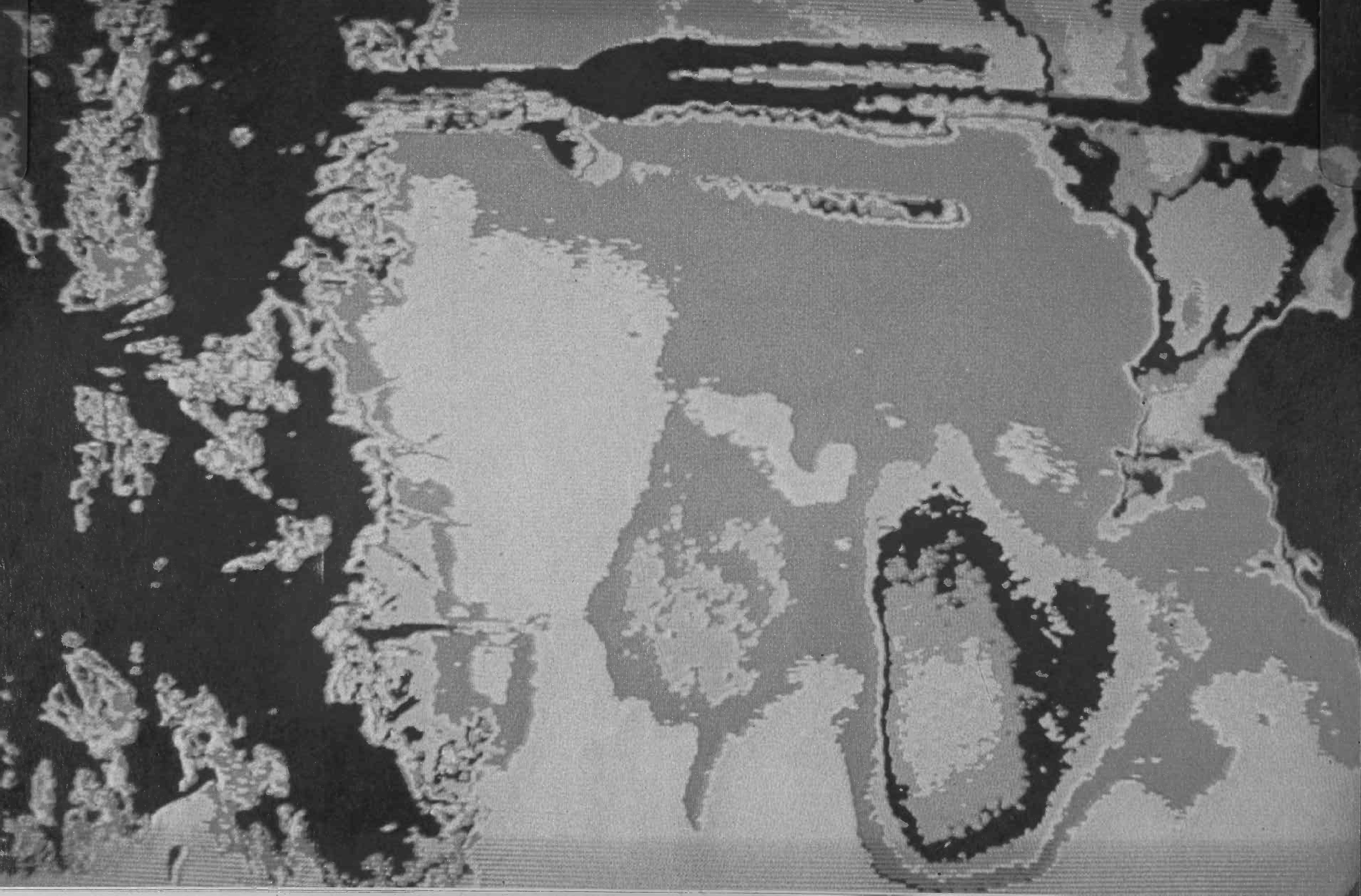
PROGRESSIVE AGRICULTURE in Arizona

Summer 1976 • The College of Agriculture • University of Arizona • Tucson



On the Cover . . .

It's not exactly *Arizona Highways*' style, but it does show vividly what a device known as a "real time slicing densitometer" can do in recognizing many different shades of gray and assigning each a separate color. The densitometer is used in interpretation of aerial photographs in the College of Agriculture's new Laboratory for Remote Sensing and Computer Mapping. The laboratory is featured in this issue in an article dealing primarily with computer mapping. At left is the original black and white desert landscape, taken in Saguaro National Monument (east section) with a Deardorff 4" x 5" camera on Plus X film by John P. Schaefer, President of the University of Arizona. Color photo by George Kew.

In This Issue . . .

We call your attention particularly to our center spread article by Jimmye Hillman, head of agricultural economics, on the feasibility of the much-discussed proposal that America use its grain as an economic weapon. Hillman has been scrutinizing the world's food supply for several years.

Note to Our Readers:

Technical problems caused the consolidation of the Spring and Summer editions of the magazine into the much enlarged version you are now receiving. Regular quarterly publication begins with this edition.

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PROGRESSIVE AGRICULTURE IN ARIZONA
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OH, THE FARMER AND THE ENVIRONMENTALIST

SHOULD BE FRIENDS

by Roger L. Caldwell*

"If we could first know where we are and whither we are tending, we could better judge what to do and how to do it."
— *Abraham Lincoln*

Beginning in the late 1960's and early 1970's, there occurred in this country and worldwide a re-awakening of a concern for the environment. Hundreds of years ago, when man was living and hunting in natural surroundings, the environment was much different from today's. Then, man did not have much capacity to pollute, the interactions between communities of men were minimal, and there were seemingly unlimited lands and resources available.

Today, the actions of one group may affect many other groups. There is more pollution, and more people

*Director, Council for Environmental Studies, associate professor of plant pathology.

are affected by it. There are few places to move to when land is worn out or mineral deposits depleted. There is a long-term shortage of water, energy, prime land, and certain minerals. There is insufficient information to evaluate all the consequences of many of our actions. Today there is little control over resources which many people must use. Examples are air and water quality, ocean fishing, and public lands. When many people must use a resource and no one has the responsibility for managing or maintaining it, many are apt to be adversely affected.

Until recently, environmental legislation generally aimed at controlling pollution and had specific impacts (such as control of air pollution from selected sources, or control of certain water pollutants). In the late 1960's, new kinds of environmental laws were passed, which recognized the complex interacting nature of environmental issues.

Perhaps the most significant was the National Environmental Policy Act of 1969 (NEPA). This Act created the federal Council on Environmental Quality and required that reports be made on the impact federal projects would have on the environment. Soon after came the Resource Recovery Act of 1970, the Clean Air Amendments of 1970, the Occupational Safety and Health Act of 1970, the Federal Environmental Pesticide Control Act of 1972, the Federal Water Pollution Control Act Amendments of 1972, the Noise Control Act of 1972, the Surface Mining and Reclamation Act of 1974, the Safe Drinking Water Act of 1974, the Energy Supply and Environmental Coordination Act of 1974, and the Energy Policy and Conservation Act of 1975.

Environmental Issues

While much of the force initially behind the "environmental movement" came from ecology groups, wilderness associations, and beautification committees, the movement has come to embrace many more and different groups and issues. The depth and type of public concern for the environment have been tapped by a number of surveys. Typical of these was a Spring 1974 survey of 1,550 people (57 percent return) by a College of Agriculture committee. Table 1 indicates the results of a question asking for a ranking of the greatest concerns among 11 possible categories. While obvious differences exist, both agricultural and environmental groups consider environmental quality as one of the more important concerns. This is even more obvious if you include other environmental factors such as energy and land use.

CONFLICTING USES: Farmland is being lost to pavem

When asked to rank the greatest environmental concerns from 17 possible categories, the groups again showed similarities (Table 2).

As indicated earlier, the first definitions of "environmental quality" were generally restricted, and included basic ecology, wildlife, and beautification. This resulted in some reaction against many of the early-day "environmentalists" and still causes statements such as "Do you want clean air or food on the table?" In the last five years, the term "environment" has been broadened to include new concepts and stresses the interaction among all of them. For example, a current definition of environment might

Table 1

ISSUES OF GREATEST CONCERN

Agricultural Groups	Environmentalists	Overall Population
1. Energy	1. Environmental quality	1. Energy
2. Economy	2. Government integrity	2. Economy
3. Government integrity	3. Energy	3. Government integrity
4. Public order	4. Public order	4. Public order
5. Land use	5. Education	5. Education
6. Environmental quality	6. Transportation	6. Land use

Table 2

ENVIRONMENTAL ISSUES OF GREATEST CONCERN

Agricultural Groups	Environmentalists	Overall Population
1. Land use planning	1. Land use planning	1. Land use planning
2. Energy	2. Air pollution control	2. Energy
3. Population growth	3. Population growth	3. Air pollution control
4. Water utilization	4. Energy	4. Population growth
5. Waste management	5. Protection of plants/animals	5. Water utilization
6. Air pollution control	6. Preservation of special areas	6. Water pollution control

ile the world is demanding increased production of food.

be "the system of interrelationships among society, economics, politics, and nature in the use and management of resources."

Only recently has there developed a widespread appreciation that there cannot be infinite growth in a finite world. We are realizing that there are limits to resources, and that shortages of energy, minerals, and food will continue. There are frequent references to the maximum population the earth can sustain in the long term (the "carrying capacity"). There are new measurements of progress developing, which evaluate all environmental factors, not just the economy.

In the past we generally measured "progress" exclusively in terms of increases in the Gross National Product. This was appropriate when natural resources were thought to be unlimited, or where the actions of one did not infringe upon the rights of others. Now the concept of "quality of life" is widely considered a better measurement of progress. From easily available statistics, a quality of life index can be developed. It might, for example, consist of personal safety, health, education, home and community environment, economic satisfaction, available recreation, and ease of access to shopping, entertainment, jobs.

Thus, the environmental issues are threaded throughout society. As society has become more complex, and we have realized some of the harmful — but delayed — effects of our past activities, we have begun to address these new issues (1).

Agricultural Issues

Agriculture has long been concerned with the environment. It was agriculture which pioneered the adoption of contour plowing, reservoir development, land and resource management, as well as establishing such agencies as the Soil Conservation Service and the U.S. Forest Service. The Cooperative Extension Service of the U.S. Department of Agriculture has an environmental thrust, and youth programs through 4-H are heavily involved in environmental activities.

It has been said that agriculturists were the first conservationists. However, some environmental problems have accompanied the boom in agricultural production over the years. Animals and plants that were not meant to be the targets of certain pesticides and herbicides have been killed. Streams have been polluted by fertilizer runoff, and the air has been fouled by crop burning. Odors, noise, and pollution have arisen from food processing plants.

We have observed tremendous increases in crop yield in the last 50 years, due primarily to improved varieties, fertilization, irrigation, and pest control; but these increases are coming more slowly and, in some cases, are declining. The oceans were once thought to be significant sources of food production (Figure 1), but the world's harvest of fish has been levelling off.

Agriculture, along with other segments of society, has substituted capital (energy) for labor, with a resulting increase in energy demand. For example, energy use for fertilizer production, equipment manufacture, fuel, and transportation has dramatically heightened production efficiencies, but these positive effects of energy use are approaching a leveling-off (Figure 2).

Agricultural land has frequently been buried under the "higher use" of residential and shopping

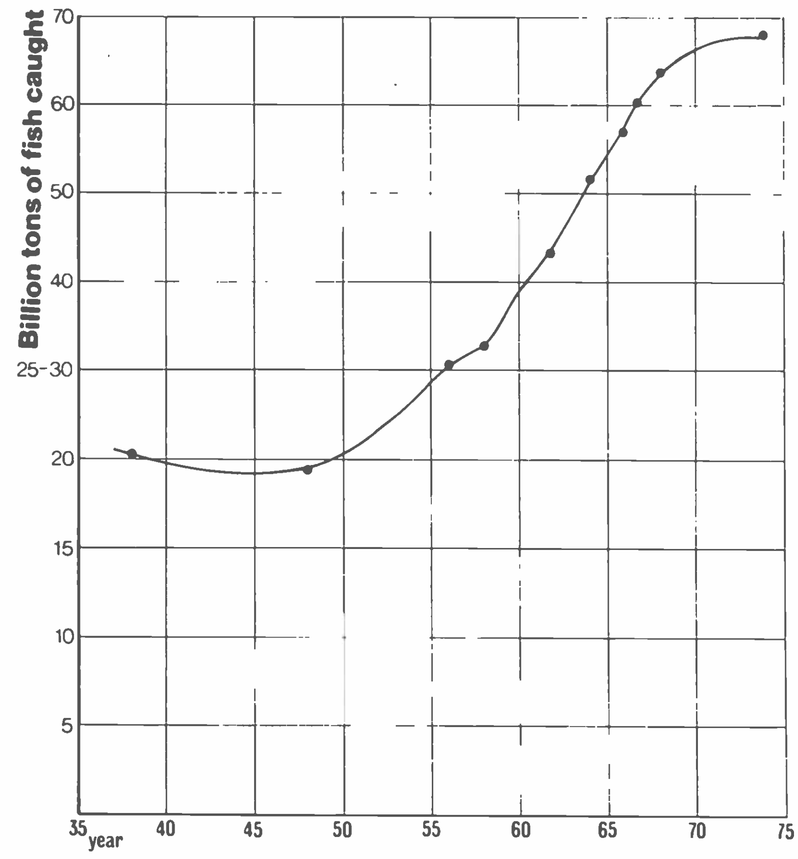


Figure 1. World Fish Catch

SALT CEDAR: Beautiful (above) nesting for birds, and a clogger of Arizona streams (right), the plant has caused bitter dispute between farmers and environmentalists.

center subdivision. This was a common and perhaps desirable pattern when agricultural land was plentiful and there were restraints on production. But now we are entering an era of shortages rather than surpluses, and new rules are required. Some states have decided that prime farm lands shall be permanently zoned as agricultural. Many states, such as California, have adopted land use plans which provide some tax incentive for retaining prime lands in agriculture. From 1950 to 1970, urban areas swallowed 13.5 million acres of rural land (1 percent of all crop land). Until 1972, crop land in the United States was in economic surplus, so urbanization had a minimal impact on productivity (Table 3). By 1974, however, farm policy and world demand had changed and required full production by U.S. agriculture. At the same time as the need for increased international cooperation has become evident, U.S. food exports have become a major factor in a favorable balance of trade program and food and energy have received a new and important world-wide status.

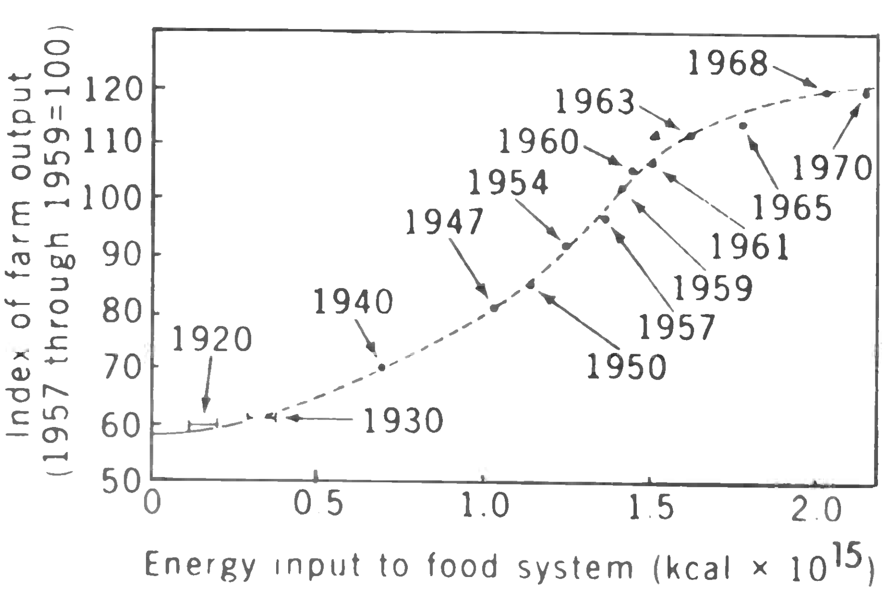
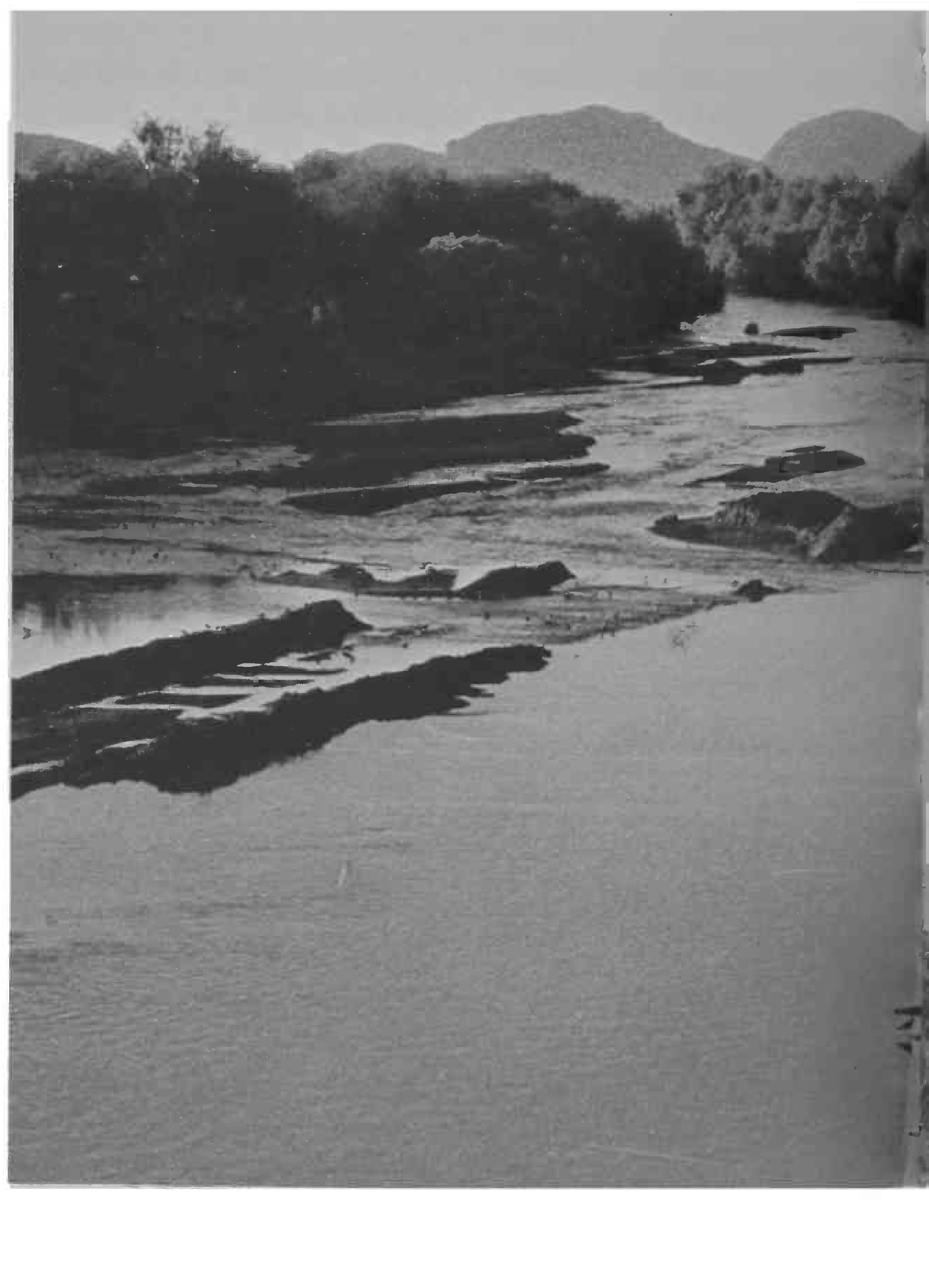


Figure 2. Farm output as a function of energy input to the U.S. food system 1920 through 1970.

