NURSE CROP

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In forestry, a nurse crop generally is a crop of trees or shrubs that fosters the development of another tree species, usually by protecting the second species, during its youth, from frost, insolation, or wind (Ford-Robertson 1971). Aspen may be a nurse crop for shade-tolerant tree species that do not become established in full sunlight (e.g., Engelmann spruce). Through the natural successional process, aspen often serves in this capacity. In the West, aspen also can be considered a nurse crop to the forage-rich mix of shade-tolerant understory species (see the VEGETATION ASSOCIATIONS and FORAGE chapters). Without the aspen overstory, many of these species, particularly the forbs, probably would die.

Aspen is intolerant of shade and able to sprout in full sunlight. Its vegetative habit of regeneration from an existing well-developed root system enables suckers to establish quickly and uniformly over a site, and gives them a spurt of growth during the first 2 years that permits domination over competing vegetation (see the MORPHOLOGY and VEGETATIVE REGENERATION chapters) (fig. 1). Therefore, the best opportunity to utilize aspen as a nurse crop is where it occurs naturally and has a competitive advantage over other species.

Incidence of Conifers Under Aspen

Many coniferous species in the West establish more readily under partial shade than in full sunlight (Alexander 1974, Alexander and Engelby 1983, Ronco and Ready 1983, Seidel and Beebe 1983, Williamson and Twombly 1983). Mature aspen stands are ideally suited for providing partial shading because the total leaf area index of aspen stands often is only one-third as much as that of mature spruce-fir stands (Kaufmann et al. 1982) (fig. 2). Much more sunlight reaches the forest floor under aspen than under coniferous stands. However, dense aspen stands do provide considerable shade. For example, light intensities beneath well-stocked stands of aspen in Russia usually were less than 15% of light intensities in the open (Alekseev 1969).

In Arizona and New Mexico, Pearson (1914) noted that, on burned areas above 8,000 feet (2,450 m), Douglas-fir, white fir, and Engelmann spruce thrived in the shade of aspen. In contrast, coniferous reproduction usually was sparse on burned areas occupied by neither aspen nor oak. In the subalpine zone, Engelmann spruce nearly always reproduced well under an aspen over-

Figure 1.—Aspen is one of the first species to reestablish on a site after a fire, giving it a competitive edge over other species.

Figure 2.—Aspen provides essential shade and favorable climate for the establishment of more shade tolerant conifer species.

story when a seed source was present (Ronco 1975). Stahelin (1943) surveyed many burned areas in Colorado and Wyoming on which the subalpine forest had been killed 50 to 70 years previously. Aspen stands there were far superior to the post-fire meadow for conifer reestablishment. Early studies (Gardner 1905, Pearson 1914, Roeser 1924) showed that an aspen overstory benefited both naturally established and planted coniferous seedlings.

Conifers growing beneath aspen usually are younger than the aspen, because on burns, aspen sprouts promptly from preexisting roots. Shade-tolerant conifers, however, restock from subsequent seed crops, usually a gradual process. Sometimes, conifers may establish rather quickly after a fire; the aspen on these sites may only be 1 or 2 years older than the conifers, especially on coarse-textured granitic soils, where ground vegetation does not seriously inhibit the reestablishment of conifers (Langenheim 1962, Stahelin 1943).

Insolation

Shade is vital for establishment of several conifer species. In the central and southern Rocky Mountains, Douglas-fir seedlings on southerly slopes did not tolerate full exposure to sunlight (Bates 1924, Krauch 1956) and survived better in shade on all exposures (Jones 1974b). Engelmann spruce seedlings are even more sensitive to strong sunlight and drought than are Douglas-fir (Pearson 1914). Engelmann spruce and subalpine fir seeded in full sunlight in Colorado seldom survived beyond the second year (LeBarron and Jemison 1953, Noble and Alexander 1977); and, in Arizona, all corkbark fir seedlings planted on sites without shade soon died (Jones 1974b). On open sites, solarization of Engelmann spruce seedlings (Ronco 1967, 1970a, 1970b, 1975), of Douglas-fir seedlings (Zavitkovski and Woodard 1970), as well as seedlings of other firs perhaps is the major cause of death, although moisture stress and temperature may play roles, too.

