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GROWTH RESPONSE OF SELECT NATIVE AND INTRODUCED PLANT SPECIES TO SOIL NUTRIENT LEVELS AND INTERSPECIFIC COMPETITION

by

Marian Gay Fluker 

A thesis submitted to the Faculty of Graduate Studies and Research in partial fulfillment of the requirements for the degree of Master of Science

in

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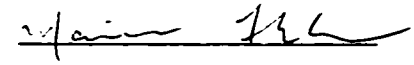

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled GROWTH RESPONSE OF SELECT NATIVE AND INTRODUCED PLANT SPECIES TO SOIL NUTRIENT LEVELS AND INTERSPECIFIC COMPETITION submitted by MARIAN GAY FLUKER in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE in LAND RECLAMATION AND REMEDIATION.

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ABSTRACT

The objectives of this research were to determine if selected native plant species - *Agropyron smithii*, *Stipa viridula* and *Vicia americana*, have higher survivability (density) and biomass on low nutrient soils than selected introduced species - *Bromus inermis*, *Phleum pratense* and *Trifolium hybridum*.

A low fertility site was treated with slow and regular release fertilizers. A high fertility site was treated with straw and sugar to immobilize available nitrogen. At both sites, the selected species were seeded in monocultures and mixes in four randomized strip-plot blocks.

Adding straw, sugar or fertilizer did not significantly affect survivability or biomass of any of the six species. The selected introduced species produced more cover and biomass than the selected native species. Leguminous species performed better than grass species on nutrient deficient soils.

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CHAPTER 1: INTRODUCTION

1.1 Background

The Canadian government has recognized the value of maintaining and re-establishing biodiversity of native flora for present and future generations (Canadian Biodiversity Strategy 1995). As resource extraction and agricultural industries continue to expand, loss of native species and ecosystems is occurring throughout Canada. In Alberta, over 121,500 ha have been disturbed by the petroleum industry (Kerr et al. 1993) and 1,960,000 ha have been cultivated (Alberta Agriculture 1996). In some areas of the province, there is less than 10% native prairie remaining (Kerr et al. 1993). Therefore, disturbed sites are prime areas to reclaim to native plant species where appropriate. The importance of these disturbed areas is being recognized through legislation. In reclaiming disturbed areas in Alberta, it is now a requirement to return the site to predisturbance capability levels (Alberta Environmental Protection 1995). If the disturbance occurs on public lands, native species are to be re-introduced onto the site. However, use of native species in reclamation is impeded by the lack of knowledge of conditions that will favour their germination and survivability (Gerling et al. 1996).

The nutrient requirements of native grass species are lower than those of introduced species (Takyi 1984). However, this does not guarantee successful establishment of native plant species where introduced species cannot grow because of low nutrient levels. Many of the sites that are to be reclaimed are low in nutrients. The benefits and limitations of applying fertilizer to these sites to promote plant establishment should be considered. There are also areas that are slated to be reclaimed that are high in nutrients. In such areas highly competitive species can become established, reducing species diversity (Grime 1973). If native plant species can outcompete introduced species on low nutrient soils, methods to reduce the nutrients available should be implemented.

In ecosystems, plants vary in growth form to compete for available nutrients (Raven et al. 1992). Rhizomatous plants have deep root systems and are used in reclamation to initiate sod formation. The long rhizomes extend over large areas, increasing the space covered by the plants (Pyke and Archer 1991). Bunchgrasses with tufted growth forms are valuable in preventing soil erosion on disturbed sites (Hardy BBT Ltd. 1989). These grasses have tightly packed tillers that can prevent the encroachment of other species (Pyke and Archer 1991). Legumes are often included in seed mixtures as they are capable of becoming

established on low nitrogen sites and, because of their associations with rhizobia, are capable of adding nitrogen to the soil (Smreciu 1993).

1.2 Role of Nutrients in Plant Nutrient Cycle

Little information is available on the nutrient requirements of native plant species. The role of macronutrients and micronutrients in the establishment of introduced species has been documented. Macronutrients are nitrogen (N), phosphorus (P), potassium (K), sulfur (S), calcium (Ca) and magnesium (Mg) and are required by plants in large amounts. Elements required in smaller amounts are classified as micronutrients and include iron (Fe), zinc (Zn), manganese (Mn), copper (Cu), boron (Bo), chlorine (Cl) and molybdenum (Mo) (Tisdale et al. 1993).

Nitrogen is required for photosynthesis and in structural components of plants (Tisdale et al. 1993). Leguminous forbs are capable of fixing atmospheric nitrogen and making nitrogen available to other plants. Nitrogen is often deficient in Alberta soils and nitrogen fertilizer is often applied to improve crop yields (Alberta Agriculture 1995). Nitrogen is available to plants in two forms, nitrate (NO_3^-) and ammonium (NH_4^+). As NO_3^- is highly soluble and mobile, it is easily leached from the soil (Jones and Schwab 1993). Volatilization and denitrification also causes nitrogen losses from the soil profile (Tisdale et al. 1993). Nitrogen is found in association with organic matter in the upper horizon of the soil profile (McGill et al. 1986). Legumes do not require nitrogen fertilizer and in grass-legume mixtures, nitrogen fertilizer will favour the growth of grass species (Hamel et al. 1992).

Phosphorus is used by plants to transport and store energy and promotes flowering, root growth and seed formation (Walton 1988). It is derived from parent geologic material and is distributed throughout the soil profile (Tisdale et al. 1993). Phosphorus is adsorbed onto clay-sized minerals in the soil and is not highly mobile (Simons et al. 1995). Microorganisms mineralize phosphate from organic residues and humus and release inorganic phosphates ($H_2PO_4^-$ / HPO_4^{2-}) that can be absorbed by plants (Tisdale et al. 1993). Available phosphorus can be low in Alberta soils but fertilizer will increase the level of phosphorus in the soil and low rates would be required in repeat applications (Alberta Agriculture 1995). In reclamation, it is often reapplied to maintain adequate levels of available phosphorus (Kerr et al. 1993). Phosphorus can increase yields of pure stands of native range if nitrogen is also applied (Alberta Agriculture 1988; Wark et al. n.d.).

Legumes and grasses will respond positively to additional phosphorus if the soil is deficient (Simons et al. 1995).

Plants require potassium in the production of energy and activation of enzymes and in regulating osmotic processes (Tisdale et al. 1993). Potassium is loosely held by ionic bonds on the cation exchange complex and soils with a high cation exchange capacity lose less potassium due to leaching (Tisdale et al. 1993). There is little movement of potassium within the soil profile (Simons et al. 1995)

Sulfur is found in some plant amino acids and other plant compounds (Tisdale et al. 1993). Approximately 45% of soils in central Alberta may have deficient levels of sulfur for growing legumes (Alberta Agriculture 1986). Sulfur is absorbed by plants in the anionic form, SO_4^{-2}. In this form, sulfur is readily leached through the soil (Tisdale et al. 1993).

Calcium is a component of plant cell walls and is required for movement of carbohydrates, and magnesium is a constituent of chlorophyll (Tisdale et al. 1993). In Alberta, there are no soils known to be deficient in these two macronutrients. (Robertson 1995).

Micronutrients are required by plants in enzymes and other plant compounds including chlorophyll (Tisdale et al. 1993). Alberta soils are generally not deficient in molybdenum and chlorine but can be deficient in iron, copper, zinc, boron and manganese (Alberta Agriculture 1993). The effect of micronutrient fertilizers on native plants has not been researched.

1.3 Native vs. Introduced Plant Species

Introduced plant species are used throughout the reclamation industry. Information is accessible on what is required to obtain successful establishment of these species under variable conditions. Seeds are readily available and introduced plants quickly become established on reclaimed sites. Introduced species are aggressive and persistent but continued inputs of nutrients are often required to maintain productivity levels (Kerr et al. 1993). These species can be invasive and give rise to plant communities with decreased biodiversity (Dodd and Lauenroth 1979 cited in Parker et al. 1993).

Native species are adapted to conditions of the area including climatic, edaphic and topographic (Kerr et al. 1993). Although native species are slow to establish and

germination and survivability are inconsistent (Gerling et al. 1996), once established, plants will survive for a long time with minimal external inputs. These plants are a source of biodiversity and genetic variability and are an integral part of their ecosystem as native plants and animals have evolved together in a way that maintains mutual sustainability (Kerr et al. 1993). Although benefits exist for using native plant species, seed sources are limited and are generally more costly. Research on native plant species is limited and procedures that will encourage establishment are inadequate.

1.4 Plant Competition

Interspecific competition is an important consideration in reclamation. Interspecific competition has been defined as "an interaction between individuals, brought about by a shared requirement for a resource in limited supply, and leading to a reduction in the survivorship, growth and/or reproduction of the competing individuals concerned" (Begon et al. 1986, cited by Grace 1990). Species compete for the available resources including nutrients, moisture and light (Raven et al. 1992). It is this competition for resources which determines plant establishment - the presence, absence, density and grouping of the various species (Pyke and Archer 1991). Competition among species can also ensure ground cover and productivity as environmental conditions vary. One species may tolerate drier conditions and flourish in dry years when other species, less tolerant of arid conditions, are less productive (Pyke and Archer 1991). Those species that can successfully extract the resources required for growth, will have a greater chance of becoming established on the site (Wilson and Tilman 1993). Introduced species can outcompete native species under various conditions. However, many native species can outcompete introduced species on low nutrient sites (Ash et al. 1994). It is this competition for resources that is not completely understood for native plant species.

It is necessary for plants to obtain a number of resources including nutrients, water and light, to germinate and survive in a given area. Often one or more of these resources are in limited supply and plants will compete for the resource. Competition for resources can be intraspecific or interspecific. The competitive advantage will vary from site to site and will go to the plant with the most appropriate growth form, rate of photosynthesis and net allocation of resources for existing conditions (DiTommaso and Aarssen 1991). Success is dependent on the environment in which the plants are trying to become established (Raven et al. 1992).

Interspecific competition is affected by resource availability and, if resources are altered, competition strategies will ultimately change the species composition of the site (Goldberg et al. 1995; Vinton and Burke 1995). Grime (1977) described three strategies used by plants to compete for resources. The competitive strategy refers to the characteristics of the plant that enables it to access essential limited resources, including water, nutrients, light and space, that are limited. C-selection species have maximum growth rates on productive sites and would be considered at the extreme of K-selection species. The stress-tolerant strategy is based on the ability of the plant to become established on a site that has less than optimum edaphic and/or environmental conditions. These species produce less biomass and fewer seeds but can endure stressful surroundings. The third strategy involves the ruderal theory that considers plant response to disturbances, including mowing, grazing, frost and drought. These species have a short life span and produce large number of seeds. These species correspond to the r-selection species.

The rate of invasion by volunteer species and the resulting community composition is influenced by the nutrient status of the soil (Rew et al. 1995). In unfertilized, low nitrogen sites, nitrogen demanding species can be replaced by other species that require less nitrogen for survival (Berendse et al. 1992).

Plants compete for different resources by modifying growth rates of plant structures. With lower rates of nitrogen, root growth rate is higher, increasing the root to shoot ratios (Buysse et al. 1996; Vinton and Burke 1995). In low nutrient sites, competition primarily occurs below ground and in higher nutrient areas, competition below and above ground regulates which plants will become established (Wilson and Tilman 1993).

1.5 Fertilizers

In reclamation, it is often not feasible to reapply fertilizer in subsequent years as not all sites are readily accessible. For reclamation certification, fertilizers cannot have been added to the site in the previous year (Alberta Environmental Protection 1995). Regular release fertilizers are usually applied to a site if it is required to promote plant establishment. Slow release urea fertilizer is available commercially and may be a viable alternative to reapplying regular fertilizer. Slow release fertilizers are coated with a polymer which allows the fertilizer to be released into the soil over two to three years (Nutting 1996). It has not been established how slow release fertilizer will affect the growth of native plant species, nor the role it may have in reclamation.

Nutrients, which usually include nitrogen, phosphorus, potassium and occasionally sulfur, are added to low fertility soils by applying fertilizers. The level of nutrients increases rapidly when regular fertilizers are applied as the granules are quickly dispersed into the soil medium. Plants cannot utilize the nutrients as rapidly as they become available, which can result in leaching of nutrients from the soil profile. If nitrogen is one of the nutrients added, nitrates can leach from the soil and enter groundwater systems. Nitrogen can also be lost from the soil profile through denitrification, which is limited in aerated soils (Jones and Schwab 1993). To increase the availability of nutrients, slow release fertilizers have been developed.

Polymer coated granules of urea are one form of slow release fertilizer on the market. Water vapour passes through the membranous outer coating and then condenses within the granules. As the amount of condensate increases, the outer coating expands, causing it to leak and allowing the nutrients to pass through the membranes (Gambash et al. 1990). The rate of releasing nutrients is dependent on the rate water vapour molecules enter the membrane and will therefore vary with coating thickness and heterogeneity of granular size (Oertli and Lunt 1962; Gambash et al. 1990). Thicker membranes slow the release process and smaller granules become permeable to nutrients at a faster rate than larger granules. The variability in granular size results in the continuing release of nutrients. Nitrogen from slow release fertilizer can be effective years after application (Gambash et al. 1990).

1.6 Role of Microorganisms in Soil

Heterotrophic microorganisms decompose carbonaceous material such as organic matter to obtain energy and carbon, and nitrogen released in the decay process is incorporated into microbial structures (Whitford 1988). Excess nitrogen is available to plants in the soil solution (Bartholomew 1965). Activity of microorganisms is dependent on the availability of readily accessible energy and nutrient sources (Dickinson 1974).

The main constituents of organic matter are carbohydrates, proteins and lignin and the major decomposers are bacteria, fungi and actinomycetes. Carbohydrates can be further classified as sugars, starches, hemicellulose and cellulose (Hausenbuiller 1985). Sugars and starches are the simplest forms of carbohydrates. Accessible energy varies with the composition of the organic matter. Simple sugars, including sucrose and glucose, are quickly metabolized by microorganisms. Starches and proteins are the next most readily available forms of energy; cellulose and hemicellulose are the last carbohydrates to be

decomposed by soil microorganisms. Hemicellulose and cellulose are complex molecules of glucose (Raven et al. 1992). They are components of cell walls and as plants age, these substances accumulate in plant structures (Hausenbuiller 1985).

Proteins are polymerized amino acids and are important components of all plant cells. As proteins are combinations of carbon, nitrogen, hydrogen, sulfur and oxygen, decomposition of proteins releases nitrogen and sulfur into the soil system (Hausenbuiller 1985).

Lignin is a large, complex molecule that adds rigidity to cell walls (Raven et al. 1992). The amount of lignin in cell walls increases as plants age. Soil microorganisms slowly decompose lignin (Hausenbuiller 1985) and the lignin can remain unaltered for long periods (Hausenbuiller 1985; Jonasson et al. 1996).

As most plants contain various amounts of the different organic constituents, microorganisms will have access to energy sources for an extended period of time. Different plant residues will have different combinations of readily, and less available, forms of energy that can affect microbial population growth. (Hausenbuiller 1985).

Soil microorganisms are important in different soil processes. Bacteria, fungi and actinomycetes are the major decomposers of organic matter and are essential parts in the carbon and nitrogen cycles. Through these cycles, microorganisms provide nutrients to plants as decomposition of organic matter releases CO_2, H_2O, NH_3 and H_2S (Jonasson et al. 1996; Waksman 1924).

Rhizobia form symbiotic relationships with legumes or can be free-living. These bacteria can utilize atmospheric nitrogen that are eventually converted to ammonium and nitrate that can be absorbed by other plant species. Bacteria initiate the nitrogen cycle by releasing NH_4^+ as a by-product of decomposition of organic matter. NH_4^+ is converted to NO_2^- by *Nitrosomonas* and then oxidized by *Nitrobacter* to NO_3^-. Other bacteria, including *Pseudomonas*, *Bacillus* and *Paracoccus*, denitrify NO_3^-, releasing N_2 back into the atmosphere to complete the cycle (Tisdale et al. 1993).

Eighty per cent of all vascular plants form mycorrhizal associations with fungi (Raven et al. 1992). Mycorrhizal fungi extend hyphae into the soil and nutrients that plants can utilize are intercepted and absorbed (Hausenbuiller 1985; Raven et al. 1992). Because an increased

volume of soil can be accessed, vascular plants can benefit from mycorrhizal associations when nitrogen and phosphorus levels are below optimum (Jonasson et al. 1996). The C:N ratio can increase from 12:1 to 80:1 due to fungal hyphae growth (Stack et al. 1987).

1.6.1 Role of Microorganisms in Nutrient Immobilization

Microorganisms require carbonaceous material as a source of energy and as organic matter is broken down, nutrients, including nitrogen are released (Whitford 1988). Soil microorganisms require nitrogen for the synthesis of microbial proteins. When organic matter is incorporated into the soil, an abundant supply of energy and carbon becomes available to microorganisms, allowing the microbial population to grow (Burges 1964). As the population grows, the microbes may assimilate all available inorganic nitrogen to organic forms (Jonasson et al. 1996).

Nitrogen is a common limiting factor in microbial growth and ultimately, the rate of decomposition (Forbes 1974). Populations of bacteria, fungi and actinomycetes are required to decompose organic matter. However, when the populations increase, nitrogen released from organic matter is used by the microorganisms, preventing plants from accessing the nutrient (Dickinson 1974). Bacteria, fungi and actinomycetes are essential to achieve soil impoverishment. These microbes can outcompete plant species for available nitrogen and immobilize this essential nutrient.

1.6.2 Environmental Factors

Microbial activity and decomposition rates are affected by soil temperature, pH, moisture and aeration (Dickinson 1974). To achieve maximum immobilization, the following factors should be within the optimal ranges.

Soil temperatures affect the availability of nitrogen and the microbial population. In cold temperatures, the availability of nitrogen is reduced whereas ammonification increases with higher temperatures (Scarsbrook 1965). The optimum temperature range for most decay organisms is 25 to 40 °C (Hausenbuiller 1985; Dickinson 1974). Some species can function at temperatures of 5 °C and others will flourish at 50 °C (Pugh 1974). If temperatures exceed the optimum range, microorganisms sensitive to the changes will move to more suitable areas in the soil profile (Dickinson 1974).

For most soil microorganisms, the optimum pH is 7 but fungi are capable of living under acidic conditions (Hausenbuiller 1985; Bollen 1959). Organic matter decomposition and nitrogen immobilization are slower in acid environments than in neutral or alkaline conditions (Allison and Klein 1962; Soderstrom et al. 1983).

Soil microorganisms require the relative humidity of soil to be in excess of 98% to function optimally (Hausenbuiller 1985). Microorganisms need moisture to move through the soil and to maintain biological activity (Dickinson 1974). Dry soils inhibit microbial activity and desiccation of organisms can occur (Hausenbuiller 1985). Some fungi can function in soils with extreme moisture deficits but most fungi species have an increase in the growth of hyphae with additional soil moisture (Dickinson 1974). Excess water can limit microbial growth due to changes in the oxygen content of the soil.

Oxygen is required for respiration by fungi and aerobic bacteria. Fungi are sensitive to low levels of oxygen and will not exist in anaerobic conditions (Dickinson 1974). Anaerobic bacteria can decompose organic matter without oxygen but the rate of decay is slower (Dickinson 1974; Bartholomew 1965). Rapid decomposition of organic matter occurs in well-aerated soils and maximum immobilization is obtained in aerobic conditions (Bartholomew 1965).

1.7 Principles of Soil Impoverishment

The underlying principles of nutrient impoverishment in soils are based on the nutrient requirements of specific plant species and the ability of soil microorganisms to immobilize nitrogen. By manipulating the soil environment to reduce available nitrogen, plant species capable of existing on low nutrient soils will be able to outcompete species that require high nutrient levels (Tilman 1987).

Increasing biodegradable carbon sources in the soil promotes microbial population growth. More nitrogen is needed to satisfy the growth requirements of the expanding population and available nitrogen in the soil is converted to microbial proteins (Biodini et al. 1985). Once immobilized into microbial structures, nitrogen is unavailable for plant uptake until mineralization occurs (Fauci and Dick 1994). Successful establishment of plants will depend on their ability to survive in the modified environment. By altering the availability of a major resource, it should be possible to achieve a system that promotes the growth of one species over another.

Native plant species can persist on low nutrient soils and if nitrogen levels are low, these species may have an advantage over species requiring moderate to high levels of nitrogen (Gerling et al. 1996). The species that can become established first would have a competitive advantage when accessing soil nutrients and other resources (Goldberg et al. 1995).

1.7.1 Soil Impoverishment Techniques

1.7.1.1 Carbon:Nitrogen Ratio

To immobilize nitrogen, a carbon to nitrogen (C:N) ratio of at least 25:1 must be obtained in the soil (Allison and Klein 1962; Aoyama and Nozawa 1983). At ratios of 15:1 to 20:1, a fraction of the available nitrogen will be immobilized prior to mineralization (Aoyama and Nozawa 1983).

The C:N ratio in soil equilibrates to a level of approximately 10:1, regardless of the ratio in the organic matter added to soil (Waksman 1924). However, Young (1962) found there is wide range of C:N ratios in soil and the ratio is dependent on the type of humus and organic matter (Table A.1, Appendix 1) (Tisdale et al. 1993; Munshower 1994). Within soil microorganisms, the C:N ratios are: fungus 10:1, bacteria 5:1 and actinomycetes 3:1 (Waksman 1924).

Soil analysis is required to ascertain the available nitrogen in the soil. Total organic matter needed to promote nitrogen immobilization is calculated from the results of soil analyses and the percentage of carbon and nitrogen in the amendments (McGill 1996). As carbon is readily available in sugar, a C:N ratio of 30:1 would result in immobilization of nitrogen and compensate for losses of sugar in the soil due to its solubility in water. Enough straw should be added to achieve a ratio of 40:1 (McGill 1996). The higher ratio compensates for the nitrogen in the straw that can be used by microorganisms and the slower rate of decomposition.

1.7.1.2 Types of Amendments

Organic amendments used to impoverish soils include sawdust, straw, sugar and grain hulls (Morgan 1994; Zimmerman et al. 1995). Decomposition and rate of immobilization will vary with the type of amendment used. When sugar is applied, 3.7% of the available

nitrogen is immobilized and 1.7% is immobilized with straw amendments (Allison and Klein 1962). Straw should be cut into 2.5 to 4 cm pieces to allow for easier incorporation of the material into the soil and to increase surface area microorganisms can access (McGill 1996).

Organic matter with high C:N ratios decompose slowly compared to material with low C:N ratios (Patra et al. 1992). Straw, wood and other amendments with high levels of lignin are resistant to microbial decomposition (Jonasson et al. 1996). Lignified matter is degraded by only a few microorganisms including the fungi, *Phanerochaete chrysosporium*, and *Streptomyces* species of bacteria (Wang et al. 1991). Woody debris decomposes slowly, generally 10% per year (Zimmerman et al. 1995).

1.7.1.3 Incorporation of Amendments

To optimize decomposition by microorganisms, the organic matter should be incorporated into the soil to maximize substrate - microorganism contact (McGill 1996). Decomposition occurs more quickly when organic matter is in the soil rather than on the surface because moisture levels and soil - residue contacts are optimal (Parker 1962; Bartholomew 1965).

Applying amendments onto the site will vary with organic material used and the size of area to be treated. The material can be applied by hand or modified manure spreaders may be used to apply wood chips or sawdust (Munshower 1994). The organic matter may have to be raked or spread out to ensure uniform application. Some amendments, including sugar, can be applied to small areas using a push type fertilizer spreader (Thurston 1996).

Amendments can be incorporated into the soil using a cultivator or rototiller set to the maximum depth. This will ensure as many microorganisms as possible will come in contact with the substrate (McGill 1996). After cultivation is complete, the site should be harrowed to provide a uniform seed bed (Munshower 1994).

1.7.1.4 Temporal Aspects of Immobilization

When organic matter is added to the soil, rapid immobilization of nitrogen occurs for a few days. The rate decreases until the readily available energy supply is depleted. Mineralization will become the dominant process after peak immobilization is reached (Allison and Klein 1962).

In experiments done by Allison and Klein (1962) immobilization of simple sugars was maximized within 10 days and after two weeks, one third of the immobilized nitrogen had been released. When straw was added, peak immobilization occurred slower and it took three to four times longer to have one third of the nitrogen mineralized. The remaining two thirds was slowly mineralized as organic material decomposed (Allison and Klein 1962). In more recent studies, Zimmerman et al. (1995) found immobilization of nitrogen from straw peaked in five days and mineralization occurred in 10 days. This variation may have been the result of using different types of straw or environmental conditions may have affected the rates. The effect of nitrogen immobilization with sugar or sawdust lasts four to six weeks. Woody debris decomposes more slowly and the effect can be prolonged (Zimmerman et al. 1995).

1.7.2 Limitations to Soil Impoverishment

The principles of soil impoverishment have been studied and it is important to look at the possible limitations of this technique. The environmental requirements for successful establishment of native plant communities have not been determined (Gerling et al. 1996). Competition intensity at various nutrient levels will differ with each plant species, making it difficult to determine which level of nutrients is adequate for each species (DiTommaso and Aarssen 1991; Wedin and Tilman 1993).

As nitrogen levels and the microsite environment varies, the species with the competitive advantage will change (Tilman and Wedin 1991). The response of plant species to nutrient depletion will vary as species with large reserves of carbohydrates can tolerate periodic changes in nutrient levels but faster growing species with small reserves will not cope with nutrient deficiencies (Jonasson et al. 1996). Even though a desired species can establish first, if the availability of the limiting resource changes, species composition will be altered (Tilman 1987).

Different plant species can affect immobilization and mineralization by microorganisms (Vinton and Burke 1995). Microbial activity existing prior to the addition of amendments can affect the rate of decomposition. A small but active population will decompose straw and turn over nitrogen faster than a large, less active, population (Nyborg et al. 1995). Fewer nitrifying bacteria exist in soils with low organic matter content, reducing the rate of immobilization (Broadbent and Tyler 1962).

As moisture is required for maximum microbial activity, immobilization and mineralization rates fluctuate as soil conditions change. A constant rate on immobilization does not occur under field conditions (Zimmerman et al. 1995).

1.8 Research Justification

As governments require reclamation companies to reintroduce native plant species into specific areas, additional information is required to ensure successful establishment of these plant communities. Information on native plant species is limited and as seed for native species is more expensive than introduced species, reclamation companies require information on how to improve the success rate of establishing native plants. There are conflicting studies on the effect of using fertilizer on native plant stands. Applying fertilizer to native species is often not recommended as this will provide soil conditions favouring invasion by introduced species (Gerling et al. 1996). Low levels of fertilizer are recommended to limit the growth of introduced plants requiring high amounts of nutrients (Ash et al. 1994). Other researchers suggest fertilizer could be beneficial in establishing native species (Wark et al. n.d.). Although adding fertilizer may promote the growth of introduced species, it may also produce an environment that will increase the survival rate of native species.

Nutrient requirements and the ability to access available nutrients by various plant species should be considered when developing seed mixes (Pyke and Archer 1991). However, there is little information on the strategies used by native plant species. The competitive interactions of the species within a mix should also be considered but research on the interaction of selected plant species is lacking (Pyke and Archer 1991).

Additional research is required on native plant response to slow release fertilizer and if it is applied in the initial year of plant establishment, whether the effect will continue into subsequent years. It is also important to determine if adding slow release fertilizer will promote the establishment of native and/or introduced plant species when seeded together. The cost effectiveness of using native species is a consideration in the reclamation industry. As native seeds are difficult to purchase and are more costly, reclamation companies require techniques that will ensure plant survivability.

Leguminous species are often included in seed mixes but more information is needed on the nutrient and establishment requirements of native legumes (Hardy BBT 1990).

The effectiveness of soil impoverishment has not been clearly demonstrated (Morgan 1994). Results of studies on incorporating crop residues into the soil indicate the effects on subsequent vegetation will vary. Ferguson (1967) did not find any statistical difference in crop yields when straw was incorporated into the soil, but it was not determined if the C:N ratio exceeded 25:1. Nyborg et al. (1995) noticed nitrogen was immobilized with additions of straw, but the effect was no longer evident after a few years. The length of time nutrients are immobilized can be short, depending on the substrate and microbial population (Vinton and Burke 1995).

The successful restoration of native plant communities requires a greater identification and understanding of factors that promote the development of these particular ecosystems (Bradshaw 1987 cited in Pyke and Archer 1991).

1.9 Research Objectives

Native plant species should have an advantage when seeded on low nutrient soils as they likely require lower levels of nutrients than introduced plant species. It is hypothesized native plant species will have a higher survival rate and produce more biomass than introduced species on low nutrient soils. Fertilizer application will affect plant community development as introduced plant species compete for the added nutrients. Soil impoverishment will lower the available nitrogen in the soil and native plant species will have better establishment rates than introduced species.

1.10 References

Alberta Agriculture. 1986. Sulphur fertilizer application in crop production. Print Media Branch, Alberta Agriculture. Edmonton, AB. Agdex 542-10. 7 pp.

Alberta Agriculture. 1988. Native range fertilizer guide. Print Media Branch, Alberta Agriculture. Edmonton, AB. Agdex 130/541. 2 pp.

Alberta Agriculture. 1993. Micronutrient requirements of crops. Print Media Branch, Alberta Agriculture. Edmonton, AB. Agdex 531-1. 6 pp.

Alberta Agriculture. 1995. Alberta fertilizer guide. Print Media Branch, Alberta Agriculture. Edmonton, AB. Agdex 541-1. 16 pp.

Alberta Agriculture. 1996. Agricultural Statistics Yearbook. Print Media Branch, Alberta Agriculture Food and Rural Development. Edmonton, AB. 175 pp.

Alberta Environmental Protection. 1995. Reclamation criteria for wellsites and associated facilities. 1995 Update. 62 pp.

Allison, F.E. and C.J. Klein. 1962. Rates of immobilization and release of nitrogen following additions of carbonaceous materials and nitrogen to soils. Soil Science 93:383-386.

Aoyama, M. and T. Nozawa. 1993. Microbial biomass nitrogen and mineralization-immobilization processes of nitrogen in soils incubated with various organic materials. Soil Science and Plant Nutrition 39(1):23-32.

Ash, H.J., R.P. Gemmell and A.D. Bradshaw. 1994. The introduction of native plant species on industrial waste heaps: a test of immigration and other factors affecting primary succession. Journal of Applied Ecology 31:74-84.

Bartholomew, W.V. 1965. Mineralization and immobilization of nitrogen in the decomposition of plant and animal residues. In: Soil nitrogen. W.V. Bartholomew and F.E. Clark, eds. American Society of Agronomy, Inc. Madison,WI. Pp. 285-306.

Begon, M., J.L. Harper and C.R. Townsend. 1986. Ecology. Sinauer. Sunderland, Massachusetts.

Berendse, F., W.T. Elberse and R.H.M.E. Geerts. 1992. Competition and nitrogen loss from grassland ecosystems. Ecology 73:46-53.

Biodini, M.E., C.D. Bonham and E.F. Redente. 1985. Relationships between induced successional patterns and soil biological activity of reclaimed areas. Reclamation and Revegetation Research 3:323-342.

Bollen, W.B. 1959. Microorganisms and soil fertility. Oregon State College Press. Corvallis, OR. 24 pp.

Bradshaw, A.D. 1987. The reclamation of derelict land and the ecology of ecosystems. In: Restoration ecology: A synthetic approach to ecological research. W.R. Jordan III, M.E. Gilpin and J.D. Aber, eds. Cambridge University Press. New York, NY. Pp. 53-74.

Broadbent, F.E. and K.B. Tyler. 1962. Laboratory and greenhouse investigations of nitrogen immobilization. Soil Science Society Proceedings 26:459-462.

Burges, A. 1964. Microorganisms in the soil. Anchor Press, Tiptree, WI. 188 pp.

Buysse, J., H. Van den Broeck, R. Merck. 1996. The effect of different levels of N limitation on sugars, amino acids, growth and biomass partitioning in broadbean (*Vicia faba* L.). Annals of Botany 78:39-44.

Canadian Biodiversity Strategy. 1995. Minister of Supply and Services. Hull, PQ. 77 pp.

Dickinson, C.H. 1974. Decomposition of litter in soil. In: Biology of plant litter decomposition. Vol. 2. C.H. Dickinson and C.J.F. Pugh, eds. American Press. London, GB. Pp. 306-336.

DiTommaso, A. and L.W. Aarssen. 1991. Effect of nutrient level on competition intensity in the field for three coexisting grass species. Journal of Vegetation Science 2:513-522.

Dodd, J.L. and W.K. Lauenroth. 1979. Analysis of the response of a grassland ecosystem to stress. In: Perspectives in grassland ecology. N. French, ed. Springer. New York, NY. Pp. 43-59.

Fauci, M.F. and R.P. Dick. 1994. Soil microbial dynamics: Short- and long-term effects of inorganic and organic nitrogen. Soil Science Society of America Journal 58:801-806.

Ferguson, W.S. 1967. Effect of repeated applications of straw on grain yields and on some soil properties. Canadian Journal of Soil Science 47:117-121.

Forbes, R.S. 1974. Decomposition of agricultural crop debris. In : Biology of plant litter decomposition. Vol. 2. C.H. Dickinson and G.J.F. Pugh, eds. Academic Press. London, GB. Pp. 723-742.

Gambash, S., M. Kochba and Y. Avnimelech. 1990. Studies on slow-release fertilizers: II. A method for evaluation of nutrient releases rate from slow-releasing fertilizers. Soil Science 150:446-450.

Gerling, H.S., M.G. Willoughby, A. Schoepf, K.E. Tannas and C.A. Tannas. 1996. A guide to using native plants on disturbed lands. Alberta Agriculture, Food and Rural Development and Alberta Environmental Protection. Edmonton, AB. 247 pp.

Goldberg, D. E., R. Turkington, and L. Olsvig - Whittaker. 1995. Quantifying the community - level consequences of competition. Folia Geobotanica Phytotaxica 30:231-242.

Grace, J.B. 1990. On the relationship between plant traits and competitive ability. In: Perspectives on plant competition. J.B. Grace and D. Tilman, eds. Academic Press. San Diego,CA. Pp. 51-65.

Grime, J.P. 1973. Competitive exclusion in herbaceous vegetation. Nature 242:345-347.

Grime, J.P. 1977. Evidence for the existence of three primary strategies in plants and its relevance to ecological and evolutionary theory. American Naturalist 111:1169-1194.

Hamel, C., V. Furlan and D.L. Smith. 1992. Mycorrhizal effects on interspecific plant competition and nitrogen transfer in legume-grass mixtures. Crop Science 32:991-996.

Hardy BBT Limited. 1989. Manual of plant species suitability for reclamation in Alberta-2nd edition. Alberta Land Conservation and Reclamation Council Report No. RRTAC 89-4. Edmonton, AB. 436 pp.

Hardy BBT Limited. 1990. Reclamation of disturbed alpine lands. A literature review. Alberta Land Conservation and Reclamation Council Report No. RRTAC 90-7. Edmonton, AB. 209 pp.

Hausenbuiller, R.L. 1985. Soil science principles and practices. Wm. C. Brown Company Publishers. Dubuque, IO. 610 pp.

Jonasson, S., P. Vestergaard, M. Jensen and A. Michelsen. 1996. Effects of carbohydrate amendments on nutrient partitioning, plant and microbial performance of a grassland-shrub ecosystem. Oikos 75:220-226.

Jones, R.D. and A.P. Schwab. 1993. Nitrate leaching and nitrite occurrence in a fine-textured soil. Soil Science 155:272-282.

Kerr, D.S., L.J. Morrison and K.E. Wilkinson. 1993. Reclamation of Native Grasslands in Alberta: A review of the Literature. Alberta Land Conservation and Reclamation Council Report No. RRTAC 93-1. Queen's Printer. Edmonton, AB. 231 pp.

McGill, W. 1996. Professor, Department of Renewable Resources, University of Alberta. Personal Communication. Edmonton. June 05,1996.

McGill, W.B., K.R. Cannon, J.A. Robertson and F.D. Cook. 1986. Dynamics of soil microbial biomass and water-soluble organic C in Breton L after 50 years of cropping to two rotations. Canadian Journal of Soil Science 66:1-19.

Morgan, J.P. 1994. Soil impoverishment: A little-known technique holds potential for establishing prairie. Restoration and Management Notes 12(1):55-56.

Munshower, F.F. 1994. Practical handbook of disturbed land revegetation. Lewis Publishers. Boca Raton, FA. 265 pp.

Nutting, M. Agrium Fertilizers. Personal Communication. Edmonton, AB. May, 1996.

Nyborg, M., E.D. Solberg, R.C. Izaurralde, S.S. Malhi and M. Moline-Ayala. 1995. Influence of long-term tillage, straw and N-fertilizer on barley yield, plant-N uptake and soil-N balance. Soil and Tillage Research 36:165-174.

Oertli, J.J. and O.R. Lunt. 1962. Controlled release of fertilizer minerals by incapsulating (sic) membranes: I. Factors influencing the rate of release. Soil Science Society of America Proceedings 26:579-583.

Parker, D.T. 1962. Decomposition in the field of buried and surface-applied cornstalk residue. Soil Science Society Proceedings 26:559-562.

Parker, I.M., S.K. Mertens and D.W. Schemske. 1993. Distribution of seven native and two exotic plants in a tallgrass prairie in southeastern Wisconsin: The importance of human disturbance. American Midland Naturalist 130:43-55.

Patra, D.D., S.C. Bhandari and A. Misra. 1992. Effect of plant residues on the size of microbial biomass and nitrogen mineralization in soil : incorporation of cowpea and wheat straw. Soil Science and Plant Nutrition 38(1):1-6.

Pugh, C.J.F. 1974. Terrestrial fungi. In : Biology of plant litter decomposition. Vol. 2. C.H. Dickinson and C.J.F. Pugh, eds. Academic Press. London, GB. Pp. 303-336.

Pyke, D.A. and S. Archer. 1991. Plant-plant interactions affecting plant establishment and persistence on revegetated rangeland. Journal of Range Management 44:550-557.

Raven, P.H., R.F. Evert and S.E. Eichhorn. 1992. Biology of plants. Worth Publishers. New York, NY. 791 pp.

Rew, L.J., R.J. Froud-Williams and N.D. Boatman. 1995. The effect of nitrogen, plant density and competition between *Bromus sterilis* and three perennial grasses : the implications for boundary strip management. Weed Research 35:363-368.

Robertson, J. 1995. Professor, Department of Renewable Resources. Soils 460 Lecture. University of Alberta, Edmonton, AB.

Scarsbrook, C.E. 1965. Nitrogen availability. In: Soil nitrogen. W.V. Bartholomew and F.E. Clark, eds. American Society of Agronomy. Madison, WI. Pp. 481-502.

Simons, R.G., C.A. Grant and L.D. Bailey. 1995. Effect of fertilizer placement on yield of established alfalfa stands. Canadian Journal of Plant Science 75:883-887.

Smreciu, A. 1993. Native legumes for reclamation in Alberta. Alberta Conservation and Reclamation Council Report No. RRTAC 93-9. Edmonton, AB. 94 pp.

Soderstrom, B., E. Baath and B. Lundgren. 1983. Decrease in soil microbial activity and biomasses owing to nitrogen amendments. Canadian Journal of Microbiology 29:1500-1506.

Stack, J.P., C.M. Kenerley and R.E. Pettit. 1987. Influence of carbon and nitrogen sources, relative carbon and nitrogen concentrations, and soil moisture on the growth in nonsterile soil of soilborne fungal antagonists. Canadian Journal of Microbiology 33:626-631.

Takyi, S.K. 1984. Role of topsoil, fertilizers and companion crops in revegetation of two severe sites in the Alberta foothills and mountains. Alberta Energy and Natural Resources. Edmonton, AB. 29 pp.

Thurston, J. 1996. Manager, University of Alberta Farm. Personal Communication. Edmonton. June 03, 1996.

Tilman, D. 1987. Secondary succession and the pattern of plant dominance along experimental nitrogen gradients. Ecological Monographs 57(3):189-214.

Tilman, D. and D. Wedin. 1991. Dynamics of nitrogen competition between successional grasses. Ecology 72(3):1038-1049.

Tisdale, S.L., W.L. Nelson, J.D. Beaton and J.L. Havlin. 1993. Soil fertility and fertilizers. Macmillan Publishing Company. New York, NY. 434 pp.

Vinton, M.A. and I.C. Burke. 1995. Interactions between individual plant species and soil nutrient status in shortgrass steppe. Ecology 76(4):1116-1133.

Waksman, S.A. 1924. Influence of microorganisms upon the carbon-nitrogen ratio in the soil. Journal of Agricultural Sciences 14:555-562.

Walton, P.D. 1988. Principles and practices of plant science. Prentice Hall. Englewood Cliffs, CA. 439 pp.

Wang, Z., D.L. Crawford, T.S. Magnuson, B.H. Bleakley and G. Hertel. 1991. Effects of bacterial lignin peroxidase on organic carbon mineralization in soil, using recombinant *Streptomyces* strains. Canadian Journal of Microbiology 33:626-631.

Wark, D.B., W.R. Poole, R.G. Arnott, L.R. Moats and L. Wetter. n.d. Revegetating with native grasses. Ducks Unlimited Canada. 133 pp.

Wedin, D. and D. Tilman. 1993. Competition among grasses along a nitrogen gradient: initial conditions and mechanisms of competition. Ecological Monographs 63(2): 199-229.

Whitford, W.G. 1988. Decomposition and nutrient cycling in disturbed arid ecosystems. In: The Reconstruction of Disturbed Arid Lands. E.B. Allen, ed. Westview Press Inc. Boulder, CO. Pp. 136-161.

Wilson, S.D. and D. Tilman. 1993. Plant competition and resource availability in response to disturbance and fertilization. Ecology 74(2): 599-611.

Young, J.L. 1962. Inorganic soil nitrogen and carbon : nitrogen ratios of some pacific northwest soils. Soil Science 93:397-404.

Zimmerman, J.K., W.M. Pulliam, D.J. Lodge, V. Quinones-Orfila, N. Fetcher, S. Guzman-Grajales, J.A. Parrotta, C.E. Asbury, L.R. Walker and R.B. Waide. 1995. Nitrogen immobilization by decomposing woody debris and the recovery of tropical wet forest from hurricane damage. Oikos 72:314-322.

CHAPTER 2: EFFECT OF APPLYING SLOW AND REGULAR RELEASE FERTILIZERS ON SIX NATIVE AND INTRODUCED PLANT SPECIES

2.1 Introduction

As resource extraction and agricultural industries continue to expand, loss of biodiversity in native plant ecosystems is occurring throughout Canada. In Alberta, it is now required that a disturbance occurring on native prairie must be reclaimed using native plant species when appropriate (Alberta Environmental Protection 1995). However, use of native plant species in reclamation is impeded by the lack of information on conditions that will favour establishment of native plant communities (Gerling et al. 1996).

Although it has been found that the nutrient requirements of native grass species are lower than those of introduced species (Takyi 1984), little information is available on the actual nutrient requirements of native plant species and if they will benefit from applying fertilizer. Most of the research conducted on nutrient deficient soils has been completed in the mountains and foothills (Takyi 1984; Takyi and Islam 1984; Russell Ecological Consultants 1986) with little research done in the Parkland region of the province. Nitrogen (N), phosphorus (P), potassium (K) and sulfur (S) are the macronutrients that are commonly added to nutrient deficient soils as fertilizers. As these nutrients are required for plant growth and survival, plant species will compete for the limited resources available. It is this competition for resources which determines plant establishment within the plant community (Pyke and Archer 1991).

The effect of adding inorganic nutrients has been studied using agronomic species (Nyborg et al. 1995; Simons et al. 1995), but few studies have been done on the effect of fertilizer on native species. It is often recommended that fertilizer not be applied to areas where native plant establishment is desired as introduced species will use the added nutrients to outcompete native plant species (Gerling et al. 1996; Wark et al. n.d.). If nutrient levels remain low, native species would have a better opportunity of becoming established onto the disturbance before introduced species.

In reclamation, it is often not feasible to reapply fertilizer in subsequent years and in Alberta, fertilizers cannot be applied the year prior to seeking a reclamation certificate (Alberta Environmental Protection 1995). Slow release fertilizers may be an alternative method of providing inorganic nutrients to a disturbed site. Information on the response of

introduced and native grass and legume species to slow release fertilizer is limited to nonexistent.

The aggressiveness of the species seeded is a factor to be considered when selecting plant species for reclamation. It is commonly believed introduced species are generally more aggressive than native species, particularly on higher nutrient soils (Kerr et al. 1993; Dodd and Lauenroth 1979 as cited by Parker et al. 1993). The competitive strategies of the species can ultimately determine which species will dominate in an area (Grime 1977; Pyke and Archer 1991). However, manipulating the soil environment in which species are seeded can alter the resulting plant community.

2.2 Objectives and Hypotheses

For six selected native and introduced plant species, the research objectives were:

1. To determine the effect of optimum and half of the recommended levels of added soil nutrients on plant vegetative characteristics and plant survivability (density).
2. To determine the effect of slow release fertilizer and regular fertilizer on plant vegetative characteristics and survivability (density).
3. To determine the effect of interspecific competition on plant vegetative characteristics and survivability (density).

Based on the aforementioned objectives, the hypotheses tested were:

1. Native and introduced plant species seeded in monocultures will survive the same for all soil nutrient levels.
2. Native and introduced plant species will survive the same in monocultures and mixes.
3. When seeded together, native and introduced plants will survive the same.
4. Both native and introduced species will grow the same and produce equal amounts of biomass irrespective of soil nutrient levels.

2.3 Materials and Methods

2.3.1 Site Location and History

The study site was located 47 km southeast of Edmonton at Fording Coal, Genesee, Alberta. The legal land description was 30-50-2 W5. This area was on the border between the mid boreal and low boreal mixedwood ecoregions and the dominant climatic

regime was classified as boreal (Strong and Leggat 1992). Average yearly rainfall was 409 mm with average maximum temperatures ranging from -8 °C in January to 22 °C in July (Environment Canada n.d.). The long term average for rainfall in each month is plotted as well as total rainfall in 1996 and 1997 in Figure A.1 (Appendix A). Data from the University of Alberta Breton Plots were used for 1996 and 1997 as this meteorological station was only 35 km north of Genesee. In 1996 rainfall events occurred often from June to August.

Plots were established on a north facing slope at the northern section of the mine site. It was an 8 to 10 degree slope to the north, and a one degree slope towards the east from mid plot. This site was selected as available nitrate, phosphate and potassium levels were deficient and soil physical parameters were within acceptable ranges for plant establishment. Sulfate levels exceeded optimum levels for plants (Table A.2, Appendix A). The site for the plot had been excavated for coal in 1988 and reclamation was started in 1995. One meter of subsoil had been replaced but no topsoil had been added. Adjacent to the plot site, where topsoil had been replaced, alfalfa had been seeded with a cover crop of barley.

2.3.2 Soil Sampling

Soil samples were taken in May 1996 to determine soil nutrient status. A composite sample was produced from 10 randomly selected sites within each block. These samples were obtained by using a 30-cm long by 3.2-cm diameter "Backsaver" soil sampler. The top 15 cm were collected separately from the 15 to 30 cm increment. The 30 to 60 cm increment was extracted with a 30-cm long by 1.9-cm diameter "Backsaver" soil sampler and was kept separate from the upper samples. The 10 samples from corresponding depth increments were thoroughly mixed and the composite samples were placed into labelled plastic bags. All samples were placed in a cooler for transport and stored in the refrigerator until taken to the soil testing laboratory the following day. Soil sampling was repeated in June and October 1997. The above method was used in June to acquire soil samples of each replicate. The October samples were amalgamated by treatment rather than replicate to determine if there was a difference in nutrient level as a result of the various treatments.

2.3.3 Soil Analyses

Soil samples were analyzed by Norwest Labs, Edmonton, according to recommendations in McKeague (1976) and Ashworth and Mrazek (1995) for available nitrate nitrogen (N), phosphorus (P), potassium (K) and sulfur (S) for the upper two depth increments. The 0 to 15 cm depth samples were also analyzed for micronutrients and salinity and the 30 to 60 cm depth samples were tested for N and P only. $CaCl_2$ solution was used as the extracting solution for nitrates and sulfates. Potassium and phosphorus levels were determined using "acetic fluoride" solution. A solution of ammonium acetate was used to determine calcium, exchangeable manganese and sodium. Iron, copper, zinc and manganese levels were ascertained by using DTPA/TEA chelating solution.

Soil pH was measured on the composite samples for each depth increment for all four blocks. The Fisher Accumet pH Meter was used to determine pH and instructions of the manufacturer were followed. Soil pH readings would not stabilize in samples that contained high amounts of sodium so readings were taken after two minutes for all samples. The slurry was prepared by mixing 10 g of soil with 25 ml of de-ionized water and stirring with a glass rod. The stirring cycle was repeated three times before the solution sat undisturbed for two hours. This slurry was also used to determine electrical conductivity using the YSI Conductivity Bridge instrument. The instrument was calibrated according to instructions by the manufacturer.

Total carbon was determined by using finely ground soil samples in the LECO carbon determinator at the University of Alberta. The Walkley-Black method was used to determine organic carbon (Black 1965b). Samples from each depth increment from each block were used to determine the proportion of sand, silt and clay of the soil by the hydrometer method (Black 1965a).

In July 1997, a cone penetrometer with a 9.5-mm diameter shaft was used to assess penetration resistance as it is an important parameter for root growth. Eight depths were measured from 2.5 cm to 33 cm at ten random sites in each block. At the same sites, an MC1 surface moisture / density gauge was used to determine soil moisture and bulk density at 25 cm depths.

2.3.4 Plot Layout

Four blocks were used in a strip-plot design. Each subplot measured 1.83 by 3.66 m. To facilitate fertilizer application and seeding, fertilizer was placed horizontally across each block and species were seeded perpendicular to the fertilizer application. Fertilizer treatments were randomly assigned across each block and each treatment covered a total area of 87.1 m^2 (3.66 m by 23.79 m). The species and mixes were randomly designated within each block and each treatment had an area of 46.9 m^2 (1.83 m by 25.62 m) (Figures A.2 and A.3, Appendix A).

2.3.5 Site Preparation and Management

To prepare the site at Genesee, the soil was deep ripped to a depth of 45 cm, then cultivated twice at a depth of 18 cm and finally harrowed with tine harrows. Rocks were then removed and the site rototillered twice with a 1.83-m rototiller. Treatments were measured and marked out prior to the application of fertilizer to the treatments using push type, drop fertilizer spreaders. The site was harrowed with tine harrows to incorporate the fertilizer into the soil. The same blend of fertilizer was re-applied with push type, drop fertilizer spreaders in June 1997.

On June 11, 1996, when weather and soil conditions permitted, a 1.83-m disc seed drill was used to seed the mixes. The depth of seed placement did not exceed 1.5 times the diameter of the seed (Gerling et al. 1996). As the seeds in the mixes varied in size, all were seeded at 1.5 cm, an average for the selected species. The eight discs were 23 cm apart and the drill was calibrated prior to seeding to ensure the seeds were planted at the desired rate. To calibrate the drill, the length of the plot was measured apart from the prepared site and seeds were added to three of the discs. The drill was driven the marked length and if seeds remained in the cones or were distributed too quickly, adjustments were made to the drill by altering the rotation speed of the cones. The process was repeated until all of the seeds within the discs were seeded over the marked distance.

One packet of the desired seed mix was added to each of the eight discs and the seeding depth was set at 1.5 cm. The species were seeded in a north-south direction in the blocks and if no species were seeded, a pass was made over the treatment with the empty drill set at the same depth as though seeding. After seeding was completed, permanent markers were installed to delineate plots.

During the course of the first growing season, *Matricaria perforata* Merat (Scentless chamomile) and species within the *Brassicaceae* family grew throughout the site and weed control was required. The site was mowed to a height of 20 cm using a Massey Ferguson 3.5-m hay bind on August 21, 1996. The cut portions of the plants were removed from the site with a pitchfork.

2.3.6 Fertilizer Treatments

Fertilizer rates were determined by averaging the recommendations from the macronutrient analyses for the four blocks. As fertilizer was applied to grasses and legumes, the rates for 50% legumes were used and the average recommended rates for the Genesee site were: N: 107, 103.5, 84 and 0 kg/ha for N, P_2O_5, K_2O and S, respectively.

The total amount of fertilizer required was calculated for 46-0-0, 41-0-0 (slow release), 12-51-0 and 0-0-60. The regular fertilizer was blended at the desired rate at the fertilizer dealer (16-19-16). It was then weighed and 2.3 kg was poured into each bag. The 12-51-0 and 0-0-60 to be used with the slow release fertilizer was preblended by the fertilizer dealer (7-34-24). Twelve bags containing 0.9 kg of slow release fertilizer and 1.5 kg of 7-34-24 mix were prepared.

The fertilizer treatments randomly assigned to the subplots were: recommended rate of regular fertilizer; half the recommended rate of regular fertilizer; recommended rate of slow release fertilizer; half the recommended rate of slow release fertilizer; or no additional nutrients (Table A.5, Appendix A).

Four treatments within each block were treated with regular fertilizer; two at the recommended rate and two at half the recommended rate. In the second year, one of each of these treatments was fertilized again to determine if it would be an effective reclamation procedure in establishing native plant species. This was done to evaluate if slow release fertilizer would be as effective as regular fertilizer applications applied over two years.

2.3.7 Species Selection and Mixes

Plant species were selected based on their different growth characteristics and properties. One native and one introduced legume were included in the selected species to provide nitrogen to the soil over extended periods of time. Tufted, low growing native and

introduced grass species were seeded to provide ground cover to minimize the risk of soil erosion. The third native and introduced species were rhizomatous, or sod forming, grasses. Rhizomatous species stabilize the soil, reducing the potential of soil erosion.

Plant species selected were native to the Parkland region or were introduced species commonly used in reclamation (Table A.3, Appendix A). Seed availability and plant tolerance to low nutrient levels were considered in the final determination of plant species. Although information on plant tolerance to low nutrients was limited, selection was based on information available (Hardy BBT 1989; Gerling et al. 1996). The native species selected were *Agropyron smithii* Rydb.(Western wheatgrass), *Stipa viridula* Trin. (Green needle grass) and *Vicia americana* Muhl. (American vetch). *A. smithii* has a rhizomatous growth form and *S. viridula* is a tufted species. Although *V. americana* has not been commonly used in reclamation, seed was available and it is a native legume. *Bromus inermis* Leyss. (Smooth brome) was the introduced species selected with rhizomatous growth patterns. The tufted introduced species seeded was *Phleum pratense* L. (Timothy) and *Trifolium hybridum* L. (Alsike clover) was the legume chosen.

Agropyron smithii Rydb. (Western wheatgrass) (Moss 1992) is a native grass species with slender rhizomes (Hitchcock 1971 cited in Hardy BBT 1989). It is a competitive species that can resist encroachment by other species (Weaver 1942). Moderate levels of nutrients are required by *A. smithii* and there is mixed success of establishing this species (Hardy BBT 1989). *A. smithii* prefers moist areas and is usually found in moderately alkaline, clay soils. The culms can grow to 30 to 60 cm high with blades 3 to 6 mm wide (Best et al. 1976; Looman and Best 1981).

Bromus inermis Leyss. (Smooth brome) (Moss 1992) is an introduced rhizomatous species. It propagates by seed and vegetatively through rhizomes. The culms of *B. inermis* can reach 60 to 100 cm high. The average width of the blades is 6 to 12 mm and the length is 30 cm (Best et al. 1976; Looman and Best 1981). It grows on a wide range of soils but cannot tolerate soils that are more than mildly alkaline (LeRoy and Keller 1972 and Hafenrichter et al. 1968 cited in Hardy BBT 1989). *B. inermis* requires a high level of available nitrogen and with adequate levels of nutrients, can be aggressive (Berg 1974 cited in Hardy BBT 1989). This species emerges quickly (Vaartnou 1979 cited in Hardy BBT 1989). Jones et al. (1975 cited in Hardy BBT 1989) found organic matter increased in stands of *B. inermis* on mine spoil.

Phleum pratense L. (Timothy) (Moss 1992) is an introduced grass commonly seeded for hay and pasture. It is a bunchgrass with a shallow fibrous root system (Elliot and Boton 1970 cited in Hardy BBT 1989) and is well adapted to loam and clayey soils (Vories and Sims 1977 cited in Hardy BBT 1989). *P. pratense* requires high levels of nutrients, but can become established on disturbed sites (Whitby-Costescu et al. 1977 cited in Hardy BBT 1989). It establishes well by seed and emerges rapidly (Plummer 1977 and Vaartnou 1979 cited in Hardy BBT 1989). The culms can reach 50 to 80 cm high with blades 6 to 12 mm wide and 30 cm long (Best et al. 1976; Looman and Best 1981).

Stipa viridula Trin. (Green needle grass) (Moss 1992) is a native species commonly found on dry to moist, fertile clay soils (Best et al. 1976). The Edmonton area is at its most northerly range (Hardy BBT 1989). The culms normally are 50 to 100 cm high with blades 2 to 5 mm wide and 25 cm long (Looman and Best 1981). *S. viridula* is a bunchgrass with a fibrous root system. It is a moderately aggressive species. Initially, there is low emergence as the seeds can remain dormant unless they are stratified (Wark et al. n.d.; Walker and Weijer 1975 cited in Hardy BBT 1989).

Trifolium hybridum L. (Alsike clover) (Moss 1992) is an introduced legume that is commonly found on waste areas (Looman and Best 1981). These plants can grow 30 to 60 cm high and have leaflets 10 to 25 cm long (Looman and Best 1981). It is short lived and usually dies after two years (Skousen 1988 cited in Hardy BBT 1989). *T. hybridum* grows well on clay soils with adequate levels of moisture, potassium and phosphorus (Vories and Sims 1977 and Buckerfield's Ltd. 1980 cited in Hardy BBT 1989). It is easily established and is weakly aggressive (USDA Soil Conservation Service 1976 as cited in Hardy BBT 1989; Buckerfield's Ltd. 1980 as cited in Hardy BBT 1989).

Vicia americana Muhl. (American vetch) (Moss 1992) is a common native legume that can reach lengths between 10 to 25 cm (Looman and Best 1981). This species grows well on loam and can become established on sandy and clay soils (Farmer and Blue 1978 cited in Hardy BBT 1989). It prefers moist sites with adequate nutrient levels (Alsands Project Group 1978 cited in Hardy BBT 1989). According to Hardy BBT (1989), there are no known pest species. *V. americana* is very aggressive and can outcompete other species (Hardy BBT 1989).

To evaluate the effect of competition, each species was seeded as a monoculture and in three mixes. Each native plant species was seeded with the introduced species with similar

growth characteristics; *A. smithii* was seeded with *B. inermis*, *S. viridula* with *P. pratense*, and *V. americana* with *T. hybridum*. The three native species were seeded as a mix as were the three introduced species. As a final mix, all six species were seeded together.

Recommended seeding rates for native species range from 8 to 11 kg pure live seed (PLS)/ha (Gerling et al. 1996; Wark et al. n.d.). The recommended number of live plants per unit area varies with species and desired end land use and ranges from 200 to 800 m^{-2} with the average between 250 and 350 (Wark et al. n.d.). Plant density is increased if erosion prevention is required but the rate is decreased if encroachment from the surrounding area is desired (Gerling et al. 1996). Seeding rates were determined based on 300 pure live seeds m^{-2} which falls within the range of normal seeding rates. The amount of seed required for each replicate was calculated and seed packages prepared prior to seeding. One thousand seeds were counted and weighed and from these data, the number of seeds per gram determined. Purity, seed viability and pure live seed were determined from information on the seed certificates. The seeding formula was according to Gerling et al. (1996):

$$\frac{\text{Desired live plants/m}^2 \text{ x } 10}{\text{Seeds/gm x \% pure live seed}} = \text{kg/ha of seed}$$

The percent pure live seed, if not provided on the seed certificates, was calculated using the formula: % pure live seed = % germination x % purity (Heady 1975 as cited in Kerr et al. 1993).

These values were used to prepare the packages for the monocultures and as the total number of desired live plants in the mixes remained at 300 m^{-2}, these values were divided by two, three and six for the corresponding mixes (Table A.4, Appendix A). The number of seeds required for each replicate was divided by eight, the number of seed discs on the drill. The required amount of each species was weighed, mixes were stirred, then placed into labelled envelopes, one envelope for each seed disc in each block. *Trifolium hybridum* was inoculated with *Rhizobium leguminosium Biovar Trifolia*. It is not known which rhizobia are required for successful establishment of *Vicia americana*. Liphatech's Nitrogen Type B *Onobrychis viciifolia* (sainfoin) inoculant was used as other researchers have had favorable results with this inoculant on vetch (Pelech 1997). The inoculated seeds were kept in the refrigerator for one week until taken to the field to be seeded.

2.3.8 Vegetation Measurements

During the first growing season, data were collected three weeks after seeding and approximately every two weeks after that until September when final growing season data were collected. Data were collected from three randomly placed 0.1-m^2 quadrats within each subplot. As erosion occurred on the uppermost treatments, a fourth quadrat reading was included. The number of forbs, grasses and legumes were counted each time and, starting six weeks after seeding, average heights of the seeded species were also taken. Starting at the third count, *Brassicaceae* species were counted separately from other volunteer forbs.

In September, within each quadrat, vegetative characteristics and species composition were determined. In May and August 1997, the same measurements and techniques were used as in the previous fall. In fall 1997, the vegetation within each quadrat was cut to a height of 3 cm, bagged and dried in a hot air dryer at 55 °C for five days. The dried samples were weighed to determine amount of biomass per quadrat.

Canopy height was measured for each canopy level, up to a maximum of three levels. A canopy level was considered present if precipitation would be intercepted by plant foliage at that level. Canopy cover was estimated by looking down from 1.5 m onto the quadrat. Ground cover was evaluated at ground level by visualizing the quadrat with all vegetation clipped to a height of 5 cm. For canopy and ground cover, estimates of percentages of live vegetation, litter, bare ground, manure, rocks and moss, totaling 100%, were determined and assigned by comparing each element to a pre-measured area.

Average litter depth was measured in centimeters from the soil upwards. Plant material was classified as litter if it was not a result of plant growth in the present year.

All species growing within the quadrat, both seeded and voluntary, were identified and counted. Species rooted outside the quadrat were not included in the plant count unless a tiller had become established within the quadrat. Tillers were counted as part of the original plant. Plants that emerged and subsequently died in the establishment year were counted as live plants for that year. A percentage value was allocated to each species indicating the proportion of total plant matter within the quadrat attributed to the species.

2.3.9 Experimental Design and Statistical Analyses

Data were input into Excel for preliminary analyses. Data were analyzed using the SPSS 6.1 statistical program. Further statistical analyses were completed using SPSS 8.0 for Windows. To determine the effect of fertilizers, the individual species within the mixes were compared across the different fertilizer treatments. Characteristics of the species mixes were compared to determine if fertilizer rates had impacted total growth patterns. Intraspecific competition was analyzed by comparing the survivability (density) rates of the specific species in monoculture and the relevant species mixes. The no amendment treatments were used as control plots. The general linear model of analysis of variance was used to run these statistical analyses. The data were not transformed, even though discrete and percent data were used. The data were initially tested by transforming percent data using square root of the square root, and density data by using the natural log. Q-Q plots did not show a change in the linearity of the residuals from raw data and transformed data. Interspecific competition between the species of similar plant characteristics was evaluated using t-tests of the average means. Density and biomass were compared for the species in monocultures and in the two mixes in which they were seeded together. The level of significance for all data analyses was $p \leq 0.05$.

2.4 Results

2.4.1 Soil Characteristics

Soil parameters were within normal ranges for plant establishment. The soil was not saline and was moderately alkaline. In May 1996, available nitrogen, phosphorus and potassium were deficient but sulfate was adequate. Micronutrient availability was marginal (Table A.2, Appendix A). The amount of available macronutrients did not vary in the second year and generally did not differ between treatments (Table A.6, Appendix A). The soil was clay loam in texture and the total organic matter was very low. Penetration resistance readings ranged from 573 kPa to 1770 kPa (Table A.2, Appendix A). All values were lower than 2000 kPa, the level at which it has been suggested that root growth may become impeded. At 17.5 cm and 33 cm, the penetration resistance was near the suggested limit but should not have interfered with root growth over the two years of the study. Soil moisture content varied from 10.2% to 17.2% (Table A.6, Appendix A).

2.4.2 Initial Vegetation

Species were not identified during summer 1996. The density of forbs, grasses and legumes peaked at the end of July to mid-August and then declined by the end of August. The density of *Brassicaceae* increased over the summer in most monocultures and mixes in all treatments. This trend was seen with all treatments and most species monocultures and mixes (Tables 2.1 to 2.13).

2.4.3 Fertilizer Effect on Species

2.4.3.1 Plant Density and Survivability

The number of plants per m^2 was not consistently affected by fertilizer treatments (Tables 2.14 to 2.31). For most species, the density in the fertilized treatments did not vary significantly from the unfertilized treatments. The number of plants was low for all seeded species (0 to 11 plants 0.1 m^{-2}) except for *V. americana* in fall 1996. Plant density of individual species was not significantly different between fall 1996 and fall 1997. *V. americana* in monoculture was the exception (Tables 2.29 and 2.31). Across all fertilizer treatments, density declined from 11 to 25 plants m^{-2} in 1996 to 4 to 14 plants m^{-2} in 1997.

Some monocultures and mixes consistently had a significant difference in density from other species and mixes. Density of *S. viridula* monoculture was generally significantly lower from that of mixes of species, irrespective of fertilizer treatments. *V. americana* monoculture and *A. smithii/S. viridula/V. americana* mix were significantly higher than most other monocultures and mixes.

Survivability followed the same trends as density of the selected species (Tables 2.14 to 2.31). *S. viridula* had the lowest survivability (density) and was significantly different from *B. inermis* and *V. americana*, regardless of fertilizer treatments. For all species, there were no significant differences in survival among varying levels of fertilizer.

Fertilizer treatments generally did not significantly affect the total density of seeded species in fall 1996. For the few mixes that responded to fertilizer, 100% regular fertilizer (years 1 and 2) was usually the treatment that was significantly higher from at least one other treatment. By spring 1997, there was more variability in the density and survivability of the seeded species. The 100% regular fertilizer (years 1 and 2) treatment was significantly

lower for many of the mixes and, although the treatment it was significant from varied, it was often the 50% or 100% regular fertilizer (year 1) treatment. However, this trend did not continue into fall 1997. Although variability did exist within the monoculture and mixes, no one treatment consistently affected survival or density (Tables 2.32 to 2.34).

The most commonly occurring non-seeded species are listed in Table A.7 (Appendix A). In fall 1996, and for many of the species in spring and fall 1997, applying fertilizer did not significantly affect the density of non-seeded species (Tables 2.35 to 2.37). In spring 1997, the density of non-seeded species on some 100% slow release fertilizer treatments was significantly higher than from one or more of the other treatments, often the no fertilizer treatment. Although there was variability within species in fall 1997, in particular the *B. inermis* and non - seeded treatments, no specific treatment consistently affected all species. Generally, the density of non-seeded species was not significantly different between the monocultures and mixes.

2.4.3.2 Biomass

The amount of biomass of the selected species did not vary significantly among fertilizer treatments (Tables 2.14 to 2.31). In the few instances where there was a difference between treatments, no fertilizer treatments were often significantly different from at least one other treatment. In monocultures, the percent biomass of native species was less than the amount for introduced species. Although for many of the species in monocultures and mixes the percent biomass did not significantly differ from fall 1996 to fall 1997, there was a general increase in the proportion of biomass assigned to the seeded species. The exception to this trend was *T. hybridum*.

Biomass production of non-seeded species usually did not differ significantly among fertilizer treatments (Tables 2.35 to 2.37). A few significant differences did occur but were erratically distributed among the species treatments. Although not significantly different, the amount of biomass for non-seeded species generally decreased from fall 1996 (33 to 98%) to fall 1997 (0 to 88%).

2.4.3.3 Canopy Height

Fertilizer treatments produced only a few significant differences in the average height of plants growing within the subplots (Tables 2.38 to 2.40). Some variability in height

occurred in spring 1997, with no fertilizer treatments being significantly lower from at least one other treatment, often the treatments with 100% slow release fertilizer.

2.4.3.4 Ground Cover

There was no significant difference in percent live vegetation among the various treatments (Tables 2.41 to 2.43). The percentage was low for all species, ranging from 0 to 13%, with the mode at 1 to 2%. Applying fertilizer did not alter the percent live vegetation for any specific species or mix. In spring 1997, *T. hybridum*, *T. hybridum / V. americana* and the non - seeded species treatments had higher percentages of live vegetation than some of the other monocultures and mixes but this difference did not continue into fall 1997.

Percent litter and litter depth did not vary significantly for most species and treatments. In spring 1997, the no fertilizer treatments had significantly lower percent litter and litter depth than the 100% slow release fertilizer treatments in six of the monocultures and mixes. There was no significant difference between any treatments in the remaining monocultures and mixes.

Generally all species and mixes had similar amounts of litter and litter depth. Although not significantly different from all other species and mixes, some species consistently had different amounts of litter. In spring 1997, *P. pratense* had low percentages of litter as ground cover in comparison with other species and mixes. In fall 1997, litter percentage was higher in the *V. americana* monoculture and in the all species mix.

The variability in litter cover in spring 1997 affected the amount of bare ground. The differences that occurred in spring 1997 was generally between 100% slow release fertilizer treatment and the no fertilizer treatment. The percent bare ground did not vary significantly with fertilizer treatments in fall 1996 and 1997.

The percent bare ground was not significantly different among most species and mixes. In spring 1997, *V. americana* had one of the highest proportion of bare ground compared to other monocultures and mixes, but in fall 1997, it had the lowest percentage overall.

2.4.3.5 Canopy Cover

Generally there was no significant difference in percent live vegetation among treatments for all monocultures and mixes (Tables 2.44 to 2.46). If there was a difference in fall 1996 and spring 1997, 100% slow release fertilizer was the treatment that was significantly greater than one or more of the other treatments, usually the no fertilizer treatment. In fall 1997, the species and mixes with a difference in live vegetation usually had the no fertilizer treatment greater from at least one alternative treatment, often 50 or 100% regular fertilizer (year 1).

In 1996, there was generally no difference in the percentage of live vegetation between species. However, in spring 1997, *T. hybridum* monoculture and *T. hybridum / V. americana* mix had significantly higher percentage of live vegetation. By fall 1997, leguminous monocultures and all mixes had higher proportions of live vegetation than grass monocultures. The monocultures and mixes with only legume species had higher percentage of live vegetation and lower percent bare ground. Generally there was no significant difference in percent litter between species, regardless of fertilizer treatments.

The percent litter seldom varied significantly with fertilizer treatments. In spring and fall 1997, if a significant difference did exist, the no fertilizer treatments had less litter than at least one other treatment that, in spring, usually included 100% slow release fertilizer.

2.4.4 Fertilizer Effect on Plant Competition

2.4.4.1 Density and Survivability

Plant survivability (density) did not vary significantly between monoculture and mixes (Tables 2.47 to 2.55). By fall 1997, most of the species had higher variability in survivability (density), having higher survivability (density) in mixes than in monocultures. When seeded as monocultures or in mixes, the density of native species was significantly less than introduced species with all levels of fertilizer. However, the actual number of plants did not vary considerably between native and introduced species in monocultures. When seeded together, there was a greater difference in the number of native and introduced plants. The exception was *V. americana* that outnumbered *T. hybridum* in all treatments. By fall 1997, there was no significant difference in the density of *V. americana*

and *T. hybridum* in 50% slow release fertilizer or in the 50 and 100% regular fertilizer (year 1) treatments.

2.4.4.2 Biomass

Biomass produced by introduced species was significantly higher from biomass produced by native species under all treatments and sampling times (Tables 2.47 to 2.55). The exceptions occurred when all six species were seeded together. In the all species mix, *P. pratense* and *T. hybridum* had similar amounts of biomass production as *S. viridula* and *V. americana*, respectively.

2.4.5 Dry Weight of Above Ground Biomass

Based on the dry weight of the vegetation for each monoculture and mix, there was no significant difference among fertilizer treatments in the amount of biomass produced (Table 2.56). There were a few significant differences among species and mixes in the 50% regular (year 1) and 100% regular (years 1 and 2) fertilizer treatments.

2.5 Discussion

2.5.1 Species Survivability

The survival rate of the seeded species was less than what was anticipated. According to Munshower (1994), the emergence of grasses should be approximately 52% if germination is greater than 80%. Of the seeded species, only *V. americana* had a germination rate less than 80% but this species had one of the highest survival rates. The low survivability (density) may have been a result of seeding depth. Although 1.5 cm is considered an adequate depth for larger seeded species, such as *A. smithii*, *B. inermis* and *V. americana*, it may have been too deep for the smaller seeded species, *T. hybridum*, *S. viridula* and *P. pratense* (Munshower 1994). However, on this site, there was generally no relationship between seed size and survivability.

Data collected were representative of the number of plants of each species that had survived up until that sampling time. From seeding to fall 1996, seeds may have germinated and emerged, but subsequently died. The actual germination rate may have been higher than the survivability (density) that were measured. Individual species were not identified

during the summer but instead were classified as grass, forb, legume or a *Brassicaceae* species.

