Fire Resistance of Forest Species as Influenced by Root Systems[1]

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Highlight

There is a close relationship between root system characteristics and the relative fire resistance of douglasfir forest zone species in southern interior British Columbia. Susceptible species are usually those that have fibrous root systems or produce stolons or rhizomes which grow above mineral soil. Moderately resistant species usually have fibrous roots with rhizomes which grow less than 5 cm below the mineral soil surface. Resistant species are those that have rhizomes which grow between 5 and 13 cm below the mineral soil surface and those species with taproots which are able to regenerate from below their crowns. Both timber milkvetch and lupine are undesirable range plants and yet both may increase after a fire.

Fire has been a significant factor affecting plant composition and forage values on forest ranges of the douglasfir zone in southern British Columbia (Tisdale and McLean, 1957).

It has been recognized that relatively few generalizations can be made about fire successions since so many conditions of the soil and living organisms affect the survival and invasion of plant species as a result of burning (Ahlgren and Ahlgren, 1960). Nevertheless, in studying range management in southern British Columbia it has been necessary to attempt to predict the plant composition of forested areas following fires. As a result, studies to this end are underway at the CDA Research Station, Kamloops, on both controlled and wild burns.

Two main processes are operative in the post-fire succession on any area, namely, regeneration either from underground reproductive structures or viable seed present in the soil and invasion by wind-, animal-, or bird-disseminated seed.

The present study is an attempt to predict and explain, to some degree at least, the relative fire-resistance of species as influenced by their root structure.

Methods

Thirty of the most commonly occurring ground-cover species of the douglasfir zone, as indicated by the work of Tisdale and McLean (1957) and subsequent observations by the author, were selected for study.

The gross root structure of at least five plants of each species on each of three sites was examined and drawings and notes were made on representative specimens. The three sites were dominated by mature douglasfir (250 years), mixed lodgepole pine and aspen, and lodgepole pine (90 years); the soils were Orthic Gray Wooded (Leahey, 1965) medium-textured till, Dark Gray Wooded moderately coarse textured till, and Degraded Brown Wooded coarse textured glacial outwash, respectively.

The species selected were observed on lightly (organic layer not completely penetrated) and heavily burned (organic layer completely penetrated) locations on sites that had been burned by wildfires 1, 4, 12, and 19 years previously. The species were subjectively classified into three categories of relative fire resistance for management purposes, namely, susceptible (S), moderately resistant (M), resistant (R).

Plant nomenclature follows Hitchcock et al. (1955, 1959, 1961, 1964) for the dicots and Davis (1955) for all other plants.

Results

The species studied were placed into seven groups based on their rooting characteristics and assigned to one of the three categories of fire resistance as indicated by the symbol following the name (see below).

A. Species that are without rhizomes but have fibrous roots (only one genus was observed in this group and it had its crown immediately under the mineral soil surface):
   - white hawkweed (*Hieracium albiflorum*) (S)
   - yellow hawkweed (*H. umbellatum*) (S)

B. Species that have fibrous roots and stolons (Fig. 1 A) (sometimes the crown of the parent plant lies just below the top of the mineral soil):
   - bearberry (*Arctostaphylos uva-ursi*) (S)
   - strawberry (*Fragaria glauca*) (S)
   - twinflower (*Linnaea borealis*) (S)

C. Species that have fibrous roots and rhizomes which grow mostly in the duff layer or between it and the mineral soil (Fig. 1 B):
   - northern sedge (*Carex concinnoides*) (S)
   - rattlesnakeplantain (*Goodyera oblongifolia*) (S)
   - sidebells pyrola (*Pyrola secunda*) (S)
   - grouse whortleberry (*Vaccinium scoparium*) (M)
   - yarrow (*Achillea millefolium*) (M)

D. Species that have fibrous roots and rhizomes which grow mostly from 1.5 to 5 cm below the mineral soil surface (Fig. 1 C) (the parent plants may or may not have crowns close to the soil surface):
   - arnica (*Arnica cordifolia*) (S)
   - american vetch (*Vicia americana*) (M)

