Aspen Invasion in a Portion of the Alberta Parklands

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Highlight: *Brush areas on ranges in the parkland region of southcentral Alberta have increased from 4.8 to 8.0% of the land area between 1907 and 1966. The invasion was not constant each year, but was concentrated in two major periods between 1937 and 1970. Annual herbage production under aspen and willow was reduced by 80 to 90% when compared with the production of adjacent rough fescue grassland. The invasion of aspen into grasslands was correlated with high temperatures, particularly during the month of June, 1 and 2 years before tree establishment and with low precipitation 2 years prior to establishment.*

The aspen parkland is a major vegetation zone where groves of aspen (*Populus tremuloides* Michx.) and willow (*Salix* spp.) are interspersed with grassland. The parkland zone is a tension area between the prairie to the south and the boreal forest to the north. The prairie vegetation occurring within the parklands has been described regionally as the rough fescue (*Festuca scabrella* Torr.) and the mixed prairie associations of western Canada (Coupland, 1950).

The invasion of fescue grassland by brush (Fig. 1) has been recorded by Moss and Campbell (1947) and Johnston and Smoliak (1968) in Alberta, by Coupland and Maini (1959) and Maini (1960) in Saskatchewan, and by Blood (1966) in Manitoba.

The purpose of our study was to establish whether brush invasion had occurred in southcentral Alberta and to determine the rate of invasion and the effect of brush on herbage production.

The study area was located on the southern edge of the parklands of southcentral Alberta in Township 34, Range 19, west of the 4th Meridian, about twenty-five miles south of Stettler, Alta. The topography was moderate to strongly rolling, known locally as knob and kettle topography. The dark brown soils had developed on glacial till. Average annual precipitation was 36 to 41 cm (14 to 16 inches). The frost-free period was 100 to 110 days. The July and January mean temperatures were 18° C (64°F) and −13°C (9°F), respectively. The study area had been lightly grazed since white settlement.

Methods

During 1969, available annual production in aspen, willow, and rough fescue communities was measured by randomly locating two 0.25-m^2 plots in each of five stands per community. The plots were clipped at ground level in late July, sorted to grass and grass-likes, forbs, and current annual growth of shrubs, air-dried, and weighed. The cover of brush along each survey line was recorded by land surveyors during the original Dominion of Canada legal land survey in 1907. Forty samples, each 1 mile in length, were randomly selected from the legal land survey field notes of Cautley (1907) for study. The same lines were then located on aerial photographs taken in 1966. For each sample transect, the length of the 1-mile line covered by brush in 1907 and 1966 was measured. The two figures were compared to determine whether brush cover had changed during the 59-year period. Four aspen groves were randomly selected to estimate tree age. The small trees (young stands) on the outer perimeter of each grove were sampled separately from the taller, larger diameter trees (mature stands) near the center of the grove. In 1970, 40 aspen trees in each grove, 20 in the young stand and 20 in the mature stand were randomly selected, cut down, the height measured and a cross-section of each stem was collected. During the winter, the block from each cross-section was sanded and the growth rings were counted using a 7 to 20X binocular microscope. Since most of the trees were less than 35 years old, false rings were either not present or were easily recognized.

Correlation coefficients and regression equations were developed relating

Fig. 1. *Small trees at the edge of the aspen clone have recently established in rough fescue grassland.*

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tree establishment to environmental factors. The precipitation data used were the average of data from the three closest meteorological stations of the Canada Department of Transport, Meteorological Division. Temperature data were obtained from the meteorological station at Calgary, Alta.

Results

Vegetation production under the closed canopies of the willow and aspen communities was reduced significantly compared to the adjacent grassland (Table 1). The grass and grass-like production was reduced to 310 kg/ha under willow and 154 kg/ha under aspen compared to 1944 kg/ha in the adjacent grassland. This represents a reduction of grass and grass-likes of 84% under willow and 92% under aspen.

