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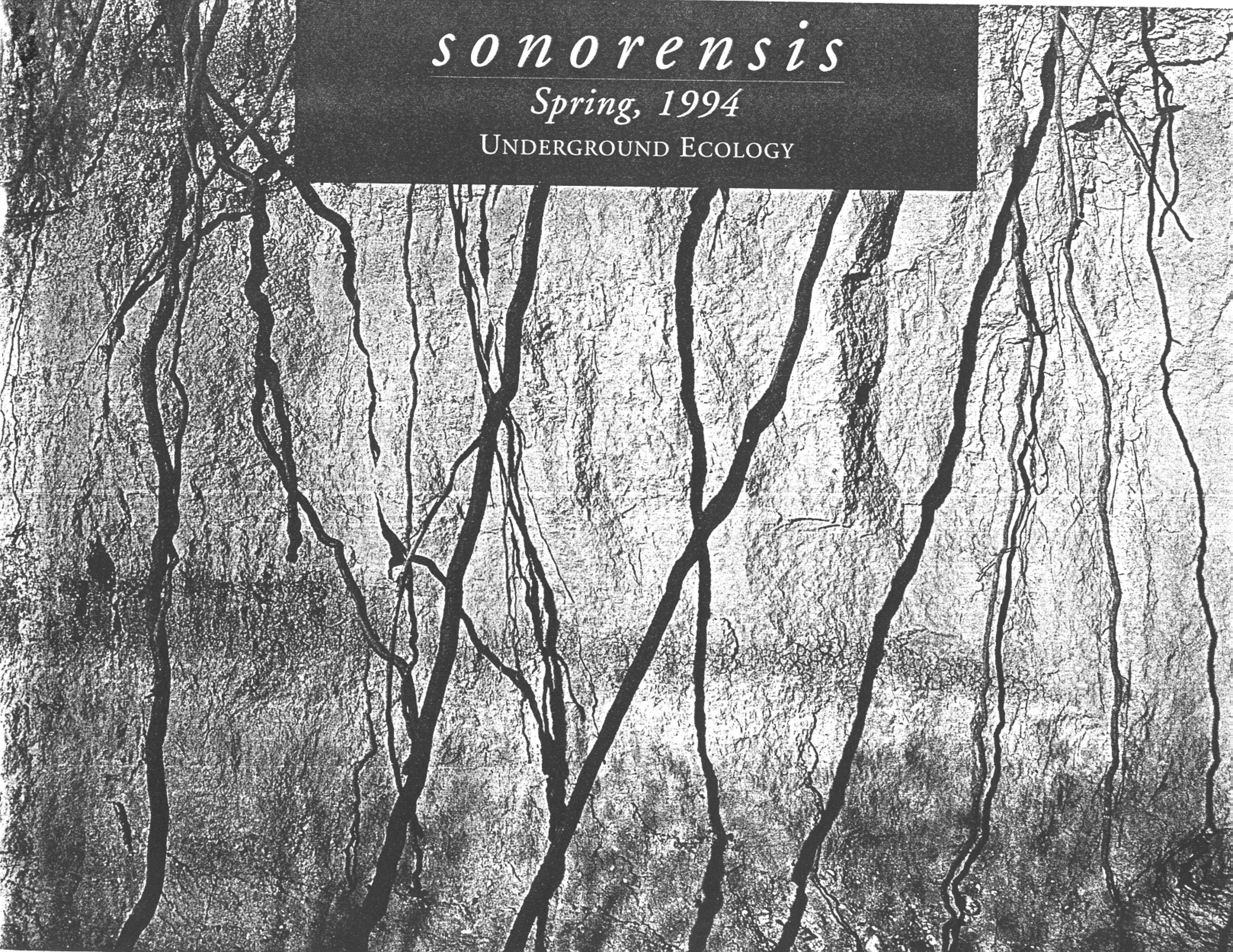
UNDERGROUND ECOLOGY



ROOT SYSTEMS OF DESERT PLANTS

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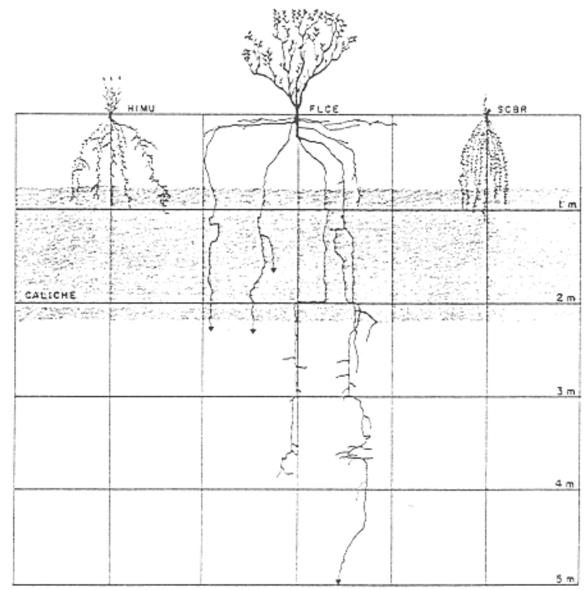
Using water spray to expose tarbush roots

