentless chamomile is approximately 3.48 metres squared, which is approximately 0.11 per cent of the corral polygon (3,096.85 metres squared). This is 0.89 per cent lower than the average percent cover of scentless chamomile from the plot surveys, which was 1 per cent, indicating we cannot accurately determine the population of scentless chamomile from imagery analysis.

Unfortunately, the imagery we collected is not high enough resolution to distinguish individual plants, especially when they are growing closely together (**Figure 18**). We cannot determine abundance or density from this imagery. We do not recommend results from imagery analysis to be taken into consideration for management decisions.

Figure 18. Clumps of scentless chamomile from the 19 metre imagery at 1:20.

Discussion

Our trial results for detection of invasive species using UAV mapping were not successful. It may be possible to track the extent of scentless chamomile if UAV mapping flights are repeated in subsequent years. Without changing methodology or equipment, differences could still be discerned visually by overlapping the images or digitizing the visible flowerheads. A more useful path forward would be to capture imagery where individual flowers can be detected, including those of species we were unable to detect in the imagery this year. This will require development of a methodology that minimizes the risk of collisions if we continue to use the Mavic Air 2 drone. Capturing the edges of the corral will pose a problem if we were to fly lower than 19 metres above ground, as the risk of flight collision greatly increases from higher tree cover. Due to this risk, it is unlikely that we would be able to use automated flight, even with obstacle avoidance

Manually delineating scentless chamomile flowerheads was good for estimating per cent cover, but it is open to human error. Because the yellow centers of the flowers cannot be seen in the imagery, we cannot verify that the object is a flowerhead. What is classified as scentless chamomile is up to the discretion of the digitizer. We had difficulty distinguishing clumps of flowers from overexposed areas. One of the main reasons why the imagery estimation is lower than the per cent cover plot estimation is due to only flowerheads being delineated, while the whole plant was considered for coverage in the field. The resolution of the imagery was too poor to confidently identify the vegetative portion of scentless chamomile. This method works well for estimating the per cent of flowering heads but not for estimating per cent cover of scentless chamomile. We likely missed delineating plants without flowerheads. This method may be useful to determine the reproduction potential of invasive species but cannot fully explain the potential impact of the species regarding loss of habitat and competition for native species.

A higher species abundance within the corral area suggests grazing from horses may over time reduce the competitiveness of dominant native species in impacted areas and enhance overall plant diversity. Our findings align with the intermediate disturbance hypothesis which suggests environments with moderate level of disturbance exhibit a higher species diversity. Other studies on grazing intensity in native grasslands show that under moderate grazing intensity, concerns have been raised regarding the increase of exotic and unpalatable species (Villalobos and Long 2024). These studies suggest that increased grazing can complicate conservation efforts in natural areas.

Due to the long-term establishment of invasive species within the corral area, it is unlikely our first attempt at management efforts this year will lead to a significant reduction in invasive species presence. If successful, we anticipate control and eradication of broadleaf invasive species will likely require several years of management efforts. Due to the extent of spread of smooth brome, it is unlikely that it will ever be successfully eradicated from the NRDNWA without the use of herbicide. To determine if these mechanical control efforts are having an effect, repeat measurements from permanent sample plots will be required. Management effort success would be indicated by no significant statistical difference in vegetation abundance and composition being detected between the corral and control plots.

Future management of invasive species within the NRDNWA would benefit from a planning exercise to determine the acceptable level of invasive species within this protected area, and the appetite for control measures such as herbicide application. Due to the proximity of standing water, any herbicide use should be thoroughly reviewed before proceeding with planning, and consultation with Teslin Tlingit Council should occur. If herbicide application is chosen as a future management tool, application will need to be completed by a trained professional.