Most one-mile transects had some brush on them in 1907 and 1966, but the mean area occupied by brush increased from 4.8% to 8.0% (Table 2). Of the 40 one-mile transects sampled, 68% increased in brush cover while only 7% decreased. The net increase in brush cover was 3.2% over 59 years; the annual rate of invasion averaged 0.05%.

In 1907 the brush cover for the one-mile transect presented in Fig. 2 was restricted to five stands of willow. By 1966, the same line crossed five stands of aspen and eight stands of willow. Cautley (1907) recorded only two groves of aspen crossing the 40 one-mile transects. In 1966, 35 of the 40 transects (88%) had one or more aspen groves present.

The growth ring analysis indicated major periods of rapid tree invasion (Fig. 3). Two periods, 1960 to 1965 (5 to 10 years ago) and 1944 to 1950 (20 to 26 years ago) had the highest frequency of tree establishment. Of the 160 aspen trees studied, the youngest tree was 3 years old and the oldest was approximately 67 years old (67 growth rings). As aspen grows older, more false rings seem to occur, making estimation of tree age more difficult.

Trees in the young aspen stands had diameters ranging from 1.3 to 7.1 cm (0.5 to 2.8 inches); the trees ranged from 1.4 to 8.7 m (5 to 28 ft) tall. In the mature aspen stands, the tree diameters ranged from 4.6 to 30.5 cm (1.8 to 12 inches); the trees ranged from 4.5 to 15.7 m (15 to 51 ft) tall.

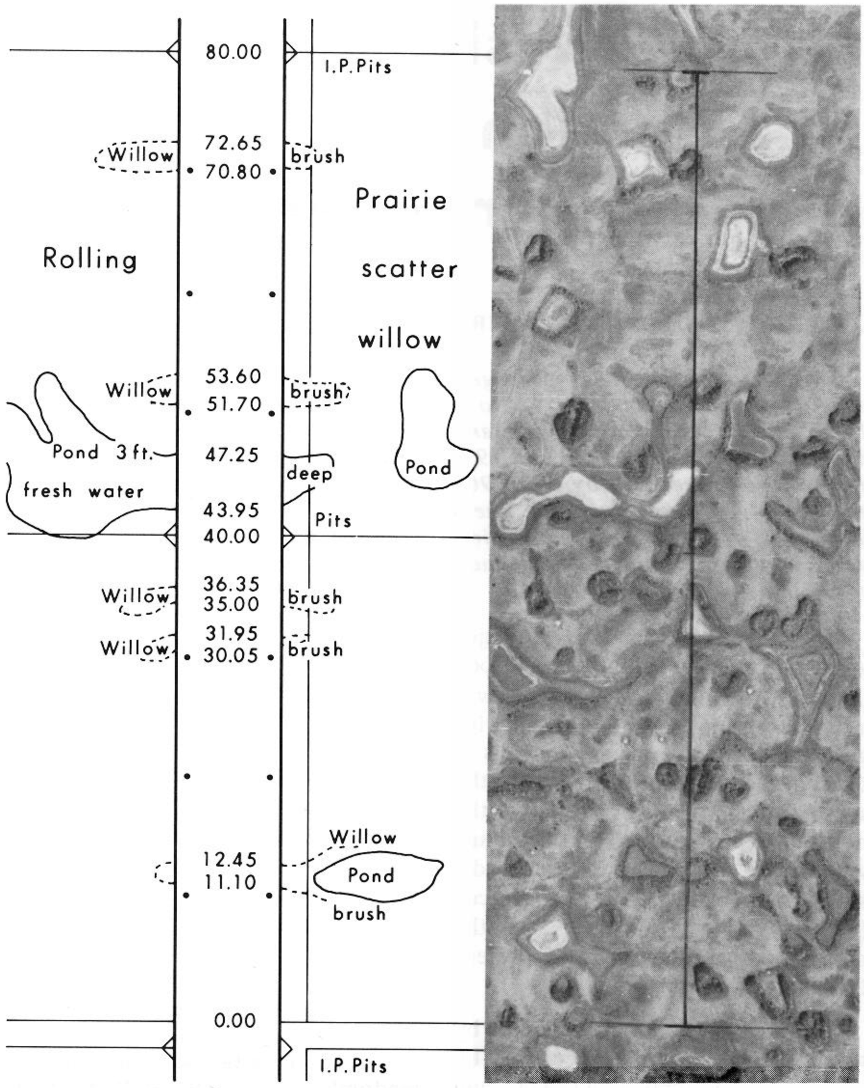

Fig. 2. *The 1907 survey line (left) and the same mile-long transect line as it appeared on the 1966 aerial photography (right).*

