



photo by M.L. Heinselman



Little Sioux Fire, Superior National Forest 1971

## General Description

Fire-Dependent Forest/Woodland (FD) communities are common across the Laurentian Mixed Forest (LMF) Province, even after nearly 100 years of wildfire suppression. As the name implies, Fire-Dependent Forest/Woodland communities are strongly influenced by wildfires. Fires are the major source of species mortality and exert strong influence on patterns of plant reproduction by exposing mineral soil seedbeds, triggering dispersal of propagules, and increasing the amount of light reaching the ground or understory. Fires periodically remove much of the litter, duff, and other organic material from the community and can have a significant effect on nutrient cycling and nutrient availability. In the LMF Province, FD communities are characterized by prevalence of evergreen species, most visibly pines and other conifers. These species, like most of the species characteristic of FD communities, are adapted to survive repeated fires or to regenerate successfully following fire.

FD communities occur in the LMF Province on sites with coarse sandy or gravelly soils or with thin soils over bedrock. These sites are often drought prone, a condition enhanced by removal by fire of organic material, such as litter and humus, that retains soil moisture. Fires also can contribute to low nutrient availability in FD communities by releasing nutrients from plant material and making them susceptible to being leached below the plant rooting zone or carried away by runoff. In comparison with other communities, such as Mesic Hardwood Forests, in which nutrient availability changes predictably over each year and remains relatively stable from year-to-year, the random behavior of wildfires causes nutrient availability in FD communities to be episodic and unpredictable.

## Plant Adaptations

Many of the plants that occur in FD communities have seeds or vegetative structures designed to survive fire or are opportunists that can take advantage of short periods when nutrients are relatively abundant and light levels are high. Plants must also survive frequent drought and potentially long periods between fires when nutrients are tied up in plant material and light levels decrease beneath increasingly dense tree canopies. Species with evergreen leaves or over-wintering leaves are particularly characteristic of FD communities; these adaptations are probably a response to low nutrient levels and enable plants to conserve scarce nutrients (in contrast to deciduous species, which lose nutrients each year when leaves are shed and must take them up again the following growing season). Many species in FD communities, including evergreens, have leaves with thickened outer membranes or other features that help to reduce water loss or even herbivory. In general, the species in FD communities have lower nutrient and water requirements and higher light requirements than plants in other forested systems.

## Fire Regimes

Fires in FD communities can vary greatly in intensity, from severe crown fires to mild surface fires. Fires also range widely in frequency. Before the onset of fire suppression

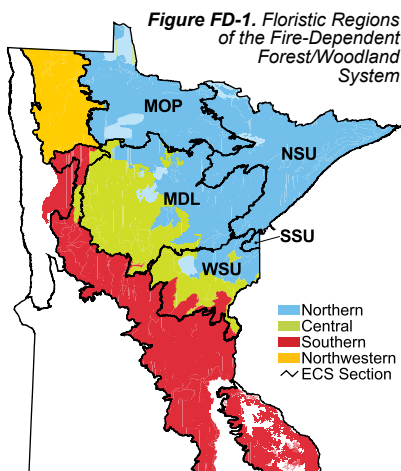


in the LMF Province, the most fire-prone FD communities experienced fires about every 20 years and the least-affected communities experienced fires about every 100 years. The frequency and intensity of fires in these communities appear to be inversely related and show a strong geographic pattern across the LMF Province. This pattern correlates with the pattern of climate in the Province, which is warmer and drier in the southwest and cooler and moister in the northeast (see Fire Regimes of FDn vs. FDc Communities below for more detail).

### Floristic Regions

FD communities in Minnesota can be grouped into four "floristic" regions, based on general differences in species composition (Fig. FD-1). Two of these floristic regions are represented in the LMF Province: the Northern Floristic (FDn) Region and the Central Floristic (FDc) Region. Communities from the other two floristic regions, the Southern (FDs) and the Northwestern (FDw), are present occasionally along the southern and western edges of the LMF Province.

The differences in species composition between communities of the FDn and FDc Regions relate strongly to regional differences in paleohistory, especially in duration of cover by fire-dependent pine forests. Pine forests have been present in the FDn Region for a long time. In the eastern half of the FDn Region (largely within the NSU, WSU, and SSU Sections of the LMF Province) fire-dependent pine forests replaced post-glacial spruce forests 8,500 to 10,000 years ago and have remained since that time. In the western half of the FDn Region (in MOP and MDL) it appears that pine forests have been a stable component of the landscape for a shorter period, but still have been present for more than 3,500 years. In contrast, pine forests did not begin developing in what is now the FDc Region until about 3,500 years ago. Before this time the area was occupied by southern fire-dependent forests, woodlands, and prairies. After 3,500 years ago, the component species of northern forests—including all three of Minnesota's native pines—began migrating westward, resulting in the development of a flora that is a mixture of species with southern affinity that have persisted on the landscape and species with northern affinity that have been migrating westward.



