Assisted Migrations of the Northern Blazing Star and Long-Leaved Bluets in Alberta: 2014 Progress Report

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Progress Report prepared for the Biodiversity Management and Climate Change Adaptation Project

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Preface:

The Alberta Biodiversity Monitoring Institute (ABMI) is an arm's-length, not-for-profit scientific organization. The primary goal of the ABMI is to provide relevant scientific information on the state of Alberta's biodiversity to support natural resource and land-use decision making in the province.

In the course of monitoring terrestrial and wetland ecosystems across the province, the ABMI has assembled a massive biodiversity database, developed reliable measurement protocols, and found innovative ways to summarize complex ecological information.

The ABMI undertakes focused projects to apply this capacity to specific management challenges, and demonstrate the value of the ABMI's long-term monitoring data to addressing these challenges. In some cases, these applied research projects also evaluate potential solutions to pressing management challenges. In doing so, the ABMI has extended its relevance beyond its original vision.

The ABMI continues to be guided by a core set of principles – we are independent, objective, credible, accessible, transparent and relevant.

This report was produced in support of the ABMI's Biodiversity Management and Climate Change Adaptation project, which is developing knowledge and tools to support the management of Alberta's biodiversity in a changing climate. The views, statements, and conclusions expressed in this report are those of the authors and should not be construed as conclusions or opinions of the ABMI.

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1. Introduction/Background

As climate change continues, climatically suitable geographic ranges of species will shift (1). Species with limited dispersal abilities may not migrate rapidly enough to respond to warming and thus may face increased risk of extinction or extirpation (1, 11). This will be particularly true for species with both narrow climatic niches and high habitat-specificity. In order to prevent such extinctions or extirpations, and the associated loss of biodiversity, assisted migration (assisted colonization) has been suggested as a proactive conservation tool (9). This process involves moving organisms to areas outside their current range, to ranges that are predicted to be more suitable under future climatic scenarios (3, 4). There have been fears that moving species out of their range may result in the species being too successful (invasive), and thus may cause negative impacts on native species and ecosystem processes (10). However, plants are demonstrably unlikely to become invasive, especially when they are translocated within the same continent (5).

This proactive tool is especially important in preventing the declines of species unable to shift their geographic distributions (8). However, assisted migration for the purpose of conservation has had few experimental trials (2).

As a case study in assisted migration, we are translocating within Alberta two rare and range-restricted plant species, the Northern Blazing Star (*Liatris ligulistylis*) and Long-Leaved Bluets (*Houstonia longifolia*) (7). The Northern Blazing Star has a conservation status in Alberta of vulnerable (S3) (7), and is found within the aspen parkland natural subregion (6). The Long-Leaved Bluets has a conservation status in Alberta of imperiled (S2) (8), and is found in the same region as the Northern Blazing Star.

Two specific research objectives are being tested in this study. First, a test of whether these narrow-ranged species in Alberta are vulnerable to projected climate change (i.e., future warming). This is being tested through translocations of the species to more southern locations in which the current climate resembles what the climate in their current geographic range is predicted to be like by ~2050. Secondly, we are testing whether assisted migration could be used as a conservation tool for preventing extinction and extirpation as climate change progresses. This is being tested through assessing survival, growth and fecundity (seed production) of both species when translocated to a region north of their current ranges. At the same time, we are undertaking studies of the autecology of these species in existing populations in order to gain more insight into their vulnerabilities and to determine which factors most affect their survival.

2. Methods

2.1 Northern Blazing Star Translocation Sites

Three Northern Blazing Star Translocation sites were established across Alberta in the fall of 2012, one in the south (Duchess), one in this species current range (Woodbend Forest), and one in the north (Lac La Biche). At each site 10 Northern Blazing Star corms were translocated from populations collected along roadside ditches in Ukalta and Bruderheim (Figure 2, Picture 1). Seed plots consisting of 200 seeds were also set up at each site, although these plots had little or no germination; and no comparison could be done due to the destruction of the southern site from third party activities. Therefore, in 2013 a thousand seeds were sown at each of these three existing 2012 translocation sites from the North Bruderheim Provincial Recreation Area (Figure 2, Picture 1).

In the fall of 2013, nine additional translocation sites were established from populations in the North Bruderheim Provincial Recreation area. At each of the nine new translocation sites, 16 adult corms were planted and 1000 seeds were sown. Seed plots, which were placed near the planted corms, were delineated using pigtails. At each plot 10 quadrants (~30 cm x 30 cm) were delineated and separated by a 20 cm buffer. A hundred seeds were placed in the center of each of these 10 quadrants (Figure 3, Picture 2).

At both the 2012 and 2013 translocation sites the influence of edaphic conditions was tested by planting/sowing this species' corms into either local (recipient) or native (source) soil. At each site, soil type was randomly assigned to plants/sown pots. This method allows for separating the effect of climatic as opposed to edaphic factors, although sites for translocation were targeted to be similar (sandy soils). At all sites chicken wire exclosures were used around each pot to prevent herbivory of adult plants, as deer grazing on Northern Blazing Stars was observed (Figure 2 and 3).

Therefore, from 2012 to 2013, 12 Northern Blazing Star translocation sites, consisting of both adult corms and seed, were established (Figure 1). Three experimental sites have been established in southern Alberta near Duchess, about 450 km south of the species' current range to determine if this species will be vulnerable to future climate change. Six experimental sites have been established in northern Alberta, north of the species' current range, with three sites in the Lac La Biche area, and three sites just north of Fort McMurray (about 500 km north of this species' current range). Finally, three sites have been established within this species' current climatic range; two in the North Bruderheim Provincial Recreation area and one in the Woodbend Forest. These three sites act as controls (within the current range and current climate). These twelve sites can be evenly divided into 4 locations: south, central, north and far north, each containing 3 replicates (Figure 1, Table 1). More details on the set up of these assisted migration sites can be found in the 2013 progress report for this project.

This spring (2014), field cameras were set up at all twelve Northern Blazing Star sites, and were programmed to take 4 pictures each day between 11:30 am to 1:00 pm. These pictures captured phenology of the adult Northern Blazing Stars including first sprouting and first bud burst.

