Success Secrets *of* Desert Plants

How do some plants manage to survive—and even thrive—on parched deserts and on arid and semiarid rangelands?

Baffled scientists have, for decades, hoped to learn how these specialized plants cope with stresses like high temperatures and scant water that often kill less hardy plants growing in more humid areas.

Then they will know more about how to repair arid Southwest rangeland that has gradually shifted from a mix of shrubs and grass to land with more shrubs and fewer grasses.

On thousands of acres, cattle and wildlife now have less forage to graze. Wind and water erosion remove more soil, and some birds and reptiles have moved to other areas.

Scientists have known about various survival mechanisms that certain plants possess. For example, cacti and agaves store water, while sagebrush has tiny leaves and creosote bush, waxy ones to slow transpiration. Other desert plants may shed leaves—or entire branches—to cope with diminished water supplies.

"Understanding these mechanisms helped. But we were still at a loss to explain the long-term interactions between plants and their environment," says ARS rangeland scientist Kris M. Havstad.

"Now we're concentrating our studies on what happens in the root zone—an aspect of arid native ecosystems that had not been extensively researched until recently."

To facilitate their studies, ARS scientists at the Jornada Experimental Range near Las Cruces, New Mexico, used a backhoe to dig trenches 15 feet deep next to plants growing on rangeland. Then, like archeologists unearthing hidden treasure, they used ice picks and high-pressure water sprays to expose plant roots.

Roots on most desert plants, like those on relatives that grow where water is plentiful, exhibit positive geotropism; that is, they grow downward in response to gravity.

But several desert shrubs have roots that defy the pull of gravity and grow straight up once they reach depths of from 1 to several feet. These upward-growing roots branch near the soil surface to capture moisture from light rainfall.

The scientists believe that a mechanism called hydrotropism can actually override geotropism.

They also learned that mesquite shrubs have taproots that penetrate deeper than 15 feet. From these grow shallow roots that spread out laterally at depths of 1 to 3 feet for distances of 50 feet or more. These lateral roots have many vertical branches that grow to within 2 to 4 inches of the soil surface.

"Mesquite plants can harvest water near the soil surface, as well as mine it from depths far below those reached by the roots of grasses," says rangeland scientist Robert P. Gibbens. "This could help explain why shrubs have successfully invaded—and now dominate—many areas that were once desert grassland."

In more basic studies, ARS plant geneticist Jerry R. Barrow and Havstad sampled native desert grasses and shrubs and identified three types of fungi that live symbiotically on their roots. These nonpathogenic fungi appear to help plants survive extended dry periods.

"Other scientists have shown that plant-fungal relationships help plants take up essential plant nutrients. We feel that in arid environments, these three types of fungi form a critical bridge between the plant and the soil," says Barrow.

One type—vesicular-arbuscular mycorrhizal fungus (VAM)—is common to most plants and develops extensively inside the roots.

A second type also develops extensive networks within root cells and can access nutrients by breaking down plant debris. It was found on grass and shrubs growing at arid sites varying in elevation, moisture, temperature, and soil types in the southwestern United States.

The third fungus appears to regulate nutrient uptake and interact with other fungi to benefit the plant.

Working in harmony, the three fungi obtain carbon—and possibly other nutrients—from the host plant and transfer it to other soil microbes, including bacteria. These organisms, in turn, take up nutrients and water from any available source, such as the atmosphere, soil minerals, or plant litter. The fungi then safeguard or store these limited but vital resources, slowly releasing them to the plant to ensure survival.

Says Barrow, "Because of their regulatory ability, the fungi may protect plants against taking in excessive or even toxic amounts of minerals and salts.

"A disturbance of the microbial populations may help explain why reseeding often fails on rangeland. Over time, beneficial fungal associations likely change as the mix of species changes. To ensure success when reseeding deteriorated rangelands, compatible symbiotic associations among fungi and seedlings must also be reestablished."

The Jornada scientists also found that fungi aggregate fine sand particles around the roots of desert shrubs, enhancing water-holding capacity of the soil. Sand particles that are attached by the fungi are coated with bacteria that appear to weather surfaces and release nutrients to the plants.

In other studies, Barrow found two populations of fourwing saltbush growing in New Mexico that reproduce asexually, which is another survival mechanism. In addition to producing seed—like most fourwing saltbush plants, as well as most other desert shrubs—these highly nutritious plants also spread by underground stems that radiate away from "mother" plants.

"The ability to produce new plants from underground stems is common in some plants but unique among saltbush to these two populations," says Barrow. "The trait appears to be under genetic control and would be valuable for incorporation into other desirable selections we need for revegetating rangeland, particularly in areas subject to fire, grazing, or other damage."

The new plants would recover more rapidly, having underground reproductive mechanisms that were not harmed by disturbances.

"We need to continue our studies to learn more about the complexity of plant-environment relationships," says Havstad.

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In studying the symbiotic relationship among soil fungi, plant geneticist Jerry Barrow checks the growth of inoculated alfalfa seedlings. (K5815-1)

"We hope to one day find simple approaches to identifying conditions and trends on arid rangelands. Our final mission will then be to develop benign practices that repair desert landscapes here in the United States and in similar areas found worldwide.—By **Dennis Senft,** ARS.