Genesee is at the northern edge of the range for *S. viridula* (Hardy BBT 1989) which may have contributed to the poor establishment rate. *S. viridula* prefers moist, fertile soils (Best et al. 1976). Although fertilizer had been applied to the treatments, nutrients may not have been available at the time of maximum growth for this species and soil conditions may not have been conducive for *S. viridula* to survive.

There were indications of nutrient deficiencies in the grasses. By the end of the second year, there were few flowering plants. The grass blades were generally a reddish-brown to purplish colour which is indicative of phosphorus and nitrogen deficiencies (Tisdale et al. 1993). The lack of organic matter may have resulted in the rapid loss of these nutrients as they are normally associated with organic matter in the soil.

The amount of available nutrients did not vary between soil tests done in spring 1996 and fall 1997. This may be the result of all available nutrients being absorbed by the plants, or nutrients may have been leached from the soil profile. However, leaching would not be expected as a major source of losing nutrients in a high clay soil. If this study is repeated at this site, the rate of absorption of the available nutrients by the plants should be followed. Different fertilizer applications should also be used as this type of soil may require even greater amounts of added nutrients to sustain a plant community.

In fall 1996, the amount of fertilizer applied to the treatments with 100% regular fertilizer (years 1 and 2) and 100% regular fertilizer (year 1) was the same. Re-application of fertilizer occurred after data were collected in spring 1997. At this time, the regular fertilizer treatments for year one and years one and two should have produced the same results. However, the 100% regular fertilizer (years 1 and 2) treatment was at the uppermost subplots for two of the four blocks. The slope of the plots was a factor as it rained shortly after the plots were seeded. The soil was high in clay and precipitation could not infiltrate the surface quickly. Runoff from the top of the slope caused erosion and some displacement of seeds, particularly in the uppermost treatments. The seeded species were moved within the subplot and were also found in adjacent subplots. In the second year, runoff did not appear to affect established growth.

Representatives of all species persisted at the end of year two across all treatments. Fertilizer application did not affect the survivability (density) of any of the species as there was no difference in survivability between fertilized and non-fertilized treatments. As the survival rate was the same between the two years, a single application of fertilizer, or lower application rates, may net the same benefits as repeat applications. This supports the results obtained by Jacobsen et al. (1996). Although statistically there was little difference between fertilizer treatments, there was a noticeable difference in the field. The plots that received fertilizer in the second year were green and more vigorous than all other fertilizer treatments.

2.5.2 Biomass

The amount of biomass produced by native species was less than the amount produced by introduced species. This was the same result Power (1980) found in his study of species of the mixed prairie. Power also found applying fertilizer increased the yield of introduced and native species, but the native species responded less. This did not occur at Genesee as none of the species used responded to fertilizer. In research done by Frank and Ries (1990), there was no difference in the amount of dry matter produced by *A. smithii* with varying rates of fertilizer. This trend was observed in the present study as dry matter did not increase significantly with higher amounts of fertilizer.

In research completed by Power (1985), all species in the study, including *B. inermis*, *A. smithii* and *S. viridula*, responded to the application of fertilizer. The amount of dry matter produced increased for all species, but the amount produced by *B. inermis* was always greater than *A. smithii* that was always greater than *S. viridula*. In studies conducted by Jacobsen et al. (1996) using varying levels of fertilizer applications, *A. smithii* produced more dry matter than *S. viridula* in the first trial, but there was no significant difference in the second trial. In the study at Genesee, the amount of biomass for *B. inermis* was greater than *A. smithii* when seeded together, and the biomass of these two species was greater than *S. viridula* when all species were seeded in the same mix.

It was expected that species that are most productive on high nutrient sites may be the least productive on low nutrient areas (Pyke and Archer 1991). However, on this site, nutrient status did not affect productivity of the species. There was no statistical difference between fertilized and non fertilized treatments for any of the species, whether they require high or low nutrient soils.

Soil parameters may have affected the growth of these species. The pH of the soil was moderately alkaline. At this pH, plant nutrients tend to become deficient (Munshower 1994). The organic matter level, at 1.8%, was very low (Munshower 1994). This may have affected the continued availability of nutrients as microorganisms are required for the immobilization/mineralization process.

2.5.3 Canopy Height

Canopy height was a measure of the average height of the species growing in the quadrat. It was not indicative of the species that had been seeded as the highest measurement was often of invasive species, particularly *Brassicaceae* species and *Matricaria perforata*. The lower height in the no fertilizer treatment in Spring 1997 indicates a lack of conditions to initiate growth but by the end of the growing season, there was little difference in height between treatments.

2.5.4 Cover

It was expected that applying fertilizer would increase the amount of live vegetation for all species but this did not occur as the percent live vegetation did not vary significantly among treatments. The early growth of *T. hybridum* in spring increased the amount of live vegetation on those treatments. Leguminous species produced more live vegetation than the grass species. This may be the result of their ability to fix nitrogen which would indicate inadequate amounts of available nutrients even on the fertilized treatments.

The difference in percent bare ground in spring 1997 was a result of the number of non-seeded species that emerged. There were higher emergence rates in the 100% slow release fertilizer treatment. Many seedlings started to grow in the spring 1997, but by fall 1997, the number had declined. This result is indicative of r-selected species that produce large numbers of seeds to increase the chance of continued existence.

Litter depth was not affected by fertilizer treatment nor plant species. As the amount of biomass produced by the species was generally low, minimal amounts of litter was produced. Leaves and seed pods from *Brassicaceae* species increased the percentage of litter on many of the treatments.

2.5.5 Competition Effects

Native plant species were expected to have higher survivability (density) than the introduced species on the low nutrient soils. This did not occur as introduced species had significantly higher survivability (density) over all treatments, both in monocultures and in mixes. Other researchers have found *A. smithii* requires a longer growing period when in a mixed plant community than when in a monoculture (Frank et al. 1985 as cited in Frank and Hofmann 1989). It was hypothesized these differences were a result of interspecific competition. Although *A. smithii* did not survive well in the all species mix, survivability (density) was highest in all treatments when seeded with other native plant species. The presence of the legume *V. americana*, may have increased the availability of nitrogen.

The length of dormancy varies with the species but generally, seeds of native species require longer periods before germination. Introduced species have been selected for their high germination rates and rapid emergence (Kerr et al. 1993).

2.5.6 Biomass

Because of the different growth forms of the selected species, it is difficult to compare biomass produced between native and introduced species. Generally, the introduced species have larger blades or leaves and would be expected to have higher amounts of biomass produced per plant. *P. pratense* and *S. viridula* had similar amounts of biomass because neither species had high survivability (density) or biomass production.

2.6 Conclusions

1. Applying fertilizer to increase nutrient levels did not affect the survivability (density) of the six selected native and introduced plant species.

2. Native and introduced species had similar survivability (density) and biomass production on fertilized and no fertilizer treatments. *S. viridula* did not survive well with any treatment.

3. Plant survivability (density) and biomass production was the same with slow release and regular fertilizer. Assessing the health of the plants visually, there was an improvement in plant colour and lushness for the selected native and introduced plant

species when fertilizer was applied two years in a row, indicating the recommended fertilizer rates provided inadequate nutrient levels.

4. Survivability (density) was generally the same for native and introduced species in monocultures and mixes, indicating competition effects were negligible.

5. Biomass production was higher for the introduced species than the native species.

2.7 References

Alberta Environmental Protection. 1995. Reclamation criteria for wellsites and associated facilities. 1995 Update. 62 pp.

Alsands Project Group. 1978. Environmental impact assessment presented to Alberta Environment in support of an oil sands mining project. Calgary, AB.

Ashworth, J. and K. Mrazek. 1995. "Modified Kelowna" test for available phosphorus and potassium. Communications in Soil Science and Plant Analysis 26:731-739.

Berg, W.A. 1974. Grasses and legumes for revegetation of disturbed subalpine areas. Pp. 31-35 In: W.A. Berg, J.A. Brown and R.L. Cuany, eds. Proceedings of a workshop on revegetation of high-altitude disturbed lands. Colorado State University. Information Series No. 10.

Best, K.F., J. Looman and J.B. Campbell. 1976. Prairie grasses identified and described by vegetative characters. Supply and Services Canada. Ottawa, ON. 237 pp.

Black, C.A. 1965a. Methods of soil analysis: physical and mineralogical properties, including statistics of measurement and sampling. Agronomy part 1. American Society of Agronomy. Madison, WI. Pp. 1-770.

Black, C.A. 1965b. Methods of soil analysis: Chemical and microbiological properties. Agronomy part 2. American Society of Agronomy. Madison, WI. Pp. 771-1572.

Buckerfield's Ltd. 1980. Seeds for revegetating disturbed land: descriptive manual. Buckerfield's Seed Division. Vancouver, BC

Dodd, J.L. and W.K. Lauenroth. 1979. Analysis of the response of a grassland ecosystem to stress. In: Perspectives in grassland ecology, N. French, ed. Springer. New York, NY. Pp. 43-59.

Elliot, C.R. and J.L. Boton. 1970. Licensed varieties of cultivated grasses and legumes. Canada Department of Agriculture, Publication No. 1405. Ottawa, ON.

Environment Canada. n.d. Canadian climate normals 1961 - 1990 prairie provinces. Environment Canada Atmospheric Environment Services.

Farmer, E.E. and W.G. Blue. 1978. Reclamation of lands mined for phosphate. Pp. 585-608. In: Reclamation of drastically disturbed lands. F.W. Schaller and P. Sutton, eds. American Society of Agronomy, Crop Science Society of America, Soil Science Society of America. Madison, WI.

Frank, A.B. and L. Hofmann. 1989. Relationship among grazing management, growing degree-days, and morphological development for native grasses on the Northern Great Plains. Journal of Range Management 42:199-202.

Frank, A.B., J.D. Berdahl and R.E. Barker. 1985. Morphological development and water use in clonal lines of four forage grasses. Crop Science 25:339-344.

Frank, A.B. and R.E. Ries. 1990. Effect of soil water, nitrogen, and growing degree-days on morphological development of crested and western wheatgrass. Journal of Range Management 43:257-260.

Gerling, H.S., M.G. Willoughby, A. Schoepf, K.E. Tannas and C.A. Tannas. 1996. A guide to using native plants on disturbed lands. Alberta Agriculture, Food and Rural Development and Alberta Environmental Protection. Edmonton, AB. 247 pp.

Grime, J.P. 1977. Evidence for the existence of three primary strategies in plants and its relevance to ecological and evolutionary theory. American Naturalist 111:1169-1194.

Hafenrichter, A. L., J.L. Schwendiman, H.L. Harris, R.S. MacLauchlan and H.W. Miller. 1968. Grasses and legumes for soil conservation in the Pacific Northwest and Great Basin States. USDA Soil Conservation Service, Agricultural Handbook No. 339.

Hardy BBT Limited. 1989. Manual of plant species suitability for reclamation in Alberta-2nd edition. Alberta Land Conservation and Reclamation Council Report No. RRTAC 89-4. Edmonton, AB. 436 pp.

Heady, H.F. 1975. Range management. McGraw-Hill Publishing Co. New York, NY.

Hitchcock, A.S. 1971. Manual of the grasses of the United States. 2nd edition revised by A. Chase. Dover Publications, Inc. New York, NY.

Jacobsen, J.S., S.H. Lorbeer, H.A.R. Houlton and G.R. Carlson. 1996. Nitrogen fertilization of dryland grasses in the Northern Great Plains. Journal of Range Management 49:340-345.

Jones, J.N. Jr., W.H. Armiger and O.L. Bennett. 1975. Forage grasses aid transition from spoil to soil. Pages 185-194 In: Proceedings of the third symposium on surface mining and reclamation, Volume II. NCA/BCR Coal Conference and Expo II. National Coal Association. Washington, D.C.

Kerr, D.S., L.J. Morrison and K.E. Wilkinson. 1993. Reclamation of native grasslands in Alberta: A review of the literature. Alberta Land Conservation and Reclamation Council Report No. RRTAC 93-1. Queen's Printer. Edmonton, AB. 231 pp.

LeRoy, J. and H. Keller. 1972. How to reclaim mined areas, tailings ponds, and dumps into valuable land. World Mining, January 1972:34-41.

Looman, J. and K.F. Best. 1981. Budd's flora of the Canadian Prairie Provinces. Canadian Government Publishing Centre Supply and Services Canada. Hull, PQ. 863 pp.

McKeague, J.A. 1976. Manual on soil sampling and methods of analysis. Canadian Society of Soil Science. Ottawa, ON.

Moss, E.H. 1992. Flora of Alberta, 2nd edition. Revised by J.G. Packer. University of Toronto Press. Toronto, ON. 687 pp.

Munshower, F.F. 1994. Practical handbook of disturbed land revegetation. Lewis Publishers. Boca Raton, FL. 265 pp.

Nyborg, M., E.D. Solberg, R.C. Izaurralde, S.S. Malhi and M. Moline-Ayala. 1995. Influence of long-term tillage, straw and N-fertilizer on barley yield, plant-N uptake and soil-N balance. Soil and Tillage Research 36:165-174.

Parker, I.M., S.K. Mertens and D.W. Schemske. 1993. Distribution of seven native and two exotic plants in a tallgrass prairie in southeastern Wisconsin: The importance of human disturbance. American Midland Naturalist 130:43-55.

Pelech, W.E. 1997. Performance of selected native and introduced plant species under mowing and herbicide management during the establishment period. MSc. Thesis, Department of Renewable Resources, University of Alberta. Edmonton, AB. 105 pp.

Plummer, A.P. 1977. Revegetation of disturbed intermountain area sites. Pp. 302-339. In: J.L. Thomas, ed. Reclamation and use of disturbed land in the southwest. The University of Arizona Press. Tucson, AZ.

Power, J.F. 1980. Response of semi-arid grassland sites to nitrogen fertilizer: I. Plant growth and water use. Soil Science Society of America Journal 44:544-550.

Power, J.F. 1985. Nitrogen- and water-use efficiency of several cool-season grasses receiving ammonium nitrate for 9 years. Agronomy Journal 77:189-192.
Pyke, D.A. and S. Archer. 1991. Plant-plant interactions affecting plant establishment and persistence on revegetated rangeland. Journal of Range Management 44:550-557.
Russell Ecological Consultants. 1986. Reclamation with native grasses in Alberta: field trial results. Alberta Forestry, Lands and Wildlife. Edmonton, AB. 57 pp.
Simons, R.G., C.A. Grant and L.D. Bailey. 1995. Effect of fertilizer placement on yield of established alfalfa stands. Canadian Journal of Plant Science 75:883-887.
Skousen, J. 1988. Species for revegetation: legumes. Green Lands 17(4):35-39.
Strong, W.L. and K.R. Leggat. 1992. Ecoregions of Alberta. Alberta Forestry, Lands and Wildlife. Edmonton, AB. 59 pp. plus map.
Takyi, S.K. 1984. Role of topsoil, fertilizers and companion crops in revegetation of two severe sites in the Alberta foothills and mountains. Alberta Energy and Natural Resources. Edmonton, AB. 29 pp.
Takyi, S.K. and R.M. Islam. 1984. Performance of native grasses and cultivated legumes and grasses on disturbances in the eastern slopes of the Rockies. Alberta Energy and Natural Resources. Edmonton, AB. 30 pp.
Tisdale, S.L., W.L. Nelson, J.D. Beaton and J.L. Havlin. 1993. Soil fertility and fertilizers. Macmillan Publishing Company. New York, NY. 434 pp.
USDA Soil Conservation Service. 1976. Standards and specifications: critical area planting. Technical Guide, Section IV. Denver, CO.
Vaartnou, M. 1979. Table 6 from unpublished M.Sc. thesis (Yukon pipeline plot studies). University of British Columbia. Vancouver, BC.
Vories, K.C. and P.L. Sims. 1977. The plant information network volume III: reclamation and PIN in the Powder River basin of Montana and Wyoming. U.S. Department of the Interior, Fish and Wildlife Service. Office of Biological Services, Report No. FWS/OBS-77/40.
Walker, D. and J. Weijer. 1975. The collection, maintenance and utilization of native grasses of the eastern slopes of the Rocky Mountains. Prepared for Department of Recreation, Parks and Wildlife, Division of Fish and Wildlife and the Department of Energy and Natural Resources, Division of Forestry. Department of Genetics, University of Alberta. Edmonton, AB.
Wark, D.B., W.R. Poole, R.G. Arnott, L.R. Moats and L. Wetter. n.d. Revegetating with native grasses. Ducks Unlimited Canada. 133 pp.
Weaver, J.E. 1942. Competition of western wheat grass with relict vegetation of prairie. American Journal of Botany 29:366-372.
Whitby-Costescu, L., J. Schillabeer and D.F. Coates. 1977. Pit slope manual, chapter 10: environmental planning. Canada Centre for Mineral and Energy Technology, Energy Mines and Resources, CANMET Report 77-2.

Table 2.1 Plant height and density of *Agropyron smithii* monoculture at Genesee during summer 1996

Species Mix	Height (cm)		Density (plants / 0.1 m^2)							
			Forbs		Grasses		Legumes		*Brassicaceae* sp.	
Treatment	Mean	S.D.	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.
50% slow fertilizer										
July 02	-	-	3	4	1	2	0	0	-	-
July 23	5.9	2.3	5	4	6	5	0	0	-	-
July 30	9.0	1.6	6	4	6	3	0	0	0	0
August 12	11.2	2.0	5	3	6	6	0	0	0	0
August 27	11.6	4.0	4	2	6	6	0	0	0	1
100% slow fertilizer										
July 02	-	-	2	3	0	1	0	0	-	-
July 23	6.2	1.4	6	4	5	3	0	0	-	-
July 30	10.0	4.5	7	5	6	4	0	0	0	0
August 12	10.2	4.5	6	3	7	7	0	0	0	0
August 27	13.2	4.7	4	2	6	4	0	0	1	1
50% regular fertilizer (yr 1)										
July 02	-	-	3	3	1	1	0	0	-	-
July 23	7.0	1.8	6	6	10	9	0	0	-	-
July 30	7.8	2.3	6	3	10	8	0	1	0	1
August 12	11.5	2.7	4	3	8	5	0	0	0	1
August 27	11.1	4.3	3	3	6	4	0	0	1	1
100% regular fertilizer (yr 1)										
July 02	-	-	5	4	1	1	0	0	-	-
July 23	7.8	3.3	7	3	5	5	0	0	-	-
July 30	11.5	2.6	6	4	10	8	0	0	0	0
August 12	12.2	2.6	5	2	8	6	0	0	0	1
August 27	12.4	6.0	4	3	6	7	0	0	0	1
50% regular fertilizer (yr 1 and 2)										
July 02	-	-	4	3	1	2	0	0	-	-
July 23	6.7	1.9	7	5	7	4	0	0	-	-
July 30	7.5	3.0	8	5	6	3	0	0	1	1
August 12	9.6	2.2	6	3	8	4	0	0	1	2
August 27	12.4	2.8	5	2	6	2	0	0	1	2
100% regular fertilizer (yr 1 and 2)										
July 02	-	-	3	2	1	2	0	0	-	-
July 23	7.6	1.8	4	3	7	6	0	0	-	-
July 30	7.4	4.6	8	4	5	6	0	0	0	0
August 12	9.0	6.0	6	3	5	6	0	0	0	1
August 27	11.7	4.2	4	2	3	2	0	0	1	1
No fertilizer										
July 02	-	-	3	4	0	1	0	0	-	-
July 23	6.6	2.2	5	4	6	4	0	0	-	-
July 30	7.8	1.9	4	3	8	4	0	0	0	1
August 12	9.7	4.0	5	5	6	4	0	0	0	1
August 27	10.7	4.3	3	2	4	3	0	0	1	1

S. D. = Standard Deviation

Table 2.2 Plant height and density of *Bromus inermis* monoculture at Genesee during summer 1996

Species Mix	Height (cm)		Density (plants / 0.1 m^2)							
			Forbs		Grasses		Legumes		*Brassicaceae* sp.	
Treatment	Mean	S.D.	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.
50% slow fertilizer										
July 02	-	-	3	2	17	11	0	0	-	-
July 23	8.9	1.3	3	2	15	7	0	0	-	-
July 30	10.1	3.4	6	3	13	9	0	0	0	1
August 12	13.2	2.5	4	2	14	10	0	0	1	1
August 27	14.9	2.2	2	1	11	8	0	0	1	1
100% slow fertilizer										
July 02	-	-	2	2	10	8	0	0	-	-
July 23	9.5	2.2	4	2	12	7	0	0	-	-
July 30	10.7	3.7	5	2	12	10	0	0	0	1
August 12	13.8	2.0	4	2	11	6	0	0	1	1
August 27	17.9	3.7	2	1	8	4	0	0	2	1
50% regular fertilizer (yr 1)										
July 02	-	-	4	3	12	8	0	0	-	-
July 23	9.6	2.6	5	3	10	5	0	0	-	-
July 30	11.6	2.2	5	2	14	5	0	0	2	2
August 12	12.2	2.4	4	3	10	5	0	0	1	2
August 27	13.0	2.5	2	2	10	5	0	0	2	1
100% regular fertilizer (yr 1)										
July 02	-	-	4	2	18	10	0	0	-	-
July 23	10.5	1.3	5	2	13	6	0	1	-	-
July 30	11.6	3.1	6	4	13	8	0	0	1	1
August 12	14.1	4.0	4	2	10	4	0	0	0	1
August 27	15.2	4.3	2	2	12	8	0	0	2	2
50% regular fertilizer (yr 1 and 2)										
July 02	-	-	3	3	13	6	0	0	-	-
July 23	9.1	2.3	3	2	11	4	0	0	-	-
July 30	9.5	2.7	3	2	12	8	0	0	2	3
August 12	11.6	2.6	4	2	11	6	0	1	1	1
August 27	13.9	3.2	3	2	11	5	0	0	1	1
100% regular fertilizer (yr 1 and 2)										
July 02	-	-	2	2	10	13	0	0	-	-
July 23	8.8	2.5	4	3	7	11	0	0	-	-
July 30	8.3	5.4	5	4	10	11	0	0	0	1
August 12	11.2	7.3	5	3	6	6	0	0	1	2
August 27	13.2	6.7	3	2	6	7	0	0	1	1
No fertilizer										
July 02	-	-	3	2	14	10	0	0	-	-
July 23	7.8	2.0	2	3	12	7	0	0	-	-
July 30	8.5	1.7	3	3	13	7	0	0	1	2
August 12	9.4	3.4	4	3	9	4	0	0	1	1
August 27	9.7	3.2	3	2	8	5	0	0	2	2

S. D. = Standard Deviation

Table 2.3 Plant height and density of *Phleum pratense* monoculture at Genesee during summer 1996

Species Mix	Height (cm)		Density (plants / 0.1 m²)							
			Forbs		Grasses		Legumes		*Brassicaceae* sp.	
Treatment	Mean	S.D.	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.
50% slow fertilizer										
July 02	-	-	2	2	3	4	0	0	-	-
July 23	3.8	2.5	4	4	4	6	0	0	-	-
July 30	6.1	3.1	5	5	4	4	0	1	0	0
August 12	7.9	3.5	3	2	4	4	0	0	0	0
August 27	7.3	7.2	3	3	1	2	0	0	1	1
100% slow fertilizer										
July 02	-	-	3	2	2	3	0	0	-	-
July 23	4.6	2.5	6	6	3	3	0	0	-	-
July 30	5.5	4.3	7	6	3	3	0	0	0	0
August 12	3.9	4.9	6	3	3	3	0	0	0	0
August 27	13.4	4.8	5	3	3	2	0	0	2	2
50% regular fertilizer (yr 1)										
July 02	-	-	4	6	2	3	0	0	-	-
July 23	4.2	2.2	7	6	4	4	0	0	-	-
July 30	6.7	3.0	6	5	5	4	0	0	0	1
August 12	7.8	5.5	4	3	4	4	0	0	0	0
August 27	10.1	5.3	3	2	5	4	0	1	1	1
100% regular fertilizer (yr 1)										
July 02	-	-	3	3	2	3	0	0	-	-
July 23	5.6	2.1	5	3	9	9	0	0	-	-
July 30	8.5	2.9	5	3	6	5	0	0	0	1
August 12	10.1	5.0	4	2	5	4	0	0	0	1
August 27	13.4	5.3	4	1	4	3	0	1	1	1
50% regular fertilizer (yr 1 and 2)										
July 02	-	-	3	4	2	2	0	0	-	-
July 23	5.0	1.9	6	4	6	4	0	0	-	-
July 30	7.7	1.9	6	5	6	5	0	0	1	2
August 12	7.5	4.8	4	3	5	3	0	0	1	2
August 27	9.7	4.6	4	2	3	2	0	0	2	2
100% regular fertilizer (yr 1 and 2)										
July 02	-	-	2	2	1	3	0	0	-	-
July 23	4.9	2.5	6	4	5	6	0	0	-	-
July 30	6.2	4.5	5	3	5	7	0	0	0	0
August 12	7.5	5.7	4	2	4	5	0	0	0	1
August 27	10.2	7.3	4	2	3	4	0	0	1	1
No fertilizer										
July 02	-	-	2	2	3	4	0	0	-	-
July 23	4.0	1.5	3	2	5	5	0	0	-	-
July 30	4.8	2.4	4	3	4	4	0	0	1	1
August 12	6.8	5.6	4	2	5	5	0	0	0	1
August 27	10.6	6.8	4	3	4	4	0	0	1	2

S. D. = Standard Deviation

Table 2.4 Plant height and density of *Stipa viridula* monoculture at Genesee during summer 1996

Species Mix	Height (cm)		Density (plants / 0.1 m²)							
			Forbs		Grasses		Legumes		*Brassicaceae* sp.	
Treatment	Mean	S.D.	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.
50% slow fertilizer										
July 02	-	-	4	3	0	0	0	0	-	-
July 23	4.8	2.6	6	3	2	2	0	0	-	-
July 30	8.9	4.5	7	5	2	2	0	0	0	1
August 12	8.9	5.7	5	2	2	2	0	0	1	1
August 27	11.2	7.0	3	2	2	1	0	0	1	1
100% slow fertilizer										
July 02	-	-	3	3	0	0	0	0	-	-
July 23	5.3	2.6	6	2	2	1	0	0	-	-
July 30	5.1	4.2	6	3	2	3	0	0	0	1
August 12	10.4	6.3	5	4	3	2	0	0	1	1
August 27	10.8	7.2	4	3	1	1	0	0	1	1
50% regular fertilizer (yr 1)										
July 02	-	-	8	6	0	0	0	0	-	-
July 23	2.9	2.6	8	4	1	2	0	0	-	-
July 30	6.5	3.0	8	3	3	2	0	0	0	1
August 12	7.9	5.4	6	2	2	2	0	0	0	1
August 27	13.0	3.9	6	3	2	1	0	0	1	1
100% regular fertilizer (yr 1)										
July 02	-	-	2	2	0	0	0	0	-	-
July 23	3.2	2.8	4	2	2	2	0	0	-	-
July 30	4.6	5.5	5	4	2	3	0	0	1	1
August 12	6.3	5.9	4	2	1	2	0	0	1	1
August 27	9.5	7.8	4	2	2	2	0	0	2	2
50% regular fertilizer (yr 1 and 2)										
July 02	-	-	2	2	0	1	0	0	-	-
July 23	5.0	3.8	5	3	2	2	0	0	-	-
July 30	5.2	3.3	5	4		2	0	0	1	1
August 12	10.2	3.9	6	4	2	2	0	0	1	1
August 27	13.5	7.0	4	2	2	2	0	0	1	1
100% regular fertilizer (yr 1 and 2)										
July 02	-	-	4	4	0	1	0	0	-	-
July 23	5.3	4.3	3	2	2	3	0	0	-	-
July 30	7.8	6.1	5	3	2	3	0	1	0	0
August 12	8.6	8.6	5	4	2	3	0	0	0	1
August 27	9.6	8.2	3	2	1	2	0	0	1	2
No fertilizer										
July 02	-	-	3	3	0	0	0	0	-	-
July 23	3.2	2.9	4	2	1	1	0	0	-	-
July 30	3.8	3.6	4	2	1	1	0	0	0	1
August 12	7.3	4.8	3	1	2	2	0	0	1	1
August 27	10.2	8.1	3	2	2	2	0	0	1	1

S. D. = Standard Deviation

Table 2.5 Plant height and density of *Trifolium hybridum* monoculture at Genesee during summer 1996

Species Mix	Height (cm)		Density (plants / 0.1 m^2)							
			Forbs		Grasses		Legumes		*Brassicaceae* sp.	
Treatment	Mean	S.D.	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.
50% slow fertilizer										
July 02	-	-	13	8	0	1	0	0	-	-
July 23	2.0	2.2	4	2	0	0	4	6	-	-
July 30	3.2	1.9	3	2	0	0	7	7	0	1
August 12	7.3	1.4	3	2	0	1	4	5	0	1
August 27	10.1	3.9	2	1	1	1	5	2	2	1
100% slow fertilizer										
July 02	-	-	5	4	0	0	0	0	-	-
July 23	2.6	2.8	5	4	0	1	2	2	-	-
July 30	3.1	1.8	5	3	0	0	3	3	1	2
August 12	3.9	4.1	4	3	0	1	1	3	1	1
August 27	8.9	6.2	2	2	0	0	2	2	2	2
50% regular fertilizer (yr 1)										
July 02	-	-	9	5	0	0	0	0	-	-
July 23	2.1	0.6	6	4	0	1	6	4	-	-
July 30	4.0	1.0	7	3	1	1	6	4	0	0
August 12	8.5	2.1	6	3	0	1	2	2	0	1
August 27	10.2	3.4	2	1	1	1	4	2	1	2
100% regular fertilizer (yr 1)										
July 02	-	-	10	9	0	0	0	0	-	-
July 23	2.6	2.8	6	4	0	1	4	4	-	-
July 30	4.8	2.9	7	6	0	1	5	3	0	1
August 12	8.9	5.0	5	4	0	0	4	6	1	1
August 27	9.6	3.4	3	1	1	1	3	3	3	4
50% regular fertilizer (yr 1 and 2)										
July 02	-	-	5	4	0	0	0	0	-	-
July 23	2.0	1.1	4	3	0	0	6	5	-	-
July 30	2.6	1.1	5	4	0	0	5	4	1	1
August 12	6.1	2.7	4	3	0	0	3	3	1	1
August 27	8.0	3.3	3	3	0	1	4	2	1	1
100% regular fertilizer (yr 1 and 2)										
July 02	-	-	8	7	0	0	0	0	-	-
July 23	1.4	0.8	4	3	0	0	2	3	-	-
July 30	2.9	2.0	4	2	0	0	3	3	0	1
August 12	6.2	3.5	4	2	0	1	2	2	1	1
August 27	9.8	4.8	3	2	0	1	2	2	1	1
No fertilizer										
July 02	-	-	10	8	0	1	0	0	-	-
July 23	1.6	1.3	3	2	0	0	6	6	-	-
July 30	2.9	1.5	5	2	0	0	6	5	0	1
August 12	4.9	2.2	4	1	0	0	2	2	1	1
August 27	11.8	16.0	3	1	0	0	4	3	1	1

S. D. = Standard Deviation

Table 2.6 Plant height and density of *Vicia americana* monoculture at Genesee during summer 1996

Species Mix	Height (cm)		Density (plants / 0.1 m^2)							
			Forbs		Grasses		Legumes		*Brassicaceae* sp.	
Treatment	Mean	S.D.	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.
50% slow fertilizer										
July 02	-	-	4	4	0	0	1	1	-	-
July 23	4.6	1.5	3	2	0	0	15	8	-	-
July 30	5.0	1.3	4	2	0	0	22	12	1	1
August 12	4.9	1.1	3	2	0	0	14	8	1	1
August 27	6.8	2.7	4	2	0	0	18	9	1	1
100% slow fertilizer										
July 02	-	-	3	2	0	0	3	4	-	-
July 23	3.8	1.7	4	3	0	0	11	8	-	-
July 30	4.4	1.6	4	4	0	0	14	8	1	1
August 12	4.2	2.1	3	2	0	0	10	8	1	1
August 27	7.3	2.7	2	2	0	0	13	8	2	1
50% regular fertilizer (yr 1)										
July 02	-	-	6	4	0	0	2	3	-	-
July 23	3.8	0.5	7	8	0	0	16	8	-	-
July 30	4.5	1.2	6	6	0	0	18	5	0	0
August 12	4.9	1.9	4	4	0	0	12	7	2	2
August 27	6.0	1.8	4	3	0	0	16	8	1	2
100% regular fertilizer (yr 1)										
July 02	-	-	5	5	0	0	1	1	-	-
July 23	4.3	1.0	4	3	0	1	16	11	-	-
July 30	4.8	1.2	4	3	0	0	18	8	0	1
August 12	5.7	1.1	5	3	0	0	14	6	0	0
August 27	5.4	1.7	2	2	0	0	15	7	1	1
50% regular fertilizer (yr 1 and 2)										
July 02	-	-	4	2	0	0	1	1	-	-
July 23	4.7	1.2	5	4	0	0	14	10	-	-
July 30	4.7	1.3	5	4	0	0	20	9	0	1
August 12	5.5	0.8	4	2	0	0	13	6	1	1
August 27	6.9	2.8	3	2	0	0	14	7	1	1
100% regular fertilizer (yr 1 and 2)										
July 02	-	-	5	4	0	0	1	3	-	-
July 23	3.7	2.5	5	3	0	0	10	10	-	-
July 30	4.4	2.7	4	4	0	0	13	12	0	0
August 12	4.8	2.8	3	2	0	0	11	9	1	1
August 27	4.1	2.1	3	2	0	0	13	12	2	2
No fertilizer										
July 02	-	-	4	3	0	1	1	3	-	-
July 23	4.7	1.1	2	2	0	1	18	11	-	-
July 30	4.8	1.5	3	2	0	0	20	13	1	1
August 12	5.7	2.2	2	2	0	0	14	12	1	1
August 27	5.9	2.5	2	2	0	0	17	10	2	2

S. D. = Standard Deviation

Table 2.7 Plant height and density of *Agropyron smithii / Bromus inermis* mix at Genesee during summer 1996

Species Mix	Height (cm)		Density (plants / 0.1 m^2)							
			Forbs		Grasses		Legumes		*Brassicaceae* sp.	
Treatment	Mean	S.D.	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.
50% slow fertilizer										
July 02	-	-	4	4	6	5	0	0	-	-
July 23	8.5	2.6	5	3	8	5	0	0	-	-
July 30	10.2	2.2	6	8	11	6	0	0	0	1
August 12	12.8	3.0	4	4	8	5	0	0	1	1
August 27	14.8	3.1	4	2	6	4	0	0	1	2
100% slow fertilizer										
July 02	-	-	2	3	4	4	0	0	-	-
July 23	9.4	1.5	5	6	8	4	0	0	-	-
July 30	11.2	3.1	5	4	10	7	0	0	0	0
August 12	15.3	2.8	4	4	7	5	0	0	0	1
August 27	15.8	3.5	3	2	7	4	0	0	1	1
50% regular fertilizer (yr 1)										
July 02	-	-	4	6	10	9	0	0	-	-
July 23	8.4	1.8	7	9	11	6	0	0	-	-
July 30	11.7	2.7	7	6	10	4	0	0	0	0
August 12	12.0	2.2	5	5	9	4	0	0	0	1
August 27	12.4	2.8	3	4	7	3	0	0	1	2
100% regular fertilizer (yr 1)										
July 02	-	-	4	4	11	8	0	0	-	-
July 23	9.2	2.5	5	4	11	5	0	0	-	-
July 30	12.2	3.2	7	6	11	3	0	0	0	1
August 12	15.1	4.2	4	4	8	7	0	0	1	2
August 27	15.0	2.3	3	3	9	4	0	0	1	1
50% regular fertilizer (yr 1 and 2)										
July 02	-	-	3	2	6	4	0	0	-	-
July 23	8.0	1.7	4	3	11	4	0	0	-	-
July 30	11.7	3.8	4	4	9	4	0	0	0	1
August 12	12.4	2.9	5	4	9	5	0	0	1	1
August 27	14.1	3.1	2	1	10	7	0	0	1	2
100% regular fertilizer (yr 1 and 2)										
July 02	-	-	3	2	3	4	0	0	-	-
July 23	6.9	4.7	5	2	6	6	0	0	-	-
July 30	9.2	4.7	5	2	5	5	0	0	0	0
August 12	8.5	6.0	4	3	4	5	0	0	0	0
August 27	11.6	6.5	3	2	5	5	0	0	1	1
No fertilizer										
July 02	-	-	2	2	6	7	0	0	-	-
July 23	6.9	1.8	4	4	6	6	0	0	-	-
July 30	8.8	2.6	5	4	7	6	0	1	0	0
August 12	10.9	3.6	4	3	6	4	0	0	1	2
August 27	13.4	5.6	4	2	5	3	0	0	0	1

S. D. = Standard Deviation

Table 2.8 Plant height and density of *Phleum pratense / Stipa viridula* mix at Genesee during summer 1996

Species Mix	Height (cm)		Density (plants / 0.1 m^2)							
			Forbs		Grasses		Legumes		*Brassicaceae* sp.	
Treatment	Mean	S.D.	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.
50% slow fertilizer										
July 02	-	-	4	4	1	1	0	0	-	-
July 23	5.2	3.4	6	3	4	4	0	0	-	-
July 30	5.8	3.4	7	4	3	2	0	0	0	1
August 12	8.9	3.2	5	4	4	4	0	0	0	0
August 27	8.8	5.8	4	2	2	2	0	0	0	0
100% slow fertilizer										
July 02	-	-	3	3	0	1	0	0	-	-
July 23	4.3	2.0	6	5	3	3	0	0	-	-
July 30	7.5	4.4	6	5	3	5	0	0	0	1
August 12	9.3	5.4	6	4	4	4	0	0	0	1
August 27	12.8	1.5	4	2	3	2	0	0	1	1
50% regular fertilizer (yr 1)										
July 02	-	-	3	3	1	2	0	0	-	-
July 23	4.8	2.4	6	4	4	3	0	0	-	-
July 30	6.2	2.1	7	4	5	4	0	0	0	0
August 12	7.1	5.4	5	3	5	4	0	0	0	0
August 27	8.7	5.6	5	3	3	3	0	0	1	1
100% regular fertilizer (yr 1)										
July 02	-	-	3	3	2	2	0	0	-	-
July 23	5.7	2.1	6	3	4	4	0	0	-	-
July 30	7.7	3.0	6	3	4	3	0	0	0	1
August 12	9.3	5.6	5	3	4	3	0	0	0	0
August 27	11.1	4.3	4	2	4	2	0	0	1	1
50% regular fertilizer (yr 1 and 2)										
July 02	-	-	2	1	2	2	0	0	-	-
July 23	4.6	3.1	6	3	3	3	0	0	-	-
July 30	7.0	1.7	5	2	3	2	0	0	0	1
August 12	8.6	4.4	5	2	4	2	0	0	0	0
August 27	10.1	5.1	4	2	2	2	0	1	1	1
100% regular fertilizer (yr 1 and 2)										
July 02	-	-	2	2	1	2	0	0	-	-
July 23	3.8	2.8	4	4	3	4	0	1	-	-
July 30	4.2	3.9	6	4	2	3	0	0	0	0
August 12	7.4	8.1	4	2	2	2	0	0	0	0
August 27	6.3	6.9	4	2	1	1	0	1	1	1
No fertilizer										
July 02	-	-	1	2	0	1	0	0	-	-
July 23	3.4	2.2	6	6	2	2	0	0	-	-
July 30	5.9	2.5	5	4	4	3	0	0	0	1
August 12	6.9	3.7	5	4	3	3	0	0	0	0
August 27	9.0	3.6	4	3	4	2	0	0	0	1

S. D. = Standard Deviation

Table 2.9 Plant height and density of *Trifolium hybridum / Vicia americana* mix at Genesee during summer 1996

Species Mix	Height (cm)		Density (plants / 0.1 m^2)							
			Forbs		Grasses		Legumes		*Brassicaceae* sp.	
Treatment	Mean	S.D.	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.
50% slow fertilizer										
July 02	-	-	6	5	0	1	1	2	-	-
July 23	4.2	1.0	4	4	0	1	12	5	-	-
July 30	4.1	1.2	3	2	0	0	15	5	1	1
August 12	6.0	1.5	4	3	0	0	12	9	1	1
August 27	7.4	2.3	2	1	0	0	9	5	1	1
100% slow fertilizer										
July 02	-	-	4	4	0	0	0	0	-	-
July 23	3.5	1.6	5	3	0	0	6	4	-	-
July 30	4.2	1.3	4	2	0	0	10	4	0	1
August 12	6.4	2.0	4	2	0	0	10	8	0	1
August 27	8.4	4.3	3	2	0	0	7	4	1	1
50% regular fertilizer (yr 1)										
July 02	-	-	6	4	0	0	1	1	-	-
July 23	3.8	0.9	4	2	0	0	11	9	-	-
July 30	4.2	1.9	4	3	0	0	13	9	0	0
August 12	6.2	1.8	3	2	0	0	11	9	0	0
August 27	8.0	1.8	3	2	0	0	10	4	1	1
100% regular fertilizer (yr 1)										
July 02	-	-	5	4	0	0	1	1	-	-
July 23	4.2	0.6	6	4	0	1	10	5	-	-
July 30	4.5	0.9	6	4	0	0	13	4	0	1
August 12	6.4	2.7	3	2	0	0	10	6	0	0
August 27	7.8	2.8	2	2	0	0	10	3	1	1
50% regular fertilizer (yr 1 and 2)										
July 02	-	-	6	5	0	0	0	1	-	-
July 23	4.0	0.9	5	3	0	0	11	6	-	-
July 30	4.6	2.1	4	2	0	0	13	7	0	1
August 12	5.8	2.1	4	2	0	0	9	4	0	1
August 27	7.5	4.7	3	1	0	0	13	5	2	2
100% regular fertilizer (yr 1 and 2)										
July 02	-	-	5	3	0	0	1	2	-	-
July 23	3.6	1.3	5	5	0	0	8	9	-	-
July 30	4.0	2.6	3	3	0	0	8	9	0	1
August 12	6.0	3.2	4	2	0	1	8	8	1	1
August 27	7.2	4.1	2	2	0	0	6	6	1	2
No fertilizer										
July 02	-	-	7	7	0	0	1	2	-	-
July 23	4.1	1.1	3	1	0	0	13	10	-	-
July 30	3.8	0.8	4	2	0	0	12	8	1	1
August 12	6.2	2.3	2	1	0	0	12	8	1	1
August 27	6.9	2.8	2	1	0	0	9	4	1	1

S. D. = Standard Deviation

Table 2.10 Plant height and density of *Agropyron smithii / Phleum pratense / Vicia americana* mix at Genesee during summer 1996

Species Mix	Height (cm)		Density (plants / 0.1 m^2)							
			Forbs		Grasses		Legumes		*Brassicaceae* sp.	
Treatment	Mean	S.D.	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.
50% slow fertilizer										
July 02	-	-	5	4	1	2	1	1	-	-
July 23	5.2	1.7	6	5	3	2	6	4	-	-
July 30	6.5	2.4	7	4	5	3	8	4	0	1
August 12	6.7	1.9	5	2	3	2	6	5	1	1
August 27	9.1	3.6	4	2	2	2	5	3	1	2
100% slow fertilizer										
July 02	-	-	3	3	0	1	0	0	-	-
July 23	4.0	1.5	5	3	1	1	5	3	-	-
July 30	4.8	1.9	6	3	2	3	5	2	0	1
August 12	6.1	4.0	4	3	2	2	4	5	1	1
August 27	13.6	5.9	3	3	4	2	4	2	2	2
50% regular fertilizer (yr 1)										
July 02	-	-	5	4	0	1	0	0	-	-
July 23	5.7	1.6	7	6	4	3	5	4	-	-
July 30	5.4	1.9	7	5	3	2	6	3	0	1
August 12	5.8	3.2	5	4	4	4	5	4	0	0
August 27	8.4	3.3	4	3	2	2	7	6	1	2
100% regular fertilizer (yr 1)										
July 02	-	-	2	2	0	1	0	1	-	-
July 23	5.2	1.9	4	3	3	2	5	4	-	-
July 30	4.5	3.2	4	4	2	2	6	5	0	1
August 12	7.6	4.8	4	3	2	2	5	4	0	1
August 27	9.4	4.0	3	2	3	2	7	4	1	1
50% regular fertilizer (yr 1 and 2)										
July 02	-	-	5	5	1	1	0	1	-	-
July 23	5.4	1.2	6	4	2	1	6	5	-	-
July 30	5.8	1.7	7	6	3	2	6	4	1	1
August 12	9.1	2.7	5	4	4	2	4	3	1	1
August 27	11.5	5.4	3	2	4	3	5	2	2	3
100% regular fertilizer (yr 1 and 2)										
July 02	-	-	4	3	1	2	0	1	-	-
July 23	4.8	2.1	5	3	2	2	3	3	-	-
July 30	4.3	2.6	7	6	2	3	4	4	0	0
August 12	6.1	4.0	4	2	2	3	4	4	1	1
August 27	8.7	5.7	3	2	2	2	4	5	2	2
No fertilizer										
July 02	-	-	2	2	0	0	0	0	-	-
July 23	3.7	1.1	3	3	2	2	6	4	-	-
July 30	4.5	1.7	4	3	2	2	6	4	1	1
August 12	6.0	2.3	3	2	2	2	6	4	2	2
August 27	7.8	2.9	2	2	3	2	5	3	2	2

S. D. = Standard Deviation

Table 2.11 Plant height and density of *Bromus inermis / Phleum pratense / Trifolium hybridum* mix at Genesee during summer 1996

Species Mix	Height (cm)		Density (plants / 0.1 m²)							
			Forbs		Grasses		Legumes		*Brassicaceae* sp.	
Treatment	Mean	S.D.	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.
50% slow fertilizer										
July 02	-	-	5	4	5	5	0	0	-	-
July 23	7.0	1.9	6	4	6	3	2	3	-	-
July 30	9.2	2.3	7	3	8	6	3	2	0	1
August 12	10.4	2.5	5	2	7	5	3	2	1	1
August 27	12.3	4.9	4	2	4	3	4	5	1	1
100% slow fertilizer										
July 02	-	-	2	3	2	2	0	0	-	-
July 23	6.7	2.6	4	2	3	2	1	1	-	-
July 30	9.6	2.7	4	3	5	3	1	1	0	0
August 12	10.8	4.1	3	2	4	3	1	1	1	1
August 27	14.1	6.3	4	3	3	3	2	2	2	2
50% regular fertilizer (yr 1)										
July 02	-	-	7	7	6	4	0	0	-	-
July 23	6.8	1.8	7	6	7	3	3	3	-	-
July 30	9.2	2.6	5	5	9	3	3	2	0	0
August 12	9.9	2.7	4	2	6	2	2	1	0	1
August 27	10.8	2.7	4	3	4	3	4	4	1	2
100% regular fertilizer (yr 1)										
July 02	-	-	4	2	5	5	0	0	-	-
July 23	9.6	3.8	4	2	6	6	0	1	-	-
July 30	10.9	4.1	6	5	5	4	0	1	0	1
August 12	11.5	5.3	4	2	6	7	1	1	0	0
August 27	15.5	3.9	2	1	5	4	2	3	1	1
50% regular fertilizer (yr 1 and 2)										
July 02	-	-	4	3	5	4	0	0	-	-
July 23	8.3	1.8	4	2	6	3	1	2	-	-
July 30	8.5	2.7	6	5	7	3	1	1	0	1
August 12	10.4	2.1	3	2	7	4	2	2	0	1
August 27	12.3	6.1	2	2	4	4	3	3	1	1
100% regular fertilizer (yr 1 and 2)										
July 02	-	-	4	2	6	5	0	0	-	-
July 23	6.8	4.3	4	3	4	4	0	1	-	-
July 30	8.1	6.6	6	3	4	4	2	2	0	0
August 12	11.2	6.3	4	2	5	5	2	2	0	1
August 27	11.7	6.5	4	2	4	3	3	4	1	1
No fertilizer										
July 02	-	-	3	2	3	3	0	0	-	-
July 23	7.0	2.2	4	3	6	5	2	2	-	-
July 30	8.4	4.4	6	2	6	4	1	1	0	1
August 12	7.0	3.1	3	2	5	4	2	2	1	1
August 27	11.3	3.0	2	1	3	2	5	8	1	1

S. D. = Standard Deviation

Table 2.12 Plant height and density of *Agropyron smithii / Bromus inermis / Phleum pratense / Stipa viridula / Trifolium hybridum / Vicia americana* mix at Genesee during summer 1996

Species Mix	Height (cm)		Density (plants / 0.1 m^2)							
			Forbs		Grasses		Legumes		*Brassicaceae* sp.	
Treatment	Mean	S.D.	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.
50% slow fertilizer										
July 02	-	-	4	2	2	2	0	0	-	-
July 23	5.6	1.9	6	5	5	2	5	4	-	-
July 30	5.5	2.2	5	4	4	3	5	2	0	0
August 12	9.3	2.9	4	2	5	3	5	4	0	1
August 27	12.7	4.9	3	2	4	3	3	2	1	1
100% slow fertilizer										
July 02	-	-	3	3	2	2	0	0	-	-
July 23	5.7	2.8	7	8	3	3	3	2	-	-
July 30	4.4	2.8	4	3	3	2	3	2	0	0
August 12	9.1	5.4	5	4	3	2	2	2	0	1
August 27	13.4	4.2	3	2	3	1	2	2	2	2
50% regular fertilizer (yr 1)										
July 02	-	-	8	10	4	2	0	0	-	-
July 23	6.8	2.3	7	6	6	3	3	3	-	-
July 30	8.2	3.0	8	8	5	2	4	2	0	1
August 12	7.0	3.2	5	2	4	2	5	4	0	1
August 27	12.4	2.2	7	6	5	2	4	2	1	1
100% regular fertilizer (yr 1)										
July 02	-	-	5	4	3	3	0	1	-	-
July 23	5.7	2.1	6	6	5	3	3	3	-	-
July 30	6.6	4.7	6	5	5	3	4	3	0	0
August 12	8.1	3.7	7	4	4	3	4	4	0	0
August 27	12.2	2.2	4	3	4	2	2	2	0	0
50% regular fertilizer (yr 1 and 2)										
July 02	-	-	4	4	4	4	1	1	-	-
July 23	5.2	2.0	5	5	4	2	4	2	-	-
July 30	6.2	3.0	4	3	4	3	5	3	0	0
August 12	5.7	3.1	4	2	3	3	4	3	0	1
August 27	10.6	3.4	5	3	3	2	3	2	0	1
100% regular fertilizer (yr 1 and 2)										
July 02	-	-	4	2	1	1	0	0	-	-
July 23	6.0	2.9	7	3	3	3	2	2	-	-
July 30	6.2	5.5	7	4	3	3	3	3	0	0
August 12	5.8	4.4	5	2	2	2	1	2	0	0
August 27	9.3	6.3	5	2	3	3	2	2	0	1
No fertilizer										
July 02	-	-	3	3	2	2	0	0	-	-
July 23	4.6	1.7	5	3	5	6	4	3	-	-
July 30	6.1	3.6	4	2	4	4	4	4	1	2
August 12	8.0	3.5	4	2	4	3	4	3	0	1
August 27	8.8	2.1	3	3	2	2	4	3	1	1

S. D. = Standard Deviation

Table 2.13 Plant height and density of non - seeded species (control) at Genesee during summer 1996

Species Mix	Height (cm)		Density (plants / 0.1 m^2)							
			Forbs		Grasses		Legumes		*Brassicaceae* sp.	
Treatment	Mean	S.D.	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.
50% slow fertilizer										
July 02	-	-	5	4	0	0	0	0	-	-
July 23	7.0	10.9	9	4	0	1	0	0	-	-
July 30	7.8	11.4	8	6	1	2	0	1	0	0
August 12	7.4	4.4	7	4	0	0	0	1	1	1
August 27	12.5	4.7	4	2	0	0	0	1	0	1
100% slow fertilizer										
July 02	-	-	3	3	0	0	0	0	-	-
July 23	1.9	2.0	6	5	0	0	0	0	-	-
July 30	6.5	4.5	7	5	0	1	0	0	0	0
August 12	7.2	5.9	6	4	0	1	0	0	1	1
August 27	32.1	60.7	5	3	1	3	0	0	1	1
50% regular fertilizer (yr 1)										
July 02	-	-	4	4	0	0	0	0	-	-
July 23	2.8	2.1	7	6	1	1	0	0	-	-
July 30	5.8	3.5	7	4	0	1	0	0	0	1
August 12	5.0	3.4	7	4	0	0	0	0	0	0
August 27	10.2	5.6	5	2	0	1	0	0	1	1
100% regular fertilizer (yr 1)										
July 02	-	-	4	3	0	0	0	0	-	-
July 23	2.5	1.8	7	5	0	0	0	0	-	-
July 30	5.7	3.5	8	5	0	1	0	0	0	0
August 12	9.0	6.9	6	3	0	1	0	0	0	1
August 27	10.0	5.4	5	2	0	1	0	0	1	2
50% regular fertilizer (yr 1 and 2)										
July 02	-	-	4	5	0	0	0	0	-	-
July 23	2.3	2.2	6	5	0	0	0	0	-	-
July 30	5.4	3.5	6	4	0	0	0	0	0	0
August 12	9.2	5.9	6	3	0	1	0	0	0	0
August 27	10.8	6.1	4	3	0	0	0	0	1	1
100% regular fertilizer (yr 1 and 2)										
July 02	-	-	5	5	0	0	0	0	-	-
July 23	2.1	1.7	8	5	0	0	0	0	-	-
July 30	7.4	7.0	8	4	0	0	0	0	0	1
August 12	10.6	5.8	6	3	0	0	0	0	0	0
August 27	11.0	5.4	5	2	0	0	0	0	1	2
No fertilizer										
July 02	-	-	1	1	0	0	0	0	-	-
July 23	4.4	10.8	6	6	0	0	0	0	-	-
July 30	5.0	6.9	5	4	0	0	0	0	0	0
August 12	4.0	3.4	5	3	0	0	0	0	0	0
August 27	6.7	5.2	4	2	0	0	0	0	1	1

S. D. = Standard Deviation

Table 2.14 *Agropyron smithii* in monoculture and mixes at Genesee in fall 1996

Species	Density (plants / 0.1 m^2)		Biomass (%)		Survivability (%)	
Treatment	Mean	S. D.	Mean	S. D.	Mean	S. D.
A. smithii monoculture						
50% slow	4 a	3	11 a	14	15 aA	10
100% slow	4 a	3	10 a	14	15 aAB	9
50% regular (yr 1)	7 a	4	20 a	26	23 aB	15
100% regular (yr 1)	6 a	4	25 a	33	19 aAB	14
50% regular (yr 1 and 2)	6 a	2	28 a	30	18 aAB	7
100% regular (yr 1 and 2)	4 a	3	10 a	13	12 aA	11
No fertilizer	6 a	2	18 a	17	21 aB	6
A. smithii / B. inermis mix						
50% slow	2 ab	2	4 a	8	14 abA	15
100% slow	2 ab	2	2 a	2	13 abA	11
50% regular (yr 1)	2 ab	1	2 a	3	11 abA	9
100% regular (yr 1)	3 b	2	6 a	6	20 bB	11
50% regular (yr 1 and 2)	2 ab	1	4 a	4	12 abA	8
100% regular (yr 1 and 2)	2 ab	2	5 a	7	11 abA	13
No fertilizer	1 a	1	1 a	2	6 aA	8
A. smithii / S. viridula / V. americana mix						
50% slow	2 a	2	8 a	10	23 aA	16
100% slow	2 a	2	6 a	6	23 aB	16
50% regular (yr 1)	2 a	2	5 a	7	17 aAB	17
100% regular (yr 1)	2 a	2	9 a	12	18 aAB	20
50% regular (yr 1 and 2)	3 a	2	8 a	6	29 aB	20
100% regular (yr 1 and 2)	2 a	2	4 a	4	16 aA	21
No fertilizer	2 a	2	4 a	4	15 aAB	16
A. smithii / B. inermis / P. pratense / S. viridula / T. hybridum / V. americana mix						
50% slow	1 a	1	3 a	6	18 aA	13
100% slow	0 a	1	1 a	2	10 aA	13
50% regular (yr 1)	1 a	1	3 a	4	18 aAB	19
100% regular (yr 1)	0 a	0	3 a	7	9 aA	10
50% regular (yr 1 and 2)	1 a	1	4 a	7	18 aAB	22
100% regular (yr 1 and 2)	0 a	1	2 a	4	9 aA	13
No fertilizer	1 a	1	10 a	17	20 aB	21
Non - seeded species (control)						
50% slow	0 a	0	0 a	0		
100% slow	0 a	0	0 a	0		
50% regular (yr 1)	0 a	0	0 a	0		
100% regular (yr 1)	0 a	0	0 a	0		
50% regular (yr 1 and 2)	0 a	0	0 a	0		
100% regular (yr 1 and 2)	0 a	0	0 a	0		
No fertilizer	0 a	0	0 a	0		

A. smithii = Agropyron smithii; B. inermis = Bromus inermis; P. pratense = Phleum pratense; S. viridula = Stipa viridula; T. hybridum = Trifolium hybridum; V. americana = Vicia americana

S. D. = Standard Deviation

Means within a column for a given species mix or monoculture followed by the same lower case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Means within % survivability column for a specific fertilizer treatment followed by the same upper case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Table 2.15 *Agropyron smithii* in monoculture and mixes at Genesee in spring 1997

Species / Treatment	Density (plants / 0.1 m^2) Mean	S. D.	Biomass (%) Mean	S. D.	Survivability (%) Mean	S. D.
A. smithii monoculture						
50% slow	6 ab	3	32 a	30	20 abA	10
100% slow	5 a	4	26 a	14	16 aA	12
50% regular (yr 1)	9 b	4	45 a	40	30 bAB	13
100% regular (yr 1)	7 ab	3	42 a	31	22 abAB	10
50% regular (yr 1 and 2)	7 ab	2	48 a	37	22 abAB	8
100% regular (yr 1 and 2)	5 ab	4	28 a	30	18 abAB	13
No fertilizer	7 ab	3	43 a	31	23 abAB	9
A. smithii / B. inermis mix						
50% slow	3 ab	2	8 a	7	22 aA	14
100% slow	2 ab	2	7 a	5	17 aA	11
50% regular (yr 1)	4 b	3	12 a	1	24 aAB	18
100% regular (yr 1)	2 ab	2	6 a	7	14 aA	11
50% regular (yr 1 and 2)	3 ab	2	9 a	8	19 aAB	14
100% regular (yr 1 and 2)	1 a	1	2 a	3	8 aA	7
No fertilizer	2 ab	1	12 a	12	12 aA	8
A. smithii / S. viridula / V. americana mix						
50% slow	3 a	2	15 a	13	30 aAB	16
100% slow	2 a	2	12 a	16	20 aA	20
50% regular (yr 1)	3 a	2	17 a	15	32 aB	20
100% regular (yr 1)	3 a	2	16 a	12	31 aB	19
50% regular (yr 1 and 2)	3 a	2	10 a	10	30 aB	22
100% regular (yr 1 and 2)	2 a	2	21 a	23	22 aB	18
No fertilizer	3 a	2	25 a	21	31 aB	21
A. smithii / B. inermis / P. pratense / S. viridula / T. hybridum / V. americana mix						
50% slow	2 b	1	2 a	3	38 aB	25
100% slow	1 ab	1	1 a	2	22 aA	23
50% regular (yr 1)	1 ab	2	1 a	4	15 aA	30
100% regular (yr 1)	2 ab	1	6 a	12	29 aB	25
50% regular (yr 1 and 2)	1 ab	1	2 a	4	15 aA	21
100% regular (yr 1 and 2)	0 a	1	1 a	5	9 aA	19
No fertilizer	1 ab	1	6 a	7	28 aB	28
Non - seeded species (control)						
50% slow	0 a	0	0 a	0		
100% slow	0 a	1	0 a	1		
50% regular (yr 1)	0 a	0	0 a	0		
100% regular (yr 1)	0 a	0	0 a	0		
50% regular (yr 1 and 2)	0 a	0	0 a	0		
100% regular (yr 1 and 2)	0 a	0	0 a	0		
No fertilizer	0 a	0	0 a	0		

A. smithii = Agropyron smithii; B. inermis = Bromus inermis; P. pratense = Phleum pratense; S. viridula = Stipa viridula; T. hybridum = Trifolium hybridum; V. americana = Vicia americana

S. D. = Standard Deviation

Means within a column for a given species mix or monoculture followed by the same lower case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Means within % survivability column for a specific fertilizer treatment followed by the same upper case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Table 2.16 *Agropyron smithii* in monoculture and mixes at Genesee in fall 1997

Species / Treatment	Density (plants / 0.1 m²) Mean	S. D.	Biomass (%) Mean	S. D.	Survivability (%) Mean	S. D.
A. smithii monoculture						
50% slow	6 a	4	22 a	17	19 aAB	12
100% slow	7 a	3	13 a	14	23 aA	10
50% regular (yr 1)	7 a	4	37 a	29	22 aB	14
100% regular (yr 1)	4 a	3	27 a	24	14 aA	9
50% regular (yr 1 and 2)	5 a	2	29 a	32	16 aAB	6
100% regular (yr 1 and 2)	4 a	4	12 a	17	14 aA	12
No fertilizer	6 a	3	22 a	27	19 aAB	9
A. smithii / B. inermis mix						
50% slow	2 a	2	2 ab	4	12 aA	12
100% slow	3 a	2	10 b	11	20 aA	17
50% regular (yr 1)	1 a	1	1 a	2	7 aA	7
100% regular (yr 1)	1 a	2	5 ab	10	9 aA	11
50% regular (yr 1 and 2)	2 a	3	4 ab	6	16 aAB	21
100% regular (yr 1 and 2)	1 a	1	3 ab	3	9 aA	9
No fertilizer	2 a	2	5 ab	8	11 aA	13
A. smithii / S. viridula / V. americana mix						
50% slow	3 a	2	17 a	17	30 aB	23
100% slow	4 a	3	10 a	13	42 aB	26
50% regular (yr 1)	2 a	3	11 a	14	25 aB	30
100% regular (yr 1)	3 a	2	10 a	8	26 aB	18
50% regular (yr 1 and 2)	3 a	2	11 a	17	28 aB	24
100% regular (yr 1 and 2)	3 a	3	6 a	9	28 aB	32
No fertilizer	3 a	3	15 a	17	29 aB	28
A. smithii / B. inermis / P. pratense / S. viridula / T. hybridum / V. americana mix						
50% slow	1 a	2	5 a	8	22 aAB	33
100% slow	1 a	1	5 a	8	23 aA	22
50% regular (yr 1)	0 a	0	7 a	25	3 aA	8
100% regular (yr 1)	0 a	1	0 a	1	5 aA	12
50% regular (yr 1 and 2)	0 a	1	6 a	19	8 aA	18
100% regular (yr 1 and 2)	0 a	1	2 a	5	11 aA	16
No fertilizer	0 a	1	2 a	6	8 aA	22
Non - seeded species (control)						
50% slow	0 a	0	0 a	0		
100% slow	0 a	0	0 a	0		
50% regular (yr 1)	0 a	0	0 a	0		
100% regular (yr 1)	0 a	0	0 a	0		
50% regular (yr 1 and 2)	0 a	0	0 a	0		
100% regular (yr 1 and 2)	0 a	0	0 a	0		
No fertilizer	0 a	0	0 a	0		

A. smithii = Agropyron smithii; B. inermis = Bromus inermis; P. pratense = Phleum pratense; S. viridula = Stipa viridula; T. hybridum = Trifolium hybridum; V. americana = Vicia americana

S. D. = Standard Deviation

Means within a column for a given species mix or monoculture followed by the same lower case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Means within % survivability column for a specific fertilizer treatment followed by the same upper case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Table 2.17 *Bromus inermis* in monoculture and mixes at Genesee in fall 1996

Species / Treatment	Density (plants / 0.1 m^2) Mean	S. D.	Biomass (%) Mean	S. D.	Survivability (%) Mean	S. D.
B. inermis monoculture						
50% slow	11 b	5	61 ab	23	38 bA	17
100% slow	9 ab	5	46 ab	26	31 abA	16
50% regular (yr 1)	6 a	2	39 ab	25	19 aA	8
100% regular (yr 1)	10 ab	4	62 ab	18	34 abA	14
50% regular (yr 1 and 2)	9 ab	3	51 ab	26	29 abA	9
100% regular (yr 1 and 2)	5 a	7	32 a	33	17 aA	22
No fertilizer	8 ab	3	66 b	36	25 abA	11
A. smithii / B. inermis mix						
50% slow	7 ab	4	46 a	29	46 abAB	25
100% slow	7 ab	5	27 a	21	44 abA	34
50% regular (yr 1)	7 ab	7	45 a	34	47 abB	47
100% regular (yr 1)	9 ab	7	46 a	29	58 abB	46
50% regular (yr 1 and 2)	10 b	6	47 a	28	64 bB	41
100% regular (yr 1 and 2)	4 ab	4	28 a	33	27 abA	24
No fertilizer	3 a	2	34 a	29	21 aA	13
B. inermis / P. pratense / T. hybridum mix						
50% slow	4 a	2	20 ab	17	39 aA	24
100% slow	3 a	2	26 ab	14	29 aA	23
50% regular (yr 1)	5 a	2	25 ab	16	51 aB	18
100% regular (yr 1)	3 a	2	40 b	27	32 aA	18
50% regular (yr 1 and 2)	4 a	2	35 ab	21	42 aAB	18
100% regular (yr 1 and 2)	2 a	3	14 a	18	24 aA	30
No fertilizer	4 a	2	25 ab	14	45 aB	23
A. smithii / B. inermis / P. pratense / S. viridula / T. hybridum / V. americana mix						
50% slow	3 a	2	26 a	24	63 aB	43
100% slow	2 a	2	25 a	29	48 aA	32
50% regular (yr 1)	4 a	3	25 a	25	69 aB	58
100% regular (yr 1)	3 a	2	34 a	24	66 aB	40
50% regular (yr 1 and 2)	3 a	2	19 a	13	62 aB	44
100% regular (yr 1 and 2)	2 a	2	10 a	16	30 aA	33
No fertilizer	3 a	2	21 a	24	52 aB	40
Non - seeded species (control)						
50% slow	0 a	0	0 a	0		
100% slow	0 a	1	1 a	3		
50% regular (yr 1)	0 a	0	0 a	0		
100% regular (yr 1)	0 a	0	0 a	1		
50% regular (yr 1 and 2)	0 a	0	3 a	11		
100% regular (yr 1 and 2)	0 a	2	1 a	2		
No fertilizer	0 a	0	0 a	0		

A. smithii = Agropyron smithii; B. inermis = Bromus inermis; P. pratense = Phleum pratense; S. viridula = Stipa viridula; T. hybridum = Trifolium hybridum; V. americana = Vicia americana

S. D. = Standard Deviation

Means within a column for a given species mix or monoculture followed by the same lower case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Means within % survivability column for a specific fertilizer treatment followed by the same upper case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Table 2.18 *Bromus inermis* in monoculture and mixes at Genesee in spring 1997

Species / Treatment	Density (plants / 0.1 m^2) Mean	S. D.	Biomass (%) Mean	S. D.	Survivability (%) Mean	S. D.
B. inermis monoculture						
50% slow	6 ab	2	84 b	14	19 abA	8
100% slow	6 ab	2	88 b	16	18 abA	7
50% regular (yr 1)	6 ab	2	90 b	13	19 abA	7
100% regular (yr 1)	6 b	2	81 b	20	20 bA	6
50% regular (yr 1 and 2)	6 ab	2	86 b	18	19 abA	6
100% regular (yr 1 and 2)	3 a	3	48 a	45	10 aA	11
No fertilizer	5 ab	2	76 ab	27	18 abA	6
A. smithii / B. inermis mix						
50% slow	5 a	2	72 a	20	33 aB	11
100% slow	5 a	3	66 a	26	32 aAB	19
50% regular (yr 1)	7 a	3	73 a	23	44 aB	23
100% regular (yr 1)	6 a	3	79 a	17	38 aB	18
50% regular (yr 1 and 2)	5 a	3	78 a	21	34 aA	22
100% regular (yr 1 and 2)	4 a	3	55 a	35	27 aB	19
No fertilizer	5 a	4	66 a	24	31 aA	24
B. inermis / P. pratense / T. hybridum mix						
50% slow	4 a	2	36 a	26	42 aBC	16
100% slow	4 a	3	48 a	30	40 aB	27
50% regular (yr 1)	4 a	3	21 a	14	45 aB	28
100% regular (yr 1)	4 a	2	38 a	22	37 aB	25
50% regular (yr 1 and 2)	4 a	2	32 a	30	36 aA	15
100% regular (yr 1 and 2)	2 a	2	24 a	28	19 aAB	22
No fertilizer	2 a	1	20 a	14	24 aA	12
A. smithii / B. inermis / P. pratense / S. viridula / T. hybridum / V. americana mix						
50% slow	2 ab	1	34 ab	23	47 abC	23
100% slow	3 b	2	35 ab	35	60 bC	32
50% regular (yr 1)	3 b	1	24 ab	17	63 bC	28
100% regular (yr 1)	3 b	1	44 b	27	60 bC	23
50% regular (yr 1 and 2)	3 b	2	24 ab	22	60 bB	37
100% regular (yr 1 and 2)	1 a	1	10 a	14	21 aAB	25
No fertilizer	3 ab	2	32 ab	21	52 abB	33
Non - seeded species (control)						
50% slow	0 a	0	0 a	0		
100% slow	0 a	0	0 a	0		
50% regular (yr 1)	0 a	0	0 a	0		
100% regular (yr 1)	0 a	0	0 a	0		
50% regular (yr 1 and 2)	0 a	0	0 a	0		
100% regular (yr 1 and 2)	0 a	1	7 a	17		
No fertilizer	0 a	0	0 a	0		

A. smithii = Agropyron smithii; B. inermis = Bromus inermis; P. pratense = Phleum pratense; S. viridula = Stipa viridula; T. hybridum = Trifolium hybridum; V. americana = Vicia americana

S. D. = Standard Deviation

Means within a column for a given species mix or monoculture followed by the same lower case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Means within % survivability column for a specific fertilizer treatment followed by the same upper case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Table 2.19 *Bromus inermis* in monoculture and mixes at Genesee in fall 1997

Species / Treatment	Density (plants / 0.1 m²) Mean	S. D.	Biomass (%) Mean	S. D.	Survivability (%) Mean	S. D.
B. inermis monoculture						
50% slow	6 a	2	65 a	31	18 aA	6
100% slow	6 a	3	88 a	14	21 aA	9
50% regular (yr 1)	4 a	1	88 a	19	15 aA	4
100% regular (yr 1)	5 a	1	75 a	30	16 aA	4
50% regular (yr 1 and 2)	6 a	3	79 a	33	19 aA	10
100% regular (yr 1 and 2)	4 a	3	62 a	40	13 aA	9
No fertilizer	5 a	2	64 a	33	16 aA	7
A. smithii / B. inermis mix						
50% slow	6 a	2	60 a	27	40 aB	14
100% slow	7 a	3	53 a	32	44 aBC	18
50% regular (yr 1)	6 a	3	58 a	37	39 aB	21
100% regular (yr 1)	7 a	3	68 a	27	46 aB	18
50% regular (yr 1 and 2)	6 a	2	62 a	34	41 aB	17
100% regular (yr 1 and 2)	4 a	2	56 a	38	29 aB	13
No fertilizer	5 a	3	42 a	35	31 aA	21
B. inermis / P. pratense / T. hybridum mix						
50% slow	4 a	2	35 a	32	42 aB	20
100% slow	3 a	2	27 a	29	28 aAB	19
50% regular (yr 1)	5 a	2	16 a	16	48 aB	22
100% regular (yr 1)	5 a	2	16 a	10	48 aB	18
50% regular (yr 1 and 2)	4 a	2	32 a	28	43 aB	21
100% regular (yr 1 and 2)	4 a	3	25 a	32	45 aB	28
No fertilizer	2 a	2	19 a	29	23 aA	19
A. smithii / B. inermis / P. pratense / S. viridula / T. hybridum / V. americana mix						
50% slow	2 a	2	20 a	23	40 aB	41
100% slow	3 a	2	24 a	28	63 aC	46
50% regular (yr 1)	2 a	2	21 a	23	46 aB	43
100% regular (yr 1)	3 a	2	23 a	32	55 aB	45
50% regular (yr 1 and 2)	3 a	3	33 a	32	53 aB	53
100% regular (yr 1 and 2)	2 a	2	17 a	20	42 aB	40
No fertilizer	3 a	3	24 a	22	60 aB	51
Non - seeded species (control)						
50% slow	0 a	0	0 a	0		
100% slow	0 a	1	7 a	14		
50% regular (yr 1)	0 a	0	7 a	26		
100% regular (yr 1)	0 a	0	0 a	0		
50% regular (yr 1 and 2)	0 a	0	3 a	11		
100% regular (yr 1 and 2)	0 a	0	0 a	0		
No fertilizer	0 a	0	1 a	3		

A. smithii = Agropyron smithii; B. inermis = Bromus inermis; P. pratense = Phleum pratense; S. viridula = Stipa viridula; T. hybridum = Trifolium hybridum; V. americana = Vicia americana