Table 3

LAND USE CHARACTERISTICS

Land Type	U.S. (50 States)	Arizona
Federal	33.7%	43.5%
State	5.9%	12.2%
Indian	2.5%	26.7%
Private	58.2%	17.6%
Crop	21%	2.1%
Pasture	26.6%	0.0%

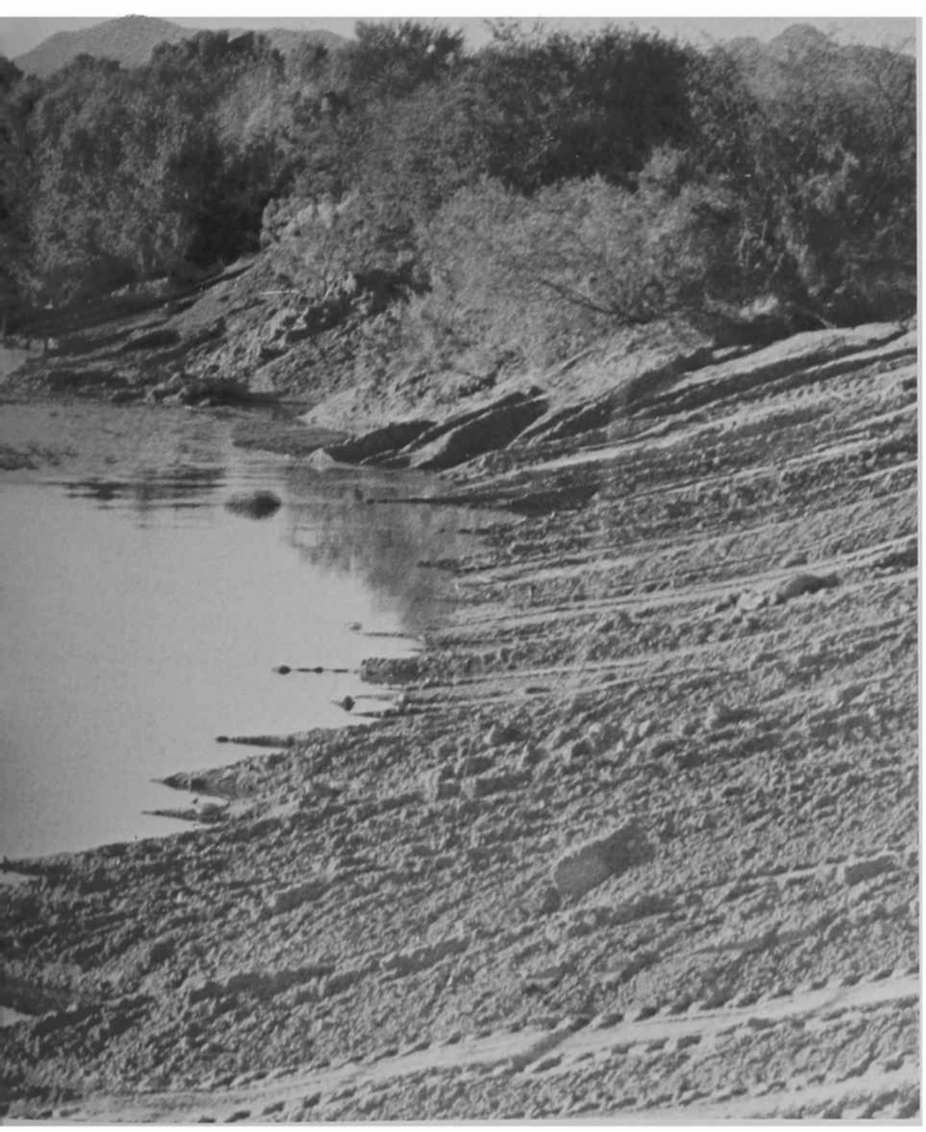


Just when increases in crop yields and fish production are leveling off and when a burgeoning world population is demanding that we produce more food, there are signs of a reduction of available agricultural lands and the possibility of an unfavorable weather trend developing. This is accompanied by environmental laws that put constraints on agricultural production in order that certain standards are met (most notably safety, pesticide use, and water quality).

These constraints are causing some friction because people tend to want to continue under past conditions, particularly when change is forced by legislation. But many of these regulatory restraints have evolved from yesterday's lack of proper attention to potential problems. Only when we discuss agricultural production in terms of years, not one season, do many of the goals of environmentalists and agriculturists seem common (2).

Interactions, Trade-offs, and Risks

Agriculture is finding itself interacting more frequently with seemingly non-agricultural concerns. In Arizona, the majority of the crop land is interspersed with urban areas. There are second-home subdivision developments in rural Arizona, and there is a greater growth rate in certain of the rural counties than in the large, metropolitan counties of Maricopa and Pima.



The demands for water by mining, agriculture, energy production, industrial and municipal use must be considered in relation to supplies. Transportation costs for agricultural products must be balanced against the advantages of localized production. When planting large acreages to single varieties of a particular crop (a common practice), the increased risk of pest infestations and climatic variation must be taken into account.

There is now a significant segment of the population that has not been "raised on the farm," and their understanding of food and fiber production is limited. Important roles for agriculture in urban areas include providing for "demonstration farms" for urban dwellers, open space in urban areas where land has been devoted to agricultural use, and an emphasis on the compatibility of strong agricultural production along with the public's deepening concerns for environmental quality. There are compromises involving trade-offs in every decision. Today society is complex, and complex mechanisms are much more apt than simple ones to go awry and to create greater hazards when they do. Major decisions cannot be carried out if they are made by one segment of society without consultation with other segments (or without strong public support).

Information as Central Problem

Top priority has to be assigned to the gathering and broadcasting of accurate information about the environmental problems that do exist. Time after time, studies show that when groups of people attempt to decide what is the most important environmental issue they find themselves frustrated by not having the information needed to evaluate the problem or to make decisions regarding it. Indeed, all other concerns could be considered to be symptoms of not having at hand the needed information.

Adding to the problem is that many persons and groups, that are sources of information about a problem, take sides on the issues. The experts and publications of many organizations present only the data that support their case. This, in the eyes of the public, gives credence to Mark Twain's declaration that there are "liars, damned liars, and statisticans." Such issues, for which there are no simple solutions, then become polarized for the public as well. This can be illustrated by one of the most significant agriculture-environment clashes — the one over DDT.

There are those who proclaim DDT one of the greatest benefits to mankind (3). There are others who conclude that it is one of the worst discoveries of the last 100 years (4).

Because so much has been written and so many studies have been completed about DDT, there are hundreds of references available. Depending on one's own feelings, and the interests of the audience the book or article is written for, a sufficient number of documented cases can be obtained to prove the insecticide holy or evil. This is not only misleading reporting, but it also polarizes and intensifies, rather than resolves, an already confusing situation. It does, however, serve the purpose of those on either side with an axe to grind.

An accurate history of DDT regulatory activity, based on available evidence, has been recently summarized and published by the Environmental Protection Agency at the request of the House of Representatives' Appropriations Committee (5).

DDT was first synthesized in 1874, but not until 1939 were its insecticidal properties first observed. During World War II, the chemical was used for the effective control of such diseases as typhus and malaria. In 1945, commercial and agricultural use of DDT was permitted. By then, many persons had observed firsthand its obvious effectiveness and its apparent safety. After peak production in 1959, manufacture of DDT dropped sharply. This decline in use was due to: (1) increased insect resistance (the house fly was first observed to have achieved resistance in 1950); (2) the development of more effective alternative pesticides; (3) the growing public concern over adverse environmental side effects; and (4) increasing governmental restrictions on DDT use.

Many DDT proponents blame the publication of *Silent Spring* in 1962 for the decline of DDT. While this did stimulate widespread public concern, the book cannot take credit for the original decline between 1959 and 1962. In 1957 the U.S. Forest Service prohibited certain DDT usage on lands under its jurisdiction. In 1964 and again in 1970, the Department of Interior restricted DDT and other chlorinated hydrocarbon pesticides on its lands. Between 1967 and 1970 the U.S. Department of Agriculture cancelled permission (registration) to use DDT on a number of crops and ornamentals.

In 1970, the Environmental Protection Agency (EPA) was formed, and under a court order in 1971 issued notices of intent to cancel the remaining DDT registrations. In 1972 the EPA cancelled all crop uses (but not public health uses) in the United States: this decision was upheld by the courts in 1973. In addition, 26 states have placed either a partial or complete restriction on DDT (Arizona issued a complete ban in 1969), and four national technical committees (1963, 1965, 1969, 1969) evaluated DDT evidence and recommended an orderly phasing out of DDT over a limited time period.

Thus, in the minds of special interest groups (for example, pesticide producers or wildlife protectionists) and many members of the public, there remains a great deal of controversy over DDT. If the vast amount of evidence from various groups were readily available and believable, the issue of DDT use could be resolved. The current DDT controversy is being kept alive by those who selectively use seemingly contradictory evidence on the insecticide. Clearly, DDT use would inevitably have declined as more evidence on its environmental effects and development of pest resistance accumulated. But it is an important insecticide and its use could have been limited short of a total ban. It is important to develop a mechanism for resolving controversies such as this, in order to deal with similar cases in the future.

Changing Times

We are in a transition period and it is always difficult to change one's ways, if sufficient incentives to do so do not appear to exist. Nearly everyone is comfortable in an established pattern; therefore the change must seem particularly advantageous, and it must not conflict directly with long-held traditions, prejudices, and value judgments. When evaluating well-established views and trends, it is often difficult to know whom to believe (for example, what is the real story on Arizona's water supply, or the world energy supply?). People become confused when technically trained persons mix fact with their opinions in reporting on a topic.

More and different kinds of people are now asking if we can continue to act on the premise of unlimited growth. And more and more leaders feel we are going through a transition stage after which our traditionally growth-oriented society will become a steady-state society (Figure 3).

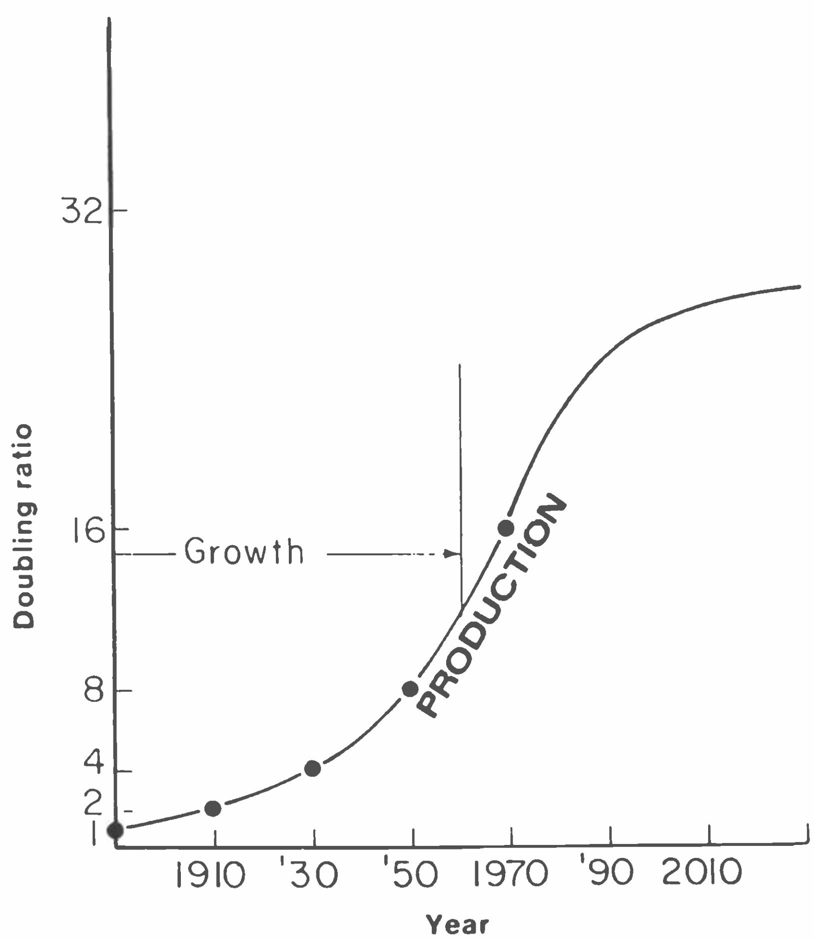
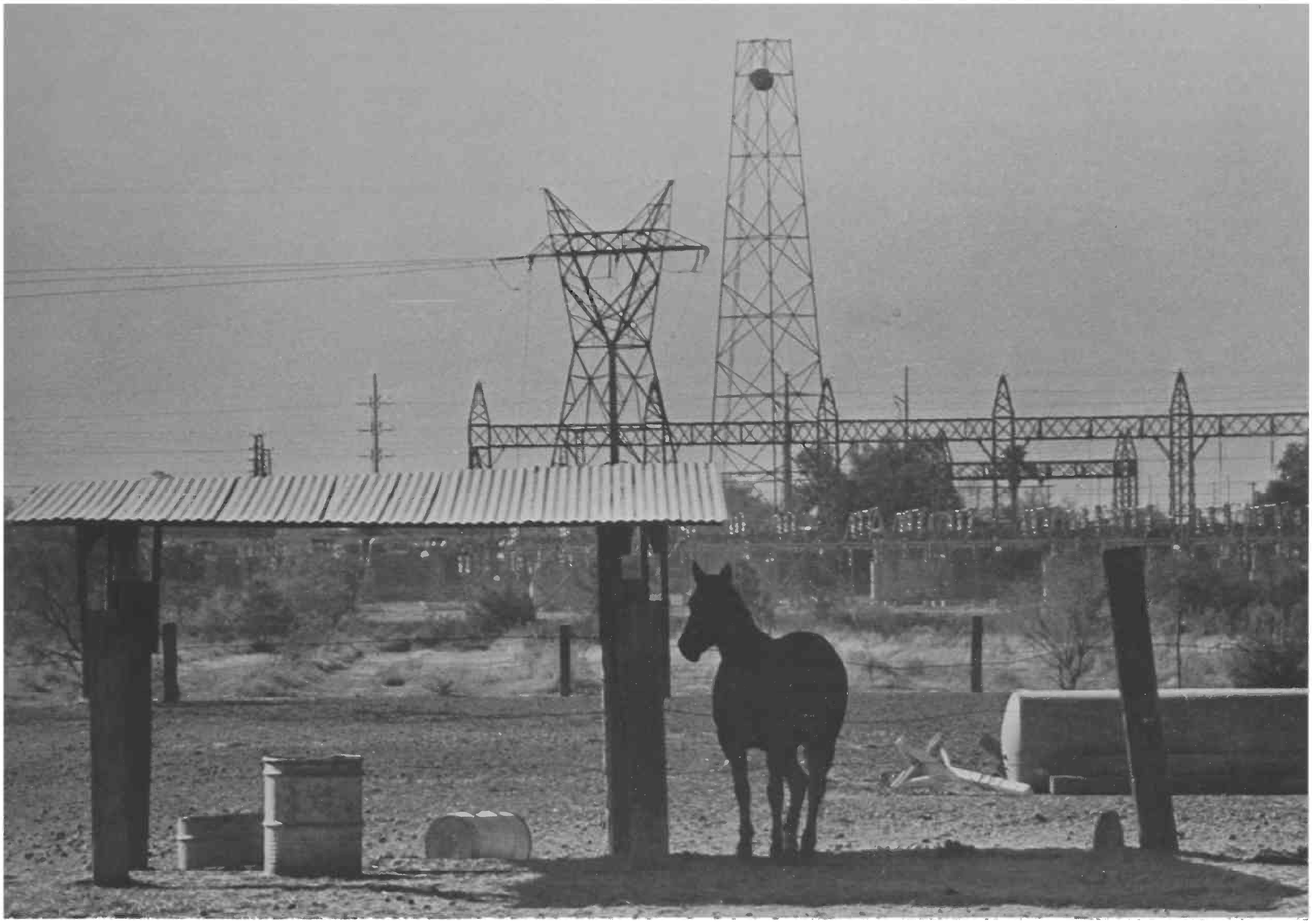


Figure 3.



OPEN SPACE: It can be preserved, but zoning measures and tax relief are needed.

Some of the major factors in this transition include population, food, natural resources and energy, capital availability, and social disruption. There is a requirement for more openness and greater public participation in the decision-making process. The evaluation in recent years of alternative solutions and consideration of their social, environmental, and economic impacts have all served to change significantly the way things are being done. It has become clear that we cannot base our long-range planning on what has happened in the past, an all-too-common practice. "Forecasting" is necessary where the many changing factors and alternative solutions are considered.

This will be complicated by a need for more information than is actually available. We will have to learn to use "best probable estimates" in place of very specific information. We may begin to base decisions on future needs rather than historical occurrence.

As we learn more of environmental variables, more regulatory restraints will be applied to society. For example, only recently have the toxic or cancer-inducing properties of asbestos, polyvinyl chloride, selected drugs, some food additives, of certain pesticides, nutritional deficiencies, or naturally occurring toxins become widely known. Exposure may take 20 to 30 years to produce symptoms. When undesirable environmental impacts are continued without correction, then regulation becomes necessary. Such delay not only increases the costs of correction but also leads to incomplete solutions and bad will among those affected.

There are certain conflicts in Arizona between environmentalists and agriculturists. These include debate over the Central Arizona Project, phreatophyte and brush control along waterways, technical solutions to water and salt content versus purchasing the farm land, predator control, and public access to leased public lands. The agriculturists and the environmentalists, however, have many goals in common including preserving prime agricultural lands, creating open space, the obligation of agriculture for energy production, new food sources, air pollution control by vegetative absorption, and soil conservation.

Once both agricultural representatives and environmental groups understand the other's viewpoint and reasons for behavior, an improved dialogue can be developed. As we learn more about the agricultural production system and the environmental conditions under which we live, there will be an increasing proportion of both groups committed to the long-term maintenance of the system.

Summary

It seems clear that we are entering a new era. There have been times when agriculturists and environmentalists have found themselves at odds; this is to be expected, as each group views an objective from a different perspective. There have also been instances when the two groups were closely aligned in viewpoint. Examples would include preservation of agricultural land, control of population growth, air pollution control, and soil conservation. Additional common goals are the use of soil and plants to absorb air pollutants, use of land for solid waste disposal (combined with crop production), use of animal waste as a feed source for micro-organisms or other animals, and use of agricultural products (biomass) as a source of energy.

As population and development pressures continue to increase, and as water and energy become reduced in supply, there will be large impacts on agriculture. Some of these impacts will appear to be favorable — and others will appear to be unfavorable — to agriculture. Since many of these impacts will be new, it will be difficult to make the necessary changes in society to resolve them. In many cases, the technology will be simple to develop compared to the problems of educating people and restructuring organizations so they most easily respond to the changes.

To address topics of environment and agriculture and to attempt to resolve some of the differences and emphasize common goals, the College of Agriculture established a Council for Environmental Studies in 1974. The Council has two major functions: (1) to provide communication on environmental subjects between College of Agriculture groups and others, and (2) to provide advice and coordination within the College of Agriculture on the variety of agricultural and environmental programs in teaching, research, and public service.

Selected References

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(3) Beatty, Rita Gray. 1973. *The DDT Myth: The Triumph of the Amateurs*. John Day Company, New York. 201 pages.

(4) Graham, Frank Jr. 1970. *Since Silent Spring*. Houghton-Mifflin Company, Boston. 333 pages.