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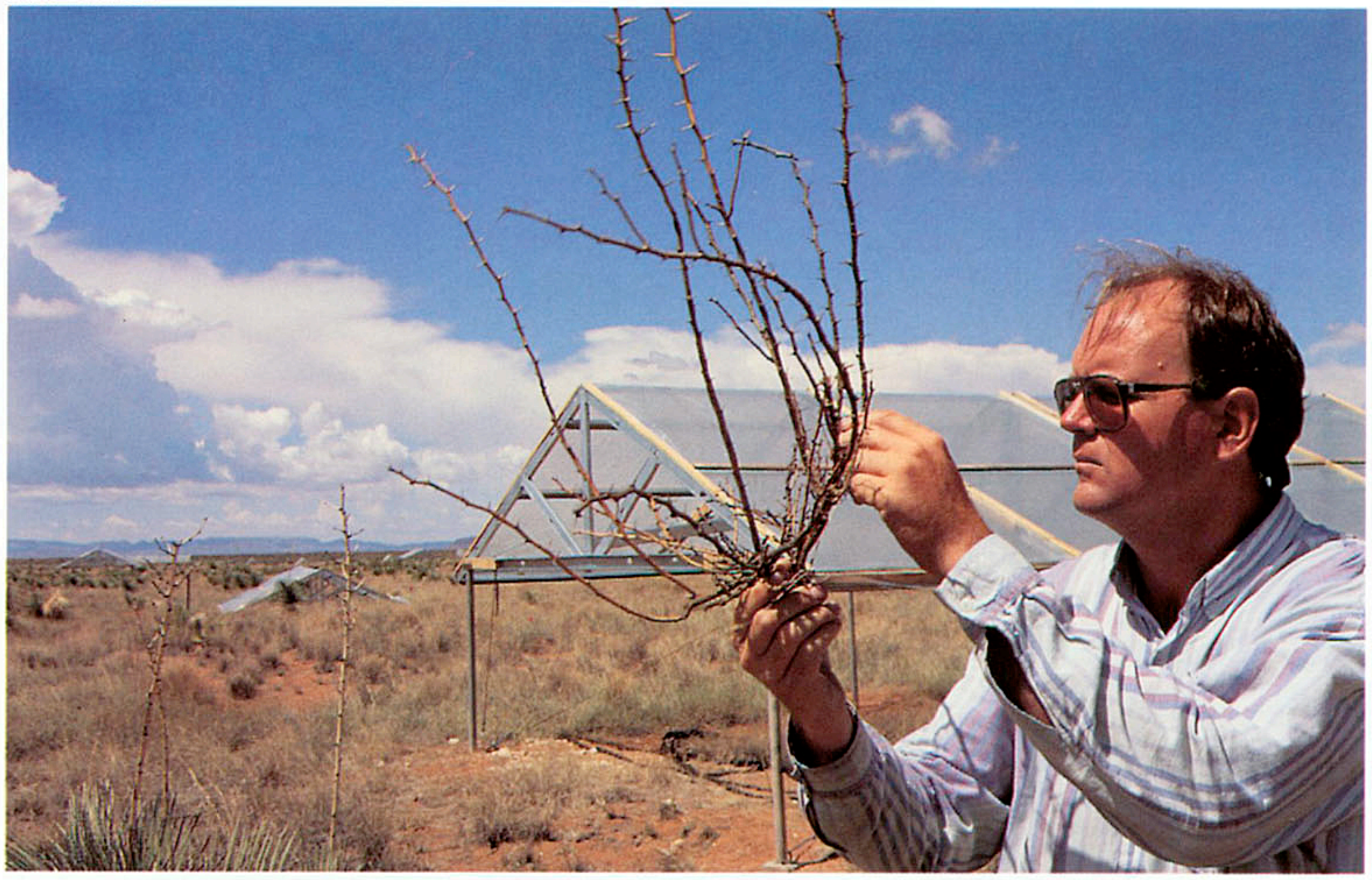

Rangeland scientist Kris Havstad examines branches of a mesquite plant. The rainout shelter in the background is used to simulate drought conditions. (K5814-2)

"Natural" Reseeding of the Desert

Natural waterways are being used to reseed rangeland on the Jornada Experimental Range near Las Cruces, New Mexico.

These waterways represent likely sites for successful revegetation because they generally receive moisture, organic matter, soil, and nutrients from recurring floods. Scientists are developing two methods to exploit these natural phenomena.

In the first method, ARS researchers seed desirable perennial shrubs and grasses along the headwaters of shallow arroyos.

They irrigate the plots and build fences to protect tender seedlings from grazing livestock.

After these plants mature, they produce seed that floodwaters carry downstream, along with silt and organic matter. As more plants become established, they slow waterflow and increase these depositions. This improves soil fertility, slows erosion, and increases water infiltration.

In the second method, scientists developed two types of pole-mounted seeders that store seed safely and stand idle in a gully until water flows through it.

On one, a wide vane positioned at a 90° angle to the gully twists when storm water begins to flow. This twisting action slides a cover off a small slit on the seed container attached to a pole. The seeds slowly slip out of the container and drop 3 to 4 feet into water that carries them downstream.

The second version has seed dispersal triggered when the flowing water pulls on a foot-long piece of railroad tie with a flexible wire attached. This pulls a cork out of the seed container's bottom.

Using automatic self-seeders, scientists have successfully dispersed and germinated grasses like alkali sacaton and blue panic and a shrub—fourwing saltbush.

If streamflow one year is not adequate to activate the seeders, the seed is protected from insect, rodent, and bird attack until the next year.

These natural methods of seed dispersal on native lands would be a low-cost, highly efficient way to upgrade rangelands for livestock grazing and to improve wildlife habitat, says ARS plant geneticist Jerry R. Barrow in Las Cruces. They would not cause severe biological or land disturbances and would be a long-term effort to revegetate desert land.—By **Dennis Senft,** ARS.