S. D. = Standard Deviation

Means within a column for a given species mix or monoculture followed by the same lower case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Means within % survivability column for a specific fertilizer treatment followed by the same upper case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Table 2.20 *Phleum pratense* in monoculture and mixes at Genesee in fall 1996

Species / Treatment	Density (plants / 0.1 m^2) Mean	S. D.	Biomass (%) Mean	S. D.	Survivability (%) Mean	S. D.
P. pratense monoculture						
50% slow	3 a	2	33 a	31	11 aB	7
100% slow	3 a	2	18 a	20	9 aAB	8
50% regular (yr 1)	5 a	5	22 a	23	17 aAB	16
100% regular (yr 1)	3 a	2	33 a	27	10 aB	8
50% regular (yr 1 and 2)	4 a	2	25 a	26	13 aB	8
100% regular (yr 1 and 2)	2 a	2	26 a	28	7 aAB	7
No fertilizer	3 a	3	27 a	30	9 aB	9
P. pratense / S. viridula mix						
50% slow	3 a	2	13 a	12	17 aB	12
100% slow	2 a	3	10 a	11	16 aB	20
50% regular (yr 1)	3 a	2	14 a	14	19 aB	14
100% regular (yr 1)	3 a	2	19 a	18	18 aC	12
50% regular (yr 1 and 2)	2 a	1	19 a	20	16 aB	09
100% regular (yr 1 and 2)	2 a	2	8 a	9	14 aB	11
No fertilizer	2 a	2	14 a	19	11 aB	10
B. inermis / P. pratense / T. hybridum mix						
50% slow	1 a	1	6 a	9	11 aB	14
100% slow	0 a	1	4 a	7	4 aA	7
50% regular (yr 1)	1 a	1	5 a	7	8 aA	9
100% regular (yr 1)	1 a	1	8 a	13	8 aB	11
50% regular (yr 1 and 2)	0 a	1	4 a	7	4 aA	7
100% regular (yr 1 and 2)	0 a	1	2 a	5	4 aA	9
No fertilizer	0 a	0	1 a	3	2 aA	4
A. smithii / B. inermis / P. pratense / S. viridula / T. hybridum / V. americana mix						
50% slow	0 a	0	0 a	0	0 aA	0
100% slow	0 a	1	3 a	5	10 aAB	18
50% regular (yr 1)	0 a	1	6 a	16	9 aA	13
100% regular (yr 1)	0 a	0	0 a	0	2 aA	6
50% regular (yr 1 and 2)	0 a	1	0 a	1	3 aA	12
100% regular (yr 1 and 2)	0 a	1	3 a	4	10 aAB	13
No fertilizer	0 a	0	1 a	3	5 aAB	9
Non - seeded species (control)						
50% slow	0 a	0	0 a	0		
100% slow	0 a	0	0 a	0		
50% regular (yr 1)	0 a	0	0 a	0		
100% regular (yr 1)	0 a	0	0 a	0		
50% regular (yr 1 and 2)	0 a	0	0 a	0		
100% regular (yr 1 and 2)	0 a	0	0 a	0		
No fertilizer	0 a	0	0 a	0		

A. smithii = Agropyron smithii; B. inermis = Bromus inermis; P. pratense = Phleum pratense; S. viridula = Stipa viridula; T. hybridum = Trifolium hybridum; V. americana = Vicia americana

S. D. = Standard Deviation

Means within a column for a given species mix or monoculture followed by the same lower case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Means within % survivability column for a specific fertilizer treatment followed by the same upper case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Table 2.21 *Phleum pratense* in monoculture and mixes at Genesee in spring 1997

Species / Treatment	Density (plants / 0.1 m^2) Mean	S. D.	Biomass (%) Mean	S. D.	Survivability (%) Mean	S. D.
P. pratense monoculture						
50% slow	3 a	3	56 a	41	11 aA	9
100% slow	3 a	2	68 a	42	9 aA	7
50% regular (yr 1)	4 a	3	61 a	35	13 aBC	9
100% regular (yr 1)	4 a	3	65 a	32	15 aB	11
50% regular (yr 1 and 2)	4 a	2	71 a	30	13 aAB	7
100% regular (yr 1 and 2)	2 a	2	63 a	47	6 aA	5
No fertilizer	3 a	3	44 a	40	9 aAB	11
P. pratense / S. viridula mix						
50% slow	2 a	1	50 a	35	12 aA	8
100% slow	2 a	2	57 a	34	16 aA	14
50% regular (yr 1)	3 a	2	50 a	36	18 aC	13
100% regular (yr 1)	2 a	2	39 a	30	14 aB	10
50% regular (yr 1 and 2)	3 a	2	59 a	31	22 aB	15
100% regular (yr 1 and 2)	1 a	1	33 a	41	8 aA	9
No fertilizer	2 a	2	55 a	35	15 aAB	12
B. inermis / P. pratense / T. hybridum mix						
50% slow	2 a	2	6 a	8	18 aA	24
100% slow	1 a	1	14 a	23	7 aA	12
50% regular (yr 1)	0 a	1	3 a	7	5 aA	9
100% regular (yr 1)	0 a	1	4 a	8	4 aA	9
50% regular (yr 1 and 2)	1 a	2	6 a	8	12 aAB	15
100% regular (yr 1 and 2)	0 a	1	3 a	5	5 aA	9
No fertilizer	2 a	2	15 a	13	18 aB	15
A. smithii / B. inermis / P. pratense / S. viridula / T. hybridum / V. americana mix						
50% slow	0 a	1	6 a	13	10 aA	16
100% slow	1 a	1	6 a	12	13 aA	29
50% regular (yr 1)	0 a	1	2 a	6	8 aAB	15
100% regular (yr 1)	1 a	0	7 a	11	12 aB	10
50% regular (yr 1 and 2)	0 a	1	3 a	7	8 aA	13
100% regular (yr 1 and 2)	0 a	1	5 a	9	9 aA	15
No fertilizer	0 a	1	8 a	15	7 aA	13
Non - seeded species (control)						
50% slow	0 a	0	4 a	13		
100% slow	0 a	0	0 a	0		
50% regular (yr 1)	0 a	0	0 a	0		
100% regular (yr 1)	0 a	0	6 a	17		
50% regular (yr 1 and 2)	0 a	0	0 a	0		
100% regular (yr 1 and 2)	0 a	0	0 a	0		
No fertilizer	0 a	0	0 a	0		

A. smithii = Agropyron smithii; B. inermis = Bromus inermis; P. pratense = Phleum pratense; S. viridula = Stipa viridula; T. hybridum = Trifolium hybridum; V. americana = Vicia americana

S. D. = Standard Deviation

Means within a column for a given species mix or monoculture followed by the same lower case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Means within % survivability column for a specific fertilizer treatment followed by the same upper case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Table 2.22 *Phleum pratense* in monoculture and mixes at Genesee in fall 1997

Species	Density (plants / 0.1 m^2)		Biomass (%)		Survivability (%)	
Treatment	Mean	S. D.	Mean	S. D.	Mean	S. D.
P. pratense monoculture						
50% slow	5 a	3	66 a	23	16 bAB	10
100% slow	3 a	2	62 a	33	11 abA	5
50% regular (yr 1)	5 a	2	69 a	32	16 abB	8
100% regular (yr 1)	4 a	2	81 a	18	14 abA	7
50% regular (yr 1 and 2)	3 a	2	61 a	34	9 abA	7
100% regular (yr 1 and 2)	2 a	2	52 a	34	7 aA	5
No fertilizer	4 a	3	64 a	31	13 abA	10
P. pratense / S. viridula mix						
50% slow	3 b	2	45 a	39	23 bB	16
100% slow	3 ab	2	56 a	34	18 abA	11
50% regular (yr 1)	2 ab	2	40 a	39	13 abAB	10
100% regular (yr 1)	2 ab	2	39 a	38	14 abA	12
50% regular (yr 1 and 2)	3 ab	2	48 a	30	19 abB	11
100% regular (yr 1 and 2)	2 ab	1	42 a	33	13 abA	6
No fertilizer	1 a	1	32 a	34	7 aA	6
B. inermis / P. pratense / T. hybridum mix						
50% slow	1 a	1	7 ab	14	8 aA	11
100% slow	1 a	1	21 b	26	13 aA	14
50% regular (yr 1)	1 a	1	2 a	6	6 aA	10
100% regular (yr 1)	1 a	1	1 a	2	6 aA	10
50% regular (yr 1 and 2)	0 a	1	7 ab	14	5 aA	8
100% regular (yr 1 and 2)	1 a	1	4 a	4	8 aA	9
No fertilizer	1 a	1	5 a	9	8 aA	8
A. smithii / B. inermis / P. pratense / S. viridula / T. hybridum / V. americana mix						
50% slow	1 a	1	8 a	0.15	14 aAB	24
100% slow	0 a	1	7 a	0.16	10 aA	16
50% regular (yr 1)	1 a	1	10 a	0.24	12 aAB	13
100% regular (yr 1)	0 a	1	3 a	0.08	8 aA	18
50% regular (yr 1 and 2)	0 a	1	14 a	0.20	10 aA	18
100% regular (yr 1 and 2)	0 a	1	8 a	0.15	8 aA	15
No fertilizer	0 a	1	3 a	0.08	8 aA	17
Non - seeded species (control)						
50% slow	0 a	0	0 a	0		
100% slow	0 a	0	0 a	0		
50% regular (yr 1)	0 a	0	0 a	0		
100% regular (yr 1)	0 a	0	0 a	0		
50% regular (yr 1 and 2)	0 a	0	3 a	9		
100% regular (yr 1 and 2)	0 a	1	2 a	5		
No fertilizer	0 a	0	0 a	0		

A. smithii = Agropyron smithii; B. inermis = Bromus inermis; P. pratense = Phleum pratense; S. viridula = Stipa viridula; T. hybridum = Trifolium hybridum; V. americana = Vicia americana

S. D. = Standard Deviation

Means within a column for a given species mix or monoculture followed by the same lower case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Means within % survivability column for a specific fertilizer treatment followed by the same upper case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Table 2.23 *Stipa viridula* in monoculture and mixes at Genesee in fall 1996

Species	Density (plants / 0.1 m^2)		Biomass (%)		Survivability (%)	
Treatment	Mean	S. D.	Mean	S. D.	Mean	S. D.
S. viridula monoculture						
50% slow	2 a	2	7 a	11	5 aA	5
100% slow	2 a	3	7 a	20	7 aA	11
50% regular (yr 1)	2 a	1	1 a	2	6 aA	5
100% regular (yr 1)	1 a	2	9 a	22	5 aA	5
50% regular (yr 1 and 2)	2 a	1	11 a	14	6 aA	5
100% regular (yr 1 and 2)	1 a	2	4 a	6	3 aAB	5
No fertilizer	1 a	1	2 a	4	4 aA	4
P. pratense / S. viridula mix						
50% slow	0 a	1	1 a	3	3 aA	5
100% slow	0 a	1	1 a	2	3 aA	5
50% regular (yr 1)	0 a	1	2 a	3	3 aA	6
100% regular (yr 1)	0 a	1	3 a	11	2 aA	4
50% regular (yr 1 and 2)	1 a	1	3 a	4	5 aA	8
100% regular (yr 1 and 2)	0 a	1	1 a	3	2 aAB	4
No fertilizer	0 a	1	3 a	8	3 aA	4
A. smithii / S. viridula / V. americana mix						
50% slow	1 a	1	1 ab	1	7 aA	10
100% slow	0 a	1	1 ab	2	5 aA	8
50% regular (yr 1)	1 a	1	1 ab	1	12 aA	9
100% regular (yr 1)	0 a	1	0 a	1	4 aA	8
50% regular (yr 1 and 2)	0 a	0	1 ab	1	3 aA	5
100% regular (yr 1 and 2)	0 a	1	1 ab	2	5 aB	10
No fertilizer	1 a	1	3 b	3	12 aB	13
A. smithii / B. inermis / P. pratense / S. viridula / T. hybridum / V. americana mix						
50% slow	0 a	1	0 a	1	3 aA	12
100% slow	0 a	0	0 a	1	3 aA	8
50% regular (yr 1)	0 a	1	1 a	1	11 aA	28
100% regular (yr 1)	0 a	0	0 a	0	2 aA	6
50% regular (yr 1 and 2)	0 a	1	1 a	1	8 aA	13
100% regular (yr 1 and 2)	0 a	0	0 a	0	0 aA	0
No fertilizer	0 a	1	2 a	7	5 aA	12
Non - seeded species (control)						
50% slow	0 a	0	0 a	0		
100% slow	0 a	0	0 a	0		
50% regular (yr 1)	0 a	0	0 a	0		
100% regular (yr 1)	0 a	0	0 a	0		
50% regular (yr 1 and 2)	0 a	0	0 a	0		
100% regular (yr 1 and 2)	0 a	0	0 a	0		
No fertilizer	0 a	0	0 a	0		

A. smithii = Agropyron smithii; B. inermis = Bromus inermis; P. pratense = Phleum pratense;
S. viridula = Stipa viridula; T. hybridum = Trifolium hybridum; V. americana = Vicia americana
S. D. = Standard Deviation
Means within a column for a given species mix or monoculture followed by the same lower case letter are not significantly different ($p < 0.05$, Tukey's HSD)
Means within % survivability column for a specific fertilizer treatment followed by the same upper case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Table 2.24 *Stipa viridula* in monoculture and mixes at Genesee in spring 1997

Species	Density (plants / 0.1 m^2)		Biomass (%)		Survivability (%)	
Treatment	Mean	S. D.	Mean	S. D.	Mean	S. D.
S. viridula monoculture						
50% slow	2 a	1	16 a	19	6 aA	4
100% slow	1 a	2	13 a	24	4 aA	6
50% regular (yr 1)	2 a	2	22 a	24	8 aA	7
100% regular (yr 1)	1 a	1	25 a	31	4 aA	5
50% regular (yr 1 and 2)	2 a	1	21 a	32	6 aAB	4
100% regular (yr 1 and 2)	1 a	1	17 a	30	5 aB	4
No fertilizer	1 a	2	12 a	17	5 aA	6
P. pratense / S. viridula mix						
50% slow	1 ab	1	9 a	17	6 abA	5
100% slow	1 ab	1	6 a	16	4 abA	5
50% regular (yr 1)	1 b	1	8 a	11	7 bA	7
100% regular (yr 1)	1 ab	1	6 a	14	5 abA	6
50% regular (yr 1 and 2)	1 ab	1	6 a	12	5 abAB	6
100% regular (yr 1 and 2)	0 a	0	0 a	0	0 aA	0
No fertilizer	0 ab	1	5 a	11	3 abA	5
A. smithii / S. viridula / V. americana mix						
50% slow	0 a	1	4 a	9	4 aA	9
100% slow	0 a	0	8 a	13	4 aA	5
50% regular (yr 1)	1 a	1	7 a	17	7 aA	12
100% regular (yr 1)	0 a	0	5 a	14	3 aA	5
50% regular (yr 1 and 2)	0 a	0	1 a	1	2 aA	5
100% regular (yr 1 and 2)	0 a	0	5 a	12	3 aAB	5
No fertilizer	0 a	1	3 a	9	2 aA	6
A. smithii / B. inermis / P. pratense / S. viridula / T. hybridum / V. americana mix						
50% slow	0 a	0	0 a	0	3 aA	8
100% slow	0 a	0	5 a	16	3 aA	8
50% regular (yr 1)	0 a	1	0 a	1	6 aA	13
100% regular (yr 1)	0 a	0	0 a	1	3 aA	8
50% regular (yr 1 and 2)	1 a	1	1 a	2	12 aB	16
100% regular (yr 1 and 2)	0 a	0	0 a	0	3 aAB	7
No fertilizer	0 a	0	0 a	1	3 aA	8
Non - seeded species (control)						
50% slow	0 a	0	0 a	0		
100% slow	0 a	0	0 a	0		
50% regular (yr 1)	0 a	0	0 a	0		
100% regular (yr 1)	0 a	0	0 a	0		
50% regular (yr 1 and 2)	0 a	0	0 a	0		
100% regular (yr 1 and 2)	0 a	0	0 a	0		
No fertilizer	0 a	0	1 a	2		

A. smithii = Agropyron smithii; B. inermis = Bromus inermis; P. pratense = Phleum pratense; S. viridula = Stipa viridula; T. hybridum = Trifolium hybridum; V. americana = Vicia americana

S. D. = Standard Deviation

Means within a column for a given species mix or monoculture followed by the same lower case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Means within % survivability column for a specific fertilizer treatment followed by the same upper case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Table 2.25 *Stipa viridula* in monoculture and mixes at Genesee in fall 1997

Species / Treatment	Density (plants / 0.1 m^2) Mean	S. D.	Biomass (%) Mean	S. D.	Survivability (%) Mean	S. D.
S. viridula monoculture						
50% slow	1 a	1	13 a	21	4 aAB	5
100% slow	2 a	1	16 a	16	6 aB	3
50% regular (yr 1)	2 a	1	24 a	31	7 aAB	4
100% regular (yr 1)	2 a	1	25 a	25	6 aB	4
50% regular (yr 1 and 2)	2 a	2	20 a	26	6 aAB	6
100% regular (yr 1 and 2)	3 a	3	17 a	19	9 aB	9
No fertilizer	1 a	1	14 a	18	4 aAB	4
P. pratense / S. viridula mix						
50% slow	1 ab	1	7 a	10	5 abB	5
100% slow	0 ab	1	2 a	3	3 abB	4
50% regular (yr 1)	2 b	2	12 a	22	11 bB	15
100% regular (yr 1)	0 ab	1	2 a	6	3 abAB	5
50% regular (yr 1 and 2)	0 a	1	0 a	0	2 aAB	4
100% regular (yr 1 and 2)	0 ab	1	2 a	3	3 abA	4
No fertilizer	0 a	0	9 a	19	2 aAB	3
A. smithii / S. viridula / V. americana mix						
50% slow	0 a	0	0 a	0	1 aA	3
100% slow	0 a	1	2 a	5	3 aB	7
50% regular (yr 1)	1 a	1	5 a	8	6 aAB	9
100% regular (yr 1)	0 a	1	2 a	3	3 aAB	7
50% regular (yr 1 and 2)	0 a	0	0 a	0	0 aA	0
100% regular (yr 1 and 2)	0 a	0	5 a	13	5 aAB	6
No fertilizer	0 a	0	4 a	14	1 aA	3
A. smithii / B. inermis / P. pratense / S. viridula / T. hybridum / V. americana mix						
50% slow	0 a	0	0 a	0	3 aAB	8
100% slow	0 a	0	0 a	0	0 aA	0
50% regular (yr 1)	0 a	1	0 a	1	3 aA	11
100% regular (yr 1)	0 a	0	0 a	0	2 aA	6
50% regular (yr 1 and 2)	1 a	2	6 a	18	15 aB	37
100% regular (yr 1 and 2)	0 a	0	0 a	0	2 aA	6
No fertilizer	0 a	1	1 a	1	8 aB	17
Non - seeded species (control)						
50% slow	0 a	1	0 a	2		
100% slow	0 a	0	0 a	0		
50% regular (yr 1)	0 a	0	0 a	0		
100% regular (yr 1)	0 a	0	1 a	3		
50% regular (yr 1 and 2)	0 a	0	0 a	0		
100% regular (yr 1 and 2)	0 a	0	0 a	0		
No fertilizer	0 a	0	0 a	0		

A. smithii = Agropyron smithii; B. inermis = Bromus inermis; P. pratense = Phleum pratense; S. viridula = Stipa viridula; T. hybridum = Trifolium hybridum; V. americana = Vicia americana

S. D. = Standard Deviation

Means within a column for a given species mix or monoculture followed by the same lower case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Means within % survivability column for a specific fertilizer treatment followed by the same upper case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Table 2.26 *Trifolium hybridum* in monoculture and mixes at Genesee in fall 1996

Species / Treatment	Density (plants / 0.1 m^2) Mean	S. D.	Biomass (%) Mean	S. D.	Survivability (%) Mean	S. D.
T. hybridum monoculture						
50% slow	4 a	3	48 ab	27	14 aA	10
100% slow	2 a	2	28 a	31	8 aA	6
50% regular (yr 1)	4 a	3	47 ab	26	15 aA	9
100% regular (yr 1)	3 a	2	48 ab	27	11 aAB	7
50% regular (yr 1 and 2)	4 a	2	58 ab	30	13 aA	7
100% regular (yr 1 and 2)	3 a	3	43 ab	33	9 aA	9
No fertilizer	5 a	4	64 b	20	18 aA	13
T. hybridum / V. americana mix						
50% slow	4 a	2	18 a	21	23 aA	17
100% slow	1 a	1	29 a	30	9 aA	6
50% regular (yr 1)	3 a	3	36 a	37	21 aAB	21
100% regular (yr 1)	1 a	1	21 a	25	9 aA	10
50% regular (yr 1 and 2)	3 a	0	27 a	29	17 aA	12
100% regular (yr 1 and 2)	2 a	2	35 a	42	10 aA	14
No fertilizer	3 a	4	29 a	39	18 aA	27
B. inermis / P. pratense / T. hybridum mix						
50% slow	2 ab	2	13 ab	11	21 abA	15
100% slow	1 a	1	8 a	13	7 aA	8
50% regular (yr 1)	3 b	2	30 b	22	30 bB	24
100% regular (yr 1)	1 ab	1	10 a	13	13 abAB	14
50% regular (yr 1 and 2)	2 ab	1	14 ab	16	15 abA	14
100% regular (yr 1 and 2)	1 a	1	11 ab	13	9 aA	7
No fertilizer	2 ab	3	25 ab	20	24 abA	26
A. smithii / B. inermis / P. pratense / S. viridula / T. hybridum / V. americana mix						
50% slow	1 a	1	7 a	6	25 aA	19
100% slow	0 a	1	10 a	18	8 aA	13
50% regular (yr 1)	1 a	1	14 a	18	22 aAB	21
100% regular (yr 1)	1 a	1	15 a	17	18 aB	17
50% regular (yr 1 and 2)	1 a	1	12 a	16	20 aA	24
100% regular (yr 1 and 2)	1 a	1	11 a	14	13 aA	19
No fertilizer	1 a	1	22 a	28	18 aA	29
Non - seeded species (control)						
50% slow	0 a	0	0 a	0		
100% slow	0 a	0	2 a	5		
50% regular (yr 1)	0 a	0	1 a	4		
100% regular (yr 1)	0 a	0	6 a	16		
50% regular (yr 1 and 2)	0 a	1	6 a	21		
100% regular (yr 1 and 2)	0 a	0	2 a	8		
No fertilizer	0 a	0	0 a	0		

A. smithii = Agropyron smithii; B. inermis = Bromus inermis; P. pratense = Phleum pratense; S. viridula = Stipa viridula; T. hybridum = Trifolium hybridum; V. americana = Vicia americana

S. D. = Standard Deviation

Means within a column for a given species mix or monoculture followed by the same lower case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Means within % survivability column for a specific fertilizer treatment followed by the same upper case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Table 2.27 *Trifolium hybridum* in monoculture and mixes at Genesee in spring 1997

Species / Treatment	Density (plants / 0.1 m^2) Mean	S. D.	Biomass (%) Mean	S. D.	Survivability (%) Mean	S. D.
T. hybridum monoculture						
50% slow	4 a	2	84 a	21	13 aA	5
100% slow	2 a	2	76 a	30	7 aAB	5
50% regular (yr 1)	5 a	3	94 a	08	16 aA	9
100% regular (yr 1)	4 a	2	80 a	26	12 aAB	6
50% regular (yr 1 and 2)	3 a	1	86 a	28	11 aA	6
100% regular (yr 1 and 2)	2 a	3	60 a	47	8 aA	9
No fertilizer	4 a	3	72 a	37	13 aA	11
T. hybridum / V. americana mix						
50% slow	3 a	3	58 a	33	22 aA	17
100% slow	2 a	2	60 a	34	16 aB	12
50% regular (yr 1)	2 a	1	67 a	29	16 aA	8
100% regular (yr 1)	3 a	2	79 a	23	19 aAB	12
50% regular (yr 1 and 2)	2 a	2	69 a	34	16 aA	12
100% regular (yr 1 and 2)	2 a	2	40 a	40	10 aA	12
No fertilizer	4 a	3	56 a	35	27 aA	22
B. inermis / P. pratense / T. hybridum mix						
50% slow	1 ab	1	28 ab	28	12 abA	12
100% slow	1 ab	1	27 ab	30	12 abAB	12
50% regular (yr 1)	3 b	2	65 c	28	28 bB	18
100% regular (yr 1)	1 a	1	18 a	18	8 aA	7
50% regular (yr 1 and 2)	2 ab	2	47 abc	31	19 abA	15
100% regular (yr 1 and 2)	1 a	2	32 abc	35	11 aA	16
No fertilizer	2 ab	2	53 bc	26	17 abA	15
A. smithii / B. inermis / P. pratense / S. viridula / T. hybridum / V. americana mix						
50% slow	1 ab	1	24 ab	33	20 abA	24
100% slow	0 a	1	9 a	18	7 aA	13
50% regular (yr 1)	2 b	1	48 b	29	40 bC	23
100% regular (yr 1)	1 ab	1	30 ab	31	20 abB	26
50% regular (yr 1 and 2)	1 ab	1	29 ab	28	20 abA	21
100% regular (yr 1 and 2)	1 ab	1	24 ab	34	17 abA	21
No fertilizer	1 ab	1	31 ab	41	18 abA	28
Non - seeded species (control)						
50% slow	0 a	0	2 a	5		
100% slow	0 a	0	8 a	29		
50% regular (yr 1)	0 a	0	11 a	27		
100% regular (yr 1)	0 a	1	12 a	29		
50% regular (yr 1 and 2)	0 a	0	3 a	9		
100% regular (yr 1 and 2)	0 a	0	0 a	0		
No fertilizer	0 a	0	0 a	0		

A. smithii = *Agropyron smithii; B. inermis* = *Bromus inermis; P. pratense* = *Phleum pratense; S. viridula* = *Stipa viridula; T. hybridum* = *Trifolium hybridum; V. americana* = *Vicia americana*

S. D. = Standard Deviation

Means within a column for a given species mix or monoculture followed by the same lower case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Means within % survivability column for a specific fertilizer treatment followed by the same upper case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Table 2.28 *Trifolium hybridum* in monoculture and mixes at Genesee in fall 1997

Species / Treatment	Density (plants / 0.1 m^2) Mean	S. D.	Biomass (%) Mean	S. D.	Survivability (%) Mean	S. D.
T. hybridum monoculture						
50% slow	3 ab	2	99 b	1	10 abA	5
100% slow	2 ab	1	92 ab	19	8 abA	4
50% regular (yr 1)	3 ab	1	93 ab	18	9 abA	4
100% regular (yr 1)	4 b	3	82 ab	38	13 bA	9
50% regular (yr 1 and 2)	2 a	2	68 ab	44	5 aA	6
100% regular (yr 1 and 2)	2 ab	2	83 ab	32	7 abA	5
No fertilizer	2 a	1	57 a	48	5 aA	4
T. hybridum / V. americana mix						
50% slow	2 a	1	89 a	27	13 aA	8
100% slow	1 a	1	47 a	49	7 aA	9
50% regular (yr 1)	2 a	1	67 a	39	11 aAB	6
100% regular (yr 1)	2 a	2	75 a	33	16 aA	10
50% regular (yr 1 and 2)	2 a	1	61 a	41	12 aAB	8
100% regular (yr 1 and 2)	2 a	2	55 a	39	14 aAB	11
No fertilizer	1 a	1	56 a	46	9 aAB	9
B. inermis / P. pratense / T. hybridum mix						
50% slow	1 a	1	42 ab	40	11 aA	11
100% slow	1 a	1	35 a	36	10 aA	9
50% regular (yr 1)	2 a	1	72 ab	33	22 aC	10
100% regular (yr 1)	2 a	1	78 b	11	23 aAB	12
50% regular (yr 1 and 2)	1 a	1	40 ab	36	14 aB	9
100% regular (yr 1 and 2)	2 a	1	60 ab	35	20 aB	14
No fertilizer	1 a	1	44 ab	43	12 aAB	12
A. smithii / B. inermis / P. pratense / S. viridula / T. hybridum / V. americana mix						
50% slow	2 a	2	52 a	36	31 aB	36
100% slow	1 a	1	40 a	33	22 aB	18
50% regular (yr 1)	1 a	1	49 a	38	17 aBC	14
100% regular (yr 1)	1 a	1	54 a	41	27 aB	23
50% regular (yr 1 and 2)	1 a	1	13 a	19	13 aAB	18
100% regular (yr 1 and 2)	1 a	0	41 a	39	18 aB	10
No fertilizer	1 a	1	23 a	29	15 aB	19
Non - seeded species (control)						
50% slow	0 a	0	17 a	31		
100% slow	0 a	0	1 a	4		
50% regular (yr 1)	0 a	0	0 a	0		
100% regular (yr 1)	0 a	1	17 a	28		
50% regular (yr 1 and 2)	0 a	0	11 a	26		
100% regular (yr 1 and 2)	0 a	1	20 a	35		
No fertilizer	0 a	1	16 a	32		

A. smithii = Agropyron smithii; B. inermis = Bromus inermis; P. pratense = Phleum pratense; S. viridula = Stipa viridula; T. hybridum = Trifolium hybridum; V. americana = Vicia americana

S. D. = Standard Deviation

Means within a column for a given species mix or monoculture followed by the same lower case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Means within % survivability column for a specific fertilizer treatment followed by the same upper case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Table 2.29 *Vicia americana* in monoculture and mixes at Genesee in fall 1996

Species	Density (plants / 0.1 m^2)		Biomass (%)		Survivability (%)	
Treatment	Mean	S. D.	Mean	S. D.	Mean	S. D.
V. americana monoculture						
50% slow	25 b	10	31 a	23	84 bB	35
100% slow	16 ab	9	27 a	26	52 abB	31
50% regular (yr 1)	20 ab	9	30 a	28	67 abB	30
100% regular (yr 1)	20 ab	9	24 a	21	65 abA	30
50% regular (yr 1 and 2)	21 ab	11	31 a	17	69 abA	35
100% regular (yr 1 and 2)	11 a	11	20 a	28	37 aA	36
No fertilizer	17 ab	8	11 a	30	57 abA	28
T. hybridum / V. americana mix						
50% slow	8 a	4	8 a	13	57 aA	27
100% slow	7 a	4	2 a	4	46 aAB	26
50% regular (yr 1)	8 a	4	12 a	27	57 aAB	28
100% regular (yr 1)	8 a	4	9 a	17	53 aA	24
50% regular (yr 1 and 2)	8 a	3	7 a	16	56 aA	22
100% regular (yr 1 and 2)	6 a	6	10 a	21	39 aA	37
No fertilizer	9 a	6	6 a	17	61 aA	42
A. smithii / S. viridula / V. americana mix						
50% slow	6 a	3	12 ab	13	58 aA	26
100% slow	5 a	3	6 a	6	48 aAB	30
50% regular (yr 1)	6 a	2	10 ab	9	55 aAB	20
100% regular (yr 1)	5 a	2	13 ab	10	54 aA	21
50% regular (yr 1 and 2)	6 a	4	12 ab	9	56 aA	35
100% regular (yr 1 and 2)	4 a	3	7 a	6	36 aA	33
No fertilizer	7 a	3	21 b	14	66 aA	34
A. smithii / B. inermis / P. pratense / S. viridula / T. hybridum / V. americana mix						
50% slow	3 a	2	4 ab	2	63 aAB	33
100% slow	1 a	2	1 a	2	28 aA	38
50% regular (yr 1)	2 a	2	4 ab	11	42 aA	33
100% regular (yr 1)	3 a	2	5 ab	4	66 aA	44
50% regular (yr 1 and 2)	3 a	2	5 ab	4	63 aA	48
100% regular (yr 1 and 2)	2 a	2	3 a	4	36 aA	43
No fertilizer	4 a	3	10 b	9	80 aA	61
Non - seeded species (control)						
50% slow	0 a	0	0 a	0		
100% slow	0 a	0	0 a	0		
50% regular (yr 1)	0 a	0	0 a	0		
100% regular (yr 1)	0 a	0	0 a	0		
50% regular (yr 1 and 2)	0 a	0	0 a	0		
100% regular (yr 1 and 2)	0 a	0	0 a	0		
No fertilizer	0 a	0	0 a	0		

A. smithii = Agropyron smithii; B. inermis = Bromus inermis; P. pratense = Phleum pratense; S. viridula = Stipa viridula; T. hybridum = Trifolium hybridum; V. americana = Vicia americana

S. D. = Standard Deviation

Means within a column for a given species mix or monoculture followed by the same lower case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Means within % survivability column for a specific fertilizer treatment followed by the same upper case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Table 2.30 *Vicia americana* in monoculture and mixes at Genesee in spring 1997

Species / Treatment	Density (plants / 0.1 m^2) Mean	S. D.	Biomass (%) Mean	S. D.	Survivability (%) Mean	S. D.
V. americana monoculture						
50% slow	13 b	4	45 ab	34	42 bA	15
100% slow	8 ab	5	39 ab	37	27 abAB	18
50% regular (yr 1)	12 ab	5	43 ab	36	39 abAB	17
100% regular (yr 1)	12 b	6	41 ab	34	39 bA	19
50% regular (yr 1 and 2)	13 b	7	49 b	31	42 bA	22
100% regular (yr 1 and 2)	5 a	4	10 a	15	18 aA	14
No fertilizer	10 ab	5	38 ab	35	32 abA	18
T. hybridum / V. americana mix						
50% slow	6 ab	5	19 a	31	42 abA	34
100% slow	3 ab	3	8 a	10	21 abA	21
50% regular (yr 1)	4 ab	4	7 a	11	29 abA	29
100% regular (yr 1)	8 b	4	15 a	22	52 bA	29
50% regular (yr 1 and 2)	7 ab	5	14 a	18	46 abA	35
100% regular (yr 1 and 2)	2 a	3	8 a	26	15 aA	20
No fertilizer	6 ab	4	8 a	9	42 abAB	28
A. smithii / S. viridula / V. americana mix						
50% slow	4 a	3	18 a	14	44 aA	26
100% slow	5 a	3	16 a	15	47 aBC	27
50% regular (yr 1)	6 a	4	23 a	19	56 aB	37
100% regular (yr 1)	5 a	2	25 a	19	47 aA	22
50% regular (yr 1 and 2)	6 a	3	17 a	10	60 aA	29
100% regular (yr 1 and 2)	4 a	4	28 a	27	43 aB	35
No fertilizer	6 a	2	30 a	19	57 aB	23
A. smithii / B. inermis / P. pratense / S. viridula / T. hybridum / V. americana mix						
50% slow	5 b	4	8 a	9	102 bB	83
100% slow	3 ab	2	4 a	7	60 abC	43
50% regular (yr 1)	2 ab	2	3 a	4	45 abAB	46
100% regular (yr 1)	3 ab	2	4 a	6	57 abA	36
50% regular (yr 1 and 2)	3 ab	2	8 a	12	60 abA	46
100% regular (yr 1 and 2)	2 a	2	7 a	12	40 aB	38
No fertilizer	3 ab	2	6 a	6	55 abB	34
Non - seeded species (control)						
50% slow	0 a	0	0 a	0		
100% slow	0 a	0	0 a	0		
50% regular (yr 1)	0 a	0	0 a	0		
100% regular (yr 1)	0 a	0	0 a	0		
50% regular (yr 1 and 2)	0 a	0	0 a	0		
100% regular (yr 1 and 2)	0 a	0	0 a	0		
No fertilizer	0 a	0	0 a	0		

A. smithii = Agropyron smithii; B. inermis = Bromus inermis; P. pratense = Phleum pratense; S. viridula = Stipa viridula; T. hybridum = Trifolium hybridum; V. americana = Vicia americana

S. D. = Standard Deviation

Means within a column for a given species mix or monoculture followed by the same lower case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Means within % survivability column for a specific fertilizer treatment followed by the same upper case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Table 2.31 *Vicia americana* in monoculture and mixes at Genesee in fall 1997

Species / Treatment	Density (plants / 0.1 m^2) Mean	S. D.	Biomass (%) Mean	S. D.	Survivability (%) Mean	S. D.
V. americana monoculture						
50% slow	11 bc	6	52 b	39	35 bcA	19
100% slow	7 ab	5	23 ab	15	24 abA	15
50% regular (yr 1)	8 ab	4	33 ab	32	27 abA	15
100% regular (yr 1)	14 c	7	38 ab	36	47 cA	23
50% regular (yr 1 and 2)	8 ab	2	31 ab	22	26 abA	6
100% regular (yr 1 and 2)	6 ab	4	27 ab	31	21 abA	15
No fertilizer	4 a	5	11 a	21	15 aA	15
T. hybridum / V. americana mix						
50% slow	5 a	3	1 a	2	31 aA	20
100% slow	5 a	4	15 a	30	34 aA	27
50% regular (yr 1)	6 a	3	14 a	23	39 aA	21
100% regular (yr 1)	7 a	6	7 a	14	46 aA	37
50% regular (yr 1 and 2)	5 a	3	4 a	6	33 aA	19
100% regular (yr 1 and 2)	5 a	4	9 a	25	31 aA	28
No fertilizer	4 a	4	9 a	27	25 aAB	30
A. smithii / S. viridula / V. americana mix						
50% slow	6 a	6	22 a	27	57 aA	63
100% slow	7 a	4	22 a	16	73 aB	39
50% regular (yr 1)	8 a	4	28 a	18	82 aB	39
100% regular (yr 1)	9 a	5	26 a	24	92 aB	51
50% regular (yr 1 and 2)	8 a	4	27 a	22	80 aB	35
100% regular (yr 1 and 2)	4 a	4	9 a	11	39 aAB	39
No fertilizer	4 a	4	5 a	9	42 aB	41
A. smithii / B. inermis / P. pratense / S. viridula / T. hybridum / V. americana mix						
50% slow	3 a	3	9 a	19	58 aA	53
100% slow	4 a	2	4 a	3	73 aB	45
50% regular (yr 1)	2 a	3	3 a	3	43 aA	53
100% regular (yr 1)	3 a	3	2 a	2	60 aAB	63
50% regular (yr 1 and 2)	2 a	1	4 a	5	33 aA	23
100% regular (yr 1 and 2)	3 a	2	4 a	4	57 aB	50
No fertilizer	2 a	3	4 a	4	51 aB	55
Non - seeded species (control)						
50% slow	0 a	0	0 a	0		
100% slow	0 a	0	0 a	0		
50% regular (yr 1)	0 a	0	0 a	0		
100% regular (yr 1)	0 a	0	0 a	0		
50% regular (yr 1 and 2)	0 a	0	0 a	0		
100% regular (yr 1 and 2)	0 a	0	0 a	0		
No fertilizer	0 a	0	0 a	0		

A. smithii = Agropyron smithii; B. inermis = Bromus inermis; P. pratense = Phleum pratense; S. viridula = Stipa viridula; T. hybridum = Trifolium hybridum; V. americana = Vicia americana

S. D. = Standard Deviation

Means within a column for a given species mix or monoculture followed by the same lower case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Means within % survivability column for a specific fertilizer treatment followed by the same upper case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Table 2.32 Total density and survivability of seeded species in monocultures and mixes at Genesee in fall 1996

Species / Treatment	Density (plants / 0.1 m^2) Mean	S. D.	Survivability (%) Mean	S. D.
A. smithii monoculture				
50% slow	4 aABC	3	15 aABC	10
100% slow	4 aABCD	3	15 aABCD	9
50% regular (yr 1)	7 aABC	4	23 aABC	15
100% regular (yr 1)	6 aABC	4	19 aABC	14
50% regular (yr 1 and 2)	6 aAB	2	18 aAB	7
100% regular (yr 1 and 2)	4 aAB	3	12 aAB	11
No fertilizer	6 aABC	2	21 aABC	6
B. inermis monoculture				
50% slow	11 bD	5	38 bD	17
100% slow	9 abD	5	31 abD	15
50% regular (yr 1)	6 aAB	2	19 aAB	8
100% regular (yr 1)	10 abCD	4	34 aCD	14
50% regular (yr 1 and 2)	9 abBC	3	29 aBC	9
100% regular (yr 1 and 2)	5 aAB	7	17 aAB	22
No fertilizer	8 abBCD	3	25 aBCD	11
P. pratense monoculture				
50% slow	3 aABC	2	11 aABC	7
100% slow	3 aAB	2	9 aAB	8
50% regular (yr 1)	5 aAB	5	17 aAB	16
100% regular (yr 1)	3 aAB	2	10 aAB	8
50% regular (yr 1 and 2)	4 aAB	2	13 aAB	8
100% regular (yr 1 and 2)	2 aAB	2	7 aAB	7
No fertilizer	3 aAB	3	9 aAB	9
S. viridula monoculture				
50% slow	2 aA	2	5 aA	5
100% slow	2 aA	3	7 aA	11
50% regular (yr 1)	2 aA	1	6 aA	5
100% regular (yr 1)	1 aA	2	5 aA	5
50% regular (yr 1 and 2)	2 aA	1	6 aA	5
100% regular (yr 1 and 2)	1 aA	2	3 aA	5
No fertilizer	1 aA	1	4 aA	4
T. hybridum monoculture				
50% slow	4 aABC	3	14 aABC	10
100% slow	2 aA	2	8 aA	6
50% regular (yr 1)	4 aAB	3	15 aAB	9
100% regular (yr 1)	3 aAB	2	11 aAB	7
50% regular (yr 1 and 2)	4 aAB	2	13 aAB	7
100% regular (yr 1 and 2)	3 aAB	3	9 aAB	9
No fertilizer	5 aABC	4	18 aABC	13

Table 2.32 Total density and survivability of seeded species in monocultures and mixes at Genesee in fall 1996 (continued)

Species / Treatment	Density (plants · 0.1 m^2) Mean	S. D.	Survivability (%) Mean	S. D.
V. americana monoculture				
50% slow	25 bE	10	84 bE	35
100% slow	16 abE	9	52 abE	31
50% regular (yr 1)	20 abD	9	67 abD	30
100% regular (yr 1)	20 abE	9	65 abE	30
50% regular (yr 1 and 2)	21 abD	11	69 abD	35
100% regular (yr 1 and 2)	11 aC	11	37 aC	36
No fertilizer	17 abE	8	57 abE	28
A. smithii / B. inermis mix				
50% slow	9 abCD	5	30 abCD	17
100% slow	9 abCD	6	29 abCD	20
50% regular (yr 1)	9 abBC	7	29 abBC	23
100% regular (yr 1)	12 bD	7	39 bD	24
50% regular (yr 1 and 2)	11 bC	6	38 bC	19
100% regular (yr 1 and 2)	6 abABC	5	19 abABC	16
No fertilizer	4 aABC	3	14 aABC	9
P. pratense / S. viridula mix				
50% slow	3 aAB	2	10 aAB	7
100% slow	3 aABC	3	10 aABC	10
50% regular (yr 1)	3 aAB	2	11 aAB	8
100% regular (yr 1)	3 aAB	2	10 aAB	5
50% regular (yr 1 and 2)	3 aA	1	10 aA	4
100% regular (yr 1 and 2)	2 aAB	2	8 aAB	6
No fertilizer	2 aAB	2	7 aAB	6
T. hybridum / V. americana mix				
50% slow	12 aD	4	40 aD	14
100% slow	8 aBCD	4	27 aBCD	15
50% regular (yr 1)	12 aC	9	39 aC	15
100% regular (yr 1)	9 aCD	4	31 aCD	14
50% regular (yr 1 and 2)	11 aC	3	37 aC	10
100% regular (yr 1 and 2)	7 aBC	6	25 aBC	21
No fertilizer	12 aDE	6	39 aDE	21
A. smithii / S. viridula / V. americana mix				
50% slow	9 aBCD	3	29 aBCD	10
100% slow	8 aABCD	4	25 aABCD	14
50% regular (yr 1)	8 aBC	3	28 aBC	11
100% regular (yr 1)	8 aBCD	3	25 aBCD	10
50% regular (yr 1 and 2)	9 aBC	4	29 aBC	12
100% regular (yr 1 and 2)	6 aABC	5	19 aABC	17
No fertilizer	9 aCD	4	31 aCD	13

Table 2.32 Total density and survivability of seeded species in monocultures and mixes at Genesee in fall 1996 (continued)

Species / Treatment	Density (plants · 0.1 m^2) Mean	S. D.	Survivability (%) Mean	S. D.
B. inermis / P. pratense / T. hybridum mix				
50% slow	7 abABCD	3	24 aABCD	11
100% slow	4 aABCD	3	13 aABCD	9
50% regular (yr 1)	9 bBC	4	30 bBC	12
100% regular (yr 1)	5 abABC	4	18 aABC	12
50% regular (yr 1 and 2)	6 abABC	2	21 aABC	8
100% regular (yr 1 and 2)	4 aAB	4	13 aAB	13
No fertilizer	7 abBCD	4	24 aBCD	15
A. smithii / B. inermis / P. pratense / S. viridula / T. hybridum / V. americana mix				
50% slow	9 aBCD	4	29 aBCD	12
100% slow	5 aABCD	4	18 aABCD	12
50% regular (yr 1)	8 aBC	5	28 aBC	16
100% regular (yr 1)	8 aBCD	4	27 aBCD	13
50% regular (yr 1 and 2)	9 aBC	3	29 aBC	11
100% regular (yr 1 and 2)	5 aAB	4	16 aAB	12
No fertilizer	9 aCD	5	30 aCD	16

A. smithii = Agropyron smithii; B. inermis = Bromus inermis; P. pratense = Phleum pratense; S. viridula = Stipa viridula; T. hybridum = Trifolium hybridum; V. americana = Vicia americana

S. D. = Standard Deviation

Means within a column for a given species mix or monoculture followed by the same lower case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Means within a column for a specific fertilizer treatment followed by the same upper case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Table 2.33 Total density and survivability of seeded species in monocultures and mixes at Genesee in spring 1997

Species / Treatment	Density (plants / 0.1 m^2) Mean	S. D.	Survivability (%) Mean	S. D.
A. smithii monoculture				
50% slow	6 abABCD	3	20 aABCD	10
100% slow	5 aABC	4	16 aABC	12
50% regular (yr 1)	9 bDEF	4	30 bDEF	13
100% regular (yr 1)	7 abBCD	3	22 aBCD	10
50% regular (yr 1 and 2)	6 abBCD	2	22 aBCD	8
100% regular (yr 1 and 2)	5 abBC	4	18 aBC	13
No fertilizer	7 abBCDE	3	23 aBCDE	9
B. inermis monoculture				
50% slow	6 abABCD	2	19 aABCD	8
100% slow	6 abBC	2	18 aBC	7
50% regular (yr 1)	6 abABCD	2	19 aABCD	7
100% regular (yr 1)	6 bBCD	2	20 bBCD	6
50% regular (yr 1 and 2)	6 abABCD	2	19 aABCD	6
100% regular (yr 1 and 2)	3 aABC	3	10 aABC	11
No fertilizer	5 abABCD	2	18 aABCD	6
P. pratense monoculture				
50% slow	3 aAB	3	11 aAB	9
100% slow	3 aAB	2	9 aAB	7
50% regular (yr 1)	4 aAB	3	13 aAB	9
100% regular (yr 1)	4 aABC	3	15 aABC	11
50% regular (yr 1 and 2)	4 aABC	2	13 aABC	7
100% regular (yr 1 and 2)	2 aAB	2	6 aAB	5
No fertilizer	3 aAB	3	9 aAB	11
S. viridula monoculture				
50% slow	2 aA	1	6 aA	4
100% slow	1 aA	2	4 aA	6
50% regular (yr 1)	2 aA	2	8 aA	7
100% regular (yr 1)	1 aA	1	4 aA	5
50% regular (yr 1 and 2)	2 aA	1	6 aA	4
100% regular (yr 1 and 2)	1 aAB	1	5 aAB	4
No fertilizer	1 aA	2	5 aA	6
T. hybridum monoculture				
50% slow	4 aABC	2	13 aABC	5
100% slow	2 aAB	2	7 aAB	5
50% regular (yr 1)	5 aABC	3	16 aABC	9
100% regular (yr 1)	4 aAB	2	12 aAB	6
50% regular (yr 1 and 2)	3 aAB	2	11 aAB	6
100% regular (yr 1 and 2)	2 aAB	3	8 aAB	9
No fertilizer	4 aABC	3	13 aABC	11

Table 2.33 Total density and survivability of seeded species in monocultures and mixes at Genesee in spring 1997 (continued)

Species / Treatment	Density (plants / 0.1 m^2) Mean	S. D.	Survivability (%) Mean	S. D.
V. americana monoculture				
50% slow	13 bF	4	42 bF	15
100% slow	8 abC	6	27 abC	18
50% regular (yr 1)	12 abF	5	39 abF	17
100% regular (yr 1)	12 bE	6	39 bE	19
50% regular (yr 1 and 2)	13 bE	7	42 bE	22
100% regular (yr 1 and 2)	5 aABC	4	18 aABC	14
No fertilizer	10 abDE	5	32 abDE	18
A. smithii / B. inermis mix				
50% slow	8 abDE	2	28 abDE	8
100% slow	7 abC	3	24 abC	10
50% regular (yr 1)	10 bEF	4	34 bEF	14
100% regular (yr 1)	8 abCDE	2	26 abCDE	8
50% regular (yr 1 and 2)	8 abCD	4	26 abCD	14
100% regular (yr 1 and 2)	5 aABC	4	18 aABC	12
No fertilizer	6 abBCDE	4	21 abBCDE	12
P. pratense / S. viridula mix				
50% slow	3 abA	2	9 abA	5
100% slow	3 abAB	2	10 abAB	8
50% regular (yr 1)	4 bAB	3	13 bAB	9
100% regular (yr 1)	3 abAB	2	9 abAB	6
50% regular (yr 1 and 2)	4 bABC	3	14 bABC	9
100% regular (yr 1 and 2)	1 aA	1	4 aA	5
No fertilizer	3 abAB	2	9 abAB	6
T. hybridum / V. americana mix				
50% slow	10 bcDEF	4	32 bcDEF	15
100% slow	5 abBC	3	18 abBC	10
50% regular (yr 1)	7 abcBCDE	4	23 abcBCDE	13
100% regular (yr 1)	11 cE	4	36 cE	14
50% regular (yr 1 and 2)	9 bcDE	5	31 bcDE	16
100% regular (yr 1 and 2)	4 aABC	4	13 aABC	12
No fertilizer	10 bcE	6	34 bcE	19
A. smithii / S. viridula / V. americana mix				
50% slow	8 aCDE	3	26 aCDE	11
100% slow	7 aC	3	24 aC	11
50% regular (yr 1)	10 aDEF	4	32 aDEF	12
100% regular (yr 1)	8 aCDE	4	27 aCDE	12
50% regular (yr 1 and 2)	9 aDE	4	31 aDE	13
100% regular (yr 1 and 2)	7 aC	5	23 aC	16
No fertilizer	9 aDE	4	30 aDE	13

Table 2.33 Total density and survivability of seeded species in monocultures and mixes at Genesee in spring 1997 (continued)

Species / Treatment	Density (plants / 0.1 m^2) Mean	S. D.	Survivability (%) Mean	S. D.
B. inermis / P. pratense / T. hybridum mix				
50% slow	7 bBCDE	3	24 bBCDE	11
100% slow	6 abBC	2	19 abBC	8
50% regular (yr 1)	8 bBCDEF	3	26 bBCDEF	10
100% regular (yr 1)	5 abABC	3	16 abABC	9
50% regular (yr 1 and 2)	7 abBCD	3	22 abBCD	11
100% regular (yr 1 and 2)	4 aABC	4	12 aABC	12
No fertilizer	6 abABCDE	2	19 abABCDE	8
A. smithii / B. inermis / P. pratense / S. viridula / T. hybridum / V. americana mix				
50% slow	11 bEF	5	37 bEF	17
100% slow	8 abC	4	28 abC	13
50% regular (yr 1)	9 abCDEF	3	29 abCDEF	11
100% regular (yr 1)	9 abDE	4	30 abDE	13
50% regular (yr 1 and 2)	9 abDE	3	29 abDE	11
100% regular (yr 1 and 2)	5 aABC	5	16 aABC	15
No fertilizer	8 abCDE	4	27 abCDE	14

A. smithii = Agropyron smithii; B. inermis = Bromus inermis; P. pratense = Phleum pratense; S. viridula = Stipa viridula; T. hybridum = Trifolium hybridum; V. americana = Vicia americana

S. D. = Standard Deviation

Means within a column for a given species mix or monoculture followed by the same lower case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Means within a column for a specific fertilizer treatment followed by the same upper case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Table 2.34 Total density and survivability of seeded species in monocultures and mixes at Genesee in fall 1997

Species / Treatment	Density (plants / 0.1 m^2) Mean	S. D.	Survivability (%) Mean	S. D.
A. smithii monoculture				
50% slow	6 aABCD	4	19 aABCD	12
100% slow	7 aCDE	3	23 aCDE	10
50% regular (yr 1)	7 aCD	4	22 aCD	14
100% regular (yr 1)	4 aABCD	3	14 aABCD	9
50% regular (yr 1 and 2)	5 aABCD	2	16 aABCD	6
100% regular (yr 1 and 2)	4 aABCD	4	14 aABCD	12
No fertilizer	6 aBC	3	19 aBC	9
B. inermis monoculture				
50% slow	6 aABCD	2	18 aABCD	6
100% slow	6 aBCDE	3	21 aBCDE	9
50% regular (yr 1)	4 aABCD	1	15 aABCD	4
100% regular (yr 1)	5 aABCD	1	16 aABCD	4
50% regular (yr 1 and 2)	6 aBCD	3	19 aBCD	10
100% regular (yr 1 and 2)	4 aABCD	3	13 aABCD	9
No fertilizer	5 aABC	2	16 aABC	7
P. pratense monoculture				
50% slow	5 bABCD	3	16 bABCD	10
100% slow	3 abABC	2	11 abABC	5
50% regular (yr 1)	5 abABCD	2	16 abABCD	8
100% regular (yr 1)	4 abABCD	2	14 abABCD	7
50% regular (yr 1 and 2)	3 abAB	2	9 abAB	7
100% regular (yr 1 and 2)	2 aA	2	7 aA	5
No fertilizer	4 abABC	3	13 abABC	10
S. viridula monoculture				
50% slow	1 aA	1	4 aA	5
100% slow	2 aA	1	6 aA	3
50% regular (yr 1)	2 aA	1	7 aA	4
100% regular (yr 1)	2 aA	1	6 aA	4
50% regular (yr 1 and 2)	2 aA	2	6 aA	6
100% regular (yr 1 and 2)	3 aABC	3	9 aABC	9
No fertilizer	1 aA	1	4 aA	4
T. hybridum monoculture				
50% slow	3 abAB	2	10 abAB	5
100% slow	2 abAB	1	8 abAB	4
50% regular (yr 1)	3 abAB	1	9 abAB	4
100% regular (yr 1)	4 bABC	2	13 bABC	8
50% regular (yr 1 and 2)	2 aA	2	5 aA	6
100% regular (yr 1 and 2)	2 abA	2	7 abA	5
No fertilizer	2 aAB	1	5 aAB	4

Table 2.3-4 Total density and survivability of seeded species in monocultures and mixes at Genesee in fall 1997 (continued)

Species / Treatment	Density (plants / 0.1 m^2) Mean	S. D.	Survivability (%) Mean	S. D.
V. americana monoculture				
50% slow	11 bcE	6	35 bcE	19
100% slow	7 abDE	5	24 abDE	15
50% regular (yr 1)	8 abDE	4	27 abDE	15
100% regular (yr 1)	14 cF	7	47 cF	23
50% regular (yr 1 and 2)	8 abDEF	2	26 abDEF	6
100% regular (yr 1 and 2)	6 abABCD	4	21 abABCD	15
No fertilizer	4 aABC	5	15 aABC	15
A. smithii / B. inermis mix				
50% slow	8 abCDE	2	26 abCDE	8
100% slow	10 bEF	3	32 bEF	11
50% regular (yr 1)	7 abCD	3	23 abCD	10
100% regular (yr 1)	8 abCDE	3	28 abCDE	10
50% regular (yr 1 and 2)	8 abEF	4	28 abEF	12
100% regular (yr 1 and 2)	6 aABCD	3	19 aABCD	10
No fertilizer	6 abC	4	21 abC	13
P. pratense / S. viridula mix				
50% slow	4 bABC	3	14 bABC	9
100% slow	3 abABC	2	11 abABC	6
50% regular (yr 1)	4 bABC	2	12 bABC	6
100% regular (yr 1)	3 abAB	2	9 abAB	8
50% regular (yr 1 and 2)	3 abABC	2	11 abABC	5
100% regular (yr 1 and 2)	2 abAB	1	8 abAB	4
No fertilizer	1 aA	1	4 aA	4
T. hybridum / V. americana mix				
50% slow	6 aBCDE	3	22 aBCDE	9
100% slow	6 aBCDE	3	21 aBCDE	11
50% regular (yr 1)	8 aDE	2	25 aDE	8
100% regular (yr 1)	9 aDEF	6	31 aDEF	21
50% regular (yr 1 and 2)	7 aDE	3	22 aDE	10
100% regular (yr 1 and 2)	7 aBCD	5	22 aBCD	16
No fertilizer	5 aABC	4	17 aABC	14
A. smithii / S. viridula / V. americana mix				
50% slow	9 aDE	7	29 aDE	23
100% slow	12 aF	5	39 aF	17
50% regular (yr 1)	11 aE	5	38 aE	18
100% regular (yr 1)	12 aEF	6	41 aEF	20
50% regular (yr 1 and 2)	11 aF	4	36 aF	14
100% regular (yr 1 and 2)	7 aD	6	24 aD	19
No fertilizer	7 aC	5	24 aC	15

Table 2.34 Total density and survivability of seeded species in monocultures and mixes at Genesee in fall 1997 (continued)

Species / Treatment	Density (plants / 0.1 m^2) Mean	S. D.	Survivability (%) Mean	S. D.
B. inermis / P. pratense / T. hybridum mix				
50% slow	6 abBCD	2	20 abBCD	7
100% slow	5 abABCD	3	17 abABCD	9
50% regular (yr 1)	8 bDE	3	26 bDE	9
100% regular (yr 1)	8 bBCDE	3	26 bBCDE	9
50% regular (yr 1 and 2)	6 abCDE	2	21 abCDE	8
100% regular (yr 1 and 2)	7 abD	3	25 abD	11
No fertilizer	4 aABC	3	14 aABC	9
A. smithii / B. inermis / P. pratense / S. viridula / T. hybridum / V. americana mix				
50% slow	8 aCDE	4	28 aCDE	14
100% slow	10 aEF	4	32 aEF	12
50% regular (yr 1)	6 aBCD	4	21 aBCD	15
100% regular (yr 1)	8 aCDE	4	26 aCDE	15
50% regular (yr 1 and 2)	7 aDE	3	22 aDE	10
100% regular (yr 1 and 2)	7 aCD	4	23 aCD	15
No fertilizer	8 aC	6	25 aC	19

A. smithii = Agropyron smithii; B. inermis = Bromus inermis; P. pratense = Phleum pratense; S. viridula = Stipa viridula; T. hybridum = Trifolium hybridum; V. americana = Vicia americana

S. D. = Standard Deviation

Means within a column for a given species mix or monoculture followed by the same lower case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Means within a column for a specific fertilizer treatment followed by the same upper case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Table 2.35 Total density and biomass of non - seeded species in monocultures and mixes at Genesee in fall 1996

Species Treatment	Density (plants / 0.1 m^2) Mean	S. D.	Biomass (%) Mean	S. D.
A. smithii monoculture				
50% slow	7 aAB	3	87 aC	17
100% slow	6 aA	3	85 aAB	23
50% regular (yr 1)	6 aA	4	79 aBCD	26
100% regular (yr 1)	6 aA	3	75 aBCDE	33
50% regular (yr 1 and 2)	5 aA	3	72 aAB	30
100% regular (yr 1 and 2)	6 aAB	3	90 aBC	13
No fertilizer	7 aB	4	80 aBC	19
B. inermis monoculture				
50% slow	5 aAB	3	39 abA	23
100% slow	4 aA	2	54 abA	26
50% regular (yr 1)	4 aA	2	61 abABC	25
100% regular (yr 1)	6 aA	3	38 abA	19
50% regular (yr 1 and 2)	6 aA	3	49 abA	26
100% regular (yr 1 and 2)	4 aA	2	68 bABC	33
No fertilizer	4 aAB	2	34 aA	36
P. pratense monoculture				
50% slow	4 aAB	3	62 aABC	30
100% slow	7 aA	3	82 aAB	20
50% regular (yr 1)	6 aA	6	78 aBCD	23
100% regular (yr 1)	5 aA	3	67 aABCDE	27
50% regular (yr 1 and 2)	6 aA	2	75 aAB	26
100% regular (yr 1 and 2)	5 aA	3	73 aABC	29
No fertilizer	4 aAB	2	73 aBC	30
S. viridula monoculture				
50% slow	6 aAB	3	88 aC	17
100% slow	7 aA	2	89 aB	21
50% regular (yr 1)	7 aA	2	98 aD	3
100% regular (yr 1)	5 aA	2	91 aE	22
50% regular (yr 1 and 2)	5 aA	3	88 aB	15
100% regular (yr 1 and 2)	6 aAB	3	95 aC	8
No fertilizer	5 aAB	2	95 aC	9
T. hybridum monoculture				
50% slow	3 aA	2	49 abAB	27
100% slow	5 aA	3	69 bAB	30
50% regular (yr 1)	6 aA	4	52 abABC	26
100% regular (yr 1)	7 aA	6	49 abABCD	25
50% regular (yr 1 and 2)	5 aA	5	42 abA	31
100% regular (yr 1 and 2)	4 aA	3	56 abA	33
No fertilizer	4 aAB	2	33 aA	16

Table 2.35 Total density and biomass of non - seeded species in monocultures and mixes at Genesee in fall 1996 (continued)

Species / Treatment	Density (plants / 0.1 m^2) Mean	S. D.	Biomass (%) Mean	S. D.
V. americana monoculture				
50% slow	5 abAB	2	68 aABC	25
100% slow	4 abA	2	70 aAB	26
50% regular (yr 1)	8 bA	5	70 aABCD	28
100% regular (yr 1)	6 abA	4	76 aCDE	21
50% regular (yr 1 and 2)	6 abA	2	69 aAB	17
100% regular (yr 1 and 2)	5 abA	2	79 aABC	28
No fertilizer	3 aAB	2	56 aAB	30
A. smithii / B. inermis mix				
50% slow	4 aAB	4	50 aAB	34
100% slow	4 aA	2	72 aAB	21
50% regular (yr 1)	4 aA	5	53 aABC	35
100% regular (yr 1)	5 aA	5	48 aABCD	32
50% regular (yr 1 and 2)	4 aA	3	47 aA	28
100% regular (yr 1 and 2)	5 aA	3	61 aAB	38
No fertilizer	5 aAB	4	63 aABC	29
P. pratense / S. viridula mix				
50% slow	6 aAB	3	84 aC	17
100% slow	6 aA	2	88 aB	14
50% regular (yr 1)	5 aA	3	84 aCD	14
100% regular (yr 1)	5 aA	3	78 aDE	26
50% regular (yr 1 and 2)	6 aA	3	74 aAB	23
100% regular (yr 1 and 2)	6 aAB	3	83 aABC	13
No fertilizer	5 aAB	4	83 aBC	20
T. hybridum / V. americana mix				
50% slow	5 aAB	4	73 aBC	26
100% slow	4 aA	2	68 aAB	33
50% regular (yr 1)	4 aA	2	52 aABC	40
100% regular (yr 1)	5 aA	2	70 aABCDE	27
50% regular (yr 1 and 2)	5 aA	3	66 aAB	34
100% regular (yr 1 and 2)	4 aA	4	55 aA	44
No fertilizer	4 aAB	3	64 aABC	40
A. smithii / S. viridula / V. americana mix				
50% slow	5 aAB	3	73 aBC	20
100% slow	5 aA	3	86 aB	12
50% regular (yr 1)	5 aA	3	81 aCD	15
100% regular (yr 1)	5 aA	4	76 aCDE	25
50% regular (yr 1 and 2)	6 aA	4	73 aAB	26
100% regular (yr 1 and 2)	4 aA	3	83 aABC	16
No fertilizer	4 aAB	2	71 aBC	14

Table 2.35 Total density and biomass of non - seeded species in monocultures and mixes at Genesee in fall 1996 (continued)

Species / Treatment	Density (plants / 0.1 m^2) Mean	S. D.	Biomass (%) Mean	S. D.
B. inermis / P. pratense / T. hybridum mix				
50% slow	7 aAB	4	60 abABC	28
100% slow	5 aA	2	61 abAB	16
50% regular (yr 1)	5 aA	4	40 aA	23
100% regular (yr 1)	4 aA	3	42 abAB	32
50% regular (yr 1 and 2)	5 aA	3	47 abA	28
100% regular (yr 1 and 2)	5 aA	2	72 bABC	27
No fertilizer	6 aAB	4	49 abAB	26
A. smithii / B. inermis / P. pratense / S. viridula / T. hybridum / V. americana mix				
50% slow	4 aA	2	60 abABC	28
100% slow	5 aA	5	59 abAB	33
50% regular (yr 1)	7 aA	7	47 abAB	32
100% regular (yr 1)	6 aA	5	43 abABC	30
50% regular (yr 1 and 2)	5 aA	2	60 abAB	17
100% regular (yr 1 and 2)	6 aAB	3	72 bABC	20
No fertilizer	3 aA	2	33 aA	26
Non - seeded species (control)				
50% slow	8 aB	3		
100% slow	7 aA	4		
50% regular (yr 1)	7 aA	4		
100% regular (yr 1)	7 aA	5		
50% regular (yr 1 and 2)	6 aA	4		
100% regular (yr 1 and 2)	9 aB	7		
No fertilizer	6 aAB	2		

A. smithii = Agropyron smithii; B. inermis = Bromus inermis; P. pratense = Phleum pratense; S. viridula = Stipa viridula; T. hybridum = Trifolium hybridum; V. americana = Vicia americana

S. D. = Standard Deviation

Means within a column for a given species mix or monoculture followed by the same lower case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Means within a column for a specific fertilizer treatment followed by the same upper case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Table 2.36 Total density and biomass of non - seeded species in monocultures and mixes at Genesee in spring 1997

Species / Treatment	Density (plants / 0.1 m^2) Mean	S. D.	Biomass (%) Mean	S. D.
A. smithii monoculture				
50% slow	32 abA	38	65 aDE	35
100% slow	47 bA	44	62 aBC	33
50% regular (yr 1)	10 aA	16	43 aBCD	40
100% regular (yr 1)	23 abA	17	58 aDE	31
50% regular (yr 1 and 2)	17 abA	21	41 aAB	32
100% regular (yr 1 and 2)	15 aA	16	60 aA	36
No fertilizer	17 abB	11	52 aBC	35
B. inermis monoculture				
50% slow	6 aA	4	16 aA	14
100% slow	50 bA	70	12 aA	16
50% regular (yr 1)	13 aA	17	43 aAB	40
100% regular (yr 1)	22 abA	28	19 aABC	20
50% regular (yr 1 and 2)	8 aA	8	10 aA	13
100% regular (yr 1 and 2)	9 aA	12	36 aA	44
No fertilizer	8 aAB	6	18 aAB	21
P. pratense monoculture				
50% slow	9 aA	10	45 aABCDE	40
100% slow	15 aA	21	31 aABC	42
50% regular (yr 1)	4 aA	3	38 aABC	36
100% regular (yr 1)	5 aA	3	35 aABCD	32
50% regular (yr 1 and 2)	5 aA	4	29 aAB	29
100% regular (yr 1 and 2)	10 aA	14	37 aA	47
No fertilizer	5 aA	6	56 aBC	40
S. viridula monoculture				
50% slow	14 abA	15	76 aE	26
100% slow	49 bA	59	70 aC	40
50% regular (yr 1)	21 abA	19	75 aD	25
100% regular (yr 1)	34 abA	20	71 aE	32
50% regular (yr 1 and 2)	20 abA	19	79 aC	32
100% regular (yr 1 and 2)	27 abA	29	80 aA	33
No fertilizer	8 aAB	8	68 aC	36
T. hybridum monoculture				
50% slow	16 abA	30	11 abA	17
100% slow	34 bA	30	24 abAB	30
50% regular (yr 1)	16 abA	20	5 aA	6
100% regular (yr 1)	10 aA	17	18 abABC	26
50% regular (yr 1 and 2)	9 aA	11	10 abA	14
100% regular (yr 1 and 2)	16 abA	20	40 bA	47
No fertilizer	4 aA	4	27 abAB	36

Table 2.36 Total density and biomass of non - seeded species in monocultures and mixes at Genesee in spring 1997 (continued)

Species / Treatment	Density (plants / 0.1 m^2) Mean	S. D.	Biomass (%) Mean	S. D.
V. americana monoculture				
50% slow	16 aA	12	55 aBCDE	34
100% slow	32 aA	58	48 aABC	41
50% regular (yr 1)	9 aA	10	51aCD	36
100% regular (yr 1)	27 aA	28	58 aDE	34
50% regular (yr 1 and 2)	8 aA	6	51 aBC	31
100% regular (yr 1 and 2)	8 aA	6	75 aA	26
No fertilizer	6 aAB	3	55 aBC	32
A. smithii / B. inermis mix				
50% slow	16 aA	22	20 aAB	18
100% slow	26 aA	56	28 aABC	24
50% regular (yr 1)	8 aA	17	16 aABC	18
100% regular (yr 1)	19 aA	26	15 aAB	16
50% regular (yr 1 and 2)	13 aA	13	13 aA	17
100% regular (yr 1 and 2)	12 aA	24	37 aA	34
No fertilizer	6 aAB	6	22 aAB	17
P. pratense / S. viridula mix				
50% slow	27 aA	42	40 aABCDE	35
100% slow	23 aA	25	37 aABC	36
50% regular (yr 1)	9 aA	14	37 aABC	38
100% regular (yr 1)	22 aA	21	53 aCDE	38
50% regular (yr 1 and 2)	13 aA	16	26 aAB	35
100% regular (yr 1 and 2)	25 aA	30	46 aA	39
No fertilizer	13 aAB	17	40 aABC	37
T. hybridum / V. americana mix				
50% slow	20 aA	22	24 abABC	27
100% slow	22 aA	32	32 abABC	33
50% regular (yr 1)	11 aA	16	24 abABC	24
100% regular (yr 1)	22 aA	31	7 aA	6
50% regular (yr 1 and 2)	21 aA	28	17 abA	17
100% regular (yr 1 and 2)	18 aA	22	50 bA	42
No fertilizer	5 aA	4	34 abABC	37
A. smithii / S. viridula / V. americana mix				
50% slow	18 abA	25	60 aCDE	26
100% slow	44 bA	37	52 aABC	32
50% regular (yr 1)	16 aA	16	48 aCD	32
100% regular (yr 1)	19 abA	23	50 aBCDE	28
50% regular (yr 1 and 2)	9 aA	15	53 aBC	29
100% regular (yr 1 and 2)	23 abA	22	46 aA	41
No fertilizer	9 aAB	10	37 aABC	30

Table 2.36 Total density and biomass of non - seeded species in monocultures and mixes at Genesee in spring 1997 (continued)

Species / Treatment	Density (plants / 0.1 m^2) Mean	S. D.	Biomass (%) Mean	S. D.
B. inermis / P. pratense / T. hybridum mix				
50% slow	9 aA	11	30 aABCD	21
100% slow	23 aA	32	11 aA	17
50% regular (yr 1)	17 aA	28	12 aAB	16
100% regular (yr 1)	22 aA	34	39 aABCDE	27
50% regular (yr 1 and 2)	9 aA	15	15 aA	18
100% regular (yr 1 and 2)	38 aA	42	41 aA	47
No fertilizer	5 aA	7	11 aA	18
A. smithii / B. inermis / P. pratense / S. viridula / T. hybridum / V. americana mix				
50% slow	32 abA	36	26 abABC	31
100% slow	46 bA	41	40 abABC	39
50% regular (yr 1)	10 aA	8	21 abABC	30
100% regular (yr 1)	17 abA	21	10 aA	12
50% regular (yr 1 and 2)	12 aA	12	33 abAB	18
100% regular (yr 1 and 2)	22 abA	22	52 bA	37
No fertilizer	6 aAB	6	18 aAB	17
Non - seeded species (control)				
50% slow	42 bA	46		
100% slow	16 abA	14		
50% regular (yr 1)	13 abA	18		
100% regular (yr 1)	34 abA	38		
50% regular (yr 1 and 2)	17 abA	18		
100% regular (yr 1 and 2)	25 abA	36		
No fertilizer	7 aAB	5		

A. smithii = Agropyron smithii; B. inermis = Bromus inermis; P. pratense = Phleum pratense; S. viridula = Stipa viridula; T. hybridum = Trifolium hybridum; V. americana = Vicia americana

S. D. = Standard Deviation

Means within a column for a given species mix or monoculture followed by the same lower case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Means within a column for a specific fertilizer treatment followed by the same upper case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Table 2.37 Total density and biomass of non - seeded species in monocultures and mixes at Genesee in fall 1997