### Plant Indicators of FDn vs. FDc Communities

Plant species that have high fidelity for FDn communities relative to FDc communities are listed in Table FD-1. These species have strongly coincidental statewide distributions that lie mostly within the LMF Province. Interestingly, when present south or west of the Province, many of these species occur primarily in wetland rather than upland habitats. Among the species with high fidelity for FDn communities are a group of evergreen species and species with over-wintering leaves that are extremely tolerant of nutrient-poor conditions and have wide tolerances for moisture; as a result these species are present in nutrient-poor coniferous wetland communities across northern Minnesota, in addition to nutrient-poor FDn communities. Many of these species, such as balsam fir and black spruce, are easily killed by fire but appear to spread readily from wetlands onto adjacent uplands following forest fires.



**Table FD-1. Plants useful for differentiating the Northern from the Central Floristic Region of the Fire-Dependent Forest/Woodland System**

| Region of the Fire-Dependent Forest/Woodland System |                           |                                    |                                 | Frequency(%)                                |     |    |
|-----------------------------------------------------|---------------------------|------------------------------------|---------------------------------|---------------------------------------------|-----|----|
|                                                     |                           | Common Name                        | Scientific Name                 | FDn                                         | FDc |    |
| Northern Floristic Region                           | Tolerant of low nutrients | Evergreen or over-wintering leaves | Balsam fir (U)                  | <i>Abies balsamea</i>                       | 76  | 8  |
|                                                     |                           |                                    | Bunchberry                      | <i>Cornus canadensis</i>                    | 73  | 11 |
|                                                     |                           |                                    | Twinflower                      | <i>Linnaea borealis</i>                     | 55  | 13 |
|                                                     |                           |                                    | Ground-pine                     | <i>Lycopodium dendroideum/hickeyi</i> group | 40  | 1  |
|                                                     |                           |                                    | White spruce (U)                | <i>Picea glauca</i>                         | 40  | 9  |
|                                                     |                           |                                    | Balsam fir (C)                  | <i>Abies balsamea</i>                       | 29  | –  |
|                                                     |                           |                                    | Running clubmoss                | <i>Lycopodium clavatum</i>                  | 24  | –  |
|                                                     |                           |                                    | Black spruce (U)                | <i>Picea mariana</i>                        | 24  | 2  |
|                                                     |                           |                                    | White spruce (C)                | <i>Picea glauca</i>                         | 18  | 2  |
|                                                     |                           |                                    | Black spruce (C)                | <i>Picea mariana</i>                        | 15  | –  |
|                                                     |                           |                                    | Common polypody                 | <i>Polypodium virginianum</i>               | 15  | –  |
|                                                     |                           |                                    | Bristly clubmoss                | <i>Lycopodium annotinum</i>                 | 14  | –  |
|                                                     |                           |                                    | White cedar (U)                 | <i>Thuja occidentalis</i>                   | 14  | –  |
|                                                     |                           |                                    | Goldthread                      | <i>Coptis trifolia</i>                      | 13  | –  |
|                                                     |                           |                                    | Naked miterwort                 | <i>Mitella nuda</i>                         | 12  | 1  |
|                                                     |                           |                                    | Common oak fern                 | <i>Gymnocarpium dryopteris</i>              | 11  | –  |
|                                                     |                           |                                    | Woodland horsetail              | <i>Equisetum sylvaticum</i>                 | 9   | –  |
|                                                     |                           |                                    | White cedar (C)                 | <i>Thuja occidentalis</i>                   | 7   | –  |
|                                                     | Labrador tea              | <i>Ledum groenlandicum</i>         | 7                               | –                                           |     |    |
|                                                     | Shining clubmoss          | <i>Huperzia lucidula</i>           | 6                               | 1                                           |     |    |
|                                                     | One-flowered pyrola       | <i>Moneses uniflora</i>            | 5                               | –                                           |     |    |
|                                                     | Deciduous                 | Velvet-leaved blueberry            | <i>Vaccinium myrtilloides</i>   | 40                                          | 8   |    |
|                                                     |                           | Bluejoint                          | <i>Calamagrostis canadensis</i> | 11                                          | –   |    |
|                                                     |                           | Palmate sweet coltsfoot            | <i>Petasites frigidus</i>       | 11                                          | 1   |    |
|                                                     |                           | Swamp gooseberry                   | <i>Ribes hirtellum</i>          | 8                                           | 1   |    |
|                                                     |                           | Swamp red currant                  | <i>Ribes triste</i>             | 6                                           | –   |    |
|                                                     |                           | Skunk currant                      | <i>Ribes glandulosum</i>        | 5                                           | –   |    |
|                                                     | Other                     | Fly honeysuckle                    | <i>Lonicera canadensis</i>      | 59                                          | 12  |    |
|                                                     |                           | Mountain maple                     | <i>Acer spicatum</i>            | 41                                          | 7   |    |
|                                                     |                           | Mountain ash (U)                   | <i>Sorbus</i> spp.              | 37                                          | 2   |    |
|                                                     |                           | Green alder                        | <i>Alnus viridis</i>            | 16                                          | 1   |    |
|                                                     |                           | Thimbleberry                       | <i>Rubus parviflorus</i>        | 10                                          | –   |    |