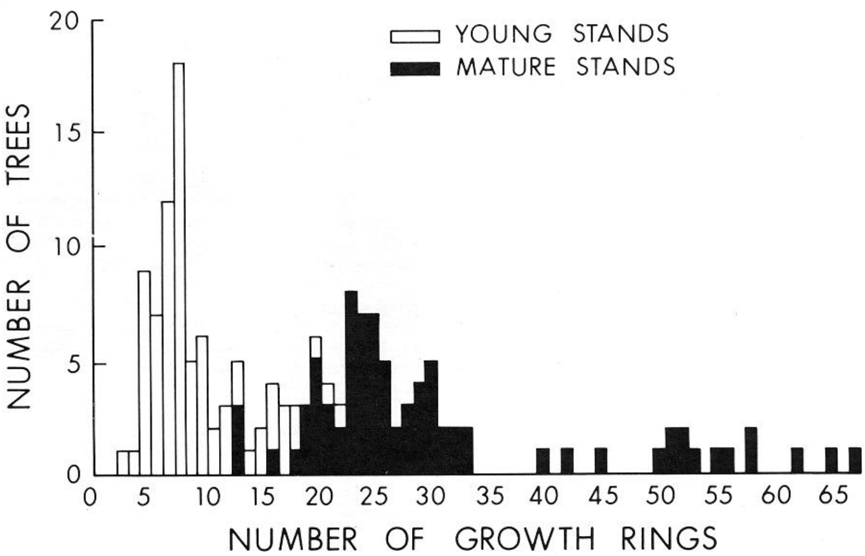

Fig. 3. *The relationship of aspen tree establishment to estimated age (growth rings).*

Table 1. Annual herbage production (kg/ha)[1] of willow, aspen, and adjacent rough fescue grassland communities in 1969.

Vegetation class	Willow (n = 10)	Aspen (n = 10)	Rough fescue (n = 10)
Grass and grass-likes	310	154	1944
Forbs	218	82	46
Shrubs	0	282	22
Total available production[2]	528 ± 64[3]	518 ± 76	2012 ± 88

[1] To convert kg/ha to lb/acre multiply by 0.89.
[2] Total annual production of the rough fescue grassland but only available annual production in the other two communities because annual growth of tall willow and aspen beyond the reach of livestock was not measured.
[3] Standard error of the mean.

Maini (1960) reported that suckering was stimulated when temperature and moisture conditions were favorable. In this study, the correlation for all 160 trees between rate of tree establishment and annual precipitation was nonsignificant (r 0.02). This value may have been influenced by climatic extremes. Aspen is a short-lived tree detrimentally affected by drought (Maini, 1960). Few trees were more than 32 years old (Fig. 3). The sample of trees surviving prolonged droughts of the 1930's may be too small to give a significant correlation. To test the relationship of tree establishment to temperature and moisture conditions since the drought of the 1930's, correlation coefficients were developed for trees established in the 1937 to 1970 period. Mean air temperatures and total precipitation were tested for the year of tree establishment as well as 1, 2 and 3 years prior to tree establishment for May, June, July, August, September, June to August, May to September, and annually. Mean air temperature 1 year prior to tree establishment was significantly correlated for June (r = 0.42*, $P<0.05$), June to August (r = 0.35*), and annually (r = 0.43*). Mean temperature 2 years prior to tree establishment was significantly correlated for June to August (r = 0.34*) and annually (r = 0.38*). Precipitation 2 years prior to tree establishment was significantly negatively correlated for May to September (r = −0.38*) and annually (r = −0.46**, $P<0.01$).