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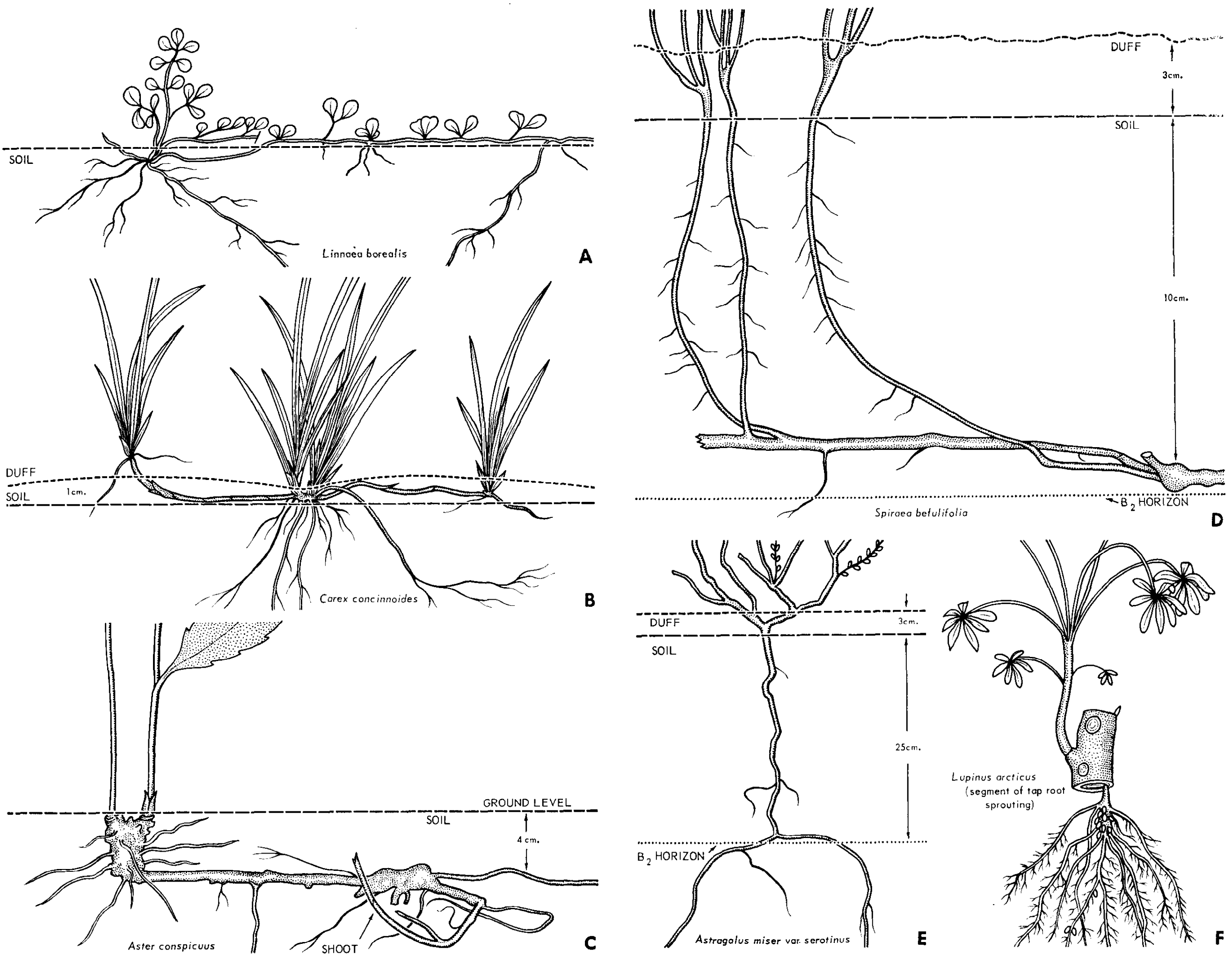

FIG. 1. Examples of various types of root systems found in forest ground-cover species. A—fibrous roots only, B—fibrous roots and stolons, C—rhizomes above mineral soil, D—rhizomes 1.5 to 5 cm below mineral soil, E—rhizomes between 5 and 13 cm below mineral soil, F—taproots.

creamy peavine (*Lathyrus ochroleucus*) (M)
fireweed (*Epilobium angustifolium*) (M)
oregongrape (*Berberis repens*) (M)
pinegrass (*Calamagrostis rubescens*) (M)
showy aster (*Aster conspicuus*) (M)