Species / Treatment	Density (plants / 0.1 m^2) Mean	S. D.	Biomass (%) Mean	S. D.
A. smithii monoculture				
50% slow	4 aA	3	56 aD	34
100% slow	7 abA	6	56 aCDE	36
50% regular (yr 1)	4 aAB	2	49 aCD	32
100% regular (yr 1)	4 aAB	3	53 aBC	31
50% regular (yr 1 and 2)	11 abAB	6	65 aBC	33
100% regular (yr 1 and 2)	11 abA	12	60 aC	34
No fertilizer	15 bA	12	76 aBCD	27
B. inermis monoculture				
50% slow	10 abA	7	22 aABCD	19
100% slow	12 abA	6	11 aAB	13
50% regular (yr 1)	9 aB	7	10 aAB	18
100% regular (yr 1)	8 aAB	9	19 aAB	26
50% regular (yr 1 and 2)	26 cC	16	10 aA	15
100% regular (yr 1 and 2)	22 bcB	14	37 aABC	38
No fertilizer	12 abA	10	28 aA	29
P. pratense monoculture				
50% slow	4 aA	4	30 aABCD	26
100% slow	10 abA	9	32 aABCD	33
50% regular (yr 1)	6 abAB	2	30 aABCD	32
100% regular (yr 1)	4 aAB	5	16 aAB	14
50% regular (yr 1 and 2)	16 bABC	9	39 aABC	34
100% regular (yr 1 and 2)	12 abAB	9	46 aABC	33
No fertilizer	12 abA	12	30 aA	30
S. viridula monoculture				
50% slow	5 aA	4	51 aCD	40
100% slow	16 bA	13	63 aDE	36
50% regular (yr 1)	7 aAB	5	61 aD	38
100% regular (yr 1)	7 aAB	5	71 aBC	27
50% regular (yr 1 and 2)	12 abAB	10	70 aC	31
100% regular (yr 1 and 2)	6 aA	5	67 aC	28
No fertilizer	12 abA	7	69 aABC	28
T. hybridum monoculture				
50% slow	7 aA	12	0 aA	1
100% slow	7 aA	7	7 abA	19
50% regular (yr 1)	4 aAB	4	7 abA	18
100% regular (yr 1)	4 aAB	4	18 abAB	38
50% regular (yr 1 and 2)	13 aABC	16	29 abABC	44
100% regular (yr 1 and 2)	6 aA	4	15 abAB	32
No fertilizer	6 aA	7	43 bABC	48

Table 2.37 Total density and biomass of non - seeded species in monocultures and mixes at Genesee in fall 1997 (continued)

Species / Treatment	Density (plants / 0.1 m^2) Mean	S. D.	Biomass (%) Mean	S. D.
V. americana monoculture				
50% slow	3 aA	3	46 aBCD	38
100% slow	8 aA	6	72 abE	20
50% regular (yr 1)	3 aAB	2	45 aBCD	37
100% regular (yr 1)	4 aAB	2	54 abBC	37
50% regular (yr 1 and 2)	7 aAB	5	66 abBC	28
100% regular (yr 1 and 2)	6 aA	6	59 abBC	39
No fertilizer	8 aA	5	88 bD	21
A. smithii / B. inermis mix				
50% slow	8 abA	8	26 aABCD	26
100% slow	10 abA	9	37 aABCDE	32
50% regular (yr 1)	4 aAB	3	31 aABCD	36
100% regular (yr 1)	4 aAB	4	21 aAB	23
50% regular (yr 1 and 2)	10 abAB	9	28 aABC	33
100% regular (yr 1 and 2)	7 abA	6	41 aABC	40
No fertilizer	15 bA	12	41 aABC	38
P. pratense / S. viridula mix				
50% slow	5 aA	5	25 aABCD	31
100% slow	8 aA	10	26 aABCD	26
50% regular (yr 1)	5 aAB	3	42 aABCD	37
100% regular (yr 1)	7 aAB	6	42 aABC	38
50% regular (yr 1 and 2)	10 aAB	10	50 aABC	29
100% regular (yr 1 and 2)	7 aA	5	52 aABC	36
No fertilizer	12 aA	13	50 aABCD	38
T. hybridum / V. americana mix				
50% slow	4 aA	4	9 aAB	27
100% slow	7 aA	5	36 aABCDE	45
50% regular (yr 1)	6 aAB	8	20 aABC	31
100% regular (yr 1)	3 aAB	3	17 aAB	25
50% regular (yr 1 and 2)	7 aAB	7	35 aABC	39
100% regular (yr 1 and 2)	9 aA	9	32 aABC	37
No fertilizer	9 aA	10	34 aAB	45
A. smithii / S. viridula / V. americana mix				
50% slow	4 aA	4	50 aCD	40
100% slow	6 aA	6	46 aBCDE	32
50% regular (yr 1)	4 aAB	4	42 aABCD	31
100% regular (yr 1)	5 aAB	4	53 aBC	31
50% regular (yr 1 and 2)	6 aA	5	52 aABC	33
100% regular (yr 1 and 2)	10 abA	9	69 aC	32
No fertilizer	20 bA	20	73 aABC	34

Table 2.37 Total density and biomass of non - seeded species in monocultures and mixes at Genesee in fall 1997 (continued)

Species	Density (plants / 0.1 m^2)		Biomass (%)	
Treatment	Mean	S. D.	Mean	S. D.
B. inermis / P. pratense / T. hybridum mix				
50% slow	10 abA	10	17 aABC	24
100% slow	9 abA	6	17 aAB	27
50% regular (yr 1)	4 aAB	6	10 aAB	15
100% regular (yr 1)	7 abAB	10	5 aA	8
50% regular (yr 1 and 2)	7 abAB	6	19 aA	30
100% regular (yr 1 and 2)	5 abA	7	11 aA	22
No fertilizer	16 bA	14	31 aAB	45
A. smithii / B. inermis / P. pratense / S. viridula / T. hybridum / V. americana mix				
50% slow	4 aA	6	6 aA	9
100% slow	6 aA	5	20 abABC	16
50% regular (yr 1)	3 aA	3	10 aAB	15
100% regular (yr 1)	3 aA	5	19 abAB	38
50% regular (yr 1 and 2)	5 aA	5	25 abAB	31
100% regular (yr 1 and 2)	2 aA	2	29 abABC	37
No fertilizer	8 aA	9	44 bABCD	32
Non - seeded species (control)				
50% slow	10 aA	6		
100% slow	17 aA	13		
50% regular (yr 1)	8 aAB	5		
100% regular (yr 1)	13 aB	20		
50% regular (yr 1 and 2)	19 aBC	12		
100% regular (yr 1 and 2)	12 aAB	9		
No fertilizer	15 aA	13		

A. smithii = Agropyron smithii; B. inermis = Bromus inermis; P. pratense = Phleum pratense; S. viridula = Stipa viridula; T. hybridum = Trifolium hybridum; V. americana = Vicia americana

S. D. = Standard Deviation

Means within a column for a given species mix or monoculture followed by the same lower case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Means within % survivability column for a specific fertilizer treatment followed by the same upper case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Table 2.38 Canopy height of monocultures and mixes at Genesee in fall 1996

Species / Treatment	Canopy Level 1 (cm) Mean	S. D.	Canopy Level 2 (cm) Mean	S. D.	Canopy Level 3 (cm) Mean	S. D.
A. smithii monoculture						
50% slow	22.4 a	10.0	8.0 a	6.7	2.4 a	3.8
100% slow	21.2 a	8.5	8.4 a	7.1	2.6 a	4.1
50% regular (yr 1)	28.7 a	12.4	10.9 a	6.2	2.2 a	3.4
100% regular (yr 1)	17.1 a	3.4	6.6 a	7.0	1.8 a	2.6
50% regular (yr 1 and 2)	18.9 a	7.4	7.3 a	5.5	0.4 a	1.0
100% regular (yr 1 and 2)	24.1 a	14.3	5.8 a	5.1	0.3 a	1.2
No fertilizer	20.2 a	10.6	6.9 a	4.7	1.2 a	2.6
B. inermis monoculture						
50% slow	18.3 a	6.9	4.7 ab	6.2	0.8 a	2.0
100% slow	30.4 b	9.6	12.8 b	8.7	1.9 a	4.6
50% regular (yr 1)	22.0 ab	6.8	12.0 ab	6.6	2.0 a	4.1
100% regular (yr 1)	17.5 a	4.4	7.0 ab	6.5	0.0 a	0.0
50% regular (yr 1 and 2)	21.4 ab	10.6	10.4 ab	8.2	2.3 a	4.0
100% regular (yr 1 and 2)	20.8 ab	11.5	6.5 ab	7.7	1.6 a	3.7
No fertilizer	16.4 a	11.3	4.0 a	4.4	0.1 a	0.2
P. pratense monoculture						
50% slow	27.8 a	9.4	10.4 a	5.3	0.5 a	1.1
100% slow	25.8 a	8.3	13.5 a	7.6	1.4 a	2.6
50% regular (yr 1)	22.7 a	7.5	9.4 a	6.4	0.7 a	2.7
100% regular (yr 1)	27.4 a	12.2	10.0 a	5.8	1.4 a	2.8
50% regular (yr 1 and 2)	21.5 a	10.0	10.2 a	8.2	1.2 a	3.0
100% regular (yr 1 and 2)	22.8 a	8.3	11.0 a	6.4	0.8 a	2.8
No fertilizer	17.7 a	12.9	7.4 a	5.7	0.0 a	0.0
S. viridula monoculture						
50% slow	17.0 a	6.8	4.0 a	5.9	0.5 a	1.4
100% slow	18.6 a	6.0	5.8 a	5.8	0.7 a	1.3
50% regular (yr 1)	23.4 a	7.7	8.1 a	5.6	1.4 a	2.9
100% regular (yr 1)	16.4 a	6.0	5.7 a	5.7	0.4 a	1.2
50% regular (yr 1 and 2)	17.0 a	4.7	4.9 a	5.7	1.0 a	1.6
100% regular (yr 1 and 2)	18.0 a	7.7	3.4 a	4.2	0.3 a	1.2
No fertilizer	16.4 a	6.0	4.5 a	6.1	0.4 a	1.6
T. hybridum monoculture						
50% slow	26.8 a	13.9	8.8 a	5.6	1.9 a	2.4
100% slow	20.5 a	6.3	7.5 a	5.1	1.4 a	2.3
50% regular (yr 1)	26.2 a	13.3	11.8 a	7.2	3.1 a	4.5
100% regular (yr 1)	19.2 a	8.5	9.0 a	6.1	2.7 a	3.3
50% regular (yr 1 and 2)	21.0 a	7.5	8.9 a	6.2	1.7 a	3.7
100% regular (yr 1 and 2)	22.7 a	15.0	8.8 a	8.0	1.4 a	2.7
No fertilizer	16.4 a	8.8	5.4 a	3.9	1.1 a	1.8

Table 2.38 Canopy height of monocultures and mixes at Genesee in fall 1996 (continued)

Species / Treatment	Canopy Level 1 (cm) Mean	S. D.	Canopy Level 2 (cm) Mean	S. D.	Canopy Level 3 (cm) Mean	S. D.
V. americana monoculture						
50% slow	17.7 a	14.2	4.7 a	4.5	1.4 a	3.9
100% slow	20.6 a	13.3	5.2 a	4.2	0.3 a	1.2
50% regular (yr 1)	17.9 a	13.2	5.8 a	6.4	0.8 a	1.4
100% regular (yr 1)	14.8 a	9.4	6.4 a	6.5	1.2 a	1.8
50% regular (yr 1 and 2)	15.5 a	9.9	3.5 a	4.2	0.3 a	1.2
100% regular (yr 1 and 2)	17.8 a	10.0	6.1 a	8.2	0.8 a	1.7
No fertilizer	9.5 a	7.2	1.8 a	2.4	0.0 a	0.0
A. smithii / B. inermis mix						
50% slow	19.0 a	9.9	5.9 a	5.5	1.2 a	2.0
100% slow	26.0 a	13.6	10.4 a	9.9	2.0 a	3.8
50% regular (yr 1)	21.8 a	11.8	9.2 a	8.6	1.9 a	3.8
100% regular (yr 1)	21.0 a	12.8	7.0 a	7.7	0.8 a	3.0
50% regular (yr 1 and 2)	17.6 a	8.3	5.7 a	5.0	1.2 a	1.9
100% regular (yr 1 and 2)	18.8 a	6.8	4.6 a	5.1	0.5 a	1.8
No fertilizer	18.0 a	11.9	5.8 a	6.3	0.9 a	2.2
P. pratense / S. viridula mix						
50% slow	30.1 a	10.6	12.6 a	6.6	1.4 a	3.4
100% slow	26.0 a	11.2	6.7 a	4.2	0.0 a	0.0
50% regular (yr 1)	26.5 a	10.2	11.3 a	6.5	1.4 a	2.2
100% regular (yr 1)	22.4 a	5.3	7.7 a	6.8	0.6 a	2.2
50% regular (yr 1 and 2)	23.8 a	6.8	6.6 a	5.2	0.0 a	0.0
100% regular (yr 1 and 2)	26.0 a	14.0	10.5 a	8.7	1.8 a	3.9
No fertilizer	21.0 a	7.4	11.0 a	10.3	1.8 a	3.7
T. hybridum / V. americana mix						
50% slow	19.1 a	10.0	6.9 a	6.0	2.8 a	2.6
100% slow	21.9 a	8.7	6.9 a	5.8	1.0 a	1.5
50% regular (yr 1)	19.2 a	14.3	7.9 a	6.7	1.6 a	2.4
100% regular (yr 1)	15.5 a	5.6	5.0 a	3.7	1.1 a	1.8
50% regular (yr 1 and 2)	20.4 a	12.5	8.1 a	4.0	1.9 a	2.0
100% regular (yr 1 and 2)	20.1 a	11.2	6.4 a	5.7	1.5 a	1.8
No fertilizer	18.2 a	12.1	6.5 a	5.8	1.4 a	2.4
A. smithii / S. viridula / V. americana mix						
50% slow	19.4 a	4.0	8.7 a	3.6	2.6 a	2.3
100% slow	22.2 a	8.0	8.8 a	4.4	1.1 a	1.7
50% regular (yr 1)	19.5 a	9.3	6.8 a	4.9	0.8 a	1.9
100% regular (yr 1)	19.0 a	5.8	7.1 a	4.7	0.9 a	2.4
50% regular (yr 1 and 2)	17.1 a	5.0	6.7 a	3.8	0.5 a	1.2
100% regular (yr 1 and 2)	20.8 a	8.3	6.6 a	5.4	1.1 a	2.3
No fertilizer	17.2 a	5.7	6.9 a	3.2	1.2 a	1.9

Table 2.38 Canopy height of monocultures and mixes at Genesee in fall 1996 (continued)

Species	Canopy Level 1 (cm)		Canopy Level 2 (cm)		Canopy Level 3 (cm)	
Treatment	Mean	S. D.	Mean	S. D.	Mean	S. D.
B. inermis / P. pratense / T. hybridum mix						
50% slow	26.8 a	15.9	9.2 a	7.3	2.3 a	3.4
100% slow	26.5 a	14.4	11.3 a	9.3	3.0 a	4.6
50% regular (yr 1)	17.6 a	9.4	6.6 a	7.7	2.1 a	4.4
100% regular (yr 1)	18.3 a	9.2	6.7 a	8.7	1.6 a	3.9
50% regular (yr 1 and 2)	15.2 a	5.7	6.4 a	6.6	2.0 a	3.6
100% regular (yr 1 and 2)	17.2 a	6.0	5.0 a	6.6	1.4 a	2.8
No fertilizer	15.5 a	6.7	5.1 a	4.0	0.6 a	1.5
A. smithii / B. inermis / P. pratense / S. viridula / T. hybridum / V. americana mix						
50% slow	18.9 a	8.3	6.8 a	6.6	0.9 a	2.2
100% slow	20.2 a	12.4	6.2 a	9.0	1.5 a	5.2
50% regular (yr 1)	22.3 a	11.0	9.2 a	6.8	1.2 a	2.2
100% regular (yr 1)	18.6 a	6.2	3.5 a	4.2	0.0 a	0.0
50% regular (yr 1 and 2)	18.2 a	9.2	4.8 a	5.9	0.8 a	2.6
100% regular (yr 1 and 2)	17.9 a	7.6	5.9 a	4.6	0.9 a	1.9
No fertilizer	13.2 a	4.3	3.6 a	3.2	0.0 a	0.0
Non - seeded species (control)						
50% slow	24.3 a	9.5	8.5 a	4.9	1.3 a	2.1
100% slow	26.2 a	12.9	8.7 a	7.8	1.1 a	2.0
50% regular (yr 1)	26.3 a	8.7	10.1 a	6.0	0.4 a	0.9
100% regular (yr 1)	18.3 a	3.7	5.6 a	3.7	0.0 a	0.0
50% regular (yr 1 and 2)	22.2 a	8.2	7.4 a	6.2	1.4 a	3.0
100% regular (yr 1 and 2)	24.5 a	10.3	9.7 a	6.2	1.2 a	3.2
No fertilizer	22.8 a	12.1	7.3 a	6.6	0.5 a	1.1

A. smithii = Agropyron smithii; B. inermis = Bromus inermis; P. pratense = Phleum pratense; S. viridula = Stipa viridula; T. hybridum = Trifolium hybridum; V. americana = Vicia americana

S. D. = Standard Deviation

Means within a column for a given species mix or monoculture followed by the same lower case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Table 2.39 Canopy height of monocultures and mixes at Genesee in spring 1997

Species / Treatment	Canopy Level 1 (cm) Mean	S. D.	Canopy Level 2 (cm) Mean	S. D.	Canopy Level 3 (cm) Mean	S. D.
A. smithii monoculture						
50% slow	10.0 a	3.7	2.8 a	3.3	0.0 a	0.0
100% slow	10.7 a	4.1	2.8 a	2.6	0.0 a	0.0
50% regular (yr 1)	8.4 a	2.0	0.7 a	1.7	0.0 a	0.0
100% regular (yr 1)	9.8 a	3.3	2.0 a	2.2	0.0 a	0.0
50% regular (yr 1 and 2)	9.1 a	2.0	1.7 a	2.2	0.0 a	0.0
100% regular (yr 1 and 2)	7.5 a	4.3	1.0 a	1.7	0.0 a	0.0
No fertilizer	8.8 a	3.5	0.8 a	1.6	0.0 a	0.0
B. inermis monoculture						
50% slow	14.0 bc	4.6	1.9 a	3.4	0.1 a	0.5
100% slow	16.2 c	4.4	2.8 a	3.9	0.2 a	0.8
50% regular (yr 1)	14.9 bc	3.2	1.8 a	3.1	0.0 a	0.0
100% regular (yr 1)	13.6 bc	2.4	1.6 a	2.3	0.1 a	0.4
50% regular (yr 1 and 2)	13.2 bc	2.6	2.2 a	3.0	0.0 a	0.0
100% regular (yr 1 and 2)	8.4 a	5.7	1.6 a	2.4	0.2 a	0.6
No fertilizer	10.8 ab	2.7	0.5 a	1.2	0.0 a	0.0
P. pratense monoculture						
50% slow	7.9 ab	2.8	0.8 a	1.6	0.0 a	0.0
100% slow	11.1 b	4.3	2.2 a	2.6	0.0 a	0.0
50% regular (yr 1)	6.9 a	1.7	0.5 a	1.0	0.0 a	0.0
100% regular (yr 1)	9.3 ab	2.7	1.8 a	2.9	0.0 a	0.0
50% regular (yr 1 and 2)	8.1 ab	2.2	1.7 a	2.0	0.0 a	0.0
100% regular (yr 1 and 2)	8.6 ab	3.8	2.1 a	3.1	0.0 a	0.0
No fertilizer	6.3 a	3.3	0.8 a	1.5	0.0 a	0.0
S. viridula monoculture						
50% slow	9.9 a	4.2	2.1 a	2.4	0.3 a	1.0
100% slow	12.2 a	5.3	2.2 a	2.6	0.0 a	0.0
50% regular (yr 1)	10.2 a	4.6	2.6 a	2.5	0.1 a	0.5
100% regular (yr 1)	11.3 a	7.2	3.0 a	3.1	0.0 a	0.0
50% regular (yr 1 and 2)	9.8 a	4.9	3.0 a	4.6	0.0 a	0.1
100% regular (yr 1 and 2)	10.5 a	2.9	2.9 a	2.9	0.0 a	0.0
No fertilizer	8.4 a	4.6	1.5 a	1.9	0.0 a	0.0
T. hybridum monoculture						
50% slow	9.7 b	3.6	1.8 a	2.6	0.4 a	0.9
100% slow	8.1 ab	1.8	1.4 a	2.4	0.4 a	0.9
50% regular (yr 1)	8.1 ab	2.3	0.8 a	1.8	0.4 a	1.0
100% regular (yr 1)	9.5 ab	3.5	1.1 a	2.1	0.2 a	0.6
50% regular (yr 1 and 2)	7.2 ab	3.5	1.0 a	1.8	0.0 a	0.0
100% regular (yr 1 and 2)	8.5 ab	3.1	1.5 a	2.1	0.2 a	0.6
No fertilizer	6.0 a	1.3	0.4 a	0.8	0.0 a	0.0

Table 2.39 Canopy height of monocultures and mixes at Genesee in spring 1997 (continued)

Species / Treatment	Canopy Level 1 (cm) Mean	S. D.	Canopy Level 2 (cm) Mean	S. D.	Canopy Level 3 (cm) Mean	S. D.
V. americana monoculture						
50% slow	7.2 a	3.0	2.2 a	2.2	0.0 a	0.0
100% slow	11.3 a	5.0	2.9 a	2.9	0.0 a	0.0
50% regular (yr 1)	9.5 a	4.4	3.1 a	3.0	0.1 a	0.3
100% regular (yr 1)	11.0 a	6.4	4.0 a	2.6	0.3 a	0.8
50% regular (yr 1 and 2)	7.6 a	3.2	2.9 a	2.5	0.3 a	1.2
100% regular (yr 1 and 2)	11.3 a	6.9	2.9 a	3.4	0.4 a	1.3
No fertilizer	8.0 a	2.5	2.9 a	2.5	0.3 a	1.2
A. smithii / B. inermis mix						
50% slow	15.5 ab	3.1	1.8 a	2.3	0.0 a	0.0
100% slow	17.9 b	4.1	2.2 a	2.8	0.3 a	0.8
50% regular (yr 1)	13.5 a	1.8	1.6 a	3.1	0.0 a	0.0
100% regular (yr 1)	14.2 a	2.9	1.9 a	2.7	0.2 a	0.6
50% regular (yr 1 and 2)	13.7 a	2.0	1.8 a	2.7	0.0 a	0.0
100% regular (yr 1 and 2)	13.2 a	3.9	1.5 a	3.1	0.0 a	0.0
No fertilizer	11.9 a	2.5	1.4 a	1.9	0.0 a	0.0
P. pratense / S. viridula mix						
50% slow	13.9 c	3.0	4.4 a	3.2	0.0 a	0.0
100% slow	12.6 bc	4.0	4.3 a	3.5	0.2 a	0.9
50% regular (yr 1)	11.0 abc	4.2	3.6 a	3.8	0.0 a	0.0
100% regular (yr 1)	9.6 ab	3.2	2.5 a	2.6	0.0 a	0.0
50% regular (yr 1 and 2)	9.0 ab	2.4	2.2 a	2.6	0.0 a	0.0
100% regular (yr 1 and 2)	7.1 a	3.6	1.2 a	2.0	0.0 a	0.0
No fertilizer	9.6 ab	3.7	2.5 a	3.3	0.4 a	1.5
T. hybridum / V. americana mix						
50% slow	8.7 a	1.8	3.6 a	2.0	0.2 a	0.5
100% slow	10.4 a	1.6	3.0 a	2.4	0.5 a	1.1
50% regular (yr 1)	12.2 a	6.6	3.6 a	3.0	0.4 a	1.1
100% regular (yr 1)	9.1 a	2.8	4.2 a	2.3	0.0 a	0.0
50% regular (yr 1 and 2)	7.8 a	1.6	1.6 a	2.0	0.4 a	1.0
100% regular (yr 1 and 2)	10.2 a	4.9	3.7 a	3.5	0.4 a	0.7
No fertilizer	9.0 a	5.7	2.6 a	2.8	0.4 a	0.9
A. smithii / S. viridula / V. americana mix						
50% slow	11.2 ab	2.7	3.2 a	2.7	0.1 a	0.5
100% slow	13.6 b	5.6	4.0 a	3.7	0.0 a	0.0
50% regular (yr 1)	9.1 a	2.9	2.4 a	2.6	0.0 a	0.0
100% regular (yr 1)	11.7 ab	2.4	3.7 a	3.0	0.1 a	0.4
50% regular (yr 1 and 2)	10.0 ab	3.1	3.4 a	3.0	0.0 a	0.0
100% regular (yr 1 and 2)	8.8 a	3.6	1.1 a	1.6	0.0 a	0.0
No fertilizer	9.2 a	2.6	2.3 a	2.0	0.0 a	0.0

Table 2.39 Canopy height of monocultures and mixes at Genesee in spring 1997 (continued)

Species	Canopy Level 1 (cm)		Canopy Level 2 (cm)		Canopy Level 3 (cm)	
Treatment	Mean	S. D.	Mean	S. D.	Mean	S. D.
B. inermis / P. pratense / T. hybridum mix						
50% slow	13.4 a	3.5	3.9 a	3.8	0.0 a	0.0
100% slow	13.7 a	4.0	2.8 a	3.2	0.0 a	0.0
50% regular (yr 1)	11.2 a	3.7	2.8 a	3.0	0.0 a	0.0
100% regular (yr 1)	11.3 a	4.0	2.6 a	3.2	0.0 a	0.0
50% regular (yr 1 and 2)	12.8 a	2.8	3.4 a	3.4	0.0 a	0.0
100% regular (yr 1 and 2)	9.8 a	3.5	2.1 a	3.0	0.0 a	0.0
No fertilizer	10.6 a	2.8	4.0 a	3.2	0.0 a	0.0
A. smithii / B. inermis / P. pratense / S. viridula / T. hybridum / V. americana mix						
50% slow	13.4 ab	4.0	5.7 a	2.1	0.0 a	0.0
100% slow	17.6 b	7.0	7.3 a	4.0	0.9 a	2.2
50% regular (yr 1)	12.3 ab	3.7	4.7 a	2.6	0.4 a	1.4
100% regular (yr 1)	13.5 ab	2.9	5.9 a	1.3	0.0 a	0.0
50% regular (yr 1 and 2)	11.9 a	3.4	4.3 a	2.8	0.2 a	0.8
100% regular (yr 1 and 2)	11.1 a	5.6	4.9 a	3.7	0.5 a	1.9
No fertilizer	10.7 a	3.3	4.4 a	2.4	0.3 a	1.1
Non - seeded species (control)						
50% slow	9.7 a	6.3	2.1 a	4.0	0.1 a	0.3
100% slow	7.3 a	3.3	1.5 a	2.4	0.1 a	0.3
50% regular (yr 1)	7.2 a	2.2	0.9 a	1.6	0.0 a	0.0
100% regular (yr 1)	8.6 a	3.7	0.8 a	1.2	0.0 a	0.0
50% regular (yr 1 and 2)	6.0 a	2.5	0.8 a	1.5	0.0 a	0.0
100% regular (yr 1 and 2)	8.6 a	4.4	1.4 a	3.5	0.2 a	0.8
No fertilizer	8.5 a	3.3	2.1 a	2.3	0.0 a	0.0

A. smithii = Agropyron smithii; B. inermis = Bromus inermis; P. pratense = Phleum pratense; S. viridula = Stipa viridula; T. hybridum = Trifolium hybridum; V. americana = Vicia americana

S. D. = Standard Deviation

Means within a column for a given species mix or monoculture followed by the same lower case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Table 2.40 Canopy height of monocultures and mixes at Genesee in fall 1997

Species / Treatment	Canopy Level 1 (cm) Mean	S. D.	Canopy Level 2 (cm) Mean	S. D.	Canopy Level 3 (cm) Mean	S. D.
A. smithii monoculture						
50% slow	39.2 a	20.7	13.0 a	6.5	2.8 a	4.0
100% slow	31.8 a	8.0	16.2 a	7.1	5.2 a	5.8
50% regular (yr 1)	29.7 a	19.4	10.2 a	7.4	1.5 a	3.7
100% regular (yr 1)	25.1 a	12.8	10.3 a	9.9	1.9 a	3.6
50% regular (yr 1 and 2)	38.7 a	22.2	14.3 a	7.1	2.2 a	2.9
100% regular (yr 1 and 2)	31.1 a	16.2	12.4 a	8.1	3.5 a	4.6
No fertilizer	31.6 a	20.8	12.8 a	8.6	4.1 a	3.2
B. inermis monoculture						
50% slow	32.5 a	15.4	12.4 a	9.9	4.3 a	7.4
100% slow	30.2 a	20.8	13.0 a	11.5	2.4 a	5.2
50% regular (yr 1)	32.5 a	16.5	12.5 a	8.0	1.5 a	4.0
100% regular (yr 1)	23.8 a	13.8	10.7 a	6.3	2.1 a	4.5
50% regular (yr 1 and 2)	36.8 a	17.7	14.5 a	10.9	1.4 a	2.8
100% regular (yr 1 and 2)	28.7 a	9.4	12.4 a	8.5	0.2 a	0.6
No fertilizer	27.1 a	19.9	9.2 a	13.0	3.1 a	4.2
P. pratense monoculture						
50% slow	50.1 ab	18.8	23.5 a	15.0	4.0 a	4.6
100% slow	46.9 ab	19.2	21.1 a	9.1	6.9 a	6.5
50% regular (yr 1)	42.0 a	15.1	16.8 a	7.5	4.8 a	5.9
100% regular (yr 1)	55.7 ab	13.9	26.8 a	7.7	7.2 a	5.1
50% regular (yr 1 and 2)	63.6 b	19.6	28.9 a	17.4	7.2 a	7.9
100% regular (yr 1 and 2)	47.4 ab	19.1	19.5 a	8.0	5.6 a	3.8
No fertilizer	44.1 ab	14.7	21.8 a	10.3	6.8 a	6.7
S. viridula monoculture						
50% slow	49.8 a	38.0	14.2 a	9.5	3.2 a	4.7
100% slow	38.3 a	29.0	12.8 a	9.2	3.7 a	4.3
50% regular (yr 1)	32.4 a	16.3	11.7 a	10.4	3.5 a	5.0
100% regular (yr 1)	26.5 a	17.4	11.1 a	10.7	3.1 a	4.8
50% regular (yr 1 and 2)	43.0 a	20.2	16.0 a	13.8	5.3 a	6.0
100% regular (yr 1 and 2)	45.5 a	19.4	17.5 a	7.7	4.7 a	6.1
No fertilizer	40.8 a	16.8	14.5 a	6.9	3.1 a	4.0
T. hybridum monoculture						
50% slow	40.6 a	9.3	17.7 a	11.5	4.8 a	6.1
100% slow	39.5 a	10.9	22.6 a	11.2	10.3 a	9.3
50% regular (yr 1)	43.5 a	7.9	25.4 a	7.4	8.6 a	7.8
100% regular (yr 1)	34.8 a	7.8	17.8 a	10.9	6.1 a	5.4
50% regular (yr 1 and 2)	43.0 a	7.8	19.7 a	11.5	7.0 a	8.3
100% regular (yr 1 and 2)	41.3 a	16.2	20.5 a	11.3	7.5 a	7.3
No fertilizer	46.3 a	22.2	21.5 a	11.0	6.6 a	7.4

Table 2.40 Canopy height of monocultures and mixes at Genesee in fall 1997 (continued)

Species / Treatment	Canopy Level 1 (cm) Mean	S. D.	Canopy Level 2 (cm) Mean	S. D.	Canopy Level 3 (cm) Mean	S. D.
V. americana monoculture						
50% slow	53.9 a	19.2	17.4 a	13.2	2.8 a	4.7
100% slow	49.7 a	13.7	14.8 a	9.2	3.8 a	5.8
50% regular (yr 1)	49.4 a	18.0	16.2 a	10.2	2.7 a	4.8
100% regular (yr 1)	48.1 a	19.9	16.5 a	12.4	3.1 a	4.7
50% regular (yr 1 and 2)	48.5 a	22.1	18.7 a	9.1	2.4 a	3.3
100% regular (yr 1 and 2)	46.8 a	26.7	14.9 a	10.1	2.5 a	5.6
No fertilizer	48.4 a	19.3	15.8 a	15.5	4.2 a	6.2
A. smithii / B. inermis mix						
50% slow	53.3 ab	21.1	20.5 ab	5.4	3.0 a	4.0
100% slow	42.2 ab	24.4	23.3 b	13.1	7.1 a	6.6
50% regular (yr 1)	38.4 b	14.0	17.8 ab	8.2	4.2 a	5.6
100% regular (yr 1)	36.2 ab	17.4	14.2 ab	8.4	3.2 a	4.1
50% regular (yr 1 and 2)	55.0 ab	25.9	19.3 ab	10.1	5.2 a	5.1
100% regular (yr 1 and 2)	48.8 ab	21.8	20.5 ab	8.9	3.1 a	4.8
No fertilizer	29.5 a	17.6	9.9 a	6.9	2.5 a	3.2
P. pratense / S. viridula mix						
50% slow	46.8 a	23.3	18.2 ab	11.4	4.4 ab	5.2
100% slow	53.8 a	20.1	22.0 ab	12.3	2.0 a	3.0
50% regular (yr 1)	49.2 a	12.7	17.2 ab	5.8	3.0 ab	2.7
100% regular (yr 1)	40.3 a	19.0	12.1 a	9.2	1.0 a	2.9
50% regular (yr 1 and 2)	59.0 a	22.2	28.2 b	18.4	4.5 ab	5.3
100% regular (yr 1 and 2)	54.8 a	11.1	22.2 ab	7.9	1.5 a	2.5
No fertilizer	46.5 a	11.5	23.3 ab	10.3	7.4 b	6.4
T. hybridum / V. americana mix						
50% slow	47.4 a	10.6	26.2 a	14.7	7.5 a	11.4
100% slow	38.1 a	13.2	16.3 a	11.1	5.6 a	7.1
50% regular (yr 1)	45.7 a	13.5	25.2 a	15.2	4.5 a	8.9
100% regular (yr 1)	46.7 a	18.8	19.8 a	8.2	6.4 a	7.6
50% regular (yr 1 and 2)	45.1 a	9.5	16.2 a	10.4	5.5 a	7.6
100% regular (yr 1 and 2)	49.1 a	17.9	21.1 a	14.6	5.3 a	7.7
No fertilizer	37.5 a	14.4	19.8 a	14.6	8.7 a	11.3
A. smithii / S. viridula / V. americana mix						
50% slow	42.1 a	24.7	14.8 ab	8.0	3.2 a	4.6
100% slow	46.1 a	15.8	18.2 ab	4.8	4.0 a	4.4
50% regular (yr 1)	50.5 a	19.8	20.7 b	6.3	5.7 a	4.3
100% regular (yr 1)	33.9 a	17.2	11.0 a	5.1	1.9 a	2.4
50% regular (yr 1 and 2)	38.2 a	20.0	16.2 ab	11.0	4.6 a	4.6
100% regular (yr 1 and 2)	47.5 a	29.3	14.2 ab	8.4	3.4 a	3.3
No fertilizer	43.6 a	19.7	18.0 ab	7.3	4.4 a	4.1

Table 2.40 Canopy height of monocultures and mixes at Genesee in fall 1997 (continued)

Species / Treatment	Canopy Level 1 (cm) Mean	S. D.	Canopy Level 2 (cm) Mean	S. D.	Canopy Level 3 (cm) Mean	S. D.
B. inermis / P. pratense / T. hybridum mix						
50% slow	56.2 a	16.7	28.8 a	13.9	7.4 a	8.6
100% slow	46.8 a	23.1	17.6 a	14.0	6.5 a	8.4
50% regular (yr 1)	45.6 a	10.6	23.5 a	9.8	2.6 a	5.2
100% regular (yr 1)	40.6 a	11.8	18.3 a	10.5	3.6 a	5.4
50% regular (yr 1 and 2)	57.8 a	22.9	29.7 a	12.8	5.7 a	9.8
100% regular (yr 1 and 2)	51.6 a	21.1	26.5 a	18.5	5.4 a	6.1
No fertilizer	48.2 a	18.8	20.3 a	7.0	3.4 a	4.4
A. smithii / B. inermis / P. pratense / S. viridula / T. hybridum / V. americana mix						
50% slow	59.5 a	19.3	24.5 a	12.2	4.2 a	6.0
100% slow	48.4 a	19.7	25.2 a	11.9	4.0 a	3.5
50% regular (yr 1)	49.2 a	13.6	15.9 a	13.6	4.6 a	7.6
100% regular (yr 1)	47.6 a	23.4	20.0 a	14.4	6.1 a	7.3
50% regular (yr 1 and 2)	62.1 a	24.6	28.2 a	15.4	6.2 a	6.8
100% regular (yr 1 and 2)	58.8 a	18.0	25.5 a	10.5	6.5 a	4.5
No fertilizer	43.3 a	12.6	17.6 a	12.3	4.2 a	4.4
Non - seeded species (control)						
50% slow	34.8 a	13.1	11.5 a	8.7	1.4 a	2.3
100% slow	30.2 a	15.9	10.5 a	6.9	2.3 a	4.3
50% regular (yr 1)	33.9 a	22.1	12.4 a	11.5	1.9 a	3.9
100% regular (yr 1)	26.7 a	15.1	9.8 a	8.0	1.4 a	2.5
50% regular (yr 1 and 2)	35.0 a	21.4	13.7 a	9.1	1.3 a	3.1
100% regular (yr 1 and 2)	30.4 a	19.2	11.5 a	11.0	1.5 a	3.8
No fertilizer	34.9 a	20.9	12.7 a	11.2	1.8 a	4.3

A. smithii = Agropyron smithii; B. inermis = Bromus inermis; P. pratense = Phleum pratense; S. viridula = Stipa viridula; T. hybridum = Trifolium hybridum; V. americana = Vicia americana

S. D. = Standard Deviation

Means within a column for a given species mix or monoculture followed by the same lower case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Table 2.41 Ground cover of monocultures and mixes at Genesee in fall 1996

Species / Treatment	Live Vegetation (%) Mean	S. D.	Litter (%) Mean	S. D.	Bare Ground (%) Mean	S. D.	Litter Depth (cm) Mean	S. D.
A. smithii monoculture								
50% slow	4 aAB	4	0 aA	0	95*aAB	5	0.0 aA	0.0
100% slow	3 aAB	3	0 aA	0	96*aAB	4	0.0 aA	0.0
50% regular (yr 1)	3 aA	4	0 aA	0	96*aA	5	0.2 aA	0.6
100% regular (yr 1)	4 aA	5	0 aA	0	95*aA	6	0.0 aA	0.0
50% regular (yr 1 and 2)	3 aA	3	0 aA	0	96*aA	3	0.0 aA	0.0
100% regular (yr 1 and 2)	2 aA	1	0 aA	0	98*aA	1	0.0 aA	0.0
No fertilizer	2 aA	3	0 aA	0	97*aA	4	0.0 aA	0.0
B. inermis monoculture								
50% slow	3 aAB	1	0 aA	0	97 aB	1	0.0 aA	0.0
100% slow	3 aAB	1	0 aA	1	97 aAB	2	0.0 aA	0.1
50% regular (yr 1)	3 aA	3	0 aA	0	96*aA	3	0.0 aA	0.0
100% regular (yr 1)	2 aA	1	0 aA	0	96*aA	2	0.0 aA	0.0
50% regular (yr 1 and 2)	2 aA	1	0 aA	0	97*aA	2	0.0 aA	0.0
100% regular (yr 1 and 2)	3 aA	3	0 aA	0	96*aA	3	0.0 aA	0.0
No fertilizer	2 aA	3	0 aA	0	97*aA	4	0.0 aA	0.0
P. pratense monoculture								
50% slow	1 aA	1	0 aA	0	97*aB	2	0.0 aA	0.0
100% slow	1 aA	1	0 aA	0	98*aAB	2	0.0 aA	0.0
50% regular (yr 1)	2 aA	1	0 aA	0	97*aA	1	0.0 aA	0.0
100% regular (yr 1)	1 aA	1	0 aA	0	97*aA	2	0.0 aA	0.0
50% regular (yr 1 and 2)	1 aA	1	0 aA	0	98*aA	1	0.0 aA	0.0
100% regular (yr 1 and 2)	1 aA	0	0 aA	0	98*aA	1	0.0 aA	0.0
No fertilizer	1 aA	1	0 aA	0	97*aA	2	0.1 aA	0.4
S. viridula monoculture								
50% slow	2 aA	1	0 aA	1	97*aB	2	0.0 aA	0.0
100% slow	3 aAB	2	0 aA	1	95*aAB	2	0.0 aA	0.0
50% regular (yr 1)	2 aA	1	0 aA	0	97*aA	2	0.0 aA	0.0
100% regular (yr 1)	2 aA	2	0 aA	0	97*aA	2	0.0 aA	0.0
50% regular (yr 1 and 2)	2 aA	1	0 aA	0	97*aA	2	0.0 aA	0.0
100% regular (yr 1 and 2)	2 aA	2	0 aA	1	97 aA	3	0.0 aA	0.1
No fertilizer	3 aA	4	0 aA	0	96*aA	6	0.0 aA	0.0
T. hybridum monoculture								
50% slow	2 aA	1	0 aA	0	97*a B	1	0.1 aA	0.4
100% slow	1 aA	1	0 aA	0	97*aAB	2	0.0 aA	0.0
50% regular (yr 1)	3 aA	1	0 aA	0	97 aA	2	0.0 aA	0.0
100% regular (yr 1)	2 aA	1	0 aA	0	97*aA	2	0.0 aA	0.0
50% regular (yr 1 and 2)	2 aA	1	0 aA	0	97*aA	2	0.0 aA	0.0
100% regular (yr 1 and 2)	2 aA	1	0 aA	0	97*aA	4	0.0 aA	0.0
No fertilizer	2 aA	1	0 aA	0	97*aA	1	0.0 aA	0.0

Table 2.41 Ground cover of monocultures and mixes at Genesee in fall 1996 (continued)

Species / Treatment	Live Vegetation (%) Mean	S. D.	Litter (%) Mean	S. D.	Bare Ground (%) Mean	S. D.	Litter Depth (cm) Mean	S. D.
V. americana monoculture								
50% slow	6 aB	5	0 aA	0	92*aA	5	0.0 aA	0.0
100% slow	5 aB	6	0 aA	1	93*aA	7	0.0 aA	0.1
50% regular (yr 1)	4 aA	5	0 aA	1	94*aA	5	0.0 aA	0.1
100% regular (yr 1)	3 aA	4	0 aA	0	96*aA	4	0.0 aA	0.0
50% regular (yr 1 and 2)	3 aA	3	0 aA	0	96*aA	4	0.0 aA	0.0
100% regular (yr 1 and 2)	2 aA	1	0 aA	0	97*aA	3	0.0 aA	0.0
No fertilizer	2 aA	2	0 aA	0	96*aA	4	0.0 aA	0.0
A. smithii / B. inermis mix								
50% slow	3 aAB	3	0 aA	0	95*aAB	4	0.0 aA	0.0
100% slow	3 aAB	2	0 aA	0	96*aAB	3	0.2 aA	0.7
50% regular (yr 1)	2 aA	2	0 aA	0	96*aA	4	0.0 aA	0.0
100% regular (yr 1)	2 aA	1	0 aA	1	96*aA	2	0.0 aA	0.0
50% regular (yr 1 and 2)	3 aA	2	0 aA	1	95*aA	3	0.0 aA	0.0
100% regular (yr 1 and 2)	3 aA	2	0 aA	1	96*aA	3	0.0 aA	0.0
No fertilizer	2 aA	1	0 aA	0	97*aA	2	0.0 aA	0.0
P. pratense / S. viridula mix								
50% slow	3 aAB	2	0 aA	0	97 aB	2	0.0 aA	0.0
100% slow	2 aAB	1	0 aA	0	98 aB	1	0.0 aA	0.0
50% regular (yr 1)	2 aA	2	0 aA	0	96*aA	4	0.0 aA	0.0
100% regular (yr 1)	2 aA	2	0 aA	0	96*aA	2	0.0 aA	0.0
50% regular (yr 1 and 2)	2 aA	2	0 aA	0	97*aA	2	0.0 aA	0.0
100% regular (yr 1 and 2)	3 aA	3	0 aA	0	96*aA	3	0.0 aA	0.0
No fertilizer	2 aA	3	0 aA	0	97*aA	3	0.0 aA	0.0
T. hybridum / V. americana mix								
50% slow	2 aA	1	0 aA	1	96*aB	2	0.0 aA	0.0
100% slow	2 aAB	2	0 aA	1	96*aAB	3	0.0 aA	0.0
50% regular (yr 1)	2 aA	2	0 aA	1	97*aA	3	0.0 aA	0.0
100% regular (yr 1)	3 aA	3	0 aA	1	96*aA	4	0.0 aA	0.0
50% regular (yr 1 and 2)	3 aA	4	0 aA	1	96*aA	5	0.1 aB	0.1
100% regular (yr 1 and 2)	2 aA	1	0 aA	0	97*aA	2	0.0 aA	0.0
No fertilizer	2 aA	2	0 aA	1	96*aA	2	0.2 aA	0.5
A. smithii / S. viridula / V. americana mix								
50% slow	2 aA	1	0 aA	0	97*aB	2	0.0 aA	0.0
100% slow	2 aA	1	0 aA	0	97*aAB	1	0.0 aA	0.0
50% regular (yr 1)	1 aA	1	0 aA	0	97*aA	1	0.0 aA	0.0
100% regular (yr 1)	1 aA	1	0 aA	0	98*aA	1	0.0 aA	0.0
50% regular (yr 1 and 2)	1 aA	0	0 aA	0	98*aA	1	0.0 aA	0.0
100% regular (yr 1 and 2)	1 aA	0	0 aA	0	98*aA	1	0.0 aA	0.0
No fertilizer	1 aA	0	0 aA	0	96*aA	2	0.0 aA	0.0

Table 2.41 Ground cover of monocultures and mixes at Genesee in fall 1996 (continued)

Species / Treatment	Live Vegetation (%) Mean	S. D.	Litter (%) Mean	S. D.	Bare Ground (%) Mean	S. D.	Litter Depth (cm) Mean	S. D.
B. inermis / P. pratense / T. hybridum mix								
50% slow	4 aAB	4	0 aA	1	94*aAB	4	0.0 aA	0.1
100% slow	3 aAB	3	0 aA	0	96*aAB	3	0.2 aA	0.6
50% regular (yr 1)	3 aA	2	0 aA	1	96*aA	3	0.1 aA	0.4
100% regular (yr 1)	3 aA	2	0 aA	1	96*aA	3	0.0 aA	0.1
50% regular (yr 1 and 2)	3 aA	1	0 aA	1	96*aA	4	0.0 aA	0.0
100% regular (yr 1 and 2)	3 aA	2	0 aA	0	96*aA	4	0.0 aA	0.0
No fertilizer	2 aA	1	1 aA	2	96*aA	3	0.0 aA	0.1
A. smithii / B. inermis / P. pratense / S. viridula / T. hybridum / V. americana mix								
50% slow	2 aAB	2	0 aA	1	96*aB	2	0.0 aA	0.0
100% slow	4 aAB	3	0 aA	1	94*aAB	4	0.0 aA	0.0
50% regular (yr 1)	3 aA	2	0 aA	1	96*aA	3	0.0 aA	0.1
100% regular (yr 1)	4 aA	3	0 aA	1	95*aA	4	0.0 aA	0.1
50% regular (yr 1 and 2)	3 aA	4	0 aA	1	94*aA	5	0.0 aAB	0.0
100% regular (yr 1 and 2)	2 aA	2	0 aA	1	96*aA	4	0.0 aA	0.1
No fertilizer	2 aA	1	1 aA	1	96*aA	2	0.0 aA	0.1
Non - seeded species (control)								
50% slow	2 abA	1	0 aA	0	97*aB	1	0.0 aA	0.0
100% slow	3 bAB	2	0 aA	0	97*aAB	2	0.0 aA	0.0
50% regular (yr 1)	2 abA	1	0 aA	0	96*aA	2	0.0 aA	0.0
100% regular (yr 1)	2 abA	1	0 aA	0	97*aA	2	0.0 aA	0.0
50% regular (yr 1 and 2)	1 aA	1	0 aA	0	97*aA	2	0.0 aA	0.0
100% regular (yr 1 and 2)	2 abA	1	0 aA	0	98*aA	2	0.0 aA	0.0
No fertilizer	1 aA	1	0 aA	0	98*aA	1	0.0 aA	0.0

* % Rocks ≥0.01

A. smithii = Agropyron smithii; B. inermis = Bromus inermis; P. pratense = Phleum pratense; S. viridula = Stipa viridula; T. hybridum = Trifolium hybridum; V. americana = Vicia americana

S. D. = Standard Deviation

Means within a column for a given species mix or monoculture followed by the same lower case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Means within a column for a specific fertilizer treatment followed by the same upper case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Table 2.42 Ground cover of monocultures and mixes at Genesee in spring 1997

Species / Treatment	Live Vegetation (%) Mean	S. D.	Litter (%) Mean	S. D.	Bare Ground (%) Mean	S. D.	Litter Depth (cm) Mean	S. D.
A. smithii monoculture								
50% slow	2 aAB	2	7 abABC	8	90*abABC	9	0.4 abA	0.6
100% slow	2 aAB	2	14 bAB	16	82*aABC	18	0.5 bA	0.4
50% regular (yr 1)	1 aAB	1	7 abABCD	7	91*abABC	8	0.1 abA	0.1
100% regular (yr 1)	1 aA	1	8 abABC	8	90*abBCD	9	0.2 abA	0.1
50% regular (yr 1 and 2)	2 aAB	3	6 abAB	8	91*abAB	10	0.2 abA	0.1
100% regular (yr 1 and 2)	2 aAB	3	8 abAB	10	89*abABC	11	0.2 abA	0.1
No fertilizer	1 aA	1	2 aABC	1	95*bBC	2	0.1 aA	0.0
B. inermis monoculture								
50% slow	2 aABCD	3	10 aABC	11	87 abABC	11	0.2 aA	0.2
100% slow	3 aAB	3	8 aAB	6	89*abABC	7	0.3 aA	0.4
50% regular (yr 1)	1 aAB	1	10 aBCD	7	89*abABC	8	0.3 aA	0.3
100% regular (yr 1)	3 aABC	5	12 aABC	12	85*aABCD	12	0.2 aAB	0.2
50% regular (yr 1 and 2)	1 aA	1	9 aAB	8	89*abAB	8	0.2 aA	0.2
100% regular (yr 1 and 2)	1 aA	1	3 aAB	4	95*bBC	4	0.2 aA	0.2
No fertilizer	1 aA	1	6 aBCD	6	91*abABC	6	0.2 aA	0.1
P. pratense monoculture								
50% slow	2 aABC	1	2 aA	1	96*aC	3	0.2 abA	0.1
100% slow	2 aAB	2	4 aA	2	93*aC	4	0.2 abA	0.2
50% regular (yr 1)	1 aAB	1	2 aA	2	95*aC	4	0.2 abA	0.1
100% regular (yr 1)	2 aAB	1	2 aA	2	95*aCD	2	0.2 abAB	0.2
50% regular (yr 1 and 2)	2 aAB	1	3 aA	3	94*aB	3	0.3 bA	0.2
100% regular (yr 1 and 2)	1 aA	1	3 aA	3	96*aC	4	0.2 abA	0.2
No fertilizer	2 aAB	2	2 aA	2	96*aC	4	0.1 aA	0.1
S. viridula monoculture								
50% slow	0 aA	1	6 abABC	9	92*abBC	9	0.3 aA	0.2
100% slow	1 aA	1	9 bAB	12	89*aABC	13	0.3 aA	0.2
50% regular (yr 1)	0 aA	1	4 abAB	3	95*abC	4	0.3 aA	0.3
100% regular (yr 1)	0 aA	1	3 abAB	2	96*abD	3	0.3 aAB	0.3
50% regular (yr 1 and 2)	1 aA	1	3 abA	5	95*abB	6	0.2 aA	0.1
100% regular (yr 1 and 2)	1 aA	1	3 abA	3	96*abC	3	0.3 aA	0.4
No fertilizer	0 aA	1	1 aA	1	97*bC	2	0.2 aA	0.1
T. hybridum monoculture								
50% slow	6 aCD	3	7 aCD	6	86*aABC	9	0.2 aA	0.2
100% slow	4 aAB	3	7 aAB	7	87*aABC	8	0.4 aA	0.6
50% regular (yr 1)	5 aCD	4	5 aABC	3	89*aABC	7	0.2 aA	0.1
100% regular (yr 1)	6 aBC	4	6 aABC	6	87*aABCD	9	0.2 aAB	0.1
50% regular (yr 1 and 2)	5 aC	6	7 aAB	6	86*aAB	12	0.2 aA	0.1
100% regular (yr 1 and 2)	7 aB	14	6 aAB	4	86*aABC	14	0.1 aA	0.1
No fertilizer	4 aBC	3	4 aABCD	4	90*aABC	6	0.2 aA	0.2

Table 2.42 Ground cover of monocultures and mixes at Genesee in spring 1997 (continued)

Species / Treatment	Live Vegetation (%) Mean	S. D.	Litter (%) Mean	S. D.	Bare Ground (%) Mean	S. D.	Litter Depth (cm) Mean	S. D.
V. americana monoculture								
50% slow	1 aA	1	3 aAB	3	96*aC	3	0.2 abA	0.2
100% slow	1 aAB	1	6 aAB	4	92*aBC	4	0.5 bA	0.6
50% regular (yr 1)	2 aABC	3	5 aABC	6	91*aABC	9	0.2 abA	0.2
100% regular (yr 1)	1 aA	1	4 aAB	4	94*aCD	4	0.3 abAB	0.3
50% regular (yr 1 and 2)	1 aA	1	3 aA	3	95*aB	4	0.2 abA	0.2
100% regular (yr 1 and 2)	1 aA	1	3 aA	3	95*aBC	4	0.3 abA	0.4
No fertilizer	1 aA	1	2 aABC	2	96*aC	3	0.2 aA	0.1
A. smithii / B. inermis mix								
50% slow	2 aABC	1	12 aABC	7	85*aABC	9	0.3 aA	0.2
100% slow	3 aAB	3	20 aAB	13	75*aA	15	0.4 aA	0.2
50% regular (yr 1)	2 aABC	3	13 aAB	11	83*aAB	14	0.3 aA	0.3
100% regular (yr 1)	2 aABC	3	16 aAB	13	80*aAB	15	0.4 aB	0.2
50% regular (yr 1 and 2)	2 aABC	3	15 aA	17	81*aA	21	0.4 aA	0.6
100% regular (yr 1 and 2)	2 aAB	2	14 aAB	12	83*aABC	16	0.4 aA	0.4
No fertilizer	1 aA	2	7 aA	6	89*aAB	8	0.2 aA	0.1
P. pratense / S. viridula mix								
50% slow	1 aA	2	4 abABC	3	93*abBC	4	0.2 aA	0.1
100% slow	2 aAB	2	10 bAB	13	86*aABC	13	0.3 aA	0.4
50% regular (yr 1)	1 aAB	1	4 abAB	3	94*abBC	4	0.2 aA	0.2
100% regular (yr 1)	1 aA	1	3 abAB	2	94*abCD	2	0.2 aAB	0.2
50% regular (yr 1 and 2)	1 aA	1	3 abA	3	95*abB	3	0.2 aA	0.2
100% regular (yr 1 and 2)	1 aA	2	7 abAB	13	91*abABC	13	0.2 aA	0.2
No fertilizer	1 aA	1	1 aA	2	97*bC	3	0.2 aA	0.1
T. hybridum / V. americana mix								
50% slow	5 aBCD	4	11 abABC	8	82*aAB	12	0.3 aA	0.2
100% slow	5 aB	3	18 bAB	15	76*aAB	18	0.3 aA	0.1
50% regular (yr 1)	5 aD	3	9 abABCD	5	83*aAB	9	0.3 aA	0.5
100% regular (yr 1)	6 aC	3	11 abABC	8	80*aAB	12	0.2 aAB	0.1
50% regular (yr 1 and 2)	5 aBC	3	9 abAB	6	84*aAB	10	0.3 aA	0.2
100% regular (yr 1 and 2)	4 aAB	4	12 abAB	12	81*aA	16	0.3 aA	0.3
No fertilizer	6 aC	5	7 aCD	5	85*aA	9	0.2 aA	0.2
A. smithii / S. viridula / V. americana mix								
50% slow	2 aAB	2	13 aBC	13	83*aABC	13	0.3 aA	0.2
100% slow	3 aAB	3	12 aAB	8	84*aABC	9	0.3 aA	0.2
50% regular (yr 1)	1 aAB	1	6 aABCD	4	90*aABC	6	0.3 aA	0.3
100% regular (yr 1)	2 aA	2	13 aBC	13	84*aABC	14	0.3 aAB	0.2
50% regular (yr 1 and 2)	2 aAB	2	6 aAB	4	89*aAB	9	0.3 aA	0.2
100% regular (yr 1 and 2)	1 aA	1	12 aAB	9	86*aABC	10	0.2 aA	0.1
No fertilizer	1 aA	1	4 aABCD	3	93*aBC	5	0.2 aA	0.1

Table 2.42 Ground cover of monocultures and mixes at Genesee in spring 1997 (continued)

Species / Treatment	Live Vegetation (%) Mean	S. D.	Litter (%) Mean	S. D.	Bare Ground (%) Mean	S. D.	Litter Depth (cm) Mean	S. D.
B. inermis / P. pratense / T. hybridum mix								
50% slow	2 aABCD	4	5 abABC	4	92*abBC	5	0.2 aA	0.2
100% slow	2 aAB	3	12 bAB	14	85*aABC	14	0.3 aA	0.2
50% regular (yr 1)	4 aBCD	3	3 aAB	3	93*abABC	4	0.1 aA	0.0
100% regular (yr 1)	2 aA	1	7 abABC	8	90*abBCD	8	0.2 aAB	0.2
50% regular (yr 1 and 2)	4 aABC	2	4 abA	4	91*abAB	6	0.2 aA	0.1
100% regular (yr 1 and 2)	2 aA	2	4 abAB	4	94*abABC	6	0.2 aA	0.1
No fertilizer	2 aAB	2	2 aAB	1	95*bBC	2	0.2 aA	0.3
A. smithii / B. inermis / P. pratense / S. viridula / T. hybridum / V. americana mix								
50% slow	1 aA	1	8 abABC	6	90*aABC	7	0.3 aA	0.2
100% slow	2 aAB	2	10 bAB	12	88 aABC	12	0.3 aA	0.2
50% regular (yr 1)	2 aABCD	2	9 abABCD	7	88*aABC	10	0.2 aA	0.1
100% regular (yr 1)	1 aA	1	4 abAB	2	94 aCD	2	0.3 aAB	0.2
50% regular (yr 1 and 2)	1 aA	1	4 abA	3	94*aB	3	0.2 aA	0.2
100% regular (yr 1 and 2)	1 aA	1	5 abAB	5	92*aABC	6	0.2 aA	0.2
No fertilizer	1 aA	1	2 aABC	1	96*aBC	2	0.2 aA	0.1
Non - seeded species (control)								
50% slow	6 aD	6	14 aC	15	77*aA	19	0.2 abA	0.2
100% slow	4 aB	4	16 aAB	14	76*aAB	18	0.3 bA	0.3
50% regular (yr 1)	3 aABCD	4	12 aCD	9	82*aA	12	0.2 abA	0.1
100% regular (yr 1)	6 aC	6	15 aC	11	76*aA	14	0.2 abAB	0.1
50% regular (yr 1 and 2)	3 aABC	4	10 aAB	11	85*aAB	13	0.2 abA	0.2
100% regular (yr 1 and 2)	4 aAB	4	11 aAB	10	82*aAB	15	0.3 abA	0.2
No fertilizer	2 aAB	2	5 aABCD	5	91*aABC	8	0.1 aA	0.0

* % Rocks $\geq$0.01

A. smithii = Agropyron smithii; B. inermis = Bromus inermis; P. pratense = Phleum pratense;
S. viridula = Stipa viridula; T. hybridum = Trifolium hybridum; V. americana = Vicia americana

S. D. = Standard Deviation

Means within a column for a given species mix or monoculture followed by the same lower case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Means within a column for a specific fertilizer treatment followed by the same upper case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Table 2.43 Ground cover of monocultures and mixes at Genesee in fall 1997

Species / Treatment	Live Vegetation (%) Mean	S. D.	Litter (%) Mean	S. D.	Bare Ground (%) Mean	S. D.	Litter Depth (cm) Mean	S. D.
A. smithii monoculture								
50% slow	2 aA	1	3 abA	3	94*aB	3	0.3 aAB	0.3
100% slow	2 aA	1	3 abA	2	94*aB	3	0.2 aA	0.2
50% regular (yr 1)	2 aA	4	2 aA	1	95*aB	4	0.2 aABC	0.2
100% regular (yr 1)	3 aA	5	2 abA	1	94*aA	5	0.3 aAB	0.2
50% regular (yr 1 and 2)	1 aA	1	6 bAB	6	91*aAB	7	0.4 aAB	0.3
100% regular (yr 1 and 2)	2 aA	1	3 abA	3	94*aC	4	0.3 aABC	0.2
No fertilizer	4 aAB	4	2 abAB	1	93*aAB	4	0.2 aA	0.2
B. inermis monoculture								
50% slow	2 aA	1	3 aA	2	94*aB	3	0.2 aAB	0.1
100% slow	2 aA	1	2 aA	2	95*aB	2	0.2 aA	0.1
50% regular (yr 1)	2 aA	1	3 aA	2	95*aB	2	0.2 aABC	0.1
100% regular (yr 1)	2 aA	1	3 aA	2	94*aA	4	0.2 aAB	0.1
50% regular (yr 1 and 2)	2 aA	1	3 aA	2	95 aB	2	0.2 aA	0.1
100% regular (yr 1 and 2)	3 aA	2	3 aA	2	94 aC	3	0.2 aAB	0.1
No fertilizer	2 aAB	1	2 aAB	1	95*aB	2	0.2 aA	0.1
P. pratense monoculture								
50% slow	1 aA	1	1 aA	1	97*aB	1	0.1 aA	0.0
100% slow	2 aA	1	2 abA	1	94*aB	2	0.1 aA	0.0
50% regular (yr 1)	2 aA	2	2 abA	2	95*aB	3	0.1 aA	0.1
100% regular (yr 1)	2 aA	1	1 abA	1	95*aA	4	0.1 aAB	0.0
50% regular (yr 1 and 2)	2 aA	1	2 bA	1	95*aB	1	0.2 aA	0.1
100% regular (yr 1 and 2)	3 aA	2	1 abA	1	95*aC	2	0.1 aA	0.0
No fertilizer	3 aAB	2	1 abA	1	95 aB	2	0.1 aA	0.0
S. viridula monoculture								
50% slow	2 abA	1	4 aA	5	93*aB	5	0.2 aA	0.1
100% slow	2 abA	1	2 aA	2	94*aB	3	0.2 aA	0.2
50% regular (yr 1)	1 abA	1	1 aA	1	96*aB	3	0.2 aAB	0.1
100% regular (yr 1)	1 aA	1	1 aA	1	96*aA	2	0.2 aAB	0.1
50% regular (yr 1 and 2)	2 abA	1	2 aA	1	95*aB	2	0.2 aA	0.1
100% regular (yr 1 and 2)	1 abA	1	2 aA	1	96*aC	2	0.2 aAB	0.1
No fertilizer	2 bAB	2	2 aAB	2	95 aB	2	0.2 aA	0.1
T. hybridum monoculture								
50% slow	3 aA	2	7 aAB	9	90*aAB	10	0.4 aB	0.4
100% slow	2 aA	1	4 aA	4	93*aB	4	0.3 aA	0.2
50% regular (yr 1)	4 aAB	2	5 aA	5	91*aAB	6	0.3 aBC	0.3
100% regular (yr 1)	2 aA	2	2 aA	2	94*aA	4	0.2 aAB	0.1
50% regular (yr 1 and 2)	2 aA	1	6 aAB	11	91 aAB	11	0.3 aAB	0.2
100% regular (yr 1 and 2)	3 aA	3	3 aA	3	93*aC	4	0.3 aABC	0.1
No fertilizer	3 aAB	3	3 aAB	4	93 aAB	5	0.3 aA	0.1

Table 2.43 Ground cover of monocultures and mixes at Genesee in fall 1997 (continued)

Species / Treatment	Live Vegetation (%) Mean	S. D.	Litter (%) Mean	S. D.	Bare Ground (%) Mean	S. D.	Litter Depth (cm) Mean	S. D.
V. americana monoculture								
50% slow	3 aA	3	19 aB	30	78*aA	30	0.2 aAB	0.2
100% slow	8 aA	18	13 aB	13	79 aA	20	0.2 aA	0.1
50% regular (yr 1)	13 aB	23	8 aAB	11	79*aA	30	0.2 aABC	0.1
100% regular (yr 1)	3 aA	3	9 aB	8	88*aA	8	0.2 aAB	0.1
50% regular (yr 1 and 2)	6 aA	8	8 aAB	9	85 aAB	11	0.3 aAB	0.2
100% regular (yr 1 and 2)	4 aAB	3	14 aB	13	81 aA	13	0.3 aABC	0.3
No fertilizer	6 aB	7	7 aAB	5	87 aAB	11	0.3 aA	0.2
A. smithii / B. inermis mix								
50% slow	1 aA	1	8 aAB	7	90*aAB	7	0.3 aAB	0.1
100% slow	1 aA	1	4 aA	3	92*aB	5	0.3 aA	0.3
50% regular (yr 1)	2 aA	2	5 aA	5	93*aB	5	0.2 aAB	0.1
100% regular (yr 1)	1 aA	1	3 aA	3	95*aA	3	0.3 aB	0.3
50% regular (yr 1 and 2)	2 aA	1	6 aAB	6	92 aAB	6	0.2 aA	0.1
100% regular (yr 1 and 2)	4 aAB	8	5 aA	5	90*aBC	10	0.2 aABC	0.2
No fertilizer	2 aAB	1	3 aAB	3	94*aAB	4	0.3 aA	0.3
P. pratense / S. viridula mix								
50% slow	3 aA	1	2 aA	2	93*aB	3	0.3 aAB	0.1
100% slow	4 aA	3	4 aAB	7	91*aB	7	0.2 aA	0.1
50% regular (yr 1)	2 aA	3	2 aA	1	95*aB	3	0.2 aAB	0.1
100% regular (yr 1)	8 aA	11	2 aA	1	88*aA	11	0.2 aAB	0.1
50% regular (yr 1 and 2)	3 aA	2	4 aA	4	91*aAB	4	0.3 aA	0.1
100% regular (yr 1 and 2)	4 aAB	6	4 aA	2	90*aBC	7	0.4 bC	0.3
No fertilizer	4 aAB	3	2 aAB	3	93*aAB	6	0.2 aA	0.1
T. hybridum / V. americana mix								
50% slow	1 aA	0	3 aA	2	96*aB	3	0.2 abA	0.1
100% slow	1 aA	0	5 aAB	9	94 aB	9	0.2 abA	0.1
50% regular (yr 1)	1 aA	1	4 aA	4	94 aB	4	0.2 abAB	0.1
100% regular (yr 1)	2 aA	1	3 aA	2	95 aA	3	0.2 aAB	0.1
50% regular (yr 1 and 2)	1 aA	1	4 aA	2	94*aB	2	0.3 bAB	0.2
100% regular (yr 1 and 2)	2 aA	1	5 aA	4	92*aC	4	0.2 abAB	0.1
No fertilizer	1 aA	1	7 aAB	10	91*aAB	10	0.2 abA	0.1
A. smithii / S. viridula / V. americana mix								
50% slow	3 aA	4	6 aA	7	90*aAB	8	0.3 aAB	0.1
100% slow	4 aA	4	8 aAB	16	88 aA	19	0.3 aA	0.1
50% regular (yr 1)	6 aAB	10	4 aA	4	89*aABC	12	0.3 aABC	0.2
100% regular (yr 1)	7 aA	19	3 aA	4	89*aAB	18	0.2 aAB	0.1
50% regular (yr 1 and 2)	8 aA	19	5 aA	4	86*aAB	19	0.3 aAB	0.2
100% regular (yr 1 and 2)	9 aB	8	7 aA	7	83*aABC	9	0.3 aABC	0.2
No fertilizer	3 aAB	2	4 aAB	7	92*aA	8	0.3 aA	0.1

Table 2-43 Ground cover of monocultures and mixes at Genesee in fall 1997 (continued)

Species / Treatment	Live Vegetation (%) Mean	S. D.	Litter (%) Mean	S. D.	Bare Ground (%) Mean	S. D.	Litter Depth (cm) Mean	S. D.
B. inermis / P. pratense / T. hybridum mix								
50% slow	2 aA	1	4 aA	3	94 aB	4	0.2 abA	0.1
100% slow	2 aA	1	3 aA	2	94 aB	4	0.2 abA	0.1
50% regular (yr 1)	2 aA	1	2 aA	1	95*aB	2	0.1 aA	0.0
100% regular (yr 1)	2 aA	1	3 aA	2	94 aA	3	0.1 aAB	0.1
50% regular (yr 1 and 2)	2 aA	1	3 aA	2	94 aAB	2	0.2 abA	0.1
100% regular (yr 1 and 2)	3 aA	1	4 aA	2	92*aC	3	0.3 bABC	0.1
No fertilizer	2 aAB	1	3 aAB	2	94*aAB	2	0.2 abA	0.1
A. smithii / B. inermis / P. pratense / S. viridula / T. hybridum / V. americana mix								
50% slow	3 aA	4	7 aAB	5	89*aAB	8	0.3 aAB	0.2
100% slow	4 aA	3	7 aAB	6	88 aAB	7	0.3 aA	0.2
50% regular (yr 1)	1 aA	1	14 aB	17	84 aAB	17	0.4 aC	0.2
100% regular (yr 1)	3 aA	2	3 aA	3	93*aA	4	0.3 aAB	0.1
50% regular (yr 1 and 2)	3 aA	2	16 aB	23	81 aA	24	0.5 aB	0.4
100% regular (yr 1 and 2)	3 aA	2	6 aA	4	90*aBC	6	0.4 aBC	0.3
No fertilizer	4 aAB	3	11 aB	22	84*aA	21	0.3 aA	0.2
Non - seeded species (control)								
50% slow	3 aA	3	3 aA	2	93*abB	3	0.1 aA	0.1
100% slow	1 aA	1	2 aA	1	95*abB	2	0.1 aA	0.1
50% regular (yr 1)	1 aA	1	3 aA	2	96*abB	2	0.2 aAB	0.1
100% regular (yr 1)	1 aA	1	1 aA	1	96*bA	2	0.1 aA	0.0
50% regular (yr 1 and 2)	3 aA	2	3 aA	2	93*aAB	2	0.1 aA	0.0
100% regular (yr 1 and 2)	2 aA	1	3 aA	1	94*abC	2	0.1 aAB	0.0
No fertilizer	3 aAB	4	2 aAB	2	94 abAB	4	0.1 aA	0.0

* % Rocks $\geq$0.01

A. smithii = Agropyron smithii; B. inermis = Bromus inermis; P. pratense = Phleum pratense; S. viridula = Stipa viridula; T. hybridum = Trifolium hybridum; V. americana = Vicia americana

S. D. = Standard Deviation

Means within a column for a given species mix or monoculture followed by the same lower case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Means within a column for a specific fertilizer treatment followed by the same upper case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Table 2.44 Canopy cover of monocultures and mixes at Genesee in fall 1996

