Conifer Encroachment on the Chilcotin Grasslands of British Columbia

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Abstract

Detailed quantitative examination of a grassland/forest ecotone near Williams Lake, B.C. showed that a combination of fire, grass competition and subtle micro-site determinants of soil moisture availability appear to be the factors influencing tree encroachment most strongly. Historically fire has inhibited tree establishment on the grasslands — between 1759 and 1926 the fire interval approximated 10 years. Presumably because of heavy grazing, no severe fires have burned the area since 1926. Conifer encroachment began in 1931 and virtually ceased in 1972.

Résumé

Un examen quantitatif détaillé d'un écotone prairie/forêt près de Williams Lake, B.C. a démontré qu'une combinaison du feu, de la rivalité de l'herbe et des déterminants de micro-site subtils de rétention d'humidité du sol semble avoir le plus d'influence sur l'empiètement des arbres. Il est reconnu historiquement que le feu a stimulé l'implantation de l'arbre dans les prairies — entre 1759 et 1926, il y eu un feu à peu près à tous les 10 ans. On présume que c'est dû au pâturage intense qu'il n'y a pas eu de grand feu depuis 1926. L'implantation des conifères a débuté en 1931 pour se terminer vers 1972.

Background

Forest encroachment upon B.C. grasslands, that is, the establishment of trees in grass communities by seed dispersed from adjacent stands, is a continuing problem for rangeland managers. The spread of forests into grasslands was well recognized in the southern interior of the Province as long as sixty years ago (Whitford and Craig, 1918), and only last year it was brought to the attention of a Select Standing Committee on Agriculture of the provincial legislature (Anon, 1977). Most of the encroachment is by Douglas-fir[1] with some lodgepole pine. Suckering of aspen is apparent too but it results more in increasing stocking of existing stands rather than an extension of the forest edge.

A dense tree cover inhibits forage production (Burkhardt and Tisdale, 1976; Eddleman and McLean, 1968), as well as impeding cattle movement. Thus, the continuing spread of trees, mostly Douglas-fir and some lodgepole pine, on to the grasslands of the Cariboo/Chilcotin is viewed with concern by ranchers and rangeland managers alike. One site where encroachment is prominent, Dester Ridge near Williams Lake (Fig. 1), was studied to elucidate the environmental conditions which foster encroachment.

Literature Review

The advance of forest tree regeneration on to grasslands adjacent to forests has been noted by a number of researchers in western North America, including British Columbia. However, the phenomenon has received little detailed study.

Rummel (1951) concluded that grazing had reduced the density of herbaceous vegetation, thus creating an environment conducive to the establishment of forest tree reproduction. Koterba and Habeck (1971) felt that the development and maintenance of certain grasslands in Glacier National Park, Montana were due to an interaction between local climate, soil texture, and fire history. Sindelar (1971) reached similar conclusions and, like Rummell (1951), found that tree invasion coincided with unusually heavy precipitation during the growing season. Gartner and Thompson (1972) attributed the encroachment of ponderosa pines in the Black Hills of South Dakota to the exclusion of periodic ground fires. They found more trees on shallow, coarse-textured soils occupied by grass species which did not compete directly with the pine seedlings, whose growth period began earlier in the season.

Study Area

Dester Ridge lies in the Fraser Plateau, an area of rolling upland with steep local relief. Much of the plateau is covered by Pleistocene glacial drift (Holland, 1976) and Ridge soils are Orthic Black Chernozems or Orthic Gray Luvisols which were derived from gravelly loam or clay loam tills. Surficial strata are friable but there is a compacted calcareous layer at about 1 m depth.

Climatic data from Big Creek, about 35 km southwest of the Ridge, depict a cool, dry region in the rain-shadow of the Coast Mountains. Precipitation is bi-modal, with peaks in June and December, and averages 32 cm annually, with about 125 cm or some 35% of the total falling as snow (Bell, 1969; Weir, 1964). Summers are short and warm while winters are long and fairly cold (Fig. 2).