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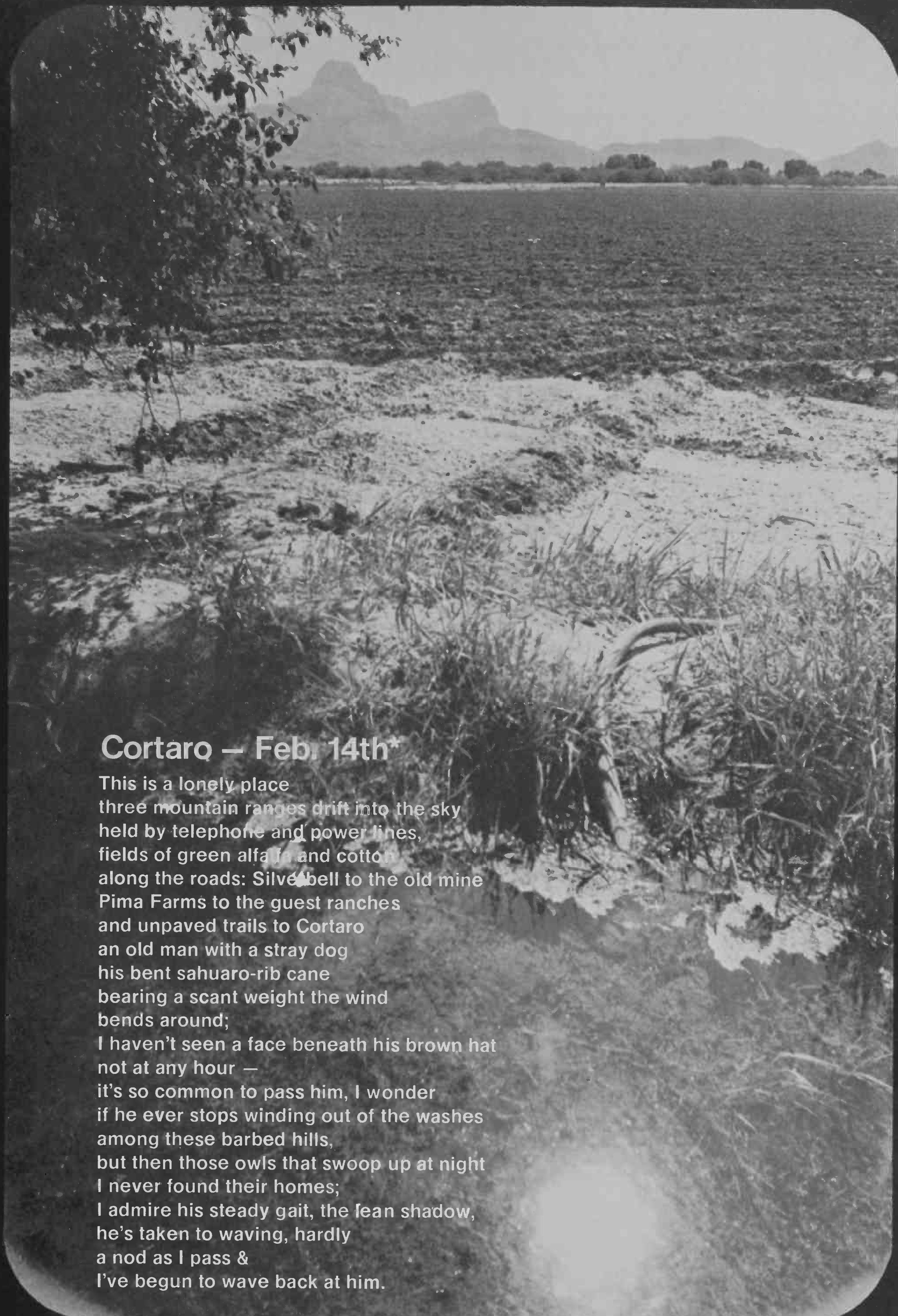


Cortaro – Feb. 14th*

This is a lonely place
three mountain ranges drift into the sky
held by telephone and power lines,
fields of green alfalfa and cotton
along the roads: Silverbell to the old mine
Pima Farms to the guest ranches
and unpaved trails to Cortaro
an old man with a stray dog
his bent sahuaro-rib cane
bearing a scant weight the wind
bends around;
I haven't seen a face beneath his brown hat
not at any hour –
it's so common to pass him, I wonder
if he ever stops winding out of the washes
among these barbed hills,
but then those owls that swoop up at night
I never found their homes;
I admire his steady gait, the lean shadow,
he's taken to waving, hardly
a nod as I pass &
I've begun to wave back at him.

*From "West of The American Dream" by Neil Claremon, William Morrow & Company, with permission.

In the space of a year or so, Cortaro won't be such a lonely place, Mr. Claremon. A subdivision – a community, really – of 16,000 persons is scheduled to begin there. Excellent growing land will be lost in one of the few areas in the state where water, via effluent, is plentiful. That, Mr. Claremon, is what some call "PROGRESS."

The Blue Aphid Arrives

FAR EASTERN PEST INVADES ARIZONA ALFALFA FIELDS

Mervin W. Nielson, Leon Moore, and R. Todd Kodet*

A new alfalfa pest invaded Arizona fields during 1975, spreading here from California where it has done severe damage in Imperial County.

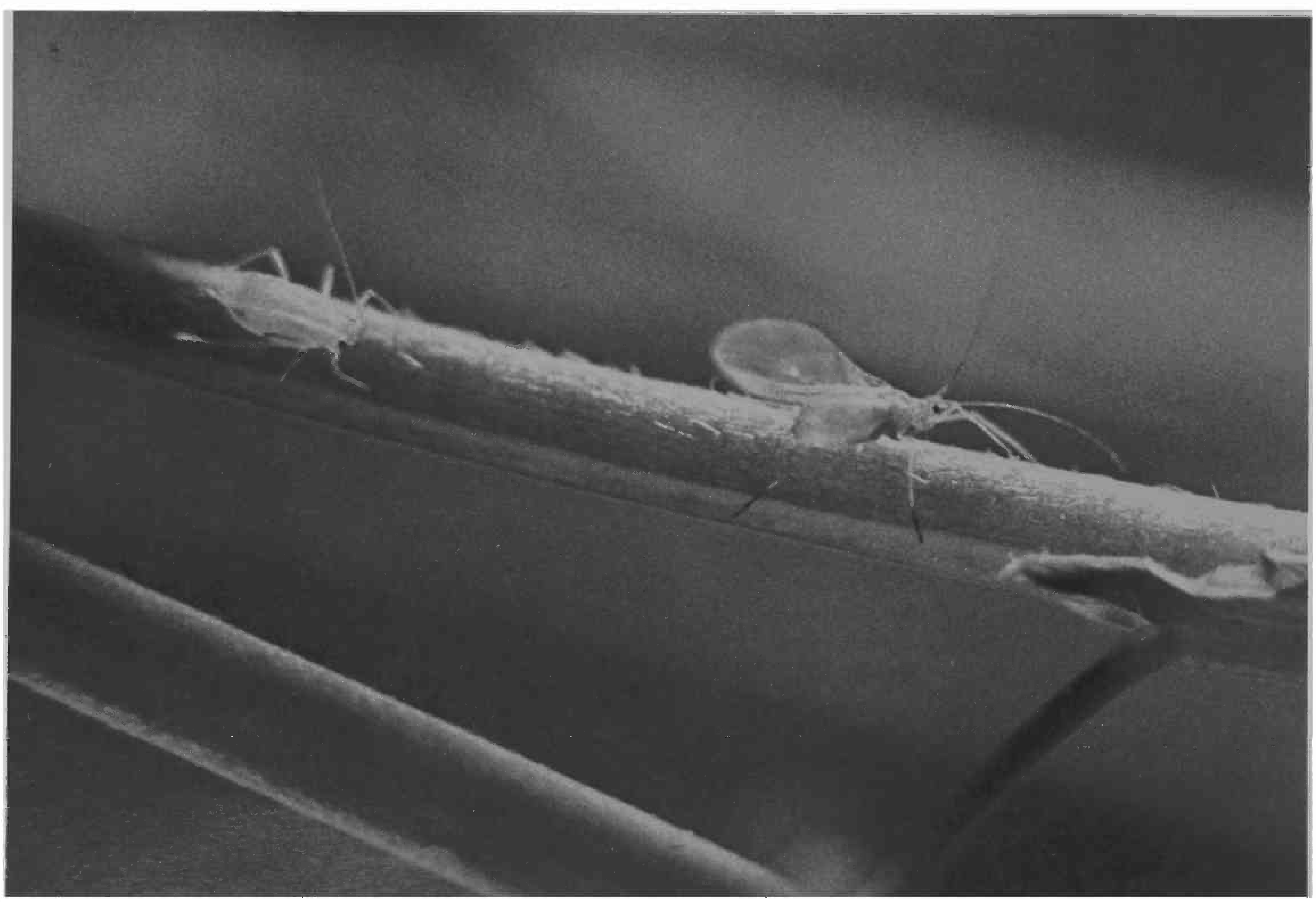
Called the "blue alfalfa aphid" (Acyrthosiphon kondoi, Shinji), the intruder was first discovered in Arizona in Yuma County last February, and may have first been introduced into California from Japan as early as 1972. Last year saw it spread not only to Arizona, but to Nevada and Utah as well, everywhere causing widespread destruction to alfalfa crops.

This aphid has now been reported in Arizona in Maricopa, Pinal, and Graham Counties, as well as Yuma, and it may be expected to spread to other alfalfa growing states. Unchecked, destruction of as much as 50 percent of a given alfalfa crop is well within the potential of this pest.

About 1/16 of an inch long, the blue alfalfa aphid resembles the pea aphid (Acyrthosiphon pisum), a common pest of alfalfa and peas. But it is smaller than the pea aphid and is bluish green, as opposed to the pea aphid's bright green color. Winged forms emerge

*Research Leader, Forage Insects Research Laboratory, U.S. Department of Agriculture; Associate Professor, Department of Entomology; Graduate Research Assistant, Department of Entomology, respectively.

BLUE APHIDS (below) in winged and wingless forms, and the damage they do alfalfa (right).



rapidly after the population becomes crowded on alfalfa, and may occur within 10 days of initial infestation. This could explain the rapid spread of the pest into three western states within one year.

Initial observations indicate that the damage done alfalfa by the blue alfalfa aphid is more severe than that caused by the pea aphid, but not as bad as the harm done by the spotted alfalfa aphid (Therioaphis maculata). Within two weeks of infestation, plants are severely stunted and the leaves are badly yellowed (see Figure 2). Recovery from the damage is slow, with regrowth reaching only about 50 percent within two weeks of the aphids' removal from the plants.

The life cycle and host plant range of the blue alfalfa aphid are virtually unknown. Recent, but incomplete studies show that the aphid prefers other species of legumes to alfalfa. However, in the absence of preferred hosts such as yellow sweetclover (Melilotus officinalis), birdsfoot trefoil (Lotus corniculatus), and Caragana arborescens, the aphid will readily infest alfalfa. Populations of the aphid were highest in the spring from February through June.

During the heat of July and August, activity was so reduced that only an occasional aphid was found. In the period of intense heat, the insects apparently become dormant. During the fall and early winter of 1975, alfalfa infestation in Arizona by the aphid was minimal. The population was expected to increase again this spring.

The development of resistant alfalfa varieties is among the most promising methods of controlling the blue alfalfa aphid. Plant materials that have already been evaluated for resistance to the aphid show that such germ plasm is available, particularly in varieties that have already combined resistance to the spotted and pea aphids. Enough seed stock to supply such resistant strains should become commercially available by the fall of 1977. Until then, infestations may be controlled by application of organophosphate insecticides.

11 YEARS

FIRE SCENE

AFTER

by Peter F. Ffolliott, Warren P. Clary, and Frederic R. Larson

Associate professor of watershed management, principle plant ecologist, and silviculturist, Rocky Mountain Forest and Range Experiment Station, U.S. Forest Service, Flagstaff, respectively.

Immediately after the deliberate burning of two quarter-acre areas in the Coconino National Forest 12 years ago, results looked good:

--Approximately three-fourths of the 1½- to 3-inch-deep forest floor had been consumed, reducing fire hazard considerably.

--Ponderosa pine seedlings established themselves rapidly on the burned areas, occupying approximately 90 percent of the 16, ¼ mil-acre (22.3-inch radius) sample plots in each of the two areas.

--Timber density decreased in both areas, although not to the point considered best for maximum wood production.

Eleven years later, conditions had changed remarkably from what had been observed immediately after the prescribed burning which was conducted on the Beaver Creek watershed south of Flagstaff.

To begin with, the forest floor, consisting principally of pine needles, had recovered some of its depth. In area A, where the burning had reduced the floor to 30 percent of its prefire depth, the 11-year interval saw an increase to 45 percent of prefire depth. In area B, where the fire had cut the floor to 25 percent, the floor had increased to 40 percent of the prefire depth of 3 inches. These depths represent about two-thirds of what might be expected in unburned ponderosa stands of similar density.

The ponderosa pine seedlings that had sprung up so rapidly in the areas burned by the moderate intensity ground fire (flame height about 2 feet), suffered severe mortality in the ensuing years. Only 25 percent of the ¼ mil-acre plots in the burned areas showed seedlings, whereas area A had shown 85 percent following the fire and area B 95 percent. However, the areas adjacent to the burns showed no seedlings in any of the plots, compared with 20 percent and 12 percent on the adjacent areas immediately following the fire.

Timber density changes varied from area A to area B. Area A, which had lost 47 percent of its basal area (basal area represents a cross section of all trees at a height 4½ feet above the ground) and was measured at 90 square feet per acre following the fire, increased in the 11-year interval to 120 square feet. Area B, which had been reduced by 25 percent to 235 square feet per acre by the fire, had further decreased to 210 square feet. The reduction in area B was apparently due to the death of trees that were initially damaged in the fire.

Area A at first lost a greater percentage of its trees because more of them were sapling size, thus more susceptable to damage by a ground fire than the larger, pole-size trees in area B.

Still, in neither case did the burn reduce density of the trees to 80 square feet per acre, generally considered best for optimum wood production.

It is also impossible to say that 11 years later the fire hazard has been reduced. As anticipated, a great number of twigs, branches, large limbs, and trees killed by the fire have fallen to the ground.

Immediately after the fire, the fall of this heavier material had not taken place and the fire hazard had been reduced both by the consumption of smaller trees and reduction of the forest floor. Perhaps if the areas in question had been treated to burns at regular intervals since the initial fire, the fire-killed trees and limbs would have been consumed and the fire hazard would have remained low.

On both areas, the growth of small plants increased from prefire levels. Area A, where herbage production jumped from 3 pounds per acre to 40 pounds per acre immediately following the fire, was still producing 40 pounds per acre 11 years later. Area B, which produced 5 pounds per acre before and immediately after the fire, increased production to 17 pounds per acre 11 years after being seared.

And where, on both plots, the predominant plant had been the relatively unpalatable mullein, 11 years later a mixture of bottlebrush squirreltail, mutton blue grass, showy goldeneye, red and yellow pea, and buckbrush had taken over.

Even so, the grazing value post fire was not appreciably increased over what it had been.

The future of prescribed burning in Southwestern Ponderosa Pine seems good. A survivor of centuries of periodic wildfires, Ponderosa should benefit from a carefully prescribed burning program. Prescribed fire is already used to dispose of debris from logging operations and to thin timber stands, with roughly 35,000 acres of debris burned each year on Forest Service land. The use of fire to reduce the pile-up of slash and unwanted brush and small trees requires more skill and probably not more than 6,000 acres of National Forest land are so treated each year.

At least three obstacles stand in the way of such a regular, prescribed burning program. These include: (1) lack of people experienced in such burning; (2) difficulty in protecting the forest from runaway fire in areas where fuels such as slash and brush have been allowed to accumulate for several decades; and (3) insufficient funds for such a program of natural hazard reduction. These are not insurmountable obstacles, and considerable progress is being made toward use of prescribed fire as an effective tool in land management.

Prescribed fire shown burning in 1964 (top left), was followed 11 years later by the conditions shown in the other photos, both of which were photographed on Site A. Note the great amount of fallen trees and branches in the photo at middle right.

JOJOBA BEATS COTTON, BUT YOU HAVE TO WAIT A WHILE

by Thomas M. Stubblefield and N. Gene Wright*

Once upon a time, the jojoba bush, with its wax-bearing seeds, was going to save the sperm whale from destruction while giving gainful employment to Arizona Indians.

Early schemes called for the Indians — Apaches in particular — to gather the nut-like seed by hand from wild plants and the liquid wax extracted would be used to replace sperm oil as a lubricant for machinery run at high temperature. It would also have a place in cosmetics and the manufacture of candles.

Thus would jojoba, native to the Sonoran desert, be benefactor to economy and ecology.

Indeed, the plant could be a real boon, but our calculations, based on experience gained by the University of Arizona's Office of Arid Land Studies with gathering seed in the wild suggest that the hand-harvesting of wild plants will not turn any sort of profit.

If jojoba is to pay, it may have to be irrigated, cultivated, grown in plantations, and subjected to the same sort of breeding improvement that other commercial crops have undergone.

This will take time and sizable investment of capital, but there is the chance that mature jojoba could one day pay an Arizona grower five times as much per acre as he can make from cotton while using one quarter the amount of water. Given this promise, it is small wonder that commercial ventures are afoot in California and Haiti, or that the San Carlos Indians are proceeding with the planting of acres of jojoba and hope for a government grant of several millions to put the scheme to work on a large scale.

What we have attempted to show is the return that can be expected based on cost and seed price. What would be the return, based on price for clean, dry seed at 50 and 75 cents per pound where the crop is hand-harvested and where it is machine-harvested?

While we know that jojoba responds to water and fertilizer in greenhouse and lath house conditions, we need more data on the degree of responsiveness. We also wish we had more information on the cost of harvesting, although our estimates were made on the best data available from our own agricultural engineers and from current commercial field operations in Arizona and other states where crops are irrigated.

To begin with, we estimate that it will take $700 per acre to bring a new area into production. Our best information shows that, for most efficient use of farm machinery, plants from cuttings should be spaced about five feet apart in rows, with ten feet separating the rows. To plant with the greatest ease, the field should be surveyed and staked before planting.

Costs here are based on fall or spring planting with a total of 875 plants per acre — 750 females and 125 males.

In our 1974 budget for raising the plants we estimated jojoba might require four acre feet of water annually, but there are indications that this may be too much, so we estimate two acre feet for this re-

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vision, and that figure might be even less, considering that jojoba grows where the rainfall may average less than 10 inches per year.

Our irrigation costs are based on current costs of $35 per acre foot in east central Arizona. Irrigation and ditch labor amounted to $3 per hour, bringing that cost to $6 per acre foot of water since it takes two hours to apply each acre foot of water.

Trickle irrigation could eliminate the expense of irrigation labor, but the cost — $500-$700 per acre — is high, and we don't know just how well the system will perform.

Included in the costs are mechanical cultivation and chemical control of weeds. Two applications of weed control are provided for as are three mechanical cultivations the first year, two cultivations in years two through five and one cultivation each succeeding year.

We estimate a loss to death of two percent annually and to keep production optimum, dead plants would have to be replaced.

Experience in California and Israel shows that pruning is desirable for plantation plantings, and our cost for this chore is based on practice in commercial fruit production. It should take about two minutes per plant during years one through three, about three minutes per plant in years four through eight, and about four minutes for succeeding years.

In addition, we built in miscellaneous costs including bookkeeping, office, telephone, pickup truck, and rent value of the land. Based on commercial farm operations in Arizona, supervision and management were assigned a cost of $12 per acre, variable farm overhead $15 per acre, and rent value $20 per acre.

The cost of harvesting presented us with one of our biggest unknowns. Mechanical harvesting costs were arrived at after consultation with engineers who have had experience in developing harvesters such as might be used to gather the jojoba seed. It should cost about $98 per hour to operate such a machine, and take about one hour to cover one acre.

We estimate that each acre would be machine-harvested twice, regardless of yield, so the cost per acre for the machine harvest is $196. Plants are expected to produce by the fourth year, hitting full production by year twelve.

Harvesting by hand is very nearly prohibitively expensive. Picking an estimated 15,000 pounds of seed per acre (double the weight of the hulled, dried, and cleaned seed), 1000 workers would be needed to finish an acre in an hour, picking at the rate of 15 pounds per hour. At a wage of $3 per hour, the cost of hand-harvesting is $3,000 per acre. If half that many workers were used, doubling the number of hours, the cost for harvest remains the same, comparing most unfavorably with the cost of $196 for machine harvest over a two-hour period.

Our budget is based on 10 pounds of dry beans per plant starting the twelfth year, and is consistent with production estimates in Israel. Cost for hulling and cleaning a pound of green seed should be 2.5 cents per pound.

The various returns for hand and machine-picked jojoba selling at either 50 cents per pound of dried seed, or 75 cents per pound are as follows:

1. Hand-harvested, selling at 50 cents per pound: Costs outrun returns through all years (Table 1).

2. Hand-harvested, selling at 75 cents per pound: Costs mount through the sixth year (Table 2). The eighth year's revenue was enough to repay that year's costs and by year 12 there is a profit of $892 above all costs incurred during years 1 through 12. Profit following year 12 amounts to $1,937 per acre.

