DYNAMICS OF SOIL FERTILITY IN THE GRIFFITH STATE NURSERY

A Record of Soil Management

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The Griffith State Forest Nursery was established in the fall of 1932 in Wood County, 3 miles south of Wisconsin Rapids (fig. 1). Strategically, this location in the center of a large region requiring reforestation presented many advantages, but in the beginning the production of tree planting stock was hindered by many tactical difficulties. The light sandy soil of the Plainfield series held less than 1 inch of water in its surface foot layer, retained a small amount of soluble fertilizers, and was subject to wind erosion. Moreover, the first 20 acres placed in tree culture had been farmed intermittently since 1880 with little, if any, soil fertility maintenance.

The first sprouting tree seedlings encountered a humus-depleted matrix critically deficient in nutrients, invaded by weeds, and harboring a vigorous community of destructive organisms-larvae of the June beetle, nematodes, and damping-off fungi. Control of these parasites by means available at that time-sulfuric acid, aluminum sulfate, and lead ar-

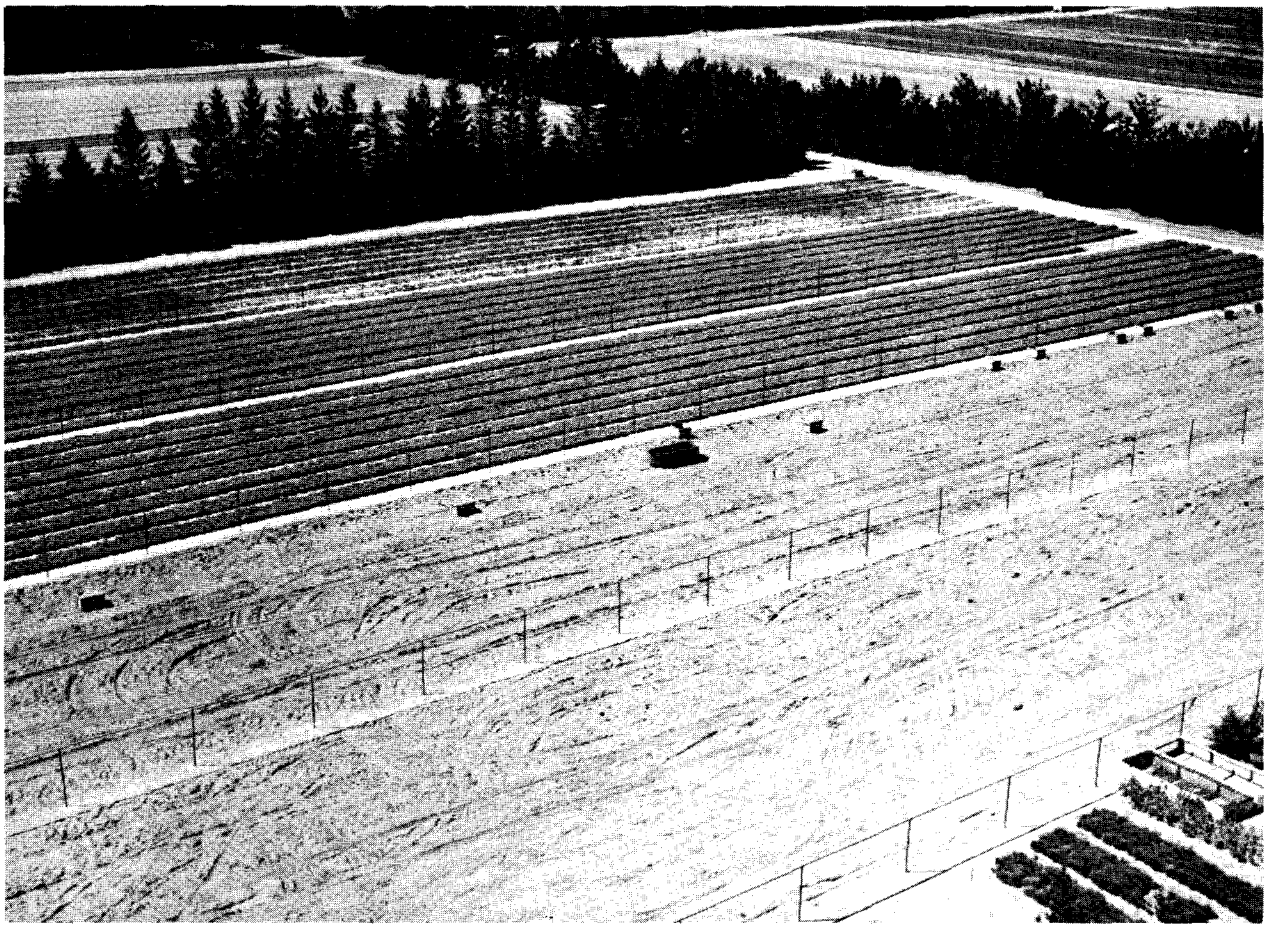

Figure 1.—General view of part of Griffith State Forest Nursery of Wisconsin; the present area is 100 acres.

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senate-provided only partial eradication of pests, but contributed greatly to deterioration of the soil-productive capacity by augmenting leaching and fixating nutrients and immobilizing mycorrhizal fungi and other beneficial micro-organisms.

The Management Program

In the spring of 1933, with help by members of the Civilian Conservation Corps, a planned soil rejuvenation program was initiated in collaboration with S. A. Wilde of the University of Wisconsin. The content of soil organic matter was increased by a generous addition of peat, often supplemented