Two grassland associations are common on the Ridge — a pussytoes/Sandberg's bluegrass association on dry sites and a Richardson's needlegrass one where there is more moisture. Forest stands are characterized by a Douglas-fir/pinegrass association (Fig. 3).

Settlement began in the region in 1829. There was a burst of activity associated with the Fraser River gold rush, which peaked in the Cariboo in 1863, and a second surge of settlement at the turn of the century (Weir, 1964). Thirty years later it was noted that the ranges were in poor condition, and by 1939 some portions had to be withdrawn from use (McKee, 1932, 1940). Nowadays some 2,000 cattle graze on the 2,600 ha West Pasture of Dester Ridge in the spring and fall in a three pasture rotation.

Method

Four randomly-located belt transects were run from the forest edge out into the grassland where young trees were encroaching, and two were established in areas where no trees were present. In the transects, which were 20 m x 120 m or 0.24 ha, ground vegetation was estimated by point sampling and all trees were measured for distance from the

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[1]Botanical names of all species cited are appended

forest/grassland boundary; height of the two lowest branches above ground, bark thickness at ground level and at 15 cm above ground; and age based on a count of annual rings at ground level. A soil pit was excavated in each transect as well. Six 0.6 ha semi-circular plots were established in the forest adjacent to the grassland, one plot adjoining each of the belt transects. Within these forest plots all trees were tallied by species for d.b.h., with a small number of trees being selected for height and age determination. Ground vegetation was sampled by the same technique employed for the grassland vegetation. Sections of wood from fire-scarred Douglas-fir trees were removed following techniques outlined by Arno and Sneck (1977) to construct a fire chronology.

Results

In the two transects which had very few or no trees, ground cover (that proportion of the ground surface occupied by vegetation) was 98% for Transect A and 82% for D. Grass species comprised 67% of the cover on A with the sod-forming Kentucky bluegrass being prominent, while on D, bare ground and pussytoes (an indicator of degradation) were more abundant than on any other transect.

For the four transects with trees, numbers of trees were plotted against distance from the forest margin in 10 m increments (Fig. 4). It was found that encroachment had begun in 1931 and ceased in 1972 (Fig. 5). Analysis of d.b.h. class distribution within stands showed a preponderance of smaller trees, that is, of juvenile age classes.

Tree age was weakly correlated with distance from the stand edge in one transect only and in this case improvement cutting confounds the results. In the other three cases there was no correlation.

Bark thickness was significantly correlated with age both at ground level and at the 15 cm mark. However, there was no significant correlation between age and height to the lowest branches.

An examination of eleven wood sections taken from fire wounds on old-growth Douglas-fir revealed a total of 54 individual fire scars. The record of ground fires indicated by these scars may be incomplete as a low-intensity fire may not scar any trees and the enlargement of fire wounds by later fires may obliterate existing scars.

Nevertheless, by comparing fire dates from different trees and weighting the comparisons according to the numbers of trees and the definition of scars, a fairly reliable chronology was constructed. Fires were indicated for the years 1759, 1790, 1796, 1811, 1824, 1832, 1838, 1845, 1848, 1864, 1868, 1878, 1888, 1905, 1910, 1920, and 1926. The fire frequency for this time period is 9.8 years and it appears that no significant ground fires have taken place since 1926.

Discussion

A. Climate

There was no obvious correlation between gross yearly climatic fluctuations and numbers of trees becoming established (Fig. 6). Nor was it possible to relate tree diameter increments to climatic data. Temperature and precipitation records for the period 1904-77 showed no distinct shifts or trends but merely short-term fluctuations about a mean. Weather during April-June would affect initial establishment of germinants while the next three months, July-September, might be sufficiently dry and hot to kill seedlings.

