CONSERVING
WILDLAND RESOURCES
THROUGH
RESEARCH

Introductory Report from the
Wildland Research Center

OCTOBER 1959

UNIVERSITY OF CALIFORNIA AGRICULTURAL EXPERIMENT STATION
SIXTY-FIVE MILLION
WILDLAND ACRES . . .

. . . a giant "farm" for timber and forage.

. . . a vital source for most of California's
water supply.

. . . an "outdoor playground" for millions of
vacationers.

. . . a keystone in California's future welfare.
THE WILDLAND RESEARCH CENTER at the University of California was established in 1958 to help meet a growing need for concentrated scientific study on the problems of California wildlands. Operating within the University's state-wide Agricultural Experiment Station, the Center . . .

...coordinates and supports the work of researchers in more than a dozen scientific fields.

...encourages scientists in different fields to integrate their studies of complex wildland problems.

...strengthens the cooperation between the University and other public agencies concerned with wildland research.

...promotes the exchange of information between research workers and those who manage wildland enterprises or set wildland policies.

...aids in the collection and dissemination of scientific data on all phases of wildland study.

FIELDS OF SCIENTIFIC STUDY represented in the Wildland Research Center include agricultural economics, agronomy, animal husbandry, biological control, botany, entomology, forestry, genetics, irrigation, plant pathology, range management, soils and plant nutrition, veterinary science, wood technology, and zoology.

THE PROGRAM of the Wildland Research Center is planned by a Coordinating Committee representing each of these fields of study. The Director of the Center is Henry J. Vaux, Dean of the School of Forestry and Assistant Director of the Agricultural Experiment Station, Berkeley.
THIS REPORT presents some basic facts about California wildlands and the resources they contain, outlines some of the state's major wildland problems and resulting needs in wildland research, and describes the present and potential role of the University's Wildland Research Center. The report is based on a detailed study of research needs made by the Agricultural Experiment Station's Committee on Water, Forest, Range, and Natural Resource Conservation.

MAJOR GOALS IN WILDLAND RESEARCH AND MANAGEMENT:

1) Accurate inventory and classification of wildland resources.

2) Determination of the most suitable uses of wildland areas according to physical, economic, and cultural factors.

3) Conversion of certain wildland areas to better uses by the most efficient methods.

4) Better protection of forests, grasslands, watersheds, and scenic values from fires, insects, and diseases.

5) Increase in timber growth and more efficient wood utilization to meet future needs for lumber and other forest products.

6) Increase in grass production and improvement in range conditions to keep pace with growing demands for meat and wool.

7) Increase in water yield from wildland watersheds, better timing of runoff, and better control of floods and erosion.

8) Improved conditions and better management of wildland areas for outdoor recreation.

9) Improved habitat and better management for fish, game, and other wildlife.
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Looking Ahead in Frontier Days...

... in my opinion, there is no country [compared with California], in the known world, possessing a soil so fertile and productive, with such varied and inexhaustible resources, and a climate of such mildness, uniformity and salubrity; nor is there a country, in my opinion, now known, which is so eminently calculated, by nature herself, in all respects, to promote the unbounded happiness and prosperity, of civilized and enlightened man. ... In view of their increasing population, accumulating wealth, and growing prosperity, I can not but believe, that the time is not distant, when those wild forests, trackless plains, untrodden valleys, and the unbounded ocean, will present one grand scene, of continuous improvements, universal enterprise, and unparalleled commerce... and when all the vastly numerous, and rich resources, of that now, almost unknown region, will be fully and advantageously developed.

—(from Lansford W. Hastings, The Emigrants' Guide to Oregon and California, Cincinnati, 1845)
Looking Ahead Today...

Within the passing of a single century, the frontiersman's optimistic predictions have come true—almost with a vengeance! His rose-colored forecast has been fulfilled beyond his wildest dreams. And present-day Californians can marvel at "a grand scene of continuous improvements, universal enterprise, and unparalleled commerce"—but with many results the pioneers did not foresee.

Californians today, including millions of modern emigrants, may well be wondering whether they can look ahead with equal optimism to the next 100 years? or the next 50? or even the next 20? A great part of the answer, we may be sure, will depend upon the progress we make—and make soon—in seeking better ways to assure that "the vastly numerous and rich resources . . . will be fully and advantageously developed."