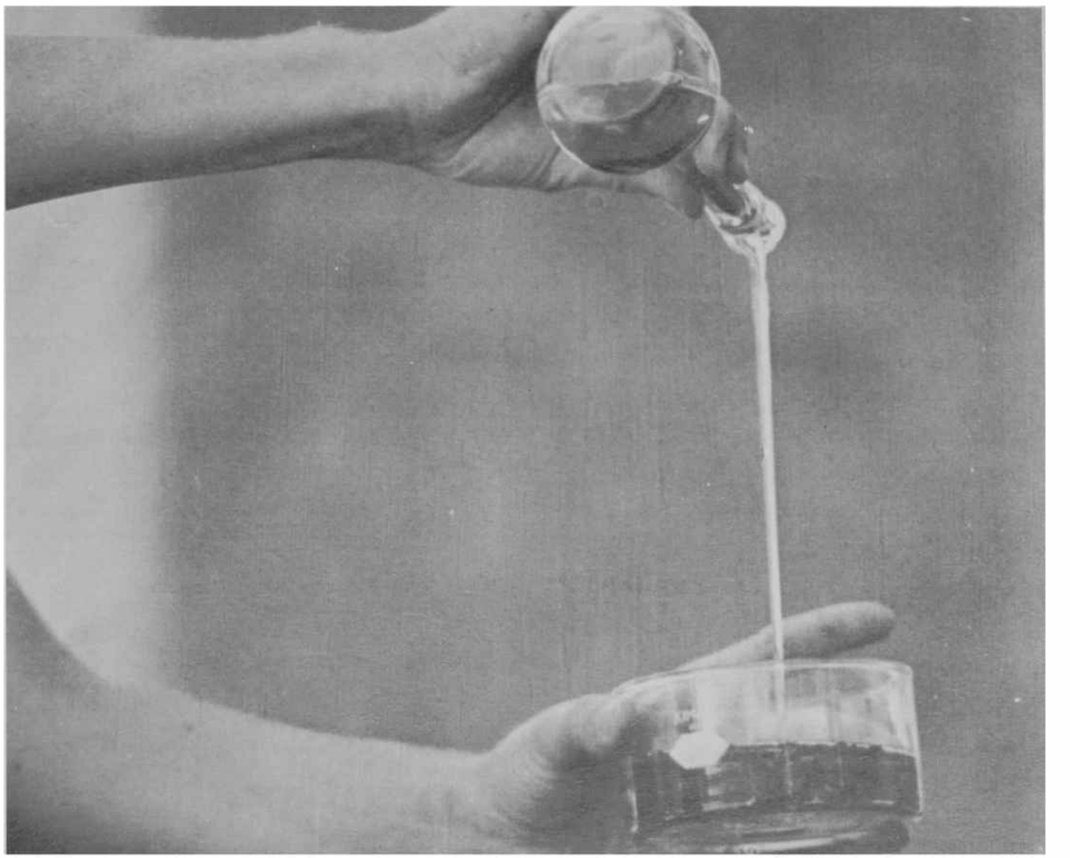
3. Mechanically harvested, selling at 50 cents per pound: Costs mount through year five (Table 3). By year seven, returns are greater than cost and by year eleven there is profit above all costs incurred during the first nine years. Net return to the enterprise increases through year twelve thanks to the increase in production per plant. Net return after year twelve levels off at $2,716 per acre.

4. Mechanically harvested, selling at 75 cents per pound: Costs mount through the fifth year (Table 4). By year six the revenue is great enough to start repaying part of the cost incurred during the first five years. By year nine, all costs have been paid back for a return of $1,661 per acre. The return here, after production has leveled out, comes to $4,591 per acre. That is approximately five to six times what the current return is per acre of cotton in central Arizona.

Before all of this can happen, though, a method for machine harvesting will have to be found, and an all-out effort needs to be made to develop high-yielding plants. A plant producing large seeds would also be helpful. Jojoba seed now varies from 350 seeds per pound to 1,000 or more.

Jojoba may yet be the salvation of the sperm whale, but only production and development on a large scale is likely to provide the keys to unanswered questions.

(Continued)



Liquid Jojoba wax may one day lubricate many types of machinery.

Table 1. JOJOBA DEVELOPMENT COSTS PER ACRE EAST CENTRAL ARIZONA — 1976

Operation	Year 1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th
Land Development Cost	700												
Land Preparation	30												
Layout and Plant @ $.30/plant	262												
Plants, 875 @ $1.25 each	1094												
Water, @ $35/AF	70	70	70	70	70	70	70	70	70	70	70	70	70
Irrigation and ditch labor @ $6/AF	12	12	12	12	12	12	12	12	12	12	12	12	12
Chemical weed control @ $6 per app.	12	12	12	12	12	12	12	12	12	12	12	12	12
Cultivation @ $5 per cultivation	15	10	10	10	10	10	10	10	5	5	5	5	5
Fertilization and application @ $.45 per unit of N	20	20	20	20	20	20	20	20	20	20	20	20	20
Plant replacement @ $2.50 per plant	45	45	45	45	45	45	45	45	45	45	45	45	45
Pruning and disposal	110	110	110	165	165	165	165	165	218	218	218	218	218
Supervision and Management	12	12	12	12	12	12	12	12	12	12	12	12	12
Variable Farm Overhead	15	15	15	15	15	15	15	15	15	15	15	15	15
Rent Value of Land	20	20	20	20	20	20	20	20	20	20	20	20	20
Subtotal	2417	326	326	381	381	381	381	381	429	429	429	429	429
Accumulative Subtotal	2417	2936	3497	4158	4844	5528	6204	6871	7577	8276	8968	9652	10328
Interest @ 8%	193	235	280	333	387	442	496	550	606	662	717	772	826
Total Production Costs	2610	3171	3777	4491	5231	5970	6700	7421	8183	8938	9685	10424	11154
Hand Harvest @ $.38/pound	0	0	0	152	456	798	1140	1482	1524	2166	2508	2850	2850
Clean and Handle Seed @ $.025/pound	0	0	0	20	60	105	150	195	240	285	330	375	375
Total Costs	2610	3171	3777	4663	5747	6873	7990	9098	10247	11389	12523	13649	14379
Revenue @ $.50 per pound	0	0	0	200	600	1050	1500	1950	2400	2850	3300	3750	3750
Costs to be Carried Forward	2610	3171	3777	4463	5147	5823	6490	7148	7847	8539	9223	9899	10629

Table 2. JOJOBA DEVELOPMENT COSTS PER ACRE EAST CENTRAL ARIZONA — 1976

Operation	Year 1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th
Land Development Cost	700												
Land Preparation	30												
Layout and Plant @ $.30/plant	262												
Plants, 875 @ $1.25 each	1094												
Water, @ $35/AF	70	70	70	70	70	70	70	70	70	70	70	70	70
Irrigation and ditch labor @ $6/AF	12	12	12	12	12	12	12	12	12	12	12	12	12
Chemical weed control @ $6 per app.	12	12	12	12	12	12	12	12	12	12	12	12	12
Cultivation @ $5 per cultivation	15	10	10	10	10	10	10	10	5	5	5	5	5
Fertilization and application @ $.45 per unit of N	20	20	20	20	20	20	20	20	20	20	20	20	20
Plant replacement @ $2.50 per plant	45	45	45	45	45	45	45	45	45	45	45	45	45
Pruning and disposal	110	110	110	165	165	165	165	165	218	218	218	218	218
Supervision and Management	12	12	12	12	12	12	12	12	12	12	12	12	12
Variable Farm Overhead	15	15	15	15	15	15	15	15	15	15	15	15	15
Rent Value of Land	20	20	20	20	20	20	20	20	20	20	20	20	20
Subtotal	2417	326	326	381	381	381	381	381	429	429	429	429	429
Accumulative subtotal	2417	2936	3497	4158	4744	5120	5239	5079	4666	3932	2851	1396	429
Interest @ 8%	193	235	280	333	379	410	419	406	373	314	228	112	34
Total Production Costs	2610	3171	3777	4491	5123	5530	5658	5485	5039	4246	3079	1508	463
Hand Harvest @ $.38/pound	0	0	0	152	456	798	1140	1482	1824	2166	2508	2850	2850
Clean and Handle Seed @ $.025/pound	0	0	0	20	60	105	150	195	240	285	330	375	375
Total Costs	2610	3171	3777	4663	5639	6433	6948	7162	7103	6697	5917	4733	3688
Revenue @ $.75 per pound	0	0	0	300	900	1575	2250	2925	3600	4275	4950	5625	5625
Costs to be Carried Forward	2610	3171	3777	4363	4739	4858	4698	4237	3503	2422	967	892*	1937*

*Profit

Table 3. JOJOBA DEVELOPMENT COSTS PER ACRE EAST CENTRAL ARIZONA — 1976

						Year						
Operation	**1st**	**2nd**	**3rd**	**4th**	**5th**	**6th**	**7th**	**8th**	**9th**	**10th**	**11th**	**12th**	**13th**
Land Development Cost	700												
Land Preparation	30												
Layout and Plant @ $.30/plant	262												
Plants, 875 @ $1.25 each	1094												
Water, @ $35/AF	70	70	70	70	70	70	70	70	70	70	70	70	70
Irrigation and ditch labor @ $6/AF	12	12	12	12	12	12	12	12	12	12	12	12	12
Chemical weed control @ $6 per app.	12	12	12	12	12	12	12	12	12	12	12	12	12
Cultivation @ $5 per cultivation	15	10	10	10	10	10	10	10	5	5	5	5	5
Fertilization and application @ $.45 per unit of N	20	20	20	20	20	20	20	20	20	20	20	20	20
Plant replacement @ $2.50 per plant	45	45	45	45	45	45	45	45	45	45	45	45	45
Pruning and disposal	110	110	110	165	165	165	165	165	218	218	218	218	218
Supervision and Management	12	12	12	12	12	12	12	12	12	12	12	12	12
Variable Farm Overhead	15	15	15	15	15	15	15	15	15	15	15	15	15
Rent Value of Land	20	20	20	20	20	20	20	20	20	20	20	20	20
Subtotal	2417	326	326	381	381	381	381	381	429	429	429	429	429
Accumulative Subtotal	2417	2936	3497	4158	4888	5316	5373	5030	4302	3111	1420	429	429
Interest @ 8%	193	235	280	333	391	425	430	402	344	249	114	34	34
Total Production Costs	2610	3171	3777	4491	5279	5741	5803	5432	4646	3360	1534	463	463
Harvest Costs @ $98/hour	0	0	0	196	196	196	196	196	196	196	196	196	196
Clean and Handle Seed @ $.025/pound	0	0	0	20	60	105	150	195	240	285	330	375	375
Total Costs	2610	3171	3777	4707	5535	6042	6149	5823	5082	3841	2060	1034	1034
Revenue @ $.50 per pound	0	0	0	200	600	1050	1500	1950	2400	2850	3300	3750	3750
Costs to be Carried Forward	2610	3171	3777	4507	4935	4992	4649	3873	2682	991	1240*	2716*	2716*

*Profit

Table 4. JOJOBA DEVELOPMENT COSTS PER ACRE EAST CENTRAL ARIZONA — 1976

						Year						
Operation	**1st**	**2nd**	**3rd**	**4th**	**5th**	**6th**	**7th**	**8th**	**9th**	**10th**	**11th**	**12th**	**13th**
Land Development Cost	700												
Land Preparation	30												
Layout and Plant @ $.30/plant	262												
Plants, 875 @ $1.25 each	1094												
Water, @ $35/AF	70	70	70	70	70	70	70	70	70	70	70	70	70
Irrigation and ditch labor @ $6/AF	12	12	12	12	12	12	12	12	12	12	12	12	12
Chemical weed control @ $6 per app.	12	12	12	12	12	12	12	12	12	12	12	12	12
Cultivation @ $5 per cultivation	15	10	10	10	10	10	10	10	5	5	5	5	5
Fertilization and application @ $.45 per unit of N	20	20	20	20	20	20	20	20	20	20	20	20	20
Plant replacement @ $2.50 per plant	45	45	45	45	45	45	45	45	45	45	45	45	45
Pruning and disposal	110	110	110	165	165	165	165	165	218	218	218	218	218
Supervision and Management	12	12	12	12	12	12	12	12	12	12	12	12	12
Variable Farm Overhead	15	15	15	15	15	15	15	15	15	15	15	15	15
Rent Value of Land	20	20	20	20	20	20	20	20	20	20	20	20	20
Subtotal	2417	326	326	381	381	381	381	381	429	429	429	429	429
Accumulative Subtotal	2417	2936	3497	4158	4788	4908	4408	3238	1392	429	429	429	429
Interest @ 8%	193	235	280	333	383	393	353	259	111	34	34	34	34
Total Production Costs	2610	3171	3777	4491	5171	5301	4761	3497	1503	463	463	463	463
Harvest Costs @ $98/hour	0	0	0	196	196	196	196	196	196	196	196	196	196
Clean and Handle Seed @ $.025/pound	0	0	0	20	60	105	150	195	240	285	330	375	375
Total Costs	2610	3171	3777	4707	5427	5602	5107	3888	1939	944	989	1034	1034
Revenue @ $.75 per pound	0	0	0	300	900	1575	2250	2925	3600	4275	4950	5625	5625
Costs to be Carried Forward	2610	3171	3777	4407	4527	4027	2857	963	1661*	3331*	3961*	4591*	4591*

*Profit

Think You Can Fight Arab Oil With U.S. Grain?

No Way!

by Jimmye Hillman

Head, Department of Agricultural Economics.

During the years 1972-74, the weather turned cold and dry worldwide, the fish catch in Peru dropped sharply, the dollar was devalued, food prices soared, and the Arabs first cut off our oil and then hiked its prices — all of which led to a wave of alarm about food shortages and some absurd economic and political reasoning about food and oil.

Hard on the heels of this abnormal string of occurrences, far too many who knew far too little about the subject became "experts" on the "world food problem," and their faulty political and economic reasoning has since filled the mass media as well as professional journals *ad nausea*.

Most of them have been predicting calamity, perhaps with reason; food is an emotional subject. To be without it, or with too little of it, is a serious matter. Even to feel threatened about possible future shortages, as did millions in the U.S. Western Europe and Japan after two decades of sufficient and even more than sufficient food stocks seemed equally serious.[1]

Here I want to address one of the most erroneous proposals that surfaced during that tumultuous period, especially following the Arab oil embargo of 1973. Emotions in this country ran high after the embargo and the "Great Grain Robbery" (the first U.S.-Russian wheat deal in 1973), and the proposition arose that if the Arabs embargo oil to us, we should cut off wheat or food to them. If not to them, to others, or if not embargo, we should raise prices and use monopolistic trading practices. Proposals included bringing economic and political pressure on the world's trading groups, including the oil exporters. It was reasoned that normally the U.S. accounts for 50 percent or more of the world's wheat exports, so let's use our muscle. Politicians, including President Ford and Agriculture Secretary Butz, at one time used the term "agri-power," implying that the U.S. could unleash a food weapon to bring the Third World and the Soviet Union to heel. (There have now, indeed, been second thoughts.) All should be well and good then both economically and politically — if not morally. But alas! The proposition is full of holes.

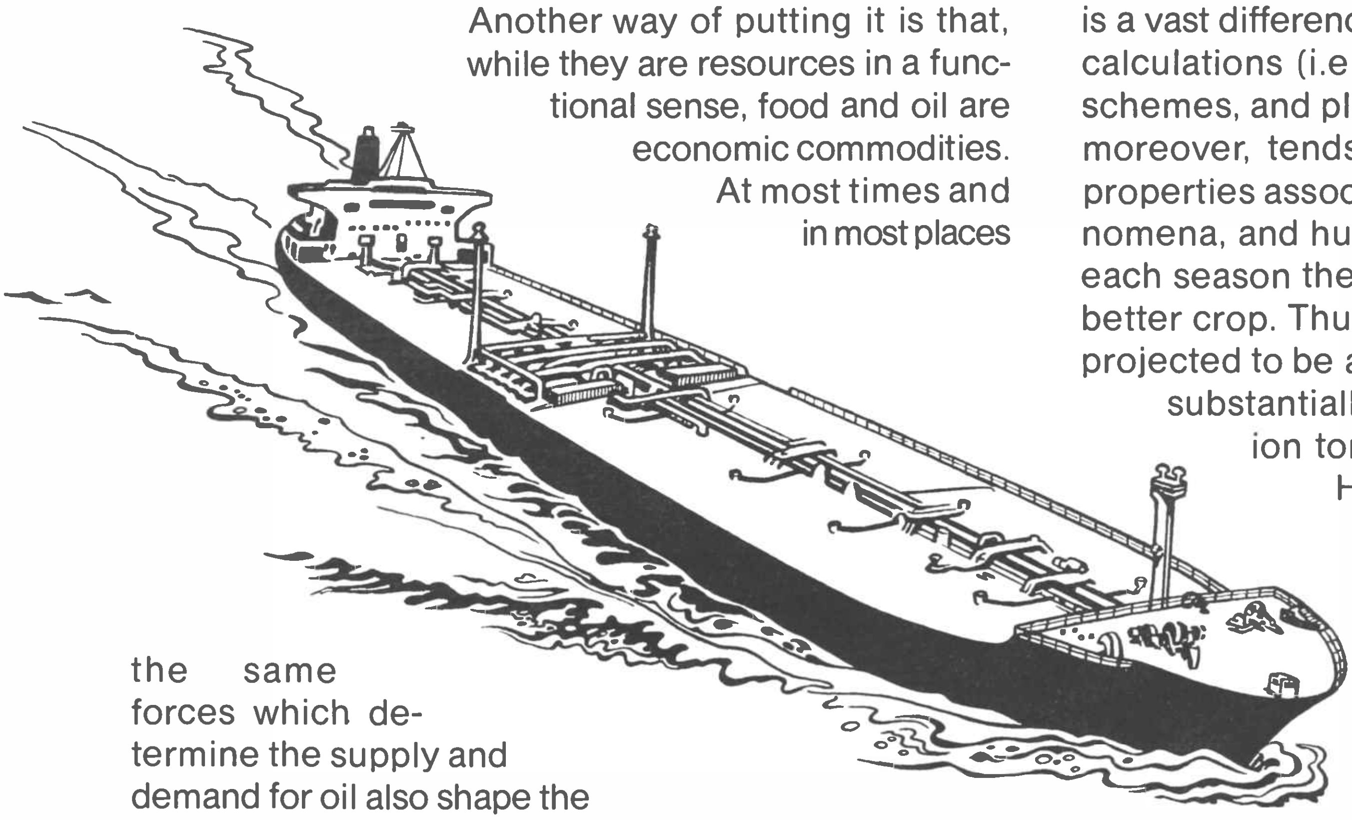
Basic Phenomena

Economists generally like to begin such an analysis by pointing out that everything is in some sense a *resource* and is subject to the broad conditions of supply and demand, that is, the market, and to a variety of other constraints. In short, in a modern economy all resources are somehow interrelated and therefore have some similarities. So it is in this instance.

Petroleum and grain are resources deriving from nature's historic conditions and man's technology, but bound together in the circuitous flow of economic goods and services which are utilized by man the producer and consumer. Both can be "inputs," both "outputs" in the economist's jargon.

Food, of which the grains are a major part, is the staff of life. Petroleum, however, is also basic energy, can be converted for direct consumption, but has been more specifically responsible in large part for the mechanical and fertilization revolutions of modern farming.

Another way of putting it is that, while they are resources in a functional sense, food and oil are economic commodities. At most times and in most places



the same forces which determine the supply and demand for oil also shape the supply and demand for types and forms of grain, and its ultimate use. How much farmers receive for their grain compared to what it costs them to produce it determines grain *supply* for the most part. How much income consumers have to spend on food (grains, etc.) will determine to a very large extent the quantities and forms of food (grain, meat, milk, etc.) different people consume and, in turn, the demand for food. Petroleum and related energy products play a major, if not dominant, role on the cost — or supply — side and the income — or demand — side of the food-grain equation.

We arrive at the first critical point in the analysis: while our senses — physical and moral — tell us that food is special (the ultimate weapon?), its behavior as a commodity in a modern economy is special only in certain ways. While we think of food as the combination of land, water, labor, oil, etc. — and as somehow uniquely limited by these — the resources used to produce many other things are also used to produce food. How we allocate *all* our resources, therefore, determines in part how much food is produced.

About the same can be said of consumption patterns. It may appear logical to think in terms of using food as a weapon, but it is the differences in people's incomes that finally determines the world's grain trade and food consumption. Much the same can be said with respect to schemes which would use food as a charitable "weapon" (moral commitment or obligation). So much for the similarities of oil and grain as resources and their roles in the circuitous flow of input-output mix to satisfy man's wants and needs. A second analytical point will try to differentiate the two.

Grain, along with many farm products and resources, would be categorized as "renewable"; oil as "nonrenewable." Flow vs. fund resources. There is a vast difference with respect to long-term economic calculations (i.e., discount rates, capital investment schemes, and planning horizons). The supply of food, moreover, tends to be unstable because of special properties associated with weather, other natural phenomena, and human and governmental decisions. But each season there is renewed hope for a bigger and better crop. Thus, in 1976 world wheat production is projected to be a record 375-385 million metric tons, substantially above last year's output of 349 milion tons.

Higher product prices and improved supplies of agricultural inputs, particularly fertilizer, have encouraged increased plantings in many countries. Agriculture response is like that and is renewable in form.

Oil reserves, on the other hand, are exhaustable and limited. And, even though we have witnessed gluts of oil and variations in supplies, depending on economic conditions, we can anticipate an approaching of a limit. For example, U.S. petroleum production peaked in 1970 and has been dropping each year since, despite rising real prices.

