INFLUENCE OF COVER TYPE AND SOIL TYPE ON UNDERSTORY PLANT BIOMASS AND COMPOSITION IN THE VIRGINIA DISTRICT OF THE SUPERIOR NATIONAL FOREST

by

Dennis L. Blinkhorn

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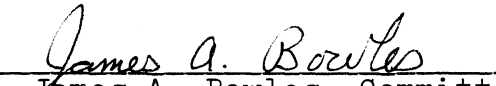

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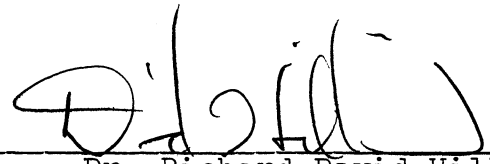
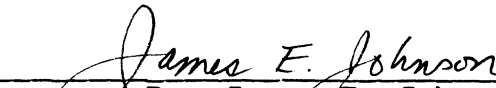
Professor of Range and Soil Science



Dr. Richard David Hillier
Associate Professor of Biology



Dr. James E. Johnson
Associate Professor of Forestry

ABSTRACT

The herbaceous and shrub vegetation of four cover types on the Virginia District of the Superior National Forest, St. Louis County, Minnesota, were investigated during July and August 1982. The cover types selected and their Forest Service identification numbers were: young quaking aspen (91-3), young jack pine (01-2), sedge meadow (263) and upland opening (251). Four stands of each cover type were examined. The major objectives of this study were: (1) the development of compositional and biomass data for the cover types and stands studied; (2) an examination of the variation in biomass production between cover types, between stands of the same cover type and within individual stands; (3) the determination of the forage value of the species found. The results provide additional compositional data for the cover types and will help support sound range management decisions while establishing a data base for the long-term evaluation of recently established grazing programs.

Substantial quantities of herbaceous and shrub biomass are produced by the cover types and stands examined. Significant compositional and biomass variation exists between cover types and between stands of the same cover type.

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INTRODUCTION

The plant communities of the northern Lake States have attracted much scientific interest. For many years, Curtis and his students studied these communities and assimilated detailed compositional data which are now available at the Plant Ecology Lab at the University of Wisconsin - Madison. Curtis compiled much of this data in The Vegetation of Wisconsin (1959) and also published much of it in individual papers. Bakuzis and his associates provided data on northern forest indicator species (Bakuzis and Hansen, 1960) as part of their extensive efforts to identify the synecological coordinates of northern plant species.

Detailed information on understory biomass production in northern plant communities is largely lacking. Many authors have reported understory biomass values, but only in general terms as part of a study of total aboveground biomass. There are, however, several authors who closely examined understory biomass production. Ohmann and Grigal (1977) examined four burn areas in Minnesota and reported average individual weights for a number of species. Ground vegetation biomass in four Wisconsin communities was reported by Zavitkovski (1976), who also noted that biomass production within a community may vary significantly from year to year.

A number of unpublished surveys have provided general information on the herbaceous biomass production of numerous northern cover types. One such survey was completed by Lounsbury and Hanowski (1979) on the Superior National

Forest. Bowles et al. (1979a, 1979b) completed surveys for the Nicolet and Chequamegon National Forests. Bowles (1980) compiled additional herbaceous biomass data for the Virginia District of the Superior National Forest.

Much recent work has focused on the development of methods for estimating the biomass of understory plants. Grigal and Ohmann (1977) and Ohmann et al. (1976) presented equations which might be used to predict the biomass value of a number of shrubs in northeast Minnesota. Estimates of the biomass of four common understory shrubs were given by Crow (1978) for several northern Wisconsin communities. Roussopoulos and Loomis (1979) also presented methods for estimating shrub biomass for northeast Minnesota. A method for estimating understory biomass based on observations of ground cover was presented for 31 Minnesota species (Ohmann et al., 1981).

Cattle have, for many years, grazed and flourished in the pine forests of Florida, Georgia and other southern states (Grelen, 1978). Grazing cattle on forest lands is also a common practice in the west. In the United States, range lands currently provide 64% of the feed consumed by beef cattle. Forest Service projections for the next 50 years show the demand for range land increasing as consumer demand for beef grows (U.S. Forest Service, 1981).

To help meet this increasing demand the Forest Service, in 1975, decided to place greater emphasis on the use of the Lake States' national forests as range land (U.S. Forest

Service, 1975). Previously mentioned studies by Rowles and his associates were undertaken as a result of this decision and were designed to provide baseline data on grazing potential.

The purpose of this work is to examine the aboveground herbaceous biomass and the twig and leaf biomass of the shrub components of four common cover types in northeast Minnesota. The variation in biomass production between cover types, between stands of the same cover type and within individual stands is also examined. Additionally, forage ratings are supplied for some species.

MATERIALS AND METHODS

Research Area

The project was carried out on the Virginia District of the Superior National Forest, St. Louis County, Minnesota, during July and August 1982. The climate at this latitude is one of moderate summer temperatures and cold winters (NOAA, 1976). The average annual temperature at Virginia for 1982 was 36° F, about 3° F below normal. The average monthly temperature for May through August 1982 was also slightly below normal at 59° F. Annual precipitation in 1982 was about normal at 31" while precipitation for May through August was about 3" greater than normal (NOAA, 1983).

A cover type is a descriptive land classification unit based on vegetation. The four cover types chosen for this study and their Forest Service identification numbers were

young quaking aspen (91-3), young jack pine (01-2), sedge meadow (263), and upland opening (251). This sedge meadow cover type was a local addition to the Forest Service classification system, having been developed for recent work on Lake States' forests. These cover types were selected because they were believed to offer substantial potential for grazing based on the results of various range surveys and on the number of acres they cover.

The aspen cover type can be found on a wide variety of soil types and occurs most frequently as a pioneer cover type on burns and clearcut areas (Eyre, 1980). In stands of the aspen cover type, quaking aspen (Populus tremuloides) is the predominant species. (Scientific and common names of species mentioned in the text are listed in Table 9, Appendix A). In the Forest Service cover type identification number 91-3, the 3 represents the size-density class and indicates that the quaking aspen are seedling to sapling in size and the stands are over 70% stocked. Associated shrub species include beaked hazel (Corylus cornuta), American hazel (Corylus americana), bushhoneysuckle (Diervilla lonicera), and bramble (Rubus spp.). Wild sarsaparilla (Aralia nudicaulis), large-leaved aster (Aster macrophyllus), Clintonia (Clintonia borealis), common strawberry, (Fragaria virginiana) and roughleaf ricegrass (Oryzopsis asperifolia) are also commonly associated species. In the stands studied, basal areas ranged from 55 sq.ft./acre to 145 sq. ft. acre.

The pine cover type often originates after forest fires and exists largely as a temporary cover type although it may become more permanent on dry outwash sands (Eyre, 1980). In this cover type, jack pine (Pinus banksiana) is the predominant species. The Forest Service size-density rating of 2 indicates that in these stands the jack pine are seedling to sapling in size and the stands are 40-69% stocked. Other tree species such as red pine (Pinus resinosa) and quaking aspen are sometimes found. Common shrubs include bearberry (Arctostaphylos uva-ursi), currant (Ribes spp.), bushhoneysuckle, and blueberry (Vaccinium spp.). Other commonly found species include common strawberry, bracken fern (Pteridium aquilinum), goldenrod (Solidago spp.), roughleaf ricegrass, and large-leaved aster. These stands are generally found on gently rolling sand plains of glacial outwash, fluvial, or lacustrine origin (Fowells, 1965). In the stands studied, the jack pine were 8 to 15 years of age and mixed with a number of red pine of the same age. The stands were undergoing natural regeneration.

Stands of the sedge meadow cover type are normally found in shallow depressions and along streams. Soils are heavy and are saturated for portions of the growing season. Standing water may be present for relatively brief periods. The sedge meadow cover type is composed largely of herbaceous species, although shrubs may be significant components. This wetland community is characterized by

various sedges (Carex spp.), bluejoint reedgrass (Calamagrostis canadensis), reed canary grass (Phalaris arundinacea), and purple-stemmed aster (Aster puniceus). Speckled alder (Alnus rugosa), meadow willow (Salix gracilis), sandbar willow (Salix interior), and meadow sweet (Spiraea alba) are commonly associated shrubs. Several of the goldenrods, common strawberry, and large-leaved aster are frequently found in the transition areas between this and adjacent cover types.

Stands of the upland opening cover type are found on level to gently rolling sites. Soils are heavy, although not excessively so. Stand origins can be directly attributed to disturbance by man in that sites were formerly maintained in an open condition for such uses as homesteads, pastures, and logging camps (Levy, 1970). Grasses and forbs dominate stands of this cover type. Timothy (Phleum pratense), Kentucky bluegrass (Poa pratensis), poverty oatgrass (Danthonia spicata), and Poa saltuensis are major grass components. Common strawberry, intermediate dogbane (Apocynum medium), fleabane (Erigeron philadelphicus), yarrow (Achillea millefolium), and trailing bramble are also common components. Woody components are few and limited to low shrubs such as upright bramble and prickly rose (Rosa acicularis).

Sampling Procedure

Using Forest Service maps, four relatively easily accessible stands of each cover type were selected (Appendix

B). Each stand was visibly examined to assure that it was representative of the cover type and also to assure that there was no indication of unrepresentative levels of disturbance.

In each stand a point was randomly selected. From this point, a transect consisting of five randomly selected points was initiated along a randomly determined bearing. Around each of these five points, five circular, 9.6 sq. ft. plots were located at random distances along random bearings. This plot size is commonly used in vegetation sampling since it permits for easy conversion between the English and metric systems. This relatively large plot size also permitted more accurate measurement of shrub biomass (Mueggler, 1976; Van Dyne et al., 1963). The use of 25 plots per stand assured a reasonably accurate assessment of within-stand variation (Mueggler, 1976; Campbell and Cassady, 1949).

