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Desert Biome Research Program Mapping an Ecosystem

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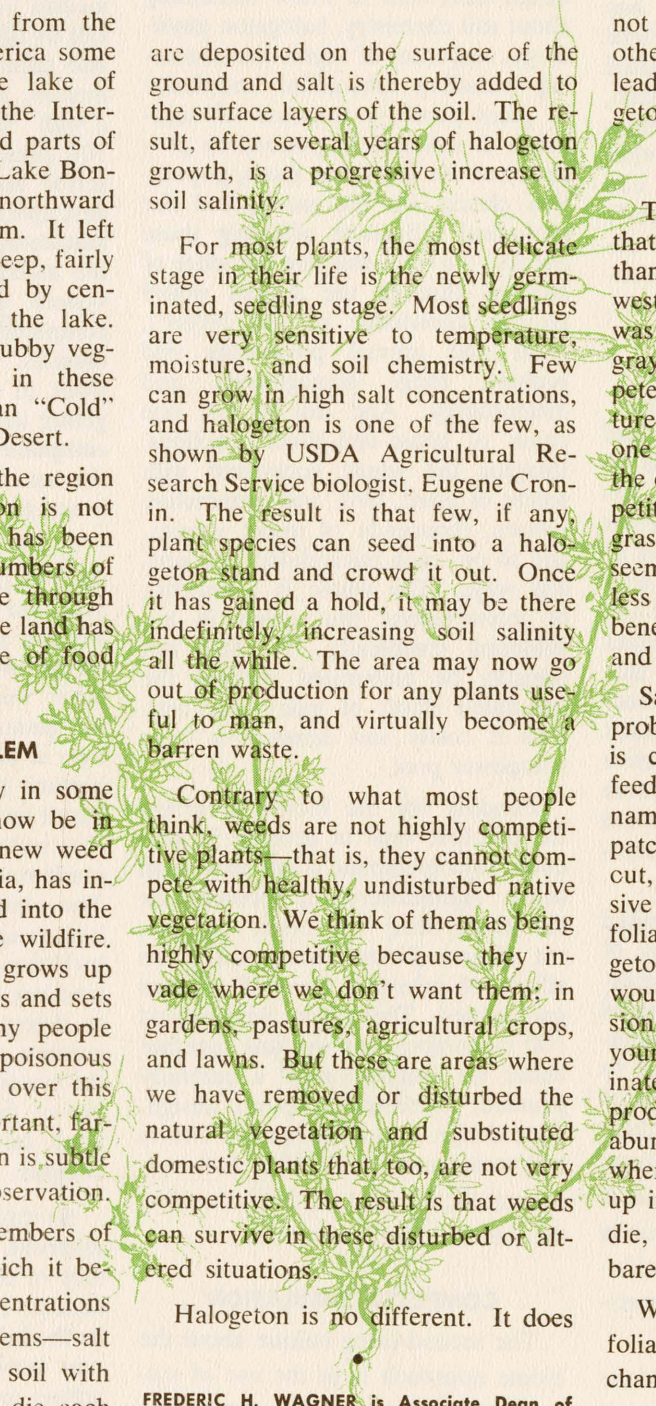

As the glaciers receded from the last Ice Age of North America some 10,000 years ago, a huge lake of melted water was left in the Intermountain West that covered parts of Utah, Nevada and Idaho. Lake Bonneville eventually drained northward into the Snake River system. It left behind broad valleys with deep, fairly rich soils that were formed by centuries of sedimentation in the lake. Ecologists now call the shrubby vegetation which developed in these valleys the North American "Cold" Desert or the Great Basin Desert.

Because the climate of the region is semi-arid, the vegetation is not highly productive. But it has been able to support limited numbers of sheep in winter, and cattle through most of the year. Hence, the land has been moderately productive of food and fiber for human use.