In the interior of B.C. good seed crops were produced on Douglas-fir in 1948, 1952, 1959, 1966, and 1971 (Wallinger, pers. comm.[2]). One would expect that a good seed year

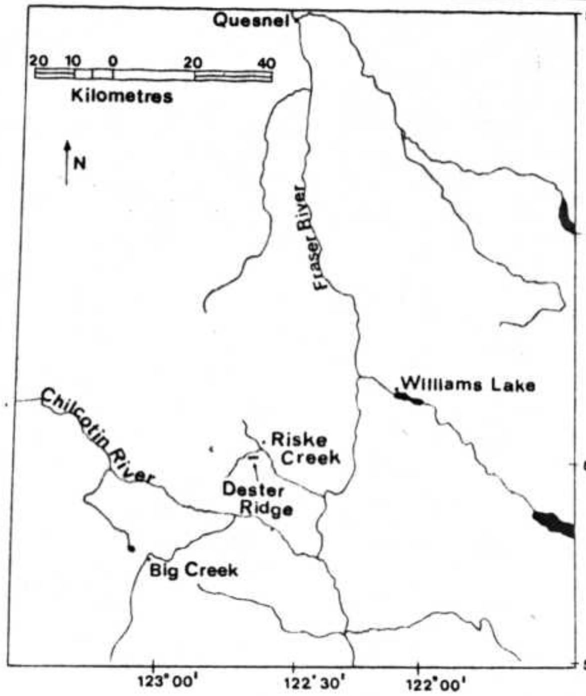

Fig. 1. Location of Study Area.

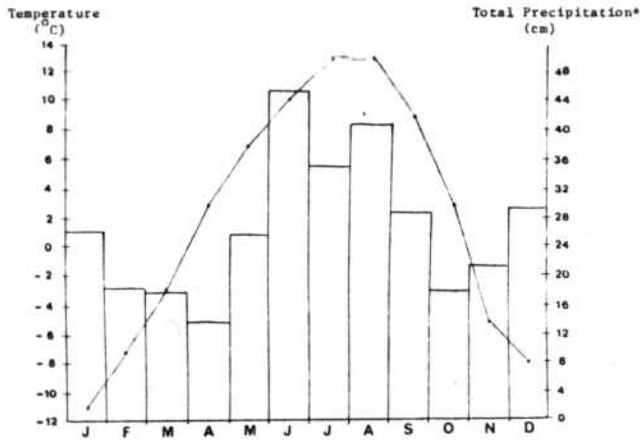

Fig. 2. Climatic Diagram.

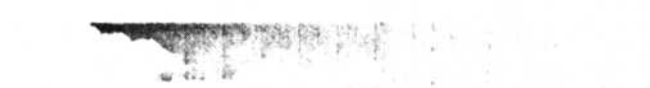

Fig. 3. General View of Study Area, Showing Encroachment.

[2]D. Wallinger, Reforestation Division, Ministry of Forests, Victoria, B.C.