Within each plot all herbaceous vegetation was clipped at a height of 1/2 inch, separated by species, and bagged. Due to the problems involved in identifying individual species of the genus Carex, members of the genus were grouped into the following four categories:

Carex spp.* - thin, upright lowland sedges of intermediate size; ex., Carex folliculata and Carex intumescens

Carex spp.** - filiform upland sedges; ex., Pennsylvania sedge (Carex pensylvanica)

Carex spp.*** - intermediate grasslike sedges of

upland waste areas; ex., Carex cristatella and Carex prasina

Carex spp.**** - large lowland sedges; ex., Carex stipata.

In this study, ferns, scouring rush (Equisetum spp.), clubmoss (Lycopodium spp.), sweet fern (Comptonia peregrina) and trailing brambles were treated as herbaceous species.

If shrubs or tree seedlings occurred in the plot, all of the current and previous years' twig growth and leaf growth between the surface and a height of five feet were clipped and bagged. These limitations were imposed to restrict sampling to those portions of woody species most likely to be browsed by cattle.

In each stand, a site was randomly selected and the soil profile was examined using a soil auger. The profile was then described using standard terminology (Soil Survey Staff, 1981).

Basal areas for aspen and pine stands were taken with a 10-factor prism.

All clipped vegetation was transported to the University of Wisconsin-Stevens Point where it was dried in ovens at 62° C until a constant weight was reached. Samples were then cooled and weighed.

Data Analysis

One-way analyses of variance and 95% confidence interval data were generated to analyze the variation in biomass production between cover types, between stands of similar cover type, and within each stand.

The fidelity of a species is a measure of the degree to which the species is confined to a particular cover type. Constancy is a measure of the distribution of a species across the separate stands of a given cover type (Curtis, 1959). In this study, fidelity values were determined by counting the number of cover types in which a species occurred. Species found in one cover type were assigned a fidelity value of 3. Species found in 2, 3, or 4 cover types were given fidelity values of 2, 1, and 0, respectively. Constancy values were determined by dividing the total number of transect points within a cover type at which a species was found by 20, the total number of transect points in each cover type. These values were then multiplied by 100.

The degree of similarity between stands of the same cover type was examined using the similarity index as outlined by Bray and Curtis (1957) and used by Beals (1960), Levy (1970), and many others. The similarity indices were determined as follows:

$$SI = \frac{2W}{a+b} \times 100$$

where

a= the sum of individual species' biomass values for a stand;
b= the sum of individual species' biomass values in a second stand;
W= the sum of the lesser of the two biomass values for species which were found in both stands.

RESULTS AND DISCUSSION

Cover Type Composition

Aspen

Possibly the most important herbaceous species in the aspen cover type was large-leaved aster. This species produced quantities of biomass ranging from 44 kg/ha in stand 4 to 273 kg/ha in stand 1. These numbers represent 4% of the total understory production in stand 4 and 29% in stand 1. The average production of this species was 14%. Biomass data for individuial species are presented in Table 10, Appendix C.

Other important understory producers were trailing bramble, which averaged 36 kg/ha, and Clintonia, which averaged 18 kg/ha. Ground cedar (Lycopodium complanatum) was found in three stands and averaged 18 kg/ha over the cover type. Bunchberry (Cornus canadensis) was also commonly found.

Sedges were important components of this cover type. The species of sedges found in the aspen cover type were typically filiform in appearance and were found on upland sites (Carex spp.**). Pennsylvania sedge is an example of this group, the production of which ranged from 14 kg/ha to 57 kg/ha in this cover type.

Lesser amounts of rough bedstraw (Galium asprellum) and wild lily-of-the-valley (Maianthemum canadense) were commonly found. The importance of bracken fern in this cover type varied greatly. While this species was absent

from stand 4, it produced 96 kg/ha in stand 2 and averaged 40 kg/ha across the cover type.

Of the grasses, roughleaf ricegrass was the most significant. Found in all stands, it contributed as much as 80 kg/ha with an average production of 58 kg/ha. Lesser amounts of bearded wheatgrass (Agropyron subsecundum) were found in all stands of this cover type and limited amounts of fringed brome (Bromus ciliatus) occurred in two stands.

Substantial portions of shrub biomass were collected in this cover type. Shrub biomass as a percent of total biomass varied greatly between stands and averaged 51%.

Of the woody species, American hazel and beaked hazel were the most important. The combined biomass values of these species ranged from 26% to 62% of total understory production. Bushhoneysuckle, although not found in large quantities, was found in all aspen stands. Scattered patches of upright bramble contributed significant quantities of biomass in stands 3 and 4. Fourteen other woody species, the most important of which were serviceberry (Amelanchier spp.) and currant, were also found in this cover type.

While a certain amount of compositional variation occurs between stands of any given cover type, the aspen cover type produced several notable variations. Bluejoint reedgrass, while totally lacking in other aspen stands, contributed 99 kg/ha of biomass in stand 4. Sixty-nine kg/ha of goldenrod were found in stand 4, while the species

was absent or very sparse in other stands. Variations in the quantities of shield fern (Dryopteris intermedia) and large-leaved aster were also notable.

The soils of the aspen cover type had surface horizons of sandy loam or loamy sand texture. Lower horizons were sandy in texture, except for the B and BC horizons of stand 1, which were a sandy loam and silty clay, respectively.

A wide range of pH values were recorded for the various horizons of stands 1, 2, and 3. The pH values for the horizons of stand 1 ranged from 5.5 to 8.0, while those of stand 2 ranged from 5.5 to 6.0. The pH values of the horizons of stand 3 ranged from 4.5 to 5.5.

The soil of stand 4 was different in that, with the exception of the A horizon, all horizons were sandy clay in texture. The pH values ranged from 4.5 to 5.5.

Individual profiles are described in Appendix D.

Pine

These stands are similar to the Myrica asperifolia - Vaccinium angustifolia openings of Levy (1970). They are also similar to the bracken grasslands of Curtis (1959), although somewhat more open.

In this cover type, four species consistently produced most of the non-grass herbaceous biomass. These species, common strawberry, bracken fern, goldenrod, and Carex spp.**, collectively contributed 179, 201, 74, and 248 kg/ha in stands 5, 6, 7, and 8, respectively. These figures represent 21%, 29%, 34%, and 45% of the total herbaceous

production of these stands.

Of these four, the sedge group Carex spp.** had the greatest average production, 68 kg/ha, followed by goldenrod, which averaged 50 kg/ha and common strawberry, which averaged 34 kg/ha. Bracken fern was collected from only three stands, resulting in a somewhat low average production of 24 kg/ha.

Roughleaf ricegrass was found to be an important component of this cover type. Found in all stands, its average production of 118 kg/ha was exceeded by that of only one other herbaceous species, sweet fern, which had exceptionally high production in stands 5 and 6 and was absent from stands 7 and 8. Small quantities of poverty oatgrass and Oryzopsis pungens were found in this cover type. Several species of panic grass (Panicum spp.) also produced small quantities of biomass.

Woody production was very important in this cover type. Woody production was found to contribute between 45 and 83% of the total stand biomass production, averaging 61%.

Blueberry was the most important woody contributor, with a variable biomass production ranging from 283 to 917 kg/ha. Although bearberry was absent from stand 7, it contributed 100 kg/ha in stand 8. Serviceberry and upright bramble also were found to have variable production. Quaking aspen was found in three stands and had an average production of 48 kg/ha.

The soils of this cover type varied little. Upper

horizons were sandy loams or loamy sands. Fine sands and medium sands were found at depths beginning at 14 to 22 cm. Coarse sand and gravel were commonly found in the C horizons. In all stands, an E horizon and a Bhs horizon were present. The horizons of stands 5, 6, and 7 had pH values ranging from 4.5 to 6.0. All horizons of stand 8 had a pH value of 6.0.

Sedge Meadow

These stands are similar to the tussock meadows examined by Costello (1936) and the northern sedge meadows of Curtis (1959), although somewhat drier.

The herbaceous biomass of this cover type consisted largely of bluejoint reedgrass, goldenrod, and two groups of sedges, Carex spp.* and Carex spp.****. These two Carex groups along with goldenrod and bluejoint reedgrass contributed 65%, 90%, 45% and 86% of the herbaceous vegetation in stands 9, 10, 11 and 12, respectively. Bluejoint reedgrass had the highest average production, 607 kg/ha, followed closely by the group Carex spp.****, which averaged 579 kg/ha. The average production of goldenrod was 215 kg/ha.

In addition to the species listed above, common strawberry was sometimes found in substantial quantities. Purple-stemmed aster and trailing bramble, although not found in all stands, were important components of this cover type.

Woody vegetation was not as important in this cover

type as it was in the aspen and pine cover types. An average of only 15% of the total stand production was woody.

Meadow sweet was a fairly consistent contributor, averaging 85 kg/ha, while upright bramble exhibited a wide range of production and averaged 86 kg/ha. Each of these figures represents 23% of the average woody production for stands of this cover type. Meadow willow, although found in only three of the sampled stands, averaged 69 kg/ha, reaching a high of 137 kg/ha in stand 12. Speckled alder, prickly rose, and sandbar willow were found to be biomass contributors of some significance.

Reed canary grass contributed an exceptional amount of biomass (869 kg/ha) to stand 11 but was lacking or very sparse in the other stands of this cover type.

Soils of the sedge meadow cover type were found to have poorly developed profiles. Silty clay was the dominant texture. This texture was found throughout the different profiles except in stand 12, where lower horizons exhibited a clay texture. Gleying was frequently found near the surface, indicating that the soils are often saturated. Mottles were also commonly found. A wide range of pH values were recorded. The A horizon pH values ranged from 4.5 to 7.0, while values of 4.5 to 8.0 were recorded for the B horizons. The range of values in the C horizons was from 5.5 to 8.5.

Upland Opening

These stands are similar to the Agropyron - Poa

community of Levy (1970) and the weed community of northern heavy soils of Curtis (1959).

Grasses and graminoids were the major biomass contributors in this cover type. While timothy was normally the most abundant grass, it was not found in stand 16. This species averaged 413 kg/ha over the remaining stands of this cover type. Of the bluegrasses, Kentucky bluegrass was most abundant, although its production was found to be somewhat erratic, ranging from 1 to 36 kg/ha. Moderate amounts of Canada bluegrass (Poa compressa) and Poa saltuensis were found in three of the four stands. Poa Chaixii, fowl meadow-grass (Poa palustris) and Poa wolfii were occasionally collected.