(C)=canopy tree (U)=understory tree

Most of the plant species that have high fidelity for FDc communities relative to FDn communities (Table FD-2) also occur in Southern Fire-Dependent Forest/Woodland (FDs) communities or in prairies, which made up the bulk of the vegetation of the FDc Region during earlier, warmer periods of the Holocene Epoch. The majority of these species are woody species, but there are also a number of herbaceous species with southern affinity that have high fidelity for the FDc Region. Quite a few of the species that help to differentiate FDc from FDn communities are species with strong affinity for prairies, especially big bluestem (*Andropogon gerardii*), wild bergamot (*Monarda fistulosa*), and skyblue aster (*Aster oolentangiensis*). A few plants with high fidelity for FDc relative to FDn communities are species common in transition areas between prairies and woodlands; these plants include tall thimbleweed (*Anemone virginiana*), two-flowered Cynthia (*Krigia biflora*), oval-leaved New Jersey tea (*Ceanothus herbaceus*), blue giant hyssop (*Agastache foeniculum*), and balsam ragwort (*Senecio pauperculus*).

## Fire Regimes of FDn vs. FDc Communities

In addition to differences in species composition, FDn and FDc communities differ in fire regime (Table FD-3). The FDn communities can be divided into two groups based on similarities in parent material and fire regime. The first group of FDn communities (Northern Dry-Bedrock Pine [Oak] Woodland [FDn22], Northern Poor Dry-Mesic Mixed



**Table FD-2** Plants useful for differentiating the Central from the Northern Floristic Region of the Fire-Dependent Forest/Woodland System

|                   |                                           | Frequency(%) |     |
|-------------------|-------------------------------------------|--------------|-----|
| Common Name       |                                           | FDn          | FDc |
| Central affinity  | Balsam ragwort                            | 1            | 24  |
|                   | Blue giant hyssop                         | 1            | 15  |
|                   | Two-flowered Cynthia                      | –            | 8   |
|                   | Tall thimbleweed                          | –            | 6   |
|                   | Oval-leaved New Jersey tea                | –            | 6   |
| Prairie affinity  | Northern bedstraw                         | 10           | 70  |
|                   | Harebell                                  | 4            | 31  |
|                   | Hoary puccoon                             | 1            | 30  |
|                   | Yarrow                                    | 4            | 29  |
|                   | Big bluestem                              | –            | 25  |
|                   | Smooth blue aster                         | 3            | 22  |
|                   | Slender wheatgrass                        | 4            | 20  |
|                   | Sky blue aster                            | –            | 16  |
|                   | Clustered muhly grass                     | 1            | 16  |
|                   | Gray goldenrod                            | 4            | 16  |
|                   | Wild bergamot                             | –            | 15  |
|                   | Kalm's brome                              | –            | 12  |
|                   | Virginia ground cherry                    | –            | 12  |
|                   | Wood betony                               | –            | 9   |
|                   | Alumroot                                  | 1            | 9   |
|                   | Heart-leaved alexanders                   | –            | 6   |
|                   | Leadplant                                 | –            | 5   |
| Southern affinity | American hazelnut                         | 5            | 62  |
|                   | Bur oak (U)                               | 12           | 59  |
|                   | Poison ivy                                | 7            | 53  |
|                   | Early meadow-rue                          | 10           | 53  |
|                   | Wolfberry                                 | 8            | 45  |
|                   | Pale bellwort                             | 9            | 38  |
|                   | Maryland black snakeroot                  | 9            | 36  |
|                   | Tall blackberries                         | 5            | 35  |
|                   | Northern red oak (C)                      | 5            | 23  |
|                   | Black cherry (U)                          | 2            | 22  |
|                   | Gray dogwood                              | 2            | 22  |
|                   | Hog peanut                                | 3            | 20  |
|                   | Virginia creeper                          | 3            | 18  |
|                   | Bur oak (C)                               | 2            | 15  |
|                   | Erect, smooth, or Illinois carrion-flower | 1            | 13  |
|                   | Hawthorn                                  | 1            | 13  |
|                   | Starry false Solomon's seal               | 1            | 12  |
|                   | Woodland sunflower                        | –            | 11  |
| Other             | Sand cherry                               | 3            | 18  |
|                   | Oval-leaved milkweed                      | –            | 12  |
|                   | Early goldenrod                           | 1            | 8   |