Species	Live Vegetation %		Litter %		Bare Ground %	
Treatment	Mean	S. D.	Mean	S. D.	Mean	S. D.
A. smithii monoculture						
50% slow	23 abAB	18	0 aA	0	76*abAB	18
100% slow	25 bA	14	0 aA	0	74*aA	14
50% regular (yr 1)	15 abA	16	0 aA	1	84*abA	16
100% regular (yr 1)	19 abA	17	0 aA	0	79*abA	18
50% regular (yr 1 and 2)	10 abA	11	0 aA	0	89*abA	11
100% regular (yr 1 and 2)	12 abA	9	0 aA	0	87*abA	9
No fertilizer	7 aAB	10	0 aA	0	92*bAB	11
B. inermis monoculture						
50% slow	27 aAB	21	0 aA	0	73 aAB	21
100% slow	25 aA	21	0 aA	0	75 aA	21
50% regular (yr 1)	15 aA	14	0 aA	0	84*aA	14
100% regular (yr 1)	18 aA	16	0 aA	0	80*aA	17
50% regular (yr 1 and 2)	14 aA	15	0 aA	0	85*aA	16
100% regular (yr 1 and 2)	15 aAB	12	0 aA	0	85 aB	12
No fertilizer	9 aAB	11	0 aA	0	90*aAB	12
P. pratense monoculture						
50% slow	6 aA	4	0 aA	0	93*aB	4
100% slow	13 aA	15	0 aA	0	86*aA	15
50% regular (yr 1)	8 aA	5	0 aA	0	91*aA	5
100% regular (yr 1)	12 aA	22	0 aA	0	87*aA	22
50% regular (yr 1 and 2)	7 aA	5	0 aA	0	92*aA	5
100% regular (yr 1 and 2)	7 aA	5	0 aA	0	92*aB	5
No fertilizer	3 aA	2	0 aA	0	95*aB	3
S. viridula monoculture						
50% slow	20 abAB	25	0 aA	1	79*abAB	24
100% slow	37 bA	29	0 aA	1	62*aA	29
50% regular (yr 1)	13 aA	10	0 aA	0	86*bA	10
100% regular (yr 1)	11 aA	8	0 aA	0	88*bA	7
50% regular (yr 1 and 2)	11 aA	9	0 aA	0	88*bA	9
100% regular (yr 1 and 2)	22 abAB	13	0 aA	1	78 abAB	13
No fertilizer	8 aAB	7	0 aA	0	90*bAB	8
T. hybridum monoculture						
50% slow	20 aAB	19	0 aA	0	79*aAB	19
100% slow	16 aA	16	0 aA	0	83*aA	16
50% regular (yr 1)	18 aA	17	0 aA	0	82 aA	17
100% regular (yr 1)	23 aA	28	0 aA	0	76*aA	27
50% regular (yr 1 and 2)	14 aA	16	0 aA	0	85*aA	16
100% regular (yr 1 and 2)	16 aAB	21	0 aA	0	83*aAB	21
No fertilizer	10 aAB	11	0 aA	0	89*aAB	10

Table 2.44 Canopy cover of monocultures and mixes at Genesee in fall 1996 (continued)

Species	Live Vegetation %		Litter %		Bare Ground %	
Treatment	Mean	S. D.	Mean	S. D.	Mean	S. D.
V. americana monoculture						
50% slow	23 abAB	16	0 aA	0	75*abAB	17
100% slow	33 bA	24	0 aA	0	66*aA	24
50% regular (yr 1)	16 aA	11	0 aA	1	83*abA	11
100% regular (yr 1)	21 abA	16	0 aA	0	79*abA	17
50% regular (yr 1 and 2)	17 abA	9	0 aA	0	82*abA	10
100% regular (yr 1 and 2)	14 aAB	9	0 aA	0	85*bA	9
No fertilizer	10 aAB	6	0 aA	0	88*bAB	7
A. smithii / B. inermis mix						
50% slow	17 aAB	18	0 aA	0	81*aAB	17
100% slow	24 aA	19	0 aA	1	75*aA	19
50% regular (yr 1)	16 aA	14	0 aA	0	83*aA	14
100% regular (yr 1)	18 aA	13	0 aA	1	81*aA	13
50% regular (yr 1 and 2)	14 aA	13	0 aA	1	84*aA	13
100% regular (yr 1 and 2)	21 aAB	21	0 aA	1	78*aAB	22
No fertilizer	8 aAB	5	0 aA	0	91*aAB	6
P. pratense / S. viridula mix						
50% slow	13 aAB	6	0 aA	0	87 aB	5
100% slow	14 aA	6	0 aA	0	86 aA	6
50% regular (yr 1)	14 aA	15	0 aA	0	84*aA	16
100% regular (yr 1)	14 aA	15	0 aA	0	85*aA	15
50% regular (yr 1 and 2)	7 aA	6	0 aA	0	92*aA	6
100% regular (yr 1 and 2)	15 aAB	9	0 aA	0	85*aB	9
No fertilizer	8 aAB	8	0 aA	0	91*aAB	7
T. hybridum / V. americana mix						
50% slow	14 aAB	10	0 aA	1	85*aAB	11
100% slow	17 aA	21	0 aA	1	82*aA	20
50% regular (yr 1)	27 aA	32	0 aA	1	72*aA	32
100% regular (yr 1)	18 aA	21	0 aA	1	81 aA	22
50% regular (yr 1 and 2)	15 aA	26	0 aA	0	76 aA	34
100% regular (yr 1 and 2)	17 aAB	22	0 aA	0	82 aAB	22
No fertilizer	10 aAB	9	0 aA	1	88*aAB	9
A. smithii / S. viridula / V. americana mix						
50% slow	10 abA	3	0 aA	0	88*abB	3
100% slow	13 bA	7	0 aA	0	86*aA	6
50% regular (yr 1)	6 aA	4	0 aA	0	92*bA	3
100% regular (yr 1)	10 abA	7	0 aA	0	90*abA	7
50% regular (yr 1 and 2)	8 abA	5	0 aA	0	91*abA	6
100% regular (yr 1 and 2)	10 abA	7	0 aA	0	89*abB	7
No fertilizer	5 aAB	2	0 aA	0	92*bAB	2

Table 2.44 Canopy cover of monocultures and mixes at Genesee in fall 1996 (continued)

Species	Live Vegetation %		Litter %		Bare Ground %	
Treatment	Mean	S. D.	Mean	S. D.	Mean	S. D.
B. inermis / P. pratense / T. hybridum mix						
50% slow	34 aB	26	0 aA	1	65*aA	25
100% slow	26 aA	15	0 aA	0	73*aA	14
50% regular (yr 1)	21 aA	17	0 aA	1	78*aA	17
100% regular (yr 1)	30 aA	27	0 aA	1	69*aA	26
50% regular (yr 1 and 2)	13 aA	5	0 aA	1	86*aA	7
100% regular (yr 1 and 2)	35 aB	30	0 aA	0	64*aA	29
No fertilizer	15 aB	12	0 aA	1	84*aA	12
A. smithii / B. inermis / P. pratense / S. viridula / T. hybridum / V. americana mix						
50% slow	19 abAB	10	0 aA	1	80*abAB	10
100% slow	34 bA	17	0 aA	1	64*aA	17
50% regular (yr 1)	24 abA	19	0 aA	0	75*abA	18
100% regular (yr 1)	27 abA	21	0 aA	1	72*abA	21
50% regular (yr 1 and 2)	19 abA	19	0 aA	0	79*abA	19
100% regular (yr 1 and 2)	23 abAB	16	0 aA	1	76*abAB	16
No fertilizer	11 aAB	5	1 aA	1	87*bAB	6
Non - seeded species (control)						
50% slow	10 aA	5	0 aA	0	89*aB	5
100% slow	18 aA	18	0 aA	0	82 aA	19
50% regular (yr 1)	13 aA	20	0 aA	0	85*aA	20
100% regular (yr 1)	23 aA	29	0 aA	0	76*aA	29
50% regular (yr 1 and 2)	12 aA	17	0 aA	0	87*aA	17
100% regular (yr 1 and 2)	11 aA	18	0 aA	0	88*aB	18
No fertilizer	5 aAB	1	0 aA	0	94*aAB	1

* % Rocks ≥0.01

A. smithii = Agropyron smithii; B. inermis = Bromus inermis; P. pratense = Phleum pratense; S. viridula = Stipa viridula; T. hybridum = Trifolium hybridum; V. americana = Vicia americana

S. D. = Standard Deviation

Means within a column for a given species mix or monoculture followed by the same lower case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Means within a column for a specific fertilizer treatment followed by the same upper case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Table 2.45 Canopy cover of monocultures and mixes at Genesee in spring 1997

Species	Live Vegetation %		Litter %		Bare Ground %	
Treatment	Mean	S. D.	Mean	S. D.	Mean	S. D.
A. smithii monoculture						
50% slow	15 aAB	14	6 aAB	6	78*abABCD	16
100% slow	12 aAB	10	16 bAB	14	71*aAB	21
50% regular (yr 1)	6 aA	5	5 aABC	6	87*abCD	10
100% regular (yr 1)	6 aA	3	8 abABC	8	84*abCDE	10
50% regular (yr 1 and 2)	10 aA	12	6 aAB	7	84*abAB	15
100% regular (yr 1 and 2)	8 aAB	8	8 abAB	9	84*abAB	13
No fertilizer	6 aAB	5	3 aABC	2	89*bBC	6
B. inermis monoculture						
50% slow	9 abA	7	8 aAB	10	82 aBCD	16
100% slow	13 bAB	8	7 aAB	5	79*aAB	12
50% regular (yr 1)	8 abAB	7	9 aBC	6	82*aCD	12
100% regular (yr 1)	12 abA	8	11 aABC	10	77*aCDE	17
50% regular (yr 1 and 2)	8 abA	6	8 aAB	7	83*aAB	13
100% regular (yr 1 and 2)	5 aAB	7	3 aAB	3	91*aB	9
No fertilizer	6 abAB	4	6 aBC	6	87*aBC	9
P. pratense monoculture						
50% slow	8 abA	9	2 aA	2	90*abCD	11
100% slow	14 bAB	19	3 aA	2	82*aAB	20
50% regular (yr 1)	4 aA	2	2 aA	3	92*abD	6
100% regular (yr 1)	6 abA	2	2 aA	2	91*abDE	3
50% regular (yr 1 and 2)	5 aA	2	3 aAB	3	91*abB	4
100% regular (yr 1 and 2)	4 aAB	4	3 aAB	4	92*abB	7
No fertilizer	4 aA	4	1 aAB	2	94*bC	6
S. viridula monoculture						
50% slow	5 aA	7	6 abAB	8	88*aCD	15
100% slow	6 aA	6	8 bAB	12	84*aAB	17
50% regular (yr 1)	6 aA	14	4 abAB	3	89*aD	16
100% regular (yr 1)	4 aA	4	2 abA	2	94*aE	6
50% regular (yr 1 and 2)	4 aA	7	3 abAB	5	92*aB	9
100% regular (yr 1 and 2)	3 aA	2	3 abAB	3	93*aB	5
No fertilizer	2 aA	2	1 aA	1	95*aC	3
T. hybridum monoculture						
50% slow	39 abC	22	5 aAB	4	55*abA	24
100% slow	32 abB	31	6 aAB	8	61*abAB	31
50% regular (yr 1)	51 bD	26	3 aAB	2	45*aA	27
100% regular (yr 1)	50 bB	28	4 aAB	4	46*aA	29
50% regular (yr 1 and 2)	31 abC	29	5 aAB	6	63*abA	30
100% regular (yr 1 and 2)	27 abC	30	6 aAB	5	67*abA	30
No fertilizer	17 aB	15	3 aABC	3	79*bB	16

Table 2.45 Canopy cover of monocultures and mixes at Genesee in spring 1997 (continued)

Species / Treatment	Live Vegetation % Mean	S. D.	Litter % Mean	S. D.	Bare Ground % Mean	S. D.
V. americana monoculture						
50% slow	5 aA	5	2 abA	2	92 aD	7
100% slow	8 aA	7	6 bAB	4	86*aB	8
50% regular (yr 1)	11 aAB	9	3 abAB	3	85*aCD	13
100% regular (yr 1)	8 aA	10	3 abAB	3	88*aCDE	11
50% regular (yr 1 and 2)	5 aA	4	2 aA	2	93* aB	6
100% regular (yr 1 and 2)	6 aAB	5	3 abA	3	91 aB	8
No fertilizer	7 aAB	9	1 aAB	2	91*aBC	10
A. smithii / B. inermis mix						
50% slow	13 abAB	9	9 aAB	6	76*abABCD	14
100% slow	23 bAB	15	17 aB	12	58*aAB	25
50% regular (yr 1)	12 abAB	8	12 aC	9	75*abBCD	15
100% regular (yr 1)	14 abA	8	14 aC	11	71*abCD	17
50% regular (yr 1 and 2)	12 abAB	11	10 aB	10	76*abAB	21
100% regular (yr 1 and 2)	12 abABC	8	12 aB	11	75*abAB	19
No fertilizer	8 aAB	6	7 aC	6	83* bBC	11
P. pratense / S. viridula mix						
50% slow	7 aA	4	5 aAB	5	87*aCD	7
100% slow	10 aA	8	10 aAB	12	79*aAB	18
50% regular (yr 1)	8 aAB	7	4 aAB	3	86*aCD	9
100% regular (yr 1)	7 aA	4	4 aAB	2	88*aDE	5
50% regular (yr 1 and 2)	5 aA	3	3 aAB	3	90*aB	5
100% regular (yr 1 and 2)	8 aAB	11	7 aAB	12	84*aAB	16
No fertilizer	5 aA	4	2 aAB	2	92*aBC	5
T. hybridum / V. americana mix						
50% slow	32 aBC	021	7 aAB	5	60*aAB	22
100% slow	32 aB	19	10 aAB	9	56*aA	24
50% regular (yr 1)	36 aCD	18	5 aAB	4	58*aAB	19
100% regular (yr 1)	43 aB	14	6 aABC	5	49*aAB	14
50% regular (yr 1 and 2)	28 aBC	17	6 aAB	4	65*aA	20
100% regular (yr 1 and 2)	21 aBC	19	11 aAB	11	66*aA	22
No fertilizer	33 aC	18	4 aABC	4	61*aA	19
A. smithii / S. viridula / V. americana mix						
50% slow	10 aA	7	13 aB	13	75*abABCD	15
100% slow	21 bAB	13	10 aAB	7	68*aAB	15
50% regular (yr 1)	10 aAB	6	5 aABC	4	83*bCD	9
100% regular (yr 1)	11 aA	9	12 aBC	10	76*abCDE	16
50% regular (yr 1 and 2)	10 aA	5	6 aAB	3	83*abAB	9
100% regular (yr 1 and 2)	9 aAB	8	11 aAB	8	78*abAB	12
No fertilizer	7 aAB	5	4 aABC	3	87*bBC	8

Table 2.45 Canopy cover of monocultures and mixes at Genesee in spring 1997 (continued)

Species	Live Vegetation %		Litter %		Bare Ground %	
Treatment	Mean	S. D.	Mean	S. D.	Mean	S. D.
B. inermis / P. pratense / T. hybridum mix						
50% slow	21 aABC	24	4 abAB	3	74*aABCD	24
100% slow	16 aAB	15	11 bAB	14	72*aAB	19
50% regular (yr 1)	25 aBC	21	2 aA	2	71*aBCD	22
100% regular (yr 1)	10 aA	6	7 abABC	8	83*aCDE	12
50% regular (yr 1 and 2)	20 aABC	18	2 aA	2	77*aAB	19
100% regular (yr 1 and 2)	13 aABC	16	3 abAB	3	83*aAB	19
No fertilizer	8 aAB	7	1 aAB	1	88*aBC	7
A. smithii / B. inermis / P. pratense / S. viridula / T. hybridum / V. americana mix						
50% slow	18 aAB	14	7 abAB	5	75*aABCD	18
100% slow	24 aAB	25	10 bAB	12	65 aAB	27
50% regular (yr 1)	26 aBC	21	7 abABC	6	67*aBC	21
100% regular (yr 1)	19 aA	18	4 abAB	3	76 aCDE	19
50% regular (yr 1 and 2)	17 aABC	18	4 abAB	3	79 aAB	19
100% regular (yr 1 and 2)	18 aABC	21	5 abAB	4	76*aAB	22
No fertilizer	10 aAB	8	2 aABC	1	87*aBC	8
Non - seeded species (control)						
50% slow	19 aAB	20	12 aAB	14	68*aABC	24
100% slow	16 aAB	11	15 aAB	14	67*aAB	22
50% regular (yr 1)	13 aAB	16	9 aBC	8	76*aBCD	19
100% regular (yr 1)	19 aA	16	11 aBC	10	68*aBC	20
50% regular (yr 1 and 2)	8 aA	11	9 aAB	11	81*aAB	16
100% regular (yr 1 and 2)	11 aABC	9	9 aAB	8	78*aAB	18
No fertilizer	8 aAB	6	4 aABC	5	86*aBC	10

* % Rocks ≥0.01

A. smithii = Agropyron smithii; B. inermis = Bromus inermis; P. pratense = Phleum pratense; S. viridula = Stipa viridula; T. hybridum = Trifolium hybridum; V. americana = Vicia americana

S. D. = Standard Deviation

Means within a column for a given species mix or monoculture followed by the same lower case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Means within a column for a specific fertilizer treatment followed by the same upper case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Table 2.46 Canopy cover of monocultures and mixes at Genesee in fall 1997

Species	Live Vegetation %		Litter %		Bare Ground %	
Treatment	Mean	S. D.	Mean	S. D.	Mean	S. D.
A. smithii monoculture						
50% slow	23 aABCD	27	2 abA	3	74*aCDE	26
100% slow	49 aABCD	25	2 aAB	2	49 aABCDE	25
50% regular (yr 1)	18 aA	25	2 abABC	1	79*aB	24
100% regular (yr 1)	22 aABC	30	2 aA	1	76*aBC	29
50% regular (yr 1 and 2)	20 aA	12	5 bB	6	74*aD	14
100% regular (yr 1 and 2)	36 aABCDE	36	2 abAB	2	61*aBCDE	35
No fertilizer	48 aAB	33	2 aAB	1	50 aAB	32
B. inermis monoculture						
50% slow	33 aABCDE	29	2 aA	2	65*abBCDE	29
100% slow	29 aAB	18	1 aAB	1	69*abDE	19
50% regular (yr 1)	14 aA	9	3 aBC	3	82*bB	10
100% regular (yr 1)	15 aAB	13	2 aA	1	82*bC	14
50% regular (yr 1 and 2)	26 aA	21	3 aAB	4	71 abBCD	20
100% regular (yr 1 and 2)	34 aABC	15	2 aAB	2	64 abCDE	14
No fertilizer	41 aAB	28	1 aAB	1	57*aAB	28
P. pratense monoculture						
50% slow	19 abAB	18	1 aA	1	80 abE	17
100% slow	26 abA	18	1 aAB	1	72*abE	17
50% regular (yr 1)	12 aA	9	1 aAB	1	85*bB	9
100% regular (yr 1)	13 aAB	13	1 aA	1	84*bC	13
50% regular (yr 1 and 2)	26 abA	16	2 aAB	2	71*abCD	15
100% regular (yr 1 and 2)	25 abAB	19	1 aAB	1	72*abDE	17
No fertilizer	37 bA	22	1 aAB	1	62 aB	21
S. viridula monoculture						
50% slow	53 bCDEF	36	2 aA	2	45 aABCD	35
100% slow	32 abAB	20	2 aAB	2	64*abBCDE	19
50% regular (yr 1)	27 abA	28	1 aAB	1	71*abB	27
100% regular (yr 1)	8 aA	7	1 aA	1	90*bC	7
50% regular (yr 1 and 2)	27 abAB	27	1 aAB	1	70*abBCD	26
100% regular (yr 1 and 2)	29 abABC	30	1 aA	2	70 abDE	29
No fertilizer	44 bAB	32	1 aAB	2	54 aAB	32
T. hybridum monoculture						
50% slow	74 abF	27	0 aA	1	26 aA	27
100% slow	64 abCD	20	0 aA	0	36 aABC	20
50% regular (yr 1)	81 bB	23	0 aA	0	19 aA	23
100% regular (yr 1)	44 aBCD	28	7 aA	24	46*aAB	30
50% regular (yr 1 and 2)	60 abBC	26	1 aA	1	40 aAB	26
100% regular (yr 1 and 2)	56 abBCDEF	28	1 aA	1	43 aABCD	28
No fertilizer	63 abAB	34	0 aA	1	36 aAB	34

Table 2.46 Canopy cover of monocultures and mixes at Genesee in fall 1997 (continued)

Species	Live Vegetation %		Litter %		Bare Ground %	
Treatment	Mean	S. D.	Mean	S. D.	Mean	S. D.
V. americana monoculture						
50% slow	55 aDEF	31	3 aA	3	42 aABC	29
100% slow	73 aD	24	3 aAB	2	24 aA	24
50% regular (yr 1)	60 aB	30	2 aABC	1	38 aA	30
100% regular (yr 1)	48 aCD	31	2 aA	2	50 aAB	31
50% regular (yr 1 and 2)	62 aC	29	4 aAB	6	35 aA	29
100% regular (yr 1 and 2)	61 aCDEF	27	6 aB	10	33 aABC	25
No fertilizer	65 aAB	31	2 aA	2	33 aAB	30
A. smithii / B. inermis mix						
50% slow	10 aA	7	7 bB	7	83*bE	13
100% slow	21 abA	14	3 abAB	2	74*abE	15
50% regular (yr 1)	14 aA	11	4 abC	4	82*bB	11
100% regular (yr 1)	12 aA	14	2 abA	2	85*bC	14
50% regular (yr 1 and 2)	25 abA	15	4 abAB	4	70 abBCD	14
100% regular (yr 1 and 2)	20 abA	22	4 abAB	5	76*abE	22
No fertilizer	37 bA	26	2 aAB	1	61*aB	25
P. pratense / S. viridula mix						
50% slow	20 aABC	15	2 aA	1	77* aDE	15
100% slow	45 aABCD	28	4 aB	7	50* aABCDE	25
50% regular (yr 1)	23 aA	20	1 aABC	1	74* aB	20
100% regular (yr 1)	30 aABC	26	1 aA	1	68* aBC	26
50% regular (yr 1 and 2)	21 aA	13	4 aAB	3	74* aD	12
100% regular (yr 1 and 2)	31 aABC	23	3 aAB	2	65* aCDE	23
No fertilizer	41 aAB	31	1 aAB	1	57 aAB	31
T. hybridum / V. americana mix						
50% slow	67 aF	22	1 aA	1	32 aAB	22
100% slow	64 aCD	24	1 aAB	1	35 aABC	24
50% regular (yr 1)	74 aB	22	1 aAB	1	24 aA	22
100% regular (yr 1)	67 aD	21	1 aA	1	31 aA	21
50% regular (yr 1 and 2)	63 aC	28	1 aAB	1	35 aA	28
100% regular (yr 1 and 2)	68 aDEF	23	1 aAB	4	31 aAB	21
No fertilizer	78 aB	23	1 aAB	1	21 aA	23
A. smithii / S. viridula / V. americana mix						
50% slow	44 aBCDEF	31	3 aA	5	52*aABCDE	30
100% slow	59 aBCD	28	2 aAB	2	39 aABCD	27
50% regular (yr 1)	31 aA	23	2 aABC	1	66*aB	24
100% regular (yr 1)	35 aABC	32	1 aA	2	63*aBC	31
50% regular (yr 1 and 2)	38 aABC	32	2 aAB	2	59*aABCD	32
100% regular (yr 1 and 2)	49 aABCDEF	34	3 aAB	4	48*aABCDE	34
No fertilizer	61 aAB	36	1 aAB	1	38 aAB	35

Table 2.46 Canopy cover of monocultures and mixes at Genesee in fall 1997 (continued)

Species	Live Vegetation %		Litter %		Bare Ground %	
Treatment	Mean	S. D.	Mean	S. D.	Mean	S. D.
B. inermis / P. pratense / T. hybridum mix						
50% slow	63 aEF	24	2 aA	1	36 aAB	24
100% slow	71 aD	22	1 aAB	1	28 aA	22
50% regular (yr 1)	64 aB	17	1 aAB	1	35 aA	18
100% regular (yr 1)	50 aCD	13	1 aA	1	48 aAB	12
50% regular (yr 1 and 2)	59 aBC	16	1 aAB	1	40 aABC	15
100% regular (yr 1 and 2)	74 aF	18	2 aAB	2	25 aA	17
No fertilizer	62 aAB	29	1 aAB	1	36*aAB	28
A. smithii / B. inermis / P. pratense / S. viridula / T. hybridum / V. americana mix						
50% slow	56 aDEF	27	2 abA	2	42 aABC	27
100% slow	65 aD	26	1 aAB	1	33 aAB	25
50% regular (yr 1)	66 aB	31	1 aAB	1	33 aA	31
100% regular (yr 1)	49 aCD	33	2 aA	2	49*aAB	33
50% regular (yr 1 and 2)	49 aABC	30	4 bAB	4	46 aABCD	28
100% regular (yr 1 and 2)	69 aEF	28	3 abAB	3	28 aA	26
No fertilizer	69 aAB	35	1 aAB	1	30 aAB	34
Non - seeded species (control)						
50% slow	44 abABCDEF	31	2 aA	1	54*abABCDE	30
100% slow	33 abABC	28	2 aAB	1	64*abCDE	27
50% regular (yr 1)	17 aA	17	2 aABC	2	80*bB	17
100% regular (yr 1)	21 abABC	19	2 aA	2	77*abBC	19
50% regular (yr 1 and 2)	35 abABC	32	2 aAB	2	62*abABCD	31
100% regular (yr 1 and 2)	35 abABCD	25	1 aA	1	63*abBCDE	25
No fertilizer	53 bAB	31	1 aAB	1	46 aAB	31

* % Rocks ≥0.01

A. smithii = Agropyron smithii; B. inermis = Bromus inermis; P. pratense = Phleum pratense; S. viridula = Stipa viridula; T. hybridum = Trifolium hybridum; V. americana = Vicia americana

S. D. = Standard Deviation

Means within a column for a given species mix or monoculture followed by the same lower case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Means within a column for a specific fertilizer treatment followed by the same upper case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Table 2.47 *Agropyron smithii* compared with *Bromus inermis* in monoculture and seeded together at Genesee in fall 1996

Species / Treatment	Density (plants / 0.1 m^2) Mean	S. D.	Biomass (%) Mean	S. D.	Survivability (%) Mean	S. D.
A. smithii monoculture						
50% slow	4 a	3	11 a	14	15 a	10
100% slow	4 a	3	10 a	14	15 a	9
50% regular (yr 1)	7 a	4	20 a	26	23 a	15
100% regular (yr 1)	6 a	4	25 a	33	19 a	14
50% regular (yr 1 and 2)	6 a	2	28 a	30	18 a	7
100% regular (yr 1 and 2)	4 a	3	10 a	13	12 a	11
No fertilizer	6 a	2	18 a	17	21 a	6
B. inermis monoculture						
50% slow	11 b	5	61 b	23	38 b	17
100% slow	9 b	5	46 b	26	31 b	16
50% regular (yr 1)	6 a	2	39 a	25	19 a	8
100% regular (yr 1)	10 b	4	62 b	18	34 b	14
50% regular (yr 1 and 2)	9 b	3	51 b	26	29 b	9
100% regular (yr 1 and 2)	5 a	7	32 b	33	17 a	22
No fertilizer	8 a	3	66 b	36	25 a	11
A. smithii in *A. smithii* / *B. inermis* mix						
50% slow	2 a	2	4 a	8	14 a	15
100% slow	2 a	2	2 a	2	13 a	11
50% regular (yr 1)	2 a	1	2 a	3	11 a	9
100% regular (yr 1)	3 a	2	6 a	6	20 a	11
50% regular (yr 1 and 2)	2 a	1	4 a	4	12 a	8
100% regular (yr 1 and 2)	2 a	2	5 a	7	11 a	13
No fertilizer	1 a	1	1 a	2	6 a	8
B. inermis in *A. smithii* / *B. inermis* mix						
50% slow	7 b	4	46 b	29	46 b	25
100% slow	7 b	5	27 b	21	44 b	34
50% regular (yr 1)	7 b	7	45 b	34	47 b	47
100% regular (yr 1)	9 b	7	46 b	29	58 b	46
50% regular (yr 1 and 2)	10 b	6	47 b	28	64 b	41
100% regular (yr 1 and 2)	4 b	4	28 b	33	27 b	24
No fertilizer	3 b	2	34 b	29	21 b	13
A. smithii in *A. smithii* / *B. inermis* / *P. pratense* / *S. viridula* / *T. hybridum* / *V. americana* mix						
50% slow	1 a	1	3 a	6	18 a	13
100% slow	0 a	1	1 a	2	10 a	13
50% regular (yr 1)	1 a	1	3 a	4	18 a	19
100% regular (yr 1)	0 a	0	3 a	7	9 a	10
50% regular (yr 1 and 2)	1 a	1	4 a	7	18 a	22
100% regular (yr 1 and 2)	0 a	1	2 a	4	9 a	13
No fertilizer	1 a	1	10 a	17	20 a	21

Table 2.47 *Agropyron smithii* compared with *Bromus inermis* in monoculture and seeded together at Genesee in fall 1996 (continued)

Species / Treatment	Density (plants / 0.1 m^2) Mean	S. D.	Biomass (%) Mean	S. D.	Survivability (%) Mean	S. D.
B. inermis in *A. smithii / B. inermis / P. pratense / S. viridula / T. hybridum / V. americana* mix						
50% slow	3 a	2	26 b	24	63 b	43
100% slow	2 a	2	25 b	29	48 b	32
50% regular (yr 1)	4 a	3	25 b	25	69 b	58
100% regular (yr 1)	3 a	2	34 b	24	66 b	40
50% regular (yr 1 and 2)	3 a	2	19 b	13	62 b	44
100% regular (yr 1 and 2)	2 a	2	10 b	16	30 b	33
No fertilizer	3 a	2	21 a	24	52 b	40

A. smithii = Agropyron smithii; B. inermis = Bromus inermis; P. pratense = Phleum pratense; S. viridula = Stipa viridula; T. hybridum = Trifolium hybridum; V. americana = Vicia americana
S. D. = Standard Deviation
Means within a column between monocultures or two species mixes or six species mixes followed by the same lower case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Table 2.48 *Agropyron smithii* compared with *Bromus inermis* in monoculture and seeded together at Genesee in spring 1997

Species / Treatment	Density (plants / 0.1 m^2) Mean	S. D.	Biomass (%) Mean	S. D.	Survivability (%) Mean	S. D.
A. smithii monoculture						
50% slow	6 a	3	32 a	30	20 a	10
100% slow	5 a	4	26 a	14	16 a	12
50% regular (yr 1)	9 b	4	45 a	40	30 b	13
100% regular (yr 1)	7 a	3	42 a	31	22 a	10
50% regular (yr 1 and 2)	6 a	2	48 a	37	22 b	8
100% regular (yr 1 and 2)	5 b	4	28 a	30	18 b	13
No fertilizer	7 a	3	43 a	31	23 a	9
B. inermis monoculture						
50% slow	6 a	2	84 b	14	19 a	8
100% slow	6 a	2	88 b	16	18 a	7
50% regular (yr 1)	6 a	2	90 b	13	19 a	7
100% regular (yr 1)	6 a	2	81 b	20	20 a	6
50% regular (yr 1 and 2)	6 a	2	86 b	18	19 a	6
100% regular (yr 1 and 2)	3 a	3	48 b	45	10 a	11
No fertilizer	5 a	2	76 b	27	18 a	6
A. smithii in *A. smithii* / *B. inermis* mix						
50% slow	3 a	2	8 a	7	22 a	14
100% slow	2 a	2	7 a	5	17 a	11
50% regular (yr 1)	4 a	3	12 a	1	24 a	18
100% regular (yr 1)	2 a	2	6 a	7	14 a	11
50% regular (yr 1 and 2)	3 a	2	9 a	8	19 a	14
100% regular (yr 1 and 2)	1 a	1	2 a	3	8 a	7
No fertilizer	2 a	1	12 a	12	12 a	8
B. inermis in *A. smithii* / *B. inermis* mix						
50% slow	5 b	2	72 b	20	33 b	11
100% slow	5 b	3	66 b	26	32 b	19
50% regular (yr 1)	7 b	3	73 b	23	44 b	23
100% regular (yr 1)	6 b	3	79 b	17	38 b	18
50% regular (yr 1 and 2)	5 b	3	78 b	21	34 b	22
100% regular (yr 1 and 2)	4 b	3	55 b	35	27 b	19
No fertilizer	5 b	4	66 b	24	31 b	24
A. smithii in *A. smithii* / *B. inermis* / *P. pratense* / *S. viridula* / *T. hybridum* / *V. americana* mix						
50% slow	2 a	1	2 a	3	38 a	25
100% slow	1 a	1	1 a	2	22 a	23
50% regular (yr 1)	1 a	2	1 a	4	15 a	30
100% regular (yr 1)	2 a	1	6 a	12	29 a	25
50% regular (yr 1 and 2)	1 a	1	2 a	4	15 a	21
100% regular (yr 1 and 2)	0 a	1	1 a	5	9 a	19
No fertilizer	1 a	1	6 a	7	28 a	28

Table 2.48 *Agropyron smithii* compared with *Bromus inermis* in monoculture and seeded together at Genesee in spring 1997 (continued)

Species / Treatment	Density (plants / 0.1 m^2) Mean	S. D.	Biomass (%) Mean	S. D.	Survivability (%) Mean	S. D.
B. inermis in *A. smithii / B. inermis / P. pratense / S. viridula / T. hybridum / V. americana* mix						
50% slow	2 a	1	34 b	23	47 a	23
100% slow	3 b	2	35 b	35	60 b	32
50% regular (yr 1)	3 b	1	24 b	17	63 b	28
100% regular (yr 1)	3 b	1	44 b	27	60 b	23
50% regular (yr 1 and 2)	3 b	2	24 b	22	60 b	37
100% regular (yr 1 and 2)	1 b	1	10 b	14	21 b	25
No fertilizer	3 b	2	32 b	21	52 b	32

A. smithii = Agropyron smithii; B. inermis = Bromus inermis; P. pratense = Phleum pratense; S. viridula = Stipa viridula; T. hybridum = Trifolium hybridum; V. americana = Vicia americana
S. D. = Standard Deviation
Means within a column between monocultures or two species mixes or six species mixes followed by the same lower case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Table 2.49 *Agropyron smithii* compared with *Bromus inermis* in monoculture and seeded together at Genesee in fall 1997

Species / Treatment	Density (plants / 0.1 m²) Mean	S. D.	Biomass (%) Mean	S. D.	Survivability (%) Mean	S. D.
A. smithii monoculture						
50% slow	6 a	4	22 a	17	19 a	12
100% slow	7 a	3	13 a	14	23 a	10
50% regular (yr 1)	7 b	4	37 a	29	22 b	14
100% regular (yr 1)	4 a	3	27 a	24	14 a	9
50% regular (yr 1 and 2)	5 a	2	29 a	32	16 a	6
100% regular (yr 1 and 2)	4 a	4	12 a	17	14 a	12
No fertilizer	6 a	3	22 a	27	19 a	9
B. inermis monoculture						
50% slow	6 a	2	65 b	31	18 a	6
100% slow	6 a	3	88 b	14	21 a	9
50% regular (yr 1)	4 a	1	88 b	19	15 a	4
100% regular (yr 1)	5 a	1	75 b	30	16 a	4
50% regular (yr 1 and 2)	6 a	3	79 b	33	19 a	10
100% regular (yr 1 and 2)	4 a	3	62 b	40	13 a	9
No fertilizer	5 a	2	64 b	33	16 a	7
A. smithii in *A. smithii* / *B. inermis* mix						
50% slow	2 a	2	2 a	4	12 a	12
100% slow	3 a	2	10 a	11	20 a	17
50% regular (yr 1)	1 a	1	1 a	2	7 a	7
100% regular (yr 1)	1 a	2	5 a	10	9 a	11
50% regular (yr 1 and 2)	2 a	3	4 a	6	16 a	21
100% regular (yr 1 and 2)	1 a	1	3 a	3	9 a	9
No fertilizer	2 a	2	5 a	8	11 a	13
B. inermis in *A. smithii* / *B. inermis* mix						
50% slow	6 b	2	60 b	27	40 b	14
100% slow	7 b	3	53 b	32	44 b	18
50% regular (yr 1)	6 b	3	58 b	37	39 b	21
100% regular (yr 1)	7 b	3	68 b	27	46 b	18
50% regular (yr 1 and 2)	6 b	2	62 b	34	41 b	17
100% regular (yr 1 and 2)	4 b	2	56 b	38	29 b	13
No fertilizer	5 b	3	42 b	35	31 b	21
A. smithii in *A. smithii* / *B. inermis* / *P. pratense* / *S. viridula* / *T. hybridum* / *V. americana* mix						
50% slow	1 a	2	5 a	8	22 a	33
100% slow	1 a	1	5 a	8	23 a	22
50% regular (yr 1)	0 a	0	7 a	25	3 a	8
100% regular (yr 1)	0 a	1	0 a	1	5 a	12
50% regular (yr 1 and 2)	0 a	1	6 a	19	8 a	18
100% regular (yr 1 and 2)	0 a	1	2 a	5	11 a	16
No fertilizer	0 a	1	2 a	6	8 a	22

Table 2.49 *Agropyron smithii* compared with *Bromus inermis* in monoculture and seeded together at Genesee in fall 1997 (continued)

Species / Treatment	Density (plants / 0.1 m^2) Mean	S. D.	Biomass (%) Mean	S. D.	Survivability (%) Mean	S. D.
B. inermis in *A. smithii / B. inermis / P. pratense / S. viridula / T. hybridum / V. americana* mix						
50% slow	2 a	2	20 b	23	40 a	41
100% slow	3 b	2	24 b	28	63 b	46
50% regular (yr 1)	2 b	2	21 a	23	46 b	43
100% regular (yr 1)	3 b	2	23 b	32	55 b	45
50% regular (yr 1 and 2)	3 b	3	33 b	32	53 b	53
100% regular (yr 1 and 2)	2 b	2	17 b	20	42 b	40
No fertilizer	3 b	3	24 b	22	60 b	51

A. smithii = Agropyron smithii; B. inermis = Bromus inermis; P. pratense = Phleum pratense; S. viridula = Stipa viridula; T. hybridum = Trifolium hybridum; V. americana = Vicia americana
S. D. = Standard Deviation
Means within a column between monocultures or two species mixes or six species mixes followed by the same lower case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Table 2.50 *Phleum pratense* compared with *Stipa viridula* in monoculture and seeded together at Genesee in fall 1996

Species	Density (plants / 0.1 m^2)		Biomass (%)		Survivability (%)	
Treatment	Mean	S. D.	Mean	S. D.	Mean	S. D.
P. pratense monoculture						
50% slow	3 b	2	33 b	31	11 b	7
100% slow	3 a	2	18 a	20	9 a	8
50% regular (yr 1)	5 b	5	22 b	23	17 b	16
100% regular (yr 1)	3 b	2	33 b	27	10 b	8
50% regular (yr 1 and 2)	4 b	2	25 a	26	13 b	8
100% regular (yr 1 and 2)	2 b	2	26 b	28	7 b	7
No fertilizer	3 b	3	27 b	30	9 b	9
S. viridula monoculture						
50% slow	2 a	2	7 a	11	5 a	5
100% slow	2 a	3	7 a	20	7 a	11
50% regular (yr 1)	2 a	1	1 a	2	6 a	5
100% regular (yr 1)	1 a	2	9 a	22	5 a	5
50% regular (yr 1 and 2)	2 a	1	11 a	14	6 a	5
100% regular (yr 1 and 2)	1 a	2	4 a	6	3 a	5
No fertilizer	1 a	1	2 a	4	4 a	4
P. pratense in *P. pratense / S. viridula* mix						
50% slow	3 b	2	13 b	12	17 b	12
100% slow	2 b	3	10 b	11	16 b	20
50% regular (yr 1)	3 b	2	14 b	14	19 b	14
100% regular (yr 1)	3 b	2	19 b	18	18 b	12
50% regular (yr 1 and 2)	2 b	1	19 b	20	16 b	9
100% regular (yr 1 and 2)	2 b	2	8 b	9	14 b	11
No fertilizer	2 b	2	14 b	19	11 b	10
S. viridula in *P. pratense / S. viridula* mix						
50% slow	0 a	1	1 a	3	3 a	5
100% slow	0 a	1	1 a	2	3 a	5
50% regular (yr 1)	0 a	1	2 a	3	3 a	6
100% regular (yr 1)	0 a	1	3 a	11	2 a	4
50% regular (yr 1 and 2)	1 a	1	3 a	4	5 a	8
100% regular (yr 1 and 2)	0 a	1	1 a	3	2 a	4
No fertilizer	0 a	1	3 a	8	3 a	4
P. pratense in *A. smithii / B. inermis / P. pratense / S. viridula / T. hybridum / V. americana* mix						
50% slow	0 a	0	0 a	0	0 a	0
100% slow	0 a	1	3 b	5	10 a	18
50% regular (yr 1)	0 a	1	6 a	16	9 a	13
100% regular (yr 1)	0 a	0	0 a	0	2 a	6
50% regular (yr 1 and 2)	0 a	1	0 a	1	3 a	12
100% regular (yr 1 and 2)	0 b	1	3 b	4	10 b	13
No fertilizer	0 a	0	1 a	3	5 a	9

Table 2.50 *Phleum pratense* compared with *Stipa viridula* in monoculture and seeded together at Genesee in fall 1996 (continued)

Species / Treatment	Density (plants / 0.1 m^2) Mean	S. D.	Biomass (%) Mean	S. D.	Survivability (%) Mean	S. D.
S. viridula in *A. smithii / B. inermis / P. pratense / S. viridula / T. hybridum / V. americana* mix						
50% slow	0 a	1	0 a	1	3 a	12
100% slow	0 a	0	0 a	1	3 a	8
50% regular (yr 1)	0 a	1	1 a	1	11 a	28
100% regular (yr 1)	0 a	0	0 a	0	2 a	6
50% regular (yr 1 and 2)	0 a	1	1 a	1	8 a	13
100% regular (yr 1 and 2)	0 a	0	0 a	0	0 a	0
No fertilizer	0 a	1	2 a	7	5 a	12

A. smithii = Agropyron smithii; B. inermis = Bromus inermis; P. pratense = Phleum pratense; S. viridula = Stipa viridula; T. hybridum = Trifolium hybridum; V. americana = Vicia americana

S. D. = Standard Deviation

Means within a column between monocultures or two species mixes or six species mixes followed by the same lower case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Table 2.51 *Phleum pratense* compared with *Stipa viridula* in monoculture and seeded together at Genesee in spring 1997

Species / Treatment	Density (plants / 0.1 m^2) Mean	S. D.	Biomass (%) Mean	S. D.	Survivability (%) Mean	S. D.
P. pratense monoculture						
50% slow	3 a	3	56 b	41	11 a	9
100% slow	3 a	2	68 b	42	9 a	7
50% regular (yr 1)	4 a	3	61 b	35	13 a	9
100% regular (yr 1)	4 b	3	65 b	32	15 b	11
50% regular (yr 1 and 2)	4 b	2	71 b	30	13 b	7
100% regular (yr 1 and 2)	2 a	2	63 b	47	6 a	5
No fertilizer	3 a	3	44 b	40	9 a	11
S. viridula monoculture						
50% slow	2 a	1	16 a	19	6 a	4
100% slow	1 a	2	13 a	24	4 a	6
50% regular (yr 1)	2 a	2	22 a	24	8 a	7
100% regular (yr 1)	1 a	1	25 a	31	4 a	5
50% regular (yr 1 and 2)	2 a	1	21 a	32	6 a	4
100% regular (yr 1 and 2)	1 a	1	17 a	30	5 a	4
No fertilizer	1 a	2	12 a	17	5 a	6
P. pratense in *P. pratense / S. viridula* mix						
50% slow	2 b	1	50 b	35	12 b	8
100% slow	2 b	2	57 b	34	16 b	14
50% regular (yr 1)	3 b	2	50 b	36	18 b	13
100% regular (yr 1)	2 b	2	39 b	30	14 b	10
50% regular (yr 1 and 2)	3 b	2	59 b	31	22 b	15
100% regular (yr 1 and 2)	1 b	1	33 b	41	8 b	9
No fertilizer	2 b	2	55 b	35	15 b	12
S. viridula in *P. pratense / S. viridula* mix						
50% slow	1 a	1	9 a	17	6 a	5
100% slow	1 a	1	6 a	16	4 a	5
50% regular (yr 1)	1 a	1	8 a	11	7 a	7
100% regular (yr 1)	1 a	1	6 a	14	5 a	6
50% regular (yr 1 and 2)	1 a	1	6 a	12	5 a	6
100% regular (yr 1 and 2)	0 a	0	0 a	0	0 a	0
No fertilizer	0 a	1	5 a	11	3 a	5
P. pratense in *A. smithii / B. inermis / P. pratense / S. viridula / T. hybridum / V. americana* mix						
50% slow	0 a	1	6 a	13	10 a	16
100% slow	1 a	1	6 a	12	13 a	29
50% regular (yr 1)	0 a	1	2 a	6	8 a	15
100% regular (yr 1)	1 b	0	7 b	11	12 b	10
50% regular (yr 1 and 2)	0 a	1	3 a	7	8 a	13
100% regular (yr 1 and 2)	0 a	1	5 b	9	9 a	15
No fertilizer	0 a	1	8 b	15	7 a	13

Table 2.51 *Phleum pratense* compared with *Stipa viridula* in monoculture and seeded together at Genesee in spring 1997 (continued)

Species	Density (plants / 0.1 m^2)		Biomass (%)		Survivability (%)	
Treatment	Mean	S. D.	Mean	S. D.	Mean	S. D.
S. viridula in *A. smithii / B. inermis / P. pratense / S. viridula / T. hybridum / V. americana* mix						
50% slow	0 a	0	0 a	0	3 a	8
100% slow	0 a	0	5 a	16	3 a	8
50% regular (yr 1)	0 a	1	0 a	1	6 a	13
100% regular (yr 1)	0 a	0	0 a	1	3 a	8
50% regular (yr 1 and 2)	1 a	1	1 a	2	12 a	16
100% regular (yr 1 and 2)	0 a	0	0 a	0	3 a	7
No fertilizer	0 a	0	0 a	1	3 a	8

A. smithii = Agropyron smithii; B. inermis = Bromus inermis; P. pratense = Phleum pratense; S. viridula = Stipa viridula; T. hybridum = Trifolium hybridum; V. americana = Vicia americana

S. D. = Standard Deviation

Means within a column between monocultures or two species mixes or six species mixes followed by the same lower case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Table 2.52 *Phleum pratense* compared with *Stipa viridula* in monoculture and seeded together at Genesee in fall 1997

Species / Treatment	Density (plants / 0.1 m^2) Mean	S. D.	Biomass (%) Mean	S. D.	Survivability (%) Mean	S. D.
P. pratense monoculture						
50% slow	5 b	3	66 b	23	16 b	10
100% slow	3 b	2	62 b	33	11 b	5
50% regular (yr 1)	5 b	2	69 b	32	16 b	8
100% regular (yr 1)	4 b	2	81 b	18	14 b	7
50% regular (yr 1 and 2)	3 a	2	61 b	34	9 a	7
100% regular (yr 1 and 2)	2 a	2	52 b	34	7 a	5
No fertilizer	4 b	3	64 b	31	13 b	10
S. viridula monoculture						
50% slow	1 a	1	13 a	21	4 a	5
100% slow	2 a	1	16 a	16	6 a	3
50% regular (yr 1)	2 a	1	24 a	31	7 a	4
100% regular (yr 1)	2 a	1	25 a	25	6 a	4
50% regular (yr 1 and 2)	2 a	2	20 a	26	6 a	6
100% regular (yr 1 and 2)	3 a	3	17 a	19	9 a	9
No fertilizer	1 a	1	14 a	18	4 a	4
P. pratense in *P. pratense / S. viridula* mix						
50% slow	3 b	2	45 b	39	23 b	16
100% slow	3 b	2	56 b	34	18 b	11
50% regular (yr 1)	2 a	2	40 b	39	13 a	10
100% regular (yr 1)	2 b	2	39 b	38	14 b	12
50% regular (yr 1 and 2)	3 b	2	48 b	30	19 b	11
100% regular (yr 1 and 2)	2 b	1	42 b	33	13 b	6
No fertilizer	1 b	1	32 b	34	7 b	6
S. viridula in *P. pratense / S. viridula* mix						
50% slow	1 a	1	7 a	10	5 a	5
100% slow	0 a	1	2 a	3	3 a	4
50% regular (yr 1)	2 a	2	12 a	22	11 a	15
100% regular (yr 1)	0 a	1	2 a	6	3 a	5
50% regular (yr 1 and 2)	0 a	1	0 a	0	2 a	4
100% regular (yr 1 and 2)	0 a	1	2 a	3	3 a	4
No fertilizer	0 a	0	9 a	19	2 a	3
P. pratense in *A. smithii / B. inermis / P. pratense / S. viridula / T. hybridum / V. americana* mix						
50% slow	1 a	1	8 a	15	14 a	24
100% slow	0 b	1	7 a	16	10 b	16
50% regular (yr 1)	1 b	1	10 a	24	12 b	13
100% regular (yr 1)	0 a	1	3 a	8	8 a	18
50% regular (yr 1 and 2)	0 a	1	14 a	20	10 a	18
100% regular (yr 1 and 2)	0 a	1	8 b	15	8 a	15
No fertilizer	0 a	1	3 a	8	8 a	17

Table 2.52 *Phleum pratense* compared with *Stipa viridula* in monoculture and seeded together at Genesee in fall 1997 (continued)

Species	Density (plants / 0.1 m^2)		Biomass (%)		Survivability (%)	
Treatment	Mean	S. D.	Mean	S. D.	Mean	S. D.
S. viridula in *A. smithii / B. inermis / P. pratense / S. viridula / T. hybridum / V. americana* mix						
50% slow	0 a	0	0 a	0	3 a	8
100% slow	0 a	0	0 a	0	0 a	0
50% regular (yr 1)	0 a	1	0 a	1	3 a	11
100% regular (yr 1)	0 a	0	0 a	0	2 a	6
50% regular (yr 1 and 2)	1 a	2	6 a	18	15 a	37
100% regular (yr 1 and 2)	0 a	0	0 a	0	2 a	6
No fertilizer	0 a	1	1 a	1	8 a	17

A. smithii = Agropyron smithii; B. inermis = Bromus inermis; P. pratense = Phleum pratense; S. viridula = Stipa viridula; T. hybridum = Trifolium hybridum; V. americana = Vicia americana

S. D. = Standard Deviation

Means within a column between monocultures or two species mixes or six species mixes followed by the same lower case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Table 2.53 *Trifolium hybridum* compared with *Vicia americana* in monoculture and seeded together at Genesee in fall 1996

Species / Treatment	Density (plants / 0.1 m²) Mean	S. D.	Biomass (%) Mean	S. D.	Survivability (%) Mean	S. D.
T. hybridum monoculture						
50% slow	4 a	3	48 a	27	14 a	10
100% slow	2 a	2	28 a	31	8 a	6
50% regular (yr 1)	4 a	3	47 a	26	15 a	9
100% regular (yr 1)	3 a	2	48 b	27	11 a	7
50% regular (yr 1 and 2)	4 a	2	58 b	30	13 a	7
100% regular (yr 1 and 2)	3 a	3	43 b	33	9 a	9
No fertilizer	5 a	4	64 b	20	18 a	13
V. americana monoculture						
50% slow	25 b	10	31 a	23	84 b	35
100% slow	16 b	9	27 a	26	52 b	31
50% regular (yr 1)	20 b	9	30 a	28	67 b	30
100% regular (yr 1)	20 b	9	24 a	21	65 b	30
50% regular (yr 1 and 2)	21 b	11	31 a	17	69 b	35
100% regular (yr 1 and 2)	11 b	11	20 a	28	37 b	36
No fertilizer	17 b	8	44 a	30	57 b	28
T. hybridum in *T. hybridum / V. americana* mix						
50% slow	4 a	2	18 a	21	23 a	17
100% slow	1 a	1	29 b	30	9 a	6
50% regular (yr 1)	3 a	3	36 a	37	21 a	21
100% regular (yr 1)	1 a	1	21 a	25	9 a	10
50% regular (yr 1 and 2)	3 a	0	27 b	29	17 a	12
100% regular (yr 1 and 2)	2 a	2	35 b	42	10 a	14
No fertilizer	3 a	4	29 b	39	18 a	27
V. americana in *T. hybridum / V. americana* mix						
50% slow	8 b	4	8 a	13	57 b	27
100% slow	7 b	4	2 a	4	46 b	26
50% regular (yr 1)	8 b	4	12 a	27	57 b	28
100% regular (yr 1)	8 b	4	9 a	17	53 b	24
50% regular (yr 1 and 2)	8 b	3	7 a	16	56 b	22
100% regular (yr 1 and 2)	6 b	6	10 a	21	39 b	37
No fertilizer	9 b	6	6 a	17	61 b	42
T. hybridum in *A. smithii / B. inermis / P. pratense / S. viridula / T. hybridum / V. americana* mix						
50% slow	1 a	1	7 b	6	25 a	19
100% slow	0 a	1	10 a	18	8 a	13
50% regular (yr 1)	1 a	1	14 a	18	22 a	21
100% regular (yr 1)	1 a	1	15 b	17	18 a	17
50% regular (yr 1 and 2)	1 a	1	12 a	16	20 a	24
100% regular (yr 1 and 2)	1 a	1	11 b	14	13 a	19
No fertilizer	1 a	1	22 a	28	18 a	29

Table 2.53 *Trifolium hybridum* compared with *Vicia americana* in monoculture and seeded together at Genesee in fall 1996 (continued)

Species	Density (plants / 0.1 m^2)		Biomass (%)		Survivability (%)	
Treatment	Mean	S. D.	Mean	S. D.	Mean	S. D.
V. americana in *A. smithii / B. inermis / P. pratense / S. viridula / T. hybridum / V. americana* mix						
50% slow	3 b	2	4 a	2	63 b	33
100% slow	1 b	2	1 a	2	28 b	38
50% regular (yr 1)	2 b	2	4 a	11	42 b	33
100% regular (yr 1)	3 b	2	5 a	4	66 b	44
50% regular (yr 1 and 2)	3 b	2	5 a	4	63 b	48
100% regular (yr 1 and 2)	2 a	2	3 a	4	36 a	43
No fertilizer	4 b	3	10 a	9	80 b	61

A. smithii = Agropyron smithii; B. inermis = Bromus inermis; P. pratense = Phleum pratense; S. viridula = Stipa viridula; T. hybridum = Trifolium hybridum; V. americana = Vicia americana

S. D. = Standard Deviation

Means within a column between monocultures or two species mixes or six species mixes followed by the same lower case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Table 2.54 *Trifolium hybridum* compared with *Vicia americana* in monoculture and seeded together at Genesee in spring 1997

Species	Density (plants / 0.1 m^2)		Biomass (%)		Survivability (%)	
Treatment	Mean	S. D.	Mean	S. D.	Mean	S. D.
T. hybridum monoculture						
50% slow	4 a	2	84 b	21	13 a	5
100% slow	2 a	2	76 b	30	7 a	5
50% regular (yr 1)	5 a	3	94 b	8	16 a	9
100% regular (yr 1)	4 a	2	80 b	26	12 a	6
50% regular (yr 1 and 2)	3 a	2	86 b	28	11 a	6
100% regular (yr 1 and 2)	2 a	3	60 b	47	8 a	9
No fertilizer	4 a	3	72 b	37	13 a	11
V. americana monoculture						
50% slow	13 b	4	45 a	34	42 b	15
100% slow	8 b	5	39 a	37	27 b	18
50% regular (yr 1)	12 b	5	43 a	36	39 b	17
100% regular (yr 1)	12 b	6	41 a	34	39 b	19
50% regular (yr 1 and 2)	13 b	7	49 a	31	42 b	22
100% regular (yr 1 and 2)	5 b	4	10 a	15	18 b	14
No fertilizer	10 b	5	38 a	35	32 b	18
T. hybridum in *T. hybridum / V. americana* mix						
50% slow	3 a	3	58 b	33	22 a	17
100% slow	2 a	2	60 b	34	16 a	12
50% regular (yr 1)	2 a	1	67 b	29	16 a	8
100% regular (yr 1)	3 a	2	79 b	23	19 a	12
50% regular (yr 1 and 2)	2 a	2	69 b	34	16 a	12
100% regular (yr 1 and 2)	2 a	2	40 b	40	10 a	12
No fertilizer	4 a	3	56 b	35	27 a	22
V. americana in *T. hybridum / V. americana* mix						
50% slow	6 a	5	19 a	31	42 a	34
100% slow	3 a	3	8 a	10	21 a	21
50% regular (yr 1)	4 a	4	7 a	11	29 a	29
100% regular (yr 1)	8 b	4	15 a	22	52 b	29
50% regular (yr 1 and 2)	7 b	5	14 a	18	46 b	35
100% regular (yr 1 and 2)	2 a	3	8 a	26	15 a	20
No fertilizer	6 a	4	8 a	9	42 a	28
T. hybridum in *A. smithii / B. inermis / P. pratense / S. viridula / T. hybridum / V. americana* mix						
50% slow	1 a	1	24 a	33	20 a	24
100% slow	0 a	1	9 a	18	7 a	13
50% regular (yr 1)	2 a	1	48 b	29	40 a	23
100% regular (yr 1)	1 a	1	30 b	31	20 a	26
50% regular (yr 1 and 2)	1 a	1	29 b	28	20 a	21
100% regular (yr 1 and 2)	1 a	1	24 a	34	17 a	21
No fertilizer	1 a	1	31 b	41	18 a	28

Table 2.54 *Trifolium hybridum* compared with *Vicia americana* in monoculture and seeded together at Genesee in spring 1997 (continued)

Species	Density (plants / 0.1 m^2)		Biomass (%)		Survivability (%)	
Treatment	Mean	S. D.	Mean	S. D.	Mean	S. D.
V. americana in *A. smithii / B. inermis / P. pratense / S. viridula / T. hybridum / V. americana* mix						
50% slow	5 b	4	8 a	9	102 b	83
100% slow	3 b	2	4 a	7	60 b	43
50% regular (yr 1)	2 a	2	3 a	4	45 a	46
100% regular (yr 1)	3 b	2	4 a	6	57 b	36
50% regular (yr 1 and 2)	3 b	2	8 a	12	60 b	46
100% regular (yr 1 and 2)	2 b	2	7 a	12	40 b	38
No fertilizer	3 b	2	6 a	6	55 b	34

A. smithii = Agropyron smithii; B. inermis = Bromus inermis; P. pratense = Phleum pratense; S. viridula = Stipa viridula; T. hybridum = Trifolium hybridum; V. americana = Vicia americana
S. D. = Standard Deviation
Means within a column between monocultures or two species mixes or six species mixes followed by the same lower case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Table 2.55 *Trifolium hybridum* compared with *Vicia americana* in monoculture and seeded together at Genesee in fall 1997

Species / Treatment	Density (plants / 0.1 m^2) Mean	S. D.	Biomass (%) Mean	S. D.	Survivability (%) Mean	S. D.
T. hybridum monoculture						
50% slow	3 a	2	99 b	1	10 a	5
100% slow	2 a	1	92 b	19	8 a	4
50% regular (yr 1)	3 a	1	93 b	18	9 a	4
100% regular (yr 1)	4 a	2	82 b	38	13 a	9
50% regular (yr 1 and 2)	2 a	2	68 b	44	5 a	6
100% regular (yr 1 and 2)	2 a	2	83 b	32	7 a	5
No fertilizer	2 a	1	57 b	48	5 a	4
V. americana monoculture						
50% slow	11 b	6	52 a	39	35 b	19
100% slow	7 b	5	23 a	15	24 b	15
50% regular (yr 1)	8 b	4	33 a	32	27 b	15
100% regular (yr 1)	14 b	7	38 a	36	47 b	23
50% regular (yr 1 and 2)	8 b	2	31 a	22	26 b	6
100% regular (yr 1 and 2)	6 b	4	27 a	31	21 b	15
No fertilizer	4 b	5	11 a	21	15 b	15
T. hybridum in *T. hybridum / V. americana* mix						
50% slow	2 a	1	89 b	27	13 a	8
100% slow	1 a	1	47 a	49	7 a	9
50% regular (yr 1)	2 a	1	67 b	39	11 a	6
100% regular (yr 1)	2 a	2	75 b	33	16 a	10
50% regular (yr 1 and 2)	2 a	1	61 b	41	12 a	8
100% regular (yr 1 and 2)	2 a	2	55 b	39	14 a	11
No fertilizer	1 a	1	56 b	46	9 a	9
V. americana in *T. hybridum / V. americana* mix						
50% slow	5 b	3	1 a	2	31 b	20
100% slow	5 b	4	15 a	30	34 b	27
50% regular (yr 1)	6 b	3	14 a	23	39 b	21
100% regular (yr 1)	7 b	6	7 a	14	46 b	37
50% regular (yr 1 and 2)	5 b	3	4 a	6	33 b	19
100% regular (yr 1 and 2)	5 b	4	9 a	25	31 b	28
No fertilizer	4 a	4	9 a	27	25 a	30
T. hybridum in *A. smithii / B. inermis / P. pratense / S. viridula / T. hybridum / V. americana* mix						
50% slow	2 a	2	52 b	36	31 a	36
100% slow	1 a	1	40 b	33	22a	18
50% regular (yr 1)	1 a	1	49 b	38	17 a	14
100% regular (yr 1)	1 a	1	54 b	41	27 a	23
50% regular (yr 1 and 2)	1 a	1	13 a	19	13 a	18
100% regular (yr 1 and 2)	1 a	0	41 b	39	18 a	10
No fertilizer	1 a	1	23 b	29	15 a	19

Table 2.55 *Trifolium hybridum* compared with *Vicia americana* in monoculture and seeded together at Genesee in fall 1997 (continued)

Species / Treatment	Density (plants / 0.1 m^2) Mean	S. D.	Biomass (%) Mean	S. D.	Survivability (%) Mean	S. D.
V. americana in *A. smithii / B. inermis / P. pratense / S. viridula / T. hybridum / V. americana* mix						
50% slow	3 a	3	9 a	19	58 a	53
100% slow	4 b	2	4 a	3	73 b	45
50% regular (yr 1)	2 a	3	3 a	3	43 a	53
100% regular (yr 1)	3 a	3	2 a	2	60 a	63
50% regular (yr 1 and 2)	2 b	1	4 a	5	33 b	23
100% regular (yr 1 and 2)	3 b	2	4 a	4	57 b	50
No fertilizer	2 b	3	4 a	4	51 b	55

A. smithii = Agropyron smithii; B. inermis = Bromus inermis; P. pratense = Phleum pratense; S. viridula = Stipa viridula; T. hybridum = Trifolium hybridum; V. americana = Vicia americana

S. D. = Standard Deviation

Means within a column between monocultures or two species mixes or six species mixes followed by the same lower case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Table 2.56 Dry weight of vegetation of monocultures and mixes at Genesee in fall 1997

Species	50% slow release (gm)		100% slow release (gm)		50% regular (yr 1) (gm)		100% regular (yr 1) (gm)		50% regular (yr. 1 and 2) (gm)		100% regular (yr. 1 and 2) (gm)		No Fertilizer (gm)	
	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.
A. smithii monoculture	9.1aA	8.6	21.4aA	21.4	10.6aAB	28.6	18.2aA	34.8	10.9aA	7.4	16.1aAB	17.4	9.9aA	10.3
B. inermis monoculture	13.2aA	27.3	8.8aA	8.2	4.4aAB	2.8	5.1aA	4.3	9.4aA	6.1	5.7aA	3.6	17.1aA	29.8
P. pratense monoculture	6.1abC	5.7	13.8abA	11.8	4.4aAB	4.7	3.6aA	1.9	12.4abA	9.6	8.4abA	6.1	17.7bA	18.4
S. viridula monoculture	9.0aA	13.1	7.7aA	8.7	2.2aA	1.8	4.2aA	8.4	7.2aA	5.9	7.3aA	5.6	12.9aA	12.8
T. hybridum monoculture	34.9aA	16.8	22.5aA	17.6	45.7aD	29.7	22.2aA	17.3	25.7aA	26.9	25.0aAB	15.3	32.7aA	28.2
V. americana monoculture	35.8aA	60.4	19.4aA	42.6	11.1aAB	17.3	21.4aA	35.2	22.7aA	33.2	47.2aB	61.3	25.3aA	30.0
A. smithii / B. inermis mix	7.0aA	4.4	7.4aA	4.0	5.6aAB	3.9	4.5aA	4.7	12.3aA	9.2	16.3aAB	32.4	12.4aA	27.3
P. pratense / S. viridula mix	9.2aA	12.1	14.4aA	8.9	13.2aABC	22.2	31.1aA	73.8	8.8aA	6.4	7.6aA	5.5	13.4aA	16.1
T. hybridum / V. americana mix	31.9aA	30.1	20.6aA	17.7	27.0aABCD	20.9	19.1aA	13.1	25.0aA	21.8	36.2aAB	21.8	24.3aA	31.5
A. smithii / S. viridula / V. americana mix	17.6aA	25.5	17.8aA	15.6	7.9aAB	7.8	8.7aA	9.4	14.5aA	17.9	18.9aAB	25.1	15.0aA	22.2

Table 2.56 Dry weight of vegetation of monocultures and mixes at Genesee in fall 1997 (continued)

Species	50% slow release (gm)		100% slow release (gm)		50% regular (yr 1) (gm)		100% regular (yr 1) (gm)		50% regular (yr. 1 & 2) (gm)		100% regular (yr. 1 & 2) (gm)		No Fertilizer (gm)	
	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.
B. inermis / P. pratense / T. hybridum mix														
	22.1aA	22.0	21.0aA	19.5	36.1aCD	24.0	23.8aA	13.5	25.6aA	23.2	22.7aAB	15.2	24.7aA	27.0
A. smithii / B. inermis / P. pratense / S. viridula / T. hybridum / V. americana mix														
	29.8aA	34.7	28.5aA	19.0	26.2aBCD	23.6	25.2aA	26.7	22.7aA	22.3	31.1aAB	26.7	22.4aA	26.4
Non - seeded species (control)														
	16.0aA	21.2	8.6aA	8.0	4.4aAB	3.9	10.8aA	31.7	13.0aA	20.5	18.2aAB	24.9	19.0aA	22.6

A. smithii = Agropyron smithii; B. inermis = Bromus inermis; P. pratense = Phleum pratense; S. viridula = Stipa viridula; T. hybridum = Trifolium hybridum; V. americana = Vicia americana

S. D. = Standard Deviation

Means within a row for a given species mix or monoculture followed by the same lower case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Means within a column for a specific fertilizer treatment that are followed by the same upper case letter are not significantly different ($p < 0.05$, Tukey's HSD)

CHAPTER 3: SURVIVABILITY AND BIOMASS PRODUCTION OF SIX PLANT SPECIES IN RESPONSE TO SOIL NUTRIENT REDUCTION

3.1 Introduction

Individuals in the reclamation industry who are required to reestablish native plant communities have limited information available on the requirements that will ensure adequate survivability of native species. Some of the sites to be reclaimed have high nutrient content that may be favourable for plant growth, particularly introduced species. These species often have high, rapid germination rates that allow them to become established on a disturbed site quickly, thus preventing other species from becoming established (Gerling et al. 1996; Kerr et al. 1993). Because the nutrient requirements of native plant species are lower than those for introduced species (Takyi 1984), if the nutrient level on the disturbed site is lowered, native species could have a competitive advantage and become established onto the site prior to the invasion by introduced species (Morgan 1994). By manipulating the soil environment to reduce available nitrogen, plant species capable of surviving on low nutrient soils, stress-tolerant species, will be able to outcompete species requiring more fertile soils (Tilman 1987).

One method of lowering soil nutrient levels is by immobilizing nitrogen (Biodini et al. 1985). The underlying principles of nutrient impoverishment in soils are based on the nutrient requirements of specific plant species and the ability of microorganisms to immobilize nitrogen. To immobilize nitrogen, a carbon to nitrogen (C:N) ratio of at least 25:1 must be obtained in the soil (Allison and Klein 1962; Aoyama and Nozawa 1993). When carbon material is incorporated into the soil, the population of soil microorganisms increases and more nitrogen is needed to satisfy the growth of the expanding population. If the relative amount of available nitrogen is less than the relative amount of substrate carbon, the available nitrogen in the soil environment is converted to microbial proteins (Biodini et al. 1985) and once immobilized into microbial structures, nitrogen is unavailable for plant uptake until the death of the microorganisms and mineralization occurs (Fauci and Dick 1994). The microbial population will grow rapidly when a readily available carbon source, such as sucrose, is incorporated into the soil. Less readily available carbon will sustain smaller microbial populations over an extended period of time as the microorganisms slowly break down the carbon material.

Most of the research on nitrogen immobilization has determined the effect of incorporating plant residues from cereal crops into the soil. The plants used in these studies are usually introduced annuals. Results on using this technique with native species is limited. Before nitrogen immobilization techniques are used extensively, it must be determined if incorporating organic matter will successfully lower nitrogen to a level that will elicit a response from plant species and which species, if any, will benefit from this procedure.

3.2 Objectives and Hypotheses

For six selected native and introduced plant species, the research objectives were:

1. To determine the effect of nitrogen immobilization on plant survivability (density and biomass production.
2. To determine the effect of nitrogen immobilization on plant interspecific competition.

Based on the aforementioned objectives, the hypotheses tested were:

1. Native and introduced plant species seeded in monocultures will have the same survivability (density) and biomass production when sugar and straw are added to the soil.
2. When seeded together, native plant species will survive the same as introduced species when sugar and straw are incorporated into the soil.
3. When seeded together, native plant species will produce the same amount of biomass as introduced species.

3.3 Materials and Methods

3.3.1 Site Location and History

The study site was located 5 km south of Edmonton at the University of Alberta Research Farm, Ellerslie, Alberta. The legal land description was NE 24-51-25 W 4. This was in the aspen parkland ecoregion and the dominant climatic regime was prairie-boreal (Strong and Leggat 1992). On average, this area receives 358 mm of rain with the average maximum daytime temperatures ranging form -8 °C in January to 22 °C in July (Environment Canada n.d.) (Figure A.4, Appendix A).

Plots were established on the southern portion of the quarter section. The site for the plot had been used for research projects in the past. No soil amendments nor fertilizers had

been used on the site and the site had been in summerfallow the previous year. This site was selected as nitrate levels were above optimum and soil quality parameters were within acceptable ranges for plant establishment (Table A.8, Appendix A).

3.3.2 Soil Sampling

Soil samples to determine soil nutrient status were taken in May 1996. A composite sample was produced from randomly selecting 10 sites within each block. These samples were obtained by using a 30-cm long by 3.2-cm diameter "Backsaver" soil sampler. The top 15 cm were collected separately from the 15 to 30 cm increment. The 30 to 60 cm increment was extracted with a 30-cm long by 1.9-cm diameter "Backsaver" soil sampler and was kept separate from the upper samples. The 10 samples from corresponding depth increments were thoroughly mixed and the composite samples were placed into labelled plastic bags. All samples were placed in a cooler for transport and stored in the refrigerator until taken to Norwest Labs the following day.

Soil sampling was repeated in June 1997 using the method as above. Three core samples were taken from each treatment in each block and mixed together to produce the sample for analyses. The samples were amalgamated by treatment rather than by block to determine if the soil amendments resulted in a difference in nutrient levels.

3.3.3 Soil Analyses

Soil samples were analyzed by Norwest Labs, Edmonton, according to recommendations in McKeague (1976) and Ashworth and Mrazek (1995) for available nitrogen (N), phosphorus (P), potassium (K) and sulfur (S) for the upper two depth increments. The 0-15 cm depth samples were also analyzed for micronutrients and salinity and the 30-60 cm depth samples were tested for N and P. $CaCl_2$ solution was used as the extracting solution for nitrates and sulfates. Potassium and phosphorus levels were determined using "Acetic fluoride" solution. A solution of ammonium acetate was used to determine exchangeable calcium, manganese and sodium. Iron, copper, zinc and manganese levels were ascertained by using DTPA/TEA chelating solution.

Soil pH was measured on the composite samples for each depth increment for all four blocks. The Fisher Accumet pH Meter was used to determine pH and instructions of the manufacturer were followed. The slurry was prepared by mixing 10 g of soil with 25 ml

of de-ionized water and stirring with a glass rod. The stirring cycle was repeated three times before the solution was allowed to sit undisturbed for two hours. This slurry was also used to determine electrical conductivity using the YSI Conductivity Bridge instrument. The instrument was calibrated according to instructions by the manufacturer. Total carbon was determined by using finely ground soil samples in the LECO carbon determinator at the University of Alberta. The Walkley-Black method was used to determine organic carbon (Black 1965b). The hydrometer method was used to determine the sand, silt and clay component of the soil from each depth increment of each block (Black 1965a).

In July 1997, a cone penetrometer with a 9.5-mm diameter shaft was used to assess penetration resistance because it is an important parameter for root growth. Eight depths were measured from 2.5 cm to 33 cm at six random sites in each block. At the same sites, an MC1 surface moisture / density gauge was used to determine soil moisture and bulk density at 25 cm depths.

3.3.4 Plot Layout

Four blocks were used in a strip-plot design. Each subplot measured 1.83 by 3.66 m. To facilitate amendment application and seeding, the amendments were placed horizontally across each block and species were seeded perpendicular to the amendment application. Amendment treatments were randomly assigned across each block and each treatment covered a total area of 87.1 m^2 (3.66 m by 23.79 m). The species and mixes were randomly designated within each block and each treatment had an area of 20.1 m^2 (1.83 m by 10.98 m) (Figure A.5, Appendix A).

3.3.5 Site Preparation and Management

The site was cultivated twice to a depth of 18 cm prior to adding the amendments. Subplots were measured and marked with temporary markers that were replaced with permanent markers once seeding was completed.

Seeding was done eight days after the amendments were incorporated into the soil. On June 24, 1996, a 1.83-m disc seed drill was used to seed the mixes at a depth of 1.5 cm. The eight discs were 23 cm apart and the drill was calibrated prior to seeding to ensure the seeds were planted at the desired rate. To calibrate the drill, the length of the plot was

measured adjacent to the prepared site and seeds were added to three of the cones. The drill was driven the marked length and adjustments to the rotation of the cones were made until all of the seeds within the cones were seeded over the marked distance.