Several other species exhibited irregular production. Moderate amounts of poverty oatgrass were collected in stands 14 and 16 but the species was found to be essentially absent from stands 13 and 15.

Fifty-eight kg/ha of quack grass (Agropyron repens) were collected in stand 14, the only stand in which it was found. Limited amounts of purple bentgrass (Agrostis stolonifera), fringed brome, and roughleaf ricegrass were occasionally collected in this cover type.

The genus Carex was an important biomass contributor in the upland opening cover type. Three groups of this genus were collected. The group Carex spp.** was extremely important, having an average production of 351 kg/ha across the four stands. The group Carex spp.**** was found in

limited to moderate amounts, reaching a high of 51 kg/ha in stand 14. The group Carex spp.*** was also found in limited to moderate quantities.

A number of forbs were also significant biomass contributors. Of these, common strawberry and goldenrod were the most important and averaged 165 and 103 kg/ha, respectively. Combined, these species contributed 5% of the total production in stand 13, 22% in stand 14, 23% in stand 15 and 19% in stand 16.

Red clover (Trifolium pratense) was collected in all stands of this cover type, its production ranging from 4 to 88 kg/ha. Intermediate dogbane, also present in all stands, ranged in production from 1 to 90 kg/ha and averaged 33 kg/ha. Large-leaved aster was present in all stands, averaging 11 kg/ha. Several fleabanes and wild peas (Lathyrus spp.) were occasionally found to be significant in this cover type.

Of the four cover types examined, the upland opening cover type had the least woody production. The woody production ranged from 15 kg/ha in stand 13 to 209 kg/ha in stand 16 and averaged 96 kg/ha, which represents only 6% of the average upland opening production.

Prickly rose and upright bramble were the only woody species found to occur with any regularity. Upright bramble values ranged from 15 to 96 kg/ha, averaging 40 kg/ha. Prickly rose was collected in only three stands and averaged 48 kg/ha across those stands. These species contributed

100% of the woody biomass in stand 13, 99% in stand 14 and 98% in stand 15.

Stand 16 was somewhat different as 10 woody species were collected. In addition to prickly rose and upright bramble, American hazel, quaking aspen, and beaked willow (Salix bebbiana) contributed significant quantities of biomass.

Notable variations in this cover type included the 65 kg/ha of bluejoint reedgrass collected in stand 14 and the 469 kg/ha of reed canary grass collected in stand 15.

The soils of stands 13, 14, and 15 had upper horizons of silty clays and clay loams. While fine textures were found throughout the profile of stand 15, the lower horizons of stands 13 and 14 were coarser in texture and consisted of sandy clay loams or sand. The A and B horizons were found to have pH values ranging from 5.5 to 6.5. Values for the C horizons of stands 14 and 15 were higher at 8.0, while the value of the C horizon in stand 13 was 5.5.

The soil of stand 16 was quite different from the soils of the other upland opening stands. Textures ranged from loamy sand to sand. An E horizon was present as was a Bhs horizon. There was little variation in pH as values ranging from 5.5 to 6.5 were recorded.

Constancy and Fidelity

While the constancy and fidelity data generated by this study provide valuable insight into the cover types examined, it should be remembered that they are the result

of relatively limited sampling.

The more important shrubs of the aspen cover type had moderate constancy values and moderate or low fidelity values (Table 11, Appendix E). Constancy and fidelity values for the more important herbaceous components of the cover type were similar.

There were several species in the aspen cover type with particularly interesting constancy and fidelity values. Clintonia had a constancy of 95 in this cover type and a fidelity value of 3, indicating that it was widespread in this cover type and found only in this cover type. Wild sarsaparilla and twisted stalk (Streptopus roseus) were widely distributed across this cover type, having constancy values of 90 and 70, respectively. These species were collected at only one other point in one other cover type.

As was the case in the aspen cover type, in the pine cover type the species which contributed significant quantities of biomass were also the species which were widely distributed across the cover type. Blueberry, Carex spp.**, common strawberry, goldenrod, large-leaved aster, and upright bramble all had constancy values of 100 in this cover type, while roughleaf ricegrass and violet (Viola spp.) had constancy values of 85. These species were found in a number of cover types, as indicated by their low fidelity values.

In the pine cover type the constancy and fidelity values of two species were notable. Wintergreen (Gaultheria

procumbens) had a constancy of 65 and a fidelity of 3, while hedge-hyssop (Gratiola neglecta) had a constancy of 60 and a fidelity of 3. These values indicate that these species were moderately well distributed across the various stands of the pine cover type and were found only in this cover type.

In the sedge meadow cover type only three species, bluejoint reedgrass, goldenrod, and Carex spp.****, were found to have constancy values of 90 or greater. These same species were also the most significant biomass contributors. When these facts are considered along with the large number of low constancy values recorded for other species, this cover type is seen to be one consisting largely of patches of the above mentioned species.

Few of the more important biomass contributors in the upland opening cover type had high constancy values. Of the species collected, common strawberry, Carex spp.**, large-leaved aster, upright bramble, and goldenrod had the higher constancy values. These species also had relatively low fidelity values, indicating that they were found in various cover types.

Total Herbaceous, Twig, and Leaf Biomass Production

Biomass production data for the cover types and stands examined are shown in Table 1. The relative importance of the woody and herbaceous material to each stand can readily be seen, as can ranges of production.

The sedge meadow cover type had the greatest average biomass

yield, 2386 kg/ha, followed in order by the upland opening, pine, and aspen cover types. The lower biomass values for the forested cover types reflect the influence of overstory, i.e., increased competition for light, water, and nutrients (Jameson, 1967). It should also be noted that the forested cover types occurred on more coarsely textured soils than the non-forested cover types.

Table 1. Herbaceous, woody, and total biomass production for four cover types in northern Minnesota.

Cover type	Stand	Herbaceous Biomass	Woody Biomass	Total Biomass
		kg/ha		
Aspen	1	605	323	930
	2	608	508	1116
	3	492	1018	1511
	4	577	691	1269
Pine	5	840	917	1757
	6	700	582	1282
	7	216	1044	1261
	8	549	977	1526
Sedge Meadow	9	1327	252	1580
	10	2760	533	3293
	11	2063	370	2433
	12	1920	316	2236
Upland Opening	13	1444	15	1459
	14	1509	83	1592
	15	1829	76	1905
	16	899	209	1108

Biomass Variation Between Cover Types

Total biomass production varied significantly (5% level) between the cover types (Table 12, Appendix F). Further analysis with Duncan's Multiple Range Test indicated that the total biomass production of the sedge meadow cover type was significantly greater than that of the other cover types (Table 2). Total biomass production did not vary

significantly between the other three cover types.

Table 2. Mean herbaceous, woody, and total biomass production and standard deviations for four cover types in northern Minnesota.

Cover Type	Herbaceous Biomass $\bar{x}$		SD	Woody Biomass $\bar{x}$		SD	Total Biomass $\bar{x}$		SD
	kg/ha								
Aspen	571	c*	54	635	b	296	1207	b	245
Pine	577	c	267	880	a	205	1457	b	233
Sedge Meadow	2018	a	588	368	c	120	2386	a	706
Upland Opening	1421	b	386	96	d	81	1517	b	330

*Numbers in columns followed by the same letter are not significantly different at the 0.05 level.

Table 2 also shows the significance of variation in the herbaceous and woody components of the cover types. Herbaceous biomass production was significantly greater in the sedge meadow cover type than in the upland opening cover type. Herbaceous biomass production was significantly greater in the upland opening cover type than in either the aspen or pine cover type. Woody biomass production varied significantly between all cover types.

Biomass Variation Between Stands of the Same Cover Type

Biomass production did not vary significantly between the aspen stands. The relatively low biomass production of stand 1 was probably the result of a greater basal area, 145

sq. ft./acre, and the resultant impact on understory growth (Jameson, 1967). The basal area of stands 2, 3, and 4 were 63, 55 and 70, respectively.

Biomass production did not vary significantly between pine stands.

The biomass production of the sedge meadow stands varied significantly (1% level). The production of stand 9 was considerably lower than that of the other stands. However, this difference can not be easily attributed to any particular site condition.

The biomass production of the upland opening stands was also found to vary significantly (1% level). The low production of stand 16, a somewhat abnormal upland opening stand, is particularly interesting. Of the stands of this cover type, it was the most diverse and appeared to have been disturbed more recently than the other stands. Also, it was located on a sandy textured soil, which is not typical of this cover type. Although this stand may be correctly mapped at the present, it is likely that through succession it will become similar to the stands of the pine cover type of this study.

Stand 15 had the highest biomass production of the upland opening stands. This was possibly due to an increased water holding capacity resulting from clay in the lower soil horizons. This clay was lacking from the soil profiles of the other upland opening stands.

Biomass Variation Within Stands

Significant production variation from point to point was found in five stands. Production from point to point in stand 3, an aspen stand, was found to vary significantly (5% level). Of the sedge meadow stands, 9 and 10 had significant internal variation (1% level) and stand 12 also had significant internal variation (5% level). Stand 14 was the only upland opening stand to have significant internal variation (1% level). The stands of the pine cover type showed no significant point to point variation.

The use of 25 9.6 sq. ft. plots per stand provided an adequate sample size for assessing vegetation even though significant variation sometimes occurred within stands. This determination is based on the work of Campbell and Cassady (1949) and Mueggler (1976). Campbell and Cassady found that only 10 to 15 9.6 sq. ft. plots were required to adequately sample some southern forest ranges. Working in Montana on ranges composed of grasses and shrubs, Mueggler found that, in some cases, as few as 13 4.8 sq. ft. plots were required to adequately sample vegetation. In more variable stands, he found that as few as 19 such plots could be adequate.

Data Comparison

Table 3 compares the average herbaceous biomass for cover types of the Virginia District as determined in this study with values found in other studies. In compiling the data for this table, only stands of similar age and density

were considered.