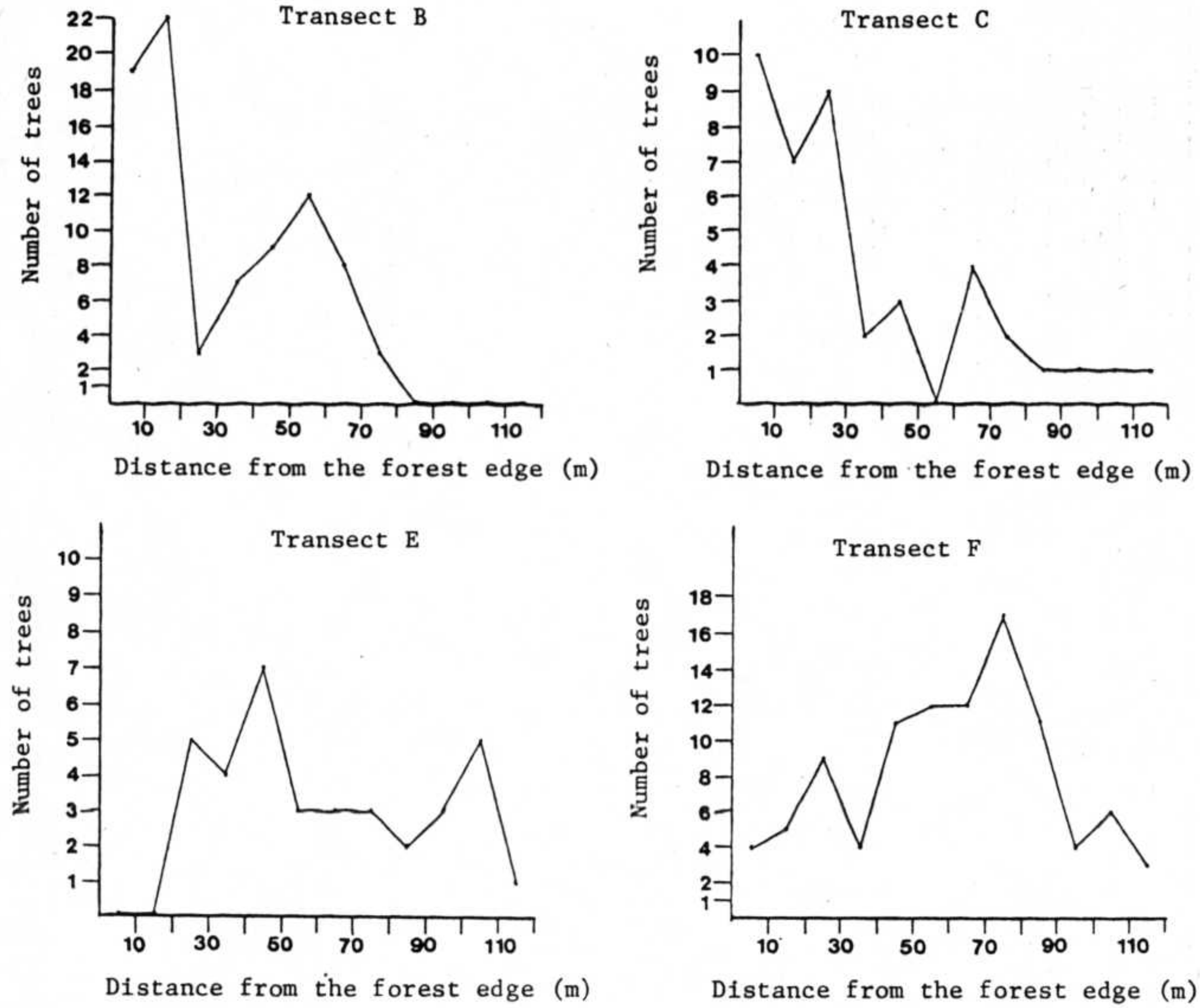

Fig. 4. Numbers of Trees Related to Distance from Forest Edge.