Our work this year highlights the importance of early detection and rapid removal of invasive species. Management of invasive species, especially in a remote area such as the NRDNWA is expensive and time consuming. If grazing permits are to be reissued in this area, we suggest yearly monitoring by regulated officials to visually inspect for invasive species. Permitters should also carefully consider the impact of pelleted feed, and the potential for introduction of invasive species from feed pellets. We suggest removal of manure from the corral locations regularly to prevent nitrification of soil in this area, as nitrogen improves the soil condition and facilitates establishment of invasive species. While this may prove logistically challenging due to the remote access of the corral site, it may be possible to remove animal waste during the winter months by snow machine.
Our data collection this year and previous reports suggest invasive species are persisting within the cleared corral area but diminish in areas where there is higher shrub or tree cover. Previous studies on vegetation changes within the Nisutlin River Delta NWA suggest an increase in shrub coverage, specifically in areas of open shrub and tall shrub habitats (Willier 2021). These data are encouraging for the potential success of active reclamation of the corral area. It may be possible to plant willow species in the area by using cuttings from the surrounding vegetation to encourage overgrowth of overstory and shading out of the invasive species understory. Replanting or reseeding with native

vegetation that occurs within the NRDNWA will limit spread of invasive species into the area that we tilled and may help to outcompete other areas in the corral that are currently dominated by smooth brome. Future planning for replanting or reseeding using native species will require input from professionals familiar with Yukon species and habitat restoration.

Conclusion

Livestock grazing can have a significant impact on local ecosystems (Villalobos and Long 2024). During this fieldwork, we monitored the presence of invasive species within an area impacted by horse grazing. During this survey, we encountered smooth brome, Kentucky bluegrass, narrowleaf hawksbeard and scentless chamomile. These species were significant in the areas inside of the horse corral but did not occur in significant abundance outside of the corral area. It is likely invasive species can persist in natural areas that have been degraded by horse activity, or areas that have experienced changes in soil conditions and vegetation communities because of horse grazing activities.

Management actions taken this year, including hand pulling and smothering may help to reduce the population of invasive species present, however several years of management actions will likely be required for a significant reduction in invasive species to be detectable. If this approach is taken, we recommend continuing to measure long term permanent plots to determine control success. Smothering tarps should be inspected yearly for damage and are not meant to be a long-term solution to invasive species management. The tarps should remain in place no longer than two growing seasons, as blocking sunlight also restricts growth to native species in the area. Direct management of the manure pile, which appears to be the main seed source of invasive species, may help mitigate and decrease the spread and establishment of the invasive species. Removal of manure or burning of organic material (manure) would assist in reducing the invasive species seedbank.

We obtained an aerial map of the corral and surrounding area that can be used for future reference. Our attempt at mapping invasive species using a UAV was only partially successful, as the only species we were able to detect was smooth brome and scentless chamomile. If we want to map other species in the future, we will need to decrease our ground sampling distance to increase the resolution. Our study shows that UAV mapping for invasive species may be successful in flat, open areas but has limited success in treed areas.

Moving forward, we recommend Environment and Climate Change Canada, the Government of Yukon and Teslin Tlingit Council determine what level of management is required for invasive species within the NDRNWA. Any future grazing lease applications in the area should carefully consider the impacts of invasive species within a natural area. Thoughtfully planned mitigation efforts, including early detection and rapid response will be crucial to avoid introduction of new species, and spread of existing species in the area.

References

BAJWA AA, MAHAJAN G, CHAUHAN BS. 2015. Nonconventional Weed Management Strategies for Modern Agriculture. Weed Science. 63(4):723–747. https://doi.org/10.1614/ws-d-15-00064.1

BENNETT B. 1998. Habitat Types of the Nisutlin Delta National Wildlife Area. Environment Yukon.

DE VILLALOBOS AE, LONG MA. 2024. Grasslands response to livestock grazing intensity in the Austral Pampas (Argentina): Testing the intermediate disturbance hypothesis. Phyt Int J Exp Bot. 93(8):2037–2050. https://doi.org/10.32604/phyton.2024.053928

DITOMASO JM, KYSER GB, WEED RESEARCH AND INFORMATION CENTER. 2013. Weed control in natural areas in the Western United States. University of California. https://wric.ucdavis.edu/information/natural%20areas/wr_B/Bromus_inermis.pdf

EPPINGA MB ET AL. Spatially explicit removal strategies increase the efficiency of invasive plant species control. Ecological Applications. 2020;31(3). https://doi.org/10.1002/eap.2257

GALLMANN J ET AL. 2022. Flower Mapping in Grasslands With Drones and Deep Learning. Front Plant Sci. 12. https://doi.org/10.3389/fpls.2021.774965

HOEFS M. 1976. Preliminary biological reconnaissance of the lower Nisutlin River floodplain. Yukon Game Branch.