HALOGETON PROBLEM

That productive capacity in some parts of the region may now be in permanent jeopardy. The new weed halogeton, a native of Russia, has inadvertently been introduced into the region and has spread like wildfire. It is an annual plant that grows up each year from seed, flowers and sets seed, and then dies. Many people know halogeton as a plant poisonous to sheep, and the concern over this is great. But the more important, far-reaching hazard of halogeton is subtle and not evident to casual observation.

Halogeton, like other members of the chenopod family to which it belongs, builds up high concentrations of salt in its leaves and stems—salt which it extracts from the soil with its roots. When the plants die each year, those salt-laden leaves and stems are deposited on the surface of the ground and salt is thereby added to the surface layers of the soil. The result, after several years of halogeton growth, is a progressive increase in soil salinity.

For most plants, the most delicate stage in their life is the newly germinated, seedling stage. Most seedlings are very sensitive to temperature, moisture, and soil chemistry. Few can grow in high salt concentrations, and halogeton is one of the few, as shown by USDA Agricultural Research Service biologist, Eugene Cronin. The result is that few, if any, plant species can seed into a halogeton stand and crowd it out. Once it has gained a hold, it may be there indefinitely, increasing soil salinity all the while. The area may now go out of production for any plants useful to man, and virtually become a barren waste.

Contrary to what most people think, weeds are not highly competitive plants—that is, they cannot compete with healthy, undisturbed native vegetation. We think of them as being highly competitive because they invade where we don't want them: in gardens, pastures, agricultural crops, and lawns. But these are areas where we have removed or disturbed the natural vegetation and substituted domestic plants that, too, are not very competitive. The result is that weeds can survive in these disturbed or altered situations.

Halogeton is no different. It does not flourish in healthy sagebrush or other desert vegetation. And this leads to another aspect of the halogeton problem.

SAGEBRUSH AND MOTHES

There is good reason to believe that there is more sagebrush today than there was 100 years ago in our west deserts. At that time there likely was more grass and such plants as gray molly. All of these plants compete with each other for space, moisture, soil nutrients, and sunlight. Any one will increase at the expense of the others if they are placed at a competitive disadvantage. Grazing of grasses and some forbs by livestock seems to have filled this role. The less palatable sagebrush seems to have benefited, and increased in numbers and distribution.

Sagebrush seems to be having its problems. A moth, the larva of which is called the sagebrush defoliator, feeds on sagebrush leaves, as the name implies. In recent years, large patches of sagebrush have been dying out, apparently because of the excessive numbers and feeding by the defoliator. Prior to the arrival of halogeton, death of a sagebrush patch would have been followed by reversion to grass and gray molly, or young sagebrush plants which germinated from the abundant seed supply produced by the shrub. With an abundance of halogeton seeds everywhere, however, their seedlings spring up in a carpet as soon as the shrubs die, and light and moisture fall on bare soil. And we are on our way.

What causes outbreaks of the defoliator moth? Have we somehow changed the checks and balances—songbirds, lizards, insect predators, and parasites—so that they can no

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longer hold the moth population in check? We are only beginning to study the moth and its population checks. These studies are showing that the animal is preyed upon by numerous parasites and predators, and we know nothing about their ecology.

It is just this kind of irrevocable change in the ecosystem that the ecologist is concerned about. Man has permanently altered lakes which once provided him with food, created deserts where livestock once grazed, and exterminated animal species which once provided food and other products. Their productivity can never be regained, and we clearly cannot afford to lose productive capacity of the earth when a burgeoning human population demands more, not less, sustenance.

ENTER IBP

To live solely for the present and close our eyes to what happens to tomorrow is prodigality in the extreme. It is therefore vitally important that we expand our understanding of the functioning of the earth's ecosystems to the point where we can predict the effects of our activities and avoid doing those things that permanently alter the earth's productive capacity. It is the development of this understanding and predictive capacity to which the Desert Biome research effort of the International Biological Program (IBP) is committed.

The IBP is sponsored in the United States by the National Academy of Sciences, and financed by Congressional appropriation administered through the National Science Foundation. Its major effort is devoted to studying the structure and function of ecosystems, with the goal of developing the capability for predicting effects of human perturbation. This effort is subdivided into five geographic units called "biomes": the tundra, deciduous forest, coniferous forest, grassland, and desert.