2.2 Long-Leaved Bluets Translocation Sites

In the summer of 2014 native pasture (privately owned) containing a large population of Long-Leaved Bluets was discovered with the help of ANPC (Alberta Native Plant Council). This place will be referred to as Gibbons Field, due to its close proximity to the town of Gibbons, AB. The property owner gave notification that this field will be destroyed in 2015 for the construction of a rest area adjacent to Highway 28. Due to the proposed future destruction of Gibbons field, permission was granted to remove 130 Long-Leaved Bluets from this area. These plants were collected in June (2014) and placed in half gallon pots. The soil type within these pots was not altered (native or local) to prevent root damage, and therefore only native soil from the field was used. Collection was split evenly between pin and thrum floral morphs. Once collected these plants were given specific ID's containing their floral morph type, and moved to a backyard in Edmonton where they were stored until translocation in the fall. These plants were frequently watered during the summer to promote their survival.

In September 2014, 13 Long-Leaved Bluets sites were established across the province. Twelve of these sites were placed at the same locations as the twelve Northern Blazing Star sites (Figure 1, red dots); and an additional single site was placed near the Gibbons field location to act as a control (Figure 1, blue dot). At each site 10 Long-Leaved Bluets pots were placed in the ground and floral morphs were divided evenly with 5 thrums and 5 pins represented at each site (Figure 4, Picture 3). Also, chicken wire exclosures were used around each pot to prevent herbivory of adult plants, due to observations of browsing in the field.

Seed plot areas were also set up near the adult Long-Leaved Bluets and delineated using pigtails. At each plot 10 quadrants (~30 cm x 30 cm) were delineated and separated by a 20 cm buffer. Unlike the Northern Blazing Star, the Long-Leaved Bluets does not require wet stratification for germination, only light and therefore 100 seeds will be placed in the center of each of these 10 quadrats in the spring 2015 (Figure 4). It should be noted that this seed set up is identical to the Northern Blazing Star seed plots established in 2013.

2.3 Northern Blazing Star Response Measures

This summer (2014) multiple measurements of success were recorded at each of the 12 Northern Blazing Star translocation sites. For the adult Northern Blazing Star, measures of success and performance included: survival, maximum height, mean height, number of florets and fecundity. To assure accurate seed counts, mesh begs were placed around flowering heads at the start of senescence to prevent dispersal. Measures of success for the Northern Blazing Star seed included: total emergence, end of summer establishment, and mean height of seedlings. Mean height for seedlings was calculated at each site by averaging up to 10 seedlings in each of the 10 quadrats.

Note: Site refers to each of the individual 12 Northern Blazing Star sites, whereas location refers to the grouping of these sites into 4 geographical locations across Alberta, each containing three sites (i.e. replicates). Finally soil refers to whether local (recipient) or native (origin) soil was used in the pots containing the Northern Blazing Star corms. (Table 1)

I. Survival

Northern Blazing Star was monitored for survival throughout the summer. Those plants that did not grow were considered mortalities and used to estimate survival rate. The software package R was used to graph difference in survival rates between the 4 Alberta locations (south, central, north and far north). R was also used to test differences in survival rate between soil types by comparing survival of Northern Blazing Star in native soil as compared to local soil.

II. Height

The Northern Blazing Star can sometimes have multiple flowering shoots, and therefore the height of the tallest shoot (maximum height) was used as a measure of growth performance. Maximum height was believed to give a more accurate representation of heights at each site than mean height. The software package R was used to graph differences in maximum height between the 4 locations (south, central, north and far north) and test differences between soil type (local or native).

III. Florets

Bud counts incorporated all flowering buds on flowering stems associated with a single plant. Northern Blazing Star does not always produce flowering stems each year. This is likely a life history trait, but may also be affected by climatic differences. Therefore, the software package R was used to graph differences in the effect of location and soil type on the proportion of plants that produced flowering stems; and of those that produced stems to test how location and soil affected the average number of florets per plant.

IV. Seeds

a) Establishment and Emergence

To examine differences between locations for Northern Blazing Star germination rates (total seed emergence and summer establishment), the software package R was used. Because soil type was always local, location was the only predictor of establishment and emergence tested.

b) Seedling Height

To examine how seedling heights differed between locations, the software package R was used to graph and test differences. Average heights in each quadrat was calculated by taking average heights of up to 10 seedlings. The mean of these 10 quadrats was used to get an overall seedling height for the site. Sites were then grouped by location. Soil type was not incorporated as these seeds were always planted in local soil.

V. Phenology

Photos from the phenology cameras placed at all twelve translocation sites were analyzed to determine dates of first sprouting and first bud burst at each site. First bud burst refers to when the top (first) bud of the Northern Blazing Star opened.

2.3 Long-Leaved Bluets Response Measures

Due to the Long-Leaved Bluets being translocated in the fall (2014), no measures of success and performance have been collected for this species. Responses will be measured in the summer of 2015. However, measurements prior to translocation were taken for comparisons with future data from 1 year after these translocations. The data collected included: mean height, maximum height, number of flowers, and seed production, which is currently being counted.

3. Results

3.1 Response Measures of Plant Performance

I. Survival

The north location had the highest survival rate (86.8%, SE=4.0) which was slightly higher than the central location (83.3%, SE=8.3). In contrast, the southern location had the lowest mean survival rate (74.6%, SE=3.3) with the central location being slightly higher (79.2, SE=5.5) (Figure 5). This suggests that the Northern Blazing Star may not be at equilibrium with its current climatic conditions and lacks suitable dispersal to northern sites where performance is higher.

Figure 6 illustrates an unclear effect of soil type on survival rates. In the south a higher percentage of Northern Blazing Stars survived in native soil than local. In contrast, at the north and central locations a higher proportion of Northern Blazing Stars survived in local than native soil. In the far north there was no difference in the percentage of Northern Blazing Stars that survived between the two soil types.