Shade also has negative effects, especially after the seedlings are well established. Species differ in their tolerance of shade. Among the important coniferous tree species associated with aspen in the Rocky Mountains, Engelmann spruce, subalpine fir, and corkbark fir are the most shade tolerant. Engelmann spruce has been rated less shade tolerant than the firs (Alexander 1974, Baker 1949, LeBarron and Jemison 1953).

Sampson (1916) wrote that subalpine fir flourished beneath aspen, that white fir was never suppressed by aspen, and that aspen probably was unable to shade out Douglas-fir (fig. 3). Clements (1910) wrote that, unlike Engelmann spruce and subalpine fir, Douglas-fir was not vigorous beneath the heavier aspen canopies, while lodgepole pine seedlings died there (fig. 4). Pearson (1914) wrote that Engelmann spruce grew in the densest aspen thickets, and that Douglas-fir vigor declined with age beneath dense aspen. Harniss and Harper (1982)

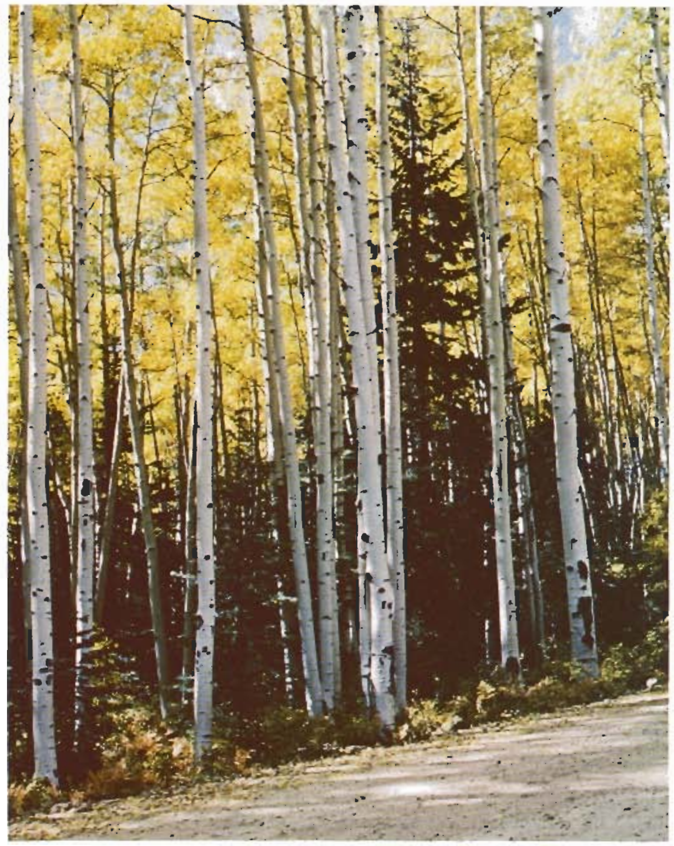

Figure 3.—Shade tolerant species can grow well under an aspen overstory, but may require aspen removal for optimum growth.

stated that white fir was able to invade their central Utah study areas more readily than subalpine fir, even though both were considered very tolerant (Baker 1949).

Baker (1918b, 1925) reported that survival of underplanted Engelmann spruce, Douglas-fir, and ponderosa pine was best under dense aspen shade; but, he recommended thinning aspen within a few years after underplanting to permit maximum conifer growth.

Shade tolerant conifers in southern Colorado, released by harvesting overstory aspen, subsequently grew faster in both height and diameter (Hittenrauch 1976). In Minnesota, balsam fir saplings and small poles grew fairly well under an aspen canopy but did much better when released (Roe 1952).

Berry (1982), in Ontario, reported substantial release of 22-year-old white pine (*Pinus strobus*), red pine (*Pinus resinosa*), and white spruce (*Picea glauca*) seedlings after the mature aspen overstory was removed. These species were rated intermediate, intolerant, and tolerant, respectively (Baker 1949). Aspen resprouting did not affect the degree of release.