We are all familiar with the above-ground parts of desert plants. While we may admire and photograph the pretty flowers or unusual plant forms that we can readily see, we seldom think of a major portion of the plant, the root system, which is concealed within the soil. Roots are very important to a plant because they not only anchor the plant in place but also are the means by which the plant acquires water and nutrients (nitrogen, phosphorus, potassium and other elements essential to growth). In low rainfall desert environments, water is often the most limiting factor for plant growth, and root systems of desert plants are often shaped to maximize the uptake of this vital element. Quite often, the weight of the root system is equal to or greater than the weight of the above-ground portion of the plant. A knowledge of the morphology or form of root systems is very helpful in understanding the ecology and interactions of the diversity of plant species found in desert environments.

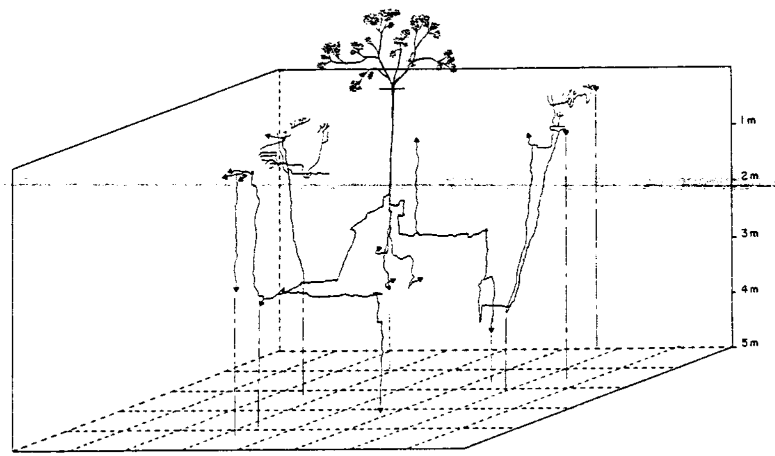
There are three basic types of root systems. Fibrous root systems consist of numerous small, fine roots and are characteristic of grasses. Tap root systems consist of a single large dominant root with branches much like an inverted tree and are characteristic of trees, some shrubs and many annual and perennial herbaceous plants. The third type is a generalized root system which is similar to a tap root system but has several large roots instead of a single tap root. This type is characteristic of many shrubs, and some trees and herbaceous plants. Root systems will, of course, be shaped to greater or lesser extent by the type of soil in which they grow. Many desert soils have a caliche layer which is a zone of accumulation of soluble calcium carbonate which is leached downward through the soil by rainfall. The caliche layer may occur at a depth of several inches to several feet and varies in thickness from one to several feet. Normally, the bottom of the caliche layer marks the lower limit of the normal percolation of rainwater. The caliche layer may be an accumulation of calcium carbonate nodules and coatings on individual soil parti-



Root systems of tobosa, Hilaria mutica *(HIMU); tarbush,* Flourensia cernua *(FLCE); and burrowgrass* Scleropogon brevifolius *(SCBR) growing on a fine sandy loam soil. Scale is in meters (1 meter = 3.3 feet).*

cles and relatively soft, or it may be petrocalcic (dense and rock-like). In the latter case it can offer a real physical impediment to the growth of roots.

It is not easy to study the morphology of root systems because it is difficult to separate roots from the soil. However, using a back hoe, pressurized water sprays, ice picks, and a great deal of patience, the morphology of root systems can be determined. Excavation of a large number of root systems in the northern Chihuahuan Desert near Las Cruces, NM has revealed some interesting features. Shrubs with generalized root systems, including the very common cresosote bush (*Larrea tridentata*) and tarbush *(Flourensia cernua)*, were found to extend well below the bottom of the caliche layer to depths greater than 16 feet/5 m (deeper excavations were not made due to safety and logistic problems). In the top foot of soil, creosote bush and tarbush roots extended horizontally up to 10 feet (3 m), many times the diameter of the top of the shrub. One of the most remarkable root systems was that of crucifixion thorn *(Koeberlinia spinosa)*. This tap-rooted species had root branches which, upon encountering hard soil layers at depths of 3 to 11 feet (1 to 3.5 m), turned and grew straight up! Some branches extended to within 4 inches (10 cm) of the soil surface. Other branches penetrated the hard layers and were still growing downward at a depth of 16 feet (5 m). Honey mesquite *(Prosopis glandulosa)*, another very common shrub in the northern Chihuahuan Desert, is usually found on sandy soils underlain with petrocalcic caliche layers. Mesquite has a taproot and also many lateral roots which grow horizontally in the soil above the caliche layer. These horizontal roots were found to extend as far as 52 feet (16 m) from the base of the plant; undoubtedly some roots are much longer.