Within his bulldozers and plows and asphalt spreaders, civilized man has extended his complete and permanent domination over a little more than one-eighth of California's land area. Most of what remains is a vast and varied region that we call the wildlands. It is within this area that we must solve many serious problems regarding the wise development, effective protection, and sustained use of the storehouse of resources still left after the first onslaughts of civilization.

WHAT ARE WILDLANDS?

Thirteen million of California's 100 million acres are occupied by crop and pasture land, urban and residential areas, industrial sites, and transportation facilities. Another 22 million acres are desert. The remaining 65 million acres—almost two-thirds of the state—are the wildlands discussed in this report. We might visualize them as California's "big back yard." The topography includes mountains, foothills, plateaus, upland valleys, canyons, lakes, rivers, alpine regions, and sea coasts. The major types of native cover on California wildlands are forests, grasses, woodland-grass combinations, sagebrush, and chaparral. Nearly all species of the state's natural fauna—mammals, birds, fish, reptiles, and insects—are represented in the wildlands. And man lives there too, in all but the most isolated areas.
HOW BIG ARE THE WILDLANDS?

California wildlands (excluding deserts) comprise 65 million of the state's 100 million acres of land, an area six times the acreage devoted to all of California's crops, fallow, hay, and cultivated pasture. By comparison, it's an area almost equal in size to the entire state of Oregon. Wildlands extend to all of the state's borders and form a portion of the land area (an integral part of our economy) in nearly all of the state's 58 counties.

WHO OWNS THE WILDLANDS?

About half of California's wildland area is in public ownership, mostly under federal jurisdiction. The other half is owned privately by lumber companies, railroads, ranchers, resorts, land and timber holding companies, and a variety of other corporate and individual owners including thousands of city dwellers who maintain vacation homes in wildland areas.

WHY ARE WILDLANDS IMPORTANT TO EVERYONE?

A glance into the average home will show how many of our basic needs are supplied by wildland products:

- Lumber for home construction and furniture, wood and charcoal for fuel, paper and other wood fiber products, wool, beef, lamb, nearly all of our water, and a large portion of our electric power.

And it's by no means a one-way traffic. Californians go to their wildlands in ever-increasing numbers to enjoy the scenery, the outdoor life, and a growing variety of outdoor sports. To the state's highly urbanized population, provision of a setting for relaxation and pleasure is one of the most important aspects of wildland use.

The major economic significance of our wildlands is founded on timber growing, forage production, watershed runoff, and recreation use:

1) California timber production in 1956 was valued at $250 million. The timber was converted into 5.9 billion board feet of lumber, 725 million square feet of plywood, and 973,000 tons of paper and paperboard. The lumber industry alone paid out more than $300 million in wages to 62,000 employees that year. Standing timber in private ownership provides a substantial part of the tax base in many forested counties. And federal timber harvested adds thousands of dollars to county treasuries.

2) The range livestock industry relies heavily on grazing from some 44.5 million acres of wildlands. The forage produced there is a key factor in an industry whose annual sales of cattle and sheep exceed $300 million. Grazed wildlands in farms contribute significantly to the general property tax base in many rural counties.

3) Some 42.5 million acres of the wildlands constitute the major water yield areas of California, producing a mean annual runoff of more than 68 million acre feet—more than 97 per cent of the state's available water resources. These watersheds are not only the source of pure, high-quality water, but they include the most strategic areas for flood prevention and control.

4) Recreationists, including fishermen and hunters, are spending over 70 million days per year in the California wildlands, or roughly five days per year per person. Their estimated annual expenditure of more than $1.5 billion on recreation emphasizes the economic significance of outdoor leisure pursuits in the state.

Wildlands are also the source of minerals, water power, and related benefits. Consideration of these values is excluded from this report, since these resources are not directly dependent on scientific management of the wildlands with their complex of soils, vegetation, and climates.

WHAT IS THE IMPACT OF EXPANDING POPULATION ON THE WILDLANDS?

Today's wildland problems threaten to become more critical in the future because of the growing population pressures affecting every phase of wildland management. The westward migration of Americans and the rising birth rate have doubled California's population within the past twenty years. It's a safe prediction that the mushrooming growth will continue for many years to come.