Cayford (1957), in Saskatchewan, found that most of the white spruce beneath aspen overstories up to 100 years old were nearly as old as the aspen that overtopped them. The spruce grew somewhat more slowly beneath aspen than in the adjacent openings. At the age when open-grown spruce were surpassing the aspen in height, those beneath aspen were 10–15 feet (3–4 m) shorter. Spruce leaders, when they began to penetrate the aspen canopy, commonly were damaged by aspen branches moving in the wind. This resulted in forked and crooked tops. In a Manitoba study, Steneker (1963) found that white spruce height growth approximately doubled after release from an aspen overstory.

Temperature

Bare ground or herbaceous cover in the open directly receives maximum radiation during daylight hours; then radiates energy back into space at night. This causes marked daily temperature changes on clear days. In contrast, in the aspen forest, the primary surface receiving and emitting radiation is the deep complex canopy with its high moisture content and very high total surface area. Therefore, the environment beneath an aspen canopy is heated much less by incoming radiation during the day and cooled much less by back radiation at night (see the CLIMATES chapter).

From the subarctic to the tropics, soil surface temperatures in the open reach 120–160°F (49–71°C) on clear summer days. They are higher with decreasing latitude and with increasing elevation (Jen-hu-Chang 1958). Noble and Alexander (1977) recorded soil surface temperatures higher than 140°F (60°C) on mineral soil seedbeds, in a spruce-fir forest clearcut, at 10,600 feet (3,250 m) elevation. In contrast to bare sites, surface temperatures beneath aspen canopies in Russia generally remained below 90°F (32°C) (Alekseev 1969). Besides its direct importance to conifer seedlings, the much lower daytime temperatures beneath aspen, compared to the open, enhance seedling survival by reducing vapor pressure gradients.

Figure 4.—Shade intolerant species—lodgepole pine in this case—are suppressed under aspen.

Nighttime temperatures would be similarly moderated. Miller (1967) wrote that, because of the porous nature of aspen canopies, air cooled by radiation from the upper canopy at night tended to settle through it to the ground. Despite this, he observed that when a summer frost coated the vegetation in a Colorado meadow, there was no frost beneath the aspen.

Wind

Air movement within aspen stands is much less than in the open, especially in summer when the aspen are in full leaf (Marston 1956, Rauner 1958). In well-stocked pole stands in summer, velocities 5 feet (1.5 m) above ground were almost zero when winds above the canopy were greater than 20 miles per hour (32 km/hr). This will reduce moisture stress in coniferous reproduction as well as all understory species.

Water

Over a period of weeks or months, any vegetation fully occupying a site usually will withdraw near equal amounts of water from the surface 2–3 feet (0.5–1 m) of soil. Therefore, by the end of the growing season, water contents of the surface soils under aspen, grassland, shrubs, and conifers usually are quite similar (Brown and Thompson 1965, Houston 1952, Johnston et al 1969). If soil water content was the only consideration, moisture stress for shallow-rooted young seedlings would be similar in all these vegetation types.

In Utah and Colorado studies, interception by aspen crowns reduced summer rainfall received at ground level by about 10% to 15%, compared to that received in the open (Croft and Monninger 1953, Dunford and Niederhof 1944, Johnston 1971).

About 1% to 2% of summer rainfall in Utah aspen stands reaches the ground through stemflow (Johnston 1971), a process that could improve the moisture regime for seedlings developing at the base of aspen trees. Waldron (1961a) found that white spruce seedlings were more frequent on seed spots at the bases of aspen than elsewhere in the stand.

Observation indicates that snow persists later in the spring under aspen than in adjacent openings (see the WATER AND WATERSHED chapter). This prolongs snowmelt later into the growing season, providing developing vegetation beneath the aspen with an abundant supply of water. In Arizona and New Mexico, where May and June are particularly dry, the later snow cover under aspen shortens the period of effective drought that precedes the monsoon rains of July and August.