Rising real prices for food could easily prompt further agricultural expansion and higher levels of food production. Due to the "renewability" of selected agricultural inputs, and despite higher relative prices for fossil fuel, there is a guarded optimism on the part of knowledgeable agricultural scientists with respect to grain production all over the world.[2]

Food Power

For simplicity, those who would use "food power" or "agri-power" may be divided into two groups. The "hard-liners" such as President Ford, Secretary Butz, Ronald Reagan, Senator Henry Jackson, and others have implied that somehow the U.S., which is a dominant supplier of grain and soybeans to the world, could use this position as political leverage, tactical and strategic, in the developed and developing countries. Moreover, Senator Jackson in particular has implied that, by denying the Russians grain, the U.S. might obtain concessions in arms reduction talks.

In a lengthy article on "U.S. Food Power Ultimate Weapon in World Politics," *Business Week,* December 15, 1975, it was reported that "nearly everyone agrees that in a world of hunger and over-population, the U.S. can apply its tremendous agricultural capacity as a lever on foreign countries to adopt policies beneficial to this nation." It went on to say ". . . there is strong evidence that, as another condition for the grain sale, the Russians were persuaded to keep their hands off during Secretary of State Henry A. Kissinger's negotiations on the Egyptian-Israeli accord."

Morality and equity questions are also involved. A second group who would use food power is composed of liberals and charitable organizations. They are repugnant to the notion that the U.S. should consider using bread — the staff of life — as a political weapon. However, in their own naivete and exaggerated accounts of the recent world food situation (it has been called a "crisis" for so long by so many that the term has lost its impact), they have given ammunition to the hard-liners. "Agri-power" of the nature implied by the two groups is over-rated and illusory.

There is a third position or group which suggests that our exportable grain should be made freely available as long as it is not controlled by monopolies to their own exclusive advantage. Also implied in this position is that the U.S. shouldn't turn over its grain to foreign governments — to state traders such as the Russians, or to other centralized purchasers — just because they have the money to buy it. Questions of economic efficiency, political power, and human equity are involved in all these positions to which we can now turn.

The United States has, in fact, become the dominant supplier of grain and soybeans in recent years. In 1973, 47.7 percent of world trade in wheat, 17.6 percent in rice, and 84.7 percent in soybeans derived from U.S. production. During years of record production in this country and of crop failures abroad, the percentages are even higher. These shares of the grain trade compare well with the position of the OPEC countries in oil. Why can't we exercise monopoly power or why don't we if we could?

In the first place, world trade in all grains in 1973 accounted for only 12 percent of world production and consumption. Therefore, even if the U.S. controls say 50 percent of that 12 percent, this is only 6 percent of world production and consumption. World trade in oil, on the other hand, is more than 50 percent of world production and consumption. The Persian Gulf States alone produce almost one-third of world oil and half of world oil exports.

A more detailed picture of the difference between grain and oil production and trade can be demonstrated. Table 1 shows that in 1973 there were 161 countries producing almost 1.4 billion metric tons of grain on over 720 million hectares (1.8 billion acres) of land throughout the world. Sizeable portions of this production are in wheat, rice, and maize. But large acreages are in barley, sorghum and the millets, crops which are adaptable to highly variable climatic, soil, and management conditions.

Only 165 million tons or 12 percent of world grain production entered world trade in 1973. Wheat is by far the most important, and wheat trade occurs mostly between the high income, industrialized countries. Only a minuscule portion of rice production enters world trade, and somewhat more of the feed grains. Even though a large number of countries are shown to be "exporters" of the various grains, the U.S. and a few other countries are the dominant exporters. This, as has been pointed out, must not mislead one to the conclusion that dominance in exports lends itself to some sort of unusual economic or political leverage.

Turning to crude petroleum, Tables 2 and 3 tell the story. Fifty-seven countries produced about 20.4 billion barrels of oil in 1973. Forty-six countries exported about 11.6 billion barrels. The ten leading countries produced 54 percent of that oil, *but the ten leading exporting countries exported 47 percent of all world trade in crude petroleum.* Compare this with the 12 percent export figure for grains, and it gives the picture of dominance and power of petroleum producers. The implications of this dominance are brought out in the next section.

As has already been mentioned, oil deposits, like many minerals, are not evenly nor everywhere distributed. It is a finite — nonrenewable — resource. Modern economics growth is closely linked to its production. But grain can be grown almost anywhere. Its production is "renewable." Moreover, as was demonstrated during 1972-74, growth in production and reduction in consumption provides a wide range of grain flexibility to certain countries. The U.S. demonstrated this by bringing additional acres into production and, by feeding less grain to livestock, cut its grain consumption 15-20 percent. The Soviets reduced grain consumption by livestock slaughter several times in the 1950's and 1960's, and are now apparently doing it again.

Given adequate economic incentives, the upward flexibility in grain production can be realized quite rapidly. This holds true for many of the current importing countries — developed and underdeveloped — with the possible exceptions of India and Japan. Rapid increases in grain stocks can result from such flexibility. The latest International Wheat Council report puts 1975-76 closing stocks for the five major exports at 11.4 percent higher than 1974-75. With further production increases in 1976, price-depressing amounts of grain could be a problem for grain producers and their governments. Rice is already in trouble.

There is yet another constraint on U.S. agripower: Other grain exporting countries might not cooperate with us in seriously limiting exports to attain economic — let alone political — objectives. Moreover, there is simply too much "leakage" in the system. Temporary shortages may give the U.S. limited, short-term leverage, but if severe measures are used, such as the 1973 general soybean embargo and the 1975 embargo on wheat to Russia, the long-term trade repercussions or short-term agricultural price gyrations may be highly counterproductive. The Soviets did agree to being overcharged for part of the shipping costs for some grain; but the leverage was not enough to extract concessions from Russia on oil or political accommodations in the Middle East or Africa. In the context of modern economic and political reality, threats toward substantial denial to the Soviets of access to U.S. grain supplies are essentially empty and counterproductive.

Lauren Soth, retired Editor of the Des Moines Register and Tribune Editorial Pages, has termed these threats "Jackson's Folly." Soth has written as follows:[3]

"If Henry Jackson thinks he can push the Russians into reducing arms output by denying them grain, he is kidding himself. In the first place, they could get a little more grain from Australia, France and elsewhere. In the second place, they could cut back livestock if they had to. In the third place, Russia is likely to have more of its own grain in four out of five years in the future.

"How about putting pressure on Third World countries by denying them food? The question almost answers

Table 1. World Grain Production and Exports 1973

	Commodities		Production		Exports	
	No. of Producing Countries	Area (1000ha)	Production (1000MT)	No. of Exporting Countries	Quantities (MT)	Values (1000$)
Wheat	98	222,268	377,017	75[1]	160,514,501[1]	16,842,186[1]
Rice[2]	114	134,163	320,714	68	9,239,841	2,023,576
Maize	136	110,924	311,780	66	49,675,687	4,475,842
Barley	81	87,712	168,749	80	12,194,679	1,140,937
Sorghum	72	42,631	51,768	--[4]	--[4]	--[4]
Millet	68	67,927	45,370	--[4]	--[4]	--[4]
Total Cereal[3]	161	720,476	1,368,146	111	165,084,473	17,143,118

[1]Exports of wheat are actually wheat, wheat flour and meslin. [2]Paddy rice. [3]This total is for *all* grain, including those listed. [4]Data not available. Source: *FAO Production Yearbook*, 1973; *FAO Trade Yearbook*, 1973

Table 2. Crude Petroleum Production and Trade 1973 (1000 barrels)

	N.C. America	S. America	W. Europe	Middle East	Africa	Asiatic Area	Sino-Soviet Areas[4]	World Total
Production								
No. of Countries Producing	4	10	10	12	10	11	--	57[3]
Production	4,201,508	1,702,458	138,513	7,744,933	2,161,473	815,845	3,603,251	20,367,981
Exports[1]								
No. of Countries Exporting	5	9	5	10	10	7	--	46[3]
Exports	367,251	897,786	34,830	7,170,524	1,984,180	464,425	644,486	11,563,482
Imports[2]								
No. of Countries Importing	15	10	17	8	18	15	--	83[3]
Imports	1,973,776	771,470	5,399,035	254,979	244,269	2,520,437	557,332	11,721,298

[1]Exports and reexports [2]Imports crude and unfinished oils [3]Excludes Sino-Soviet areas [4]Excludes Cuba, the data of Cuba is included in the N.C. America Area. Source: *International Petroleum Annual,* 1973.

Table 3. Production and Exports of Crude Petroleum by Leading Countries 1973

Countries	Production	Export	Production Exported
	(1000 barrels)	(1000 barrels)	%
Saudi Arabia	2,677,146	2,479,202	92.61
Iran	2,139,229	1,926,517	90.06
Kuwait	1,007,002	965,937	95.92
Libya	793,839	793,055	99.90
Venezuela	1,228,594	775,092	63.09
Nigeria	749,820	698,779	93.19
Iraq	736,607	696,854	94.60
United Arab Emirates	559,399	552,298	98.73
Indonesia	488,536	369,543	75.64
Canada	648,348	365,370	56.35
Total	11,028,520[1]	9,622,647[2]	87.25[3]
World Total	20,367,981	11,563,482	56.77[4]

[1]The ratio of the leading exporting countries' production of the World total is 54.15% (11,028,520 divided by 20,367,981). [2]The ratio of the leading exporting countries' exports of the World total production is 47.24% (9,622,647 divided by 20,367,981). [3]This is the percentage of production exported by leading countries. [4]This is the percentage of World total production exported. Source: *International Petroleum Annual,* 1973.

itself in political terms. A trade war with these countries, such as OPEC on oil and others on tin, copper, zinc, etc., would not necessarily be to our economic advantage.

"In most cases, they would have more power than we could exercise with food. The political effect of the U.S. denying people food in case of real hunger, as in Bangladesh, would be disastrous. It would be a godsend to the Communists."

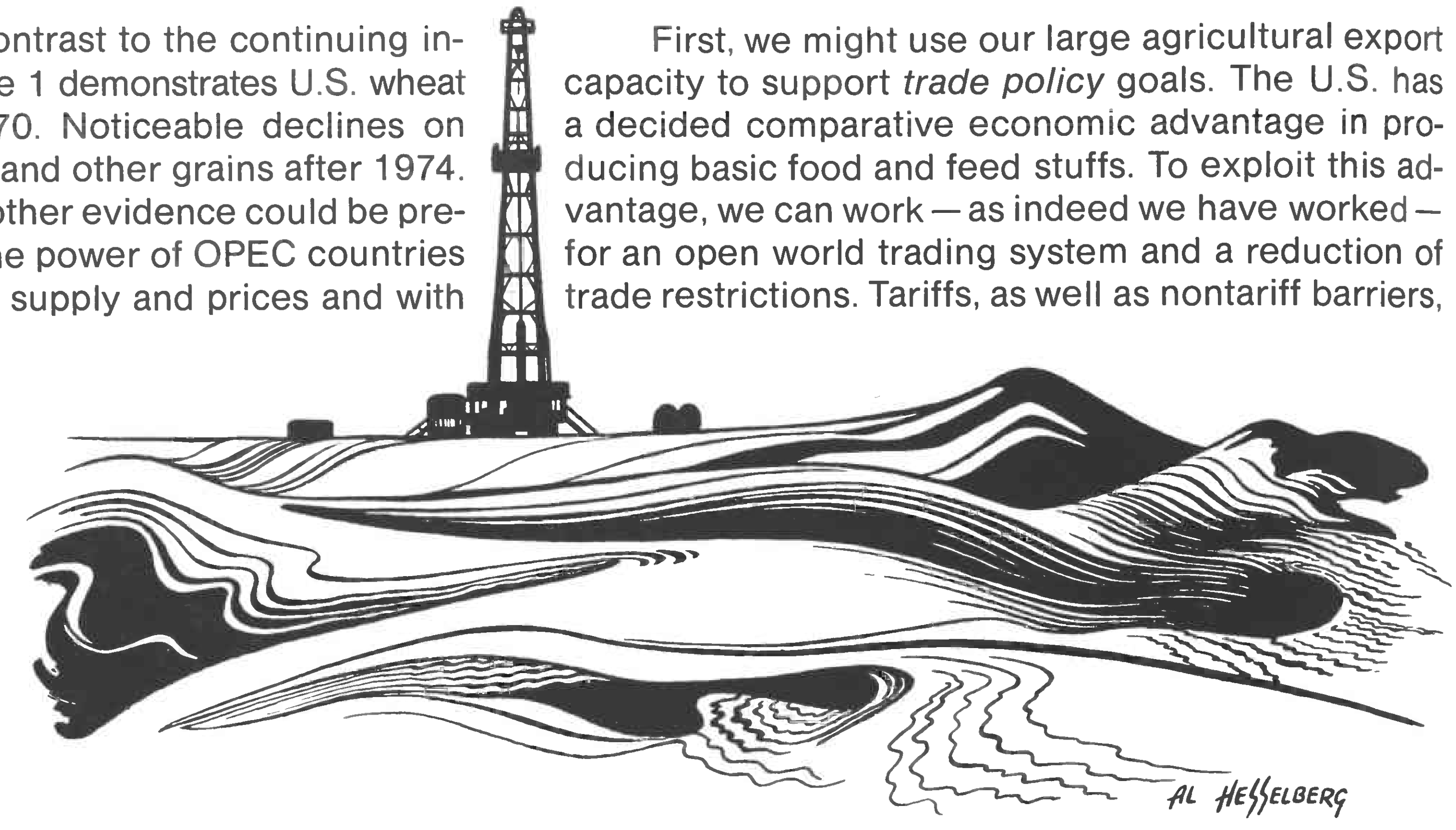
A word might be said on the growth in output in the agricultural sector. While the instability in world grain markets since World War II has been largely Russian-induced, gains in total agricultural output in the USSR during the 20-year period from 1950-71 compared very well with that in North America. Soviet agricultural output rose at an annual compound rate of 3.9 percent vs. 2.0 percent in the U.S. Moreover, national investment in Soviet agriculture has been increasing rapidly during the past decade. This is not to suggest that the Soviets are about to solve all their agricultural problems, but it is neither correct nor reasonable to expect them to be overly susceptible to our use of agri-power.

Petroleum Power

As has already been intimated, it is fallacious to equate power generated by the grain production and export capabilities of the U.S. and other temperate-zone countries with the power which can be exerted on world economies and politics by the organized oil producers. Comparisons of agricultural production, markets, and trade with the oil industry's ability to manipulate supplies and prices yield different results. The difference lies not only in the nature of the resources in question but, in particular, in the structure and organization of the industries.

Despite the economic concentration in the handling of grain[4] in this country and elsewhere, there is no economic organization and cartel action comparable to OPEC. The 1972-73 run-up of grain prices was the result of a set of the anomalous circumstances — mentioned at the beginning of this article[5] — not cartel and monopoly power as was true in the 1973 oil action. The price of food has since declined or moderated, in sharp contrast to the continuing increase of oil prices. Figure 1 demonstrates U.S. wheat and oil prices since 1970. Noticeable declines on prices occurred in wheat and other grains after 1974.

If space permitted, other evidence could be presented to demonstrate the power of OPEC countries to manipulate petroleum supply and prices and with them the energy sector of the world economy.[6] Suffice it to say that the crude petroleum industry once characterized by gluts in international markets and low relative prices, is now organized, and able and willing to use economic power to obtain economic and political objectives of its respective states. Grain producing and exporting countries have no such power. The position of the industry today is a far cry from that day in 1960 when the seven multinational oil companies which dominated world oil commerce announced a unilateral 10-15 percent price cut to oil-producing states.



Food Production and U.S. Policy

The preceding analysis and discussion are not meant to imply that the U.S. cannot use its enormous agricultural abundance to further its economic and political objectives abroad. Moreover, certain moral objectives might also be attained in the process.[7]

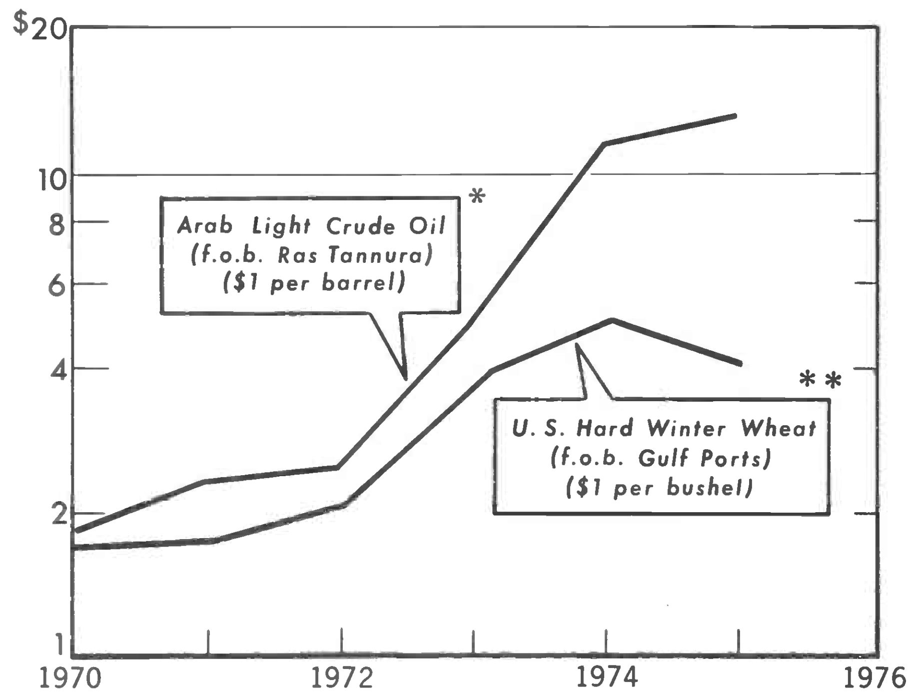


Figure 1. U.S. Wheat and Arab Oil Prices

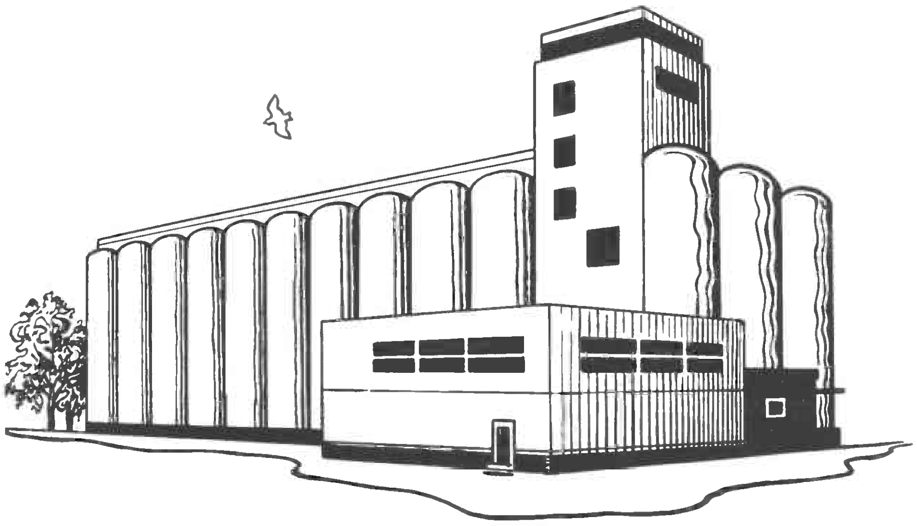
*Compiled from *Petroleum Economist*, various issues.
**Compiled from *Foreign Agricultural Trade of the United States*, various issues.

First, we might use our large agricultural export capacity to support *trade policy* goals. The U.S. has a decided comparative economic advantage in producing basic food and feed stuffs. To exploit this advantage, we can work — as indeed we have worked — for an open world trading system and a reduction of trade restrictions. Tariffs, as well as nontariff barriers, could be reduced. We can further modify domestic agricultural programs which stand in the way of optimum use of our agricultural resources. At the same time, we can insist that other countries work toward that end. The current stalemate in the Multilateral Trade Negotiations in Geneva attest to the fact that the commercial agricultural policy of the industrialized West has a way to go in this respect. (The U.S. has serious barriers to the import of manufactured dairy products and a potentially serious restrictive quota policy on beef. We are net importers of these products.) On the whole, however, more liberalized trade policies and market-oriented domestic agricultural policies have already resulted in very large increases in the volume of agricultural trade between countries — over 300 percent in volume since World War II. U.S. grain exports have quadrupled; soybeans have developed into a phenomenal dollar-earner.