The data from this study are the lowest for each cover type. They do, however, agree reasonably well with the data from the Lounsbury and Hanowski study. The values reported by Bowles for the Chequamegon, Nicolet and Superior National Forests are consistently higher.

Table 3. Comparison of average herbaceous biomass.

Cover Type	Virginia District	Superior[1]	Superior[2]	Chequa-megon[1]	Nicolet[1]
	kg/ha				
Aspen	571	975	619	1300	1181
Pine	577	785	440	1117	1424
Sedge Meadow	2018	3800	2926	7288	4288
Upland Opening	1421	2742	2610	3278	2099

[1]Data collected by Dr. James A. Bowles.
[2]Data collected by Lounsbury and Hanowski.

Part of the variation in Table 3 might be explained by differences in sampling technique. The other studies used smaller plots and, in at least one instance, fewer plots. For example, Lounsbury and Hanowski sampled only five .96 sq. ft. plots per stand, considerably less than the various recommendations of Mueggler (1976). Additionally, in a number of instances only a few stands of a cover type were examined, thus increasing the potential for error.

One other possible explanation of the variation seen in Table 3 was reported by Zavitkovski (1976), who found that

average production within a cover type could vary from year to year by nearly 50%. It is possible, though not likely given the favorable climatic conditions during the growing season of 1982, that this study was done during a poor growth year.

Similarity Index

Although the stands of a given cover type are considered to be fairly similar, there are many differences between them. In an attempt to better determine the compositional similarity between stands of each cover type the similarity index was used (Tables 4-7).

Table 4. Similarity index, aspen stands.

Stand	Stand 2	Stand 3	Stand 4
1	62	43	30
2		60	40
3			60
4			

Table 5. Similarity index, pine stands.

Stand	Stand 6	Stand 7	Stand 8
5	50	59	49
6		38	51
7			46
8			

Table 6. Similarity index, sedge meadow stands.

Stand	Stand 10	Stand 11	Stand 12
9	23	34	43
10		38	63
11			54
12			

Table 7. Similarity index, upland opening stands.

Stand	Stand 14	Stand 15	Stand 16
13	50	48	26
14		63	44
15			34
16			

Possibly the most striking thing about the similarity indices is that they appear to be somewhat low. It should be remembered, however, that each stand is being acted upon by different environmental factors which cause differences in composition. Additionally, as Gauch (1982) points out, individual species are subject to non-environmental influences such as seed dispersal, seedling establishment and sampling limitations. Gauch indicates that from 10 to 50% of the compositional variation within a cover type is due to this "noise." Viewed in this light, the similarity indices become more reasonable.

The aspen cover type had a fairly great range of similarity index values, 61 to 30. The pine cover type had an average similarity index of 49, equal to that of the aspen cover type, however, the range of similarity index values, 59 to 38, was the smallest of the four cover types, indicating relatively good similarity. The stands of the sedge meadow cover type exhibited the least similarity with the lowest average similarity index, 43. This cover type had the greatest range of similarity index values, 63 to 23. The upland opening cover type also proved to have relatively great dissimilarity between stands. The average similarity index was 44 and values ranged from 63 to 26. This was only slightly narrower than the range of values found for the sedge meadow cover type. The highest similarity index found in this study, 63, was found in this cover type.

Forage Value

The data collected in this study indicate that a grazing program of some magnitude can be supported by the cover types studied. Still, the question of the suitability of the species as potential forage for cattle should be addressed. A literature search was conducted for this purpose. However, as relatively little research has been done on the utilization of northern plant species by cattle, few data are available for such an analysis. It was possible, therefore, to rate only a limited number of the species found in the current study. The forage ratings and the sources from which they were derived are listed in Table 8.

Of the species rated in the aspen cover type, only two provide quality forage. Carex spp.** is considered to be good forage and was found in moderate quantities in stands of this cover type. White clover (Trifolium repens), although an excellent forage, was only occasionally found in aspen stands and only in limited quantities. Although forage ratings were not available for bearded wheatgrass and fringed brome, both were found in limited amounts in this cover type and may prove to be good forage, as they are closely related to good forage species.

Of the species offering fair or fair to poor forage, large-leaved aster is the most significant due to the quantities produced. Serviceberry, goldenrod, currant,

Table 8. Forage values.

Herbaceous species	Forage rating
Achillea spp.	poor[1]
Agropyron repens	good[1]
Agropyron trachycaulum	excellent[2]
Agrostis alba	good[1]
Agrostis perennans	fair[1]
Antennaria spp.	poor to fair[1]
Apocynum spp.	toxic[1]
Aster spp.	poor to fair[1]
Bromus inermis	excellent[2]
Carex spp.	good[1]
Cicuta maculata	toxic[1]
Danthonia spicata	poor[1]
Equisetum spp.	toxic[1]
Erigeron spp.	poor[1]
Festuca obtusa	good[1]
Galium spp.	poor[1]
Helianthus spp.	fair to excellent[2]
Hepatica spp.	poor[1]
Hieracium spp.	good[1]
Lactuca spp.	fair[1]
Muhlenbergia spp.	fair[1]
Panicum spp.	poor to excellent[1]
Phleum pratense	good[1]
Poa compressa	excellent[1]
Poa pratense	excellent[1]

Table 8.- continued.

Herbaceous species	Forage value
Potentilla spp.	poor[1]
Prunella vulgaris	poor[1]
Pteridium aquilinum	toxic[1]
Scirpus spp.	fair[1]
Solidago spp.	poor to fair[1]
Taraxacum officinale	good[2]
Trifolium spp.	excellent[1]
Vicia spp.	fair[1]
Trees and shrubs	
Amelanchier spp.	fair[1] (toxic)
Arctostaphylos uva-ursi	poor[2]
Cornus spp.	poor[1]
Populus tremuloides	fair[2]
Ribes spp.	poor to fair[1]
Rosa spp.	poor to fair[1]
Rubus spp. (upright)	poor to fair[1]

Sources from which ratings were derived.

1. Crawford et al. (1969)
2. Stubbendieck et al. (1982)

prickly rose and upright bramble offer acceptable forage and were found in limited to moderate amounts, but their relatively limited combined quantities should be considered when evaluating the aspen cover type as potential range.

Personal observations by the author on grazed stands

near the study sites suggest that desirable forage is limited in the aspen cover type, forcing stock to graze on less desirable species. Observations showed that Carex spp.** was heavily grazed and large-leaved aster, rated only fair forage, was also heavily grazed. Wild sarsaparilla and bushhoneysuckle were also being consumed. Bracken fern, sometimes a heavy producer in aspen stands and a toxic species, is known to be consumed by cattle when more desirable forage is not available (Evers and Link, 1972). However, cattle were observed grazing this species very heavily after only ten days on a grazing allotment composed of young aspen and regenerating pine cover types.

Of the sixteen pine cover type species which were rated, slender wheatgrass (Agropyron trachycaulum) and white clover are considered excellent forage. Several of the panic grasses provide forage of poor to excellent quality. These species were found only in limited quantities in this cover type. Carex spp.** was often found in moderate quantities and is considered to be good forage. Serviceberry, large-leaved aster, quaking aspen, goldenrod, upright bramble, and prickly rose were common, and are considered fair to poor forage. Yarrow and poverty oatgrass produced limited quantities of poor quality forage. Intermediate dogbane and bracken fern are toxic species which were frequently found in stands of this cover type.

Personal observations on a range of this cover type on

the Virginia District found that bracken fern was again heavily grazed. Large-leaved aster was also heavily grazed, while serviceberry, lettuce (Lactuca spp.), false melic (Schizachne purpurascens), and roughleaf ricegrass were less heavily grazed.

The best quality forage in the sedge meadow cover type was produced by slender wheatgrass, the various bluegrasses, and sunflower (Helianthus spp.). These species occurred irregularly and only in limited quantities, however.

The genus Carex was the most important producer of good forage in this cover type. Two groups of this genus were present and consistently produced moderate to large quantities of good forage. Autumn bentgrass (Agrostis perennans), nodding fescue (Festuca obtusa), timothy, and muhly (Muhlenbergia spp.) produced forage of reasonable quality but, again, they were not commonly found. Bulrush (Scirpus spp.) was commonly found and is considered fair forage. The asters, currants, roses, upright bramble, and goldenrods produced important quantities of poor to fair forage. Less desirable forage was provided by yarrow and bedstraw.

Two toxic species were collected in this cover type. Water hemlock (Cicuta maculata), found in stand 9, is considered deadly even in limited amounts (Evers and Link, 1972). Scouring rush (Equisetum spp.) was more commonly found and is also poisonous to livestock. The presence of these species should be considered during the planning of

future grazing rotations.

The upland opening cover type produced better quality forage than the other cover types. Three species of clover were frequently collected in varying amounts and provide excellent forage. Varying quantities of several bluegrasses and wheatgrasses were found and are considered excellent forage. Various species of sunflowers and panic grasses were occasionally found in this cover type and are considered fair to excellent and poor to excellent forage, respectively, although quantities were usually limited.

Perhaps the most important forage species in this cover type was timothy, which contributed large quantities of good quality forage. Three groups of sedges also produced large quantities of good forage. Lettuce and vetch (Vicia spp.) were frequently found in limited quantities and are considered fair forage, as are several less frequent species such as autumn bentgrass, quaking aspen and muhly. Other important but less desirable species included poverty oatgrass, fleabane, goldenrod, prickly rose, and bramble.

Toxic species included intermediate dogbane, an important component of this cover type, scouring rush, and bracken fern.

CONCLUSIONS

1. The composition of northern Lake States' forest cover types has been well documented. However, extensive biomass data for the herbaceous and shrub components of

these cover types is largely lacking. An understanding of the impact that grazing will have on northern forest cover types is also lacking. Under grazing pressure, compositional changes are likely to occur as Steinbrenner (1951) points out. In order to assure that these changes are not harmful, careful monitoring will be required and periodic in-depth examinations will be required to identify invading, increasing and decreasing species and to supply the information that is essential to fully evaluate the long term effects of the grazing program.