INVASIVE PLANT PROGRAM, MINISTRY OF FORESTS, PROVINCE OF BC. 2023. Invasives BC Reference Guide. https://www2.gov.bc.ca/assets/gov/environment/plants-animals-and-ecosystems/invasive-species/invasivesbcresources/invasivesbc_guidance_document.pdf

KLEIN H. 2011. Black bindweed. https://accs.uaa.alaska.edu/wp-content/uploads/Fallopia_convolvulus_BIO_FACO.pdf

PICKERING CM, HILL W, NEWSOME D, LEUNG Y. 2009. Comparing hiking, mountain biking and horse riding impacts on vegetation and soils in Australia and the United States of America. Jour of Env Man. 91(3):551–562. https://doi.org/10.1016/j.jenvman.2009.09.025

PLUMB S. [date unknown]. Proper disposal methods. The Nature Conservancy. https://cdnsm5hosted.civiclive.com/UserFiles/Servers/Server_15207780/File/Departments/Conservation/Landscaping,%20Plants,%20Trees/disp.pdf

YUKON GOVERNMENT. 2021. Placer Class 1 Activities and Prospecting Leases: Working Near Water. https://yukon.ca/sites/default/files/emr/emr-placer-class-1-activities-prospecting-leases-working-near-water.pdf

YUKON INVASIVE SPECIES COUNCIL A. [date unknown]. Narrowleaf Hawksbeard Fact Sheet. https://www.yukoninvasives.com/plants/Narrowleaf_Hawksbeard.pdf

YUKON INVASIVE SPECIES COUNCIL B. [date unknown]. Scentless Chamomile Fact Sheet. https://www.yukoninvasives.com/plants/Scentless_Chamomile.pdf

YUKON INVASIVE SPECIES COUNCIL C. [date unknown]. Smooth Brome Fact Sheet. https://www.yukoninvasives.com/plants/Smooth_Brome.pdf

WILLIER, CAITLIN. 2021. Assessing vegetation change within the Nisutlin River Delta National Wildlife Area: 1984 to 2018 (SR-21-xx). Government of Yukon, Whitehorse, Yukon, Canada.

Appendix 1

Table A-1. Species list for per cent cover plots. Origin status based on VASCAN database.

Species Name	Origin in the Yukon
Achillea millefolium	Native
Aulacomnium sp.	Native
Aulacomnium spp.	Native
Bromus inermis	Introduced
Calamagrostis canadensis	Native
Calamagrostis purpurascens	Native
Calamagrostis stricta	Native
Cerastium beeringianum	Native
Chamaenerion angustifolium	Native
Climacium dendroides	Native
Comarum palustre	Native
Crepis tectorum	Introduced
Dicranum sp.	Native
Equisetum arvense	Native
Equisetum pratense	Native
Eurybia sibirica	Native
Fragaria virginiana	Native
Galium boreale	Native
Hylocomium splendens	Native
Lupinus arcticus	Native
Mnium sp.	Native
Peltigera sp.	Native
Picea glauca	Native
Plantago major	Introduced
Pleurozium schreberi	Native
Poa pratensis ssp. *pratensis*	Introduced
Polytrichum juniperinum	Native
Populus balsamifera	Native
Populus tremuloides	Native
Potentilla norvegica	Native
Rorippa palustris	Native
Rosa acicularis	Native
Salix barclayi	Native
Salix glauca	Native
Salix scouleriana	Native
Taraxacum officinale	Introduced
Tomenthypnum nitens	Native
Tripleurospermum inodorum	Introduced
Viburnum edule	Native
Vicia americana	Native