II. Height

The far north location had the greatest average maximum height (37.4 cm, SE=2.7) followed by the north (33.8 cm, SE=2.7), central (29.8 cm, SE=2.1) and south (28.3, SE=2.5) locations respectfully (Figure 7). This supports the theory that this species does have climate change vulnerabilities and that it will thrive in areas north of its current range. However further analysis is needed to determine the significance of these height differences.

When examining height grouped by soil type, corms placed in native soil had greater maximum heights than those placed in local soil at the north and far north location as well as the south location (Figure 8). In the central site, those pots containing local soil had greater average maximum heights than those in native soil. However, the standard error bars are overlapping within this graph and two of the three replicates at the central location only used native soil. Therefore, further analysis is needed to determine the significance of this relationship.

III. Florets

Figure 9 illustrates the proportion of Northern Blazing Stars that flowered of those that survived. The far north location had a higher flowering percentage (49.6%, SE=3.8) than the central location (47.8%, SE=7.8), while the south location had the lowest flowering percentage (42.7%,

SE=4.0) (Figure 9). Additional analyses are needed to determine if these differences are significant.

Figure 10 illustrates the percentage of Northern Blazing Stars that produced flowering stems based on soil type. A greater percentage of Northern Blazing Stars produced flowering stems in native soil than in local soil at the south, north and far north locations. Whereas at the central location Northern Blazing Stars in local soil produced a greater percentage of flowering stems.

Figure 11 illustrates the average number of florets produced per flowering plant. It seems the far north location had the highest average number of florets (6.1, SE=1.1) followed by the central (5.4, SE=1.6), south (5.0, SE=1.4) and north (4.2, SE=1.0) locations respectfully.

For all 4 locations the average number of florets of plants that produced flowering stems was higher in pots containing native soil than local soil (Figure 12). Additional tests will need to be carried out to determine the level of significance for these differences.

IV. Seed

a) Establishment and Emergence

The north (20.6%, SE=2.3) and far north locations (21.4%, SE=3.1) had higher emergence rates than the south (1.3%, SE=0.3) and central locations (5.9%, SE=1.2) (Figure 13).

The north (16.8%, SE=2.2) and far north locations (20.3%, SE=3.0) also had higher seed establishment rates than the south (0.3%, SE=0.1) and central locations (4.5%, SE=1.0) (Figure 14).

This suggests that this species may require cooler temperatures for successful recruitment and will potentially be negatively affected by rising temperatures associated with climate change. It also suggests that the current range conditions in central Alberta are no longer in equilibrium with this species optimal environmental conditions and likely has been dispersal limited in its ability to colonize suitable habitat further north.

b) Seedling Height

Mean seedling height was greater in the north (4.8 cm, SE=0.3) and far north sites (4.6 cm, SE=0.2) than compared to the south (4.1 cm, SE=0.7) and central sites (3.7, SE=0.2) (Figure 15). This again suggests that cooler temperatures at higher latitudes may promote successful recruitment of this species.

V. Phenology

The south location sprouted first (May 6th - May 20th), followed by the central (May 11th - May 25th), north (May 19th - June 1st), and far north (May 31st - June 4th) locations. Date of first sprouting for the Northern Blazing Star was therefore inversely related to latitude and presumably early spring climate conditions. A similar trend with latitude was observed for first bud burst. First bud burst occurred first at the south location (July 13th – July 21st), followed by the central (July 20th – 24th), north (July 18th – August 1st) and far north (July 28th – August 3rd) locations.

4.0 Next Steps

Analysis of performance measures for the Northern Blazing Star will continue in 2015. This will include statistical analyses using generalized linear mixed effect models with random effects to account for location and site allowing assessment of how soils and climate affect the success of this species. From this analysis statistical significances will be determined. Also, seed emergence and establishment monitoring of both the Long-Leaved Bluets and Northern Blazing Star will continue, in order to determine the regeneration niche of these species.

In the spring of 2015, 1000 Long-Leaved Bluets seeds will be placed at each of the 13 sites established this fall. In the summer of 2015, performance measurements will be taken at each of the 12 Northern Blazing Star translocation sites, as well as the 13 Long-Leaved Bluets translocation sites. Performance measurements will include: survival, mean height, maximum height, number of florets, fecundity, seed height, seed emergence and seed establishment. These final performance measurements will be added to the final analysis of this project.

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Appendix

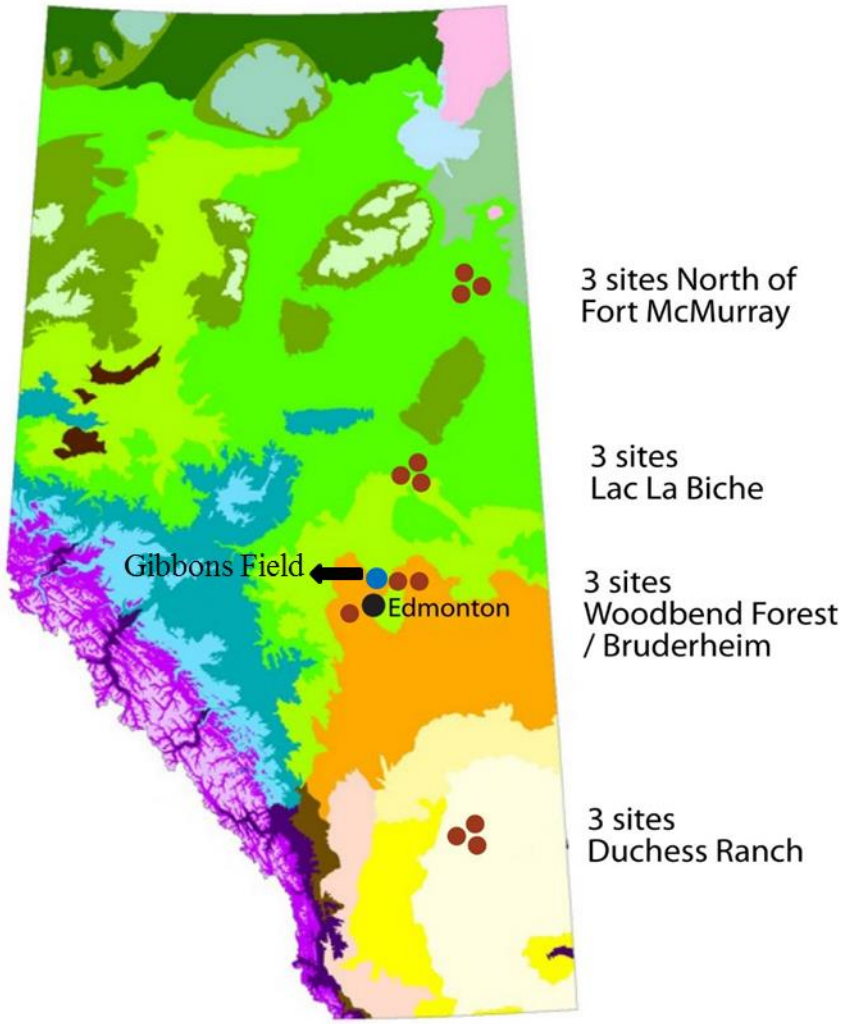
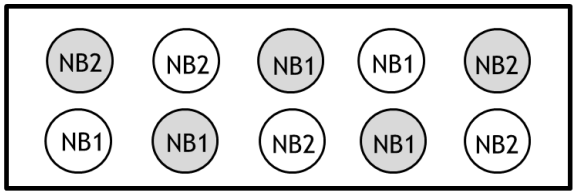