2. Substantial compositional and biomass variation commonly exists between cover types and between the stands of a given cover type. Although this variation is frequently minor, being nothing more than small fluctuations in the relative importance of key species, it is sometimes great, and in some cases extreme. This question of variation in herbaceous composition was addressed by Grigal and Arneman (1970). These authors suggested that, since herbaceous compositional variation is sometimes great, management decisions would be more sound if they were based on classification schemes in which stands were classified by evaluating the frequency of all species present. They further concluded that management policies based on other classification schemes may fail. In light of the variations found in this study, and in others, it is obvious that great care should be taken in evaluating each stand for possible inclusion in the grazing program.

3. All cover types and stands examined appear capable of supporting a properly managed grazing rotation of some magnitude. In terms of quantities of potential forage, the sedge meadow cover type offers the greatest potential for grazing, followed in order by the upland opening, pine and aspen cover types.

Although it is hard, given the lack of published data, to rate the species of each cover type as potential forage, the available data suggest that the upland opening cover type has better quality forage than the other cover types. The sedge meadow cover type, while lacking high quality forage, produces great amounts of acceptable or good forage. The forage of the pine and aspen cover types is not as desirable as that of the other cover types, although several species do offer excellent or good quality forage. Additional research is needed to fully evaluate the desirability of northern plant species.

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APPENDIX A

Table 9. Scientific and common names of species cited in text.

HERBACEOUS SPECIES

Scientific name	Common name
Achillea millefolium	yarrow
Agropyron repens	quack grass
Agropyron subsecundum	bearded wheatgrass
Agropyron trachycaulum	slender wheatgrass
Agrostis perennans	autumn bentgrass
Agrostis stolonifera	purple bentgrass
Apocynum medium	intermediate dogbane
Aralia nudicaulis	wild sarsaparilla
Aster puniceus	purple-stemmed aster
Bromus ciliatus	fringed brome
Calamagrostis canadensis	bluejoint reedgrass
Carex spp.	sedges
Carex cristatella	
Carex folliculata	
Carex intumescens	
Carex pensylvanica	Pennsylvania sedge
Carex prasina	
Carex stipata	
Cicuta maculata	water hemlock
Clintonia borealis	Clintonia
Comptonia peregrina*	sweet fern

Table 9.- continued

Scientific name	Common name
Cornus canadensis	bunchberry
Danthonia spicata	poverty oatgrass
Dryopteris intermedia	shield fern
Erigeron spp.	fleabane
Equisetum spp.	scouring rush
Festuca obtusa	nodding fescue
Fragaria virginiana	common strawberry
Galium asprellum	rough bedstraw
Gaultheria procumbens	wintergreen
Gratiola neglecta	hedge-hyssop
Helianthus spp.	sunflower
Lactuca spp.	lettuce
Lathyrus spp.	wild pea
Lycopodium complanatum	ground cedar
Lycopodium spp.	clubmoss
Maianthemum canadense	wild lily-of-the-valley
Muhlenbergia spp.	muhly
Oryzopsis asperifolia	roughleaf ricegrass
Oryzopsis pungens	
Panicum spp.	panic grass
Phalaris arundinacea	reed canary grass
Phleum pratense	timothy
Poa chaixii	
Poa compressa	Canada bluegrass

Table 9.- continued

Scientific name	Common name
Poa palustris	fowl meadow-grass
Poa pratensis	Kentucky bluegrass
Poa saltuensis	
Poa wolfii	
Pteridium aquilinum	bracken fern
Rubus spp.	bramble (trailing)
Schizachne purpurascens	false melic
Scirpus spp.	bulrush
Solidago spp.	goldenrod
Streptopus roseus	twisted stalk
Trifolium hybridum	alsike clover
Trifolium pratense	red clover
Trifolium repens	white clover
Vicia spp.	vetch
Viola spp.	violet

* Also known as Myrica asplenifolia.

TREES AND SHRUBS

Scientific name	Common name
Alnus rugosa	speckled alder
Amelanchier spp.	serviceberry
Arctostaphylos uva-ursi	bearberry
Corylus americana	American hazel
Corylus cornuta	beaked hazel
Ribes spp.	currant

Table 9. - Continued

Scientific name	Common name
Diervilla lonicera	bushhoneysuck
Rosa acicularis	prickly rose
Pinus banksiana	jack pine
Rubus spp.	bramble (upright)
Pinus resinosa	red pine
Salix bebbiana	beaked willow
Populus tremuloides	quaking aspen
Salix gracilis	meadow willow
Salix interior	sandbar willow
Spiraea alba	meadow sweet
Vaccinium spp.	blueberry

APPENDIX B

STAND LOCATIONS

Compartment 28

All stands are located in the grazing allotment north and east of the intersection of State Route 73 and County 688.

Stand 1.
The aspen stand located east of Route 73 about a quarter mile north of County 688. It is about 100 yards north of the stock pond.

Stands 9 and 12.
The sedge meadows that parallel Route 73 immediately north of County 688. They are separated by stand 14. Stand 9 is to the east of stand 14, while stand 12 is between stand 14 and Route 73.

Stand 14.
The upland opening that parallels Route 73 for approximately 1/4 mile north of County 688. The stand is approximately 150 yards east of Route 73.

Compartment 32

All stands are immediately west of an abandoned house located at the end of an unimproved road which begins where County 652 makes a 90-degree turn from west to north.

Stand 10.
A sedge meadow which forms a "Y" with one branch located approximately 150 yards northwest of the abandoned house.

Stand 11.
The other branch of the "Y" mentioned in stand 10. It is approximately 200 yards southwest of the house.

Stand 15.
The upland opening located between the branches of stands 10 and 11.

Compartment 51

Stand 2.
Young aspen stand located on an unimproved road 1/8 mile north of the point where County Road 481 turns 90 degrees from due north to east. The site is approximately 1/4 mile south of the Dark River. The stand is on the west side of and adjacent to the unimproved road at the intersection of a second unimproved road.

Compartment 60

One half mile northwest of Moose Lake.

Stand 7.
Young pine stand located north of County 461, 2 1/2 miles south of County 65. The stand is on the east side of an unimproved road approximately 1/2 mile north of County 461. The stand is bounded on the north and south by marsh. Samples were taken within 100 yards of the unimproved road.

Stand 8.
Young jack pine stand located on the west side of and adjacent to the unimproved road mentioned in stand 7. Samples were taken within 100 yards of the unimproved road.

Compartment 61

Stand 16.
Upland opening west of U.S. Route 53, 1/4 mile north of the intersection of County 377. Follow Forest Service road 260 (Taconite Trail) west, taking the first left turn and proceeding past the next right turn to where the road turns south. Samples were taken on the east side of the road within 150 yards of the road.

Compartment 75

Stand 3.
The young aspen stand located on the east side of County 461, one mile south of County 65. The stand is about 200 yards east of 461. It is bounded on the east by a marshy area and on the west by stand 6.

Stand 4.
The young aspen stand southwest of the upland opening located at the end of the unimproved road bisecting stand 3.

Stand 5.
Pine stand located on the west of County 461 1/2 mile south of County 65. Samples were taken within 200 yards of County 461.

Stand 6.
Pine stand located on the east side of 461, one mile south of County 65. This stand parallels 461 and is bounded on the east by stand 3. An unimproved road bisects this stand.

Stand 13.
The upland opening located at the end of the unimproved

road bisecting stands 3 and 6.

TABLE 10. Species' biomass values.

Species	ASPEN				PINE				SEDGE MEADOW				UPLAND OPENING			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	kg/ha															
Achillea lanulosa															.4	.1
Achillea millefolium			.2		.1	1.8	.2	13.2	8.2	3.8	1.9	4.9	2.5	3.4	4.4	46.1
Actaea pachypoda	.1															
Agropyron repens														58.8		
Agropyron subsecundum	15.8	6.3	2.0	47.9		4.7			8.9							13.3
Agropyron trachycaulum					6.6			7.4	17.5							11.4
Agrostis alba								27.2					3.2			
Agrostis hiemalis									.7							4.0
Agrostis perennans									4.0							1.5
Agrostis stolonifera												2.8	.4	7.6	7.7	
Anaphalis margaritacea																4.9
Anemone quinquefolia	1.7	.9	13.0	.7	2.0	10.9	2.5	.1	.7							1.8
Antennaria neglecta					.6	4.7	1.9	10.7								1.4
Apocynum androsaemifolium			1.5													4.1
Apocynum medium					.5	3.2	1.5	5.1					89.7	21.1	.7	20.6
Aralia nudicaulis	26.4	19.8	83.7	28.8			.3									

TABLE 10.-continued

Species	ASPEN				PINE				SEDGE MEADOW				UPLAND OPENING			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Asarum canadense	4.7			.7												
Aster junciformis								.5			6.1					
Aster macrophyllus	273.1	250.4	115.2	44.2	23.4	29.9	16.3	7.2	9.3	9.3	6.6	3.1	1.5	22.2	7.7	11.8
Aster puniceus									3.3	70.1	36.6					1.2
Aster umbellatus															.3	
Athyrium filix-femina	14.4			3.1												
Bromus ciliatus			.4	1.6			.1		14.4		7.4	1.8		5.7	1.4	1.1
Bromus inermis										1.5						
Calamagrostis canadensis				99.3					61.4	872.4	585.1	910.0		65.2		
Campanula rotundifolia							.3									
Carex spp.*			3.4	6.8					203.8	.7	61.2	71.0				
Carex spp.**	13.8	30.1	15.1	57.1	35.1	129.3	31.0	76.0					500.6	359.7	358.1	186.4
Carex spp.***													1.8	6.9	47.6	
Carex spp.****									209.4	1471.9	106.3	527.4	10.2	51.4	.9	4.1
Castilleja coccinea									2.1					3.9	.1	
Chrysanthemum leucanthemum															.1	
Cicuta maculata									11.8							