There will be more and more demand for water, for lumber and other forest products, for places to live in wildland areas, for elbow room among sportsmen and other outdoor vacationers, and for new farmlands to replace those lost to urban expansion. Danger from wildfire will increase, and far greater
protection will be required against losses from disease, insects, and wasteful utilization. Competition between the alternative wildland uses is already keen. As needs increase, these conflicts will become more severe and the problems of optimum use of the land will demand increasing attention.

WHY IS THERE A CRITICAL NEED FOR MORE WILDLAND RESEARCH?

Specialists in every field agree (and strong evidence supports them) that current efforts in wildland research are falling far short of what is needed. We know that our present rate of timber growth is less than half what it could be; moreover, we use less than half the wood actually felled in the forest. We know that on soils suited to grazing, current meat production is less than one-third of its potential. We know that our watersheds under careful management could yield more water than they do today. We know that recreation values can be greatly improved through scientific wildland management. And we know that we are currently losing tens of millions of dollars worth of commodity and other values from our wildlands because of wildfire, insects, and diseases.

The key to reducing these losses and to developing vast potentialities of our wildlands lies in securing more scientific information through research.

Mistakes in wildland management cannot be corrected quickly. If we plant trees on a site to which they ultimately prove poorly adapted, several decades of valuable time may be lost before the error is detected and corrected. If we convert a brush site to grass when it should have been converted to trees, the error will be troublesome for a long time.

Since most wildlands are subject to multiple uses, the complex technical problems of coordinating two or more uses in an area involve the application of a variety of skills. Often, these can be provided only when several researchers from different scientific disciplines work together cooperatively.

The job for research is to develop more knowledge—and better integrated knowledge—about factors affecting wildland benefit; to design better techniques for using land in the light of this information; and to make certain that the results of this research reach land managers in a form they can readily apply.

CALIFORNIA WILDLANDS . . . exhibit widely varied types of landform, plant cover, and climate. Shown on the next page are some typical wildland environments. The snow-covered upper slopes of Mt. Shasta (elev. 14,162 ft.) are a year-round source of water and a place for skiing and climbing. The forested middle elevations are managed for recreation and timber production. The manzanita brushland in the foreground, resulting from forest fires in the early 1900's, represents one of the challenging problems of wildland research and management. The scene below shows a typical woodland-grass-brushland combination found in many foothill areas of California. For such areas, management and research aim for increased forage production for sheep and cattle; protection from fire, insects, and rodents; better yield of water with less erosion; elimination of undesirable plant species; and better conditions for wild game.
THESE ARE CALIFORNIA’S WILDLANDS

Forests and Alpine areas
Grass, woodland - grass, sagebrush
Chaparral

Source: U.S. Forest Service
WHO IS RESPONSIBLE FOR WILDLAND RESEARCH IN CALIFORNIA?

Among the organizations that maintain regular programs of wildland research in California are the University of California, the Pacific Southwest Forest and Range Experiment Station of the U. S. Forest Service, other agencies of the U. S. Department of Agriculture and the U. S. Department of the Interior, the Division of Forestry of the California Department of Natural Resources, the California Department of Fish and Game, the California Department of Water Resources, and the research departments of several private organizations and companies. The research activities of these units vary widely in size and objectives.

Californians can take pride in the fact that their state is the first to prepare a complete statewide “Wildland Research Plan” outlining research needs and furnishing the basis for coordinating the research of the public agencies. This plan is the result of a careful study and analysis of wildland problems and of the past work of the various research organizations. A report on this over-all plan, prepared by a representative committee, has been published by the State Board of Forestry.

WHAT ARE THE SPECIAL ROLES OF UNIVERSITY WILDLAND RESEARCH?

For more than fifty years, the University of California’s Agricultural Experiment Station has maintained broad responsibility and a vital interest in wildland research. As the state’s major center for agricultural research, the University has developed a staff of scientists highly expert in all aspects of the plant and animal sciences, soils, hydrology, entomology, pathology, economics, and other fields—all fundamental to enlargement of our knowledge of wildland resources.