Figure 1: Map of Alberta, showing the location of the translocation sites. The red dots indicate both Long-Leaved Bluets (established 2014) and Northern Blazing Star (established 2012-2013) translocation sites. The blue dot indicates the additional Long-Leaved Bluets control site (Gibbons Field).



100 seeds	100 seeds	100 seeds	100 seeds	100 seeds
100 seeds	100 seeds	100 seeds	100 seeds	100 seeds

NB1= 1 Northern Blazing Star Corm from Ukalta, AB

Native (Source) Soil

NB2 = 1 Northern Blazing Star Corm from Bruderheim, AB

Local (Recipient) Soil

Figure 2: 2012 set up of Northern Blazing Star translocations. 10 Northern Blazing Stars were placed at each site from two source areas: Ukalta (NB1) and Bruderheim (NB2). The soil type was altered between native (white circle) and local (grey circle) soil. Note the seed plot was set up in the fall 2013 and contains 1000 seeds.

Picture 1: Northern Blazing Star translocation site established in 2012 near Lac La Biche, Alberta.

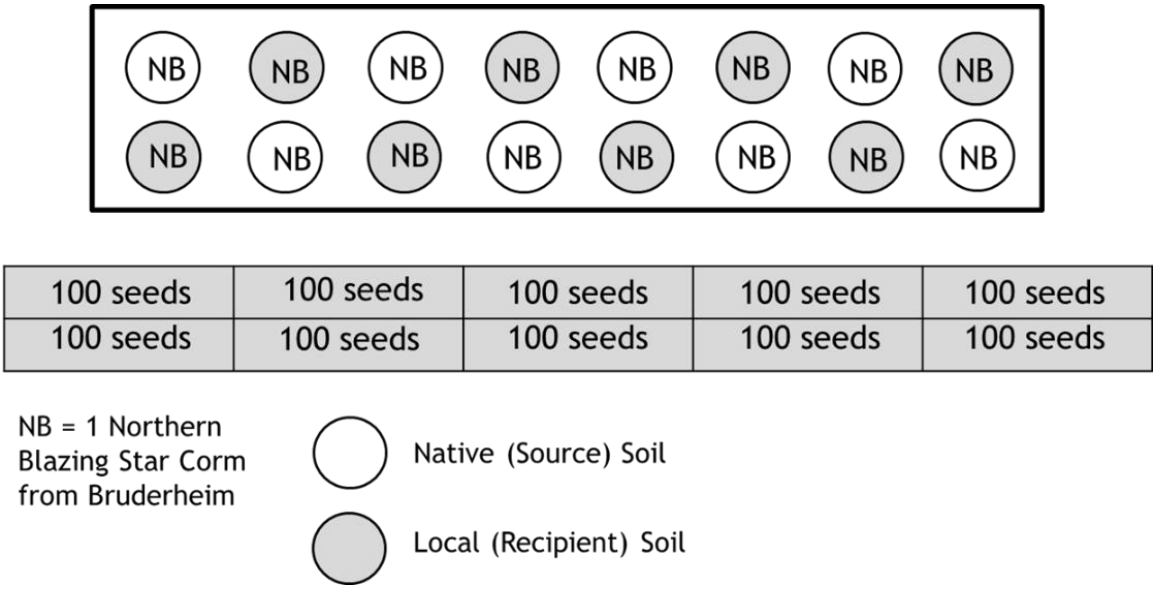


Figure 3: 2013 set up of Northern Blazing Star translocations. 16 Northern Blazing Stars were placed from the source location of North Bruderheim Provincial Recreational Area, Alberta. The soil type was altered between native (white circle) and local (grey circle) soil. Seed plot contained 1000 seeds.

Picture 2: Northern Blazing Star site established in 2013, north of Fort McMurray near McClelland Lake, Alberta.