E. Species that have fibrous roots and rhizomes which grow mostly between 5 and 13 cm below the mineral soil surface and show signs of being able to regenerate from those depths (Fig. 1 D) (often they will extend down to and creep along just above the textural B (Bt) soil horizon:

pipsissewa (*Chimaphila umbellata*) (S)
bunchberry (*Cornus canadensis*) (M)
snowberry (*Symphoricarpos albus*) (R)
spirea (*Spiraea betulifolia*) (R)

F. Species that are without rhizomes but have taproots. These taproots may split on contact with the Bt soil horizon and creep sideways until they find cracks in the horizon:

buffaloberry (*Shepherdia canadensis*) (M)
indian paintbrush (*Castilleja miniata*) (M)
pachistima (*Pachistima myrsinites*) (M)
lupine (*Lupinus arcticus*) (R)
timber milkvetch (*Astragalus miser* var. *serotinus*) (R)

Lupine and milkvetch are able to form new shoots in the field from buds along the taproots which may be at least 5 cm below the crown (Fig. 1 E). To demonstrate the regenerative potential of the taproots of these two species, 10 plants each were dug up, the taproots cut into 3 cm segments, and planted 3 cm deep in moist sand. These segments produced shoots from buds that originated from as much as 20 cm below the original soil surface. In some cases new roots were produced from the cambium as well (Fig. 1 F).

Discussion

From observations in this study groups A, B, and C could all be considered susceptible to fires. Group D is intermediate in fire damage resistance, while group E and F appear resistant even to severe fires.

Ahlgren and Ahlgren (1960) in their review indicate that fires only rarely raise soil temperatures appreciably at depths greater than 4 cm under exposed mineral soil.

A few species merit special comment. Bearberry produces extensive trailing stems most of which will, after the second year, produce many small feeding roots that penetrate the duff layer. At the point of origin of a plant or at any point on the stem which is severed from the original plant a substantial main root develops which penetrates the soil, generally to the Bt horizon. If the crown is destroyed these roots apparently are not able to regenerate new stems. As a result, this species is susceptible to killing by even relatively light ground fires. Lutz (1956) quotes Kujala as including bearberry in the group of plants incapable of vegetative reproduction from underground parts.

The stems of twinflower produce many small feeder roots after the first year. At the point of origin of the plant a small crown develops just below the ground surface. This crown develops many small feeding roots and occasionally substantial main roots that penetrate the ground to the top of the Bt horizon. The stems of the plant are extremely susceptible to even light duff fires. Lutz (1956) quotes Sarvas as saying that twinflower is completely destroyed by fire, depending for survival on unburned spots which serve as centers from which the plants spread.

Pinegrass may produce moderate sized clumps rather than single stems. The rhizomes appear to wander greatly within the top 5 cm of soil. Periodically, as they approach the soil surface, they may produce new shoots. There is not generally any heavy production of fibrous roots. Any fire that completely penetrates the duff layer should be expected to do extensive damage.

Although arnica has rhizomes that creep laterally 1 to 2 cm below the mineral soil surface, the shoots produce small crowns within the duff layer and are very susceptible to killing by fire.

Pipsissewa has a heavy production of stout rootstalks which are usually somewhat soft and often penetrate to the top of the dense Bt soil horizon. It is only the rootstalks close to the soil surface, however, that appeared to produce new shoots.

Lupine and timber milkvetch have the ability to regenerate from the taproot even when the entire plant crown is destroyed. They can send up shoots and set seed the first year after a fire. If much of the ground cover has been destroyed a good crop of seedlings are usually produced and the population of these species may increase greatly. This can be detrimental to the range since the lupine is unpalatable to cattle and the milkvetch is poisonous to sheep and cattle.

Apart from lupine and timber milkvetch, fireweed and showy aster are the only other species studied to increase rapidly after a fire. These latter two also spread quickly by means of their windborne seed.

There are a number of valuable forage species in the moderately-resistant category, mostly from Group D, namely, oregongrape, peavine, american vetch, aster, fireweed, paintbrush, and pinegrass.

Of the nine species in the susceptible category (mostly in groups A, B, and C) hawkweed and arnica, however, invade burned-over areas rapidly because of their wind-borne seed.

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