FESTUCA HALLII (VASEY) PIPER (PLAINS ROUGH FESCUE)
AND FESTUCA CAMPESTRIS RYDB (FOOTHILLS ROUGH FESCUE)
RESPONSE TO SEED MIX DIVERSITY AND MYCORRHIZAE

by

Darin Earl Sherritt

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DEDICATION

This MSc thesis is dedicated to my grandfather, Fred A. Forster,
who instilled in me a passion for always learning,
and for always reminding me that if you’re going to do a job,
do it right the first time.
ABSTRACT

Rough fescue (*Festuca hallii* (Vasey) Piper (plains rough fescue) and *Festuca campestris* Rydb (foothills rough fescue)) are long lived perennials that have been difficult to establish on disturbed sites. This research assessed the impact of seed mix diversity and suppression of arbuscular mycorrhizal fungi on fescue establishment. Three research sites were examined in each of the northern fescue and foothills fescue subregions. Fescue seeded alone, a mix of fescue and closely associated species and fescue with a cover crop of *Elymus dahuricus* (dahurian wild rye) were seeded and compared. Mycorrhizae impact was assessed by comparing plots treated with a fungicide (Rovral) to controls. Rough fescue was able to establish by seeding in the field. Fescue monocultures had better fescue establishment than mixes. *Elymus dahuricus* was not a successful cover crop for *Festuca hallii* and was marginal for *Festuca campestris*. Fungicide application did not have any impact on fescue establishment.
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“Variability is the rule not the exception”

Edward Bork
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CHAPTER I. INTRODUCTION

1.1 BACKGROUND

Alberta fescue grassland is divided into three ecoregion types. Northern fescue and aspen parkland subregions were historically dominated by Festuca hallii (Vasey) Piper (plains rough fescue), montane grasslands were dominated by Festuca altaica Trin. (altai fescue) and foothills fescue grasslands were dominated by Festuca campestris Rydb. (foothills rough fescue) (Pavlick and Looman 1984).

Fescue grasslands perform important ecological, aesthetic and economical functions. Rough fescue is a large bunch grass often growing over 1 m in height with roots that can exceed 1 m in depth (Looman 1969). This deep rooting characteristic is one factor that led to formation of the characteristic black chernozemic soils of the fescue grasslands. Ecologically, the rough fescue plant growth form aids in preventing weedy species from invading and increases site stability (Looman 1969). Rough fescue productivity is high and contributes to litter formation which helps maintain soil water and infiltration capacity (Naeth et al. 1991a, 1991b, 1990). Economically, fescue grasslands are an important grazing resource. They have higher forage production than any other native grassland in western Canada except tallgrass prairie remnants in Manitoba (Looman 1969). Using these grasslands for winter forage helps protect fescue prairie while reducing the cost of feeding livestock (Willms 1992).

Fescue grasslands have high intrinsic value. Approximately 150 plant species have been recorded for the foothills fescue region and just over 100 plant species have been recorded for the northern fescue region (Moss and Campbell 1947). Fehr (1982) reported 290 species for Rumsey Block; nine were considered rare at the time. The greater number of species in the foothills could be explained by proximity to mountains and other vegetation types not found in the northern fescue region (Moss and Campbell 1947). Bradley et al. (2002) noted two species currently on the Alberta Natural History Information Centre (ANHIC) vascular plant tracking list and over 60 plants on the list could potentially occur within the foothills fescue grasslands.
Fescue grasslands currently comprise approximately 112,000 km² of southern Alberta, with 15 % being northern and foothills fescue and 5 % central parkland and mixed grass (Adams et al. 2003). Of 1,686 grassland sites studied in the Alberta central parkland, only 12.5 % had plains rough fescue communities (Holcroft-Weerstra 2003). Once comprising about 1.5 million ha, foothills fescue grassland is now reduced to about 16.8 % (252,000 ha) of its original size (Adams et al. 2003).

Historically there have been two major disturbances to fescue grassland, semi frequent fires and grazing. Since the turn of the 20th century, two more major disturbances have been added, conventional dryland agriculture and natural resource development and extraction in the form of well sites and pipelines. These disturbances differ from grazing and fire in that they cause a greater degree of soil disturbance. To date there have been no documented examples in western Canada of successful reclamation of fescue grassland (Alberta Wildlife Association 2006).