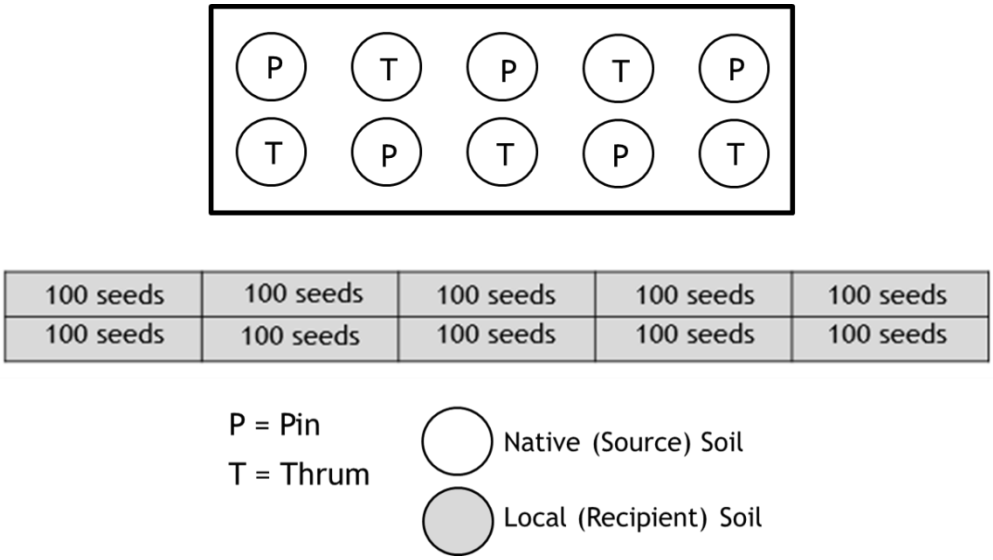


Figure 4: 2014 set up of Long-Leaved Bluets translocations. 10 Long-Leaved Bluets were placed at each site and evenly divided between the two floral morphs Pin (P) and Thrum (T). All plants were moved from Gibbons Field and the soil type was not altered in the pots.

Picture 3: A) Long-Leaved Bluets site established in 2014, north of Fort McMurray near McClelland Lake, Alberta. B) Close up of Long-Leaved Bluets before translocation.

Translocation Sites	Alberta Location	Total Planted/Site	Years Since Establishment	Total Planted
Duchess 2012 Site	South	10	2	42
Duchess Site 1	South	16	1	
Duchess Site 2	South	16	1	
Bruderheim Site 1	Central	16	1	42
Bruderheim Site 2	Central	16	1	
Devon 2012 Site	Central	10	2	
Lac La Biche Site 2012	North	10	2	41
Lac La Biche Site 1	North	15*	1	
Lac La Biche Site 2	North	16	1	
Fort McMurray Site 1	Far North	16	1	48
Fort McMurray Site 2	Far North	16	1	
Fort McMurray Site 3	Far North	16	1	

* Third party influence (site vandalism leading to the removal of 1 Northern Blazing Star)

Table 1: Summary of the 12 Northern Blazing Star translocation Sites. Alberta location refers to where it is located in the province (South, Central, North, and Far North). Total planted refers to how many Northern Blazing Stars planted at each of the 4 locations.

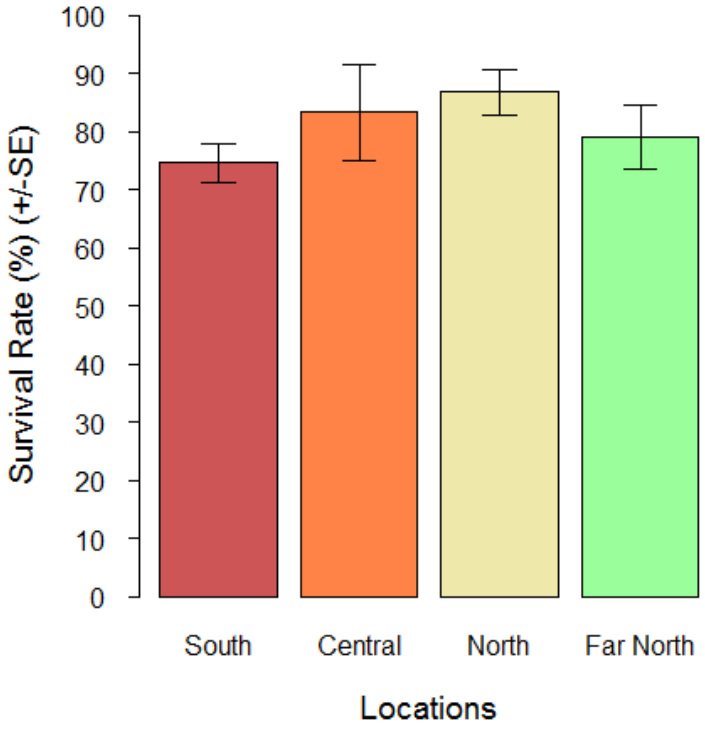


Figure 5: Average survival rate of Northern Blazing Stars at the

4 locations (3 replicates per location) in 2014.

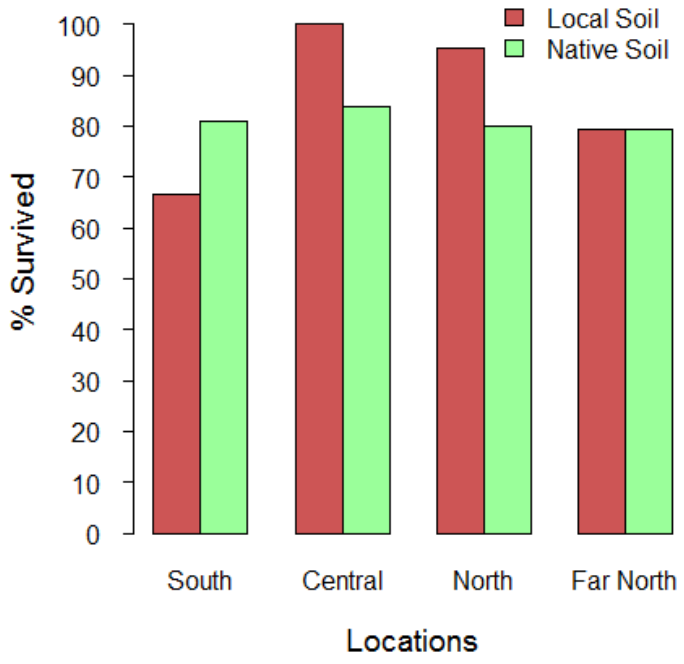


Figure 6: Percentage of Northern Blazing Stars that survived in 2014 divided by soil type at each location.

