FOREST RESEARCH LABORATORY

RESEARCH NOTE 68

EXCAVATING ROOTS WITH EXPLOSIVES

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INTRODUCTION

An important limitation in the study of tree roots has traditionally been the time necessary to excavate roots without injuring their fine structure. Thus, many root studies have been based on small samples and consequently contain large errors of estimation. This Note describes how large numbers of root systems from sapling-sized trees can be excavated rapidly and with minimum injury by placing patterned charges of high explosive in the soil.

The techniques described were developed while examining root growth in Douglas-fir and red alder plantations in western Oregon. The studies were conducted to evaluate the effects of spacing and other manipulations on the root systems of trees ranging from 0.6 m to 6 m in height and growing in several soils. Over 1,180 root systems were evaluated. Implementation of the technique followed discoveries that (1) excavation of roots by washing required bulky equipment plus more than two manhours per tree and resulted in substantial damage to the roots and their mycorrhizae and (2) that explosives had been used successfully in excavating roots of larger trees (Hertert et al. 1975).

Our criteria for successful use of explosives for excavation of roots were as follows:

(1) Soil must be pulverized so that it shakes free from the loosened roots.

(2) The explosion must be contained by the soil so that roots and debris are not ejected.

(3) Charges must be placed so that the zone of pulverized soil is uniform and includes the entire volume occupied by the roots under study.

SOIL PULVERIZATION

Velocity of detonation and soil moisture content were found to affect loosening of the soil. We used dynamite of the highest and lowest velocities generally available, at 85 percent and 20 percent nitroglycerine equivalent, respectively. When

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placed 4 feet below the surface, the low-velocity "stumping" dynamite loosened the soil in the form of large clods; surface blocks with this type of dynamite were a foot or more in diameter under dry conditions. Clod size with low-velocity dynamite was smaller after some irrigation but was still too large for easy extraction of fine roots. When the soil was moist but not wet, the high-velocity dynamite pulverized all soils into fine fragments. Dry soils with heavy grass cover did not break up satisfactorily on the surface but were substantially loosened below ground. Our soils included clay loams and fine sandy loams. For soils in this range, texture did not have an obvious effect on results.

For irrigation of dry soils prior to excavation, we used a portable pump and 800-gallon tanker trailer and applied about 2 inches of water with a sprinkler. After two days were allowed for drainage, deep percolation, and equilibration, the surface soil was at an ideal moisture content for excavating, i.e., somewhat below field capacity.[1] In areas of weed control, stored water within the soil substantially reduced the need for irrigation except on the surface. When explosives were fired too soon after watering, the increased density of the soil resulted in violent soil movement without concurrent breakage into fine fragments.

[1]Moisture content at ideal blasting condition varied with soil texture. Best results were obtained at about 2 bars tension or more, but with enough moisture to pack well without stickiness. Soil moisture suitable for tillage with light equipment is also suitable for this blasting method.

CONTAINING THE CHARGE

The amount of explosive used determines the degree to which a given volume of soil is lifted by the explosion. A series of test patterns demonstrated that one stick (1-1/4 x 8 inches) of high-velocity dynamite (Hi-Drive®) per cubic yard of soil gave about the right degree of lifting and pulverization when placed 3-1/2 to 4-1/2 feet below the surface. Lower charges resulted in erratic lifting or soil that was too coarse, and higher charges threatened to eject too much material from the area.

Those preparing to excavate should conduct preliminary tests in areas without valuable roots. We recommend starting with 3/4 stick per cubic yard and working up by increments of 1/4 stick per yard to the desired amount of lift and fragmentation of soil. Soil conditions during such tests should be substantially identical. When lifting roots for study, one should have adequate charges in the first attempt, because subsequent charges may not work well in the partly loosened soil.

PLACEMENT OF CHARGES

Sticks of dynamite should be placed in a pattern (fig. 1) so that simultaneous explosions converge as a lifting plane. The charges are placed in vertical bore holes made by a power auger approximately 1/4 inch larger in diameter than the sticks. The bottoms of the bore holes should be at a uniform depth and spacing inside the perimeter of the blasting area. When a charge of one stick per cubic yard is used and holes are 48 inches deep, the holes should be drilled in a square pattern about 30 inches apart. They should be about 36 inches apart when they are 36