University scientists are working toward the development and application of new techniques and toward an understanding of the “unknowns” that underlie many of the basic wildland problems. An example of this approach “in depth” can be cited in the study of the physiology of forest seedlings:

A persistent obstacle to the planting of unstocked forest land in California has been the high percent-age of losses experienced in many forest plantations set out in the past. A hit-or-miss approach to this kind of problem would have little chance of providing a solution. University forestry scientists, in their current studies, are investigating (under carefully-controlled conditions) the basic factors affecting seedling survival—climate, moisture, soil properties, nursery conditions, and variations in the seedlings themselves. Information developed through such fundamental research can be carried into practical application to overcome a major barrier to wildland improvement—and can lead to establishing productive forests on thousands of currently idle acres.

WHAT ARE THE UNIVERSITY’S RESOURCES FOR EXPANDED WILDLAND RESEARCH?

A staff of skilled scientists, adequate facilities for experiments, and effective administrative coordination are the essentials in any successful research program. In the fields of wildland study, the University offers:

1) A highly competent staff of scientists assigned to the following departments: Agricultural Economics, Agronomy, Animal Husbandry, Biological Control, Botany, Entomology and Parasitology, Forestry, Genetics, Irrigation, Plant Pathology, Soils and Plant Nutrition, Zoology, and the Forest Products Laboratory. The University’s campuses at Berkeley, Davis, Los Angeles, Riverside, and Santa Barbara all contribute to this staff.

2) An array of up-to-date facilities including laboratories, greenhouses, test plots, libraries, climate chambers, a computer center, and insectaries located on several campuses; field stations for experimental work in a number of wildland locations (including 4,600-acre Hopland Field Station and 70-acre Howard Forest in Mendocino County, 2,731-acre Blodgett Forest in El Dorado County, 5,000-acre Sierra Foothill Beef Cattle Ranch in Yuba County, and Sagehen Creek Experimental Wildlife and Fisheries Station in Nevada County); and a variety of project areas maintained in cooperation with other research agencies or with private landowners.

3) An administrative headquarters—the Wildland Research Center—established within the University’s statewide Agricultural Experiment Station.
WILDLAND RESOURCES AT YOUR SERVICE

(Annual Production — 1956)

FOREST PRODUCTS

Lumber 5.8 billion board feet
Plywood 725 million square feet
Paper and paperboard 973 thousand tons
Firewood and charcoal 1-6 million cords
Other products 53 million board feet

WATER YIELD

68 million acre feet per year
mean annual runoff

RANGE FORAGE

12 million animal unit months

WILDLIFE and RECREATION

Over 70 million man-days
The scale of the University's past and present efforts in wildland research is apparent in the 71 different wildland research studies currently under way in 14 departments. Some 84 papers a year were published during the period 1953-1958 to place wildland research information in the hands of people who need it.

But significant as this effort has been, it falls far short of what is required if emerging wildland problems are to be dealt with on the basis of adequate scientific knowledge. The rate of research expansion during recent years—particularly expansion in basic research—has not kept pace with the rapid increase of wildland problems and values. It is important to point out that current total wildland research expenditures by the University amount to only a small fraction of one per cent of the direct economic returns from wildland use. Experience in both industry and agriculture emphasize the need for a several-fold increase in wildland research efforts if we are to provide the basic knowledge essential for wise conservation and development of these key resources.

The sections that follow in this report afford a closer look at some of the more important problems of our wildlands and at the current University research programs aimed toward providing solutions. Suggestions are included to point out many of the urgent research needs in wildland study requiring greater attention in the years immediately ahead. If these are ignored or slighted, the promises of future abundance in California's wildlands cannot be fulfilled.

These research proposals are regarded as a minimum needed program in University wildland research and are based upon a five-year study completed by a committee in the Agricultural Experiment Station. The recommended additional research has been carefully screened in the light of costs, potential benefits, relation to research already under way, research done by other agencies, and the relative importance of different types of wildland resources. The proposals should merit the careful attention of each person having an interest and a stake in the wildlands—whether as owner, operator, policymaker, researcher, or consumer.

A TOUR OF U.C. WILDLAND RESEARCH FACILITIES . . . would take you from border to border visiting many counties in the state. The Wildland Research Center has access to an array of laboratories and experimental areas on the major campuses, at field stations, on government land, and on the property of many private cooperators. The pictures on the next four pages provide a few examples of these "working" laboratories; others are illustrated in the sections that follow.
This aerial view of the University's 4,600-acre Hopland Field Station in Mendocino County has been "typed" by a research worker into three vegetation classes: (1) brushland, (2) woodland, and (3) grassland. The scientist then will study each class on the ground to determine its carrying capacity for both sheep and deer.