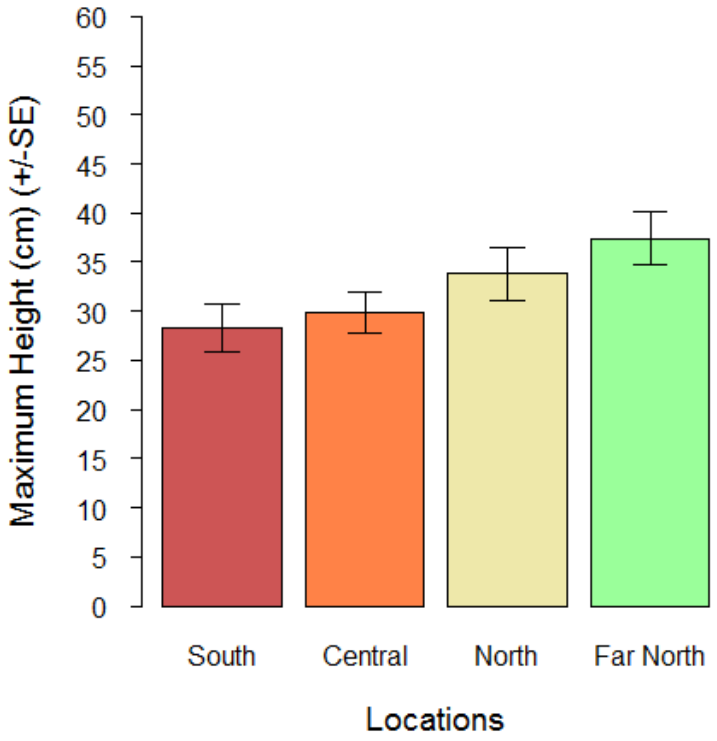


Figure 7: Average Maximum Height of the Northern Blazing Stars at the 4 locations (3

replicates per location) in 2014.

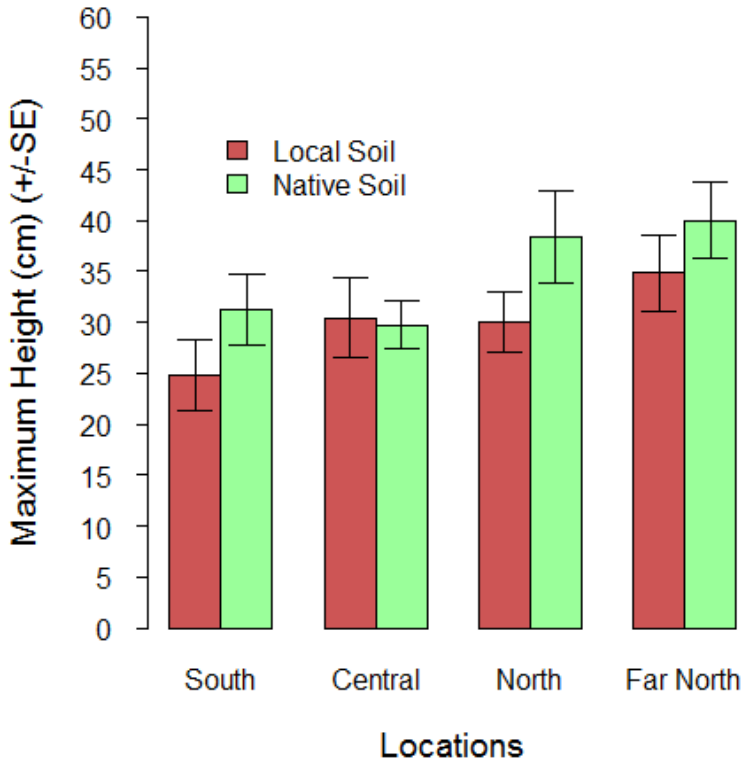


Figure 8: Average maximum height of Northern Blazing Stars in 2014 at the 4 locations (3 replicates per location) grouped by soil type (native or local)

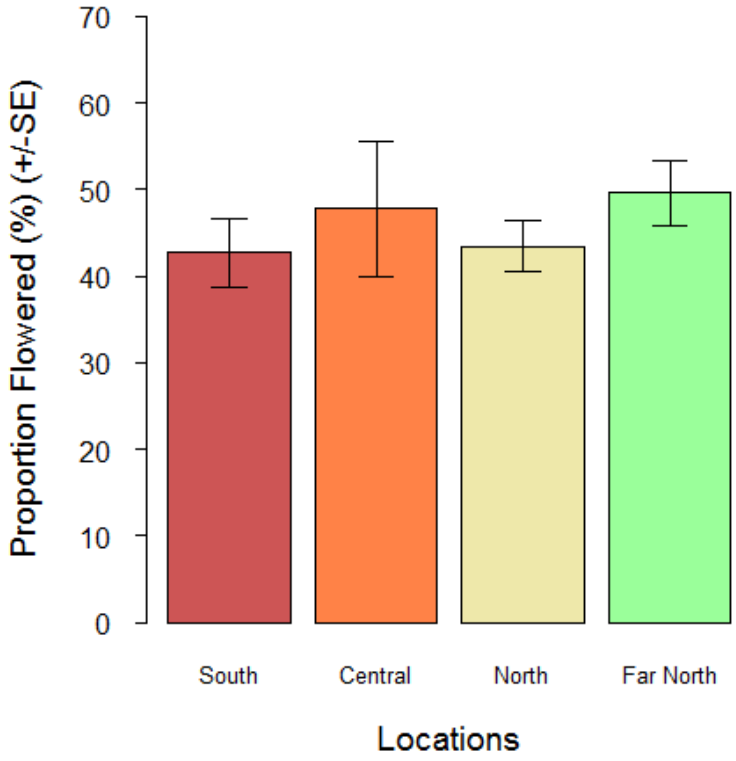


Figure 9: Proportion of Northern Blazing Stars that produced flowering stems out of those that survived in 2014.