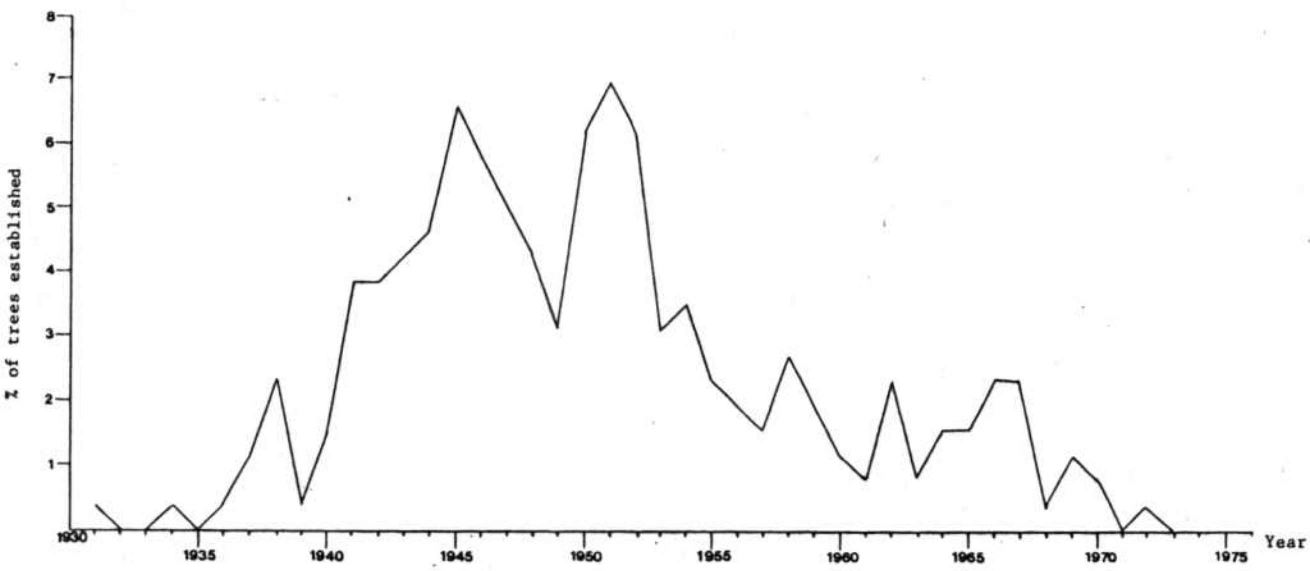

Fig. 5. Proportion of Encroaching Trees Plotted Against Year of Establishment.

followed by suitable weather would foster tree seedlings. If Dester Ridge conformed to the general pattern, and since 1972 was wetter than normal, more seedlings than the average might be expected to become established at this time. In fact, only one tree was found in this age class and very few younger than seven years were to be seen. The weather conditions in 1951 and 1971 were almost the same but the number of trees established per year peaked in 1951 and was zero in 1971. Again, weather in 1945 and 1972 was similar (though the 1972 spring was cool) but numbers of trees becoming established were very different.

If weather is a determinant of seedling establishment, more subtle, site-specific effects must be sought — micro-topography, and such micro-site parameters as surface temperature, soil moisture in the uppermost strata and evaporation. Also, extreme events rather than averages should be considered. Existing data do not permit such detailed examinations.

B. Fire

The fire chronology and the absence of charcoal indicate that no fire, or at least no fire intense enough to cause scarring, has occurred since 1926 although fire suppression was not organized in this area until 1961 (Muraro, pers. comm.[3]). Since the weather during these 51 years has not been exceptional, the absence of fire is attributed to a reduction in litter accumulation, i.e. potential ground fuels, consequent upon fairly intensive grazing by domestic stock (Campbell, 1954: Burkhardt and Tisdale, 1976).

Periodic ground fires have maintained the forest on Dester Ridge in an "open" condition and have helped keep tree regeneration off the grassland. The direct relationship found between tree age and bark thickness at and near the ground implies that if fires were frequent enough the encroaching trees would probably be killed by cambial heating before they could develop adequate insulation to survive a fire. The consistently low branching habit of the trees encourages "crowning out" which could also lead to mortality.

C1. Grazing —Domestic Stock

Grazing by domestic animals can have a two-fold effect on grass x tree interactions — by removing grasses and herbs it eliminates the trees' competitors and, by trampling and tilling, hoof action exposes soil and provides a suitable seedbed for invading tree seeds (Rummell, 1951; Tisdale, 1950). Only hearsay evidence is available but what there is suggests that the Dester Ridge range was in very poor condition just prior to 1940, the beginning of a decade when many trees became established. It is not unreasonable then to assume that competition was slight and exposure of mineral soil extensive when the majority of encroaching trees took hold.

C2 Grazing — Wildlife

Damage to Douglas-fir seedlings and saplings can result from deer browsing, clipping by rodents and other small mammals or disbudding by grouse. Black *et al.* (1979) found that young Douglas-fir could endure up to five years of such animal use with negligible effect on survival. However no signs of dead stems or of young, damaged trees were to be found on Dester Ridge and only cattle faeces were seen. Some browsing or de-barking of saplings was evident but it appeared to be by cattle. Squirrels are common in the mature stands but they are unlikely to venture into open grasslands frequented by raptors from the shelter of the trees where food is plentiful.

[3]S. J. Muraro, Research Scientist, Canadian Forestry Service, Pacific Forest Research Centre, Victoria, B.C.