During the course of the first growing season, *Hordeum vulgare* L. (barley), *Triticum aestivum* L. (wheat), and *Avena fatua* L. and *Avena sativa* L., (wild and cultivated oats) grew on the treatments amended with straw, and members of the *Brassicaceae* family dominated the treatments with no amendments. During the week of July 21, 1996, all treatments with no amendments and the straw treatments were weeded by pulling out all undesirable species, except on the no seeded treatment. Because rainfall events occurred often throughout the growing season, moisture was adequate. The density and growth rate of the species on the sugar/straw treatments were lower than on the other treatments so these treatments were not weeded (Figure 4, Appendix A). The volunteer cereals and *Brassicaceae* regrew so the site was mowed on August 14, 1996 to a height of 20 cm using a hay bind. The cut portions of the plants were removed from the site with a pitchfork. The site was swathed to a height of 20 cm on October 16, 1996, and a pitchfork was again used to remove the swaths.

3.3.6 Soil Amendments

The three treatments were straw, sugar and straw and no amendments. Barley straw was cut into 1 to 2 cm pieces using a New Holland 355 hammer mill with a 2.5-cm screen. The cut straw was placed into bags and weighed. On June 15 and 16, 1996, straw was added to the treatments at a rate of 102.9 kg per treatment (87.1 m^2) to achieve a carbon to nitrogen ratio of 40:1 to the 30 cm depth (Table A.9, Appendix A). The straw was spread onto the plot by hand and was raked to distribute it evenly to a depth of 3 cm.

Granulated sugar was applied to the surface of the treatments using a push type, drop fertilizer spreader. To acquire a carbon to nitrogen ratio of 30:1 in the upper 15 cm of soil, 44.7 kg of sugar was spread onto each treatment (87.1 m^2) (Table A.9, Appendix A). Straw was then added at a rate of 102.9 kg per treatment.

The entire site was then rototilled twice to a depth of 18 cm to incorporate the straw and sugar into the soil and to prepare the site for seeding. Tine harrows were used behind the second rototilling to even the seed bed. Each treatment was prepared as a unit to prevent amendments from being transferred to different treatments.

3.3.7 Species Selection and Mixes

Different growth patterns and properties were used to select the plant species. One native and one introduced legume were included in the selected species to provide nitrogen to the soil over extended periods of time. Tufted, low growing native and introduced grass species were seeded to provide ground cover to minimize the risk of soil erosion. The third native and introduced species were rhizomatous, or sod forming grasses. These species stabilize the soil, reducing the potential for soil erosion.

Plant species selected were native to the Parkland region or were introduced species commonly used in reclamation (Table A.3, Appendix A). Seed availability and plant tolerance to low nutrient levels were considered in the final determination of plant species. Although information on plant tolerance to low nutrients was limited, selection was based on information available (Hardy BBT 1989; Gerling et al. 1996). The native species selected were *Agropyron smithii* Rydb., *Stipa viridula* Trin. and *Vicia americana* Muhl. *A. smithii* has a rhizomatous growth form and *S. viridula* is a tufted species. Although *V. americana* has not been commonly used in reclamation, seed was available and it is a native legume. *Bromus inermis* Leyss. was the introduced species selected with rhizomatous growth patterns. The tufted introduced species seeded was *Phleum pratense* L. and *Trifolium hybridum* L. was the legume chosen.

Agropyron smithii Rydb. (Western wheatgrass) (Moss 1992) is a native grass species with slender rhizomes (Hitchcock 1971 cited in Hardy BBT 1989). It is a competitive species that can resist encroachment by other species (Weaver 1942). Moderate levels of nutrients are required by *A. smithii* and there is mixed success of establishing this species (Hardy BBT 1989). *A. smithii* prefers moist areas and is usually found in moderately alkaline, clay soils. The culms can grow to 30 to 60 cm high with blades 3 to 6 mm wide (Best et al. 1976; Looman and Best 1981).

Bromus inermis Leyss. (Smooth brome) (Moss 1992) is an introduced rhizomatous species. It propagates by seed and vegetatively through rhizomes. The culms of *B. inermis* can reach 60 to 100 cm high. The average width of the blades is 6 to 12 mm and the length is 30 cm (Best et al. 1976; Looman and Best 1981). It grows on a wide range of soils but cannot tolerate soils that are more than mildly alkaline (LeRoy and Keller 1972 and Hafenrichter et al. 1968 cited in Hardy BBT 1989). *B. inermis* requires a high level of available nitrogen and with adequate levels of nutrients, can be aggressive (Berg 1974 cited

in Hardy BBT 1989). This species emerges quickly (Vaartnou 1979 cited in Hardy BBT 1989). Jones et al. (1975 cited in Hardy BBT 1989) found organic matter increased in stands of *B. inermis* on mine spoil.

Phleum pratense L. (Timothy) (Moss 1992) is an introduced grass commonly seeded for hay and pasture. It is a bunchgrass with a shallow fibrous root system (Elliot and Boton 1970 cited in Hardy BBT 1989) and is well adapted to loam and clayey soils (Vories and Sims 1977 cited in Hardy BBT 1989). *P. pratense* requires high levels of nutrients, but can become established on disturbed sites (Whitby-Costescu et al. 1977 cited in Hardy BBT 1989). It establishes well by seed and emerges rapidly (Plummer 1977 and Vaartnou 1979 cited in Hardy BBT 1989). The culms can reach 50 to 80 cm high with blades 6 to 12 mm wide and 30 cm long (Best et al. 1976; Looman and Best 1981).

Stipa viridula Trin. (Green needle grass) (Moss 1992) is a native species commonly found on dry to moist, fertile clay soils (Best et al. 1976). The Edmonton area is at its most northerly range (Hardy BBT 1989). The culms normally are 50 to 100 cm high with blades 2 to 5 mm wide and 25 cm long (Looman and Best 1981). *S. viridula* is a bunchgrass with a fibrous root system. It is a moderately aggressive species. Initially, there is low emergence as the seeds can remain dormant unless they are stratified (Wark et al. n.d.; Walker and Weijer 1975 cited in Hardy BBT 1989).

Trifolium hybridum L. (Alsike clover) (Moss 1992) is an introduced legume that is commonly found on waste areas (Looman and Best 1981). These plants can grow 30 to 60 cm high and have leaflets 10 to 25 cm long (Looman and Best 1981). It is short lived and usually dies after two years (Skousen 1988 cited in Hardy BBT 1989). *T. hybridum* grows well on clay soils with adequate levels of moisture, potassium and phosphorus (Vories and Sims 1977 and Buckerfield's Ltd. 1980 cited in Hardy BBT 1989). It is easily established and is weakly aggressive (USDA Soil Conservation Service 1976 as cited in Hardy BBT 1989; Buckerfield's Ltd. 1980 as cited in Hardy BBT 1989).

Vicia americana Muhl. (American vetch) (Moss 1992) is a common native legume that can reach lengths between 10 to 25 cm (Looman and Best 1981). This species grows well on loam and can become established on sandy and clay soils (Farmer and Blue 1978 cited in Hardy BBT 1989). It prefers moist sites with adequate nutrient levels (Alsands Project Group 1978 cited in Hardy BBT 1989). According to Hardy BBT (1989), there are no known pest species. *V. americana* is very aggressive and can outcompete other species

(Hardy BBT 1989).

To evaluate the effect of competition, each species was seeded as a monoculture and in three mixes. Each native plant species was seeded with the introduced species with similar growth characteristics; *A. smithii* was seeded with *B. inermis*, *S. viridula* with *P. pratense*, and *V. americana* with *T. hybridum*. The three native species were seeded as a mix as were the three introduced species. As a final mix, all six species were seeded together.

Recommended seeding rates for native species range from 8 to 11 kg pure live seed (PLS)/ha (Gerling et al. 1996; Wark et al. n.d.). The recommended number of live plants per unit area varies with species and desired end land use and ranges from 200 to 800 m^{-2} with the average between 250 and 350 (Wark et al. n.d.). Plant density is increased if erosion prevention is required but the rate is decreased if encroachment from the surrounding area is desired (Gerling et al. 1996). Seeding rates were determined based on 300 pure live seeds m^{-2} which falls within the range of normal seeding rates. The amount of seed required for each replicate was calculated and seed packages prepared prior to seeding. One thousand seeds were counted and weighed and from these data, the number of seeds per gram determined. Percent live seed, seed viability and pure live seed were determined from information on the seed certificates. The seeding formula was according to Gerling et al. (1996):

$$\frac{\text{Desired live plants/m}^2 \times 10}{\text{Seeds/gm} \times \%\text{ pure live seed}} = \text{kg/ha of seed}$$

The percent pure live seed, if not provided on the seed certificates, was calculated using the formula : % pure live seed = % germination x % purity (Heady 1975 as cited in Kerr et al. 1993).

These values were used to prepare the packages for the monocultures and because the total number of desired live plants in the mixes remained at 300 m^{-2}, these values were divided by two, three and six for the corresponding mixes (Table A.4, Appendix A). The number of seeds required for each replicate was divided by eight, the number of seed discs on the drill. The required amount of each species was weighed and placed into labelled envelopes, one envelope for each disc in each block. The seeds in mixes were stirred together and placed in an envelope for each disc. *Trifolium hybridum* was inoculated with *Rhizobium leguminosium Biovar Trifolia*. Because it is not known which mycorrhiza are required for successful germination of *Vicia americana*, *Onobrychis viciifolia* (sainfoin)

inoculant, Liphatech's Nitrogen type B. was used because other researchers have had favorable results with this inoculant on vetch (Pelech 1997). The inoculated seeds were kept in the refrigerator for one day until seeded.

3.3.8 Vegetation Measurements

During the first growing season, data were collected three weeks after seeding and every two weeks after that until September when final growing season data were collected. Data were collected from three randomly placed 0.1-m^2 quadrats within each subplot. The numbers of forbs, grasses and legumes were counted each time and, starting six weeks after seeding, average heights of the seeded species were also taken. Starting at the second count, numbers of cereal grains, including barley, wild and cultivated oats and wheat were counted separately from other grasses. *Brassicaceae* species were also counted separately from other forbs.

In September, within each quadrat, vegetative characteristics and species composition were determined. In May and August 1997, the same measurements and techniques were used as in the previous fall. In fall 1997, the vegetation within each quadrat was cut to a height of 3 cm bagged and dried in a hot air dryer at 55 °C for five days. The dried samples were weighed to determine amount of biomass per quadrat.

Canopy height was measured for each canopy level up to a maximum of three levels. A canopy level was considered present if precipitation would be intercepted by plant foliage at that level. Canopy cover and ground cover were assessed for live vegetation, litter, bare ground, manure, rocks and moss. Canopy cover was estimated by looking down from 1.5 m onto the quadrat. Ground cover was evaluated at ground level by visualizing the quadrat with all vegetation clipped to a height of 5 cm. Percentages, totaling 100%, were assigned to each element contributing to canopy and ground cover.

Average litter depth was measured in centimeters from the soil surface upwards. Plant material was classified as litter if it was not a result of plant growth in the present year.

All species growing within the quadrat, seeded and voluntary, were identified and counted. Species rooted outside of the quadrat were not included in the plant count unless a tiller had become established within the quadrat. Tillers were counted as part of the original plant. Plants that emerged and subsequently died in the establishment year, were counted as live

plants for that year. A percentage value was allocated to each species indicating the proportion of total plant matter within the quadrat that was attributed to the species.

3.3.9 Experimental Design and Statistical Analyses

Data were input into Excel for preliminary analyses. Data were analyzed using the SPSS 6.1 statistical program. Further statistical analyses were completed using SPSS 8.0 for Windows. To determine the effect of organic amendments, the individual species within the mixes were compared across the different treatments. Characteristics of the species mixes were compared to determine if amendments had impacted total growth patterns. Intraspecific competition was analyzed by comparing the survivability (density) of the specific species in monoculture and the relevant species mixes. The no amendment treatments were used as control plots. The general linear model of analysis of variance was used to run these statistical analyses. The data were not transformed, even though discrete and percent data were used. The data were initially tested by transforming percent data using square root of the square root, and density data by using the natural log. Q-Q plots did not show a change in the linearity of the residuals from raw data and transformed data. Interspecific competition between the species of similar plant characteristics was evaluated using t-tests of the average means. Density and biomass were compared for the species in monocultures and in the two mixes in which they were seeded together. The level of significance for all data analyses was $p \leq 0.05$.

3.4 Results

3.4.1 Soil Characteristics

The soil was silt loam in texture. The amount of available nitrate decreased in 1997 to deficient levels for all treatments. The sulfate levels also decreased from 1996 to 1997 but were still above optimal levels. Other soil parameters measured the same in 1996 and 1997 and did not vary between treatments (Table A.10. Appendix A). Penetration resistance readings varied from 907 kPa at 2.5 cm to 2362 kPa at 33 cm (Table A.8, Appendix A). It has been suggested that 2000 kPa is the level at which root growth may be impeded. At 17.5 cm and 33 cm the measured resistance may interfere with plant root growth. Soil moisture content varied from 13.6% to 15.4% (Table A.10, Appendix A).

3.4.2 Initial Vegetation

Volunteer cereals were higher in the straw/sugar treatment because this treatment was not weeded during the summer. However, the number of grasses and legumes did not differ from the weeded straw treatments (Tables 3.1 to 3.13). The high level of rainfall during the summer reduced the competition for moisture (Figure A.4, Appendix A). The total number of grasses and legumes was generally higher in the no amendments treatment. However, the individual seeded species were not identified during the summer.

3.4.3 Effect of Soil Amendments on Selected Plant Species

3.4.3.1 Plant Density and Survivability

The means and significance of plant density and survivability are in Tables 3.14 to 3.31. Generally, there was no significant difference in the density of seeded species when amendments were incorporated into the soil. There was minimal variability in treatment effect for the grass species in fall 1996. Where differences occurred, the no amendments treatment usually had significantly higher densities than amended treatments. By fall 1997, only *S. viridula* had a significant difference between amended and no amended treatments. However, the actual number of plants per 0.1 m^2 would not make a difference ecologically. There was no difference between the straw and sugar/straw treatments for any species at any time counts were taken.

Percent survivability (density) was not affected by soil amendments. Although not significantly different, the density and survival of seeded plants were frequently higher in the no amendments than in the amended treatments. This trend extended from fall 1996 to fall 1997. However, the survivability (density) of two species were notable. *V. americana* had high survivability (density) in fall 1996 and increased significantly in spring 1997. In fall 1997, survivability (density) decreased for all treatments to levels of 0 to 8%. The second species, *B. inermis*, generally had the highest survivability of the grasses for all treatments. The percentage did not vary significantly from fall 1996 to fall 1997 as it did for *V. americana*.

In fall 1996, the density of the total seeded species in almost half of the monocultures and mixes was significantly higher in the no amendments treatments (Tables 3.32 to 3.34). In spring and fall 1997, only *S. viridula* monoculture, and *T. hybridum/V. americana* and *A.*

smithii/S. viridula/V. americana mixes, had a significant difference between amended and no amendments treatments. The survivability (density), although not significantly different, were generally higher in the no amendments treatment for all species and mixes.

In fall 1996 and spring 1997, *V. americana* monoculture and mixes had significantly higher survivability (density) than most other species and mixes. However, by fall 1997, the highest survivability (density) was generally found in the *A. smithii* and *B. inermis* monocultures and *A. smithii/B. inermis* and all six species mixes. The lowest survivability (density) was consistently found in the *V. americana* and *T. hybridum* monocultures and *V. americana/T. hybridum* mix.

The commonly occurring non-seeded species are listed in Table A.11 (Appendix A). The number of non-seeded species was higher in the sugar/straw treatments in fall 1996 as these treatments were not weeded during the summer. However, total biomass was not significantly different from the straw plot that had been weeded. There was no significant difference between any of the treatments for almost all of the species and mixes in spring and fall 1997. The density of non-seeded plants was significantly higher in spring 1997. By fall 1997, numbers had declined for all treatments and the number of non-seeded plants was generally highest in the native species monocultures and mixes.

3.4.3.2 Biomass

The addition of organic amendments generally did not affect the amount of biomass produced by each species (Tables 3.14 to 3.31). In most instances where there was a difference, the no amendments treatment had a significantly higher proportion of biomass attributed to the seeded species. This trend occurred with all species for the duration of the study. In fall 1996, biomass of non-seeded species in the no amendments treatment was generally significantly less than in the amended treatments (Tables 3.35 to 3.37). The amount of biomass attributed to non-seeded species in spring and fall 1997 was generally not affected by soil amendments. If differences occurred, the non-seeded species in the no amendments treatment produced less biomass.

3.4.3.3 Canopy Height

Tables 3.38 to 3.40 include the mean heights for each canopy level for the various monocultures and mixes. In fall 1996, heights in the no amendments treatments were

generally lower than those in the treatments with added amendments. In 1997, generally the height was similar for all treatments, but if a difference occurred, heights in the no amendments treatment were greater than those in the amended treatments. The second canopy level varied with the treatments in fall 1996, with sugar/straw treatment often significantly higher than in the no amendments treatment. By spring 1997, the addition of soil amendments did not produce much variability in the second level. There was little variation in the third canopy level throughout the study.

3.4.3.4 Ground Cover

Generally, there were no significant differences in the percent live vegetation between any of the treatments for any of the species (Tables 3.41 to 3.43). In the few instances where there were differences, the no amendments treatment had a higher proportion of live vegetation than the amended treatments. Generally, the percent of bare ground and litter depth did not vary significantly between amended and non amended treatments.

The amount of litter varied in spring 1997. At this time, the proportion of litter was significantly higher in the sugar/straw treatment than in the no amendments treatment (Tables 3.41 to 3.43). This occurred in native and introduced monoculture and mixes.

The percent live vegetation and bare ground did not vary significantly among species and mixes for most of the treatments. In spring 1997, there was significantly different amounts of litter between species in both straw and no amendments treatments. On straw treatments, the percent litter varied from 14% in *S. viridula* monoculture to 71% in *B. inermis* monoculture. The range for the no amendments treatment was 7% in the control to 61% in *B. inermis* monoculture (Tables 3.41 to 3.43).

3.4.3.5 Canopy Cover

In fall 1996, some of the species and mixes had significantly less live vegetation in the sugar/straw treatment than in the straw treatment. This trend continued into spring 1997, but the difference was against the no amendments treatment. In fall 1997, there was no difference between any treatment for any species or mix. Generally, there was no significant difference in the percent bare ground for any treatment. For the few species where a difference occurred, the straw treatment had less bare ground than either sugar/straw or no amendments treatments. Results are included in Tables 3.44 to 3.46.

The percent litter only varied in spring 1997. At that time, the sugar/straw treatments had significantly greater amounts of litter than no amendments treatment in nearly all monocultures and mixes. The sugar/straw treatments were significantly greater compared to straw treatment in half of the monocultures and mixes (Tables 3.44 to 3.46).

There was little variation in the proportion of live vegetation, litter and bare ground between species and mixes. No one species or mix was significantly different from all other species or mixes for any treatment. Although there a slight difference in the amount of bare ground between species in fall 1996 and spring 1997, this difference no longer existed by fall 1997. The amount of canopy cover for two species stood out in spring 1997. The control for all three treatments generally had a low proportion of live vegetation for all three treatments. *B. inermis* monoculture had greater amounts of litter in the straw and no amendments treatments but the variability did not continue into fall 1997.

3.4.4 Effect of Soil Amendments on Plant Competition

3.4.4.1 Density and Survivability

In fall 1996 and spring 1997, the densities of native and introduced species were not significantly different for most species in monoculture or mixes (Tables 3.47 to 3.55). The exception was *V. americana* compared to *T. hybridum*. By fall 1997, the density of *B. inermis* was greater than *A. smithii* when seeded in the same mixes. The density of *T. hybridum* was greater than *V. americana* in monoculture and in the *T. hybridum/V. americana* mix, and there was no significant difference in the all six species mix.

3.4.4.2 Biomass

Biomass produced by introduced species was generally greater than that attributed to native species. The biomass of *B. inermis* was greater than *A. smithii* throughout the study. *P. pratense* generally had greater biomass than *S. viridula* for most treatments and mixes. The biomass produced by *T. hybridum* and *V. americana* were not significantly different in fall 1996. However, in spring and fall 1997, *T. hybridum* generally produced more biomass than *V. americana* (Tables 3.47 to 3.55).

3.4.4.3 Dry Weight

There was no difference in the amount of dry biomass between the three treatments in the monocultures and mixes (Table 3.56). The mix of *B. inermis/P. pratense/T. hybridum* consistently had greater weight of dry vegetation. The species and mixes it was significant from varied with each treatment. No one species or mix was significant from all others.

3.5 Discussion

3.5.1 Species Survivability

It was anticipated that native plant species would have better survivability (density) and greater biomass production than introduced species on the treatments with organic amendments (Morgan 1994). The survivability (density) of the selected species was affected minimally by the incorporation of soil amendments. The emergence and growth of all species, seeded and non-seeded, were slower in the sugar/straw treatment. By the end of the second year, only *S. viridula* monoculture and two mixes were affected by the treatments. As *S. viridula* requires high nutrient soils (Best et al. 1976), it would be expected that survivability (density) of *S. viridula* would be highest in the no amendments treatment. This did occur in fall 1997 even though available nitrate levels were similar in all treatments. The sugar/straw combination may have reduced the amount of available nitrogen to a level that can suppress the survival rate of this species. At the time of germination, there may have been a difference in nutrient levels among the different treatments. If this study is repeated, soil samples should be taken after amendments are added and prior to seeding to determine if there was a change in available nitrogen levels. The nutrient level at the time of germination may be crucial in plant establishment.

The seeds of many native species, including *S. viridula*, can remain dormant in the soil for extended periods of time (Walker and Weijer 1975 as cited in Hardy BBT 1989). The low survivability may be a result of delayed germination and emergence. Although not significantly different, the higher number of plants surviving in the no amendments treatment for all species and mixes, indicates the soil environment was altered by adding amendments. However, only *S. viridula* in monoculture and mixes was affected by the addition of soil amendments.

The increase in the survival rate of *V. americana* in spring 1997 indicates this species may require vernalization to increase emergence. Counting the individual plants was difficult, particularly in the monocultures as the trailing stems intertwined. This may have resulted in an inaccurate count. It was possible to have greater than 100% germination rate as the seeding rates were based on 50% germination. This was an estimate of the germination as no specific tests had been performed with these seeds. Although there are no known pests to *V. americana* (Hardy BBT 1989), there was evidence of insect pests on the plant stems and leaves. The defoliation caused by these insects resulted in the massive decline in survivability (density) from spring 1997 to fall 1997.

The high density of non-seeded species in spring 1997 was due to the large numbers of weed seedlings that had emerged. During the summer, most of these seedlings died. This is indicative of r-selected species that produce large numbers of seeds to promote successful establishment. Swathing the site in late fall 1996 virtually eliminated the cereal grasses from the plots in the second year. *Brassicaceae* species continued to grow as seeds were released prior to swathing.

3.5.2 Biomass

It was expected the introduced species would produce less biomass on the amended treatments than on the no amendments treatment. The amendments were not expected to significantly affect biomass production of native species.

Jonasson et al. (1996) found when sugar was added to soil as a labile sugar source, microbes assimilated nitrogen and phosphorus from inorganic sources, decreasing the amount of plant biomass. However, this was not seen on the Ellerslie site. When organic amendments were added, there was generally no difference in the amount of biomass produced by each species.

There was no difference in the amount of available nitrates between treatments in 1997. However, there was a large decrease in the amount of nitrates from spring 1996 to spring 1997. This may be a result of plants absorbing all of the available nitrogen or some nitrogen could be lost due to leaching, immobilization or denitrification. The difference in the results could also be the result of the cyclic nature of soil nitrogen. As the site was summerfallow in 1995, plant growth would have been limited and available nitrogen reserves would not have been utilized. This resulted in the higher levels of nitrogen in

1996. There was a reduction in the amount of available nitrogen in 1997 because nitrogen could have been immobilized into the microbial biomass after the amendments were added to the soil and what was not immobilized, could have been absorbed by the plants.

Immobilization and mineralization occur simultaneously, but nitrogen may be held in the organic form for extended periods of time (Broadbent and Tyler 1962). Nitrogen immobilized in soil organic matter becomes slowly available to plants over the succeeding years (Jacobsen et al. 1996). If the available nitrogen had been incorporated into the soil organic matter, the effects of immobilization may not be seen until available nitrogen levels have been depleted. The slow mineralization of nitrogen from soil organic matter would act as a continuing source of plant nutrients.

The amount of biomass measured was affected by other living organisms on the site. There was evidence of rodents and porcupines throughout the plots. The rodents destroyed some of the vegetation, especially in the *B. inermis* treatments.

3.5.3 Canopy Height

The average height of all species in the quadrat was used to determine canopy height. This included non-seeded species so the measurements do not necessarily correspond to the actual height of the seeded species.

In research done by Parker (1962), buried residue led to an increase in the amount of nitrogen immobilized which stunted the growth of the plants. In fall 1996, the plants in the no amendments treatment were shorter, but in spring and fall 1997, the plants in the amended treatments were shorter. Immobilization of nitrogen is a slow process (Jones and Schwab 1993) so the effects may not be evident until the following year. This does not agree with the research done by Allison and Klein (1962) and Zimmerman et al. (1995) where it was found maximum immobilization occurred in five to 15 days.

3.5.4 Cover

Soil amendments did not ultimately affect the percentage of live vegetation for any species or mix even though it was expected that native plants would outperform introduced species on the amended plots. The percentage of live vegetation in the canopy was less in the

sugar/straw treatment until fall 1997. This was evident in the field as emergence was delayed on this treatment.

The high amount of litter in the *B. inermis* monoculture in spring 1997 was a result of the high percentage of live vegetation on the treatments in fall 1996. The sugar/straw treatment had less live vegetation in fall 1996 but high levels of litter 1997. Non-seeded species contributed to the litter accumulation. *B. inermis* in monoculture and mixes was able to outcompete non-seeded species due to its aggressive growth patterns. Its rapid establishment resulted in the lowest amount of bare ground in fall 1996.

3.5.5 Competition Effects

It was expected the native plant species would become established faster and survive better on the amended treatments than the introduced species. Over the two year period, introduced species did as well as, or better than, the native species in all treatments. The selected native and introduced species tolerated the amended sites equally well. Adequate levels of nutrients were available for all the species to survive.

It has been advised that when seeding *A. smithii* in a mix, no more than 2.5 seeds be planted per 0.09 m^2 as its rhizomatous growth dominates other species (Wark et al. n.d). When seeded in mixes, it was less aggressive than *B. inermis*, and it was no more aggressive than the other species in the native seed mix and all species mix.

3.5.6 Biomass

The different growth form of the various species makes it difficult to compare the amount of biomass produced by each species. The introduced species generally had higher amounts of biomass, but this was expected due to the structure of the introduced plant species. The selected introduced species had larger blades or leaves than the corresponding native species (Best et al. 1971; Looman and Best 1979).

3.6 Conclusions

1. Sugar added to the soil slowed emergence and growth of the six selected species and non-seeded species but the effect was not evident by the fall of the second growing season.

2. Sugar and straw, and straw did not affect survivability (density) or biomass of the six native and introduced species.

3.7 References

Allison, F.E. and C.J. Klein. 1962. Rates of immobilization and release on nitrogen following additions of carbonaceous materials and nitrogen to soils. Soil Science 93:383-386.

Alsands Project Group. 1978. Environmental impact assessment presented to Alberta Environment in support of an oil sands mining project. Calgary, AB.

Aoyama, M. and T. Nozawa. 1993. Microbial biomass nitrogen and mineralization-immobilization processes of nitrogen in soils incubated with various organic materials. Soil Science and Plant Nutrition 39 (1):23-32.

Ashworth, J. and K. Mrazek. 1995. "Modified Kelowna" test for available phosphorus and potassium. Communications in Soil Science and Plant Analysis 26:731-739.

Berg, W.A. 1974. Grasses and legumes for revegetation of disturbed subalpine areas. Pp. 31-35 In: W.A. Berg, J.A. Brown and R.L. Cuany, eds. Proceedings of a workshop on revegetation of high-altitude disturbed lands. Colorado State University. Information Series No. 10.

Best, K.F., J. Looman and J.B. Campbell. 1971. Prairie grasses identified and described by vegetative characters. Supply and Services Canada. Ottawa, ON. 237 pp.

Biodini, M.E., C.D. Bonham and E.F. Redente. 1985. Relationships between induced successional patterns and soil biological activity of reclaimed areas. Reclamation and Revegetation Research 3:323-342.

Black, C.A. 1965a. Methods of soil analysis: physical and mineralogical properties, including statistics of measurement and sampling. Agronomy part 1. American Society of Agronomy. Madison, WI. Pp. 1-770.

Black, C.A. 1965b. Methods of soil analysis: Chemical and microbiological properties. Agronomy part 2. American Society of Agronomy. Madison, WI. Pp. 771-1572.

Broadbent, F.E. and K.B. Tyler. 1962. Laboratory and greenhouse investigations of nitrogen immobilization. Soil Science Society Proceedings 26:459-462.

Buckerfield's Ltd. 1980. Seeds for revegetating disturbed land: descriptive manual. Buckerfield's Seed Division. Vancouver, BC

Elliot, C.R. and J.L. Boton. 1970. Licensed varieties of cultivated grasses and legumes. Canada Department of Agriculture, Publication No. 1405. Ottawa, ON.

Environment Canada. n.d. Canadian climate normals 1961 - 1990 prairie provinces. Environment Canada Atmospheric Environment Services.

Farmer, E.E. and W.G. Blue. 1978. Reclamation of lands mined for phosphate. Pp. 585-608. In: Reclamation of drastically disturbed lands. F.W. Schaller and P. Sutton, eds. American Society of Agronomy, Crop Science Society of America, Soil Science Society of America. Madison, WI.

Fauci, M.F. and R.P. Dick. 1994. Soil microbial dynamics: Short- and long-term effects of inorganic and organic nitrogen. Soil Science Society of America Journal 58:801-806.

Gerling, H.S., M.G. Willoughby, A. Schoepf, K.E. Tannas and C.A. Tannas. 1996. A guide to using native plants on disturbed lands. Alberta Agriculture, Food and Rural Development and Alberta Environmental Protection. Edmonton, AB. 247 pp.

Hafenrichter, A. L., J.L. Schwendiman, H.L. Harris, R.S. MacLauchlan and H.W. Miller. 1968. Grasses and legumes for soil conservation in the Pacific Northwest and Great Basin States. USDA Soil Conservation Service, Agricultural Handbook No. 339.

Hardy BBT Limited. 1989. Manual of plant species suitability for reclamation in Alberta-2nd edition. Alberta Land Conservation and Reclamation Council Report No. RRTAC 89-4. Edmonton, AB. 436 pp.

Heady, H.F. 1975. Range management. McGraw-Hill Publishing Co. New York, NY.

Hitchcock, A.S. 1971. Manual of the grasses of the United States. 2nd edition revised by A. Chase. Dover Publications, Inc. New York, NY.

Jacobsen, J.S., S.H. Lorbeer, H.A.R. Houlton and G.R. Carlson. 1996. Nitrogen fertilization of dryland grasses in the Northern Great Plains. Journal of Range Management 49:340-345.

Jones, J.N. Jr., W.H. Armiger and O.L. Bennett. 1975. Forage grasses aid transition from spoil to soil. Pages 185-194 In: Proceedings of the third symposium on surface mining and reclamation, Volume II. NCA/BCR Coal Conference and Expo II. National Coal Association. Washington, D.C.

Jonasson, S., P. Vestergaard, M. Jensen and A. Michelsen. 1996. Effects of carbohydrate amendments on nutrient partitioning, plant and microbial performance of a grassland-shrub ecosystem. Oikos 75:220-226.

Jones, R.D. and A.P. Schwab. 1993. Nitrate leaching and nitrite occurrence in a fine-textured soil. Soil Science 155:272-282.

Kerr, D.S., L.J. Morrison and K.E. Wilkinson. 1993. Reclamation of native grasslands in Alberta: A review of the literature. Alberta Land Conservation and Reclamation Council Report No. RRTAC 93-1. Queen's Printer. Edmonton, AB. 231 pp.

LeRoy, J. and H. Keller. 1972. How to reclaim mined areas, tailings ponds, and dumps into valuable land. World Mining, January 1972:34-41.

Looman, J. and K.F. Best. 1979. Budd's flora of the Canadian prairie provinces. Canadian Government Publishing Centre Supply and Services Canada. Hull, PQ. 863 pp.

McKeague, J.A. 1976. Manual on soil sampling and methods of analysis. Canadian Society of Soil Science. Ottawa, ON.

Morgan, J.P. 1994. Soil impoverishment: a little-known technique holds potential for establishing prairie. Restoration and Management Notes 12 (1):55-56.

Moss, E.H. 1992. Flora of Alberta, 2nd edition. Revised by J.G. Packer. University of Toronto Press. Toronto, ON. 687 pp.

Parker, D.T. 1962. Decomposition in the field of buried and surface-applied cornstalk residue. Soil Science Proceedings 26:559-562.

Pelech, W.E. 1997. Performance of selected native and introduced plant species under mowing and herbicide management during the establishment period. MSc. Thesis, Department of Renewable Resources, University of Alberta. Edmonton, AB. 105 pp.

Plummer, A.P. 1977. Revegetation of disturbed intermountain area sites. Pp. 302-339. In: J.L. Thomas, ed. Reclamation and use of disturbed land in the southwest. The University of Arizona Press. Tucson, AZ.

Skousen, J. 1988. Species for revegetation: legumes. Green Lands 17(4):35-39.

Strong, W.L. and K.R. Leggat. 1992. Ecoregions of Alberta. Alberta Forestry, Lands and Wildlife, Edmonton. 59 pp. plus map.

Takyi, S.K. 1984. Role of topsoil, fertilizers and companion crops in revegetation of two severe sites in the Alberta foothills and mountains. Alberta Energy and Natural Resources. Edmonton, AB. 29 pp.

Tilman, D. 1987. Secondary succession and the pattern of plant dominance along experimental nitrogen gradients. Ecological Monographs 57 (3):189-214.

USDA Soil Conservation Service. 1976. Standards and specifications: critical area planting. Technical Guide, Section IV. Denver, CO.

Vaartnou, M. 1979. Table 6 from unpublished M.Sc. thesis (Yukon pipeline plot studies). University of British Columbia. Vancouver, BC.

Vories, K.C. and P.L. Sims. 1977. The plant information network volume III: reclamation and PIN in the Powder River basin of Montana and Wyoming. U.S. Department of the Interior, Fish and Wildlife Service. Office of Biological Services, Report No. FWS/OBS-77/40.

Walker, D. and J. Weijer. 1975. The collection, maintenance and utilization of native grasses of the eastern slopes of the Rocky Mountains. Prepared for Department of Recreation, Parks and Wildlife, Division of Fish and Wildlife and the Department of Energy and Natural Resources, Division of Forestry. Department of Genetics, University of Alberta. Edmonton, AB.

Wark, D.B., W.R. Poole, R.G. Arnott, L.R. Moats and L. Wetter. n.d. Revegetating with native grasses. Ducks Unlimited Canada. 133 pp.

Weaver, J.E. 1942. Competition of western wheat grass with relict vegetation of prairie. American Journal of Botany 29:366-372.

Whitby-Costescu, L., J. Schillabeer and D.F. Coates. 1977. Pit slope manual, chapter 10: environmental planning. Canada Centre for Mineral and Energy Technology, Energy Mines and Resources, CANMET Report 77-2.

Zimmerman, J.K., W.M. Pulliam, D.J. Lodge, V. Quinones-Orfila, N. Fetcher, S. Guzman-Grajales, J.A. Parrotta, C.E. Asbury, L.R. Walker and R.B. Waide. 1995. Nitrogen immobilization by decomposing woody debris and the recovery of tropical wet forest from hurricane damage. Oikos 72:314-322.

Table 3.1 Plant height and density of *Agropyron smithii* monoculture at Ellerslie during summer of 1996

Species Mix	Height (cm)		Density (plants / 0.1 m²)									
			Volunteer Cereals		Forbs		Grasses		Legumes		*Brassicaceae* Sp.	
Treatment	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.
Straw												
July 15	-	-	-	-	3	2	4	4	0	0	-	-
July 29	6.9	3.1	0	1	4	3	7	5	0	0	-	-
August 13	11.5	2.8	1	2	3	2	7	5	0	0	2	1
August 26	14.7	4.0	1	1	3	2	7	4	0	0	1	1
Straw / Sugar												
July 15	-	-	-	-	2	2	7	4	0	0	-	-
July 29	6.0	1.8	5	2	4	2	7	4	0	0	-	-
August 13	9.7	3.4	4	2	2	2	8	3	0	0	0	1
August 26	13.9	3.2	4	2	2	2	7	5	0	0	1	1
No Amendments												
July 15	-	-	-	-	10	6	8	4	0	0	-	-
July 29	12.4	3.0	0	0	4	3	11	6	0	0	-	-
August 13	13.7	2.7	0	0	3	2	12	5	0	0	2	2
August 26	132.6	407.0	0	0	4	3	9	6	0	0	2	2

S. D. = Standard Deviation

Table 3.2 Plant height and density of *Bromus inermis* monoculture at Ellerslie during summer of 1996

Species Mix	Height (cm)		Density (plants / 0.1 m²)									
			Volunteer Cereals		Forbs		Grasses		Legumes		*Brassicaceae* Sp.	
Treatment	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.
Straw												
July 15	-	-	-	-	3	2	9	7	0	0	-	-
July 29	13.4	4.0	0	1	2	2	11	7	0	0	-	-
August 13	16.0	5.2	1	1	2	2	12	6	0	0	1	1
August 26	26.2	12.8	2	1	1	1	6	6	0	0	1	1
Straw / Sugar												
July 15	-	-	-	-	1	2	7	4	0	0	-	-
July 29	8.8	3.1	4	2	4	3	8	3	0	0	-	-
August 13	14.5	4.3	4	2	2	2	7	5	0	0	1	1
August 26	22.5	9.1	3	2	3	3	6	4	0	0	1	1
No Amendments												
July 15	-	-	-	-	10	7	11	9	0	0	-	-
July 29	22.3	28.9	0	0	6	4	15	8	0	0	-	-
August 13	15.4	4.2	1	2	4	4	11	8	0	0	1	1
August 26	25.2	3.7	1	1	2	2	8	6	0	0	2	2

S. D. = Standard Deviation

Table 3.3 Plant height and density of *Phleum pratense* monoculture at Ellerslie during summer of 1996

Species Mix	Height (cm)		Density (plants / 0.1 m²)									
			Volunteer Cereals		Forbs		Grasses		Legumes		*Brassicaceae* Sp.	
Treatment	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.
Straw												
July 15	-	-	-	-	3	4	3	4	0	0	-	-
July 29	5.1	2.5	0	1	2	1	3	3	0	0	-	-
August 13	9.9	4.8	1	2	2	2	4	3	0	0	2	2
August 26	18.3	10.6	3	2	3	2	3	3	0	0	1	1
Straw / Sugar												
July 15	-	-	-	-	1	2	9	4	0	0	-	-
July 29	3.9	4.1	5	3	4	4	9	7	0	0	-	-
August 13	5.8	4.8	3	2	1	1	8	7	0	0	2	2
August 26	14.4	10.7	3	2	2	1	6	6	0	0	1	1
No Amendments												
July 15	-	-	-	-	6	5	6	6	0	0	-	-
July 29	9.1	3.6	0	0	3	3	7	7	0	0	-	-
August 13	10.2	4.6	0	0	2	2	4	3	0	0	1	1
August 26	20.9	6.5	0	0	2	2	3	2	0	0	2	1

S. D. = Standard Deviation

Table 3.4 Plant height and density of *Stipa viridula* monoculture at Ellerslie during summer of 1996

Species Mix	Height (cm)		Density (plants / 0.1 m²)									
			Volunteer Cereals		Forbs		Grasses		Legumes		*Brassicaceae* Sp.	
Treatment	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.
Straw												
July 15	-	-	-	-	3	3	2	1	0	0	-	-
July 29	8.1	3.8	1	2	3	4	3	2	0	0	-	-
August 13	13.8	6.0	1	1	2	2	4	2	0	0	1	2
August 26	20.9	8.1	2	2	3	2	3	2	0	0	1	1
Straw / Sugar												
July 15	-	-	-	-	3	1	2	2	0	0	-	-
July 29	5.8	3.4	5	4	4	2	3	2	0	0	-	-
August 13	12.5	6.0	4	3	4	3	3	3	0	0	1	1
August 26	11.5	8.1	4	2	4	2	2	1	0	0	2	2
No Amendments												
July 15	-	-	-	-	12	8	4	3	0	0	-	-
July 29	9.0	3.9	0	0	4	3	6	4	0	0	-	-
August 13	14.2	5.5	0	0	2	3	6	3	0	0	1	1
August 26	21.6	5.4	0	0	4	4	6	2	0	0	1	1

S. D. = Standard Deviation

Table 3.5 Plant height and density of *Trifolium hybridum* monoculture at Ellerslie during summer of 1996

Species Mix	Height (cm)		Density (plants / 0.1 m²)									
			Volunteer Cereals		Forbs		Grasses		Legumes		*Brassicaceae* Sp.	
Treatment	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.
Straw												
July 15	-	-	-	-	5	4	0	1	1	1	-	-
July 29	2.3	1.1	1	0	3	2	1	1	2	2	-	-
August 13	5.3	2.9	1	1	2	2	0	0	2	2	2	2
August 26	8.4	5.4	2	2	3	2	0	0	2	2	1	1
Straw / Sugar												
July 15	-	-	-	-	2	2	0	1	1	1	-	-
July 29	1.2	0.8	4	3	4	2	0	0	2	3	-	-
August 13	4.3	3.5	4	3	3	2	0	0	2	4	1	1
August 26	7.9	5.1	3	2	2	2	0	0	2	2	1	1
No Amendments												
July 15	-	-	-	-	10	8	0	0	1	1	-	-
July 29	3.2	2.2	0	0	3	2	0	1	4	4	-	-
August 13	5.3	4.0	0	1	2	1	0	0	3	4	1	1
August 26	10.0	5.1	0	0	2	2	0	0	4	4	2	1

S. D. = Standard Deviation

Table 3.6 Plant height and density of *Vicia americana* monoculture at Ellerslie during summer of 1996

Species Mix	Height (cm)		Density (plants / 0.1 m²)									
			Volunteer Cereals		Forbs		Grasses		Legumes		*Brassicaceae* Sp.	
Treatment	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.
Straw												
July 15	-	-	-	-	3	3	1	2	8	5	-	-
July 29	4.2	1.3	0	0	2	3	0	1	14	8	-	-
August 13	6.1	1.3	1	2	2	2	0	0	15	9	0	0
August 26	6.7	2.1	1	1	2	1	3	5	12	7	1	1
Straw / Sugar												
July 15	-	-	-	-	2	2	1	3	7	5	-	-
July 29	4.5	0.8	3	3	4	3	0	0	15	11	-	-
August 13	6.9	3.2	3	2	2	2	0	0	14	10	1	1
August 26	6.4	2.6	3	2	2	1	2	6	11	5	1	1
No Amendments												
July 15	-	-	-	-	7	7	0	1	12	6	-	-
July 29	5.6	1.0	0	0	2	2	0	0	23	9	-	-
August 13	6.0	1.3	0	0	2	2	0	0	19	7	1	1
August 26	7.5	2.7	0	0	2	1	4	7	16	6	1	1

S. D. = Standard Deviation

Table 3.7 Plant height and density of *Agropyron smithii / Bromus inermis* mix at Ellerslie during summer of 1996

Species Mix	Height (cm)		Density (plants / 0.1 m^2)									
			Volunteer Cereals		Forbs		Grasses		Legumes		*Brassicaceae* Sp.	
Treatment	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.
Straw												
July 15	-	-	-	-	3	2	6	4	0	0	-	-
July 29	11.2	5.1	0	1	3	3	11	6	0	0	-	-
August 13	13.5	5.3	2	2	2	3	7	5	0	0	1	1
August 26	17.6	9.9	2	2	3	2	4	3	0	0	1	1
Straw / Sugar												
July 15	-	-	-	-	2	1	10	5	0	0	-	-
July 29	8.4	3.1	4	2	4	4	11	5	0	0	-	-
August 13	13.7	4.4	4	2	2	2	8	4	0	0	1	1
August 26	18.4	6.8	4	2	3	2	4	3	0	0	1	1
No Amendments												
July 15	-	-	-	-	11	10	9	4	0	0	-	-
July 29	11.7	2.8	0	0	3	3	12	6	0	0	-	-
August 13	15.6	3.8	0	0	2	1	16	8	0	0	1	1
August 26	19.0	8.2	1	1	2	2	9	6	0	0	1	1

S. D. = Standard Deviation

Table 3.8 Plant height and density of *Phleum pratense / Stipa viridula* mix at Ellerslie during summer of 1996

Species Mix	Height (cm)		Density (plants / 0.1 m^2)									
			Volunteer Cereals		Forbs		Grasses		Legumes		*Brassicaceae* Sp.	
Treatment	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.
Straw												
July 15	-	-	-	-	3	2	1	2	0	0	-	-
July 29	6.7	4.0	0	0	3	2	4	3	0	0	-	-
August 13	8.4	5.7	1	1	3	3	2	2	0	0	1	1
ugust 26	14.6	9.7	2	1	2	2	2	1	0	0	1	1
Straw / Sugar												
July 15	-	-	-	-	2	1	4	5	0	0	-	-
July 29	5.4	2.5	4	3	3	2	4	4	0	0	-	-
August 13	10.2	4.7	5	1	1	2	4	3	0	0	1	1
August 26	15.3	8.8	5	2	2	2	2	2	0	0	1	1
No Amendments												
July 15	-	-	-	-	10	6	4	2	0	0	-	-
July 29	9.1	2.9	0	0	3	3	6	5	0	0	-	-
August 13	13.0	6.0	1	1	3	3	7	4	0	0	1	1
August 26	23.4	4.2	0	1	3	2	5	2	0	1	1	1

S. D. = Standard Deviation

Table 3.9 Plant height and density of *Trifolium hybridum / Vicia americana* mix at Ellerslie during summer of 1996

Species Mix	Height (cm)		Density (plants / 0.1 m²)									
			Volunteer Cereals		Forbs		Grasses		Legumes		*Brassicaceae* Sp.	
Treatment	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.
Straw												
July 15	-	-	-	-	2	2	0	0	2	1	-	-
July 29	4.3	1.3	0	0	2	2	0	0	9	6	-	-
August 13	6.0	1.4	3	2	1	1	0	0	6	4	1	1
August 26	8.8	2.2	2	1	2	1	0	0	7	5	2	2
Straw / Sugar												
July 15	-	-	-	-	1	1	0	0	3	3	-	-
July 29	4.3	1.2	5	3	2	2	0	0	6	5	-	-
August 13	6.3	1.3	4	2	1	1	0	0	8	3	2	2
August 26	7.3	2.5	2	2	3	2	0	0	5	3	1	1
No Amendments												
July 15	-	-	-	-	6	4	0	0	6	3	-	-
July 29	4.9	2.2	0	0	5	3	0	0	10	6	-	-
August 13	5.6	1.5	0	0	3	4	0	0	19	30	2	1
August 26	8.1	3.4	0	0	2	2	0	0	10	4	2	1

S. D. = Standard Deviation

Table 3.10 Plant height and density of *Agropyron smithii / Stipa viridula / Vicia americana* mix at Ellerslie during summer of 1996

Species Mix	Height (cm)		Density (plants / 0.1 m²)									
			Volunteer Cereals		Forbs		Grasses		Legumes		*Brassicaceae* Sp.	
Treatment	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.
Straw												
July 15	-	-	-	-	5	6	2	1	1	2	-	-
July 29	6.5	3.2	1	1	2	2	4	4	5	3	-	-
August 13	7.5	2.4	1	1	2	1	4	3	6	4	1	1
August 26	11.0	6.1	2	2	2	2	3	4	3	2	1	1
Straw / Sugar												
July 15	-	-	-	-	1	1	3	2	1	2	-	-
July 29	5.5	1.5	4	3	2	2	3	2	4	3	-	-
August 13	9.0	2.2	4	2	1	1	4	3	4	3	1	1
August 26	10.1	2.8	3	1	2	2	3	2	4	2	2	2
No Amendments												
July 15	-	-	-	-	7	6	3	2	3	3	-	-
July 29	7.5	2.0	0	0	2	2	5	3	6	3	-	-
August 13	8.1	3.2	0	0	2	2	5	3	7	3	2	2
August 26	11.5	4.0	0	0	2	1	5	3	7	4	2	2

S. D. = Standard Deviation

Table 3.11 Plant height and density of *Bromus inermis / Phleum pratense / Trifolium hybridum* mix at Ellerslie during summer of 1996

Species Mix	Height (cm)		Density (plants / 0.1 m²)									
			Volunteer Cereals		Forbs		Grasses		Legumes		*Brassicaceae* Sp.	
Treatment	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.
Straw												
July 15	-	-	-	-	2	2	4	2	1	1	-	-
July 29	9.2	3.0	1	1	2	2	6	4	1	2	-	-
August 13	10.5	4.8	2	1	2	2	5	5	1	2	2	2
August 26	20.0	9.8	2	1	2	1	3	3	1	2	1	1
Straw / Sugar												
July 15	-	-	-	-	1	1	4	3	0	0	-	-
July 29	8.7	4.7	4	3	5	3	3	2	0	1	-	-
August 13	10.3	6.2	4	3	1	2	2	1	0	0	1	1
August 26	19.6	11.5	4	2	2	2	2	2	1	1	2	2
No Amendments												
July 15	-	-	-	-	5	4	3	2	0	1	-	-
July 29	10.5	3.9	0	0	3	4	6	4	1	1	-	-
August 13	11.5	4.1	0	1	2	4	7	5	2	2	2	2
August 26	18.1	6.4	1	2	3	2	4	3	2	1	1	1

S. D. = Standard Deviation

Table 3.12 Plant height and density of *Agropyron smithii / Bromus inermis / Phleum pratense / Stipa viridula / Trifolium hybridum / Vicia americana* mix at Ellerslie during summer of 1996

Species Mix	Height (cm)		Density (plants / 0.1 m²)									
			Volunteer Cereals		Forbs		Grasses		Legumes		*Brassicaceae* Sp.	
Treatment	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.
Straw												
July 15	-	-	-	-	4	2	1	2	1	2	-	-
July 29	7.3	3.0	0	1	3	3	4	4	2	2	-	-
August 13	9.7	2.8	1	1	1	1	5	4	3	2	1	1
August 26	17.2	8.5	1	1	2	2	5	3	3	2	2	2
Straw / Sugar												
July 15	-	-	-	-	2	1	2	2	1	2	-	-
July 29	6.8	3.0	5	3	4	3	4	3	2	2	-	-
August 13	10.2	4.7	4	3	2	2	5	3	3	1	1	1
August 26	15.1	5.8	3	2	1	1	3	2	3	3	1	1
No Amendments												
July 15	-	-	-	-	9	8	4	3	2	2	-	-
July 29	8.3	3.4	0	0	3	2	5	3	3	2	-	-
August 13	9.3	3.2	0	0	2	3	7	5	4	3	1	2
August 26	17.2	6.3	1	1	2	2	4	4	4	2	2	2

S. D. = Standard Deviation

Table 3.13 Plant height and density of non - seeded species (control) at Ellerslie during summer of 1996

Species Mix	Height (cm)		Density (plants / 0.1 m^2)									
			Volunteer Cereals		Forbs		Grasses		Legumes		*Brassicaceae* Sp.	
Treatment	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.
Straw												
July 15	-	-	-	-	2	2	0	0	1	3	-	-
July 29	20.7	10.3	5	4	6	4	2	3	0	0	-	-
August 13	33.5	17.9	4	2	2	2	0	0	0	0	2	1
August 26	22.0	5.5	5	2	2	1	0	0	0	0	1	1
Straw / Sugar												
July 15	-	-	-	-	2	2	1	2	0	1	-	-
July 29	17.2	11.5	4	4	4	2	3	4	0	0	-	-
August 13	22.4	14.7	4	2	2	2	0	0	0	0	1	1
August 26	29.8	7.7	4	2	2	2	0	0	0	0	1	1
No Amendments												
July 15	-	-	-	-	5	4	0	0	2	3	-	-
July 29	21.3	10.4	0	0	17	10	0	1	0	0	-	-
August 13	40.5	20.4	0	0	3	2	0	0	0	0	8	4
August 26	11.1	3.7	0	0	3	1	0	0	0	0	7	4

S. D. = Standard Deviation

Table 3.14 *Agropyron smithii* in monoculture and mixes at Ellerslie in fall 1996

Species / Treatment	Density (plants / 0.1 m²) Mean	S. D.	Biomass (%) Mean	S. D.	Survivability (%) Mean	S. D.
A. smithii monoculture						
Straw	5 a	4	9 a	15	15 aA	13
Sugar Straw	5 a	4	11 a	26	15 aA	13
No Amendments	7 a	4	29 a	23	23 aA	13
A. smithii / B. inermis mix						
Straw	2 a	1	5 a	10	13 aA	10
Sugar Straw	2 a	2	0 a	1	14 aA	14
No Amendments	3 a	2	19 a	34	23 aA	15
A. smithii / S. viridula / V. americana mix						
Straw	2 ab	2	6 a	7	23 abA	21
Sugar Straw	2 a	2	3 a	3	19 aA	16
No Amendments	4 b	4	20 b	18	45 bB	36
A. smithii / B. inermis/ P. pratense / S. viridula / T. hybridum / V. americana mix						
Straw	1 a	1	2 a	2	16 aA	24
Sugar Straw	0 a	1	1 a	2	11 aA	18
No Amendments	1 a	1	6 b	7	25 aA	23
Non - seeded species (control)						
Straw	0 a	0	2 a	6		
Sugar Straw	0 a	1	3 a	11		
No Amendments	0 a	0	0 a	0		

A. smithii = Agropyron smithii; B. inermis = Bromus inermis; P. pratense = Phleum pratense; S. viridula = Stipa viridula; T. hybridum = Trifolium hybridum; V. americana = Vicia americana

S. D. = Standard Deviation

Means within a column for a given species mix or monoculture followed by the same lower case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Means within % survivability column for a specific amendment treatment followed by the same upper case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Table 3.15 *Agropyron smithii* in monoculture and mixes at Ellerslie in spring 1997

Species / Treatment	Density (plants / 0.1 m^2) Mean	S. D.	Biomass (%) Mean	S. D.	Survivability (%) Mean	S. D.
A. smithii monoculture						
Straw	6 a	4	30 a	25	19 aB	12
Sugar / Straw	5 a	2	25 a	17	17 aAB	7
No Amendments	7 a	3	41 a	26	23 aAB	11
A. smithii / B. inermis mix						
Straw	1 a	1	3 a	7	6 aA	6
Sugar / Straw	1 a	2	2 a	3	8 aA	11
No Amendments	2 a	2	13 a	28	13 aA	11
A. smithii / S. viridula / V. americana mix						
Straw	3 a	2	7 a	8	28 aB	22
Sugar / Straw	2 a	2	12 a	12	25 aB	15
No Amendments	3 a	2	11 a	9	33 aB	19
A. smithii / B. inermis/ P. pratense / S. viridula / T. hybridum / V. americana mix						
Straw	0 a	0	2 a	4	6 aA	9
Sugar / Straw	1 a	1	3 a	5	14 aA	17
No Amendments	2 b	2	5 a	6	38 bB	39
Non - seeded species (control)						
Straw	0 a	0	0 a	0		
Sugar / Straw	0 a	0	0 a	0		
No Amendments	0 a	0	0 a	0		

A. smithii = Agropyron smithii; B. inermis = Bromus inermis; P. pratense = Phleum pratense; S. viridula = Stipa viridula; T. hybridum = Trifolium hybridum; V. americana = Vicia americana

S. D. = Standard Deviation

Means within a column for a given species mix or monoculture followed by the same lower case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Means within % survivability column for a specific amendment treatment followed by the same upper case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Table 3.16 *Agropyron smithii* in monoculture and mixes at Ellerslie in fall 1997

Species / Treatment	Density (plants / 0.1 m^2) Mean	S. D.	Biomass (%) Mean	S. D.	Survivability (%) Mean	S. D.
A. smithii monoculture						
Straw	4 a	2	13 a	21	12 aA	8
Sugar / Straw	3 a	2	8 a	18	9 aA	5
No Amendments	4 a	3	38 b	35	13 aB	9
A. smithii / B. inermis mix						
Straw	2 b	2	2 a	4	10 bA	11
Sugar / Straw	1 ab	1	3 a	6	8 abA	8
No Amendments	0 a	1	0 a	1	3 aA	4
A. smithii / S. viridula / V. americana mix						
Straw	1 a	2	4 a	8	14 aA	19
Sugar / Straw	1 a	1	3 a	8	8 aA	11
No Amendments	2 a	2	7 a	11	18 aB	19
A. smithii / B. inermis/ P. pratense / S. viridula / T. hybridum / V. americana mix						
Straw	1 a	1	2 a	4	13 aA	15
Sugar / Straw	0 a	1	1 a	2	8 aA	13
No Amendments	1 a	1	9 a	27	12 aB	13
Non - seeded species (control)						
Straw	0 a	0	0 a	0		
Sugar / Straw	0 a	0	0 a	0		
No Amendments	0 a	0	0 a	0		

A. smithii = Agropyron smithii; B. inermis = Bromus inermis; P. pratense = Phleum pratense; S. viridula = Stipa viridula; T. hybridum = Trifolium hybridum; V. americana = Vicia americana

S. D. = Standard Deviation

Means within a column for a given species mix or monoculture followed by the same lower case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Means within % survivability column for a specific amendment treatment followed by the same upper case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Table 3.17 *Bromus inermis* in monoculture and mixes at Ellerslie in fall 1996

Species / Treatment	Density (plants / 0.1 m^2) Mean	S. D.	Biomass (%) Mean	S. D.	Survivability (%) Mean	S. D.
B. inermis monoculture						
Straw	4 a	2	28 ab	22	13 aA	8
Sugar / Straw	3 a	2	13 a	10	11 aA	8
No Amendments	6 a	3	51 b	38	19 aA	10
A. smithii / B. inermis mix						
Straw	2 a	2	9 a	12	16 aA	11
Sugar / Straw	3 a	2	5 a	7	17 aAB	13
No Amendments	4 a	2	52 b	37	23 aA	14
B. inermis / P. pratense / T. hybridum mix						
Straw	2 ab	2	13 a	21	20 abA	20
Sugar / Straw	1 a	1	4 a	8	10 aA	10
No Amendments	3 b	2	39 b	32	32 bAB	22
A. smithii / B. inermis/ P. pratense / S. viridula / T. hybridum / V. americana mix						
Straw	2 a	2	10 ab	10	37 aB	37
Sugar / Straw	1 a	1	4 a	5	25 aB	26
No Amendments	2 a	2	14 b	13	42 aB	36
Non - seeded species (control)						
Straw	0 a	0	0 a	0		
Sugar / Straw	0 a	0	0 a	0		
No Amendments	0 a	0	0 a	0		

A. smithii = Agropyron smithii; B. inermis = Bromus inermis; P. pratense = Phleum pratense; S. viridula = Stipa viridula; T. hybridum = Trifolium hybridum; V. americana = Vicia americana
S. D. = Standard Deviation
Means within a column for a given species mix or monoculture followed by the same lower case letter are not significantly different ($p < 0.05$, Tukey's HSD)
Means within % survivability column for a specific amendment treatment followed by the same upper case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Table 3.18 *Bromus inermis* in monoculture and mixes at Ellerslie in spring 1997

Species / Treatment	Density (plants / 0.1 m^2) Mean	S. D.	Biomass (%) Mean	S. D.	Survivability (%) Mean	S. D.
B. inermis monoculture						
Straw	5 a	3	94 a	15	16 aA	9
Sugar / Straw	6 a	2	94 a	10	19 aA	7
No Amendments	5 a	2	91 a	28	17 aA	8
A. smithii / B. inermis mix						
Straw	4 a	2	86 a	27	26 aA	15
Sugar / Straw	4 a	2	69 a	27	26 aAB	11
No Amendments	5 a	2	82 a	34	33 aB	15
B. inermis / P. pratense / T. hybridum mix						
Straw	3 a	2	60 ab	34	26 aA	15
Sugar / Straw	2 a	2	46 a	31	24 aAB	17
No Amendments	4 a	3	79 b	21	42 aB	26
A. smithii / B. inermis/ P. pratense / S. viridula / T. hybridum / V. americana mix						
Straw	2 a	2	42 a	35	50 aB	46
Sugar / Straw	2 a	1	40 a	31	34 aB	24
No Amendments	2 a	1	38 a	33	29 aAB	25
Non - seeded species (control)						
Straw	0 a	0	0 a	0		
Sugar / Straw	0 a	0	0 a	0		
No Amendments	0 a	0	0 a	0		

A. smithii = Agropyron smithii; B. inermis = Bromus inermis; P. pratense = Phleum pratense; S. viridula = Stipa viridula; T. hybridum = Trifolium hybridum; V. americana = Vicia americana

S. D. = Standard Deviation

Means within a column for a given species mix or monoculture followed by the same lower case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Means within % survivability column for a specific amendment treatment followed by the same upper case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Table 3.19 *Bromus inermis* in monoculture and mixes at Ellerslie in fall 1997

Species / Treatment	Density (plants / 0.1 m^2) Mean	S. D.	Biomass (%) Mean	S. D.	Survivability (%) Mean	S. D.
B. inermis monoculture						
Straw	4 a	2	88 a	22	12 aA	5
Sugar / Straw	4 a	1	84 a	21	14 aA	3
No Amendments	4 a	1	98 a	4	13 aA	4
A. smithii / B. inermis mix						
Straw	4 a	2	61 ab	35	24 aA	12
Sugar / Straw	4 a	2	57 a	30	27 aB	11
No Amendments	4 a	1	89 b	23	27 aB	8
B. inermis / P. pratense / T. hybridum mix						
Straw	2 a	2	72 a	36	22 aA	15
Sugar / Straw	2 a	2	59 a	44	25 aAB	19
No Amendments	2 a	1	60 a	28	23 aB	13
A. smithii / B. inermis/ P. pratense / S. viridula / T. hybridum / V. americana mix						
Straw	2 a	2	54 a	36	43 aB	30
Sugar / Straw	2 a	1	32 a	32	37 aB	27
No Amendments	2 a	1	56 a	37	48 aC	22
Non - seeded species (control)						
Straw	0 a	0	0 a	0		
Sugar / Straw	0 a	0	0 a	0		
No Amendments	0 a	0	0 a	0		

A. smithii = Agropyron smithii; B. inermis = Bromus inermis; P. pratense = Phleum pratense;
S. viridula = Stipa viridula; T. hybridum = Trifolium hybridum; V. americana = Vicia americana
S. D. = Standard Deviation
Means within a column for a given species mix or monoculture followed by the same lower case letter are not significantly different ($p < 0.05$, Tukey's HSD)
Means within % survivability column for a specific amendment treatment followed by the same upper case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Table 3.20 *Phleum pratense* in monoculture and mixes at Ellerslie in fall 1996

Species / Treatment	Density (plants / 0.1 m^2) Mean	S. D.	Biomass (%) Mean	S. D.	Survivability (%) Mean	S. D.
P. pratense monoculture						
Straw	2 a	2	21 a	22	8 aA	6
Sugar / Straw	2 a	2	9 a	17	7 aA	8
No Amendments	4 b	2	66 b	22	15 bAB	6
P. pratense / S. viridula mix						
Straw	1 a	1	6 a	9	7 aA	9
Sugar / Straw	1 a	1	2 a	4	5 aA	7
No Amendments	3 b	2	33 b	28	18 bAB	15
B. inermis / P. pratense / T. hybridum mix						
Straw	0 a	1	1 a	3	4 aA	8
Sugar / Straw	1 a	1	3 ab	6	9 aA	13
No Amendments	1 a	1	10 b	14	11 aA	10
A. smithii / B. inermis/ P. pratense / S. viridula / T. hybridum / V. americana mix						
Straw	0 a	0	2 a	4	6 aA	9
Sugar / Straw	0 a	1	2 a	4	9 aA	16
No Amendments	1 b	1	18 b	24	25 bB	20
Non - seeded species (control)						
Straw	0 a	0	0 a	0		
Sugar / Straw	0 a	0	0 a	0		
No Amendments	0 a	0	0 a	0		

A. smithii = Agropyron smithii; B. inermis = Bromus inermis; P. pratense = Phleum pratense; S. viridula = Stipa viridula; T. hybridum = Trifolium hybridum; V. americana = Vicia americana
S. D. = Standard Deviation
Means within a column for a given species mix or monoculture followed by the same lower case letter are not significantly different ($p < 0.05$, Tukey's HSD)
Means within % survivability column for a specific amendment treatment followed by the same upper case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Table 3.21 *Phleum pratense* in monoculture and mixes at Ellerslie in spring 1997

Species	Density (plants / 0.1 m^2)		Biomass (%)		Survivability (%)	
Treatment	Mean	S. D.	Mean	S. D.	Mean	S. D.
P. pratense monoculture						
Straw	2 a	1	68 a	31	7 aAB	4
Sugar / Straw	2 a	2	58 a	41	7 aAB	6
No Amendments	2 a	1	81 a	37	8 aA	5
P. pratense / S. viridula mix						
Straw	1 a	2	32 ab	38	9 aAB	10
Sugar / Straw	2 a	1	22 a	28	10 aAB	6
No Amendments	2 a	1	61 b	33	12 aA	9
B. inermis / P. pratense / T. hybridum mix						
Straw	1 a	2	21 b	25	14 aB	17
Sugar / Straw	1 a	2	5 a	9	12 aB	20
No Amendments	1 a	1	7 ab	11	6 aA	10
A. smithii / B. inermis/ P. pratense / S. viridula / T. hybridum / V. americana mix						
Straw	0 a	1	14 a	29	6 aA	12
Sugar / Straw	0 a	0	4 a	10	3 aA	8
No Amendments	0 a	0	24 a	31	9 aA	10
Non - seeded species (control)						
Straw	0 a	0	0 a	0		
Sugar / Straw	0 a	0	0 a	0		
No Amendments	0 a	0	0 a	0		

A. smithii = Agropyron smithii; B. inermis = Bromus inermis; P. pratense = Phleum pratense; S. viridula = Stipa viridula; T. hybridum = Trifolium hybridum; V. americana = Vicia americana

S. D. = Standard Deviation

Means within a column for a given species mix or monoculture followed by the same lower case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Means within % survivability column for a specific amendment treatment followed by the same upper case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Table 3.22 *Phleum pratense* in monoculture and mixes at Ellerslie in fall 1997

Species / Treatment	Density (plants / 0.1 m^2) Mean	S. D.	Biomass (%) Mean	S. D.	Survivability (%) Mean	S. D.
P. pratense monoculture						
Straw	2 a	1	66 ab	38	8 aA	4
Sugar / Straw	2 a	2	43 a	47	6 aAB	6
No Amendments	3 a	2	85 b	30	9 aA	6
P. pratense / S. viridula mix						
Straw	1 a	1	35 ab	32	8 aA	7
Sugar / Straw	1 a	1	17 a	29	6 aAB	6
No Amendments	2 a	1	58 b	34	13 aA	8
B. inermis / P. pratense / T. hybridum mix						
Straw	1 a	0	13 a	19	6 aA	5
Sugar / Straw	0 a	1	4 a	13	4 aA	6
No Amendments	1 a	1	19 a	19	8 aA	7
A. smithii / B. inermis/ P. pratense / S. viridula / T. hybridum / V. americana mix						
Straw	0 a	1	7 a	14	10 aA	19
Sugar / Straw	0 a	1	11 a	16	11 aB	13
No Amendments	0 a	1	3 a	8	8 aA	15
Non - seeded species (control)						
Straw	0 a	1	2 a	9		
Sugar / Straw	0 a	0	2 a	9		
No Amendments	0 a	0	0 a	0		

A. smithii = Agropyron smithii; B. inermis = Bromus inermis; P. pratense = Phleum pratense;
S. viridula = Stipa viridula; T. hybridum = Trifolium hybridum; V. americana = Vicia americana
S. D. = Standard Deviation
Means within a column for a given species mix or monoculture followed by the same lower case letter are not significantly different ($p < 0.05$, Tukey's HSD)
Means within % survivability column for a specific amendment treatment followed by the same upper case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Table 3.23 *Stipa viridula* in monoculture and mixes at Ellerslie in fall 1996

Species / Treatment	Density (plants / 0.1 m²) Mean	S. D.	Biomass (%) Mean	S. D.	Survivability (%) Mean	S. D.
S. viridula monoculture						
Straw	2 a	1	24 ab	33	7 aA	5
Sugar / Straw	2 a	2	3 a	5	6 aA	5
No Amendments	6 b	3	40 b	25	19 bA	10
P. pratense / S. viridula mix						
Straw	0 a	1	1 a	2	3 aA	5
Sugar / Straw	1 a	1	1 a	2	7 aA	8
No Amendments	2 b	1	14 b	11	15 bA	9
A. smithii / S. viridula / V. americana mix						
Straw	1 a	1	3 a	5	9 aA	9
Sugar / Straw	1 a	1	1 a	3	6 aA	9
No Amendments	2 b	2	17 b	16	22 bA	15
A. smithii / B. inermis/ P. pratense / S. viridula / T. hybridum / V. americana mix						
Straw	0 ab	1	1 a	2	9 abA	15
Sugar / Straw	0 a	1	1 a	2	6 aA	13
No Amendments	1 b	1	7 a	12	26 bA	29
Non - seeded species (control)						
Straw	0 a	0	0 a	0		
Sugar / Straw	0 a	0	0 a	0		
No Amendments	0 a	0	0 a	0		

A. smithii = Agropyron smithii; B. inermis = Bromus inermis; P. pratense = Phleum pratense; S. viridula = Stipa viridula; T. hybridum = Trifolium hybridum; V. americana = Vicia americana

S. D. = Standard Deviation

Means within a column for a given species mix or monoculture followed by the same lower case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Means within % survivability column for a specific amendment treatment followed by the same upper case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Table 3.24 *Stipa viridula* in monoculture and mixes at Ellerslie in spring 1997

Species	Density (plants / 0.1 m^2)		Biomass (%)		Survivability (%)	
Treatment	Mean	S. D.	Mean	S. D.	Mean	S. D.
S. viridula monoculture						
Straw	2 a	2	27 ab	31	6 aAB	5
Sugar / Straw	2 a	2	5 a	6	6 aAB	5
No Amendments	4 b	2	52 b	38	14 bA	8
P. pratense / S. viridula mix						
Straw	2 a	2	16 a	30	10 aAB	17
Sugar / Straw	1 a	1	13 a	19	9 aB	6
No Amendments	2 a	2	23 a	28	16 aA	11
A. smithii / S. viridula / V. americana mix						
Straw	1 a	2	8 a	9	12 aB	15
Sugar / Straw	0 a	1	4 a	8	4 aA	6
No Amendments	2 a	2	19 a	28	15 aA	19
A. smithii / B. inermis/ P. pratense / S. viridula / T. hybridum / V. americana mix						
Straw	0 a	0	1 a	3	3 aA	7
Sugar / Straw	0 a	0	1 a	3	3 aA	8
No Amendments	0 a	1	2 a	3	11 aA	13
Non - seeded species (control)						
Straw	0 a	0	0 a	0		
Sugar / Straw	0 a	0	0 a	0		
No Amendments	0 a	0	0 a	0		

A. smithii = Agropyron smithii; B. inermis = Bromus inermis; P. pratense = Phleum pratense; S. viridula = Stipa viridula; T. hybridum = Trifolium hybridum; V. americana = Vicia americana

S. D. = Standard Deviation

Means within a column for a given species mix or monoculture followed by the same lower case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Means within % survivability column for a specific amendment treatment followed by the same upper case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Table 3.25 *Stipa viridula* in monoculture and mixes at Ellerslie in fall 1997

Species / Treatment	Density (plants / 0.1 m^2) Mean	S. D.	Biomass (%) Mean	S. D.	Survivability (%) Mean	S. D.
S. viridula monoculture						
Straw	2 ab	2	27 a	28	7 abB	7
Sugar / Straw	2 a	1	4 a	7	5 aA	4
No Amendments	4 b	2	76 b	32	12 bAB	7
P. pratense / S. viridula mix						
Straw	1 a	1	9 a	13	7 aB	6
Sugar / Straw	1 a	1	8 a	12	7 aA	6
No Amendments	2 b	1	22 a	20	14 bB	9
A. smithii / S. viridula / V. americana mix						
Straw	2 ab	1	10 a	18	16 abC	15
Sugar / Straw	0 a	1	2 a	4	5 aA	8
No Amendments	2 b	2	48 b	37	23 bC	16
A. smithii / B. inermis/ P. pratense / S. viridula / T. hybridum / V. americana mix						
Straw	0 a	0	0 a	0	0 aA	0
Sugar / Straw	0 a	1	3 a	9	5 aA	12
No Amendments	0 a	0	1 a	1	6 aA	10
Non - seeded species (control)						
Straw	0 a	0	0 a	0		
Sugar / Straw	0 a	0	0 a	0		
No Amendments	0 a	0	0 a	0		