Rough fescue plant communities are at more risk of conversion to non-native community types than other native grasslands in Alberta. Once disturbed or invaded by non-native species, rough fescue grasslands are less likely to be restored (Alberta Wildlife Association 2006). Looman (1969) documented that Bromus inermis Leyss. (smooth brome) and Medicago falcata L. Arcang. (yellow alfalfa) could successfully replace the native cover of black soils when seeded. Based on lack of restoration success to date, and given the value of these grasslands, strategies other than seeding disturbances need to be considered if the end goal is a grassland that can resemble undisturbed areas. This research will focus on re-establishment of fescue on well site disturbances.

1.2 ROUGH FESCUE AND ROUGH RESCUE GRASSLANDS

1.2.1 Rough Fescue Grasslands

Foothills fescue grasslands are typically associated with black chernozemic soils on moist sites. Northern rough fescue grassland is associated with black chernozems on moist sites in northern parts of the ecoregion and dark brown chernozems on southern parts, which is typically drier (Moss and Campbell
The dark brown soil zone is approximately the middle of the tension zone between fescue grassland to the north and Stipa grassland to the south. Foothills fescue grasslands are also typically associated with black chernozems, but do not have the dark brown association, as precipitation is greater than that of the northern fescue region.

The modal plant community on mesic sites in the northern fescue subregion is *Festuca hallii* associated with *Stipa curtiseta* (A.S. Hitchc.) Barkworth (western porcupine grass) (Moss and Campbell 1947). It changes slightly on drier southern parts as *Bouteloua gracilis* Willd. ex Kunth (blue grama grass) becomes dominant. The modal plant community for foothills fescue is *Festuca campestris* associated with *Danthonia parryi* Scribn. (Parry’s oat grass). *Danthonia* appears to be a local dominant of importance in restricted areas, especially on shallow soils of rocky and gravelly slopes. It may be best to regard *Danthonia parryi* as forming an edaphic climax.

Both foothills and northern fescue grasslands are presumed to have formed under co-evolution with grazing by plains bison (Morgan 1980). Bison wintered on fescue prairie and aspen parkland, thus supporting the idea that fescue prairie evolved under a history of dormant season grazing. This is also evidence that these grasslands have evolved under a dormant season disturbance regime.

When comparing climates of fescue grasslands to those of other vegetation types, Weaver (1979) noted that the climate of fescue grasslands is more similar to those of some coniferous forest types than those of other grassland types. This could suggest that other factors besides temperature and precipitation are responsible for maintaining fescue prairies, potentially including wind, snow cover, soil characteristics or fire frequency. Fescue grasslands occur in regions of greater water efficiency than do mixed prairie communities. The availability of water is enhanced by lower temperatures which lead to lower evaporation rates, and slightly higher precipitation in fescue grasslands (Anderson 2006).

### 1.2.2 Rough Fescue Biology and Ecology

*Festuca campestris* is a cool season grass adapted to short growing seasons (Anderson 2006). It is a large bunch grass, usually comprised of up to 250 culms,
that rarely has rhizomes (Pavlick and Looman 1984). This growth form suggests that it is adapted to periodic low intensity fires (Aiken and Darbyshire 1990). In undisturbed areas, crown diameters can be 20 to 50 cm (Moss and Campbell 1947). Festuca hallii is a cool season grass adapted to short growing seasons (Anderson 2006). It differs from Festuca campestris in usually being rhizomatous, and forms smaller (three to five culms) bunches (Pavlick and Looman 1984).

Both fescues are characteristic of climax grasslands (Tirmenstein 2000, Willms and Fraser 1992) and are also present in other successional stages. As long lived perennial species that devote several years to vegetative growth before reproducing via seed, and fit into a K selected classification (Anderson 2006). Both reproduce primarily by seed (Pavlick and Looman 1984) although seed production does not occur often or in a predictable manner. In southern Alberta, Johnston and MacDonald (1967) reported large seed production in 1902, 1952, 1964 and 1966. Both species typically initiate growth immediately following snow melt, start to senesce before the onset of summer drought and are dormant by October (Johnston and MacDonald 1967).

The response of Festuca campestris to infection by mycorrhizal fungi may impact plant growth characteristics. These changes could include larger size or production of wide, flat leaves. Aiken and Fedak (1992) describe two plants of Festuca campestris in Alberta that were growing close together but were different in size and morphology. The arbuscular mycorrhizal (AM) fungus Glomus fasciculatus was found in the roots of the larger individual. Although no evidence has been found for similar effects on Festuca hallii, Anderson (2006) stated that infection by mycorrhizae could have similar impacts to growth morphology.