D. Integration

If one accepts that no fire of consequence has burned since 1926, that cattle grazing has been more or less uniform and wildlife impacts have been small, and that no significant shift in meso-climate has taken place on Dester Ridge in the last half-century, it appears that micro-site factors, strongly influenced by existing ground vegetation, determine the success or failure of tree seedling invasion.

Density of encroaching trees decreased with distance from the forest margin. Since Douglas-fir seed can travel at least six times as far as the parent tree is tall (U.S.D.A. Forest Service, 1965) and old trees on the Ridge were upwards of 25 m tall, distance from seed source should not be an important determinant of seedling numbers within a 120 m transect. Qualitative examination suggests that shelter from the adjacent tree stand has a marked bearing on establishment, which agrees with Bell's (1969) finding that soil moisture was more abundant because of a greater accumulation of snow and slower melting in the lee of a tree stand. Transect B illustrates this point also. There, that half of the transect which is sheltered by adjoining trees and topography has the majority of the trees occurring, and half of these trees are within the first 20 m out from the stand. That slope and aspect themselves are not critical is demonstrated by a comparison of the treeless Transect D with Transects E (36 trees) and F (98 trees). D has a southerly aspect and a 4% slope while E and F have 5%/150° and 8-17%/170-219° slopes respectively. D. is on an exposed spur of the main Ridge with a shallow solum and some exposed bedrock while E and F are somewhat sheltered by adjacent tree stands.

E. Management Implications

Ecesis of forest trees in grasslands can be regarded as a natural process, fostered by human activities. Whether it is 'good' or 'bad' depends on the objectives of management. If wood fibre is the principal product desired then encroachment is beneficial, though increment rates and tree form will be less than ideal. If forage is wanted, encroachment is undesirable and will have to be controlled. Prescribed burning could be an effective tool for this purpose but only if grazing were reduced to permit adequate fuel accumulation for an effective fire. Individual torching might be used but it is labour-intensive. Any burning technique carries the attendant risk of a fire escaping and has a variable kill success, also resultant dead material may impede access. Individual herbicide treatments would be effective but expensive, and broadcast application of herbicides appears inappropriate for such irregular and dispersed stands. Hand felling followed by piling and burning would be labour intensive, too, but might be practical if combined with salvage logging and Christmas tree production.

For multiple use of an area subject to encroachment, a decision will be required as to the desirable mix of products before the appropriate balance of treatments can be decided.

Conclusion

The process of forest tree encroachment on to the grasslands of Dester Ridge is the result of a sequence of changes in a number of factors and the interaction amongst them. In the recent past, periodic fires apparently maintained the grasslands. Some fifty years ago increased grazing pressure minimised the amount of fine fuels and thus inhibited burning. More recently fire protection measures have been instituted so that, despite grazing control and a consequent increase in fine fuels, fires will still be limited. Heavy grazing by domestic stock also provided vegetation and so, in this period, invasion by trees was common.

Those sites which are very exposed to dessicating winds and insolation are not likely to support many trees, if any, tree mortality being induced by a deficit of available soil water. Sites which benefit from shelter from the adjacent tree regeneration because of the presence of a physical barrier to seedling establishment and subsequent competition for growing space, water, and nutrients.

On those sites which fall between these two extremes the density of the encroaching trees is related to microsite characteristics as is propounded by Sindelar (1971). Initial