A second, and closely related objective which can be furthered by our agricultural abundance is the assurance of a reasonable stability in worldwide food supplies at reasonable prices. The unwanted agricultural surpluses of the 1950's and 1960's were a byproduct of high price supports, and food reserves were taken for granted by the American consumer and trading nations abroad.

After recent experiences, the world is now in a mood to move toward a more conscious reserves policy which would have considerable economic and social benefits. The U.S. must not neglect opportunities to make bargains with its trading partners that will provide improved access to their markets in return for our supply guarantees. At a minimum, we might bargain for a sharing of our costs of storing food. Our recent long-term grain contracts with the USSR must be viewed in this context.

A third, and more humanitarian, argument for a strong U.S. food position is our ability to provide leadership to assuage suffering in cases of disaster or emergency at home and abroad. Closely allied to this is the objective of famine relief. The U.S. Foreign



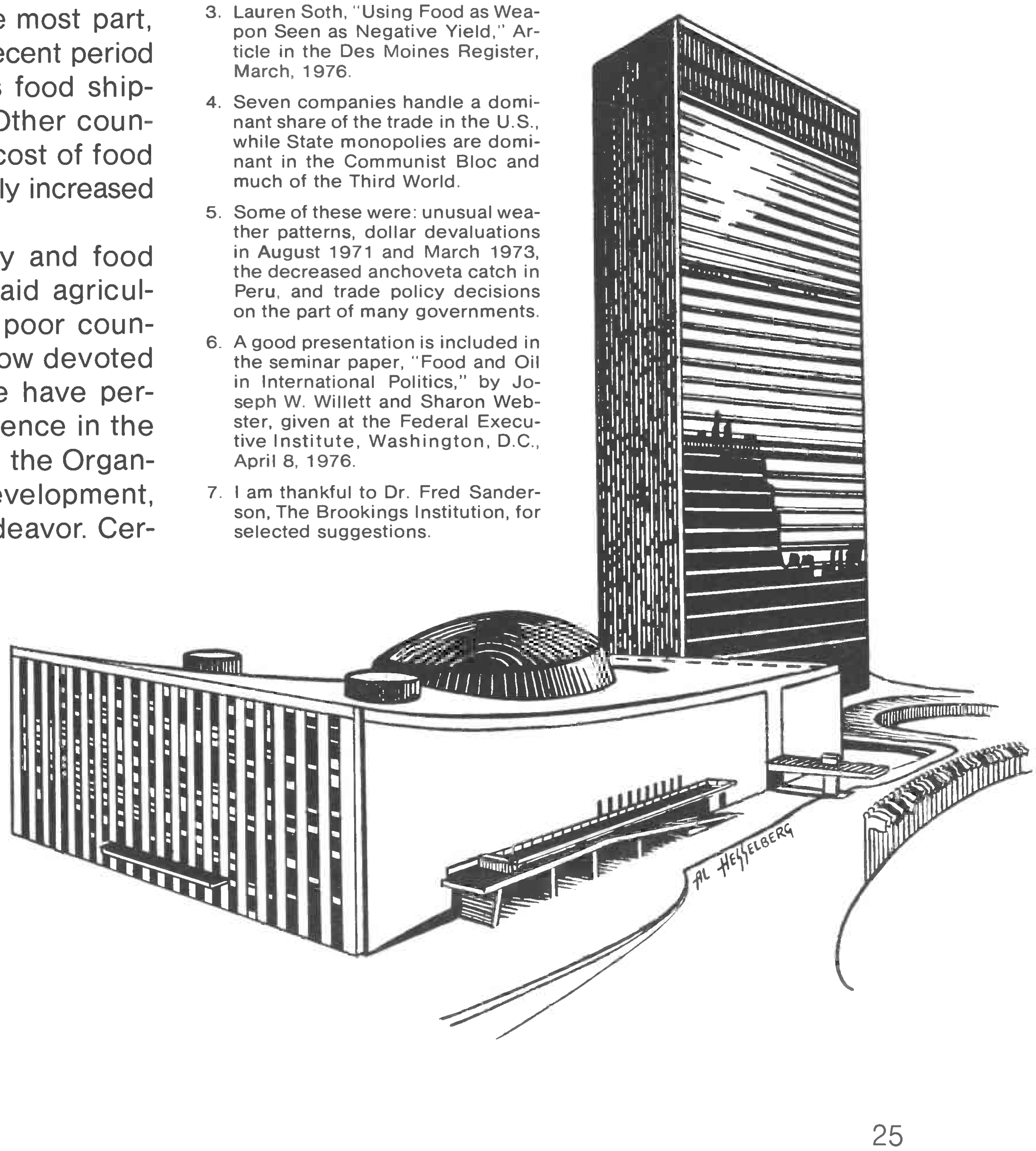
Development and Assistance Act of 1954 was originally conceived as a surplus disposal program. Over two decades, however, it became, for the most part, a food aid program and, even during the recent period of high prices, the U.S. was meeting its food shipment commitments under the program. Other countries have joined the U.S. in bearing the cost of food aid, and European countries have noticeably increased their commitment.

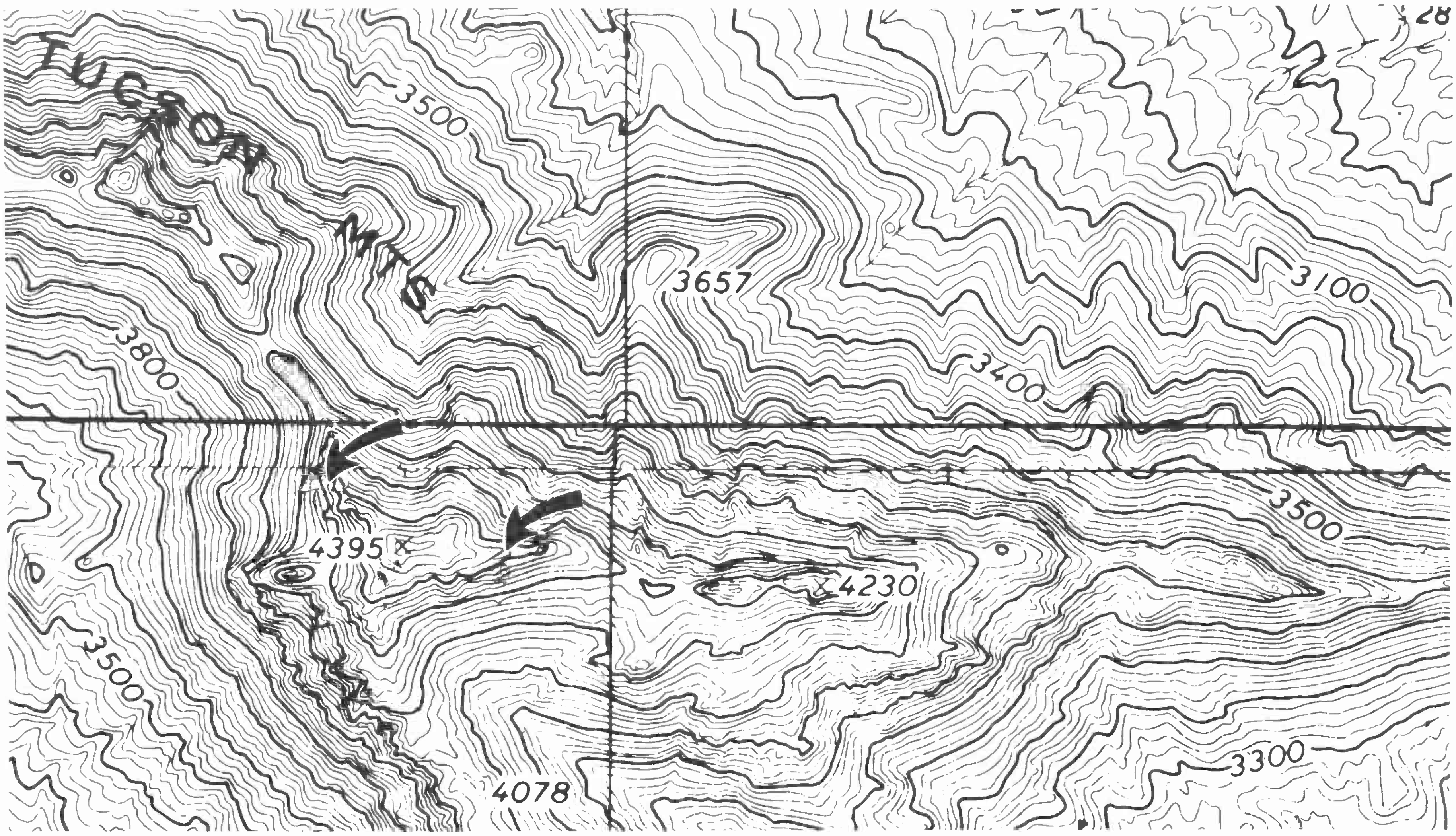
Finally, U.S. agricultural technology and food abundance can be increasingly used to aid agricultural and economic development in the poor countries. A large part of our bilateral aid is now devoted to agriculture and related industries. We have persuaded other countries through our influence in the World Bank, the World Food Conference, the Organization for Economic Cooperation and Development, and other organizations to join in this endeavor. Certain Arab petroleum producers are lending assistance in this regard. A $1 billion International Agricultural Development Fund has been established and total aid commitments for agricultural development have risen accordingly.

In sum, it is obvious that instead of using our agricultural abundance as a "threat" or to make power plays we, and the world, will benefit more from a positive policy of cooperation. This does not mean that the U.S. should walk away from tough bargaining and negotiations relative to trade policy and cost-sharing on reserves and food aid policies. It means that we take a realistic view of our possibilities for advancing U.S. interests rather than entertaining illusory notions about "agri-power."

References

1. See, for example, "The Impact of an International Food Bank" by a Task Force of the Council for Agricultural Science and Technology, Iowa State University, Ames, Iowa, December, 1973; and D. Gale Johnson, "World Food Problems and Prospects," American Enterprise Institute for Public Policy Research, Washington, D.C., Foreign Affairs Study No. 20, June 1975.
2. See Jimmye S. Hillman, "Land Needs for Food and Fiber with a Population of Six Billion," Proceedings, Soil Conservation Society of America, August, 1975, pp. 107-112.
3. Lauren Soth, "Using Food as Weapon Seen as Negative Yield," Article in the Des Moines Register, March, 1976.
4. Seven companies handle a dominant share of the trade in the U.S., while State monopolies are dominant in the Communist Bloc and much of the Third World.
5. Some of these were: unusual weather patterns, dollar devaluations in August 1971 and March 1973, the decreased anchoveta catch in Peru, and trade policy decisions on the part of many governments.
6. A good presentation is included in the seminar paper, "Food and Oil in International Politics," by Joseph W. Willett and Sharon Webster, given at the Federal Executive Institute, Washington, D.C., April 8, 1976.
7. I am thankful to Dr. Fred Sanderson, The Brookings Institution, for selected suggestions.





WHICH MAP would you prefer as a county official trying to understand just where in nearby mountains a developer wished to put something: the topographic map above, or the perspective map — computer-produced from the topo — at right? Arrows show corresponding locations on each map where development is proposed.

COMPUTER

A SCIENCE THAT IS ALSO SOMETHING OF AN ART IS COMING OF AGE AND MAKING A PLACE FOR ITSELF IN AGRICULTURE AND NATURAL RESOURCES

MAPPING

by David Hoyt*

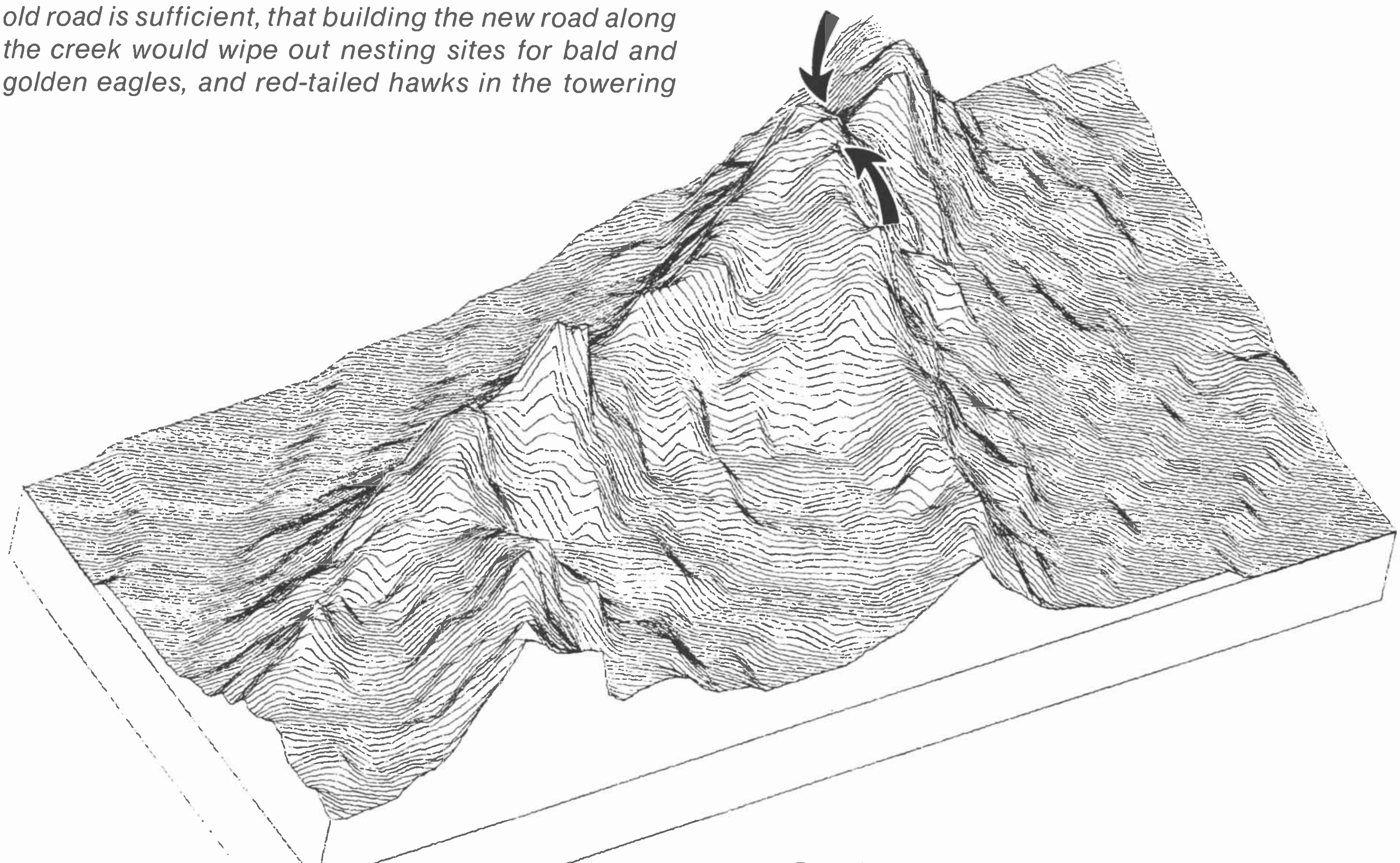
Behold the government official in muted brown double-knit, sitting with several of his colleagues behind an elevated desk, looking out over a packed meeting room. He is a hearing officer, possibly from the U.S. Department of Highways, or with the U.S. Forest Service. A two-lane, hard-surfaced, and comfortably wide road is to be built, connecting the fictitious town of Sharpsville, Arizona (pop. 18,000) to an Interstate Highway 40 miles to the north. There is a road now, but it is oiled dirt, narrow, and runs along a creek that sometimes floods it out. The new road can either follow the creek all the way to the Interstate on built-up roadbed, or it can swing quite a distance west along higher ground through timber country.

Federal, state, and county agencies involved have had their say and a report has come out listing possible alternatives. An environmental impact statement has been filed as required by law, and the current hearings are final ones before deciding where the road will run.

Nobody in the room is happy. The environmentalists are unhappy because they claim that the old road is sufficient, that building the new road along the creek would wipe out nesting sites for bald and golden eagles, and red-tailed hawks in the towering cottonwoods that cluster near the water. They are also unhappy because the other route would cut through the only habitat in the state where native antelope may still be found. They want "NO ROAD" and say so in brochure and bumper sticker.

Local forest industry representatives are unhappy because they claim the only sensible way to build the road is through the high timber country, and they believe the government agencies seem to be leaning toward following the creek bed. The higher route, say the timber interests, would allow them to get their product to market faster, boost employment. They are also unhappy with the environmentalists who have mailed out brochures showing antelope being fed into buzz saws.

The local merchants are unhappy because they want the road to follow the creekbed, a shorter and more scenic route that they claim would help boost tourism and thus bring more money into the coffers of Sharpsville. And it seems to them the government report favors the higher, longer route. They are also unhappy with the environmentalists who say that access to the scenic country along the creek should be restricted to persons on foot.



Ranchers who own patented land along either route are hoping the road will come their way, thus increasing the value of their property; several would like to turn their ranch land into "ranchettes," and retire from the business of mending fences, animals, and bank loans.

*Editor, *Progressive Agriculture*

The antagonism of the groups is reflected in the disparity of their footwear, muses the official. Buckled white shoes of the merchants; tank-tread, vibram-soled hiking boots on the ecology types; well-worn, pointy-toed riding boots on the ranchers. Thank God, he reflects, he has an ace up his sleeve — one that will not satisfy everybody except in their belief that the government agencies have done just about all that is possible to find a way that will do the most good and the least harm.

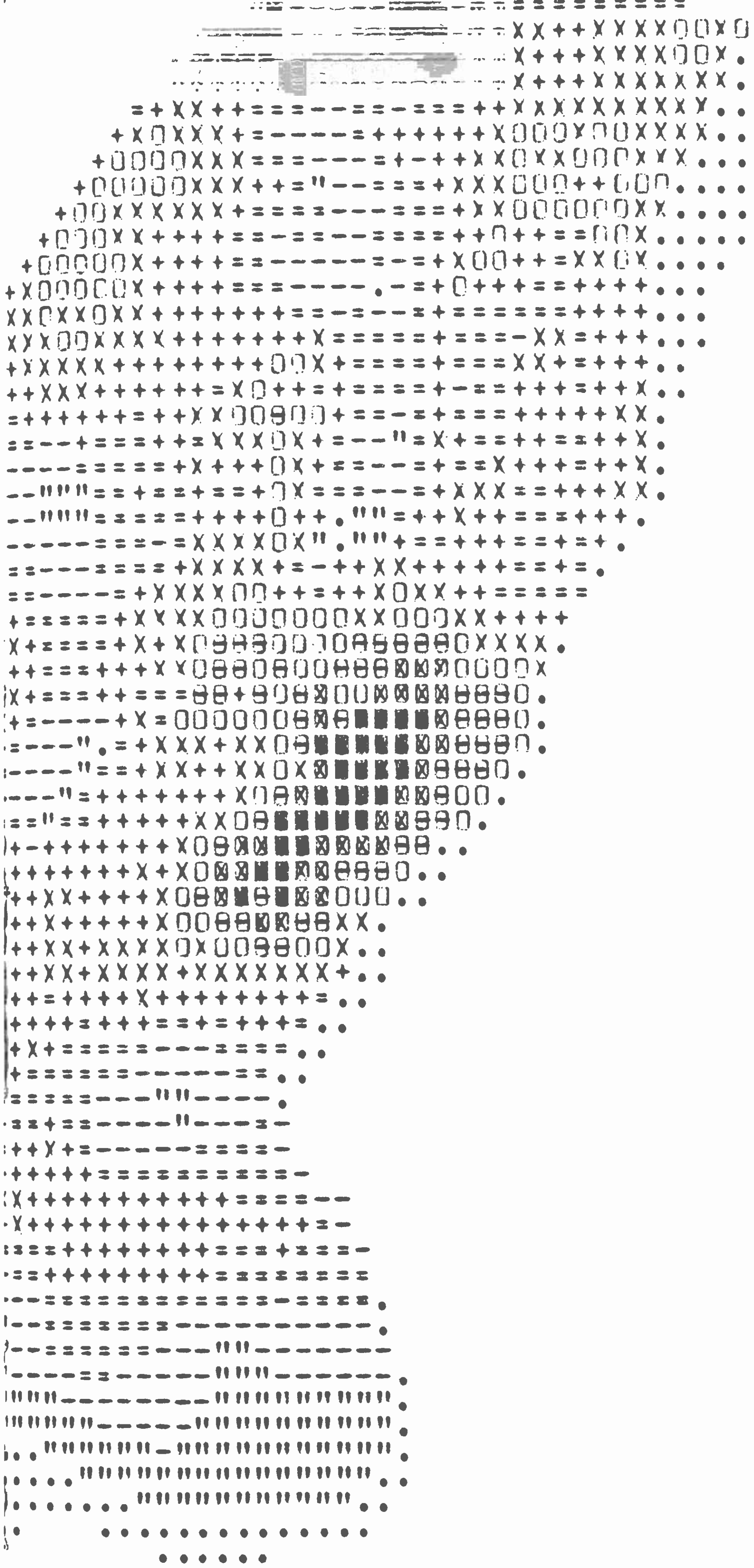
Three people sit together in the back of the room, next to a slide projector. They are experts from the University of Arizona in biology, psychology, watershed management, and something new — remote sensing and computer mapping.