1.2.3 Rough Fescue Establishment

The few attempts to restore Festuca hallii plant communities in the parkland and northern fescue subregions have been unsuccessful, mainly due to the difficulty in establishing rough fescue. Gas well sites and pipelines reclaimed in these ecoregions had fair to poor establishment of native species, including rough fescue, from seed mixes and sod salvage (Elsinger 2006, AXYS Environmental Consulting 2003, Petherbridge 2000, Integrated Environments Ltd. 1991). A restoration experiment in the grasslands of central Saskatchewan resulted in the
conclusion that conserving remaining rough fescue prairie rather than restoring it would have greater benefit (Clark 1986).

Grassland restorations are often unsuccessful due to unreliable seed sources, competition from weeds and agronomic species and variation in climate (Desserud 2006, Wilson 2002). Perennial weed invasion is a problem throughout the fescue prairie, which can negatively impact rough fescue re-establishment (Clark 1998). Research preventing or reducing competition from non-native or weed species includes burning, grazing or mowing and applying herbicides. Stromberg and Kephart (1996) reviewed successful restoration techniques to reduce competition for native seedlings, including mowing annuals before their seeds mature. Ewing (2002) concluded that lower weed biomass was associated with greater Festuca idahoensis survival.

In 1991, an assessment of revegetation of 14 industrial sites was conducted in Rumsey Block including well sites, pipelines, an access road and a right-of-entry (Integrated Environments Ltd. 1991). These sites varied in age from 4 to 14 years. Results varied from persistence of wheat grasses, such as Agropyron dasystachyum (Hook.) Scribn. & J.G. Sm. (northern wheat grass) or Agropyron smithii (Rydb.) A. Löve (western wheat grass) from the seed mix, encroachment of Phleum pratense L. (timothy) or Bromus inermis and natural recovery of rough fescue and other native species. Plant species composition of the majority of disturbed sites was not similar to adjacent native range. A few exceptions occurred where natural recovery resulted in encroachment of Festuca hallii and Stipa curtiseta on pipelines.

Two studies examined long term (> 20 years) restoration success of Festuca hallii. Vujnovic (1998) studied species composition after 20 years of grazing or other disturbance in Festuca hallii dominated communities in the central parkland. Slogan (1997) studied vegetation dynamics after 23 years in Festuca hallii grasslands in Manitoba. No other research studies examined the long term results of revegetation of rough fescue grasslands (Desserud 2006).

Spring seeding is recommended over fall seeding, as in the spring seedbed temperatures are increasing and become more conducive to germination. Temperatures near 15 °C seem to be most favourable for germination of Festuca hallii (Grilz 1992). The higher soil water in spring, due to snow melt, also favours
germination. Optimal growth and regrowth following defoliation occurs near or below 17 °C for Festuca hallii; as temperatures increase above this, growth starts to decline (King et al. 1998).

1.3 MYCORRHIZAL FUNGI

1.3.1 Mycorrhizal Fungi Classification

Mycorrhizal fungi are classified into two main groups, endomycorrhizal and ectomycorrhizal, based on hyphal association with plant roots (Smith and Read 2008). Endomycorrhizal fungi are further divided into three groups, arbuscular mycorrhizae (AM), ericoid mycorrhizae and orchidaceous mycorrhizae.

Endomycorrhizal fungi bodies grow branched in root cortical cells, forming an arbuscule. External structures, hyphae, extend from the root surface several mm into the soil. Ectomycorrhizal fungi form a hartig net, a mycelia complex between root cortical cells and the mantle, and a hyphal network that partially or fully encloses the root. Endomycorrhizae and ectomycorrhizae differ in plant species associations. Endomycorrhizae do not form associations with specific plants; ectomycorrhizae are highly specific in their plant associations. Ectomycorrhizae are commonly associated with woody plant species; arbuscular mycorrhizal fungi occur in herbaceous and woody plants (Gurevitch et al. 2006).

Arbuscular mycorrhizal fungi are the most common mycorrhizal type associated with flowering plants. They are possible major factors in determining interactions between plants, and on a larger scale, vegetation ecosystem functioning (Smith and Read 2008). Arbuscular mycorrhizal fungi require plant hosts to complete their life cycle, but many of these potential hosts plants grow and survive without fungi. Historically the relationship between fungi and plant was considered a mutualism. Asai (1944) first recognized a relationship between development of fungi and plant growth. Recently the relationship has been evaluated on a continuum of interactions, ranging from mutualism to parasitism depending on the partners and the environmental variables (Jones and Smith 2004, Johnson et al. 1997). Fungi require a plant host for a carbon source for energy, and thus use a considerable amount of carbon that is fixed by the plants themselves through the process of photosynthesis.