(C)=canopy tree (U)=understory tree

Woodland [FDn32], and Northern Mesic Mixed Forest [FDn43] occurs mostly on coarse loamy till over bedrock (primarily in NSU) and is characterized by relatively long intervals between fires. The rotation period for intense, stand-replacing fires in this group is about 170 to 220 years, and for surface fires about 210 to 260 year; the combined rotation period for all fires is 100 to 115 years. The second group of FDn communities (Northern Dry-Sand Pine Woodland [FDn12] and Northern Dry-Mesic Mixed Woodland [FDn33]) occurs on sand and gravel deposits and has shorter intervals between fires, especially surface fires. The fire-regime for this group is intermediate between that of



**Table FD-3.** Historic tree species composition & disturbance regimes in FDn and FDc communities

| Historic Tree Species Frequency by Class and Stand Age |                                                                           |                                                                                      |                                                                          |                |                    | Historic Disturbance Rotation Periods by Class (in years) |                       |               |                        |
|--------------------------------------------------------|---------------------------------------------------------------------------|--------------------------------------------------------------------------------------|--------------------------------------------------------------------------|----------------|--------------------|-----------------------------------------------------------|-----------------------|---------------|------------------------|
| young forest age                                       | young forest species                                                      | mature forest age                                                                    | mature forest species                                                    | old forest age | old forest species | Stand-Regenerating Fire                                   | Moderate Surface Fire | All Fires     | Catastrophic Windthrow |
| <b>Northern Floristic Region</b>                       |                                                                           |                                                                                      |                                                                          |                |                    | <b>170-220</b>                                            | <b>50-260</b>         | <b>50-115</b> | <b>&gt;610</b>         |
| FDn12                                                  | 0 - 55 yrs<br>jack pine<br>red pine                                       | 75 - 195 yrs<br>red pine<br>(jack pine)                                              | > 195 yrs<br>(red pine)<br>(jack pine)<br>(white pine)<br>(white spruce) |                |                    | 170                                                       | 50                    | 42            | 610                    |
| FDn22                                                  | 0 - 55 yrs<br>jack pine<br>(red pine)                                     | 75 - 115 yrs<br>red pine<br>(jack pine)<br>(white spruce)<br>(white pine)            | > 115 yrs<br>red pine<br>jack pine<br>(white spruce)                     |                |                    | 195                                                       | 225                   | 107           | >1000                  |
| FDn32                                                  | 0 - 55 yrs<br>jack pine<br>(quaking aspen)<br>(paper birch)               | > 95 yrs<br>spruce**<br>(paper birch)<br>(balsam fir)<br>(white pine)<br>(jack pine) | I                                                                        |                |                    | 170                                                       | 210                   | 100           | >1000                  |
| FDn33                                                  | 0 - 35 yrs<br>quaking aspen<br>(red pine)<br>(paper birch)<br>(jack pine) | 55 - 125 yrs<br>red pine<br>(paper birch)<br>(white pine)                            | > 125 yrs<br>white pine<br>(red pine)<br>(paper birch)<br>(white spruce) |                |                    | 220                                                       | 75                    | 53            | >1000                  |
| FDn43                                                  | 0 - 35 yrs<br>quaking aspen<br>(jack pine)<br>(paper birch)               | 55 - 95 yrs<br>paper birch<br>(white pine)<br>(quaking aspen)<br>(balsam fir)        | > 115 yrs<br>white pine<br>white spruce<br>(paper birch)<br>(balsam fir) |                |                    | 220                                                       | 260                   | 115           | >1000                  |
| <b>Central Floristic Region</b>                        |                                                                           |                                                                                      |                                                                          |                |                    | <b>80-130</b>                                             | <b>10-30</b>          | <b>10-25</b>  | <b>&gt;1000</b>        |
| FDc12                                                  | 0-55 yrs<br>jack pine                                                     | >115 yrs<br>jack pine<br>red pine                                                    | I                                                                        |                |                    | 120                                                       | 30                    | 25            | >1000                  |
| FDc23                                                  | 0-55 yrs<br>jack pine                                                     | 75-155 yrs<br>jack pine<br>red pine                                                  | >155 yrs<br>jack pine<br>(red pine)                                      |                |                    | 110                                                       | 30                    | 22            | >1000                  |
| FDc24                                                  | 0-55 yrs<br>jack pine                                                     | 75-155 yrs<br>jack pine<br>red pine                                                  | >195 yrs<br>jack pine<br>(white pine)                                    |                |                    | 130                                                       | 30                    | 23            | >1000                  |
| FDc25                                                  | 0-55 yrs<br>bur oak<br>quaking aspen<br>(jack pine)<br>(northern pin oak) | 55-135 yrs<br>bur oak<br>(northern pin oak)                                          | >195 yrs<br>jack pine<br>bur oak                                         |                |                    | 80                                                        | 10                    | 9             | --                     |
| FDc34                                                  | 0-55 yrs<br>quaking aspen*<br>red pine<br>(white pine)<br>(jack pine)     | 95-135 yrs<br>red pine<br>white pine                                                 | >195 yrs<br>white pine<br>(red pine)                                     |                |                    | 110                                                       | 30                    | 23            | >1000                  |