A. smithii = Agropyron smithii; B. inermis = Bromus inermis; P. pratense = Phleum pratense; S. viridula = Stipa viridula; T. hybridum = Trifolium hybridum; V. americana = Vicia americana

S. D. = Standard Deviation

Means within a column for a given species mix or monoculture followed by the same lower case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Means within % survivability column for a specific amendment treatment followed by the same upper case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Table 3.26 *Trifolium hybridum* in monoculture and mixes at Ellerslie in fall 1996

Species / Treatment	Density (plants / 0.1 m^2) Mean	S. D.	Biomass (%) Mean	S. D.	Survivability (%) Mean	S. D.
T. hybridum monoculture						
Straw	2 a	1	28 ab	32	5 aA	5
Sugar / Straw	2 a	2	12 a	16	5 aA	6
No Amendments	2 a	2	42 b	28	6 aA	7
T. hybridum / V. americana mix						
Straw	1 a	0	16 ab	18	6 aA	4
Sugar / Straw	1 a	1	14 a	14	8 aA	9
No Amendments	2 a	3	36 b	32	16 aA	21
B. inermis / P. pratense / T. hybridum mix						
Straw	1 a	1	11 a	19	9 aA	13
Sugar Straw	1 a	1	8 a	14	7 aA	8
No Amendments	1 a	1	13 a	14	9 aA	8
A. smithii / B. inermis/ P. pratense / S. viridula / T. hybridum / V. americana mix						
Straw	0 a	0	4 a	9	4 aA	9
Sugar Straw	0 a	1	4 a	6	9 aA	13
No Amendments	1 a	1	5 a	9	14 aA	15
Non - seeded species (control)						
Straw	0 a	0	0 a	0		
Sugar Straw	0 a	0	0 a	0		
No Amendments	0 a	0	0 a	0		

A. smithii = Agropyron smithii; B. inermis = Bromus inermis; P. pratense = Phleum pratense; S. viridula = Stipa viridula; T. hybridum = Trifolium hybridum; V. americana = Vicia americana

S. D. = Standard Deviation

Means within a column for a given species mix or monoculture followed by the same lower case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Means within % survivability column for a specific amendment treatment followed by the same upper case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Table 3.27 *Trifolium hybridum* in monoculture and mixes at Ellerslie in spring 1997

Species / Treatment	Density (plants / 0.1 m^2) Mean	S. D.	Biomass (%) Mean	S. D.	Survivability (%) Mean	S. D.
T. hybridum monoculture						
Straw	1 a	1	46 a	41	4 aA	3
Sugar / Straw	2 a	4	35 a	35	7 aA	12
No Amendments	3 a	3	68 a	34	10 aA	9
T. hybridum / V. americana mix						
Straw	1 a	1	32 a	36	7 aA	7
Sugar / Straw	1 a	1	27 a	32	5 aA	6
No Amendments	1 a	2	31 a	39	8 aA	12
B. inermis / P. pratense / T. hybridum mix						
Straw	0 a	1	5 a	10	4 aA	6
Sugar / Straw	1 a	1	15 a	22	9 aA	13
No Amendments	1 a	1	9 a	9	12 aA	9
A. smithii / B. inermis/ P. pratense / S. viridula / T. hybridum / V. americana mix						
Straw	0 a	0	0 a	1	3 aA	7
Sugar / Straw	0 a	1	19 a	32	11 aA	16
No Amendments	0 a	1	8 a	17	11 aA	24
Non - seeded species (control)						
Straw	0 a	0	0 a	0		
Sugar / Straw	0 a	0	0 a	0		
No Amendments	0 a	0	0 a	0		

A. smithii = Agropyron smithii; B. inermis = Bromus inermis; P. pratense = Phleum pratense; S. viridula = Stipa viridula; T. hybridum = Trifolium hybridum; V. americana = Vicia americana

S. D. = Standard Deviation

Means within a column for a given species mix or monoculture followed by the same lower case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Means within % survivability column for a specific amendment treatment followed by the same upper case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Table 3.28 *Trifolium hybridum* in monoculture and mixes at Ellerslie in fall 1997

Species / Treatment	Density (plants / 0.1 m^2) Mean	S. D.	Biomass (%) Mean	S. D.	Survivability (%) Mean	S. D.
T. hybridum monoculture						
Straw	1 a	1	50 ab	42	3 aA	2
Sugar / Straw	1 a	1	29 a	31	3 aA	3
No Amendments	1 a	1	67 b	46	3 aA	2
T. hybridum / V. americana mix						
Straw	1 a	1	46 a	44	6 aA	6
Sugar / Straw	1 a	1	36 a	41	5 aA	5
No Amendments	1 a	1	50 a	49	6 aA	6
B. inermis / P. pratense / T. hybridum mix						
Straw	0 a	1	7 a	23	4 aA	6
Sugar / Straw	0 a	0	15 a	31	3 aA	5
No Amendments	0 a	0	13 a	23	5 aA	5
A. smithii / B. inermis/ P. pratense / S. viridula / T. hybridum / V. americana mix						
Straw	0 a	1	13 a	34	6 aA	17
Sugar / Straw	0 a	1	12 a	20	8 aA	13
No Amendments	0 a	0	9 a	15	8 aA	10
Non - seeded species (control)						
Straw	0 a	0	0 a	0		
Sugar / Straw	0 a	0	0 a	0		
No Amendments	0 a	0	0 a	0		

A. smithii = Agropyron smithii; B. inermis = Bromus inermis; P. pratense = Phleum pratense; S. viridula = Stipa viridula; T. hybridum = Trifolium hybridum; V. americana = Vicia americana

S. D. = Standard Deviation

Means within a column for a given species mix or monoculture followed by the same lower case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Means within % survivability column for a specific amendment treatment followed by the same upper case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Table 3.29 *Vicia americana* in monoculture and mixes at Ellerslie in fall 1996

Species / Treatment	Density (plants / 0.1 m^2) Mean	S. D.	Biomass (%) Mean	S. D.	Survivability (%) Mean	S. D.
V. americana monoculture						
Straw	12 a	7	22 ab	28	40 aAB	24
Sugar / Straw	8 a	4	6 a	4	27 aA	12
No Amendments	15 a	10	38 b	29	49 aA	32
T. hybridum / V. americana mix						
Straw	7 a	5	5 a	4	49 aAB	36
Sugar / Straw	8 a	4	9 a	15	54 aB	28
No Amendments	9 a	6	13 a	11	58 aA	40
A. smithii / S. viridula / V. americana mix						
Straw	6 a	3	11 a	10	59 aB	29
Sugar / Straw	5 a	4	4 a	4	48 aB	37
No Amendments	8 a	7	23 b	20	82 aA	70
A. smithii / B. inermis/ P. pratense / S. viridula / T. hybridum / V. americana mix						
Straw	2 a	2	5 a	9	31 aA	36
Sugar / Straw	2 a	1	2 a	2	46 aB	25
No Amendments	3 a	2	4 a	2	57 aA	37
Non - seeded species (control)						
Straw	0 a	0	0 a	0		
Sugar / Straw	0 a	0	0 a	0		
No Amendments	0 a	0	0 a	0		

A. smithii = Agropyron smithii; B. inermis = Bromus inermis; P. pratense = Phleum pratense; S. viridula = Stipa viridula; T. hybridum = Trifolium hybridum; V. americana = Vicia americana

S. D. = Standard Deviation

Means within a column for a given species mix or monoculture followed by the same lower case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Means within % survivability column for a specific amendment treatment followed by the same upper case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Table 3.30 *Vicia americana* in monoculture and mixes at Ellerslie in spring 1997

Species / Treatment	Density (plants / 0.1 m^2) Mean	S. D.	Biomass (%) Mean	S. D.	Survivability (%) Mean	S. D.
V. americana monoculture						
Straw	32 a	18	60 a	37	107 aA	61
Sugar / Straw	30 a	9	62 a	24	100 aB	29
No Amendments	38 a	17	65 a	33	128 aA	55
T. hybridum / V. americana mix						
Straw	12 ab	7	25 a	22	83 abA	45
Sugar / Straw	9 a	6	22 a	22	62 aA	39
No Amendments	19 b	11	42 a	37	125 bA	74
A. smithii / S. viridula / V. americana mix						
Straw	11 ab	11	15 a	11	109 abA	106
Sugar Straw	6 a	5	38 b	29	62 aA	52
No Amendments	15 b	11	18 a	15	152 bA	111
A. smithii / B. inermis/ P. pratense / S. viridula / T. hybridum / V. americana mix						
Straw	5 a	4	15 a	25	94 aA	82
Sugar / Straw	4 a	2	7 a	7	69 aAB	49
No Amendments	7 a	6	9 a	20	132 aA	111
Non - seeded species (control)						
Straw	0 a	0	0 a	0		
Sugar / Straw	0 a	0	0 a	0		
No Amendments	0 a	0	0 a	0		

A. smithii = Agropyron smithii; B. inermis = Bromus inermis; P. pratense = Phleum pratense; S. viridula = Stipa viridula; T. hybridum = Trifolium hybridum; V. americana = Vicia americana

S. D. = Standard Deviation

Means within a column for a given species mix or monoculture followed by the same lower case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Means within % survivability column for a specific amendment treatment followed by the same upper case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Table 3.31 *Vicia americana* in monoculture and mixes at Ellerslie in fall 1997

Species	Density (plants / 0.1 m^2)		Biomass (%)		Survivability (%)	
Treatment	Mean	S. D.	Mean	S. D.	Mean	S. D.
V. americana monoculture						
Straw	0 a	1	0 a	1	1 aA	2
Sugar / Straw	0 a	1	0 a	1	1 aAB	4
No Amendments	0 a	1	1 a	3	1 aA	2
T. hybridum / V. americana mix						
Straw	0 a	0	0 a	0	1 aA	3
Sugar / Straw	1 a	1	0 a	0	4 aB	6
No Amendments	0 a	0	0 a	0	1 aA	2
A. smithii / S. viridula / V. americana mix						
Straw	0 a	0	0 a	0	1 aA	5
Sugar / Straw	0 a	0	0 a	0	0 aA	0
No Amendments	0 a	0	0 a	0	1 aA	3
A. smithii / B. inermis/ P. pratense / S. viridula / T. hybridum / V. americana mix						
Straw	0 a	0	0 a	0	3 aA	7
Sugar / Straw	0 a	0	0 a	0	2 aAB	6
No Amendments	0 a	1	0 a	1	8 aB	15
Non - seeded species (control)						
Straw	0 a	0	0 a	0		
Sugar / Straw	0 a	0	0 a	0		
No Amendments	0 a	0	0 a	0		

A. smithii = Agropyron smithii; B. inermis = Bromus inermis; P. pratense = Phleum pratense; S. viridula = Stipa viridula; T. hybridum = Trifolium hybridum; V. americana = Vicia americana

S. D. = Standard Deviation

Means within a column for a given species mix or monoculture followed by the same lower case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Means within % survivability column for a specific amendment treatment followed by the same upper case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Table 3.32 Total density and survivability of seeded species in monocultures and mixes at Ellerslie in fall 1996

Species / Treatment	Density (plants / 0.1 m^2) Mean	S. D.	Survivability (%) Mean	S. D.
A. smithii monoculture				
Straw	5 aABC	4	15 aABC	13
Sugar / Straw	5 aABC	4	15 aABC	13
No Amendments	7 aABC	4	23 aABC	13
B. inermis monoculture				
Straw	4 aAB	2	13 aAB	8
Sugar / Straw	3 aAB	2	11 aAB	8
No Amendments	6 aABC	3	19 aABC	10
P. pratense monoculture				
Straw	2 aA	2	7 aA	6
Sugar / Straw	2 aA	2	7 aA	8
No Amendments	4 bAB	2	15 bAB	6
S. viridula monoculture				
Straw	2 aA	1	7 aA	5
Sugar / Straw	1 aA	2	6 aA	5
No Amendments	6 bABC	3	19 bABC	10
T. hybridum monoculture				
Straw	2 aA	1	5 aA	5
Sugar / Straw	2 aA	2	5 aA	6
No Amendments	2 aA	2	6 aA	7
V. americana monoculture				
Straw	12 aD	7	40 aD	24
Sugar / Straw	8 aCD	4	27 aCD	12
No Amendments	15 aD	10	49 aD	32
A. smithii / *B. inermis* mix				
Straw	4 aAB	3	15 aAB	9
Sugar / Straw	5 aABC	4	16 aABC	12
No Amendments	7 aABC	4	23 aABC	14
P. pratense / *S. viridula* mix				
Straw	1 aA	2	5 aA	6
Sugar / Straw	2 aA	2	6 aA	6
No Amendments	5 bAB	3	16 bAB	11
T. hybridum / *V. americana* mix				
Straw	8 aBCD	5	27 aBCD	18
Sugar / Straw	9 aD	4	31 aD	14
No Amendments	11 aCD	5	37 aCD	17

Table 3.32 Total density and survivability of seeded species in monocultures and mixes at Ellerslie in fall 1996 (continued)

Species / Treatment	Density (plants / 0.1 m^2) Mean	S. D.	Survivability (%) Mean	S. D.
A. smithii / S. viridula / V. americana mix				
Straw	9 abCD	5	30 abCD	16
Sugar / Straw	7 aBCD	6	25 aBCD	18
No Amendments	15 bD	8	49 bD	27
B. inermis / P. pratense / T. hybridum mix				
Straw	3 abA	3	11 abA	10
Sugar / Straw	3 aA	2	9 aA	6
No Amendments	5 bABC	3	17 bABC	10
A. smithii / B. inermis/ P. pratense / S. viridula / T. hybridum / V. americana mix				
Straw	5 aABC	4	17 aABC	12
Sugar / Straw	5 aABCD	3	18 aABCD	10
No Amendments	9 bBCD	4	31 bBCD	12

A. smithii = Agropyron smithii; B. inermis = Bromus inermis; P. pratense = Phleum pratense; S. viridula = Stipa viridula; T. hybridum = Trifolium hybridum; V. americana = Vicia americana

S. D. = Standard Deviation

Means within a column for a given species mix or monoculture followed by the same lower case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Means within a column for a specific amendment treatment followed by the same upper case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Table 3.33 Total density and survivability of seeded species in monocultures and mixes at Ellerslie in spring 1997

Species / Treatment	Density (plants / 0.1 m²) Mean	S. D.	Survivability (%) Mean	S. D.
A. smithii monoculture				
Straw	6 aAB	4	19 aAB	12
Sugar / Straw	5 aABCD	2	17 aABCD	7
No Amendments	7 aAB	3	23 aAB	11
B. inermis monoculture				
Straw	5 aAB	3	16 aAB	9
Sugar / Straw	6 aBCD	2	19 aBCD	7
No Amendments	5 aAB	2	17 aAB	8
P. pratense monoculture				
Straw	2 aA	1	7 aA	4
Sugar / Straw	2 aAB	2	7 aAB	6
No Amendments	2 aAB	1	8 aAB	5
S. viridula monoculture				
Straw	0 abA	0	1 abA	1
Sugar / Straw	0 aA	0	0 aA	0
No Amendments	1 bA	0	2 bA	1
T. hybridum monoculture				
Straw	1 aA	1	4 aA	3
Sugar / Straw	2 aAB	4	7 aAB	12
No Amendments	3 aAB	3	10 aAB	9
V. americana monoculture				
Straw	32 aD	18	107 aD	61
Sugar / Straw	30 aE	9	100 aE	29
No Amendments	38 aD	17	128 aD	55
A. smithii / *B. inermis* mix				
Straw	5 aAB	3	16 aAB	9
Sugar / Straw	5 aABCD	3	17 aABCD	9
No Amendments	7 aAB	3	23 aAB	10
P. pratense / *S. viridula* mix				
Straw	3 aA	3	10 aA	9
Sugar / Straw	3 aAB	1	10 aAB	4
No Amendments	4 aAB	2	14 aAB	8
T. hybridum / *V. americana* mix				
Straw	14 abBC	7	45 abBC	24
Sugar / Straw	10 aD	6	34 aD	19
No Amendments	20 bC	11	66 bC	36

Table 3.33 Total density and survivability of seeded species in monocultures and mixes at Ellerslie in spring 1997 (continued)

Species / Treatment	Density (plants / 0.1 m^2) Mean	S. D.	Survivability (%) Mean	S. D.
A. smithii / S. viridula / V. americana mix				
Straw	15 abC	13	50 abC	43
Sugar / Straw	9 aCD	6	30 aCD	19
No Amendments	20 bC	14	67 bC	45
B. inermis / P. pratense / T. hybridum mix				
Straw	4 aA	2	15 aA	8
Sugar / Straw	4 aABC	3	15 aABC	10
No Amendments	6 aAB	4	20 aAB	13
A. smithii / B. inermis/ P. pratense / S. viridula / T. hybridum / V. americana mix				
Straw	8 aABC	5	27 aABC	16
Sugar / Straw	7 aBCD	3	22 aBCD	11
No Amendments	12 aBC	7	38 aBC	23

A. smithii = Agropyron smithii; B. inermis = Bromus inermis; P. pratense = Phleum pratense; S. viridula = Stipa viridula; T. hybridum = Trifolium hybridum; V. americana = Vicia americana
S. D. = Standard Deviation
Means within a column for a given species mix or monoculture followed by the same lower case letter are not significantly different ($p < 0.05$, Tukey's HSD)
Means within a column for a specific amendment treatment followed by the same upper case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Table 3.34 Total density and survivability of seeded species in monocultures and mixes at Ellerslie in fall 1997

Species / Treatment	Density (plants / 0.1 m^2) Mean	S. D.	Survivability (%) Mean	S. D.
A. smithii monoculture				
Straw	4 aDE	2	12 aDE	8
Sugar / Straw	3 aBCD	2	9 aBCD	5
No Amendments	4 aC	3	13 aC	9
B. inermis monoculture				
Straw	4 aDE	2	12 aDE	5
Sugar / Straw	4 aDE	1	14 aDE	3
No Amendments	4 aC	1	13 aC	4
P. pratense monoculture				
Straw	2 aABCD	1	8 aABCD	4
Sugar / Straw	2 aABC	2	6 aABC	6
No Amendments	3 aBC	2	9 aBC	6
S. viridula monoculture				
Straw	2 abABCD	2	7 aABCD	7
Sugar / Straw	2 aABC	1	5 aABC	4
No Amendments	4 bC	2	12 bC	7
T. hybridum monoculture				
Straw	1 aAB	1	3 aAB	2
Sugar / Straw	1 aA	1	3 aA	3
No Amendments	1 aAB	1	3 aAB	2
V. americana monoculture				
Straw	0 aA	1	1 aA	2
Sugar / Straw	0 aA	1	1 aA	4
No Amendments	0 aA	1	1 aA	2
A. smithii / *B. inermis* mix				
Straw	5 aE	2	17 aE	8
Sugar / Straw	5 aE	2	17 aE	6
No Amendments	4 aC	2	15 aC	5
P. pratense / *S. viridula* mix				
Straw	2 aABCD	2	7 aABCD	6
Sugar / Straw	2 aABC	2	6 aABC	5
No Amendments	4 bC	2	14 bC	7
T. hybridum / *V. americana* mix				
Straw	1 aABC	1	4 aABC	3
Sugar / Straw	1 aAB	1	5 aAB	4
No Amendments	1 aAB	1	3 aAB	3

Table 3.34 Total density and survivability of seeded species in monocultures and mixes at Ellerslie in fall 1997 (continued)

Species / Treatment	Density (plants / 0.1 m^2) Mean	S. D.	Survivability (%) Mean	S. D.
A. smithii / S. viridula / V. americana mix				
Straw	5 abBCDE	2	10 abBCDE	8
Sugar / Straw	5 aAB	2	4 aAB	5
No Amendments	4 bC	2	14 bC	8
B. inermis / P. pratense / T. hybridum mix				
Straw	3 aCDE	2	11 aCDE	6
Sugar / Straw	3 aBCD	2	11 aBCD	6
No Amendments	4 aC	1	12 aC	5
A. smithii / B. inermis/ P. pratense / S. viridula / T. hybridum / V. americana mix				
Straw	4 aDE	2	12 aDE	7
Sugar / Straw	4 aCDE	2	12 aCDE	6
No Amendments	4 aC	2	15 aC	6

A. smithii = Agropyron smithii; B. inermis = Bromus inermis; P. pratense = Phleum pratense; S. viridula = Stipa viridula; T. hybridum = Trifolium hybridum; V. americana = Vicia americana
S. D. = Standard Deviation
Means within a column for a given species mix or monoculture followed by the same lower case letter are not significantly different ($p < 0.05$, Tukey's HSD)
Means within a column for a specific amendment treatment followed by the same upper case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Table 3.35 Total density and biomass of non-seeded species in monocultures and mixes at Ellerslie in fall 1996

Species / Treatment	Density (plants / 0.1 m²) Mean	S. D.	Biomass (%) Mean	S. D.
A. smithii monoculture				
Straw	6 aAB	2	91 aA	15
Sugar / Straw	8 aAB	4	89 aAB	26
No Amendments	6 aAB	4	71 aC	23
B. inermis monoculture				
Straw	5 aAB	3	72 abA	22
Sugar / Straw	6 aAB	2	87 bAB	10
No Amendments	5 aA	4	49 aABC	38
P. pratense monoculture				
Straw	5 abAB	2	78 bA	23
Sugar / Straw	6 bAB	2	89 bAB	16
No Amendments	3 aA	3	34 aAB	22
S. viridula monoculture				
Straw	5 aAB	2	76 abA	33
Sugar / Straw	9 bB	3	97 bB	5
No Amendments	4 aA	3	60 aBC	25
T. hybridum monoculture				
Straw	5 bAB	2	71 abA	33
Sugar / Straw	6 bAB	2	87 bAB	17
No Amendments	3 aA	2	58 aBC	28
V. americana monoculture				
Straw	3 aA	2	78 abA	28
Sugar / Straw	6 bA	2	92 bAB	10
No Amendments	4 aA	2	61 aBC	29
A. smithii / B. inermis mix				
Straw	4 abA	3	86 bA	14
Sugar / Straw	6 bAB	3	95 bAB	8
No Amendments	2 aA	1	21 aA	25
P. pratense / S. viridula mix				
Straw	5 aAB	3	93 bA	9
Sugar / Straw	6 aAB	3	97 bB	5
No Amendments	4 aA	2	53 aABC	29
T. hybridum / V. americana mix				
Straw	4 aAB	2	79 bA	20
Sugar / Straw	5 aA	1	77 bA	18
No Amendments	4 aA	2	51 aABC	27

Table 3.35 Total density and biomass of non-seeded species in monocultures and mixes at Ellerslie in fall 1996 (continued)

Species / Treatment	Density (plants / 0.1 m^2) Mean	S. D.	Biomass (%) Mean	S. D.
A. smithii / S. viridula / V. americana mix				
Straw	4 aA	2	80 bA	18
Sugar / Straw	7 bAB	3	92 bA	9
No Amendments	4 aA	3	40 aABC	32
B. inermis / P. pratense / T. hybridum mix				
Straw	4 aAB	2	75 bA	32
Sugar / Straw	8 bAB	2	85 bAB	26
No Amendments	3 aA	2	37 aABC	39
A. smithii / B. inermis/ P. pratense / S. viridula / T. hybridum / V. americana mix				
Straw	4 aA	1	77 bA	21
Sugar / Straw	7 bAB	4	86 bAB	12
No Amendments	5 abA	3	46 aABC	21
Non - seeded species (control)				
Straw	7 aB	3		
Sugar / Straw	7 aAB	3		
No Amendments	9 aB	6		

A. smithii = Agropyron smithii; B. inermis = Bromus inermis; P. pratense = Phleum pratense;
S. viridula = Stipa viridula; T. hybridum = Trifolium hybridum; V. americana = Vicia americana
S. D. = Standard Deviation
Means within a column for a given species mix or monoculture followed by the same lower case letter are not significantly different ($p < 0.05$, Tukey's HSD)
Means within a column for a specific amendment treatment followed by the same upper case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Table 3.36 Total density and biomass of non-seeded species in monocultures and mixes at Ellerslie in spring 1997

Species Treatment	Density (plants / 0.1 m^2) Mean	S. D.	Biomass (%) Mean	S. D.
A. smithii monoculture				
Straw	71 abA	57	68 aDE	24
Sugar / Straw	42 aA	25	75 aDE	17
No Amendments	112 bA	70	58 aD	25
B. inermis monoculture				
Straw	43 aA	20	6 aA	15
Sugar / Straw	32 aA	26	6 aA	10
No Amendments	129 aA	267	9 aAB	28
P. pratense monoculture				
Straw	107 aA	136	32 aABCD	32
Sugar / Straw	29 aA	29	42 aABCD	41
No Amendments	81 aA	93	19 aABC	37
S. viridula monoculture				
Straw	67 aA	77	73 bE	31
Sugar / Straw	54 aA	63	95 bE	6
No Amendments	67 aA	44	44 aBCD	38
T. hybridum monoculture				
Straw	109 aA	99	54 aCDE	40
Sugar / Straw	64 aA	64	65 aCDE	35
No Amendments	125 aA	142	32 aABCD	34
V. americana monoculture				
Straw	25 aA	16	40 aABCDE	37
Sugar / Straw	42 aA	32	38 aABC	24
No Amendments	61 aA	77	30 aABCD	33
A. smithii / B. inermis mix				
Straw	110 aA	176	12 abAB	26
Sugar / Straw	20 aA	11	29 bABC	27
No Amendments	50 aA	57	5 aA	11
P. pratense / S. viridula mix				
Straw	50 aA	41	52 bCDE	41
Sugar / Straw	46 aA	44	65 bCDE	32
No Amendments	122 aA	154	16 aAB	27
T. hybridum / V. americana mix				
Straw	39 aA	33	43 aBCDE	31
Sugar / Straw	34 aA	33	50 aBCD	36
No Amendments	28 aA	18	26 aABCD	31

Table 3.36 Total density and biomass of non-seeded species in monocultures and mixes at Ellerslie in spring 1997
(continued)

Species / Treatment	Density (plants / 0.1 m^2) Mean	S. D.	Biomass (%) Mean	S. D.
A. smithii / S. viridula / V. americana mix				
Straw	114 aA	149	67 aDE	26
Sugar / Straw	23 aA	18	45 aBCD	33
No Amendments	117 aA	135	52 aCD	34
B. inermis / P. pratense / T. hybridum mix				
Straw	26 aA	27	14 abAB	28
Sugar / Straw	41 aA	27	33 bABC	32
No Amendments	53 aA	72	5 aA	10
A. smithii / B. inermis/ P. pratense / S. viridula / T. hybridum / V. americana mix				
Straw	61 aA	67	27 aABC	25
Sugar / Straw	30 aA	28	26 aAB	31
No Amendments	88 aA	151	13 aAB	19
Non - seeded species (control)				
Straw	32 aA	19		
Sugar / Straw	41 aA	54		
No Amendments	58 aA	30		

A. smithii = Agropyron smithii; B. inermis = Bromus inermis; P. pratense = Phleum pratense; S. viridula = Stipa viridula; T. hybridum = Trifolium hybridum; V. americana = Vicia americana
S. D. = Standard Deviation
Means within a column for a given species mix or monoculture followed by the same lower case letter are not significantly different ($p < 0.05$, Tukey's HSD)
Means within a column for a specific amendment treatment followed by the same upper case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Table 3.37 Total density and biomass of non-seeded species in monocultures and mixes at Ellerslie in fall 1997

Species / Treatment	Density (plants / 0.1 m²) Mean	S. D.	Biomass (%) Mean	S. D.
A. smithii monoculture				
Straw	18 aE	14	85 abEFG	24
Sugar Straw	12 aABC	4	92 bDEF	18
No Amendments	15 aAB	11	62 aCD	35
B. inermis monoculture				
Straw	4 abABC	5	12 aAB	22
Sugar Straw	6 bAB	5	16 aA	21
No Amendments	2 aA	2	2 aA	4
P. pratense monoculture				
Straw	9 aABCDE	4	34 abABC	38
Sugar Straw	10 aAB	7	57 bBCD	47
No Amendments	6 aAB	6	15 aAB	29
S. viridula monoculture				
Straw	14 aDE	12	73 bDE	28
Sugar Straw	13 aBC	10	96 bDEF	7
No Amendments	8 aAB	10	24 aABC	32
T. hybridum monoculture				
Straw	3 aAB	2	48 aBCDE	41
Sugar Straw	4 aA	3	58 aBCDE	34
No Amendments	3 aA	4	32 aABC	46
V. americana monoculture				
Straw	12 aBCDE	7	93 aFG	26
Sugar Straw	13 aBC	7	96 aEF	12
No Amendments	19 aB	10	93 aD	23
A. smithii / B. inermis mix				
Straw	7 aABCD	9	37 bABCD	35
Sugar Straw	5 aA	4	40 bABC	32
No Amendments	3 aA	5	6 aAB	16
P. pratense / S. viridula mix				
Straw	9 bABCDE	5	56 bABCDE	36
Sugar Straw	9 bAB	4	75 bAB	36
No Amendments	3 aA	4	20 aA	33
T. hybridum / V. americana mix				
Straw	7 aABCD	8	49 aBCDE	43
Sugar Straw	5 aA	6	63 aCDEF	41
No Amendments	10 aAB	14	46 aBC	50

Table 3.37 Total density and biomass of non-seeded species in monocultures and mixes at Ellerslie in fall 1997 (continued)

Species	Density (plants / 0.1 m^2)		Biomass (%)	
Treatment	Mean	S. D.	Mean	S. D.
A. smithii / S. viridula / V. americana mix				
Straw	14 aDE	8	86 bEFG	20
Sugar / Straw	10 aAB	4	94 bDEF	11
No Amendments	9 aAB	8	41 aABC	36
B. inermis / P. pratense / T. hybridum mix				
Straw	3 aA	3	8 aA	27
Sugar / Straw	5 aA	4	22 aAB	40
No Amendments	4 aA	6	8 aAB	28
A. smithii / B. inermis/ P. pratense / S. viridula / T. hybridum / V. americana mix				
Straw	5 aABCD	3	24 aABC	34
Sugar / Straw	8 aAB	6	42 aABC	37
No Amendments	6 aAB	7	21 aAB	33
Non - seeded species (control)				
Straw	13 aCDE	5		
Sugar / Straw	18 aC	7		
No Amendments	37 bC	28		

A. smithii = Agropyron smithii; B. inermis = Bromus inermis; P. pratense = Phleum pratense; S. viridula = Stipa viridula; T. hybridum = Trifolium hybridum; V. americana = Vicia americana

S. D. = Standard Deviation

Means within a column for a given species mix or monoculture followed by the same lower case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Means within a column for a specific amendment treatment followed by the same upper case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Table 3.38 Canopy height of monocultures and mixes at Ellerslie in fall 1996

Species / Treatment	Canopy Level 1 (cm) Mean	S.D.	Canopy Level 2 (cm) Mean	S.D.	Canopy Level 3 (cm) Mean	S.D.
A. smithii monoculture						
Straw	52.2 a	23.1	28.8 a	19.6	7.6 a	10.0
Sugar / Straw	64.2 a	15.8	34.1 a	15.7	9.7 a	9.1
No Amendments	47.7 a	25.3	22.6 a	17.5	7.1 a	9.7
B. inermis monoculture						
Straw	70.9 b	19.0	38.9 b	16.0	14.4 a	16.7
Sugar / Straw	68.8 b	9.4	32.3 ab	11.4	7.5 a	8.2
No Amendments	47.1 a	30.9	21.2 a	24.2	9.1 a	13.2
P. pratense monoculture						
Straw	54.9 ab	11.8	21.1 a	15.6	0.9 a	3.2
Sugar / Straw	63.8 b	19.5	30.9 a	19.0	3.1 a	7.4
No Amendments	42.5 a	16.4	19.3 a	17.4	1.3 a	3.9
S. viridula monoculture						
Straw	51.8 b	16.5	16.8 ab	13.6	3.6 a	6.1
Sugar / Straw	62.3 b	21.0	26.7 b	18.0	4.7 a	7.4
No Amendments	27.5 a	10.4	10.2 a	10.1	2.9 a	5.9
T. hybridum monoculture						
Straw	52.4 b	15.0	22.2 ab	12.4	1.6 a	4.1
Sugar / Straw	72.6 c	19.6	35.2 b	19.8	11.4 b	13.2
No Amendments	31.6 a	16.9	10.5 a	9.1	0.5 a	1.8
V. americana monoculture						
Straw	41.8 ab	20.5	18.0 a	16.3	2.5 a	4.9
Sugar Straw	55.3 b	23.0	21.7 a	21.0	2.7 a	4.6
No Amendments	31.2 a	19.8	9.9 a	9.4	2.8 a	4.8
A. smithii / B. inermis mix						
Straw	52.5 b	15.5	18.9 ab	9.8	0.3 a	1.3
Sugar / Straw	62.6 b	7.9	24.0 b	11.8	2.8 a	7.1
No Amendments	29.5 a	15.8	10.4 a	11.8	0.8 a	2.9
P. pratense / S. viridula mix						
Straw	59.9 ab	13.3	23.6 a	13.6	1.4 a	3.9
Sugar / Straw	69.4 b	23.2	28.8 a	26.3	4.8 a	17.5
No Amendments	50.7 a	14.2	22.8 a	12.5	1.1 a	2.7
T. hybridum / V. americana mix						
Straw	62.2 b	15.0	27.2 a	18.9	5.6 a	7.3
Sugar / Straw	55.5 b	19.3	24.0 a	17.2	5.7 a	8.9
No Amendments	38.8 a	15.7	13.4 a	10.0	2.7 a	3.4
A. smithii / S. viridula / V. americana mix						
Straw	50.4 b	17.9	21.2 a	12.2	5.8 a	5.8
Sugar / Straw	69.7 c	13.8	35.0 b	15.0	8.2 a	7.2
No Amendments	36.1 a	11.4	13.2 a	7.8	4.5 a	9.6

Table 3.38 Canopy height of monocultures and mixes at Ellerslie in fall 1996 (continued)

Species	Canopy Level 1 (cm)		Canopy Level 2 (cm)		Canopy Level 3 (cm)	
Treatment	Mean	S. D.	Mean	S. D.	Mean	S. D.
B. inermis / P. pratense / T. hybridum mix						
Straw	57.9 b	16.1	27.8 a	13.8	5.1 a	7.7
Sugar / Straw	66.0 b	18.8	25.9 a	19.1	6.8 a	9.6
No Amendments	41.4 a	12.2	16.5 a	10.5	0.6 a	2.2
A. smithii / B. inermis / P. pratense / S. viridula / T. hybridum / V. americana mix						
Straw	58.5ab	22.2	25.2 ab	19.5	7.4 a	11.0
Sugar / Straw	68.0 b	15.2	34.4 b	16.0	5.8 a	8.3
No Amendments	45.8 a	20.5	16.8 a	11.2	3.3 a	7.1
Non - seeded species (control)						
Straw	49.5 b	16.7	17.7 ab	15.9	1.9 a	5.4
Sugar / Straw	62.8 b	22.0	27.6 b	24.2	2.7 a	5.5
No Amendments	19.7 a	13.2	9.0 a	15.8	0.0 a	0.0

A. smithii = Agropyron smithii; B. inermis = Bromus inermis; P. pratense = Phleum pratense; S. viridula = Stipa viridula; T. hybridum = Trifolium hybridum; V. americana = Vicia americana
S. D. = Standard Deviation
Means within a column for a given species mix or monoculture followed by the same lower case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Table 3.39 Canopy height of monocultures and mixes at Ellerslie in spring 1997

Species / Treatment	Canopy Level 1 (cm) Mean	S. D.	Canopy Level 2 (cm) Mean	S. D.	Canopy Level 3 (cm) Mean	S. D.
A. smithii monoculture						
Straw	15.0 a	3.8	6.4 a	3.6	1.6 a	1.5
Sugar / Straw	13.4 a	2.5	5.2 a	3.1	1.3 a	2.1
No Amendments	16.4 a	4.5	6.3 a	4.6	2.0 a	2.8
B. inermis monoculture						
Straw	28.8 a	7.0	12.5 a	11.3	5.2 a	5.4
Sugar / Straw	26.4 a	10.5	11.5 a	12.9	3.5 a	4.6
No Amendments	27.2 a	11.1	10.3 a	11.7	4.3 a	5.9
P. pratense monoculture						
Straw	23.0 a	8.2	8.4 a	6.4	2.0 a	2.6
Sugar / Straw	19.6 a	12.7	4.6 a	5.3	1.3 a	2.7
No Amendments	30.4 a	15.3	9.8 a	9.3	3.0 a	6.0
S. viridula monoculture						
Straw	16.3 ab	9.0	6.7 a	6.0	2.1 a	2.5
Sugar / Straw	11.7 a	5.7	4.5 a	3.5	1.7 a	2.0
No Amendments	22.9 b	9.6	9.2 a	6.5	2.2 a	2.6
T. hybridum monoculture						
Straw	10.9 a	7.2	3.2 a	2.8	1.4 a	3.0
Sugar / Straw	9.6 a	6.0	3.5 a	4.6	1.8 a	3.8
No Amendments	14.7 a	7.6	6.5 a	7.9	2.8 a	5.2
V. americana monoculture						
Straw	12.6 a	6.4	6.3 a	6.1	2.2 a	2.7
Sugar / Straw	10.2 a	4.4	4.2 a	3.8	1.6 a	1.9
No Amendments	14.4 a	9.4	7.7 a	8.3	3.3 a	5.1
A. smithii / B. inermis mix						
Straw	24.9 ab	9.8	11.9 ab	11.9	4.5 a	6.2
Sugar / Straw	23.2 a	6.8	8.7 a	6.7	2.0 a	2.3
No Amendments	33.8 b	11.6	18.7 b	11.4	5.9 a	7.9
P. pratense / S. viridula mix						
Straw	19.7 ab	9.2	5.4 a	5.5	2.6 a	3.4
Sugar / Straw	12.8 a	9.2	4.9 a	6.9	1.6 a	2.2
No Amendments	27.3 b	8.8	11.3 a	10.3	2.8 a	3.7
T. hybridum / V. americana mix						
Straw	11.3 a	9.1	4.6 a	6.7	3.0 a	5.5
Sugar / Straw	10.1 a	8.4	3.0 a	4.1	1.0 a	1.9
No Amendments	12.9 a	10.0	5.2 a	7.2	2.4 a	4.6

Table 3.39 Canopy height of monocultures and mixes at Ellerslie in spring 1997 (continued)

Species	Canopy Level 1 (cm)		Canopy Level 2 (cm)		Canopy Level 3 (cm)	
Treatment	Mean	S. D.	Mean	S. D.	Mean	S. D.
A. smithii / S. viridula / V. americana mix						
Straw	15.0 ab	8.0	5.7 ab	5.9	2.2 a	4.6
Sugar / Straw	9.0 a	6.3	2.9 a	3.2	0.7 a	1.4
No Amendments	19.4 b	14.9	10.2 b	11.0	3.9 a	7.4
B. inermis / P. pratense / T. hybridum mix						
Straw	30.7 a	11.4	14.5 a	14.1	7.4 a	8.5
Sugar / Straw	26.1 a	12.9	10.3 a	11.2	3.6 a	6.3
No Amendments	46.2 b	16.3	18.8 a	17.9	5.5 a	8.2
A. smithii / B. inermis / P. pratense / S. viridula / T. hybridum / V. americana mix						
Straw	23.6 ab	10.2	9.4 a	8.2	3.0 a	3.9
Sugar / Straw	15.2 a	7.4	4.1 a	4.4	1.4 a	2.4
No Amendments	24.4 b	10.8	9.6 a	8.0	2.6 a	4.0
Non - seeded species (control)						
Straw	7.3 a	4.8	1.8 a	2.6	0.4 a	1.2
Sugar / Straw	6.2 a	2.9	1.1 a	1.3	0.0 a	0.0
No Amendments	5.6 a	2.8	1.6 a	2.4	0.4 a	0.9

A. smithii = *Agropyron smithii*; *B. inermis* = *Bromus inermis*; *P. pratense* = *Phleum pratense*; *S. viridula* = *Stipa viridula*; *T. hybridum* = *Trifolium hybridum*; *V. americana* = *Vicia americana*

S. D. = Standard Deviation

Means within a column for a given species mix or monoculture followed by the same lower case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Table 3.40 Canopy height of monocultures and mixes at Ellerslie in fall 1997

Species	Canopy Level 1		Canopy Level 2		Canopy Level 3	
Treatment	Mean	S. D.	Mean	S. D.	Mean	S. D.
A. smithii monoculture						
Straw	84.7 a	19.7	54.1 a	22.2	18.8 a	22.6
Sugar / Straw	88.5 a	26.9	39.3 a	23.5	16.8 a	19.2
No Amendments	66.5 a	27.4	42.4 a	18.2	18.7 a	20.8
B. inermis monoculture						
Straw	121.9 a	13.9	77.0 a	18.8	32.5 b	25.1
Sugar / Straw	109.1 a	16.2	66.1 a	16.4	4.5 a	11.0
No Amendments	122.9 a	21.1	66.8 a	32.2	16.8 ab	24.2
P. pratense monoculture						
Straw	120.5 a	18.2	78.0 a	17.1	19.2 a	23.2
Sugar / Straw	114.3 a	10.6	67.3 a	19.4	10.6 a	15.4
No Amendments	120.8 a	18.6	76.5 a	17.6	24.8 a	23.3
S. viridula monoculture						
Straw	85.9 a	27.6	42.9 a	24.6	14.8 a	18.8
Sugar / Straw	108.3 ab	21.3	66.7 b	24.0	22.5 a	20.7
No Amendments	126.0 b	25.2	63.0 ab	26.4	21.7 a	21.3
T. hybridum monoculture						
Straw	47.8 a	24.5	20.2 a	13.2	6.9 a	9.2
Sugar / Straw	75.4 a	47.4	36.6 a	37.0	17.3 a	25.1
No Amendments	42.9 a	35.2	16.6 a	20.7	5.0 a	10.2
V. americana monoculture						
Straw	75.3 a	28.0	26.9 a	25.2	3.7 a	6.1
Sugar / Straw	86.1 a	19.6	46.7 a	22.0	8.9 a	10.2
No Amendments	76.5 a	27.9	35.8 a	28.1	6.9 a	8.7
A. smithii / B. inermis mix						
Straw	110.1 a	19.7	52.9 a	25.1	10.4 a	14.7
Sugar / Straw	114.3 a	11.6	70.2 a	19.7	20.9 a	32.3
No Amendments	130.6 b	14.8	52.4 a	33.6	10.8 a	17.3
P. pratense / S. viridula mix						
Straw	111.7 a	23.0	63.7 a	25.3	21.3 a	20.9
Sugar / Straw	112.2 a	17.5	61.0 a	16.6	10.7 a	17.0
No Amendments	124.2 a	16.5	68.3 a	15.0	21.8 a	25.4
T. hybridum / V. americana mix						
Straw	59.6 a	31.7	27.4 a	19.4	9.7 a	12.1
Sugar / Straw	59.5 a	18.6	30.8 a	23.2	14.5 a	18.5
No Amendments	59.8 a	34.2	18.5 a	20.2	5.1 a	5.7

Table 3.40 Canopy height of monocultures and mixes at Ellerslie in fall 1997 (continued)

Species	Canopy Level 1		Canopy Level 2		Canopy Level 3	
Treatment	Mean	S. D.	Mean	S. D.	Mean	S. D.
A. smithii / S. viridula / V. americana mix						
Straw	91.9 a	30.4	49.3 a	28.5	15.8 a	22.4
Sugar / Straw	86.4 a	20.8	45.5 a	15.5	9.1 a	14.2
No Amendments	89.8 a	33.9	44.4 a	21.1	9.9 a	14.0
B. inermis / P. pratense / T. hybridum mix						
Straw	121.1 a	20.5	76.2 a	19.0	33.5 a	25.4
Sugar / Straw	110.9 a	18.1	65.4 a	13.6	24.8 a	22.5
No Amendments	123.8 a	22.2	66.4 a	17.1	25.2 a	23.3
A. smithii / B. inermis / P. pratense / S. viridula / T. hybridum / V. americana mix						
Straw	114.4 a	26.7	57.4 a	31.2	17.6 a	24.5
Sugar / Straw	108.4 a	21.6	68.4 a	19.3	16.1 a	19.1
No Amendments	117.4 a	25.6	66.5 a	24.0	15.8 a	18.5
Non - seeded species (control)						
Straw	99.1 b	20.3	52.4 a	24.0	14.2 a	19.9
Sugar / Straw	104.5 b	16.5	48.2 a	19.6	15.1 a	13.4
No Amendments	76.4 a	21.6	44.2 a	15.6	12.6 a	12.8

A. smithii = Agropyron smithii; B. inermis = Bromus inermis; P. pratense = Phleum pratense; S. viridula = Stipa viridula; T. hybridum = Trifolium hybridum; V. americana = Vicia americana
S. D. = Standard Deviation
Means within a column for a given species mix or monoculture followed by the same lower case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Table 3.41 Ground cover of monocultures and mixes at Ellerslie in fall 1996

Species	Live Vegetation (%)		Litter (%)		Bare Ground (%)		Litter Depth (%)	
Treatment	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.
A. smithii monoculture								
Straw	5 aA	3	0 aA	1	95 aB	3	0.0 aA	0.1
Sugar / Straw	4 aA	1	0 aA	0	96 aB	1	0.0 aA	0.1
No Amendments	5 aA	2	0 aA	1	95 aA	2	0.0 aA	0.1
B. inermis monoculture								
Straw	8 aAB	3	1 aA	2	91 aAB	4	0.0 aA	0.1
Sugar / Straw	6 aAB	2	1 aA	2	93 aAB	2	0.1 aA	0.1
No Amendments	7 aA	7	0 aA	1	92 aA	7	0.0 aA	0.1
P. pratense monoculture								
Straw	5 aA	4	1 aA	2	94 aB	5	0.0 aA	0.1
Sugar / Straw	4 aA	2	0 aA	1	96 aB	3	0.0 aA	0.1
No Amendments	6 aA	3	0 aA	1	94 aA	3	0.0 aA	0.0
S. viridula monoculture								
Straw	4 aA	3	0 aA	1	96 aB	3	0.0 aA	0.0
Sugar / Straw	3 aA	2	1 aA	3	95 aB	4	0.1 aA	0.2
No Amendments	5 aA	4	0 aA	0	95 aA	3	0.0 aA	0.0
T. hybridum monoculture								
Straw	8 aAB	7	0 aA	1	92 aAB	7	0.0 aA	0.0
Sugar / Straw	4 aA	4	1 aA	3	94 aAB	5	0.0 aA	0.1
No Amendments	4 aA	3	0 aA	0	96*aA	3	0.0 aA	0.0
V. americana monoculture								
Straw	14 aB	17	0 aA	0	86 aA	17	0.0 aA	0.0
Sugar / Straw	11 aB	11	0 aA	1	89 aA	11	0.0 aA	0.1
No Amendments	13 aA	19	0 aA	1	87 aA	19	0.0 aA	0.1
A. smithii / B. inermis mix								
Straw	4 aA	2	0 aA	0	96 aB	2	0.0 aA	0.1
Sugar / Straw	4 aA	2	0 aA	1	96 aB	3	0.0 aA	0.0
No Amendments	5 aA	2	1 aA	2	94*aA	4	0.0 aA	0.1
P. pratense / S. viridula mix								
Straw	5 aA	4	0 aA	0	95 aB	4	0.1 aA	0.2
Sugar / Straw	4 aA	3	1 aA	1	95 aB	3	0.1 aA	0.2
No Amendments	5 aA	3	0 aA	0	95 aA	3	0.0 aA	0.0
T. hybridum / V. americana mix								
Straw	4 aA	2	0 aA	1	96 aB	2	0.0 aA	0.1
Sugar / Straw	3 aA	2	0 aA	1	96 aB	2	0.0 aA	0.1
No Amendments	5 aA	3	0 aA	0	95 aA	3	0.0 aA	0.0

Table 3.41 Ground cover of monocultures and mixes at Ellerslie in fall 1996 (continued)

Species	Live Vegetation (%)		Litter (%)		Bare Ground (%)		Litter Depth (%)	
Treatment	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.
A. smithii / S. viridula / V. americana mix								
Straw	4 aA	3	0 aA	1	95 aB	3	0.0 aA	0.0
Sugar / Straw	4 aA	2	0 aA	1	96 aB	2	0.0 aA	0.1
No Amendments	4 aA	2	0 aA	0	96 aA	2	0.0 aA	0.1
B. inermis / P. pratense / T. hybridum mix								
Straw	4 aA	2	0 aA	0	96 aB	2	0.0 aA	0.0
Sugar / Straw	3 aA	2	0 aA	1	96 aB	3	0.0 aA	0.0
No Amendments	5 aA	5	0 aA	1	95 aA	5	0.0 aA	0.1
A. smithii / B. inermis / P. pratense / S. viridula / T. hybridum / V. americana mix								
Straw	4 aA	2	0 aA	1	95 aB	2	0.0 aA	0.1
Sugar / Straw	6 aAB	4	1 aA	1	93 aAB	4	0.0 aA	0.1
No Amendments	4 aA	2	0 aA	0	96 aA	2	0.0 aA	0.0
Non - seeded species (control)								
Straw	6 aA	4	1 aA	1	94 aB	4	0.1 aA	0.2
Sugar / Straw	5 aA	4	0 aA	0	95 aB	4	0.0 aA	0.0
No Amendments	10 aA	20	0 aA	0	90 aA	20	0.0 aA	0.0

* Rocks ≥0.01

A. smithii = *Agropyron smithii*; *B. inermis* = *Bromus inermis*; *P. pratense* = *Phleum pratense*; *S. viridula* = *Stipa viridula*; *T. hybridum* = *Trifolium hybridum*; *V. americana* = *Vicia americana*

S. D. = Standard Deviation

Means within a column for a given species mix or monoculture followed by the same lower case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Means within a column for a specific amendment treatment followed by the same upper case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Table 3.42 Ground cover of monocultures and mixes at Ellerslie in spring 1997

Species	Live Vegetation (%)		Litter (%)		Bare Ground (%)		Litter Depth (%)	
Treatment	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.
A. smithii monoculture								
Straw	13 aAB	22	38 bABCD	22	49 aAB	24	0.9 aA	0.6
Sugar / Straw	6 aA	5	48 bA	17	46 aA	18	1.1 aA	0.8
No Amendments	42 bB	36	16 aAB	14	42 aAB	27	0.7 aAB	0.8
B. inermis monoculture								
Straw	5 aA	4	71 aE	16	24 aA	15	0.6 aA	0.3
Sugar / Straw	4 aA	6	50 aA	27	45 aA	26	0.6 aA	0.3
No Amendments	12 aA	20	61 aD	32	27 aA	27	0.9 aB	0.8
P. pratense monoculture								
Straw	15 aAB	26	26 abABCD	24	59 aB	31	0.7 aA	0.3
Sugar / Straw	3 aA	2	40 bA	26	58 aA	25	0.7 aA	0.4
No Amendments	12 aA	12	16 aAB	14	72 aBCD	17	0.5 aAB	0.3
S. viridula monoculture								
Straw	18 aAB	24	14 aA	10	68 aB	25	0.6 aA	0.4
Sugar / Straw	14 aA	23	40 bA	22	46 aA	24	0.6 aA	0.5
No Amendments	25 aAB	29	12 aA	18	63 aBCD	31	0.3 aAB	0.3
T. hybridum monoculture								
Straw	14 aAB	24	19 abAB	12	66 aB	24	0.8 aA	0.5
Sugar / Straw	7 aA	7	33 bA	22	59*aA	23	1.0 aA	0.5
No Amendments	11 aA	12	13 aA	11	76 aCD	20	0.7 aAB	0.8
V. americana monoculture								
Straw	6 aAB	13	24 abABCD	13	70 aB	21	0.6 aA	0.7
Sugar / Straw	16 aA	26	32 bA	16	52 aA	24	0.7 aA	0.4
No Amendments	16 aAB	27	15 aAB	13	68 aBCD	27	0.3 aAB	0.2
A. smithii / B. inermis mix								
Straw	12 aAB	19	48 aDE	24	39 aAB	25	0.8 aA	0.6
Sugar / Straw	4 aA	3	49 aA	19	47 aA	20	0.8 aA	0.7
No Amendments	6 aA	4	46 aCD	25	47 aABC	27	0.5 aAB	0.2
P. pratense / S. viridula mix								
Straw	15 aAB	20	26 aABCD	20	58**abB	23	0.5 bA	0.3
Sugar / Straw	5 aA	6	52 bA	23	44 aA	19	0.6 bA	0.2
No Amendments	22 aAB	25	12 aA	11	65 bBCD	24	0.3 aAB	0.1
T. hybridum / V. americana mix								
Straw	25 aAB	27	24 abABCD	17	51 aAB	26	0.4 abA	0.2
Sugar / Straw	14 aA	20	34 bA	19	51 aA	26	0.6 bA	0.5
No Amendments	16 aAB	25	12 aA	9	72 aBCD	24	0.2 aA	0.1

Table 3.42 Ground cover of monocultures and mixes at Ellerslie in spring 1997 (continued)

Species / Treatment	Live Vegetation (%) Mean	S. D.	Litter (%) Mean	S. D.	Bare Ground (%) Mean	S. D.	Litter Depth (%) Mean	S. D.
A. smithii / S. viridula / V. americana mix								
Straw	32 aB	34	23 aABC	18	46 aAB	31	0.5 aA	0.3
Sugar / Straw	9 aA	10	56 bA	18	34*aA	19	1.2 bA	1.2
No Amendments	29 aAB	22	19 aAB	15	52**aABCD	23	0.3 aAB	0.2
B. inermis / P. pratense / T. hybridum mix								
Straw	5 aA	7	47 aCDE	24	48 aAB	23	0.7 aA	0.6
Sugar / Straw	5 aA	4	49 aA	23	46 aA	23	0.9 aA	0.6
No Amendments	7 aA	6	36 aBC	22	57 aABCD	25	0.6 aAB	0.6
A. smithii / B. inermis / P. pratense / S. viridula / T. hybridum / V. americana mix								
Straw	14 aAB	20	42 abBCD	28	44 aAB	33	0.9 aA	1.4
Sugar / Straw	12 aA	19	45 bA	21	42 aA	21	1.1 aA	1.3
No Amendments	16 aAB	19	24 aABC	16	60 aBCD	25	0.4 aAB	0.5
Non - seeded species (control)								
Straw	3 aA	4	35 bABCD	21	62**aB	20	0.8 aA	0.5
Sugar / Straw	6 abA	6	41 bA	24	53 aA	24	0.9 aA	0.4
No Amendments	12 bA	12	7 aA	5	81 bD	12	0.5 aAB	0.4

* Moss ≥0.01

** Manure ≥0.01

A. smithii = Agropyron smithii; B. inermis = Bromus inermis; P. pratense = Phleum pratense; S. viridula = Stipa viridula; T. hybridum = Trifolium hybridum; V. americana = Vicia americana

S. D. = Standard Deviation

Means within a column for a given species mix or monoculture followed by the same lower case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Means within a column for a specific amendment treatment followed by the same upper case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Table 3.43 Ground cover of monocultures and mixes at Ellerslie in fall 1997

Species / Treatment	Live Vegetation (%) Mean	S. D.	Litter (%) Mean	S. D.	Bare Ground (%) Mean	S. D.	Litter Depth (%) Mean	S. D.
A. smithii monoculture								
Straw	2 aA	1	44 aA	34	53*aA	34	0.4 aA	0.1
Sugar / Straw	3 a A	1	55 aAB	32	42*aAB	32	0.7 bA	0.4
No Amendments	11 aA	24	39 aABC	36	49*aAB	38	0.2 aAB	0.1
B. inermis monoculture								
Straw	5 aA	3	47 abA	33	48 abA	33	0.4 aA	0.5
Sugar / Straw	3 aA	1	44 aAB	31	53 bAB	31	0.5 aA	0.3
No Amendments	4 aA	2	75 bBC	29	21 aA	29	0.4 aAB	0.3
P. pratense monoculture								
Straw	4 abA	1	59 aA	24	38 aA	25	0.4 aA	0.4
Sugar / Straw	3 aA	2	56 aAB	20	42 aAB	21	0.4 aA	0.2
No Amendments	5 bA	3	48 aABC	29	46 aAB	29	0.3 aAB	0.2
S. viridula monoculture								
Straw	4 aA	4	63 aA	30	33 aA	31	0.3 aA	0.2
Sugar / Straw	2 aA	1	62 aAB	29	36 aAB	29	0.5 aA	0.4
No Amendments	3 aA	2	49 aABC	27	48*aAB	27	0.3 aAB	0.2
T. hybridum monoculture								
Straw	3 aA	3	54 aA	28	43 aA	29	0.5 aA	0.4
Sugar / Straw	2 aA	1	52 aAB	31	46 aAB	31	0.7 aA	0.8
No Amendments	3 aA	2	31 aAB	27	66 aB	27	0.3 aAB	0.2
V. americana monoculture								
Straw	7 abA	6	63 aA	26	30 aA	29	0.4 aA	0.2
Sugar / Straw	3 aA	1	51 aAB	38	47*aAB	38	0.5 aA	0.2
No Amendments	14 bA	17	60 aABC	20	26*aA	25	0.6 aB	0.3
A. smithii / B. inermis mix								
Straw	4 aA	6	52 abA	32	44 abA	30	0.4 aA	0.2
Sugar / Straw	2 aA	1	41 aAB	23	56 bAB	22	0.4 aA	0.3
No Amendments	2 aA	2	74 bBC	27	24 aA	27	0.4 aAB	0.2
P. pratense / S. viridula mix								
Straw	4 abA	3	51 aA	26	45 aA	25	0.3 aA	0.2
Sugar / Straw	3 aA	2	53 aAB	31	44 aAB	30	0.6 bA	0.4
No Amendments	6 bA	2	44 aABC	35	50 aAB	37	0.3 aAB	0.2
T. hybridum / V. americana mix								
Straw	4 aA	2	53 aA	35	43 aA	35	0.4 aA	0.3
Sugar / Straw	3 aA	4	60 aAB	38	37 aAB	38	0.4 aA	0.2
No Amendments	5 aA	5	56 aABC	30	39 aAB	31	0.4 aAB	0.1

Table 3.43 Ground cover of monocultures and mixes at Ellerslie in fall 1997 (continued)

Species / Treatment	Live Vegetation (%) Mean	S. D.	Litter (%) Mean	S. D.	Bare Ground (%) Mean	S. D.	Litter Depth (%) Mean	S. D.
A. smithii / S. viridula / V. americana mix								
Straw	3 aA	3	69 aA	34	28 aA	33	0.4 abA	0.2
Sugar / Straw	3 aA	2	70 aB	23	27 aA	23	0.5 bA	0.3
No Amendments	7 aA	9	68 aBC	30	24*aA	29	0.2 aA	0.1
B. inermis / P. pratense / T. hybridum mix								
Straw	4 aA	2	42 aA	28	54 aA	27	0.5 aA	0.5
Sugar / Straw	3 aA	1	30 aA	27	67 aB	27	0.4 aA	0.3
No Amendments	3 aA	1	24 aA	19	73 aB	19	0.4 aAB	0.4
A. smithii / B. inermis / P. pratense / S. viridula / T. hybridum / V. americana mix								
Straw	4 aA	3	54 aA	22	42 aA	23	0.4 aA	0.3
Sugar / Straw	2 aA	1	60 aAB	21	37 aAB	21	0.5 aA	0.4
No Amendments	3 aA	1	59 aABC	29	38 aAB	30	0.4 aAB	0.4
Non - seeded species (control)								
Straw	5 aA	3	43 aA	36	52 aA	36	0.6 bA	0.3
Sugar / Straw	16 aB	27	43 aAB	26	41 aAB	34	0.4 abA	0.2
No Amendments	12 aA	23	33 aAB	35	54 aAB	33	0.3 aAB	0.2

* Moss ≥0.01

A. smithii = Agropyron smithii; B. inermis = Bromus inermis; P. pratense = Phleum pratense; S. viridula = Stipa viridula; T. hybridum = Trifolium hybridum; V. americana = Vicia americana

S. D. = Standard Deviation

Means within a column for a given species mix or monoculture followed by the same lower case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Means within a column for a specific amendment treatment followed by the same upper case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Table 3.44 Canopy cover of monocultures and mixes at Ellerslie in fall 1996

Species	Live Vegetation %		Litter %		Bare Ground %	
Treatment	Mean	S. D.	Mean	S. D.	Mean	S. D.
A. smithii monoculture						
Straw	60 aA	32	0 aA	0	40 aB	32
Sugar / Straw	58 aA	28	0 aA	0	42 aA	28
No Amendments	63 aABC	25	0 aA	0	37 aABC	25
B. inermis monoculture						
Straw	90 bB	8	0 aA	1	10 aA	8
Sugar / Straw	73 aA	14	0 aA	1	27 bA	14
No Amendments	93 bC	9	0 aA	0	7 aA	9
P. pratense monoculture						
Straw	81 aAB	10	0 aA	1	18 aAB	10
Sugar / Straw	68 aA	20	0 aA	1	32 aA	20
No Amendments	71 aBC	17	0 aA	0	29 aAB	17
S. viridula monoculture						
Straw	77 bAB	16	0 aA	0	23 aAB	16
Sugar / Straw	67 abA	16	1 aA	1	33 abA	16
No Amendments	56 aAB	14	0 aA	0	44 bBC	14
T. hybridum monoculture						
Straw	78 bAB	25	0 aA	0	22 aAB	25
Sugar / Straw	49 aA	38	1 aA	1	51 aA	38
No Amendments	63 abABC	28	0 aA	0	37 aABC	28
V. americana monoculture						
Straw	79 aAB	19	0 aA	0	21 aAB	19
Sugar / Straw	65 aA	29	0 aA	1	35 aA	29
No Amendments	62 aAB	29	0 aA	1	38 aBC	30
A. smithii / B. inermis mix						
Straw	68 aAB	33	0 aA	0	32 aAB	33
Sugar / Straw	72 aA	33	0 aA	0	28 aA	33
No Amendments	76 aBC	34	0 aA	0	24 aAB	34
P. pratense / S. viridula mix						
Straw	70 aAB	32	0 aA	0	30 aAB	32
Sugar / Straw	64 aA	27	0 aA	1	36 aA	26
No Amendments	66 aBC	28	0 aA	0	34 aAB	28
T. hybridum / V. americana mix						
Straw	88 bAB	8	0 aA	0	12 aAB	8
Sugar / Straw	65 aA	15	0 aA	0	35 bA	15
No Amendments	84 bBC	15	0 aA	0	16 aAB	15

Table 3.44 Canopy cover of monocultures and mixes at Ellerslie in fall 1996 (continued)

Species	Live Vegetation %		Litter %		Bare Ground %	
Treatment	Mean	S. D.	Mean	S. D.	Mean	S. D.
A. smithii / S. viridula / V. americana mix						
Straw	65 aAB	30	0 aA	1	35 aAB	30
Sugar / Straw	73 aA	19	0 aA	0	27 aA	19
No Amendments	73 aBC	15	0 aA	0	27 aAB	15
B. inermis / P. pratense / T. hybridum mix						
Straw	73 aAB	26	0 aA	0	27 aAB	26
Sugar / Straw	66 aA	22	0 aA	0	34 aA	22
No Amendments	83 aBC	21	0 aA	0	17 aAB	21
A. smithii / B. inermis / P. pratense / S. viridula / T. hybridum / V. americana mix						
Straw	80 aAB	11	0 aA	0	20 aAB	11
Sugar / Straw	75 aA	11	0 aA	0	25 aA	11
No Amendments	85 aBC	11	0 aA	0	15 aAB	11
Non - seeded species (control)						
Straw	68 bAB	34	0 aA	0	32 aAB	34
Sugar / Straw	47 abA	25	0 aA	0	53 abA	25
No Amendments	34 aA	35	0 aA	0	66 bC	35

A. smithii = *Agropyron smithii; B. inermis* = *Bromus inermis; P. pratense* = *Phleum pratense; S. viridula* = *Stipa viridula; T. hybridum* = *Trifolium hybridum; V. americana* = *Vicia americana*

S. D. = Standard Deviation

Means within a column for a given species mix or monoculture followed by the same lower case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Means within a column for a specific amendment treatment followed by the same upper case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Table 3.45 Canopy cover of monocultures and mixes at Ellerslie in spring 1997

Species	Live Vegetation %		Litter %		Bare Ground %	
Treatment	Mean	S. D.	Mean	S. D.	Mean	S. D.
A. smithii monoculture						
Straw	39 abAB	26	34 bAB	22	27 aABC	18
Sugar / Straw	25 aABC	17	45 bA	17	31 aABC	14
No Amendments	58 bB	29	14 aA	11	27 aAB	22
B. inermis monoculture						
Straw	49 abAB	21	40 aB	21	11 aA	7
Sugar / Straw	35 aABCD	24	34 aA	26	31 bABC	24
No Amendments	61 bB	22	27 aB	20	12 aA	15
P. pratense monoculture						
Straw	50 bAB	30	15 aA	13	36 aABC	31
Sugar / Straw	18 aA	17	39 bA	29	43 aBC	24
No Amendments	66 bB	19	6 aA	4	28 aAB	17
S. viridula monoculture						
Straw	37 aAB	26	15 aA	13	48 aC	27
Sugar / Straw	29 aABC	26	39 bA	23	32 aABC	17
No Amendments	48 aAB	28	9 aA	14	43 aBC	28
T. hybridum monoculture						
Straw	58 aB	29	19 abAB	20	24 aABC	21
Sugar Straw	46 aBCD	28	29 bA	25	25 aAB	18
No Amendments	67 aB	20	7 aA	7	25 aAB	17
V. americana monoculture						
Straw	67 aB	32	15 abA	18	18 aAB	23
Sugar Straw	57 aD	31	27 bA	21	16 aA	20
No Amendments	74 aB	23	4 aA	3	23 aAB	23
A. smithii / B. inermis mix						
Straw	56 bB	20	26 aAB	15	18 aAB	15
Sugar / Straw	24 aABC	15	42 bA	18	35 aABC	18
No Amendments	62 bB	20	16 aAB	8	22 aAB	20
P. pratense / S. viridula mix						
Straw	50 bAB	26	19 aAB	16	31 aABC	24
Sugar / Straw	13 aA	12	52 bA	23	35 aABC	18
No Amendments	58 bB	28	6 aA	6	36 aAB	28
T. hybridum / V. americana mix						
Straw	55 aB	30	18 abAB	18	27 aABC	22
Sugar / Straw	50 aCD	22	28 bA	16	22 aAB	18
No Amendments	66 aB	27	5 aA	4	29 aAB	24

Table 3.45 Canopy cover of monocultures and mixes at Ellerslie in spring 1997 (continued)

Species	Live Vegetation %		Litter %		Bare Ground %	
Treatment	Mean	S. D.	Mean	S. D.	Mean	S. D.
A. smithii / S. viridula / V. americana mix						
Straw	57 bB	26	17 aAB	14	26 aABC	18
Sugar / Straw	21 aAB	17	51 bA	20	28*aABC	13
No Amendments	70 bB	14	9 aA	7	21**aAB	11
B. inermis / P. pratense / T. hybridum mix						
Straw	45 aAB	21	29 bAB	21	26 aABC	16
Sugar / Straw	38 aABCD	26	36 bA	21	27 aAB	22
No Amendments	68 bB	21	11 aA	9	22 aAB	20
A. smithii / B. inermis / P. pratense / S. viridula / T. hybridum / V. americana mix						
Straw	43 aAB	28	24 aAB	21	33 aABC	32
Sugar / Straw	30 aABCD	20	43 bA	21	27 aAB	18
No Amendments	46 aAB	18	13 aA	10	41 aB	20
Non - seeded species (control)						
Straw	18 aA	24	36 bAB	25	46 aBC	28
Sugar Straw	15 aA	12	33 bA	19	53 abC	26
No Amendments	25 aA	18	5 aA	5	70 bC	18

* Moss ≥0.01

** Manure ≥0.01

A. smithii = Agropyron smithii; B. inermis = Bromus inermis; P. pratense = Phleum pratense; S. viridula = Stipa viridula; T. hybridum = Trifolium hybridum; V. americana = Vicia americana

S. D. = Standard Deviation

Means within a column for a given species mix or monoculture followed by the same lower case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Means within a column for a specific amendment treatment followed by the same upper case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Table 3.46 Canopy cover of monocultures and mixes at Ellerslie in fall 1997

Species	Live Vegetation %		Litter %		Bare Ground %	
Treatment	Mean	S. D.	Mean	S. D.	Mean	S. D.
A. smithii monoculture						
Straw	67 aAB	36	21 aA	26	12*aA	21
Sugar / Straw	56 aA	19	26 aB	17	18 aA	18
No Amendments	79 aAB	26	8 aA	12	13 aA	22
B. inermis monoculture						
Straw	84 aAB	24	7 aA	13	9 aA	16
Sugar / Straw	80 aAB	21	9 aAB	16	11 aA	17
No Amendments	59 aA	35	33 aB	33	8 aA	17
P. pratense monoculture						
Straw	60 aA	23	19 aA	17	21 aA	20
Sugar / Straw	58 aA	22	22 aAB	18	20 aA	14
No Amendments	67 aAB	20	14 aAB	17	19 aA	17
S. viridula monoculture						
Straw	71 aAB	23	15 aA	16	15 aA	21
Sugar / Straw	66 aAB	26	14 aAB	13	20 aA	22
No Amendments	78 aAB	22	15 aAB	17	7 aA	7
T. hybridum monoculture						
Straw	92 aB	9	4 aA	8	4 aA	5
Sugar / Straw	88 aB	18	9 aAB	15	2 aA	3
No Amendments	86 aAB	17	8 aA	13	7 aA	9
V. americana monoculture						
Straw	63 aA	25	25 aA	21	12 aA	22
Sugar / Straw	62 aAB	32	26 aB	31	12 aA	16
No Amendments	78 aAB	22	18 aAB	20	4 aA	4
A. smithii / *B. inermis* mix						
Straw	85 aAB	12	9 aA	11	5 abA	6
Sugar / Straw	74 aAB	23	11 aAB	12	14 bA	17
No Amendments	77 aAB	20	19 aAB	20	4 aA	3
P. pratense / *S. viridula* mix						
Straw	66 aAB	24	19 aA	20	15 aA	13
Sugar / Straw	80 aAB	16	11 aAB	11	10 aA	12
No Amendments	80 aAB	14	7 aA	8	13 aA	13
T. hybridum / *V. americana* mix						
Straw	86 aAB	19	10 aA	17	4 aA	4
Sugar / Straw	82 aAB	16	7 aAB	10	11 aA	14
No Amendments	91 aB	6	3 aA	3	5 aA	6

Table 3.46 Canopy cover of monocultures and mixes at Ellerslie in fall 1997 (continued)

Species	Live Vegetation %		Litter %		Bare Ground %	
Treatment	Mean	S. D.	Mean	S. D.	Mean	S. D.
A. smithii / S. viridula / V. americana mix						
Straw	76 aAB	23	19 aA	23	5 aA	7
Sugar / Straw	74 aAB	20	19 aAB	16	7 aA	10
No Amendments	86 aAB	11	11 aA	10	3 aA	2
B. inermis / P. pratense / T. hybridum mix						
Straw	91 aB	9	3 aA	5	6 aA	8
Sugar / Straw	89 aB	5	3 aA	3	8 aA	4
No Amendments	78 aAB	28	4 aA	4	18 aA	27
A. smithii / B. inermis / P. pratense / S. viridula / T. hybridum / V. americana mix						
Straw	85 aAB	12	11 aA	9	4 aA	6
Sugar Straw	81 aAB	22	16 aAB	19	3 aA	5
No Amendments	84 aAB	14	8 aA	7	9 aA	13
Non - seeded species (control)						
Straw	66 aAB	29	21 aA	27	13 aA	21
Sugar / Straw	57 aA	30	24 aAB	28	19 aA	20
No Amendments	74 aAB	32	13 aAB	25	13 aA	16

* Moss ≥0.01

A. smithii = Agropyron smithii; B. inermis = Bromus inermis; P. pratense = Phleum pratense; S. viridula = Stipa viridula; T. hybridum = Trifolium hybridum; V. americana = Vicia americana

S. D. = Standard Deviation

Means within a column for a given species mix or monoculture followed by the same lower case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Means within a column for a specific amendment treatment followed by the same upper case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Table 3.47 *Agropyron smithii* compared with *Bromus inermis* in monoculture and seeded together at Ellerslie in fall 1996

Species / Treatment	Density (plants / 0.1 m^2) Mean	S. D.	Biomass (%) Mean	S. D.	Survivability (%) Mean	S. D.
A. smithii monoculture						
Straw	5 a	4	9 a	15	15 a	13
Sugar / Straw	5 a	4	11 a	26	15 a	13
No Amendments	7 a	4	29 a	23	23 a	13
B. inermis monoculture						
Straw	4 a	2	28 b	22	13 a	8
Sugar / Straw	3 a	2	13 a	10	11 a	8
No Amendments	6 a	3	51 b	38	19 a	10
A. smithii in *A. smithii / B. inermis* mix						
Straw	2 a	1	5 a	10	13 a	10
Sugar / Straw	2 a	2	0 a	1	14 a	14
No Amendments	3 a	2	19 a	34	23 a	15
B. inermis in *A. smithii / B. inermis* mix						
Straw	2 a	2	9 a	12	16 a	11
Sugar / Straw	3 a	2	5 b	7	17 a	13
No Amendments	4 a	2	52 b	37	23 a	14
A. smithii in *A. smithii / B. inermis/ P. pratense / S. viridula / T. hybridum / V. americana* mix						
Straw	1 a	1	2 a	2	16 a	24
Sugar / Straw	0 a	1	1 a	2	11 a	18
No Amendments	1 a	1	6 a	7	25 a	23
B. inermis in *A. smithii / B. inermis/ P. pratense / S. viridula / T. hybridum / V. americana* mix						
Straw	2 b	2	10 b	10	37 b	37
Sugar / Straw	1 b	1	4 b	5	25 b	26
No Amendments	2 a	2	14 b	13	42 a	36