Multiple regression equations were developed using 33 years of tree establishment data and 51 temperature and precipitation variables. One equation having nine independent variables accounted for 55% of the total variation. A more readily understandable equation is the one following which accounted for 41% of the total variation:

$$Y = -31.501 - 0.453\,X_1 + 0.587\,X_2 + 0.373\,X_3$$

where Y = number of trees established, X_1 = annual precipitation 2 years before tree establishment, X_2 = mean annual temperature 1 year before tree establishment, and X_3 = mean temperature for June the year before tree establishment. The multiple correlation coefficient (R = 0.642) was significant ($P < 0.01$). The t-test on the slope b for each variable (X_1, X_2, X_3) was also significant ($P < 0.05$).

A single variable, June mean temperature 1 year before tree establishment was found to be highly significant (r = 0.556) for the 22 years having three or more trees established (Fig. 3). The linear regression equation was:

$$Y = -27.861 + 0.607\,X$$

where Y = number of trees established and X = mean June temperature the year before tree establishment. This accounted for 31% of the variation and the t-test on the slope b was significant ($P < 0.01$).

Discussion

Brush species, particularly aspen, have invaded grassland along the southern edge of the aspen parkland where the study area was located. Our findings agree with other research in Alberta by Moss and Campbell (1947) and Johnston and Smoliak (1968). The rate of invasion of brush on to grassland, however, averaged only 0.05% per year compared to 0.75% per year in the Porcupine Hills of Southwestern Alberta, an area of higher annual precipitation. The dark brown soil zone in Saskatchewan where Maini (1960) worked had a climate similar to that of the study area. He reported rates of invasion of 1.0 to 2.5 ft/mile per year; these rates (0.02 to 0.5% per year) are very similar to the average rate of invasion of 0.05% annually found in the study area.

The area now dominated by aspen may have produced more than 1990 kg/ha prior to the invasion of aspen. Under mature aspen stands sampled, 60% of the soils were black chernozems, and the remaining were carbonated regosolic humic gleysols. In contrast, 80% of the soils under rough fescue grasslands were dark brown chernozems, soils which have developed under drier climatic conditions than those under aspen. Aspen groves generally occur downslope from fescue grasslands or on north-facing slopes. In the dark brown soil zone of Saskatchewan, Ayyad and Dix (1964) have demonstrated that north-facing slopes usually have higher soil moisture than middle or upper slope positions. An 88% reduction in annual herbage production is probably a conservative estimate because aspen now occupies more productive soils.

The invasion of aspen into adjacent grasslands as has occurred in the young stands studied was assumed to have occurred in years of high precipitation as indicated by Maini (1960). It has been demonstrated for beech (*Fagus grandifolia*) that the width of annual rings is positively related to June precipitation of that year but negatively related to June mean temperatures of 1 year before (Diller, 1935). However, in this study, tree establish-

Table 2. A comparison of brush cover on 40 one-mile transects in 1907 and 1966 in south central Alberta.

Item	1907	1966
Transects having some brush cover (%).	92	95
Transects having no brush cover (%).	8	5
Range in brush cover per mile (%).	0–18	0–26
Mean brush cover (%).[1]	4.8	8.0**[1]
Transects that increased in brush cover (%).		68
Transects that decreased in brush cover (%).		7
Transects that remained the same (%).		25

[1] Significantly greater ($P < 0.01$) than brush cover in 1970 using the paired t-test.

ment in aspen was found to be negatively related to the precipitation and positively related to the mean temperature regimes that occurred 1 and 2 years previous. It would appear that aspen suckering and invasion of grasslands is closely linked to high soil temperature (Shirley, 1932; Maini, 1968), low precipitation, and possibly also to apical dominance (Farmer, 1962). Our findings are in agreement with Maini (1968), who maintains that any disturbance resulting in an increase in soil temperature stimulates aspen suckering. The greatest invasion of aspen into grassland in the study area occurred in 1962, 1 year after the 1961 drought, when the June mean temperature was 8° F above the 33-year average. Suckering continued for 1963 and 1964, when the June mean temperature the year before had also been higher than average.