How does this differ from previous ecological research, and why has it created such a stir in the scientific community? There are basically two characteristics to the biome programs which are new to ecological research. The first is in the size and integration of the venture. If we go back to the halogeton story, we can ask what kinds of knowledge we would have needed to predict the lost productivity of the Lake Bonneville valleys. We would have had to know something about soil chemistry, halogeton physiology, responses of vegetation to grazing including substantial knowledge of plant ecology, response of sagebrush to defoliation, population processes of the defoliator moth, population checks on the moth, and the ecological influences affecting those checks. To trace this one sequence of changes through the system would require knowledge of soil physics, plant and animal physiology and ecology, range management, and meteorology. And this is just one chain of cause-and-effect reactions. Imagine the whole ecosystem with scores of plant, bird, and mammalian species, thousands of insect species, and so on, each interrelated in countless ways. The whole is a network of interrelations that exists in bewildering complexity. It could not possibly be elaborated without the integrated effort of many scientists. This is costly and demands a large manpower pool.

Funding for the biome programs for the first time in ecology is adequate to contemplate a full ecosystem study. Administered by ecologists on the Utah State University campus, the Desert Biome incorporates the efforts of scientists from 18 western universities. These men, who exceed 100 in number, are working together under the integration of a carefully planned, elaborate research design. That design insures that their efforts will complement each other and contribute to the goal of understanding the whole desert ecosystem.

COMPUTER SIMULATION

The second thing unique about the biome approach is in the use of systems analysis or computer simulation. If we go back to our view that an ecosystem consists of thousands of plant and animal species, all tied together in thousands of different interrelationships along with weather and soil, it is immediately obvious that the whole is too complex for the human mind to comprehend at one time.

To get around this problem, we are building what are called simulation models to be handled by a computer. Let us think of the individual species and their relationships as bricks and mortar, and the whole ecosystem as a wall. It is possible for each of our 100 plus scientists to study and describe one or a few bricks. Those descriptions are made in the form of mathematical equations that tell how the individual species perform in the system. These descriptions then go to computer specialists who are also biologists, and who do the masonry work in fitting all of the bricks together into a wall. The wall is a long computer program containing all of the equations, and which we now call a simulation model of the ecosystem.

If we program into the computer the water, solar energy, and other inputs into the ecosystem, the computer will run along, calculating the growth, births, deaths, seasonal changes, and other things that take place among the plants and animals in the system over a period of time. Now we can perturb the system by programming into it the effects of grazing, modifying the weather, fertilizing, controlling predators, introducing halogeton, etc. The computer should then tell us the long-range consequences of such perturbations. And through alternative land-use patterns, we should be able to determine how we can derive the greatest, long-range production from the system for human welfare. Modeling of the desert ecosystem is being done on the Utah State University campus.

So this is the reason for all the excitement. For the first time in the history of ecology we have sufficient financial resources and the analytical methods for attempting this most complex problem in all of science. Scientists are working together as they

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UTAH SCIENCE

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Research scientists, professional ecologists, at Utah State University are very much aware that the decisions of today will shape the environment of tomorrow. They know that the environmental issues so prevalent in public conversation and the mass media will not be solved or erased by shouting rhetoric, or press releases. Instead, they must continually develop and apply ecologically sound principles to most effectively utilize and protect our natural resources.

Our scientists are interested in developing better methods for measuring public opinion, educating the traveling public to the scenic grandeur of Utah's national parks, controlling vertebrate pests such as starlings and coyotes, and finding out why our depleted ranges are not "coming back". Measuring the chemical profile of a mountain stream, discovering the secret of fragile desert ecosystems, making ranges more productive of game and livestock, protecting prairie dogs, climatic planning, and low pressure fruit storage are some of the subjects discussed in this issue of **Utah Science.**

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UTAH SCIENCE

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