New varieties of range grasses are grown and tested in experimental plots on the 3,000-acre Davis campus.
Research and instruction on the physiology and growth of forest seedlings is conducted in this greenhouse on the Berkeley campus.

An experiment in forest thinning is under way in this plot on the University's 2,731-acre Blodgett Forest in El Dorado County.
An inside-out fishbowl is provided for University zoologists by this underwater observation tank at the Sagehen Creek Experimental Wildlife and Fisheries Station near Truckee.

Use of air-applied herbicides for brush control is tested at Piney Creek, Mariposa County, on an experimental watershed maintained in cooperation with the federal government and private landowners.
The University's Forest Products Laboratory, completed at Richmond in 1955, conducts research on the utilization of native California woods. Major facilities in the large testing and processing area shown here include two experimental dry kilns (left rear), a new solvent seasoning unit (center rear), and a high-frequency bonding apparatus (right foreground) shielded by a screened cage.
An accurate inventory of physical wildland resources provides the essential basis for effective wildland research and management.

IN RESEARCH, the data from inventories helps point out the nature and location of major problems. Scientists can use inventory reports and maps to guide research into the most promising areas and to avoid many time-consuming efforts in gathering preliminary data. Like savings banks, inventories store up information about soils, plants, water, wildlife, and climate that can be put to valuable use in specialized studies.

IN MANAGEMENT, inventory data can be put to immediate practical use in measuring the present and potential resource values in each area. Inventories are a guide in land buying and in tax appraisal. They show where vegetation can be altered for greater productivity. They point out areas where fertilizer applications and other management techniques can be effective. They help in watershed management, in guiding the location of new roads in wildland areas, and in the selection of new farmlands needed to replace those lost through urban expansion.

Here are some examples to show the need for one fundamental kind of wildland inventory—the soil-vegetation survey:

1: A piece of land in El Dorado County was cleared for farming in the 19th Century. Later the farm failed, and forests grew back over the land. Now the trees are being felled again in preparation for planting an apple orchard. In the long run, what use would really provide the best returns from this land—orchard, timber, pasture, or something else? Data from a soil-vegetation survey could help in making a wise decision.

2: Many acres of timber were burned in a recent fire in Modoc County. Managers must decide which portions of this area are suitable for forest replanting, which would serve better as grazing lands, and which should be managed only as erosion-controlling brush. Reliable answers could be formed from soil-vegetation survey data.

3: Because brush plants may develop deeper root systems than grass, valuable water may sometimes be conserved by converting brush to grass. But many watershed areas in southern California and elsewhere are clothed with a soil mantle so shallow that either type of vegetation will use most of the available water. A soil-vegetation survey is a valuable forerunner to vegetation conversion projects so that costly effort is expended only on those areas that promise substantial gains in water yield.
TAKING STOCK OF SOIL AND VEGETATION

Progress as of September 1958

MILLION ACRES SURVEYED
(Cumulative)

1945 1950 1955 1960

MILLION ACRES OF WILDLAND

THE JOB TO BE DONE

Soil-Vegetation maps available

Soil-Vegetation mapping in progress
THE SOIL-VEGETATION SURVEY in California is an excellent example of close cooperation between various research agencies—the University, the State Division of Forestry, the Pacific Southwest Forest and Range Experiment Station of the U. S. Forest Service, and to some extent the U. S. Soil Conservation Service.

The work is complex and exacting, involving the services of foresters, soil scientists, agronomists, range specialists, and experts in aerial photogrammetry. Working in teams, the scientists develop the preliminary data from aerial photographs and extensive field reconnaissance. They collect soil samples in the field and analyze them in laboratories and greenhouses. They determine vegetative composition and densities for each area. Finally, they transfer the essential information to quadrangle maps in the form of standard symbols.

TWO UNIVERSITY DEPARTMENTS contribute active programs to the soil-vegetation survey. Specialists in the Department of Soils and Plant Nutrition (center for the well-known California Soil Survey) are engaged in mapping, analyzing, and characterizing soils and vegetation in wildland areas, with work currently under way in six counties. The Department of Agronomy participates in grassland aspects of the inventory by identifying and classifying range plants, developing range sampling procedures, and appraising grazing potential as influenced by herbaceous composition, nutrient status, and land use history.