TABLE 10-continued

Species	ASPEN				PINE				SEDGE MEADOW				UPLAND OPENING			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Cinna latifolia											2.3					
Cirsium arvense										2.7			14.7	5.4	1.0	.9
Cirsium muticum									1.7	11.7	.9	4.1	1.0	.6		
Cirsium vulgare				.5												
Clintonia borealis	32.0	16.8	11.9	10.7												
Comptonia peregrina			10.4		454.6	110.0										
Convolvulus arvensis	.6	.1			.3				.1							
Convolvulus spithamaeus					2.6				.3							2.0
Coptis groenlandica	.4	.2	.8	.8												
Cornus canadensis	3.1	1.9	5.5	3.1	.6		6.7									
Crepis capillaris					2.0								1.4			1.4
Danthonia spicata					11.1	5.0	2.1	50.5	2.7					46.0	.2	26.3
Dryopteris intermedia	.1		.8	18.8					.4							
Dryopteris marginalis	1.4															
Dryopteris spinulosa	50.6			3.0						3.5						
Epilobium angustifolium							34.0		5.9			8.3				23.4
Equisetum spp.	4.8								3.9		2.2	2.5		4.2		

TABLE 10-continued

Species	ASPEN				PINE				SEDGE MEADOW				UPLAND OPENING			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Erigeron annuus														6.3	15.1	4.1
Erigeron canadensis													11.3			
Erigeron philadelphicus		2.0										.8		10.9	11.6	2.4
Festuca obtusa									16.2							
Fragaria virginiana	12.9		23.0	2.2	44.2	19.3	22.8	48.4	145.6	1.6	57.4	56.1	39.6	162.4	297.2	159.2
Galeopsis tetrahit									5.3			.5				
Galium aparine	1.0															
Galium asprellum	5.9	6.1	3.7	9.3					3.7	5.3		10.3			1.7	
Galium boreale	.6			.9					6.7					28.3	11.1	
Galium triflorum	.3			.1												
Gaultheria procumbens					11.8	3.1	6.9	2.8								
Geum aleppicum					1.0				1.7	4.8	6.1	10.9		16.2	2.5	.5
Geum laciniatum												1.9				
Geum macrophyllum												2.9			.4	
Geum vernum									.9		.6	.8				
Glyceria canadensis											2.2					

TABLE 10-continued

Species	ASPEN				PINE				SEDGE MEADOW				UPLAND OPENING			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Gratiola neglecta					.4	3.5	3.8	.7								
Gymnocarpium dryopteris																8.9
Helianthus divaricatus														12.0		
Helianthus giganteus									.7		7.2	4.4		7.0	1.6	
Helianthus laetiflorus									1.5			1.4		3.5		
Hepatica americana		1.5		.3					1.2							
Hieracium canadense						.1										
Hieracium pilosella					.1											
Hieracium scabrum																1.4
Impatiens capensis				5.0						.9						
Lactuca canadensis						1.4		.6	.4				1.0	1.8	12.7	9.6
Lactuca hirsuta					.5		.1	.7						.3	.3	3.7
Lactuca scariola	1.1								.3			.6			1.4	.7
Lathyrus ochroleucus	.3	4.3	.4	.4					1.7		1.0			.2		13.2
Lathyrus palustris										.2				4.8		
Lathyrus venosus		1.1			.1				1.7	.9				14.8	.1	15.3
Lilium superbum												2.1				

TABLE 10.-continued

Species	ASPEN				PINE				SEDGE MEADOW				UPLAND OPENING			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Linaria vulgaris													1.5			
Linnaea borealis			3.9													
Lycopodium clavatum				.9												
Lycopodium complanatum	39.2		19.0	12.2	.1		3.6									
Lycopodium obscurum		68.4	1.3	3.5												
Lycopus americanus				1.2								1.2				
Lycopus uniflorus				.9							.5					
Lysimachia ciliata									12.6		2.7	11.3		1.0		
Maianthemum canadense	6.0	9.7	27.2	4.8	5.7	19.1	10.0	3.5	.5							4.0
Malva neglecta	3.8															
Mentha arvensis										1.2		.1				
Muhlenbergia spp.						3.6			1.8	1.0						14.2
Oryzopsis asperifolia	39.8	67.0	80.0	46.3	128.3	260.6	43.5	36.6	32.0			1.0	4.5			18.3
Oryzopsis pungens					.9	1.7	3.3	.1								
Panicum boreale					.8			1.0								
Panicum wilcoxianum						.5		1.4								35.0

TABLE 10.-continued

Species	ASPEN				PINE				SEDGE MEADOW				UPLAND OPENING			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Panicum xanthopysum					.5		.1	1.9								8.6
Petasites palmatus	4.9			7.9					11.5							
Phalaris arundinacea										9.8	869.1	45.7			469.0	
Phleum pratense									23.1			10.2	635.3	263.4	341.1	
Plantago major															1.3	
Poa chaixii														12.9		
Poa compressa												.9	21.7		4.5	8.3
Poa palustris									1.0		12.6	1.4			5.2	2.1
Poa pratensis								1.3	.5				35.8	1.9	1.4	8.1
Poa saltuensis								14.0						14.0	7.4	15.8
Poa wolfii											1.0			4.6		
Potentilla simplex															23.7	
Prenanthes alba					.3	.5	.2		.2					1.9	3.3	
Prunella vulgaris									.4		3.1	2.7		.4	1.8	
Pteridium aquilinum	.8	95.7	64.3		42.2	10.1		41.6								31.2
Pyrola secunda					.8	.3			4.0							
Rubus spp. (trailing)	40.9	13.9	12.6	79.2	.6		2.5		39.3			44.9	.1			

TABLE 10.-continued

Species	ASPEN				PINE				SEDGE MEADOW				UPLAND OPENING			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Schizachne purpurascens					.6	20.5			.6							
Scirpus spp.									9.0		69.6	5.4	9.2			
Scutellaria incana										.3						
Scutellaria lateriflora										14.4	18.6	.1				
Senecio pauperculus																.8
Solidago spp.	1.4			69.1	57.3	42.0	19.9	81.7	391.7	142.4	175.2	150.2	35.5	180.1	147.6	48.1
Stachys palustris				.3												
Stachys tenuifolia									2.6		4.8	4.7				
Streptopus roseus	2.2	10.5	1.1	4.4								.2				
Taraxacum officinale	.5		.3			1.1			.2		.7		.4	.4		1.5
Thalictrum dioicum						.7										
Tragopogon pratensis														4.9		1.5
Trientalis borealis	.3	1.2	.9	1.5												
Trifolium hybridum											7.3			51.0	20.9	
Trifolium pratense													4.4	27.6	5.0	88.3
Trifolium repens			3.0				.2	108.9	23.1			.4	17.2	.3		.5
Urtica gracilis										1.4	3.0					

TABLE 10-continued

Species	ASPEN				PINE				SEDGE MEADOW				UPLAND OPENING			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Vicia americana									.9		.2		.2	3.0		
Vicia cracca									.5					7.2	.5	
Viola spp.	.7			.3	5.7	13.5	3.2	6.9	14.3		3.3	11.8		3.9	10.5	26.8
Woodsia ilvensis		.2								2.1	.6					
TREES AND SHRUBS																
Alnus crispa				4.6						18.6						
Alnus rugosa	13.6							17.1	23.2	173.0						1.6
Amelanchier spp.	27.2			4.0	75.0	.1	43.1	82.1								
Amelanchier arborea									5.0							
Arctostaphylos uva-ursi					2.8	57.4		99.5								
Cornus stolonifera						13.1										
Corylus americana		206.2	694.4	548.3	2.2		.5	15.5								20.4
Corylus cornuta	244.7	298.3	247.0	77.5	.5	13.3		.9								
Diervilla lonicera	17.9	3.4	8.8	7.0	9.9		40.1	65.9	1.6					.6		

TABLE 10,-continued

Species	ASPEN				PINE				SEDGE MEADOW				UPLAND OPENING			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Lonicera canadensis			6.6													
Lonicera dioica	.7															
Lonicera hirsuta				1.8												
Lonicera oblongifolia			.4		26.2											
Populus balsamifera								23.8			18.9					
Populus grandidentata						.5										
Populus tremuloides	2.5				17.0	73.6		100.3		5.9	8.3				1.1	26.4
Prunus pensylvanica	.9		7.4	.4	7.4	23.1										2.1
Prunus virginiana										1.3						
Rhamnus alnifolius	1.8															
Ribes spp.	3.9	.3		10.5					8.7	.6	1.1	1.8			.7	
Rosa acicularis	7.7		1.8	1.2	4.2	6.3	15.3	1.0	48.7	14.2	7.4	18.7		61.2	49.1	33.0
Rubus spp. (upright)	1.4		14.0	36.2	28.9	72.7	24.2	166.6	7.3	213.7	85.3	38.6	15.2	21.5	25.4	96.1
Salix bebbiana					16.6	39.1	4.7			47.1		3.3				15.8
Salix discolor									2.5		4.0					4.0
Salix gracilis									55.2		84.1	136.8				

TABLE 10-continued

Species	ASPEN				PINE				SEDGE MEADOW				UPLAND OPENING			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Salix interior									21.3		20.9	57.1				
Salix pedicellaris																3.2
Salix pyrifolia			7.3													
Salix serissima					87.4											
Spiraea alba									79.7	58.9	140.2	59.8				
Vaccinium spp.	1.2		30.5		639.6	282.8	916.9	404.4								6.6

* Thin, upright lowland sedges
** Filiform upland sedges
*** Intermediate grasslike sedges of upland waste areas
**** Large lowland sedges

APPENDIX D

SOIL PROFILES

Stand 1

A	0-11 cm; (5 YR 2.5/1): sandy loam; medium crumb structure; moderately acid (pH 6.0)
B	11-32 cm; (5 YR 5/1): sandy loam: medium crumb and fine granular structure: very friable: strongly acid (pH 5.5)
BC	32-100 cm; (10 YR 5/1); silty clay: subangular blocky structure; moderately alkaline (pH 8.0)
C	100+ cm; (7.5 YR 5/4); medium sand; single grain; moderately acid (pH 6.0)

Water table located at 107 cm.