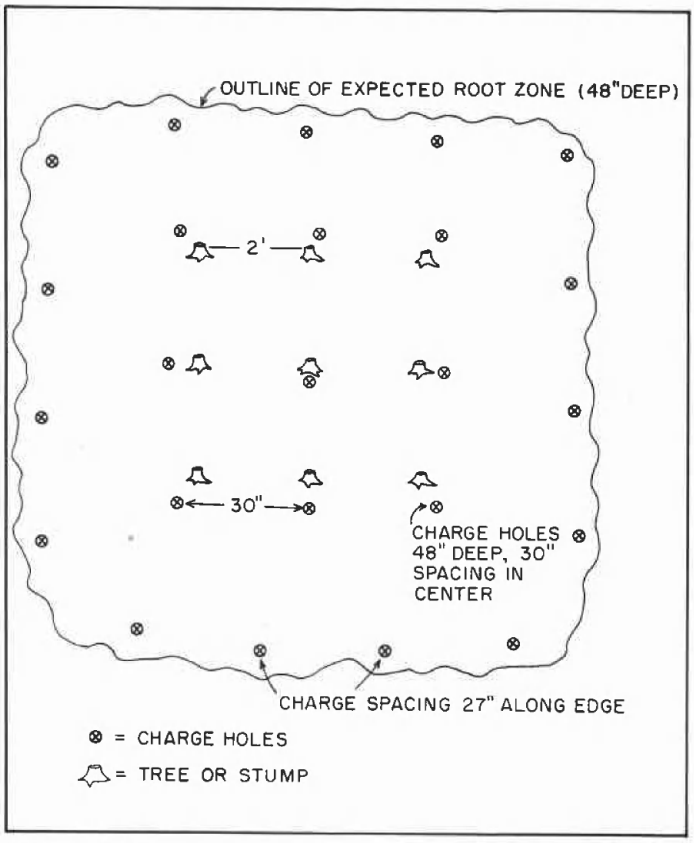

FIGURE 1.

SAMPLE PATTERN FOR PLACING CHARGES WHEN EXCAVATING ROOTS IN SMALL PLOTS OF SAPLINGS.

inches deep and about 27 inches apart when they are 5 feet deep. All charges should be tamped carefully with soil containing enough moisture to pack readily.

Charges along the edge of the plot should be somewhat closer together than those in the center. A good guide is two-thirds to three-quarters of the average distance between the charges beneath the trees. Such an arrangement will produce a clean edge around the plot and easy excavation across the entire blast area.

When charges are placed in the proper pattern, the entire mass of soil is raised and pulverized. When the soil drops back into place, the roots are freely accessible and largely intact to the smallest growing tip (fig. 2). In our studies with Douglas-fir and alder saplings, root breakage occurred only when large roots extended deeper than the charges or outside the perimeter of the blast area. Root damage was slight to undetectable under ideal moisture conditions and charge placement. Damage can occur when the soil is too wet or too dry or when too few charges are placed. Rocks may affect the charge density needed and may also become missiles if charges are too heavy.

All charges must be interconnected to insure simultaneous detonation. Our charges were all rigged individually with electrical caps. The same result may be obtained with detonating cord at lower cost and less risk during tamping of charges. Instructions of the manufacturer of either caps or cord should be followed to the letter.

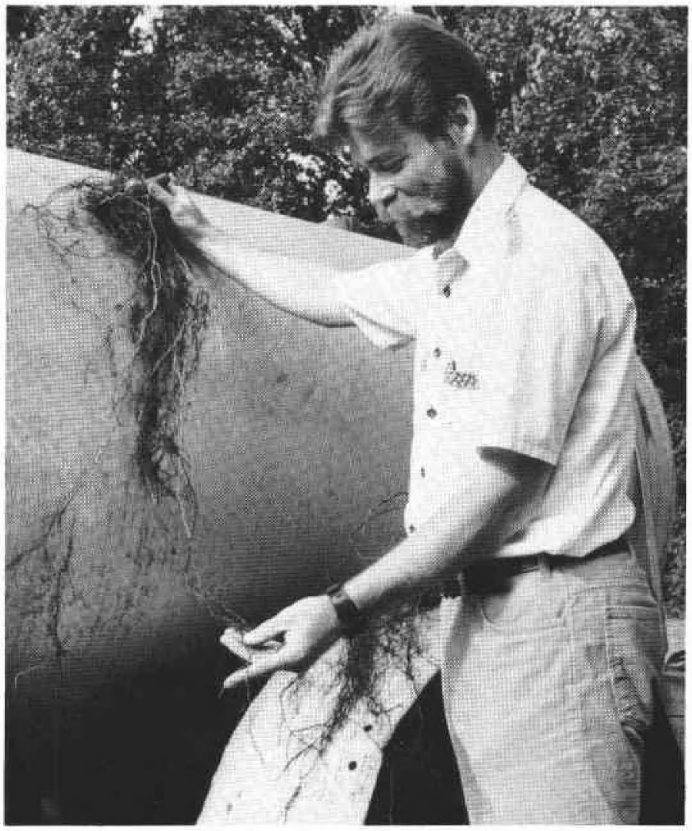

FIGURE 2.

ROOTS OF DOUGLAS-FIR SAPLINGS AFTER REMOVAL BY BLASTING.