The Department of Forestry is studying aerial photo specifications to improve the kind and detail of inventory information observable by this technique. Currently, these studies are developing the use of aerial color photography in appraising the value of rangelands for forage production, in the detection of diseases and insect attacks on timber, and in identifying details of species, age, and condition of wildland vegetation. This research contributes directly and continually to improvements in a relatively new and very important inventory technique—the aerial photo survey.

THE CALIFORNIA INSECT SURVEY, conducted by the Department of Entomology, is another type of inventory that stores up valuable knowledge for wildland research and management. Moving into several wildland areas, the Insect Survey is obtaining information on the identity, hosts, and distribution of both beneficial and destructive insects.

Other inventory activities are conducted as a regular part of research by University scientists in such fields as plant pathology, biological control, zoology, and climatology.

Needed Research—Only ten per cent of California's wildland soils and vegetation have been inventoried in detail; some 58 million acres remain to be covered. Recommended is a three-fold expansion of the present University contribution in field inventory of soil and vegetation resources; a comparable expansion of work on analysis of physical, chemical, and biological properties of each major soil type and of soil-plant relationships; expanded surveys of insect fauna in the wildlands; and continued effort on other biological inventories.

Soil-vegetation maps, like this one showing a portion of Mendocino County, enable land managers and researchers to obtain accurate information on actual and potential wildland resources. On a typical map, symbols written on the mapping units show (1) soil series and phases; (2) the species of significant woody plants and the occurrence of grass, wet meadow, marsh, and other land classes; (3) timber site quality in areas suitable for conifer timber production; and (4) unclassified areas, such as agricultural land or areas with little or no soil. Legends accompanying each quadrangle explain the map symbols and give information on (1) common and scientific names of plant species; (2) habit of growth, sprouting or nonsprouting characteristics, and browse value of woody and brushy herb vegetation for livestock and wildlife; (3) some of the more important soil characteristics such as depth, color, texture, acidity or alkalinity, kind of parent material, permeability of soil to water, and erosion hazard; (4) estimated suitability of the soils for timber production; and (5) estimated suitability of the soils for extensive range use.
Modern methods of aerial photogrammetry in soil-vegetation surveying haven't eliminated the need for field checking on the ground (and even underground) to insure accuracy of data.

U.C. researchers are improving techniques for aerial survey of forest insect damage, as in this photo showing trees attacked by the western pine beetle (light areas) on the University's Blodgett Forest.
WILDFIRES cost Californians some $25 million annually in prevention and control programs. In spite of this expenditure and intensified efforts, resources and improvements valued at over $25 million are destroyed yearly by fire. And wildfires are a constant threat to human life, to wildlife, and to scenic beauty. Natural influences are partly to blame, for we know that the state has one of the most difficult fire control problems in the world because of topography, fuels, and climatic conditions. Wildfires take tolls on forests, brushlands, and grasslands, with each type of vegetation posing special protection problems. In spite of continued efforts to educate the public in fire prevention, mounting human use will increase fire danger.

INSECTS do their work more stealthily than fires, but they chew their way through timber and forage resources of greater value than those destroyed by fire. Each year in California, insects destroy more than one billion board-feet of timber—valued at more than $20 million. Insect defoliators cause the loss of large volumes of timber growth. Regeneration pests destroy future timber stands in the seed or seedling stages. Wood borers ruin otherwise salvageable timber that has been killed by diseases, fire, or other insects. Recreational values in wildland areas are often impaired or destroyed by insect attacks. And brush and grass feeding pests, like the well-known grasshopper, reduce the productivity of many rangelands.

DISEASES are often the hardest to detect of all wildland invaders, unseen except by the expert. Yet long-term losses in California from forest diseases rank nearly as high as insect-caused losses. The major forest diseases include root and stem rots, dwarf mistletoes, needle blights, native stem rusts, and white pine blister rust. Of these, only blister rust can be adequately controlled (and then only at substantial cost and under favorable topographic and climatic conditions). As virgin stands are cut and management turns to second-growth stands, disease losses threaten to increase rapidly in California forests.