Stand 2

A	0-7 cm: (5 YR 2.5/1); loamy sand; fine crumb structure; moderately acid (pH 6.0)
Bo	7-19cm; (7.5 YR 4/6); fine sand; fine crumb and fine granular structure: strongly acid (pH 5.5)
BC	19-41 cm; (7.5 YR 4/4); fine sand: fine crumb and fine granular structure: strongly acid (pH 5.5)
CB	41-51 cm; (10 YR 5/4); fine sand; fine crumb and fine granular structure; moderately acid (pH 6.0)
C	51+ cm; (10 YR 4/4); gravelly fine sand; fine crumb and fine granular structure: moderately acid (pH 6.0)

Stand 3

A 0-11 cm; (5 YR 2.5/1); loamy sand; fine crumb and very fine granular structure; very strongly acid (pH 4.5)

B 11-99 cm; (7.5 YR 4/4); medium sand; very fine granular structure; very strongly acid (pH 4.5)

CB 99-132 cm; (7.5 YR 5/4); coarse sand; fine granular structure; few silt lenses present; strongly acid (pH 5.5)

Stand 4

A 0-10 cm; (5 YR 2.5/1); sandy clay loam; medium crumb structure; very strongly acid (pH 4.5)

B 10-24 cm; (7.5 YR 3/4); sandy clay; medium crumb and subangular blocky structure; very strongly acid (pH 4.5)

BC 24-54 cm; (10 YR 5/3); sandy clay; medium crumb and subangular blocky structure; common medium and coarse fragments; very strongly acid (pH 4.5)

CB 54-67 cm; (10 YR 6/4); sandy clay; subangular blocky and medium crumb structure; strongly acid (pH 5.5)

C 67+ cm; (10 YR 5/3); sandy clay; subangular blocky and medium crumb structure; strongly acid (pH 5.5)

Stand 5

A 0-8 cm; (7.5 YR 2/0); sandy loam: fine crumb structure; strongly acid (pH 5.5)

E 8-15 cm; (10 YR 3/3); sandy loam; fine granular and fine crumb structure; very strongly acid (pH 5.0)

Bhs 15-22 cm; (7.5 YR 3/4); sandy loam; medium granular structure; very strongly acid (pH 5.0)

BCs 22-39 cm; (10 YR 3/4); medium sand; medium granular structure; very strongly acid (pH 4.5)

CBs 39-51 cm; (7.5 YR 4/4); medium sand; medium granular structure; strongly acid (pH 5.5)

C 51+ cm; (10 YR 6/6); gravelly very coarse sand; medium granular structure; moderately acid (pH 6.0)

Stand 6

A 0-4 cm; (7.5 YR 2/0); loamy sand; fine crumb structure; strongly acid (pH 5.5)

E 4-7 cm; (10 YR 2/2); loamy sand; fine granular and medium crumb structure; very strongly acid (pH 4.5)

Bhs 7-17 cm; (10 YR 3/2); loamy sand; fine granular and medium crumb structure; very strongly acid (pH 4.5)

BC 17-31 cm; (10 YR 4/4); fine sand; fine granular and medium crumb structure; strongly acid (pH 5.5)

CB 31-44 cm; (10 YR 5/6); fine sand; fine granular and medium crumb structure; strongly acid (pH 5.5)

C 44+ cm; (10 YR 6/4); gravelly medium sand; fine granular and medium crumb structure; strongly acid (pH 5.5)

Stand 7

A	0-6 cm; (7.5 YR 2/0): loamy sand: medium crumb and fine granular structure; common roots: very strongly acid (pH 4.5)
E	6-11 cm: (10 YR 6/2): loamy sand: fine crumb and fine granular structure; very strongly acid (pH 4.5)
Bhs	11-20 cm; (10 YR 4/6); loamy sand; fine subangular and fine crumb structure; very strongly acid (pH 4.5)
B	20-49 cm; (10 YR 4/4); medium sand: fine granular structure; strongly acid (pH 5.5)
CB	49-61 cm: (10 YR 4/6); medium sand; fine granular structure; moderately acid (pH 6.0)
C	61+ cm; (10 YR 5/4); gravelly medium sand with clay lenses; fine granular structure; moderately acid (pH 6.0)

Stand 8

A	0-1 cm; (10 YR 3/3); loamy sand; fine subangular blocky structure; moderately acid (pH 6.0)
E	1-4 cm; (10 YR 3/2); loamy sand; fine crumb and fine granular structure; moderately acid (pH 6.0)
Bhs	4-14 cm; (7.5 YR 3/4); loamy sand; medium crumb and fine granular structure; moderately acid (pH 6.0)
Bs	14-60 cm; (7.5 YR 4/4); fine sand: medium granular structure; moderately acid (pH 6.0)
BCs	60-90 cm; (7.5 YR 4/6); medium sand; medium granular structure; moderately acid (pH 6.0)
C	90+ cm; (10 YR 6/2); gravelly medium sand; medium granular structure; moderately acid (pH 6.0)

Stand 9

A 0-9 cm: (7.5 YR 2/0); silty clay: subangular blocky and medium crumb structure; strongly acid (pH 5.5)

Bg 9-46 cm; (2.5 YR 4/0); silty clay with few faint, fine mottles; subangular blocky structure; strongly acid (pH 5.5)

Cg 46+ cm: (2.5 YR 5/2); silty clay with few common distinct mottles: subangular blocky structure; slightly acid (pH 6.5)

Stand 10

A 0-14 cm; (10 YR 2/1); silty clay loam; medium crumb structure; neutral (pH 7.0)

B 14-35 cm; (7.5 YR 2/0); silty clay; subangular blocky and medium crumb structure: moderately alkaline (pH 8.0)

Cg 35+ cm; (10 YR 5/1): silty clay with few medium, distinct mottles; subangular blocky structure; moderately alkaline (pH 8.0)

Stand 11

A 0-21 cm: (10 YR 2/1); clay loam; very fine crumb structure; very strongly acid (pH 4.5)

Bg 21-46 cm; (10 YR 4/2); silty clay with common faint, medium yellowish-brown mottles (10 YR 5/6); subangular blocky structure; very strongly acid (pH 4.5)

Cg 46+ cm; (10 YR 3/2): silty clay with common distinct medium yellowish-brown mottles (10 YR 6/8); subangular blocky structure: strongly acid (pH 5.5)

Water table at 46 cm.

Stand 12

A 0-20 cm; (7.5 YR 2/0); silty clay; fine subangular blocky and fine crumb structure: moderately acid (pH 6.0)

ABg 20-31 cm; (7.5 YR 3/0); clay with few faint fine mottles; subangular blocky structure: moderately alkaline (pH 8.0)

Bg 31-47 cm; (2.5 YR 4/0); clay with few faint fine mottles; subangular blocky structure: neutral (pH 7.0)

Cg 47+ cm; (2.5 YR 5/2); clay with common distinct medium mottles; subangular blocky structure; strongly alkaline (pH 8.5)

Stand 13

A 0-15 cm; (10 YR 3/3); clay loam; medium crumb and fine subangular blocky structure; moderately acid (pH 6.0)

B 15-31 cm; (10 YR 5/3); gravelly sandy clay; fine crumb structure; strongly acid (pH 5.5)

CB 31-41 cm; (10 YR 5/3); gravelly sandy clay loam; fine crumb and very fine granular structure; strongly acid (pH 5.5)

C 41+ cm; (10 YR 6/3); gravelly sandy clay loam; fine crumb and fine granular structure; strongly acid (pH 5.5)

Stand 14

A 0-10 cm; (10 YR 4/1); silty clay; medium crumb and fine subangular blocky structure; slightly acid (pH 6.5)

AB 10-40 cm; (10 YR 5/3); silty clay; subangular blocky structure; moderately acid (pH 6.0)

Bog 40-73 cm; (10 YR 6/2); sandy clay loam with common faint, coarse mottles; medium crumb and subangular blocky structure; moderately alkaline (pH 8.0)

Cg 73+ cm; (10 YR 5/1); clay with common distinct, coarse mottles; subangular blocky structure; moderately alkaline (pH 8.0)

Stand 15

A 0-14 cm; (10 YR 3/1): sandy clay loam; medium crumb and fine subangular blocky structure; moderately acid (pH 6.0)

B 14-59 cm; (10 YR 5/3); silty clay; medium subangular blocky structure; moderately acid (pH 6.0)

BC 59-78 cm; (10 YR 5/2); silty clay; medium subangular blocky structure: moderately alkaline (pH 8.0)

C 78+ cm: (10 YR 5/1); silty clay; medium subangular blocky and medium crumb structure: moderately alkaline (pH 8.0)

Stand 16

A 0-6 cm: (7.5 YR 4/4); loamy sand; fine crumb structure; moderately acid (pH 6.0)

E 6-14 cm; (10 YR 4/2); loamy sand; very fine subangular blocky and fine crumb structure; moderately acid (pH 6.0)

Bhs 14-41 cm; (7.5 YR 4/6); fine sand; medium crumb and very fine granular structure; strongly acid (pH 5.5)

CB 41-69 cm: (7.5 YR 5/4); medium sand; fine granular structure; moderately acid (pH 6.0)

C 69+ cm; (7.5 YR 5/4); gravelly coarse sand; medium granular structure; slightly acid (pH 6.5)

Appendix E

Table 11. Constancy and fidelity values.

Species	CONSTANCY ASPEN	PINE	SEDGE MEADOW	UPLAND OPENING	FIDELITY
Achillea lanulosa				10	3
Achillea millefolium	5	35	55	70	0
Actaea pachypoda	5				3
Agropyron repens				15	3
Agropyron subsecundum	70	5	5	10	0
Agropyron trachycaulum		25	20	5	1
Agrostis alba		5		5	2
Agrostis hiemalis			10	15	2
Agrostis perennans			10	5	2
Agrostis stolonifera			5	25	2
Anaphalis margaritacea				10	3
Anemone quinquefolia	55	70	10	10	0
Antennaria neglecta		35		5	2
Apocynum androsaemifolium	5			5	2
Apocynum medium		45		55	2
Aralia nudicaulis	90	5			2
Asarum canadense	15				3
Aster junciformis		5	5		2
Aster macrophyllus	100	100	40	80	0
Aster puniceus			55	5	2
Aster umbellatus				5	3
Athyrium filix-femina	15				3
Bromus ciliatus	10	5	35	15	0

Table 11. - Continued.