Moisture stresses in coniferous seedlings are reduced by shade. In some situations, this is essential to conifer seedling survival (Noble and Alexander 1977). On large seedlings, stresses were significantly lower on a shadyside twig than on a sunnyside twig of the same seedling (Jones 1972). The combined protection under an aspen canopy from direct insolation and from drying winds can be quite significant. In eastern Arizona, moisture stresses in coniferous seedlings were highest on a windy day (Jones 1972). Pearson (1914) reported that evaporation in the open on a windy June day was 60% greater when overcast, and 90% greater when sunny, than under aspen. He felt that the better Douglas-fir seedling survival under aspen mainly resulted from lower seedling moisture stresses.

Seedling Burial by Aspen Leaf Fall

Pearson (1914) wrote that one cause of coniferous seedling deaths in Arizona was burial by aspen leaves. "Smothering" by fallen leaves is widely considered to slow conversion to conifers in boreal forests of aspen and birch (Gregory 1966, Hughes 1967, Koroleff 1954, Pratt 1966, Rowe 1955) (fig. 5). In the Sierra Nevada of California, white fir and especially Douglas-fir are particularly susceptible to damping-off fungi when covered during the winter by dead plant material, such as shrub leaves (Tappeiner and Helms 1971). Fallen aspen leaves may have similar effects.

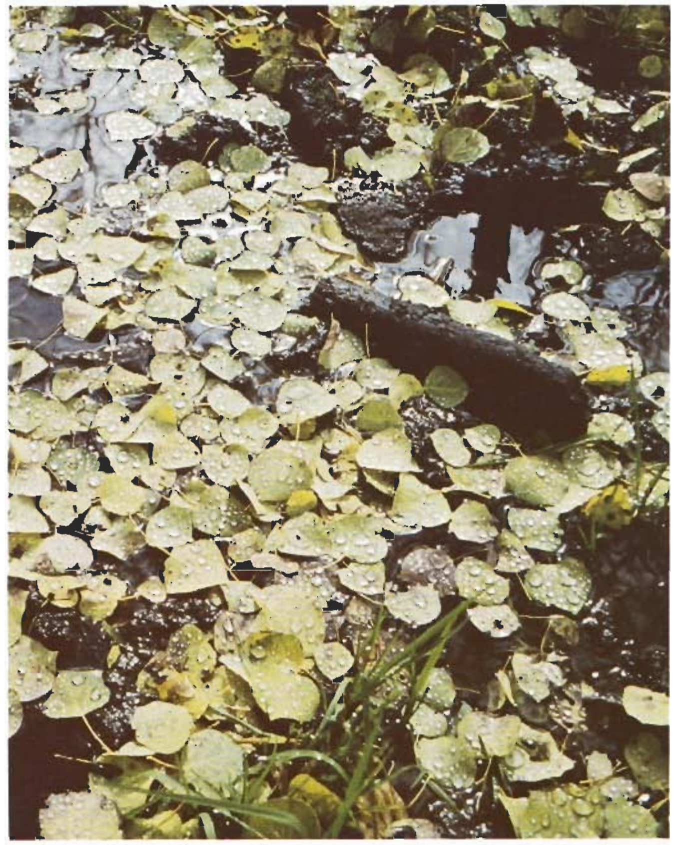

Figure 5.—In some cases, aspen leaf fall may smother newly germinated conifer seedlings.

Herbaceous Layer

As noted in the FORAGE chapter, the herbaceous layer under aspen is usually described as heavy, approaching or exceeding that in meadows (Ellison and Houston 1958, Paulsen 1969, Pearson 1914). This herbaceous cover removes water from the soil and also shades conifer seedlings. Like aspen leaves, it buries seedlings temporarily in autumn, when the dead herbs are packed down by snow. Tucker et al (1968) reported burial by dead herbs as a cause of seedling deaths in Canada. This happened even to nursery-grown stock, which were much larger than natural seedlings germinated only a few months earlier in the forest.

Sometimes, however, herbaceous cover and shrubs can be somewhat sparse under aspen (Langenheim 1962, Stahelin 1943). Langeheim reported more coniferous invasion where the herbaceous cover was light than where it was heavier.

The degree of understory competition depends on the community type. Some community types may be better suited for use as nurse crop stands than others.