Other enemies that invade the wildlands include WEEDS, crowding out forage grasses and sometimes poisoning livestock, and RODENTS, destroying grass and forest seedlings and contributing to erosion damage.

Wildland losses can be reduced through better control techniques and wise management practices. The problem is to find those controls and practices that will provide the greatest protection at the least
cost. A greater concentration of research in these areas is needed—research that can pay substantial and prompt dividends to the entire state.

Reduction of fire hazard is a research area of this kind in which University scientists are probing for answers. One project is investigating fire hazard reduction in second-growth pine stands through the elimination of accumulating tinder fuels. Others are testing the fuel-reduction aspects of brush range improvement. University specialists are also cooperating in the "Fuel-Break" program organized by federal, state, and local agencies in southern California.

How about fire control? Research in this area lies mainly within the province of federal and state agencies, but the Wildland Research Center is assisting with an intensive study on the economics of fire protection. This study is concerned with economic values of lands protected by the state. It includes an estimation of the effect of alternative levels of protection on the damage incurred and an approximation of the optimum level of fire protection effort under prevailing conditions. Current research is concentrated on the following topics:

1) A review of current administrative practices in fire-damage appraisal.

2) A statistical analysis of relationships shown by 1,250 large fires (over 300 acres).

3) Development of a statistical model for isolating the effects of protection expenditures from historical cost-loss records.

4) Development of a basis for improving the appraisal of fire damage to both merchantable and young timber.

5) Formulation of a general method for appraising the value of watershed cover.

University studies in entomology, plant pathology, and weed and rodent control are aimed toward providing much-needed basic biological and ecological information on insects, diseases, and other enemies. From this basic data, the researchers develop new control measures utilizing latest advances in chemical insecticides and herbicides, biological control (including the use of introduced insects to control both weeds and insect pests and the application of the new "living" microbial insecticides), and better management techniques. The following list of project titles shows the scope of University research in this area:

- Biological Control of Forest Insects
- Control of Range Weeds by Imported Insects
- Biology and Ecology of Rangeland Grasshoppers
- Biology, Ecology, and Control of Regeneration Insect Pests
- Physiology, Ecology, and Control of California Forest Bark Beetles
- Morphology, Classification, Biology, and Control of Coleopterous Insects Injurious to Forests and Forest Products
- Sawflies Attacking Trees in California
- Fungi Associated with Branch Dieback in Mistletoe-Infested Conifers
- Fungi Diseases of Mistletoe
- Environmental and Host-Parasite Relationships of Dwarf Mistletoe
- Botryosphaeria Canker and Other Cankers of Conifers and Hardwoods
- Identification and Exploratory Study of Miscellaneous Disease Problems in California Forests
- Environmental Effects on Bister Rust Spread
- Relation of Wildlife to Agriculture with Emphasis on Rodents and Rabbits

**Needed Research**—Current research on protection problems has barely begun to tap the potential benefits that could be obtained from prevention of wildland resource losses. Recommended by the Wildland Research Center are intensive studies to improve the measurement and evaluation of wildfire hazards; studies to develop methods of reducing fuel accumulation through chemicals, planned burning, mechanical means, and other treatments; expanded work on the physiology, ecology, and control of such forest pests as bark beetles, cone and seed insects, secondary insects, and defoliators; similar studies of major grassland insect pests; increased work on biological control of forest and range insects; fundamental studies of the taxonomic relationships among forest and range insects; studies of the role of insects in the dissemination of plant diseases; more research on the control of rangeland weeds and rodents; and further work on the biology of dwarf mistletoe and related organisms, environmental requirements for establishment of major fungi of conifers, factors affecting the establishment and growth of root rots and rusts, and diseases of economically valuable browse species.
MAJOR FIRES IN CALIFORNIA
1948-1957

10,000-20,000 acres burned

Over 20,000 acres burned

Sources: California Division of Forestry
U.S. Forest Service
Eliminate hazardous fuel accumulation in brush and you've gone a long way toward preventing wildfires and improving conditions for wild game. This bulldozer is mashing brush in an experimental project at Kinsman Flat, Madera County; later, the area will be control-burned and reseeded to grass.