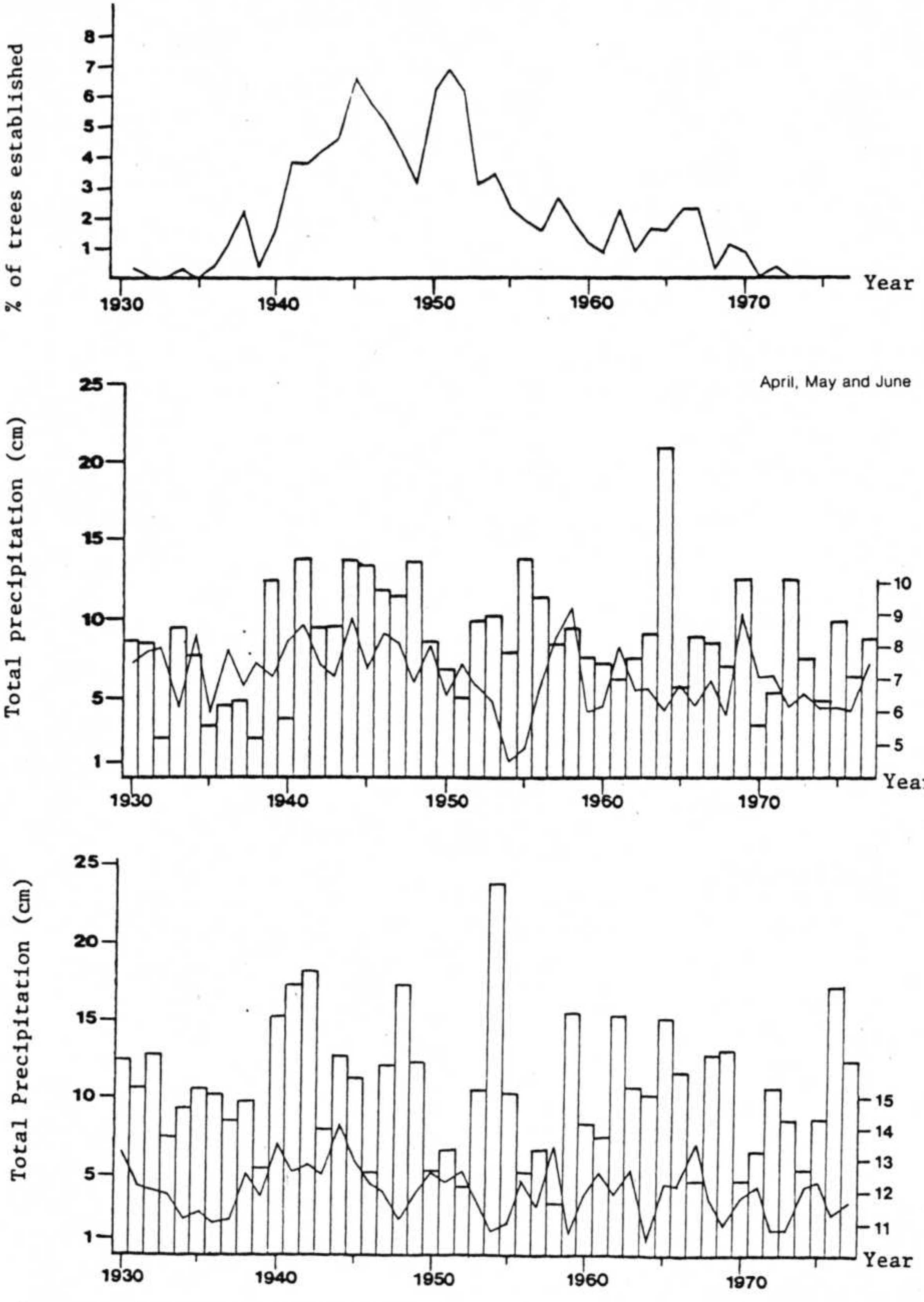

Fig. 6. Percentage of Encroaching Trees Plotted Against Climatic parameters.

advance of the forest will depend on seed from the parent stand but may gain momemtum as the first generation encroachment bears seed.

A study has now been instituted to examine the controlling factors in detail so that land managers will be better placed to understand the ecological processes going on and to determine how best to achieve their management objectives.

Common and Botanical Names of Species Cited in the Text

Pussytoes	*Antennaria* spp.
pinegrass	*Calamagrostis rubescens* Buckl.
lodgepole pine	*Pinus contorta* var. *latifolia* Engelm.
Kentucky bluegrass	*Poa pratensis* L.
Sandberg's bluegrass	*Poa secunda* Vasey
Douglas-fir	*Pseudotsuga menziesii* (Mirb.) Franco
Richardson's needlegrass	*Stipa richardsonii* Link.

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