Species	CONSTANCY ASPEN	PINE	SEDGE MEADOW	UPLAND OPENING	FIDELITY
Bromus inermis			5		3
Calamagrostis canadensis	15		90	10	1
Campanula rotundifolia		5			3
Carex spp.*	25		65		2
Carex spp.**	100	100		100	1
Carex spp.***				40	3
Carex spp.****			100	30	2
Castilleja coccinea			15	20	2
Chrysanthemum leucanthemum				5	3
Cicuta maculata			5		3
Cinna latifolia			5		3
Cirsium arvense			5	45	2
Cirsium muticum			40	10	2
Cirsium vulgare		5			3
Clintonia borealis		95			3
Comptonia peregrina		5	45		2
Convolvulus arvensis		10	5	5	1
Convolvulus spithamaeus		15	5	10	1
Coptis groenlandica	20				3
Cornus canadensis	55	20			2
Crepis capillaris		10		10	2
Danthonia spicata		45	5	25	1

Table 11. - Continued.

Species	CONSTANCY ASPEN	PINE	SEDGE MEADOW	UPLAND OPENING	FIDELITY
Dryopteris intermedia	30		5		2
Dryopteris marginalis	5				3
Dryopteris spinulosa	20		15		2
Epilobium angustifolium		25	15	25	1
Equisetum spp.	25		55	10	1
Erigeron annuus				30	3
Erigeron canadensis				5	3
Erigeron philadelphicus	5		5	55	1
Festuca obtusa			15		3
Fragaria virginiana	55	100	75	95	0
Galeopsis tetrahit			15		3
Galium aparine	5				3
Galium asprellum	85		35	5	1
Galium boreale	10		15	25	1
Galium triflorum	10				3
Gaultheria procumbens		65			3
Geum aleppicum		5	45	25	1
Geum laciniatum			5		3
Geum macrophyllum			5	5	2
Geum vernum			30		3

Table 11.- Continued.

Species	CONSTANCY ASPEN	PINE	SEDGE MEADOW	UPLAND OPENING	FIDELITY
Glyceria canadensis			5		3
Gratiola neglecta		60			3
Gymnocarpium dryopteris				25	3
Helianthus divaricatus				5	3
Helianthus giganteus			15	10	2
Helianthus laetiflorus			10	10	2
Hepatica americana		15	5		2
Hieracium canadense		5			3
Hieracium pilosella		5			3
Hieracium scabrum				10	3
Impatiens capensis	10		5		2
Lactuca canadensis		20	5	60	1
Lactuca hirsuta		15		20	2
Lactuca scariola	5		10	10	1
Lathyrus ochroleucus	30		25	10	1
Lathyrus palustris			5	5	2
Lathyrus venosus	5	5	15	45	0
Lilium superbum			5		3
Linaria vulgaris				5	3
Linnaea borealis	10				3
Lycopodium clavatum	5				3
Lycopodium complanatum	40	10			2

Table 11.- Continued.

Species	CONSTANCY ASPEN	PINE	SEDGE MEADOW	UPLAND OPENING	FIDELITY
Lycopodium obscurum	35				3
Lycopus americanus	5		5		2
Lycopus uniflorus	10		5		2
Lysimachia ciliata			40	10	2
Maianthemum canadense	90	90	5	15	0
Malva neglecta	15				3
Mentha arvensis				10	3
Muhlenbergia spp.		5	10	10	1
Oryzopsis asperifolia	100	85	25	15	0
Oryzopsis pungens		45			3
Panicum boreale		10			3
Panicum wilcoxianum		10		25	2
Panicum xanthophysum		25		10	2
Petasites palmatus	45		10		2
Phalaris arundinacea			35	20	2
Phleum pratense			20	75	2
Plantago major				5	3
Poa chaixii				5	3
Poa compressa			5	55	2
Poa palustris			20	15	2
Poa pratensis		5	5	30	1
Poa saltuensis		5		30	2
Poa wolfii			5	10	2
Potentilla simplex				15	3

Table 11.- Continued.

Species	CONSTANCY ASPEN	PINE	SEDGE MEADOW	UPLAND OPENING	FIDELITY
Prenanthes alba		15	5	15	1
Prunella vulgaris			15	20	2
Pteridium aquilinum	50	45		20	1
Pyrola secunda		10	10		2
Rubus spp. (trailing)	90	15	45	5	0
Schizachne purpurascens		30	5		2
Scirpus spp.			35	5	2
Scutellaria incana			5		3
Scutellaria lateriflora			45		3
Senecio pauperculus				5	3
Solidago spp.	25	100	100	95	0
Stachys palustris	5				3
Stachys tenuifolia			45		3
Streptopus roseus	70		5		2
Taraxacum officinale	10	10	20	20	0
Thalictrum dioicum		5			3
Tragopogon pratensis				15	3
Trientalis borealis	35				3
Trifolium hybridum			5	35	2
Trifolium pratense				50	3
Trifolium repens	5	30	20	20	0
Urtica gracilis			10		3
Vicia americana			20	25	2
Vicia cracca			5	20	2

Table 11. - Continued.

Species	CONSTANCY ASPEN	PINE	SEDGE MEADOW	UPLAND OPENING	FIDELITY
Viola spp.	15	85	55	55	0
Woodsia ilvensis	5		15		2
TREES AND SHRUBS					
Alnus crispa	5		5		2
Alnus rugosa	10	10	25	5	0
Amelanchier spp.	20	45			2
Amelanchier arborea			5		3
Arctostaphylos uva-ursi		30			3
Cornus stolonifera		5			3
Corylus americana	60	15		15	1
Corylus cornuta	75	15			2
Diervilla lonicera	50	45	5	5	0
Lonicera canadensis	5				3
Lonicera dioica	5				3
Lonicera hirsuta	5				3
Lonicera oblongifolia	5	5			2
Populus balsamifera		5	5		2
Populus grandidentata		5			3
Populus tremuloides	10	55	10	20	0
Prunus pensylvanica	15	10		15	1
Prunus virginiana			5		3
Rhamnus alnifolius	5				3
Ribes spp.	30		35	5	1

Table 11.- Continued.

Species	CONSTANCY ASPEN	PINE	SEDGE MEADOW	UPLAND OPENING	FIDELITY
Rosa acicularis	30	65	50	45	0
Rubus spp. (upright)	50	100	55	75	0
Salix bebbiana		20	15	5	1
Salix discolor			20	5	2
Salix gracilis			45		3
Salix interior			20		3
Salix pedicellaris				5	3
Salix pyrifolia	5				3
Salix serissima		5			3
Spiraea alba			60		3
Vaccinium spp.		20	100	5	1

* Thin upright lowland sedges
** Filiform upland sedges
*** Intermediate grasslike sedges of upland waste areas
**** Large lowland sedges

APPENDIX F

Table 12. Analyses of variance.

	Source	df	SS	MS	F
Between Cover Types	Factor	3	15853329	5284443	5.93**
	Error	12	10695297	891275	
	Total	15	26548625		

	Source	df	SS	MS	F
Between Aspen Stands	Factor	3	180908	60303	2.68*
	Error	16	360138	22509	
	Total	19	541046		

	Source	df	SS	MS	F
Between Pine Stands	Factor	3	162999	54333	1.86*
	Error	16	466162	29135	
	Total	19	629161		

	Source	df	SS	MS	F
Between Sedge Meadows	Factor	3	1473239	491080	5.35***
	Error	16	1468930	91808	
	Total	19	2942168		

	Source	df	SS	MS	F
Between Upland Openings	Factor	3	334759	108253	15.22***
	Error	16	113798	7112	
	Total	19	438557		

	Source	df	SS	MS	F
Within Stand 1	Factor	4	9961	2490	1.94*
	Error	20	25681	1284	
	Total	24	35642		

	Source	df	SS	MS	F
Within Stand 2	Factor	4	15583	3896	2.72*
	Error	20	28634	1432	
	Total	24	44217		

Table 12.- Continued.

Within Stand 3

Source	df	SS	MS	F
Factor	4	37677	9419	3.11**
Error	20	60505	3025	
Total	24	98182		

Within Stand 4

Source	df	SS	MS	F
Factor	4	8807	2202	2.67*
Error	20	16494	825	
Total	24	25301		

Within Stand 5

Source	df	SS	MS	F
Factor	4	6931	1733	.47*
Error	20	73202	3660	
Total	24	80135		

Within Stand 6

Source	df	SS	MS	F
Factor	4	14807	3702	1.25*
Error	20	59161	2958	
Total	24	73968		

Within Stand 7

Source	df	SS	MS	F
Factor	4	24401	6100	2.37*
Error	20	51384	2569	
Total	24	75785		

Within Stand 8

Source	df	SS	MS	F
Factor	4	47100	11775	2.16*
Error	20	108874	5444	
Total	24	155974		

Within Stand 9

Source	df	SS	MS	F
Factor	4	30399	7600	5.43***
Error	20	28012	1401	
Total	24	58411		

Table 12.- Continued.

Within Stand 10

Source	df	SS	MS	F
Factor	4	197432	49358	7.52***
Error	20	131257	6563	
Total	24	328689		

Within Stand 11

Source	df	SS	MS	F
Factor	4	25706	6427	1.85*
Error	20	69582	3479	
Total	24	95288		

Within Stand 12

Source	df	SS	MS	F
Factor	4	39940	9985	3.90**
Error	20	51269	2563	
Total	24	91208		

Within Stand 13

Source	df	SS	MS	F
Factor	4	2441	610	.62*
Error	20	19734	987	
Total	24	22176		

Within Stand 14

Source	df	SS	MS	F
Factor	4	13809	3452	10.00***
Error	20	6902	345	
Total	24	20711		

Within Stand 15

Source	df	SS	MS	F
Factor	4	2981	745	.87*
Error	20	17184	859	
Total	24	20165		

Within Stand 16

Source	df	SS	MS	F
Factor	4	3528	882	.47*
Error	20	37773	1889	
Total	24	41302		

* not significant at .05 or .01 levels
** significant at .05 level
*** significant at .01 level