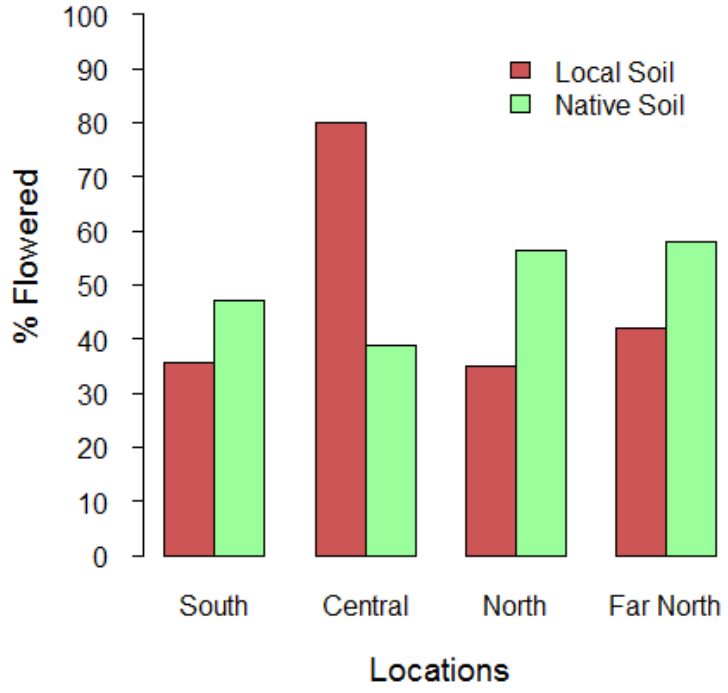


Figure 10: Percentage of Northern Blazing Stars that produced flowering stems in 2014 divided by soil type at each location.

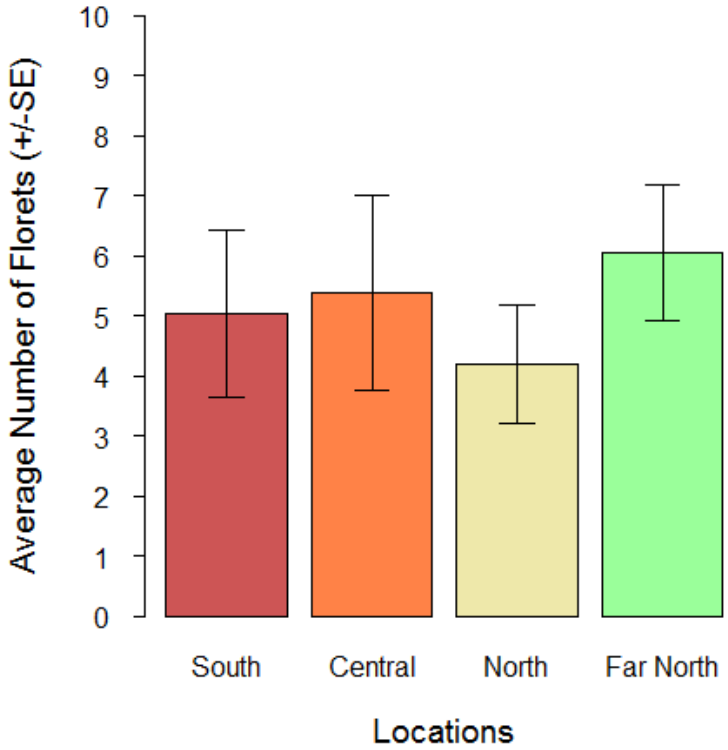


Figure 11: Average number of florets produced per plant with flowering stems at each location in 2014.

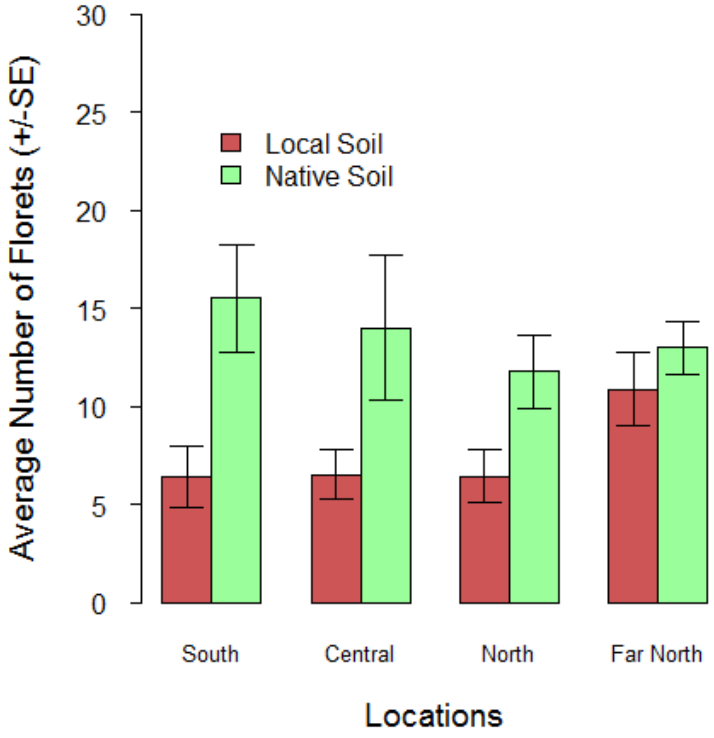


Figure 12: Average number of florets produced per plants with flowering stems at each site in 2014 grouped by soil type (local or native).