What they have done is transfer by computer all matter of vital information onto maps of the area. Included were type, location, and density of wildlife; wildlife migration routes; wildlife habitat; slope of land; scenic quality; erosion potential; cost per mile of roadway; economic constraints of reaching either proposed route.

And they have come up with a series of maps, each map showing by its density of a certain symbol where the road will do the least harm to any of the interests represented. In fact, a composite of all the maps shows several possible routes. In each case, somebody's ox will be gored, but nobody could argue that the goring was done senselessly.

The new road, according to the UA report, can run initially along the creek, then swing up to the ridge and west through the timber, but not so far as to approach dangerously the habitat of the antelope. The road is thus extended only 5 miles beyond what the creek route would have provided, avoids the disrupting of the eagles and hawks.

The sacrifices (trade-offs) are: neither group of ranchers stands to benefit now by the new route; only



ECONOMICS was given preference over scenic outlook in this map that shows possible low-cost routes through Thomas Creek watershed in the Coconino National Forest. Avoiding the edges, which routes would you choose to save money? A low number means less cost and the code is as follows: 1,• • • • ; 2,"""" ; 3,— — — —; 4,= = = =; 5,+ + + +; 6,X X X X; 7,OOOO; 8,ӨӨӨӨ; 9,⊠⊠⊠⊠; 10,████. The generally higher values in the upper right were caused by steep slopes, and the steeper the slope, the higher the cost of road building.

a part of the timber industry will be served as directly as it might have been; there will be some unsightliness to people hiking or birdwatching away from the road because there will be a scar up the ridge; and some erosion will result.

The quiet man in the soft, grey flannel jacket sitting toward the front should be pleased, speculates the official. Attorney for a mining firm, the man was probably there to protest the western route because it approached closely a group of claims that could one day become a mile-wide, half-mile-deep, open pit copper mine. The hearing officer sits a bit straighter and picks up the gavel.

None of this is far-fetched and it illustrates a capability that is being developed at the University of Arizona's College of Agriculture. Just about to announce itself in a brochure that graphically portrays what it can do is the Laboratory for Remote Sensing and Computer Mapping in the college's School of Renewable Natural Resources.

Now while computer mapping is in its childhood, remote sensing is neither new nor easy to define. A geiger counter senses something, remotely. So does a telescope; so does a camera-equipped plane or satellite. And certainly various space probes have given man some very remotely obtained images of planetary members of our solar system. Here we are talking mostly about use of aerial photography and space satellite imagery to find out things about the surface of the earth in general.

The challenge in remote sensing is to get images that are as distortion-free as possible and this may involve design of camera lenses or working to piece together a color portrait of Jupiter from a space probe's television equipment that is not sending a color message.

The sophisticated use of computer mapping, on the other hand, was born in the mid 1960's, took its first hesitant steps at Northwestern University and the Harvard University Graduate School of Design, and is now finding widespread applications in government and industry. It has been discovered that you can teach a computer to draw a very adequate map of just about anything, and very quickly at that, provided you have the equipment to feed the data into the computer.

The reason the computer maps are catching on, according to William Rasmussen, head of the College of Agriculture's lab, is that "You can comprehend them immediately. You can't do that with tabular data."

The real magic of the technique is its ability to make upon demand maps that don't exist anywhere of almost anything, from the number of low-income minority persons per block in a city through the patterns of slope and drainage in the Salt River Canyon. Taking things a step further, the computer can be asked to produce a map that shows a combination of various factors so that their relationship can be seen. Further yet, weights or values may be assigned to given amounts of a factor — high or low soil productivity, high or low water availability, high or low degree of slope.

Say you came up with an area that boasted Class 1 soils, readily available water, and low slope. The computer might produce a map that identifies such areas as "prime agricultural land" and planners can be *shown* where it is.

The frequency of occurrence, physical prominence, or amount of just about anything may be mapped by computer. For example, computer maps have shown the locations of low-income minorities in New York City so that health centers and welfare offices could be properly located. The number of tourists visiting virtually every town in Massachusetts was plotted — a map that was probably used by state tourism officials as well as motel and restaurant chains wanting to know where the action is. Another problem tackled by computer mapping was the best way to get a supersonic transport from one city to another in a manner that achieved the least number of "manbooms."

But nowhere is the need for and advantage of computer mapping greater than in agriculture and the allocation and use of natural resources. With cities spreading the stain of asphalt and concrete over vast amounts of the nation's farmlands (even faster in the Phoenix area than in the nation as a whole [see *Progressive Agriculture,* Oct.-Nov. 1975]), and with fierce competition looming for the use of the open space and natural resources remaining, some tough decisions on land use will have to be made. Computer mapping can show alternatives perhaps better than any other device.

Currently, Rasmussen is assembling as many existing, useful programs as he can. Other newly hatched, computer mapping labs he says, "build in-

SCENIC QUALITY was given the nod over economics by a 3-1 margin in weighting (same ratio as on previous map) in this computer map of Thomas Creek. The idea is to put the road through an area that will give the tourist a pleasing view. In this case the higher weighted values (same symbols as previous map) represent areas where scenic quality, as measured by viewer preference, was found to be low because of such factors as downed timber, or crowded stands of uniformly sized trees.

house software and expand on that. They tend to reinvent the wheel because they are not using the best of what is available. I use the optimum programs in the arsenal for each problem." In some cases he has modified programs so that they can work together.

Generally, the process of getting data into the computer goes something like this:

The characteristics of the area, urban or rural, are fed into the computer either from existing maps or by aerial photograph. This is done by means of a device known as a digitizer, which is linked directly to the main computers at the UA computer center. There the information is stored on magnetic tape, ready for instant recall. The digitizer itself is like a large grid, electronically sensitive, upon which a map is placed. The scale of the map or aerial photo can be adjusted for. A stylus, not unlike a ballpoint pen, and attuned to exact map location by wires attached to it, is used to either mark point locations of data (buildings, bridges, gauging stations, etc.) or line type data (streams, highways, faults in the earth's crust), or to delineate one area from another (classificatory, such as vegetation type, or quantitative, such as amount of rainfall).

You wind up with a file of data-locating points, lines, and areas within a coordinate system and the values associated with them.

Used in conjunction with the digitizer is the lab's zoom transfer scope which can take information from an aerial photograph and transfer it to the computer where it would be stored and could automatically be included on any map the computer was ordered to produce of the area in question.

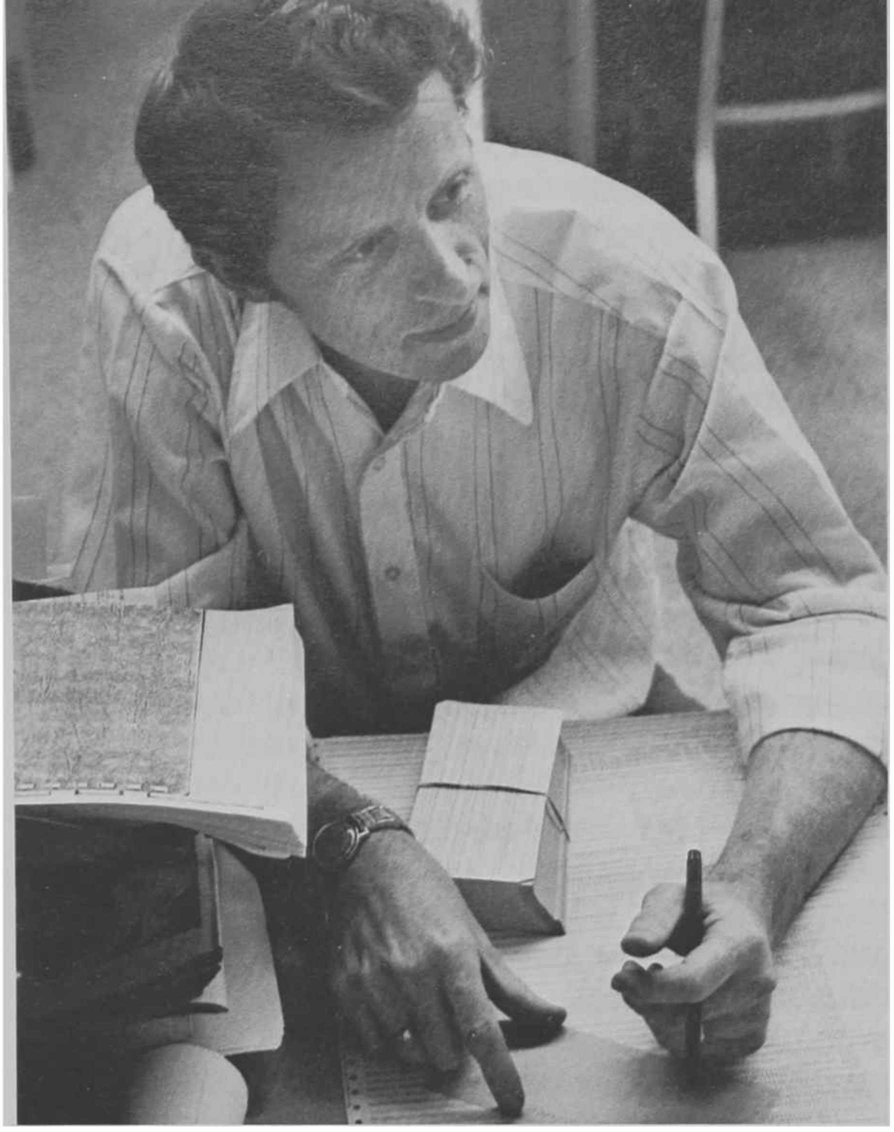
Another helpful instrument is the real time slicing densitometer, which produced the bizarrely-colored cover for this issue. A black and white aerial photo may be placed under the camera lens of the densitometer. The image is then projected on the screen of a video display terminal. The densitometer assigns different colors to features of different optical density. Ponderosa pine, for example, might be assigned a different color than Juniper. The densitometer will then give a readout on the percentage of the area that is composed of each vegetation type. The same operation can be performed for other, specifically-selected, physical features.

Once the computer has been given all the information the user wishes to consider, it may be ordered to produce maps that show:

(1) Inventory — The computer simply draws a map depicting the data fed the computer.

(2) Interpretative — function — The user defines a new characteristic — say "building loss hazard" — as a function of characteristics included in the inventory — say soil and slope, soil shrink-swell, and depth to water table.

(3) Evaluation maps — Where the various data,



WILLIAM RASMUSSEN: Finding programs to do the job.

interpretative variables, and states fed into the computer are assigned differing values depending on how much or little of a desirable or undesirable characteristic they display. The example mentioned earlier of identifying "prime agricultural land" involved evaluation.

There is, of course, the possibility that one person might give considerably more weight to one factor (say economics) than another person. Rasmussen says all that can be done is to strive for objectivity in the weightings. If there is, indeed, some bias in the way a mapping program is set up, and public officials make decisions on this basis, it is ultimately up to the public to see that things get straightened out.

(4) Perspective maps — Where physical relief or structures are involved, they may be drawn in three-dimensional perspective and the perspective rotated or tilted to give different views of the same area or object. It may be that the simple act of viewing itself is important and the computer may produce maps from a program such as "VIEWIT" that show the user whether or not a given object or feature may be seen from any point on the map.

Maps of all types can be drawn on paper or by a pen plotter. They may then be stored and presented on a video display terminal when needed instantly.

From Coconino County in the north to Cochise in the south, the UA lab has been at work for government agencies and private firms, attempting to graphically assess the impact that certain development policies would have on the land.

For the U.S. Forest Service, Rasmussen and his colleagues have been trying to find the best routes for roads in Woods Canyon and Thomas Creek near Flagstaff. Variables such as slope, geology, drainage, vegetation, topography, timber type, scenic quality, and wildlife habitat are evaluated along with visibility. Slope maps are built from existing topographic maps, while an economic map ("surface") is derived from cost of road per mile as a function of slope and the timber to be removed. This is combined with the scenic data to arrive at the best route for the road.

Here each variable was given a range of different ratings in terms of desirability. High cost and high aesthetic damage were weighted negatively. It is possible, where compromise between different interests is desired, to arrange for middle values to have the greatest weight in summation.

Rasmussen says the lab is working to rationalize the conflict between various factors now in the road siting program and hopes to have the new program model ready to go in a few months.

Pioneering work is being done for the Forest Service in modeling the tree canopy of forest lands.

This program, using scenic quality appraisal results arrived at by Terry Daniel, UA experimental psychologist and others, could be used to present an apparent view from any point in a forest when a ground perspective photo is not available. In other words, the computer will be able to draw the view a person has from somewhere in a national forest of a point at which a development of some kind is proposed. Will the person be able to see it? Will it be viewed as aesthetically displeasing? The computer will be able to give a graphic response and provide the user with answers.

For the Tortolita Town Hall, which considered Pima County's development plan for the area northwest of Tucson, the lab produced eight maps, each of which displayed a consideration factor that might be considered in deciding if a part of the area should be built up. Economics, vegetation, wildlife habitat, slopè vegetation, floodplains, and transportation were among the factors. Participants were then able to assign weights to differing degrees of each characteristic, and with the maps decide where development should or should not take place.

Elsewhere in Pima County, the lab is cooperating in a university-wide study for Anamax Mining Company's soon-to-be-developed mine at Helvetia in the Santa Rita Mountains. It will be very visible and the firm wants to find out what its visual alternatives are in siting the mine, methods of excavation, and size of the open pit. Considering the howl that went up from residents of Tucson and Green Valley when a highly visible limestone quarry was started not far from the mine property, Anamax would appear prudent in minimizing its visibility at Helvetia.

A rational basis for deciding just where houses and other developments should be permitted was the goal Cochise County had in mind when it turned two years ago to the UA for help.

The county was divided into sections, and for each section, with the aid of the county planning department, maps are being made showing such factors as slope, soil type, floodplain areas, wildlife habitat. From these maps, composites are to be made that show where urban development can take place without being subject to flooding, with assurance that septic tanks will work, that water table recharge zones and primary wildlife habitats are disturbed as little as possible.

Big city planners may be the next to turn to Rasmussen and the lab. Tucson officials have expressed interest in knowing the number of residents whose view of the surrounding mountains would be cut off by a building of a given height in a given place. Lab software on hand could do just that.

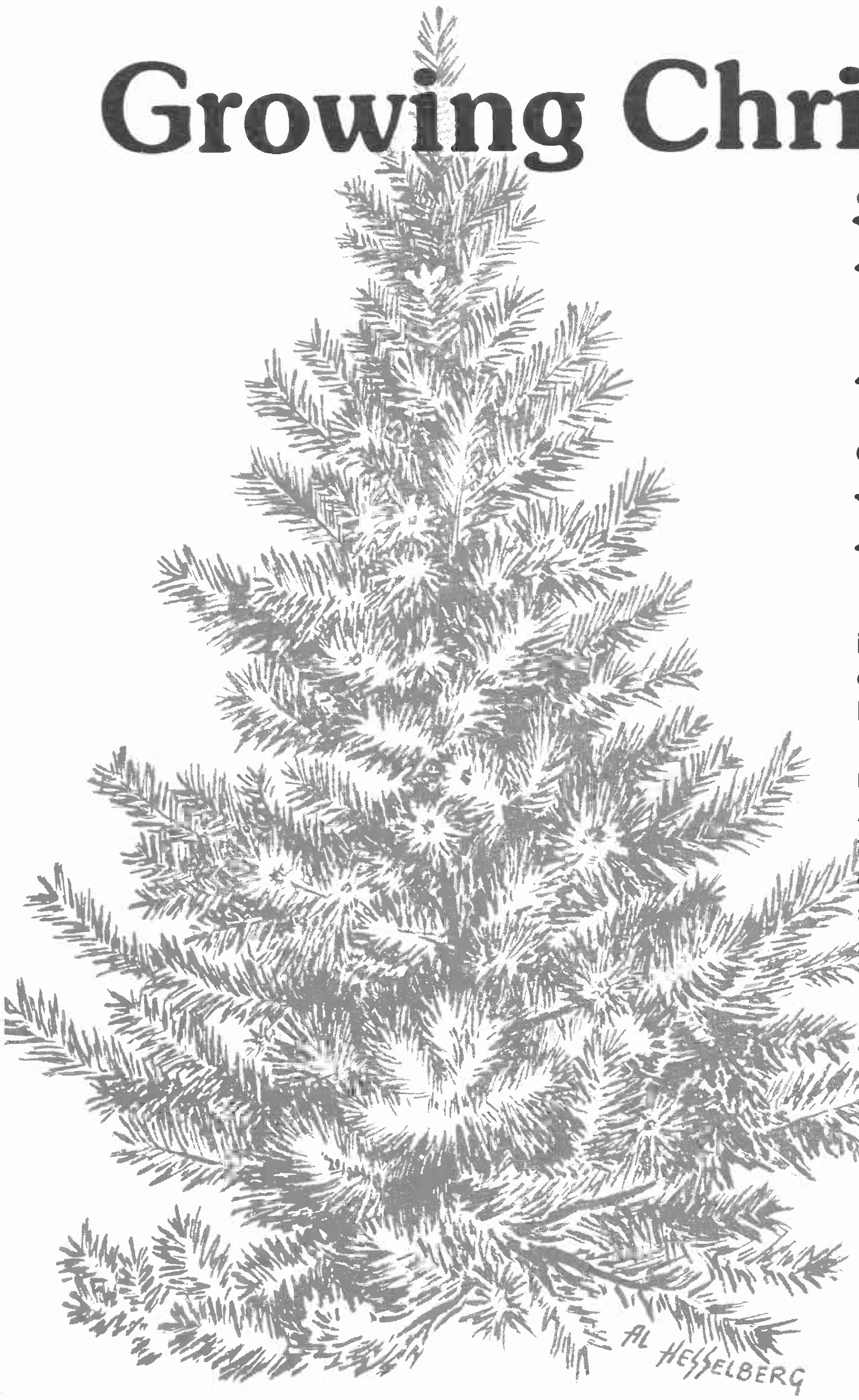
In addition to making his facilities available to others, and doing contract work, Rasmussen teaches a course in introductory computer mapping in which students are shown how the various programs work and are then allowed to pursue projects of their own interest, applying the principles they have learned.

This year, Rasmussen said he is going to insist that those registering for the course have "a working knowledge of Fortran Computer language." Then he shrugged and added, "They at least ought to be able to find the computer center."

MAPPING the soils of Cochise County, Karen Warren sends data directly to the computer from the stylus she uses to trace soil class boundaries.

Growing Christmas Trees in Arizona –

A Native and a Foreigner Look Promising



by David C. Chojnacky and Robert F. Wagle*

With place names like Alpine, Spruce Mountain, Aripine, Pine Top, Indian Pine, Pine Flat, Pinedale, Piñon, Cedar Creek, Pine, and Christmas Tree Lake, you might think Arizona would be a sizeable producer of its own Christmas trees, mightn't you?

Not so.

Deceiving, the high fir country of the Pinaleno, White, and San Francisco Mountains. Deceiving, the whole ponderosa sweep of the Coconino National Forest. Pine trees, pine trees everywhere, but not a Christmas tree crop to cut. Very nearly.

With few exceptions, the Christmas tree demand in Arizona is met by plantations in eastern and northern mountain states. The trees are cut in October and lie about drying a month or more in shipment.

So there is economic appeal in growing Christmas trees here to meet the in-state demand, and the Arizona Land Department has, for the past three to four years, been encouraging small land owners to grow such trees. While most of the plantations are small (the largest containing about 1500 trees), there are plans afoot for an 80-acre venture in the Chino Valley, north of Prescott.

To date, one of the primary obstacles to commercial Christmas tree plantations is Arizona's long, dry spring. This is a critical period for survival of seedlings. Frequently there is insufficient moisture.

This study focused on the feasibility of starting small Christmas tree plantations in the White Mountains and on the White Mountain Apache Reservation, with a particular eye on what types of trees are most promising and how to ensure or enhance the survival of seedlings.