**bold** = >50%    **normal** = 25-50%    (*italics*) = 10-25%    \*includes big-toothed aspen    \*\*either black or white spruce

the first group of FDn communities and that of the FDc communities (which, like the second FDn group, occur primarily on sand and gravel deposits). The estimated rotation of stand-replacing fires in this second FDn group is 170-220 years, and the rotation of surface fires is estimated to be 50 to 75 years; this results in a combined frequency for all fires of about 40 to 50 years.



The FDc communities have much shorter rotation periods than either of the two groups of FDN communities. In addition, whereas the rotation periods for stand-replacing and surface fires are more similar in length in the FDN communities, in FDc communities surface fires recur at much shorter intervals than stand-replacing fires. Most of the FDc Region lies in the western parts of MDL and WSU (see Fig. FD-1). This area is characterized by woodland and forest communities (Central Poor Dry Woodland [FDc12], Central Dry Pine Woodland [FDc23], Central Rich Dry Pine Woodland [FDc24], and Central Dry-Mesic Pine-Hardwood Forest [FDc34]) that experienced stand-replacing fires every 110 to 130 years and surface fires about every 30 years; the combined frequency of all fires in these communities is estimated to be 22 to 25 years (see Table FD-3). Along the St. Croix River Valley in the eastern part of the FDc Region, the fire-regime of the mid-1800s appears to have been strongly influenced by humans. This is also the only area in the LMF Province where fire-dependent vegetation is dominated mostly by deciduous trees rather than pines. The single FDc class that occurs in this area (Central Dry Oak-Aspen [Pine] Woodland [FDc25]) has an estimated rotation of stand-replacing fires of about 80 years. Such fires probably removed aspen and jack pines, leaving mature oaks. The rotation of surface fires in this area was very short, just 10 years, and the frequency of all fires is estimated to be 9 years.

The differences in fire regime between the FDN and FDc Regions correlate with variation in vegetation structure and composition. Most prominent are differences in the age-structure of mature and old-growth forests. For most of the FDN Region, where the rotation period for surface fires was often equal to or longer than that for stand-regenerating fires, stands were as likely to experience intense, stand-regenerating fires as moderate surface fires. Stands in this area of the LMF Province tended to become multiple-aged as they matured, with rather constant recruitment in the understory of shade-tolerant species, especially balsam fir, white spruce, and northern white cedar, along with some paper birch and white pine. The establishment of fir and spruce in the understory of FDN forests is important, because these trees are highly flammable and help to promote stand-regenerating fires. In the FDc Region, where the rotation for surface fires was much shorter than that for stand-replacing fires, individual stands commonly experienced several surface fires in the intervals between intense crown fires. These stands also became multiple-aged as they matured, but the understories had cohorts of early-successional species that regenerate vigorously following fire (in contrast to the shade-tolerant species more common in the understory in FDN communities). These understory cohorts included quaking aspen, big-toothed aspen, jack pine, and oak, in addition to progeny of overstory red and white pines. These stands also became multiple-aged as they matured, but the understories had cohorts of early-successional species that regenerate vigorously following fire (in contrast to the shade-tolerant species more common in the understory in FDN communities). These understory cohorts included quaking aspen, big-toothed aspen, jack pine, and oak, in addition to progeny of overstory red and white pines.