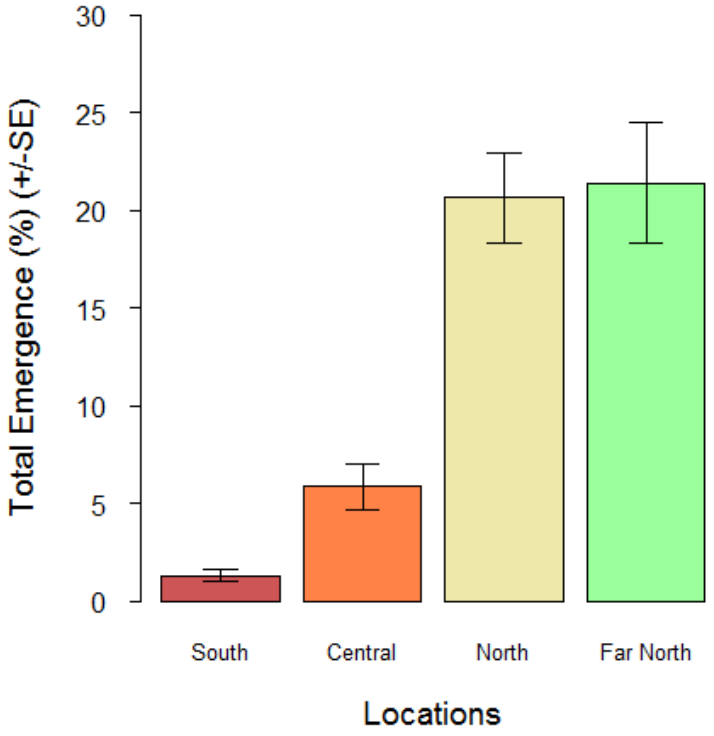


Figure 13: Total Emergence of Northern Blazing Star seedlings over the course of the 2014 summer at the 4 locations (3 replicates per location).

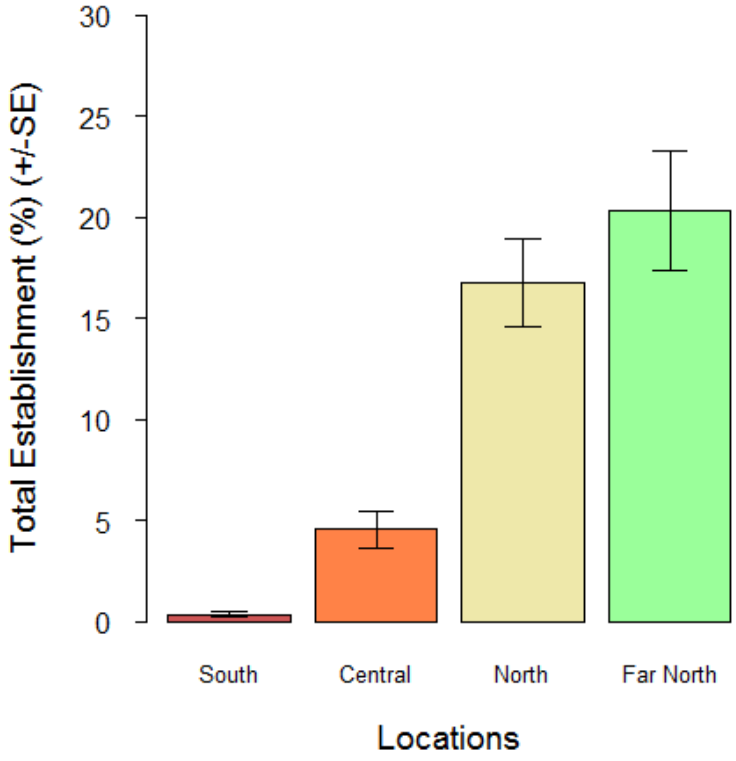


Figure 14: Total Establishment of Northern Blazing Star seedlings at the end of the summer (September 2014), at the 4 locations (3 replicates per location).

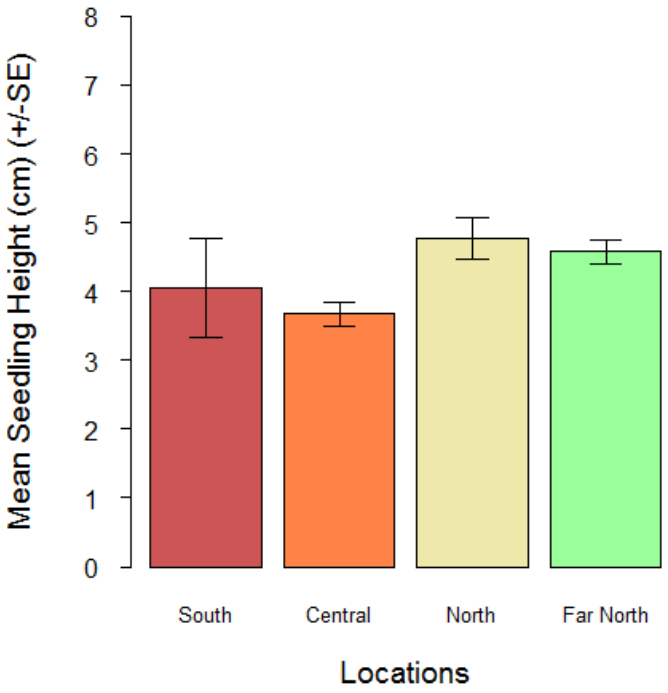


Figure 15: Mean height of Northern Blazing Star seedlings at the end of the summer (September 2014), at the 4 locations (3 replicates per location).

Sites	Location	Camera ID	First Sprout	First Bud Burst
Duchess Site 1	South	AM6	May 20, 2014	July 13, 2014
Duchess Site 2	South	AM3	May 15, 2014	July 20, 2014
Duchess 2012 Site	South	AM4	May 6, 2014	July 21, 2014
Bruderheim Site 1	Central	AM5	May 25, 2014	July 20, 2014
Bruderheim Site 2	Central	AM2	May 22, 2014	July 24, 2014
Devon 2012 Site	Central	AM1	May 11, 2014	July 22, 2014*
Lac La Biche 2012 Site	North	AM10	May 19, 2014	July 18, 2014
Lac La Biche Site 1	North	AM11	Destroyed	Destroyed
Lac La Biche Site 2	North	AM12	June 1, 2014	August 1, 2014
Fort Mac Site 1	Far North	AM7	May 31, 2014	August 3, 2014
Fort Mac Site 2	Far North	AM9	June 4, 2014	July 28, 2014
Fort Mac Site 3	Far North	AM8	June 1, 2014	after July 29, 2014**

*Camera tipped over so first photo of bud burst (July 22, 2014)
**Camera malfunctioned no pictures after July 29, 2014

Table 2: Summary of dates for sprouting and first bud burst at the 12 Northern Blazing Star translocation Sites. Location refers to where it is located in the province (South, Central, North, and Far North). Information at Lac La Biche Site 1 could not be obtained as the camera was destroyed from third party activities.