We found two species — one native and one exotic — that seem most promising: the Arizona cypress and the brutia pine (also known as quetta pine), native to southern Russia and planted commonly in Afghanistan. These species were planted as seedlings along with three other native types at three sites of differing elevations in the White Mountains of east central Arizona.

Also included in the study were Douglas fir, piñon pine, and southwestern white pine. Douglas fir is widely planted as a Christmas tree. Arizona cypress has been popular as a Christmas tree for more than 20 years in the southeastern United States, and southwestern white pine has been suggested as a good bet for Christmas tree usage. We selected piñon and brutia because they do well in dry climates.

The lowest site was at 4,600 feet on an old field surrounded by riparian vegetation on the east fork of the White River. A second was located at 5,800 feet near Post Office Canyon (south of McNary), and the

*Masters graduate and professor, respectively, of watershed management.

third was at 6,000 feet near the Wagon Wheel Ranch (east of Show Low). The two higher plots were previously cleared woodlots located above the Mogollon Rim in ponderosa pine woodland.

Compared on the three sites were the effects of containerized plantings, different mulch covering, and artificial shading.

Seedlings were grown in two types of containers: half-gallon metal juice cans and 6-inch-deep by 1-inch-wide plastic mesh tubes. Both containers were filled with a mixture of four parts desert topsoil, two parts mortar sand, and three parts peat. To this potting soil was added 6 kilograms of 7-40-6 NPK fertilizer per cubic meter of soil. The containerized seedlings were grown in green houses and lath houses during the winter and early spring of 1975.

Planting was done in May and June, with a space of 4½ feet between trees in each row and 7½ feet between rows. The seedlings were watered every ten days until the summer monsoon rains came July 1. Thereafter rainfall kept soil moisture adequate.

The seedlings shaded for the purpose of the study were protected from the sun from noon until 5 p.m. during the summer growing season.

Can- and tube-grown brutia and piñon pine were planted on a quarter acre plot on the east fork of the White River, shaded and unshaded, to see if there were any differences in survival due to these various methods.

At Post Office Canyon, a quarter acre was planted with Arizona cypress and piñon pine seedlings, all having been grown in metal can containers. These seedlings were observed for different treatments of wood chip mulch, black polyethylene mulch, and shade applied to both species.

At the Wagon Wheel Ranch plot, a half acre was planted with Douglas fir and southwestern white pine. For comparison, some were planted bare root, some planted from the containers in which they had been grown with no disturbance to earth around the roots. All Douglas firs were shaded, since it has been shown that Douglas fir seedlings require shade to survive.

In November 1975 — after a full growing season — and in April 1976 — after a winter — the survival of the seedlings on the three plots was checked. The first check was made to see what the different treatments of mulch, shade, and containerized plantings had on survival of the various tree types.

Other than discovering that the brutia pine seedlings grown in metal cans survived better than those grown in the plastic mesh tubes, it was found the various treatments had no effect on survival. Apparently the irrigation during the spring plus regular weeding did more than any of the various treatments to ensure survival.

During the November check the brutia pine and Arizona cypress seedlings enjoyed the highest percentage of survival and the greatest growth as well (see table).

But survival of the brutia dropped drastically over the winter and there was damage to the cypress. Rabbits apparently found the succulent brutias to their taste, killing many. The piñon pine seedlings at the White River site (same site as brutia) grew slowly, and many died apparently due to poor adaptation after transplanting.

Both the cypress and the piñon pine seedlings survived nicely at the Post Office Canyon site, with the growth of the cypress suggesting that it has great potential as a Christmas tree type for Arizona.

Eight of the cypress did suffer dead tops from frost, and the tips (terminal leaders) of many others darkened considerably, leading to the conclusion that this species is near its upper elevational limit at 5,800 feet. The piñon there grew slowly, but its survival shows that it is well adapted to that site.

Douglas fir and southwestern white pine seedlings on the Wagon Wheel Ranch site didn't survive particularly well over the summer growing season and suffered frost heave during the winter which killed an additional 20-25 percent of the seedlings that had survived the first growing season. Both grew fairly slowly compared with the brutia and cypress, and they do not look promising as Christmas trees, given the site conditions in this study.

The Christmas tree project will continue with further studies of the brutia and cypress. Cypress seed from six isolated mountain ranges (Catalinas, Chiricahuas, Rincons, Blue Range, Santa Teresas, Apache) was gathered at varying elevations and will be planted at the White River and Wagon Wheel Ranch sites in a comparison of survival. The brutia will be replanted at the White River site and enclosed with wire mesh to prevent predation during the first winter.

While we continue with our experimentation with these two species, there are indications that commercial growers are taking brutia pine seriously. Reports are that the venture north of Prescott will see much planting of brutias, and the trees have already been raised for several years on small acreage near Willcox and sold successfully as Christmas trees.

Table 1. a listing by species of the total numbers planted, percent survival and average height for each plot in the study

	Total Planted	Percent Survival (Nov. 1975)	Percent Survival (Apr. 1976)	Average Height (Nov. 1975)
East Fork of the White River Plot				
Brutia Pine	126	94%	13%	25.06 cm
Pinon Pine	126	71%	45%	6.39 cm
Post Office Canyon Plot				
Arizona Cypress	93	90%	90%	49.73 cm
Pinon Pine	94	90%	89%	7.93 cm
Wagon Wheel Ranch Plot				
Douglas Fir	126	75%	51%	12.59 cm
Southwestern White Pine	167	86%	67%	6.50 cm

RESEARCH NOTES

Beginning with this, the first quarterly issue of the magazine, we hope to keep you apprised of the research projects under way at the College of Agriculture. Because we are playing catch-up on all projects currently being pursued, descriptions in this and the fall issues will be necessarily cryptic. Beginning with the winter issue, we hope to be more selective in the projects we present, and slightly more detailed in their description.

Title	Leader	Start Date	Close Date
ADMINISTRATION			
Relationships Between Environment and Cotton Fruiting Using Time Series Analysis	Robert O. Kuehl	01-07-75	30-09-78
AGRICULTURAL ECONOMICS			
Impact of Changing Production Costs, Product Prices & Technology on Arizona Farm & Ranch Adjustments	John L. Fischer Revised	01-07-59 01-07-74	30-06-72 30-06-77
Allocation of Resource Uses on Central Arizona Watersheds	William E. Martin Revised	01-07-59 01-07-74	30-06-64 30-06-77
Export and Import Policies as They Affect the Agricultural Sector in the United States and Arizona	Jimmye S. Hillman Revised	14-07-59 01-07-75	14-07-63 30-09-79
Agricultural Statistics	Horace M. Mayes Revised	01-07-65 01-07-74	30-06-72 30-06-77
Factors Affecting Producer Prices for Cotton	Robert S. Firch Revised	25-09-67 24-05-73	 01-07-77
Administration Project	Jimmye S. Hillman		01-01-99
Impact of changes in world food supply-demand conditions upon selected agricultural factor markets	Roger W. Fox Revised	01-07-69 01-07-74	30-06-74 30-06-77
Impacts of Relative Price Changes of Feeds & Cattle on Marketing of U.S. Beef	Jimmye S. Hillman Revised	01-07-70 01-07-75	30-06-75 30-09-80
The Marketing & Pricing of Arizona-Grown Horticultural Products	Robert S. Firch	01-07-71	30-06-76
Institutional Structures for Improving Rural Community Services	Thomas M. Stubblefield	01-07-71 Extended	30-06-76 30-09-76
Economic and Social Significance of Human Migration for the Western Region	Edwin H. Carpenter	14-02-73	30-06-76
Soil Interpretations and Socio-Economic Criteria for Land Use Planning (SWE)	Rueben N. Weisz	01-07-73	30-06-77
Sources and Alternative Systems of Marketing Feeder Cattle: An Arizona Case Study	C. Curtis Cable	15-03-74	14-03-77
Evaluation of Financial Problems Relating to the Development of Arizona's Agricultural Production and Credit Sectors	John L. Fischer	01-07-74	30-06-77

Title	Leader	Start Date	Close Date
Western Region Area Development Research Center (Social Marginalization of Human Resources in Declining Rural Industries in Southern Arizona)	William E. Martin	19-02-74 Extended	30-06-75 30-09-76
Alternative Marketing Channels for Whey Disposal in Arizona (Dairy)	Robert C. Angus	01-07-74	30-09-77
Determinants of Choice in Outdoor Recreation (WM)	William E. Martin	01-07-74	30-09-77
Distribution Among Rural People of Benefits and Costs of Selected Government Programs	Harry W. Ayer	01-01-75	30-09-79
Energy in Western Agriculture, Requirements, Adjustments, and Alternatives	Rueben N. Weisz	01-07-75	30-09-78
Jobs for Rural Areas Through Community Industrial Training and Improved Transportation Services (Title V — Rural Development Act of 1972 — 5010-4152-26)		01-07-74	30-06-75
AGRICULTURAL EDUCATION			
Instructional Units for Teaching Principles of Agricultural Science	Floyd McCormick Revised Revised	30-04-68 01-07-72 01-07-75	 30-06-75 30-06-78
Model/Unit Instruction Concept for Teaching Operating Principles of Agricultural Mechanics	Clinton O. Jacobs Revised Revised	01-07-70 01-07-72 01-07-75	30-06-72 30-06-75 30-06-78
Occupational Opportunities for Agricultural Employment in Arizona	Phillip R. Zurbrick	01-07-72	30-06-77
ANIMAL SCIENCES			
Interrelationship of Serum Lipid, Certain Hormones and Carcass Fat of the Ruminant	Forrest D. Dryden Revised Revised Revised	12-05-66 01-07-69 01-07-73 01-07-75	 30-06-75 30-09-78
Improvement of Arizona Feedlot Rations	William H. Hale Revised	21-01-69 01-07-74	30-06-74 30-09-77
Feeder Calf Production Under Intensive Systems of Management	Bruce R. Taylor Revised	19-01-68 01-07-74	30-06-73 30-09-77
Administration Project	Richard W. Rice		01-01-99
Evaluation and Utilization of Roughages by Growing and Fattening Beef Cattle	William H. Hale Roy S. Swingle Revised	 01-07-69 01-07-74	 30-06-74 30-09-77

Title	Leader	Start Date	Close Date
Physiological Mechanisms Involved in Improving Intake and Utilization of Nutrients in Ruminants	C. Brent Theurer Revised	01-07-69 01-07-74	30-06-74 30-09-77
Reproductive Performance in Beef Cattle (Vet Sci and Dairy & Food Sci)	Donald E. Ray Revised	01-07-70 01-07-75	30-06-75 30-09-80
Impacts of Relative Price Changes of Feeds and Cattle on Marketing of U.S. Beef	John A. Marchello Revised	01-07-70 01-07-75	30-06-75 30-09-80
Improving the Marketability of Cull Range Cows	Carl B. Roubicek	28-11-73	27-11-76
Limiting Stress of Food Producing Animals to Increase Efficiency	Donald E. Ray	01-07-74	30-09-79
Genotype-Environment Interactions Related to End-Product Uses in Small Grains	Roy S. Swingle	01-07-74	30-09-79
Limiting Stress of Food Producing Animals to Increase Efficiency	Thomas N. Wegner James D. Schuh	01-07-74	30-09-79
Improving Large Dairy Herd Management Practices	Dennis V. Armstrong	01-10-74	30-09-77
Effect of Land Utilization on Rodent Populations	E. Lendell Cockrum	01-07-71	30-09-76
Use of Arizona Crops in Poultry Diets	Charles W. Weber Bobby L. Reid Revised	 23-02-65 01-07-73	 30-09-78
Dietary Composition on Mineral Utilization	Bobby L. Reid Revised	01-07-64 01-07-72	 30-09-77
Avian Environmental Stresses	Bobby L. Reid Thomas N. Wegner	01-07-71 Extended	30-06-76 30-09-76
Amino Acids in Poultry Nutrition	Bobby L. Reid	01-07-71 Extended	30-06-76 30-09-76
The Role of Hay Cubes in Energy Utilization and Fat Secretion in the Lactating Bovine	William H. Brown Revised	01-07-64 01-07-73 Extended	 30-06-76 30-09-76
Metabolism of Chlorinated Hydrocarbons by the Bovine	Frank M. Whiting William H. Brown	23-12-64 01-07-73	 30-09-78
Improving Methods of Raising Dairy Heifers	James D. Schuh	11-07-68 01-07-74 Extended	30-06-73 30-06-77 30-09-77
Limiting Stress of Food Producing Animals to Increase Efficiency (SWE)	Gerald H. Stott	01-07-74	30-09-79
ENTOMOLOGY			
Residues of Pesticides and Related Chemicals in the Agricultural Environment — Their Nature, Distribution, Persistence, & Toxicological Implications (Mktg)	Larry A. Crowder Extended	01-07-68 01-07-73	 30-06-78
Biology and Control of Insects Affecting Cotton in Arizona	Theo F. Watson Revised	01-07-55 26-06-73	 1-03-78
Environmental Improvement Through Biological Control and Pest Management	Theo F. Watson Revised Revised	10-02-65 01-07-69 01-07-74	10-02-70 30-06-74 30-06-79
Residues of Pesticides and Related Chemicals in the Agricultural Environment — Their Nature, Distribution, Persistence, & Toxicological Implications (Metabolism)	Larry A. Crowder Extended	01-07-68 01-07-73	 30-06-78
Insect Pests of Arizona Vegetable Crops	Paul D. Gerhardt Revised	01-07-57 01-07-72	 30-06-77
Administration Project	George W. Ware Revised	01-07-55 01-07-68	 01-01-99
Physiological Studies of Arizona Insects: Termites as Decomposers and Producers	William L. Nutting Revised Revised	01-07-59 01-07-68 01-07-74	 30-06-73 30-06-77
Taxonomy of Arizona Economic Insects	Floyd G. Werner Revised	01-07-59 01-07-69	 Indefinite
Mites of Arizona: Systematic, Bionomic, and Control Studies	Donald M. Tuttle Revised	01-07-67 01-07-72	 30-06-77
Pesticide Residues on Arizona Crops	George W. Ware Revised	01-07-61 01-07-72	 30-06-77
Arthropods of Public Health Importance	Gary S. Olton Revised Revised	01-07-68 01-01-73 01-07-75	 30-06-75 30-09-78
Insects and Arachnids Infesting Homes and Commercial Buildings in Arizona: Their Biology and Control	Gary S. Olton Revised	01-07-68 01-07-72	 30-06-77
Insects and Mites Affecting Citrus in Arizona: Economic Importance, Biology and Control	Donald M. Tuttle Revised	01-01-68 01-07-72	 30-06-77
Biology and Control of Insects Attacking Flowers, Shrubs and Shade Trees	Gary S. Olton Revised	01-01-68 01-07-72	 30-06-77
Pesticide Application Equipment in Relation to Drift of Pesticide and Pest Control	George W. Ware Revised	10-02-65 17-04-73	 01-03-78
Turfgrass Management	Gary S. Olton Revised	01-05-63 01-07-74	30-06-66 30-06-77
A Predictive Model to Forecast Changes in Density of Pink Bollworm Populations (CSRS Special Grant 316-15-33)	Roger T. Huber	01-03-73 Extended	28-02-75 28-02-76
Monitoring Insect Parasites in a Cotton Pest Management Program (CSRS Special Grant 316-15-34)	Floyd G. Werner	01-03-73	31-08-76
SCHOOL OF HOME ECONOMICS			
Administration Project	Robert R. Rice		01-01-99
Nutrition and Food Acceptance as Related to Selected Environmental Factors	Mary A. Kight	01-07-71 Extended	30-06-76 30-09-76
Personal Bankruptcy and Extension of Credit	Janet L. Vaughn	01-07-02	30-06-76
Effectiveness of Teaching Approaches and Materials for Home Economics Teachers	Doris E. Manning Amy J. Knorr	01-07-72	30-06-78
Effect of Fluctuating Food Costs on Human Consumption of Lipids, Proteins and Calories	Edward T. Sheehan	29-10-74	30-06-77
Development of Social Competencies in Children	Victor A. Christopherson	01-07-75	30-09-80
Energy Conservation and Consumer Acceptance in the Care and Maintenance of Textile Products	Mary J. Wylie	21-07-75	30-09-78
NUTRITION & FOOD SCIENCE			
Availability of Amino Acids and Other Nutrients in Food for Nutritional Requirements	Mitchel G. Vavich Revised Revised	11-01-61 01-07-69 01-01-73	 30-09-77
Factors Affecting the Nutritive Value of Dietary Proteins	Mitchel G. Vavich Revised	11-01-61 01-01-73	 30-09-77
Pollen Substitute for Honeybees	William F. McCaughey Revised	21-07-55 24-04-73	 30-09-77
Administration Project	Mitchel G. Vavich		01-01-99
A Molecular Approach to the Development of a Chemotherapeutic Treatment for Plant Virus Diseases	Don P. Bourque	01-07-71 Extended	30-06-76 30-09-76
Utilization of Sterols by Insects for Growth, Maturation and Reproduction	Henry W. Kircher	01-07-72	30-09-77
Elimination of Atmospheric Pollution by Sulfur Dioxide During Copper Smelting	James W. Berry Archie Deutchman	01-07-72	30-09-77

COOPERATIVE EXTENSION SERVICE
U.S. DEPARTMENT OF AGRICULTURE
THE UNIVERSITY OF ARIZONA
TUCSON, ARIZONA 85721

Title	Leader	Start Date	Close Date
Demand Factors in Egg Marketing (Ag Econ)	Bobby L. Reid Revised	17-06-65 01-07-73 Extended	 30-06-76 30-09-76
Discovery and Control of Natural Toxicants in the Food Chain (DFS and PP)	Charles W. Weber	01-07-73	30-09-77
Market Acceptance of Arizona Fruits	Ralph L. Price	08-03-65 01-07-73	 30-09-77
Estimation of Indicator Microorganisms in Foods	F. Eugene Nelson	01-07-71	30-09-76
Discovery and Control of Natural Toxicants in the Food Chain (Plant Path)	Ralph L. Price	01-07-72	30-09-77
Correlation of Subjective-Objective Methods in the Study of Milk Flavors	Warren J. Stull	01-07-74	30-06-77
Alternative Marketing Channels for Whey Disposal in Arizona (Ag Econ)	Warren J. Stull	01-07-74	30-09-77
Domestication and Utilization of the Buffalo Gourd, **Curcurbita Foetidissima** HBK	Charles W. Weber	01-07-75	30-09-78

PLANT PATHOLOGY

Title	Leader	Start Date	Close Date
Management of the Biologic Balance in Soil for Control of **Phymatotrichum Omnivorum** and Achievement of Root Health	Homer E. Bloss	31-07-72	30-06-77
Plant Viruses and Virus Diseases in Arizona	Merritt R. Nelson Revised Revised Revised	01-07-65 01-07-69 01-07-73 01-07-75	 30-06-75 30-09-78
Administration Project	Edward L. Nigh		01-01-99
Morphology, Taxonomy, and Pathological Relationship of Arizona Wood-Rotting Fungi	Robert L. Gilbertson Revised	01-07-69 01-07-74	30-06-72 30-06-77
Control of Root Rot of Alfalfa Caused by **Phytophthora Megasperma**	Richard B. Hine Revised	01-01-72 01-07-74	30-06-73 30-06-77
Discovery and Control of Natural Toxicants in the Food Chain (with DFS and PS)	Thomas E. Russell	01-07-72	30-06-77
Clean West: Decision-making framework involving environmental planning in the West	Roger L. Caldwell	01-07-72 Extended Extended Extended	31-12-73 30-06-74 30-06-76 30-09-76
Relationship of Mycoplasma-like Organisms to Plant Diseases in Arizona	Ross M. Allen Revised	31-07-72 01-07-75	30-06-75 30-09-78
Pythium Aphanidermatum Root and Tuber Root of Sugarbeets, Potatoes and Peppers in Arizona	Michael E. Stanghellini	01-07-74	30-06-77
Etiology of Bacterially Induced Market Spoilage of Potatoes	Michael E. Stanghellini	01-07-74	30-06-76
Research, Development and Use of Nematode Pest Management Systems (SWE, Hort)	Edward L. Nigh	01-07-74	30-06-79
Pathogens Affecting Stand Establishment of Lettuce Grown From Vermiculite Seed Tablets (Hort-SWE)	Thomas E. Russell	01-10-74	30-06-77
Chemical Control of Powdery Mildew of Cantaloupe and Sclerotinia Drop of Lettuce	Joseph L. Troutman	01-10-74	30-06-77
Host Plant Resistance in Cotton to Insects, Mites, Nematodes and Diseases	Michael A. McClure	01-07-75	30-09-80