by leaf mold and fermented sawdust composts. This undoubtedly was the most important amelioration as it stabilized the soil water supply, reduced leaching losses of fertilizers, and provided a suitable environment for beneficial microbes. To minimize fertilizer loss, the fertilizers were first incorporated by composting with highly absorbent peat or applied ahead of the "catch crops." This mixture subsequently entered the soil as slowly available constituents of green manure tissues. Occasional deficiency of nutrients caused by rain-especially those of nitrogen and potassiumwere corrected by applying fertilizer solutions, humate suspensions, and interrow top dressings.

The soil fertility maintenance was conducted in correlation with various biocidic treatments prescribed by the University Departments of Entomology and Plant Pathology. The reliability of the entire program, now in existence for 37 years, was constantly verified by analyses of the quality of produced planting stock, its top-root ratio, absorbing capacity of root systems, abundance of mycorrhizal short roots, specific gravity of stems, and the internal balance of plant nutrients (fig. 2). The outcome is expressed in the total present production of more than 350 million trees and about 250,000 acres of established plantations of jack, red, and white pines, white spruce, other tree species, and game food plants.

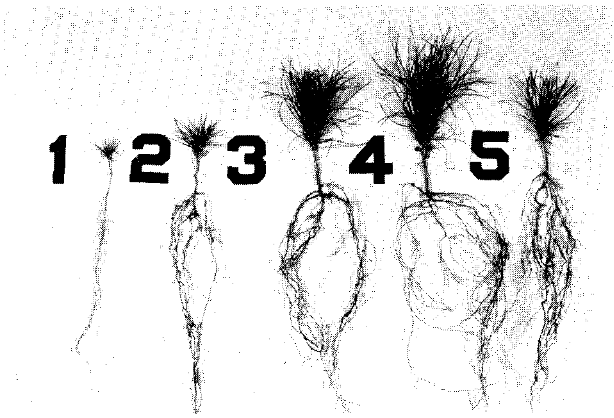

Figure 2.—"Taylor-made" seedlings of 2-year-old red pine whose root systems and top-root ratio were adjusted to desired dimensions by a suitable combination of N–P–K fertilizers. The seedling No. 5 exhibits the best root system and top-root ratio.

The management program was facilitated by a number of innovations, such as assemblies for mechanized treatments of peat and sawdust, modifications of tree lifting and transplanting machines, and a multiple use pressure sprayer (fig. 3).