A. smithii = Agropyron smithii; B. inermis = Bromus inermis; P. pratense = Phleum pratense; S. viridula = Stipa viridula; T. hybridum = Trifolium hybridum; V. americana = Vicia americana
S. D. = Standard Deviation
Means within a column between monocultures or two species mixes or six species mixes followed by the same lower case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Table 3.48 *Agropyron smithii* compared with *Bromus inermis* in monoculture and seeded together at Ellerslie in spring 1997

Species / Treatment	Density (plants / 0.1 m²) Mean	S. D.	Biomass (%) Mean	S. D.	Survivability (%) Mean	S. D.
A. smithii monoculture						
Straw	6 a	4	30 a	25	19 a	12
Sugar / Straw	5 a	2	25 a	17	17 a	7
No Amendments	7 b	3	41 a	26	23 b	11
B. inermis monoculture						
Straw	5 a	3	94 b	15	16 a	9
Sugar / Straw	6 a	2	94 b	10	19 a	7
No Amendments	5 a	2	91 b	28	17 a	8
A. smithii in *A. smithii / B. inermis* mix						
Straw	1 a	1	3 a	7	6 a	6
Sugar / Straw	1 a	2	2 a	3	8 a	11
No Amendments	2 a	2	13 a	28	13 a	11
B. inermis in *A. smithii / B. inermis* mix						
Straw	4 b	2	86 b	27	26 b	15
Sugar / Straw	4 b	2	69 b	27	26 b	11
No Amendments	5 b	2	82 b	34	33 b	15
A. smithii in *A. smithii / B. inermis/ P. pratense / S. viridula / T. hybridum / V. americana* mix						
Straw	0 a	0	2 a	4	6 a	9
Sugar / Straw	1 a	1	3 a	5	14 a	17
No Amendments	2 a	2	5 a	6	38 a	39
B. inermis in *A. smithii / B. inermis/ P. pratense / S. viridula / T. hybridum / V. americana* mix						
Straw	2 b	2	42 b	35	50 b	46
Sugar / Straw	2 b	1	40 b	31	34 b	24
No Amendments	2 a	1	38 b	33	29 a	25

A. smithii = Agropyron smithii; B. inermis = Bromus inermis; P. pratense = Phleum pratense; S. viridula = Stipa viridula; T. hybridum = Trifolium hybridum; V. americana = Vicia americana

S. D. = Standard Deviation

Means within a column between monocultures or two species mixes or six species mixes followed by the same lower case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Table 3.49 *Agropyron smithii* compared with *Bromus inermis* in monoculture and seeded together at Ellerslie in fall 1997

Species / Treatment	Density (plants / 0.1 m²) Mean	S. D.	Biomass (%) Mean	S. D.	Survivability (%) Mean	S. D.
A. smithii monoculture						
Straw	4 a	2	13 a	21	12 a	8
Sugar / Straw	3 a	2	8 a	18	9 a	5
No Amendments	4 a	3	38 a	35	13 a	9
B. inermis monoculture						
Straw	4 a	2	88 b	22	12 a	5
Sugar / Straw	4 b	1	84 b	21	14 b	3
No Amendments	4 a	1	98 b	4	13 a	4
A. smithii in *A. smithii / B. inermis* mix						
Straw	2 a	2	2 a	4	10 a	11
Sugar / Straw	1 a	1	3 a	6	8 a	8
No Amendments	0 a	1	0 a	1	3 a	4
B. inermis in *A. smithii / B. inermis* mix						
Straw	4 b	2	61 b	35	24 b	12
Sugar / Straw	4 b	2	57 b	30	27 b	11
No Amendments	4 b	1	89 b	23	27 b	8
A. smithii in *A. smithii / B. inermis/ P. pratense / S. viridula / T. hybridum / V. americana* mix						
Straw	1 a	1	2 a	4	13 a	15
Sugar / Straw	0 a	1	1 a	2	8 a	13
No Amendments	1 a	1	9 a	27	12 a	13
B. inermis in *A. smithii / B. inermis/ P. pratense / S. viridula / T. hybridum / V. americana* mix						
Straw	2 b	2	54 b	36	43 b	30
Sugar / Straw	2 b	1	32 b	32	37 b	27
No Amendments	2 b	1	56 b	37	48 b	22

A. smithii = *Agropyron smithii*; *B. inermis* = *Bromus inermis*; *P. pratense* = *Phleum pratense*; *S. viridula* = *Stipa viridula*; *T. hybridum* = *Trifolium hybridum*; *V. americana* = *Vicia americana*

S. D. = Standard Deviation

Means within a column between monocultures or two species mixes or six species mixes followed by the same lower case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Table 3.50 *Phleum pratense* compared with *Stipa viridula* in monoculture and seeded together at Ellerslie in fall 1996

Species / Treatment	Density (plants / 0.1 m^2) Mean	S. D.	Biomass (%) Mean	S. D.	Survivability (%) Mean	S. D.
P. pratense monoculture						
Straw	2 a	2	21 a	22	8 a	6
Sugar / Straw	2 a	2	9 a	17	7 a	8
No Amendments	4 a	2	66 b	22	15 a	6
S. viridula monoculture						
Straw	2 a	1	24 a	33	7 a	5
Sugar / Straw	2 a	2	3 a	5	6 a	5
No Amendments	6 a	3	40 a	25	19 a	10
P. pratense in *P. pratense / S. viridula* mix						
Straw	1 a	1	6 b	9	7 a	9
Sugar / Straw	1 a	1	2 a	4	5 a	7
No Amendments	3 a	2	33 b	28	18 a	15
S. viridula in *P. pratense / S. viridula* mix						
Straw	0 a	1	1 a	2	3 a	5
Sugar / Straw	1 a	1	1 a	2	7 a	8
No Amendments	2 a	1	14 a	11	15 a	9
P. pratense in *A. smithii / B. inermis/ P. pratense / S. viridula / T. hybridum / V. americana* mix						
Straw	0 a	0	2 a	4	6 a	9
Sugar / Straw	0 a	1	2 a	4	9 a	16
No Amendments	1 a	1	18 a	24	25 a	20
S. viridula in *A. smithii / B. inermis/ P. pratense / S. viridula / T. hybridum / V. americana* mix						
Straw	0 a	1	1 a	2	9 a	15
Sugar / Straw	0 a	1	1 a	2	6 a	13
No Amendments	1 a	1	7 a	12	26 a	29

A. smithii = Agropyron smithii; B. inermis = Bromus inermis; P. pratense = Phleum pratense; S. viridula = Stipa viridula; T. hybridum = Trifolium hybridum; V. americana = Vicia americana

S. D. = Standard Deviation

Means within a column between monocultures or two species mixes or six species mixes followed by the same lower case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Table 3.51 *Phleum pratense* compared with *Stipa viridula* in monoculture and seeded together at Ellerslie in spring 1997

Species / Treatment	Density (plants / 0.1 m²) Mean	S. D.	Biomass (%) Mean	S. D.	Survivability (%) Mean	S. D.
P. pratense monoculture						
Straw	2 a	1	68 b	31	7 a	4
Sugar Straw	2 a	2	58 b	41	7 a	6
No Amendments	2 a	1	81 b	37	8 a	5
S. viridula monoculture						
Straw	2 a	2	27 a	31	6 a	5
Sugar Straw	2 a	2	5 a	6	6 a	5
No Amendments	4 b	2	52 a	38	14 b	8
P. pratense in *P. pratense / S. viridula* mix						
Straw	1 a	2	32 a	38	9 a	10
Sugar Straw	2 a	1	22 a	28	10 a	6
No Amendments	2 a	1	61 b	33	12 a	9
S. viridula in *P. pratense / S. viridula* mix						
Straw	2 a	2	16 a	30	10 a	17
Sugar Straw	1 a	1	13 a	19	9 a	6
No Amendments	2 a	2	23 a	28	16 a	11
P. pratense in *A. smithii / B. inermis/ P. pratense / S. viridula / T. hybridum / V. americana* mix						
Straw	0 a	1	14 a	29	6 a	12
Sugar Straw	0 a	0	4 a	10	3 a	8
No Amendments	0 a	0	24 b	31	9 a	10
S. viridula in *A. smithii / B. inermis/ P. pratense / S. viridula / T. hybridum / V. americana* mix						
Straw	0 a	0	1 a	3	3 a	7
Sugar Straw	0 a	0	1 a	3	3 a	8
No Amendments	0 a	1	2 a	3	11 a	13

A. smithii = Agropyron smithii; B. inermis = Bromus inermis; P. pratense = Phleum pratense; S. viridula = Stipa viridula; T. hybridum = Trifolium hybridum; V. americana = Vicia americana

S. D. = Standard Deviation

Means within a column between monocultures or two species mixes or six species mixes followed by the same lower case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Table 3.52 *Phleum pratense* compared with *Stipa viridula* in monoculture and seeded together at Ellerslie in fall 1997

Species / Treatment	Density (plants / 0.1 m^2) Mean	S. D.	Biomass (%) Mean	S. D.	Survivability (%) Mean	S. D.
P. pratense monoculture						
Straw	2 a	1	66 b	38	8 a	4
Sugar / Straw	2 a	2	43 b	47	6 a	6
No Amendments	3 a	2	85 a	30	9 a	6
S. viridula monoculture						
Straw	2 a	2	27 a	28	7 a	7
Sugar / Straw	2 a	1	4 a	7	5 a	4
No Amendments	4 a	2	76 a	32	12 a	7
P. pratense in *P. pratense / S. viridula* mix						
Straw	1 a	1	35 b	32	8 a	7
Sugar / Straw	1 a	1	17 a	29	6 a	6
No Amendments	2 a	1	58 b	34	13 a	8
S. viridula in *P. pratense / S. viridula* mix						
Straw	1 a	1	9 a	13	7 a	6
Sugar / Straw	1 a	1	8 a	12	7 a	6
No Amendments	2 a	1	22 a	20	14 a	9
P. pratense in *A. smithii / B. inermis/ P. pratense / S. viridula / T. hybridum / V. americana* mix						
Straw	0 b	1	7 b	14	10 b	19
Sugar / Straw	0 a	1	11 a	16	11 a	13
No Amendments	0 a	1	3 a	8	8 a	15
S. viridula in *A. smithii / B. inermis/ P. pratense / S. viridula / T. hybridum / V. americana* mix						
Straw	0 a	0	0 a	0	0 a	0
Sugar / Straw	0 a	1	3 a	9	5 a	12
No Amendments	0 a	0	1 a	1	6 a	10

A. smithii = Agropyron smithii; B. inermis = Bromus inermis; P. pratense = Phleum pratense; S. viridula = Stipa viridula; T. hybridum = Trifolium hybridum; V. americana = Vicia americana

S. D. = Standard Deviation

Means within a column between monocultures or two species mixes or six species mixes followed by the same lower case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Table 3.53 *Trifolium hybridum* compared with *Vicia americana* in monoculture and seeded together at Ellerslie in fall 1996

Species / Treatment	Density (plants / 0.1 m²) Mean	S. D.	Biomass (%) Mean	S. D.	Survivability (%) Mean	S. D.
T. hybridum monoculture						
Straw	2 a	1	28 a	32	5 a	5
Sugar / Straw	2 a	2	12 a	16	5 a	6
No Amendments	2 a	2	42 a	28	6 a	7
V. americana monoculture						
Straw	12 b	7	22 a	28	40 b	24
Sugar / Straw	8 b	4	6 a	4	27 b	12
No Amendments	15 b	10	38 a	29	49 b	32
T. hybridum in *T. hybridum / V. americana* mix						
Straw	1 a	0	16 b	18	6 a	4
Sugar / Straw	1 a	1	14 a	14	8 a	9
No Amendments	2 a	3	36 b	32	16 a	21
V. americana in *T. hybridum / V. americana* mix						
Straw	7 b	5	5 a	4	49 b	36
Sugar / Straw	8 b	4	9 a	15	54 b	28
No Amendments	9 b	6	13 a	11	58 b	40
T. hybridum in *A. smithii / B. inermis/ P. pratense / S. viridula / T. hybridum / V. americana* mix						
Straw	0 a	0	4 a	9	4 a	9
Sugar / Straw	0 a	1	4 a	6	9 a	13
No Amendments	1 a	1	5 a	9	14 a	15
V. americana in *A. smithii / B. inermis/ P. pratense / S. viridula / T. hybridum / V. americana* mix						
Straw	2 b	2	5 a	9	31 b	36
Sugar / Straw	2 b	1	2 a	2	46 b	25
No Amendments	3 b	2	4 a	2	57 b	37

A. smithii = Agropyron smithii; B. inermis = Bromus inermis; P. pratense = Phleum pratense; S. viridula = Stipa viridula; T. hybridum = Trifolium hybridum; V. americana = Vicia americana

S. D. = Standard Deviation

Means within a column between monocultures or two species mixes or six species mixes followed by the same lower case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Table 3.54 *Trifolium hybridum* compared with *Vicia americana* in monoculture and seeded together at Ellerslie in spring 1997

Species / Treatment	Density (plants / 0.1 m²) Mean	S. D.	Biomass (%) Mean	S. D.	Survivability (%) Mean	S. D.
T. hybridum monoculture						
Straw	1 a	1	46 a	41	4 a	3
Sugar / Straw	2 a	4	35 a	35	7 a	12
No Amendments	3 a	3	68 a	34	10 a	9
V. americana monoculture						
Straw	32 b	18	60 a	37	107 b	61
Sugar / Straw	30 b	9	62 b	24	100 b	29
No Amendments	39 b	17	65 a	33	128 b	55
T. hybridum in *T. hybridum / V. americana* mix						
Straw	1 a	1	32 a	36	7 a	7
Sugar / Straw	1 a	1	27 a	32	5 a	6
No Amendments	1 a	2	31 a	39	8 a	12
V. americana in *T. hybridum / V. americana* mix						
Straw	12 b	7	25 a	22	83 b	45
Sugar / Straw	9 b	6	22 a	22	62 b	39
No Amendments	19 b	11	42 a	37	125 b	74
T. hybridum in *A. smithii / B. inermis/ P. pratense / S. viridula / T. hybridum / V. americana* mix						
Straw	0 a	0	0 a	1	3 a	7
Sugar / Straw	0 a	1	19 a	32	11 a	16
No Amendments	0 a	1	8 a	17	11 a	24
V. americana in *A. smithii / B. inermis/ P. pratense / S. viridula / T. hybridum / V. americana* mix						
Straw	5 b	4	15 b	25	94 b	82
Sugar / Straw	4 b	2	7 a	7	69 b	49
No Amendments	7 b	6	9 a	20	132 b	111

A. smithii = Agropyron smithii; B. inermis = Bromus inermis; P. pratense = Phleum pratense; S. viridula = Stipa viridula; T. hybridum = Trifolium hybridum; V. americana = Vicia americana

S. D. = Standard Deviation

Means within a column between monocultures or two species mixes or six species mixes followed by the same lower case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Table 3.55 *Trifolium hybridum* compared with *Vicia americana* in monoculture and seeded together at Ellerslie in fall 1997

Species / Treatment	Density (plants / 0.1 m^2) Mean	S. D.	Biomass (%) Mean	S. D.	Survivability (%) Mean	S. D.
T. hybridum monoculture						
Straw	1 b	1	50 b	42	3 b	2
Sugar / Straw	1 a	1	29 b	31	3 a	3
No Amendments	1 b	1	67 b	46	3 b	2
V. americana monoculture						
Straw	0 a	1	0 a	1	1 a	2
Sugar / Straw	0 a	1	0 a	1	1 a	4
No Amendments	0 a	1	1 a	3	1 a	2
T. hybridum in *T. hybridum / V. americana* mix						
Straw	1 b	1	46 b	44	6 b	6
Sugar / Straw	1 a	1	36 b	41	5 a	5
No Amendments	1 b	1	50 b	49	6 b	6
V. americana in *T. hybridum / V. americana* mix						
Straw	0 a	0	0 a	0	1 a	3
Sugar / Straw	1 a	1	0 a	0	4 a	6
No Amendments	0 a	0	0 a	0	1 a	2
T. hybridum in *A. smithii / B. inermis/ P. pratense / S. viridula / T. hybridum / V. americana* mix						
Straw	0 a	1	13 a	34	6 a	17
Sugar / Straw	0 a	1	12 b	20	8 a	13
No Amendments	0 a	0	9 b	15	8 a	10
V. americana in *A. smithii / B. inermis/ P. pratense / S. viridula / T. hybridum / V. americana* mix						
Straw	0 a	0	0 a	0	3 a	7
Sugar / Straw	0 a	0	0 a	0	2 a	6
No Amendments	0 a	1	0 a	1	8 a	15

A. smithii = Agropyron smithii; B. inermis = Bromus inermis; P. pratense = Phleum pratense; S. viridula = Stipa viridula; T. hybridum = Trifolium hybridum; V. americana = Vicia americana

S. D. = Standard Deviation

Means within a column between monocultures or two species mixes or six species mixes followed by the same lower case letter are not significantly different ($p < 0.05$, Tukey's HSD)

Table 3.56 Dry weight of vegetation of monocultures and mixes at Ellerslie in fall 1997

Species	Straw (gm) Mean	S. D.	Straw / Sugar (gm) Mean	S. D.	No Amendments (gm) Mean	S. D.
A. smithii monoculture						
	47.1 aABC	33.2	32.3aA	15.0	34.1aAB	18.9
B. inermis monoculture						
	69.9 aABC	49.1	61.2aAB	28.4	60.6aABCD	28.7
P. pratense monoculture						
	67.0 abABC	20.0	53.8aAB	21.1	95.1bCD	51.8
S. viridula monoculture						
	53.5 aABC	42.1	46.3aAB	27.9	59.6aABCD	29.1
T. hybridum monoculture						
	29.6 aA	27.1	37.5aAB	41.4	56.3aABCD	40.6
V. americana monoculture						
	37.5 aAB	29.6	41.8aAB	43.5	45.4aABC	46.7
A. smithii / B. inermis mix						
	57.3 aABC	28.9	73.2aB	29.9	82.2aBCD	53.0
P. pratense / S. viridula mix						
	59.9 aABC	30.5	63.3aAB	33.8	93.0aCD	54.4
T. hybridum / V. americana mix						
	44.9 aABC	29.9	37.8aAB	20.7	41.1aABC	29.5
A. smithii / S. viridula / V. americana mix						
	54.1 aABC	43.6	39.2aAB	29.6	74.2aABCD	62.6
B. inermis / P. pratense / T. hybridum mix						
	86.1 aC	42.2	74.2aB	39.5	102.8aD	47.3
A. smithii / B. inermis / P. pratense / S. viridula / T. hybridum / V. americana mix						
	73.4 aBC	35.6	49.6aAB	30.2	53.5aABCD	42.3
Non - seeded species (control)						
	56.8 bABC	26.4	45.2abAB	33.4	25.4aA	25.6

A. smithii = Agropyron smithii; B. inermis = Bromus inermis; P. pratense = Phleum pratense; S. viridula = Stipa viridula; T. hybridum = Trifolium hybridum; V. americana = Vicia americana
S. D. = Standard Deviation
Means within a row for a given species mix or monoculture followed by the same lower case letter are not significantly different ($p < 0.05$, Tukey's HSD)
Means within a column for a specific treatment followed by the same upper case letter are not significantly different ($p < 0.05$, Tukey's HSD)

CHAPTER 4: SYNTHESIS

4.1 Introduction

This research was based on the hypothesis that native plant species require lower levels of nutrients to survive than introduced species do and would therefore be able to outcompete introduced plant species on low fertility soils. The objectives of this research were to ascertain if native plant species would have higher survivability and produce more biomass than introduced plant species on low nutrient soils. The results obtained through this research can be beneficial to reclamation companies and other individuals wanting to re-establish native plant communities. The soils at sites where re-establishment of native plant communities are being attempted have differing nutrient levels so different techniques are required to provide the most favourable conditions for species germination and survivability. Nutrient levels in soils can be adjusted by applying fertilizer to increase levels or by applying organic amendments to immobilize available nitrogen. The sites chosen in this research represented two extremes of soil fertility.

4.2 Native and Introduced Plant Response

The survival rate between the selected native and introduced plant species did not differ when fertilizer was applied to the site nor when straw or sugar and straw were used to immobilize available nitrogen. Biomass production of the selected species was also not affected by adding nutrients or organic amendments to the soil.

Slow germination and long periods of dormancy of seeds of native species would affect overall establishment in the short term. It would also affect the overall competitiveness of the species compared with introduced and non-seeded species. There were more non-seeded species in the native plant species monocultures and mixes than in the monocultures and mixes with introduced plant species. Rapid establishment provided introduced species with a competitive advantage over native and non-seeded species for the available nutrients. Introduced species, in particular *B. inermis*, were aggressive and established expeditiously, limiting the number of non-seeded species invading the treatments.

In reclamation, a high percentage of live vegetation and litter is required quickly to reduce the effect of wind and water erosion on susceptible areas. The amount of biomass was generally less for the native plant species than for the introduced species. Plant

characteristics of the six species used in this study would account for some of the differences. The introduced grass species used in this study generally grow taller and have broader leaf blades than the selected native plant species. *Bromus inermis* grows to a height of 60 to 100 cm with blades 6 to 12 mm wide while *Agropyron smithii* usually reaches heights of 30 to 60 cm with blades 3 to 6 mm wide. Although *Phleum pratense* and *Stipa viridula* can grow to similar heights, 50 to 100 cm, the blades of *P. pratense* are 6 to 12 mm wide compared to the blades of *S. viridula* that are generally 2 to 5 mm wide. *Trifolium hybridum* can grow 30 to 60 cm high with leaflets 10 to 25 cm long. *Vicia americana* reaches lengths of 10 to 25 cm (Looman and Best 1981). The larger growth forms of the introduced species would result in a higher percentage of live vegetation accountable to the species.

Although all species grew on the subsoil at Genesee, the percentage of bare ground was indicative of the poor growth of the species at this site. The legumes seeded at Genesee fared better than the grass species and should be considered as reliable options in reclaiming areas with harsher edaphic environments. *Vicia americana* had high survival rates. Although *Trifolium hybridum* had low survivability, biomass production was high. Nitrogen fixing species can become established on nitrogen deficient soils and will provide initial ground cover.

4.3 Ellerslie vs. Genesee Sites

There were vast differences in plant establishment at Ellerslie and Genesee. Although the seeds planted at both sites were from the same seed sources, the grass species at Genesee were stunted and lacked the colour and vigour (lushness, tillering rate and number of flowering culms) of their counterparts at Ellerslie. At Ellerslie, survivability and biomass production was higher for all species except *Vicia americana* in fall 1997. This study was to determine the effect of soil macronutrient levels on plant survivability and biomass production. Other edaphic factors may also have affected the successful establishment of the selected species. Although soil parameters at Genesee were within normal ranges for successful plant establishment, none of the species appeared to do well. Micronutrient levels were generally higher at Ellerslie than at Genesee. The role of micronutrients in plant growth is being studied for introduced species but the requirements for native plant species has not been addressed. The high soil pH at Genesee could also have affected the availability of soil nutrients (Munshower 1994). Soil organic matter has a crucial role in plant growth as microorganisms are involved in the immobilization/mineralization

processes. Soil tilth can also be a factor in plant establishment. The soil surface at Genesee was cloddy compared to the soil surface at Ellerslie which may have impeded plant emergence. As the soil surface at Genesee became crusted, it may have made it more difficult for seedlings to emerge.

By fall 1997, *V. americana* had higher survivability (density) at Genesee because insects had destroyed the plants at Ellerslie. The surrounding vegetation and plant diseases and insect pests should be considered when deciding which species to seed onto a disturbed site.

4.4 Fertilizers

As neither native nor introduced plant species had high survivability (density) or biomass production when fertilizer was applied, the fate of the fertilizer would have to be ascertained before any conclusive statements can be made regarding the benefits of applying inorganic nutrients. In the few instances where there was a significant difference in biomass production of the seeded species, the slow release fertilizer had higher amounts of biomass. Further study is required to determine how long the effect of slow release fertilizer remains in the soil and the rate it should be applied. The effect of slow release fertilizer on the establishment of native plant species should be studied further to determine if it is a viable alternative to repeat applications of regular fertilizer.

Re-application of regular fertilizer in the second year did not significantly affect survivability or biomass production of the native or introduced species. However, visually there was a difference in these treatments as the plants were greener and more supple than the plants in the other treatments. On soils with extreme nutrient deficiencies, repeat applications of fertilizer may be required for successful plant establishment.

It was expected the level of available nutrients would have increased with fertilizer treatments. However, the available nitrate level did not vary between years and treatments. Application of regular fertilizer in the second year did not affect the amount of available nitrate in the soil. If this study was to be repeated, nutrient analyses should be done regularly to assist in determining the fate of the added nutrients. A site with different soil characteristics should be used in future studies. Research should be done on reclaimed sites with topsoil as this would be more representative of reclaimed sites. The amount of available nutrient could be affected by soil texture and organic matter.

4.5 Organic Soil Amendments and Soil Impoverishment

Many aspects of soil impoverishment techniques have not been thoroughly addressed. Available nitrogen levels in the soil must be ascertained before incorporating organic amendments. As results of soil tests vary with time, it may be difficult to determine the volume of organic matter required to obtain the desired C:N ratio in the soil. By-products of the organic amendments should be taken into consideration. Incorporating straw may introduce agronomic and weedy species onto the site that can compete for existing resources. Volunteer cereals, primarily *Hordeum vulgare* L. (barley), emerged on the treatments with added straw. As these plants became established before the seeded species, competition for space and light could affect survivability and growth rates of the desired species. Competition for moisture was not a factor as rainfall was above normal in the establishment year. The straw treatments were weeded but the cereal grains regrew during the summer. However, the volunteer cereals were controlled by swathing in the fall prior to the seeds ripening.

The rate of immobilization may affect the timing of seeding. If a readily available carbon source such as sugar is used, germination of the plant species and peak immobilization should coincide to obtain maximum benefits from nitrogen immobilization. More slowly decayed carbon sources would maintain a microbial population for a longer period of time. but the rate of immobilization and mineralization would affect plant survivability. The amount of available nitrogen lower in the second year, which could affect species survivability in subsequent years. Long term studies are required to determine if adding sugar and straw to soil will alter species establishment. As different plant species require different levels of nutrients, it can be assumed some native plant species will benefit from soil impoverishment while for others it will be detrimental to their survival.

Adding straw and sugar was expected to reduce the available nutrient levels of the soil. However, available nitrogen levels did not vary among treatments in the second year. The length of time nutrients are immobilized has not been determined. Analyses of nutrient levels should be taken after incorporating the amendments and repeated periodically to determine the rate of immobilization/mineralization. Based on the literature (Allison and Klein 1962; Zimmerman et al. 1995), soil nutrient levels should be assessed one week after adding straw and sugar and reassessments would be dependent on the growth rate of the plants.

It is has not been established how soil impoverishment will affect the availability of other soil nutrients. Nitrogen uptake and utilization can be altered by the presence or absence of other nutrients as other nutrients, including potassium, sulfur, iron and molybdenum are interrelated with nitrogen (Tisdale et al. 1993).

4.6 Management Considerations

Control of non-seeded species with herbicides can be difficult in a grass/legume mix. It is therefore important to control undesirable species with alternative methods. When adding straw as an organic amendment, weed-free, inert sources are required. If straw is used, it may be advisable to incorporate the straw into the soil; allow volunteer cereals and forbs to emerge; use a non-residual herbicide to control them; and then seed the desired species. If volunteer cereals do become established, swathing before the seeds mature will control the re-emergence of these species the following year.

4.7 Further Research

Before adding fertilizer or organic amendments to promote the establishment of native plant communities, an understanding of nutrient requirements of native plant species is essential. At present, information on growth requirements is limited and further research is required for the various species. Information is still required before nitrogen immobilization techniques can be implemented throughout the reclamation industry. It has not been determined when the opportune time is to seed the species after soil amendments have been incorporated into the soil. It is important to know the rate of immobilization to know the time available to seed the species.

Similar studies on plant response to fertilizers should be completed on low nutrient soils with higher amounts of organic matter. Varying rates and types of fertilizer nutrients should be used with native plant species commonly used in reclamation. More information is required on species used in reclamation.

V. americana is one of the few native legumes available for reclamation, but little information is available on what insects will destroy the species. It is also important to learn more about intraspecific competition for *V. americana* and if its life cycle is similar to *T. hybridum* in that it slowly dies out after two years.

Although most studies consider the benefits provided by seeded species, non-seeded species may play a role in modifying soil conditions for future plant community establishment. Non-seeded species, including *Brassicaceae* spp., *Matricaria perforata* and *Melilotus officinalis*, had high density and productivity on subsoil at Genesee. Research should be conducted to ascertain the characteristics that allow these species to proliferate on low fertility soils and the effect these species have in reclaiming disturbed sites.

Longer-term studies are required to determine how, if at all, the plant community changes once nutrient levels have stabilized. As nitrogen levels decreased after organic amendments were added, longer studies would be required to determine if the native plants that had become established during the two years of this study, would be able to outcompete the introduced species for the limited resources available.

4.8 Conclusions

In conclusion, the six selected native and introduced species were not affected by fertilizer regime. Although introduced plant species had higher biomass production, individual plant characteristics would account for the variability.

Adding sugar and straw to decrease nutrient levels in soil did not affect the establishment of either the native or introduced plant species at Ellerslie. Although soil impoverishment may be a viable method of encouraging the establishment of native plant communities, more studies are required to determine its effectiveness.

4.9 References

Allison, F.E. and C.J. Klein. 1962. Rates of immobilization and release on nitrogen following additions of carbonaceous materials and nitrogen to soils. Soil Science 93:383-386.

Looman, J. and K.F. Best. 1981. Budd's flora of the Canadian Prairie Provinces. Canadian Government Publishing Centre Supply and Services Canada. Hull, PQ. 863 pp.

Munshower, F.F. 1994. Practical handbook of disturbed land revegetation. Lewis Publishers. Boca Raton, FA. 265 pp.

Tisdale, S.L., W.L. Nelson, J.D. Beaton and J.L. Havlin. 1993. Soil fertility and fertilizers. Macmillan Publishing Company. New York, NY. 434 pp.

Zimmerman, J.K., W.M. Pulliam, D.J. Lodge, V. Quinones-Orfila, N. Fetcher, S. Guzman-Grajales, J.A. Parrotta, C.E. Asbury, L.R. Walker and R.B. Waide. 1995. Nitrogen immobilization by decomposing woody debris and the recovery of tropical wet forest from hurricane damage. Oikos 72:314-322.

APPENDIX A

Table A.1 C:N ratios of organic matter in soil and amendments

Organic substance	C:N ratio
Soil microorganisms	8:1
Soil organic matter	10:1
Wheat straw	130 to 150:1
Oat straw	48:1
Sawdust	400:1
Spruce	1000:1
Pine	286:1

Adapted from Tisdale et al. (1993) and Munshower (1994)

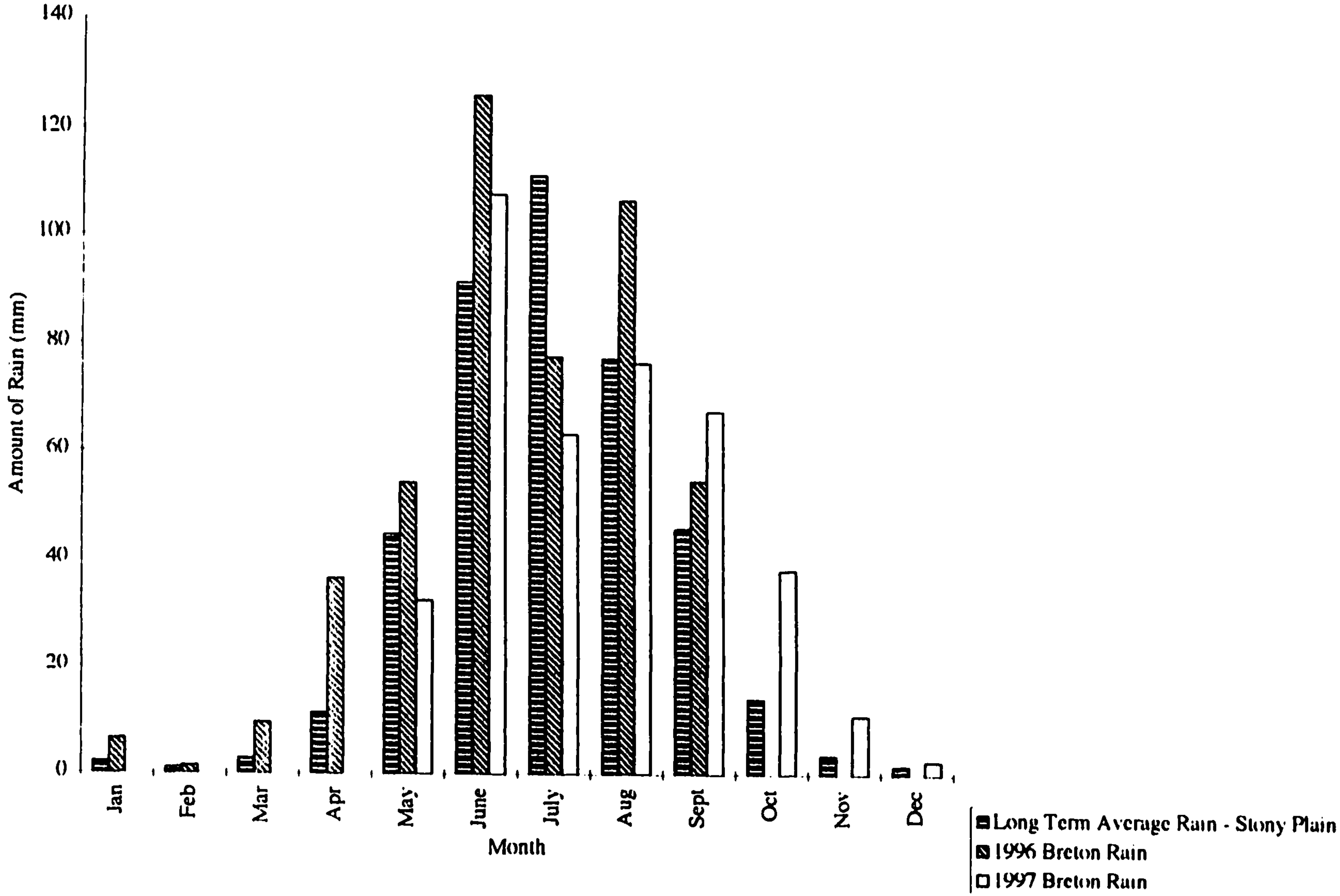


Figure A.1 Long term average of rainfall at Stony Plain and 1996 and 1997 rainfall at Breton

Table A.2 Soil parameters at Genesee in spring 1996

	0-15 cm		15-30 cm		30-60 cm	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
Clay (%)	29	2	28	1	24	5
Silt (%)	37	3	37	3	41	7
Sand (%)	34	2	35	3	35	4
Texture	clay loam		clay loam		loam	
pH	8.0		8.1			
EC (dS/m)	0.5		0.6			
SAR	1.7					
Total Carbon (%)	1.5		1.8		1.6	
Organic Carbon (%)	1.0		1.5		0.9	
Organic Matter (%)	1.8		2.5		1.6	
Nitrate (ppm)	<1		<1		<1	
Phosphate (ppm)	4.5		8.2			
Potassium (ppm)	110		89.8			
Sulfate (ppm)	>16.8		>20		>20	
Iron (ppm)	28.5					
Copper (ppm)	1.8					
Zinc (ppm)	1.1					
Boron (ppm)	1.8					
Manganese (ppm)	2.7					

Depth (cm)	Penetration Resistance (kPa)
2.5	573
5.0	893
7.5	943
10.0	934
12.5	1131
15.0	1442
17.5	1635
33.0	1769

Table A.3 Seeded species at Genesee and Ellerslie

Latin Name	Common Name
Agropyron smithii Rydb.	Western wheat grass (rhizomatous native grass)
Bromus inermis Leyss.	Smooth brome (rhizomatous introduced grass)
Phleum pratense L.	Timothy (tufted introduced grass)
Stipa viridula Trin.	Green needle grass (tufted native grass)
Trifolium hybridum L.	Alsike clover (introduced legume)
Vicia americana Muhl.	American vetch (native legume)

Species nomenclature according to Moss (1992)

Table A.4 Seed characteristics and proportion in monocultures and mixes

Species	Variety	Weight (gm)/1000 seeds	Germination (%)	Purity (%)	PLS	Seeds (weight of species (gm) / block)	
						Genesee (46.9 m²)	Ellerslie (20.1 m²)
Agropyron smithii monoculture							
	Walsh	4.12	88	98.7	0.92	63.1	27.0
Bromus inermis monoculture							
	Magna	3.73	91	95.8	0.87	60.8	26.1
Phleum pratense monoculture							
	Climax	0.48	97	99	0.96	7.0	3.0
Stipa viridula monoculture							
	n/a	1.77	90	98.9	0.89	28.0	12.0
Trifolium hybridum monoculture							
	Aurora	0.78	85	99	0.84	12.8	5.5
Vicia americana monoculture							
	n/a	12.57	50	93	0.46	380.0	162.9
Agropyron smithii in *Agropyron smithii / Bromus inermis* mix							
	Walsh	4.12	88	98.7	0.92	31.6	13.5
Bromus inermis in *Agropyron smithii / Bromus inermis* mix							
	Magna	3.73	91	95.8	0.87	30.4	13.0
Phleum pratense in *Phleum pratense / Stipa viridula* mix							
	Climax	0.48	97	99	0.96	3.5	1.5
Stipa viridula in *Phleum pratense / Stipa viridula* mix							
	n/a	1.77	90	98.9	0.89	14.4	6.0
Trifolium hybridum in *Trifolium hybridum /Vicia americana* mix							
	Aurora	0.78	85	99	0.84	6.4	2.8
Vicia americana in *Trifolium hybridum /Vicia americana* mix							
	n/a	12.57	50	93	0.46	190.4	81.4

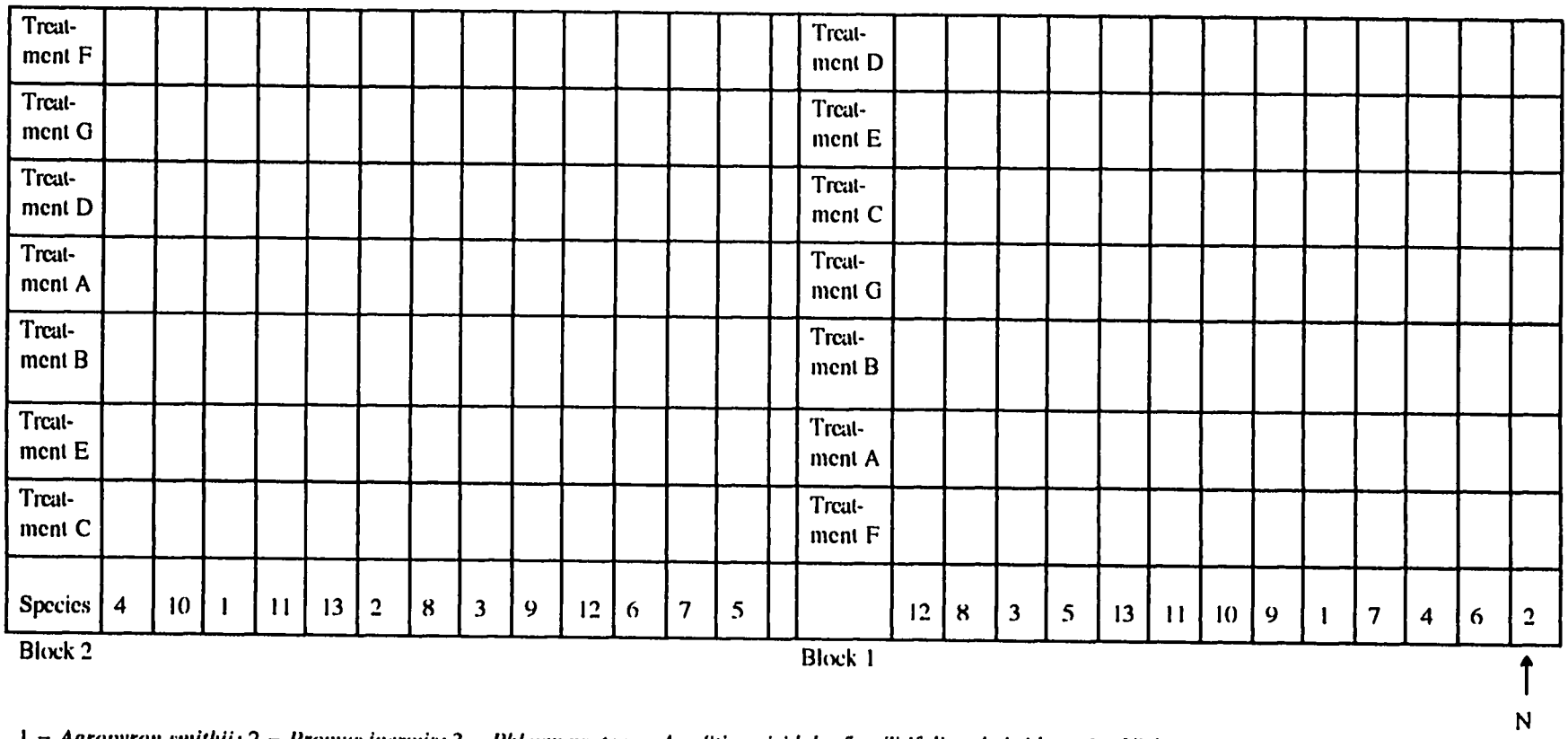
Table A.4 Seed characteristics and proportion in monocultures and mixes (continued)

Species	Variety	Weight (gm)/1000 seeds	Germination (%)	Purity (%)	PLS	Seeds (weight of species (gm) / block)	
						Genesee (46.9 m^2)	Ellerslie (20.1 m^2)
Agropyron smithii in *Agropyron smithii / Stipa viridula / Vicia americana* mix							
	Walsh	4.12	88	98.7	0.92	21.0	9.0
Stipa viridula in *Agropyron smithii / Stipa viridula / Vicia americana* mix							
	n/a	1.77	90	98.9	0.89	9.6	4.0
Vicia americana in *Agropyron smithii / Stipa viridula / Vicia americana* mix							
	n/a	12.57	50	93	0.46	126.4	54.3
Bromus inermis in *Bromus inermis / Phleum pratense / Trifolium hybridum* mix							
	Magna	3.73	91	95.8	0.87	20.0	8.7
Phleum pratense in *Bromus inermis / Phleum pratense / Trifolium hybridum* mix							
	Climax	0.48	97	99	0.96	2.3	1.0
Trifolium hybridum in *Bromus inermis / Phleum pratense / Trifolium hybridum* mix							
	Aurora	0.78	85	99	0.84	4.2	1.8
Agropyron smithii in *Agropyron smithii / Bromus inermis / Phleum pratense / Stipa viridula / Trifolium hybridum / Vicia americana* mix							
	Walsh	4.12	88	98.7	0.92	10.6	4.5
Bromus inermis in *Agropyron smithii / Bromus inermis / Phleum pratense / Stipa viridula / Trifolium hybridum / Vicia americana* mix							
	Magna	3.73	91	95.8	0.87	10.4	4.4
Phleum pratense in *Agropyron smithii / Bromus inermis / Phleum pratense / Stipa viridula / Trifolium hybridum / Vicia americana* mix							
	Climax	0.48	97	99	0.96	1.2	0.5
Stipa viridula in *Agropyron smithii / Bromus inermis / Phleum pratense / Stipa viridula / Trifolium hybridum / Vicia americana* mix							
	n/a	1.77	90	98.9	0.89	4.8	2.0
Trifolium hybridum in *Agropyron smithii / Bromus inermis / Phleum pratense / Stipa viridula / Trifolium hybridum / Vicia americana* mix							
	Aurora	0.78	85	99	0.84	2.16	0.9
Vicia americana in *Agropyron smithii / Bromus inermis / Phleum pratense / Stipa viridula / Trifolium hybridum / Vicia americana* mix							
	n/a	12.57	50	93	0.46	63.2	27.2

PLS = pure live seed (% germination * % purity)

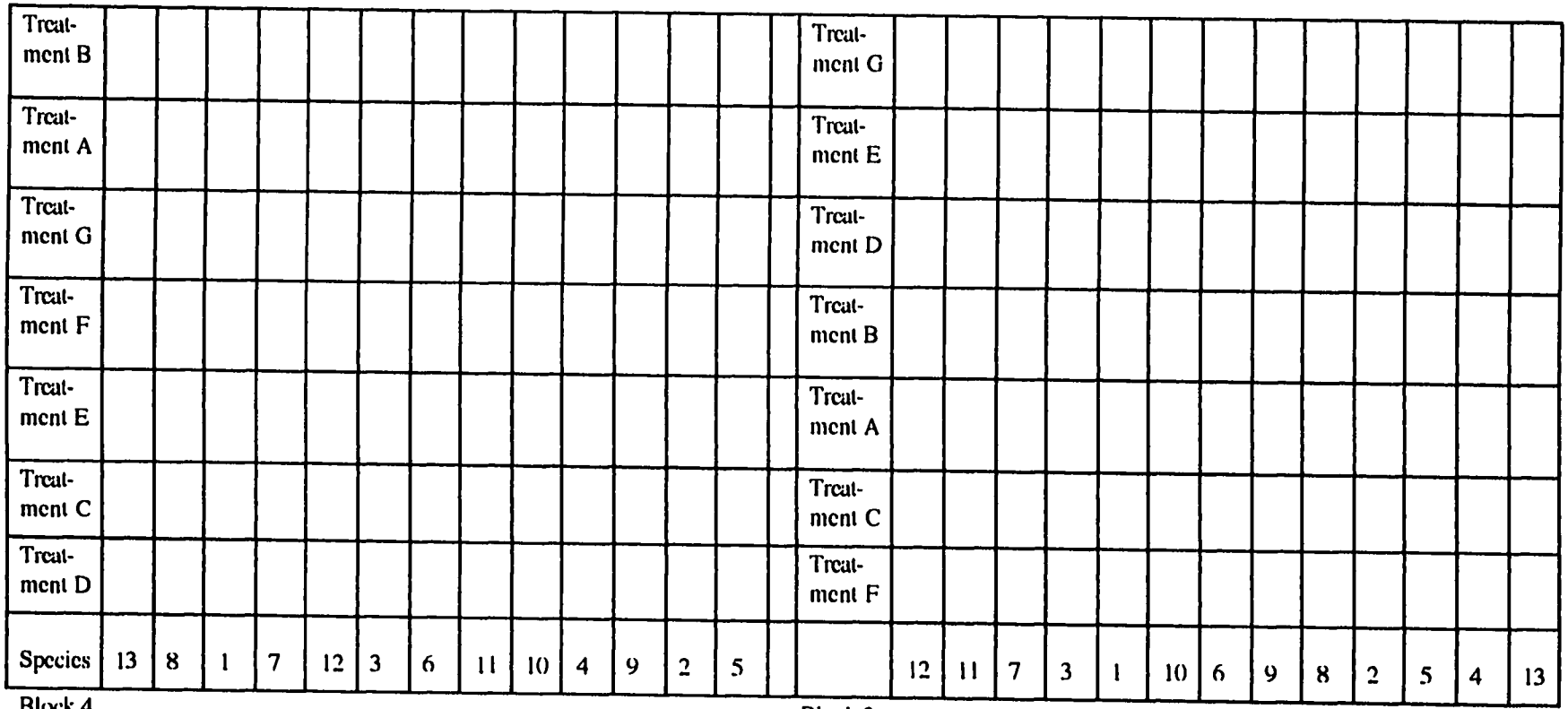
Table A.5 Amount of fertilizer added in each treatment at Genesee

	Slow release 41-0-0 (kg/87.1 m^2)	Regular release 16-19-16-0 (kg/87.1 m^2)	Regular release 7-34-24-0 (kg/87.1 m^2)
Treatment 1			
Year 1	0.9	0	1.5
Year 2	0	0	0
Treatment 2			
Year 1	1.8	0	3.0
Year 2	0	0	0
Treatment 3			
Year 1	0	2.3	0
Year 2	0	0	0
Treatment 4			
Year 1	0	4.7	0
Year 2	0	0	0
Treatment 5			
Year 1	0	2.3	0
Year 2	0	2.3	0
Treatment 6			
Year 1	0	4.7	0
Year 2	0	4.7	0
Treatment 7			
Year 1	0	0	0
Year 2	0	0	0



1 = *Agropyron smithii;* 2 = *Bromus inermis;* 3 = *Phleum pratense;* 4 = *Stipa viridula;* 5 = *Trifolium hybridum;* 6 = *Vicia americana;* 7 = *Agropyron smithii/Bromus inermis;* 8 = *Phleum pratense/Stipa viridula;* 9 = *Trifolium hybridum/Vicia americana;* 10 = *Agropyron smithii/Stipa viridula/Vicia americana;* 11 = *Bromus inermis/Phleum pratense/Trifolium hybridum;* 12 = All species; 13 = No seeded species
A = 50% slow release; B = 100% slow release; C = 50% regular (yr. 1); D = 100% regular (yr. 1); E = 50% regular (yr. 1&2); F = 100% regular (yr. 1&2); G = No fertilizer

Figure A.2 Layout of Genesee Plot - Blocks 1 and 2 (not to scale)



1 = *Agropyron smithii*; 2 = *Bromus inermis*; 3 = *Phleum pratense*; 4 = *Stipa viridula*; 5 = *Trifolium hybridum*; 6 = *Vicia americana*; 7 = *Agropyron smithii/Bromus inermis*; 8 = *Phleum pratense/Stipa viridula*; 9 = *Trifolium hybridum/Vicia americana*; 10 = *Agropyron smithii/Stipa viridula/Vicia americana*; 11 = *Bromus inermis/Phleum pratense/Trifolium hybridum*; 12 = All species; 13 = No seeded species
A = 50% slow release; B = 100% slow release; C = 50% regular (yr. 1); D = 100% regular (yr. 1); E = 50% regular (yr. 1&2); F = 100% regular (yr. 1&2); G = No fertilizer

Figure A.3 Layout of Genesee Plot - Blocks 3 and 4 (not to scale)

Table A.6 Soil parameters in Genesee treatments in 1997

Depth Interval (cm)	June 0-15	October	June 15-30	October	June 30-60
50% Slow release fertilizer (fertilized in year 1)					
Nitrate (ppm)	<1	1	<1	<1	<1
Phosphate (ppm)	2	4	5		
Potassium (ppm)	156	133	120		
Sulfate (ppm)	19	16	>20	>20	>20
pH	8.3	8.1	8.4	8.0	8.4
EC (dS/m)	0.5	0.4	0.5	0.5	0.5
Volumetric moisture content (%)					13.2
Bulk density (Mg m^{-3})					1.47
100% Slow release fertilizer (fertilized in year 1)					
Nitrate (ppm)	<1	<1	<1	<1	<1
Phosphate (ppm)	4	5	3		
Potassium (ppm)	140	154	112		
Sulfate (ppm)	11	20	>20	>20	>20
pH	8.3	9.3	8.3	9.3	9.1
EC (dS/m)	0.4	0.5	0.5	0.6	0.8
Volumetric moisture content (%)					10.8
Bulk density (Mg m^{-3})					1.47
50% Regular fertilizer (fertilized in year 1)					
Nitrate (ppm)	<1	<1	<1	<1	<1
Phosphate (ppm)	3	4	27		
Potassium (ppm)	142	160	93		
Sulfate (ppm)	8	10	>20	>20	>20
pH	8.2	8.2	8.3	9.3	8.4
EC (dS/m)	0.4	0.5	0.6	0.8	0.5
Volumetric moisture content (%)					13.6
Bulk density (Mg m^{-3})					1.38
100% Regular fertilizer (fertilized in year 1)					
Nitrate (ppm)	<1	<1	<1	<1	<1
Phosphate (ppm)	3	6	32		
Potassium (ppm)	162	136	90		
Sulfate (ppm)	14	12	>20	>20	>20
pH	8.2	8.2	9.4	8.2	9.5
EC (dS/m)	0.4	0.4	0.8	0.4	0.9
Volumetric moisture content (%)					12.3
Bulk density (Mg m^{-3})					1.48
50% Regular fertilizer (fertilized in year 1 and 2)					
Nitrate (ppm)	<1	<1	<1	<1	<1
Phosphate (ppm)	3	5	11		
Potassium (ppm)	145	156	112		
Sulfate (ppm)	>13	8	>20	>20	>20
pH	8.4	8.1	8.6	8.3	9.1
EC (dS/m)	0.4	0.4	0.6	0.5	0.6
Volumetric moisture content (%)					17.2
Bulk density (Mg m^{-3})					1.44

Table A.6 Soil parameters in Genesee treatments in 1997 (continued)

Depth Interval (cm)	June 0-15	October	June 15-30	October	June 30-60
100% Regular fertilizer (fertilized in year 1 and 2)					
Nitrate (ppm)	<1	<1	<1	<1	<1
Phosphate (ppm)	8	13	20		
Potassium (ppm)	158	201	99		
Sulfate (ppm)	8	5	>19	>20	>20
pH	8.3	8.0	8.6	8.8	9.1
EC (dS/m)	0.4	0.4	0.6	0.6	0.7
Volumetric moisture content (%)					12.0
Bulk density (Mg m^{-3})					1.40
No fertilizer added					
Nitrate (ppm)	<1	<1	<1	<1	<1
Phosphate (ppm)	3	3	2		
Potassium (ppm)	171	140	156		
Sulfate (ppm)	>20	10	>20	>20	>20
pH	8.2	8.2	8.1	7.9	8.7
EC (dS/m)	0.5	0.4	0.6	0.6	0.9
Volumetric moisture content (%)					10.2
Bulk density (Mg m^{-3})					1.45

Table A.7 Alphabetical listing of non-seeded species at Genesee in 1996 and 1997

Latin Name	Common Name
Artemisia absinthium L.	Wormwood; Absinthe
Brassica kaber (DC.) L.C. Wheeler	Wild mustard
Capsella bursa-pastoris (L.) Medic.	Shepherd's purse
Chenopodium album L.	Lamb's quarters
Cirsium arvense (L.) Scop.	Canada thistle
Crepis tectorum L.	Hawksbeard
Equisetum spp.	Horsetail
Erucastrum gallicum (Willd.) Schulz	Dog mustard
Fagopyrum tartaricum (L.) Gaertn.	Tartary buckwheat
Galeopsis tetrahit L.	Hemp nettle
Hordeum jubatum L.	Foxtail barley
Matricaria matricarioides (Less.) Porter	Pineapple weed
Matricaria perforata Merat	Scentless chamomile
Melilotus officinalis (L.) Lam.	Sweet clover
Medicago sativa L.	Alfalfa
Plantago major L.	Plantain
Polygonum amphibium L.	Smartweed
Polygonum arenastrum Jord. *ex* Bor.	Common knotweed
Senecio vulgaris L.	Common grounsel
Sonchus asper (L.) Hill	Sow thistle
Spergula arvensis L.	Corn spurry
Stellaria media (L.) Cyrill.	Common chickweed
Taraxacum officinale Weber	Common dandelion
Thlaspi arvense L.	Stinkweed
Trifolium pratense L.	Red clover
Trifolium repens L.	White clover

Species nomenclature according to Moss (1992)

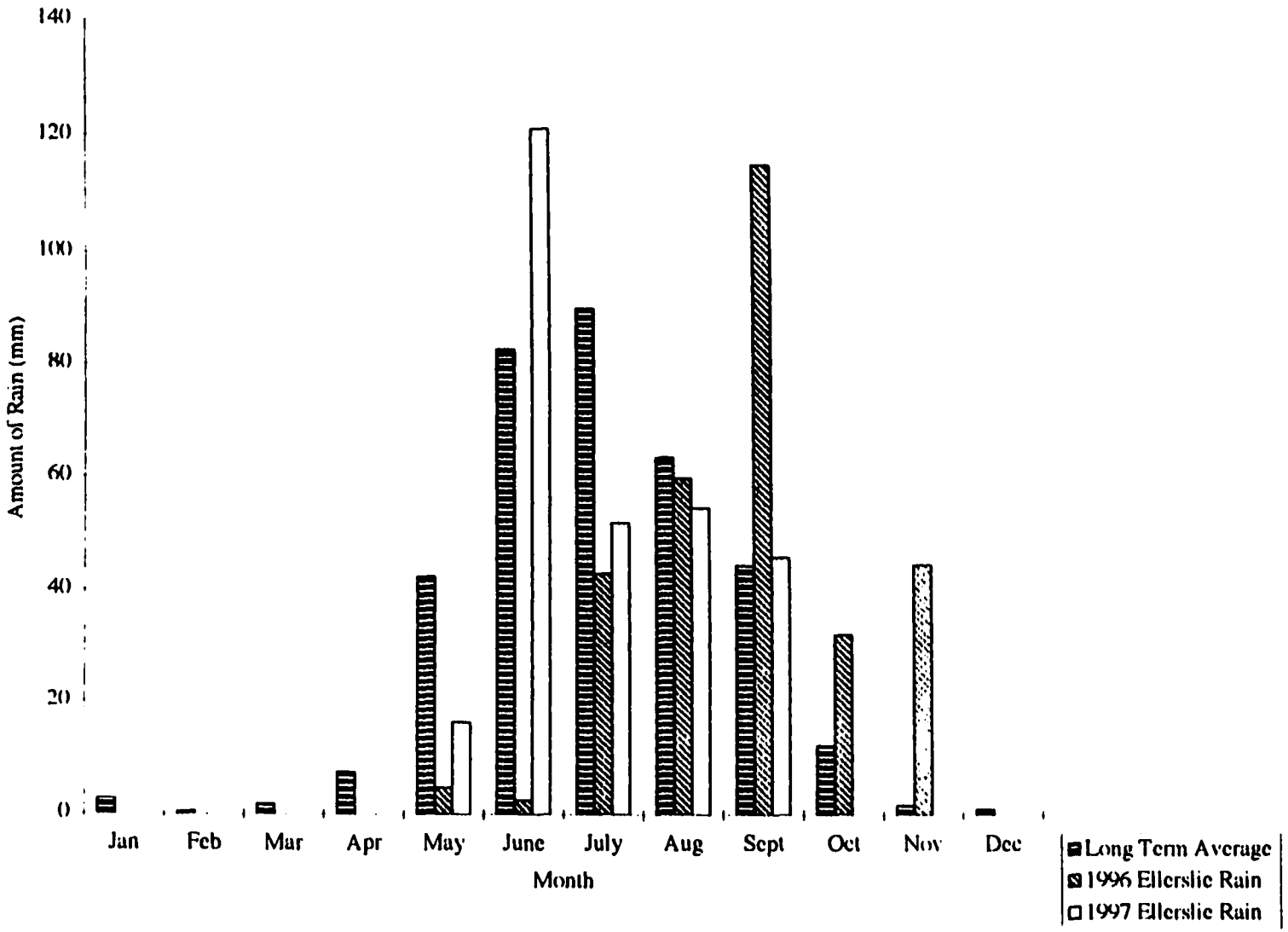


Figure A.4 Long term average and 1996 and 1997 rainfall at Ellerslie

Table A.8 Soil parameters at Ellerslie in spring 1996

	0-15 cm		15-30 cm		30-60 cm	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
Clay (%)	18	2	20	2	30	7
Silt (%)	53	1	52	3	41	8
Sand (%)	29	2	28	5	29	3
Texture	silt loam		silt loam		clay loam	
pH	6.0		6.2			
EC (dS/m)	0.4		0.4			
SAR	0.2					
Total Carbon (%)	5.7		4.2		2.2	
Organic Carbon (%)	5.7		4.3		2.1	
Organic Matter (%)	9.9		7.5		3.6	
Nitrate (ppm)	37		29		50	
Phosphate (ppm)	14		4			
Potassium (ppm)	143		57			
Sulfate (ppm)	13		13		15	
Iron (ppm)	117					
Copper (ppm)	0.4					
Zinc (ppm)	4.9					
Boron (ppm)	1.3					
Manganese (ppm)	10.8					

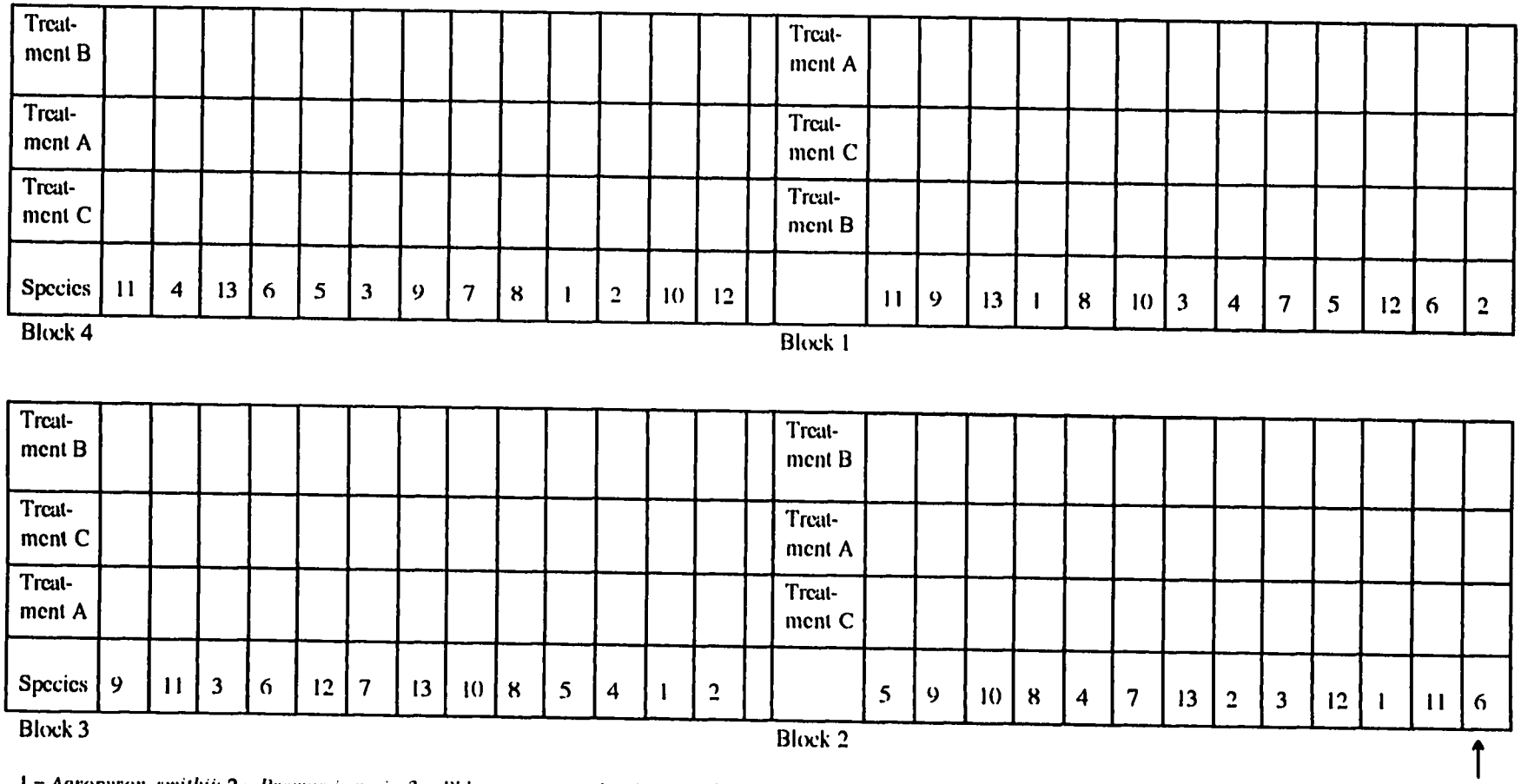
Depth (cm)	Penetration resistance (kPa)
2.5	907
5.0	1278
7.5	1414
10.0	1282
12.5	1436
15.0	1561
17.5	2053
33.0	2362

Table A.9 Amount of organic amendments added in each treatment at Ellerslie

	Straw (kg/87.1 m^2)	Sugar (kg/87.1 m^2)
Straw Treatment	102.9 kg	0
Sugar/Straw Treatment	102.9 kg	44.7 kg
No Amendments	0	0

Table A.10 Soil parameters in Ellerslie treatments in 1997

Depth Intervals (cm)	0-15	15-30	30-60
Amendment: Straw			
Nitrate (ppm)	2	<1	<2.5
Phosphate (ppm)	11.2	2.5	
Potassium (ppm)	170	128	
Sulfate (ppm)	8.2	7	10
pH	6.3	6.5	6.4
EC (dS/m)	0.2	0.2	0.2
Volumetric moisture content (%)			15.4
Bulk density (Mg m^{-3})			1.03
Amendment: Sugar / Straw			
Nitrate (ppm)	<1.5	<1.2	<1
Phosphate (ppm)	11.5	2.8	
Potassium (ppm)	158	111.8	
Sulfate (ppm)	7.2	7.8	8.8
pH	6.3	6.3	6.4
EC (dS/m)	0.2	0.2	0.2
Volumetric moisture content (%)			13.6
Bulk density (Mg m^{-3})			1.06
Amendment: None			
Nitrate (ppm)	1	<1.5	4.8
Phosphate (ppm)	10.5	2.8	
Potassium (ppm)	126	148	
Sulfate (ppm)	7	9	8.2
pH	6.1	6.3	6.3
EC (dS/m)	0.2	0.2	0.2
Volumetric moisture content (%)			14.3
Bulk density (Mg m^{-3})			1.15



1 = *Agropyron smithii*; 2 = *Bromus inermis*; 3 = *Phleum pratense*; 4 = *Stipa viridula*; 5 = *Trifolium hybridum*; 6 = *Vicia americana*; 7 = *Agropyron smithii/Bromus inermis*; 8 = *Phleum pratense/Stipa viridula*; 9 = *Trifolium hybridum/Vicia americana*; 10 = *Agropyron smithii/Stipa viridula/Vicia americana*; 11 = *Bromus inermis/Phleum pratense/Trifolium hybridum*; 12 = All species; 13 = No seeded species
A = Straw; B = Sugar/Straw; C = No Amendments

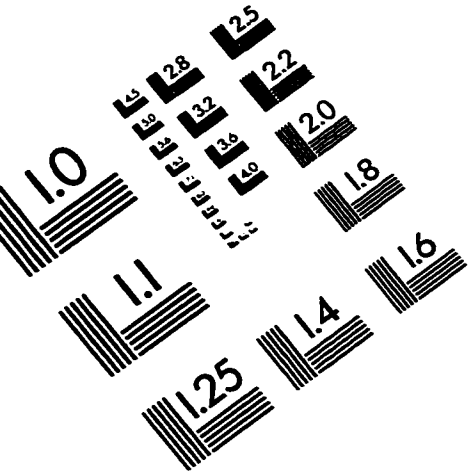
Figure A.5 Layout of Ellerslie Plots (not to scale)

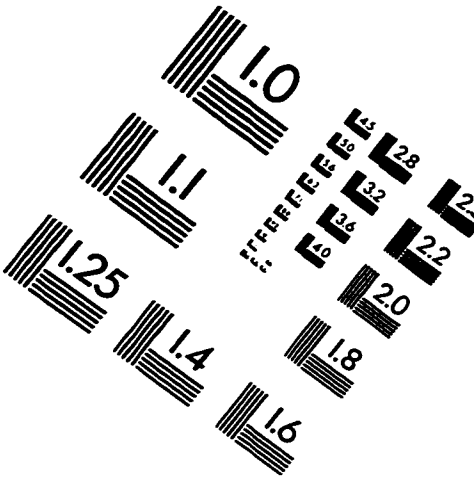
Table A.11 Alphabetical listing of non-seeded species at Ellerslie in 1996 and 1997

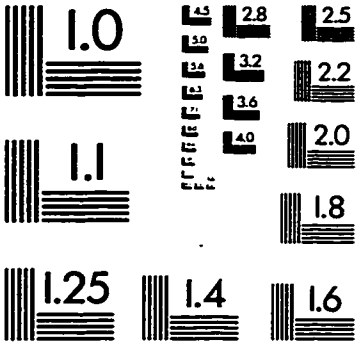
Latin Name	Common Name
Artemisia absinthium L.	Wormwood; Absinthe
Avena fatua L.	Wild oat
Avena sativa L.	Cultivated oat
Brassica kaber (DC.) L.C. Wheeler	Wild mustard
Capsella bursa-pastoris (L.) Medic.	Shepherd's purse
Chenopodium album L.	Lamb's quarters
Chenopodium salinum Standl.	Oak leaf goosefoot
Cirsium arvense (L.) Scop.	Canada thistle
Crepis tectorum L.	Hawksbeard
Descurainia sophia (L.) Webb	Flixweed
Echinochloa crusgalli (L.) Beauv.	Barnyard grass
Epilobium angustifolium L.	Fireweed
Equisetum spp.	Horsetail
Erucastrum gallicum (Willd.) Schultz	Dog mustard
Galeopsis tetrahit L.	Hemp nettle
Hordeum jubatum L.	Foxtail barley
Hordeum vulgare L.	Cultivated barley
Matricaria matricarioides (Less.) Porter	Pineapple weed
Matricaria perforata Merat	Scentless chamomile
Melilotus officinalis (L.) Lam.	Sweet clover
Poa compressa L.	Canada bluegrass
Poa pratensis L.	Kentucky bluegrass
Plantago major L.	Plantain
Polygonum amphibium L.	Smartweed
Polygonum arenastrum Jord. ex Bor.	Common knotweed
Polygonum convolvulus L.	Wild buckwheat
Senecio vulgaris L.	Common grounsel
Setaria viridis (L.) Beauv.	Green foxtail
Silene spp.	Cockle sp.
Sonchus asper (L.) Hill	Sow thistle
Spergula arvensis L.	Corn spurry
Stellaria media (L.) Cyrill.	Common chickweed
Taraxacum officinale Weber	Common dandelion
Thlaspi arvense L.	Stinkweed
Trifolium pratense L.	Red clover
Trifolium repens L.	White clover
Triticum aestivum L.	Cultivated wheat

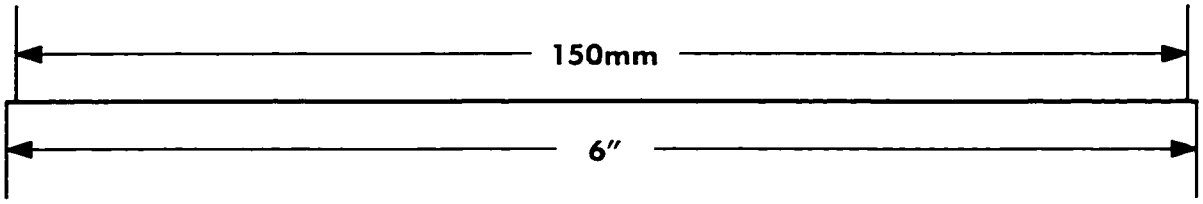
Species nomenclature according to Moss (1992)

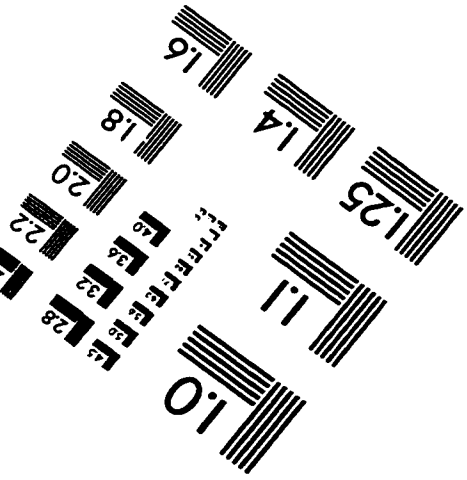
IMAGE EVALUATION
TEST TARGET (QA-3)

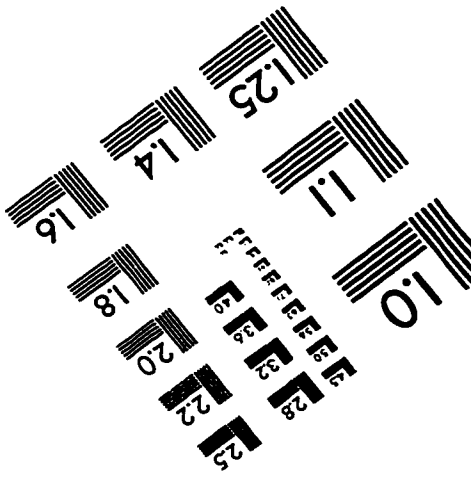












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