EQUIPMENT NEEDED

The only major items of equipment needed are the power auger, a machine for detonating electrical caps, and a circuit-testing device. The detonating machine and auger can often be obtained from equipment rental agencies or distributors of explosives. In addition to major items, one needs a non-sparking, spikelike instrument about 5/16-inch in diameter (ideally a crimping tool) for punching a hole for the cap in the dynamite stick, a roll of two-strand wire 500 feet long, rubber gloves for handling dynamite, and a square-ended wooden pole 7 feet long and 1 inch in diameter for tamping the charges. Be certain to test the electrical circuit before firing. Instructions for such tests can be found on the detonating machine or in a handbook on blasting.

EXCAVATION AND TIME REQUIREMENTS

With this technique, complete root systems may be extracted from soil almost as if they were embedded in loose sand. The blast lifts the roots and soil up in one disintegrating mass, from which the roots settle back more slowly than the soil. Thus, the roots are closer to the surface after the blast than before it. The loose structure of the soil renders manual excavation easy (fig. 3).

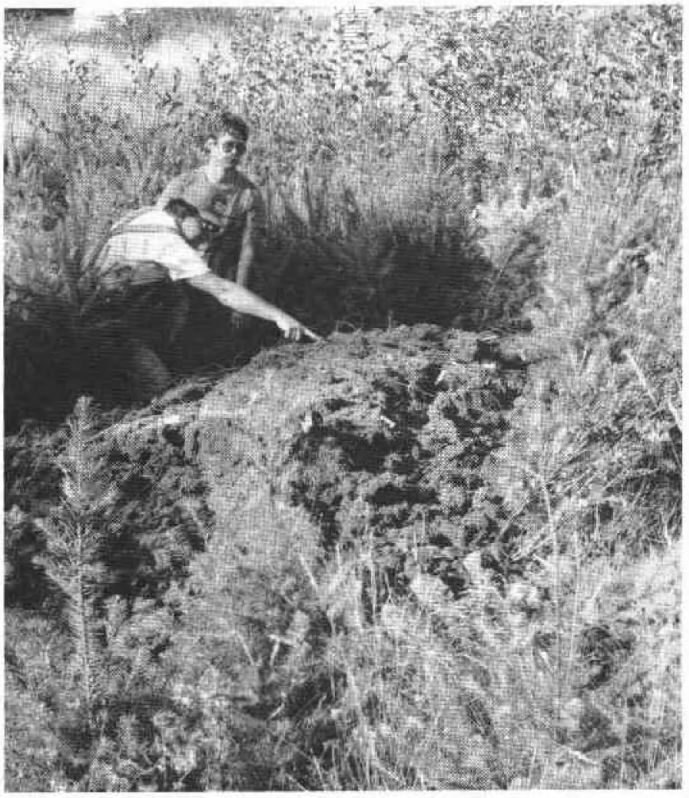

FIGURE 3.

BLASTED SITE READY FOR ROOT REMOVAL.

Time requirements for excavation vary widely, depending on the size of trees and depth of roots. The trees in our study were removed intact at the rate of about 10 per manhour.

Time requirements for blasting were less than for excavating. A blast involving 10 holes at 48-inch depth required a preparation time of about 40 minutes for a crew of 2. An allowance of 2 minutes per additional charge should suffice when estimating time requirements for a job. Our trees were planted in clusters of 33 on wedge-shaped plots of about 100 square feet, requiring 11 sticks in as many holes per blast. These plots each required 40 minutes to prepare and blast; slightly more than an hour was needed to remove all roots. Rainfall after blasting resettled the soil and made it sticky, substantially increasing the time needed for lifting.

We are not certain as to the upper limit on tree sizes suitable for this technique. It is not unreasonable to assume that any size of tree may be so handled, provided the grid of dynamite extends under the full spread of roots. Because fine roots extending into the plane of lifting will be sheared, an estimate of root depth and spread is desirable when diagraming charge placement.

SAFETY

The sale of explosives is regulated by law as administered by the U.S. Bureau of Alcohol, Tobacco and Firearms. A permit is necessary to buy and use industrial explosives. Such permits are obtainable in Oregon through offices of county sheriffs.

Those interested in using explosives for any purpose are well advised to read pertinent literature on the subject before proceeding. A useful general reference, updated periodically, is "The Blaster's Handbook," published by the DuPont Corporation, Wilmington, Delaware. This reference outlines all the procedures used here and gives instructions for applying them correctly. Our Note merely reports on a constructive use of explosives for a specific purpose. Users should become familiar with the general properties of explosives and with particulars of handling beforehand. FOLLOW INSTRUCTIONS PROVIDED WITH EXPLOSIVES CAREFULLY. THIS RESEARCH NOTE DOES NOT PROVIDE ADEQUATE INSTRUCTION FOR BLASTING.

REFERENCES

HERTERT, H. D., D. L. MILLER, and A. D. PARTRIDGE. 1975. Interaction of bark beetles (Coleoptera: Scolytidae) and root-rot pathogens in grand fir in northern Idaho. Canadian Entomologist 107:899-904.

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