The major soil fertility factors during the last 35 years are given in figure 4, which shows 5-year averages of the results of annual soil analyses. This diagram describes the important periods in the life of a nursery soil. The first 5 years' average reflects generous additions of peat, leaf mold, and fertilizers applied broadcast, in solution, and in the form of composts. These treatments brought the depleted soil to a productive capacity expressed by about 1.5-percent content of organic matter, 0.07-percent of total N, 100 lbs./acre of P2O5, and 140 lbs./a. of K_2O in available form (table 1). This improvement was followed by a war-caused intermission in the active management and subsequent loss of humus and nutrients, particularly potassium, through biological decomposition, oxidation, and leaching; phosphates alone resisted the depletion.

TABLE 1.—*State of fertility factors in soil of the Griffith State Forest Nursery in 1935 and 1970*

Time of soil analysis	Reaction *pH*	Organic matter *Percent*	Exch. capacity *ml./* 100 g.	Total N *Percent*	Avail. P_2O_5 *Lbs./acre*	Avail. K_2O *Lbs./acre*	Exch. Ca *ml./* 100 g.	Exch. Mg *ml./* 100 g.
Summer 1935	5.5	0.9	3.1	0.055	42	66	1.28	0.32
Winter 1970	5.4	2.0	4.9	0.085	163	241	1.45	0.48

Figure 3.—Multiuse sprayer with a pressure pump and agitators that apply rapidly liquid fertilizers, acidifying solutions, and hydrosolic eradicants.

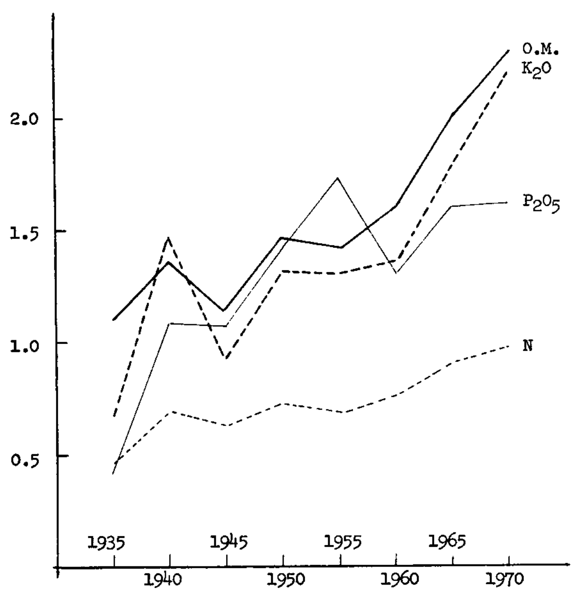

Figure 4.—Dynamics of organic matter and major nutrient elements in soil of the Griffith State Forest Nursery. Each ordinate represents the average of 5-year averages in the state of soil fertility factors (one unit equals 100 pounds per acre of K_2O and P_2O_5, 1.0 percent of organic matter, and 0.1 percent of total nitrogen).

Beginning in 1946, there was another effort to re-establish soil fertility, rather difficult to accomplish in the absence of vigorous detachments of the CCC enrolees. The decade between 1950 and 1960 was marked by a uniform level of soil fertility except for an occasional, slightly excessive supply of available phosphorus. This phosphorus is increased by applications of fermented sawdust compost enriched with ammonium phosphate.

A highly significant moment in the life of the soil was manifest in 1960, a moment inescapable in soils of all permanent nurseries-the time when the supply of silicate minerals becomes exhausted. In the early stages of production, the nursery stock received a part of its sustenance from a concealed source of nutrients, which does not appear in the results of soil analyses. This source is a small fraction of micas, feldspar, and ferromagnesian minerals incorporated in the quartzitic deposit of glacial outwash. These unweathered minerals are insoluble in weak extracting solutions used in laboratory determinations, but their nutrients are extractable by roots of seedlings endowed with mycorrhizal fungi and other rhizospheric microorganisms producing potent chelating compounds. Since 1945 the action of these weathering agents supplemented the diet of the Griffith nursery stock, but by 1960 the supply of silicate minerals was nearly exhausted. In turn, there was need to increase the content of nutrients by soluble fertilizers and to combat their leaching losses by augmented additions of adsorbing material-organic matter. The rigid correlation between the content of humus and that of available potassium is a striking feature of the Griffith nursery soil.