Root system of a large crucifixion thorn (Koeberlinia spinosa) *growing on a clay loam soil. Vertically ascending roots had branches which extended to within 4 inches of the soil surface. Scale is in meters (1 meter = 3.3 feet).*

Many vertically growing roots which ascended to within 2 to 4 inches (4 to 10 cm) of the soil surface were found arising from the wide-spreading horizontal roots. Upward-growing roots do not support the statement often found in basic biology texts that roots are positively geotropic and grow downward. Rather it appears that roots can be water seeking, and hydrotropism can override geotropism. The tap root of mesquite and other downward growing branches followed cracks through the caliche and penetrated to depths of more than 16 feet (5 m). The deeply penetrating shrub roots can access soil water which results from the occasional periods of high rainfall and percolates below the caliche layer.

Roots of grasses were not found below depths of 4 feet (1.2 m) and usually did not extend more than a few inches in the caliche layer. Grass roots did extend horizontally up to 3 feet (1 m) from the base of the plants. Perennial herbaceous plants often had roots which grew to depths of 10 feet (3 m), and even annual herbaceous plants had roots

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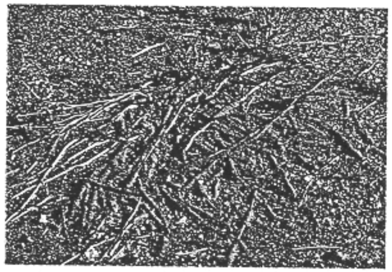
ters, economically and every other way. Fortunately, the research of New Mexico State University's Walt Whitford, his students and colleagues, has revealed something of the function of termites in southwestern deserts and desert grasslands. Whitford has written a summary of this research which will appear in a forthcoming ASDM book on desert grasslands; that summary informs the following remarks.

Termites eat dead plant material and animal dung, thereby removing this litter from the surface of the land, permitting sunlight and moisture to reach new growth. On its own, dry cow dung decomposes very slowly. Without subterranean termites to break it down, Whitford estimated that cow pies would smother the land, covering 20% of the surface in 50 years.

When dead plant material is broken down inside a termite's gut, carbon and minerals such as nitrogen, phosphorus and sulfur are released from storage in the plant. These nutrients are used by the insect and its gut flora, or are deposited as feces. Through these feces or through the feces of predators which have eaten the termites, these nutrients are returned to the soil, where they can again be used by living plants. In these ways subterranean termites are responsible for most of the cycling of carbon and other nutrients in a desert or desert grassland.



ASDM

When they are above the surface, termites work inside galleries or shelter tubes which they've constructed out of soil, fecal material and saliva. These galleries protect the termites from predation and from drying out. In this photo a gallery surrounds a dead plant.

As subterranean termites build their nests and foraging galleries, they greatly improve the fertility and productivity of the soil. In plots of soil from which they had chemically excluded termites, scientists found that water infiltrated much more slowly, and that the soil was more dense and stored less water than in plots which contained termites. Foraging galleries around dead grass stems and other food items are made with material brought up from deep in the soil. These galleries eventually erode and are added to the surface soil—at a rate of 44 kilograms per hectare (about 40 pounds per acre) per day, according to one study. Over time, the turnover of soil significantly affects the content and even the creation of soil.

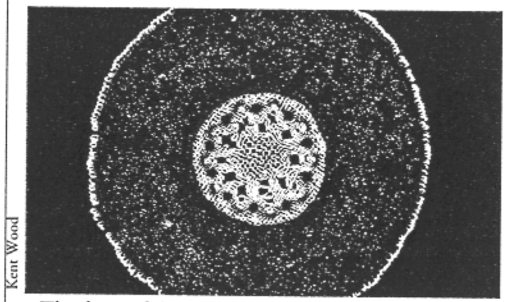
Predation rates for termites are very high; it has been estimated that in one year predators will eat 2.5 times the mass of subterranean termites alive at any one time. Many birds, mammals and especially lizards prey on termites which are caught foraging above ground, making termites an important part of the food chain.

Unless they bother us, we don't think much about termites because they're small and they live underground. But these tiny creatures with their secret lives are crucial to our existence.

ROOT SYSTEM *(cont. from page 5)*

extending to depths of 4 feet (1.2 m) or more. (See drawing, p. 4.) Roots are not respectors of territory, and the root systems of shrubs, grasses and herbaceous plants were highly intermingled in the upper soil layers.

Shrub root systems occupy a much greater volume of soil than do the root systems of grasses. Because shrubs can use soil water resulting from small rainfall events as well as water from depths below that attained by grass roots, they have a competitive advantage. This helps to explain why shrubs have successfully invaded and now dominate many areas which were once desert grasslands.•



Kent Wood

This beautiful photo of a cross-section of a root, dyed to highlight certain tissues, shows that roots are complex organs, made up of many different tissues with many different functions. Different cells transport or store water and nutrients, support and anchor the plant, or produce new cells.