Dix and Steen (1968) recorded the widespread dieback of aspen groves in the parklands of Saskatchewan in the mid-1960's and suggested that the dieback was triggered by the severe drought of 1961. Dead aspen trees were observed in some groves studied, but it is not known when mortality occurred. The 1961 drought apparently triggered a massive invasion of aspen suckers into the grassland. The invasion was closely related to high mean temperatures and low precipitation 1 and 2 years prior to establishment. It is not known whether this invasion was related to the loss of apical dominance caused by dieback of some of the mature trees.

Summary and Conclusions

Annual herbage production under brush was only 10 to 25% of that of the adjacent grassland. Brush cover of aspen and willow showed a net increase of 3.2% during the 59-year period of 1907 to 1966. Age distribution of the trees indicated that the invasion was concentrated into two major periods of expansion. The increase in cover of brush included the establishment of new stands as well as the increase in size of established stands. In 1907, only two groves of aspen were recorded in 40 one-mile transects but by 1966, 88% of the transects had aspen groves present. The rate of invasion may well be increasing because of the greater number of brush patches becoming established. Over many years, the invasion of aspen and willow would mean a loss in forage production and a decline in carrying capacity of these ranges for domestic livestock.

The invasion of aspen into rough fescue grassland was found to be related to high growing season temperatures, particularly during the month of June 1 and 2 years prior to establishment and to low May to September and annual precipitation 2 years prior to establishment. The effect of the loss of apical dominance in aspen on invasion into grassland by suckers was uncertain.

Literature Cited

Ayyad, M. A. G., and R. L. Dix. 1964. An analysis of a vegetation-microenvironmental complex on prairie slopes in Saskatchewan. Ecol. Monogr. 34:421-442.

Blood, D. A. 1966. The *Festuca scabrella* association in Riding Mountain National Park, Manitoba. Can. Field Naturalist 80:24-32.

Cuatley, R. H. 1907. Field notes of township 34, range 19, west of the 4th Meridian. Dominion of Canada, legal land survey, Field Book 9874, Prov. Dep. Highways Bldg., Edmonton, Alta.

Coupland, R. T. 1950. Ecology of the mixed prairie in Canada. Ecol. Monogr. 20:271-315.

Coupland, R. T., and J. S. Maini. 1959. Woodland invasion of western Canadian grasslands. IX Inter. Bot. Cong. Proc. II, IIA. Montreal.

Diller, O. O. 1935. The relation of temperature and precipitation to the growth of beech in northern Indiana. Ecology 16:72-81.

Dix, R. L., and O. A. Steen. 1968. Aspen dieback in the parklands of Saskatchewan. Late Spring Issue, Bull. Ecol. Soc. Amer. p. 81.

Farmer, R. E., Jr. 1962. Aspen root sucker formation and apical dominance. Forest Sci. 8:403-410.

Johnston, A. M., and S. Smoliak. 1968. Reclaiming brushland in southwestern Alberta. J. Range Manage. 21:404-406.

Maini, J. S. 1968. Silvics and ecology of *Populus* in Canada. p. 20-69. *In* Maini, J. S., and J. H. Cayford, ed. Growth and utilization of poplars in Canada. Dep. Forest. and Rural Div., Forest. Branch Dep. Publ. 1205.

Maini, J. S. 1960. Invasion of grassland by *Populus tremuloides* in the Northern Great Plains. PhD thesis, Univ. Saskatchewan, Canada. 231 p.

Moss, E. H., and J. A. Campbell. 1947. The fescue grassland of Alberta. Can. J. Res. 25:209-227.

Shirley, H. L. 1932. Does light burning stimulate aspen suckers? II. J. Forest 30:419-420.

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**The date was given erroneously as Feb. 4-9 in two previous issues.*