Another fuel-reduction project undertaken by U.C. foresters involves the study of a portable chipper, shown here mounted on a bulldozer. The chipper macerates and scatters the slash from a logging operation.
LOSSES TO FOREST PESTS AND FIRE

AFFECT PRESENT AND FUTURE TIMBER SUPPLIES

CURRENT ANNUAL LOSS
OF STANDING TIMBER

RESULTING LOSS OF
FUTURE TIMBER GROWTH

TOTAL LONG RUN TIMBER LOSS

INSECTS
1.4

DISEASE
0.9

DISEASE
1.1

INSECTS
1.5

Fire
0.3

Other
0.2

Source: U.S. Forest Service
(California Commercial Forests)
Destructive bark beetles cannot be studied easily in the forest, so entomologists on the Berkeley campus store beetle-infested logs in this screened cage and collect the pests for study when they emerge.

This experimental rodent-trapping device set up on a drift fence in Modoc County preserves the catch in an underground jar and allows the researcher to chart the size, composition, and direction of rodent migrations. Current studies in this region center on meadow mice.
A mysterious ailment known as “X” disease has struck in certain southern California recreational forests, causing the decline and death of pines like this one in the Crestline area on the San Bernardino National Forest. Forest pathologists with the University and the Pacific Southwest Forest and Range Experiment Station are applying research to track down the exact nature and cause of the disease. (U. S. Forest Service Photo)

An introduced insect knocked out invading Klamath weed on more than two million acres of California rangeland—dramatic proof of the capability of biological control. In this photo, unchecked Klamath weed is in bloom on the left, the weed is dying under attack of beetles in the darker center strip, and the field at right has been cleared of the noxious weed. The project was supervised by U.C. and U. S. Department of Agriculture specialists.
Charting the Economic Course

As we noted earlier, inventories of wildland physical resources can provide a set of guideposts for effective research and efficient management. Another set of criteria, equally important for maintaining research and management on the most profitable course, is provided by economic analysis of wildland problems.

"Will it pay?" is the question usually preceding adoption of any new management technique. The answer in wildland management often depends on a complex set of factors related to present and potential values and to market conditions. Before owners and managers can apply physical and biological information, they must have a clear understanding of the economic facts and trends determining the returns from wildlands.

Complicating these problems are the revolutionary changes occurring in the economics of wildland use. Many lands and commodities that were almost worthless a few years ago now command substantial prices. Continuing population increases will intensify such changes in the years ahead. And the multiple-use character of the wild lands adds to their economic complexity. As one member of the Wildland Research Center recently commented before a forestry conference in San Francisco:

"During the next fifteen years, our major problems will be in the area of fuller and more effective utilization of forest resources other than wood—recreation, water, wildlife, and the like…and whole forest use will be the key to the future just as whole log use has been the key to much of our past progress."

UNIVERSITY ECONOMISTS in the Department of Agricultural Economics and School of Forestry are investigating the costs and returns for a number of important types of wildland management practices. Some of these studies involve specific types of improvement that private landowners might make. Others are concerned with larger public questions, such as the economic problems of public investment in multiple-purpose projects (with special reference to water), a benefit-cost analysis to help both public officials and private operators answer questions about investments in wildland resources, and the economics of renewable resource conservation. A partial list of project titles indicates the scope of current economic study:

• Economics of Conservation
• Economics of Public Resource Development
• Cost of Range Improvement on California Brushland
• Economics of Range Fertilization
• Economic Use and Integration of Pasture and Dryland Range for Beef Cattle Production
• Economics of Fire Protection
• Forest Taxation in Mendocino County
• Marketing Practices and Other Price Determining Factors for Logs and Stumpage
• Logging Costs

As examples of the type of information developed in University research on wildland economic problems, the results of two recent studies may be cited:

1) An extensive survey in Humboldt County showed that timber is being used faster than it is being grown, and that the county faces potential declines in tax base, employment, and income unless its lands are managed to produce more timber. Conducted in cooperation with county officials, the survey probed deeply to determine the trends, the opportunities, and the dangers in the economic picture of Humboldt County. The conclusions were published for eventual use in public and private management decisions.

2) The University and the California Division of Forestry cooperated recently in a study to measure costs and returns of controlled brush burning for range improvement in northern California. The study involved cost analysis of 190 controlled burn records covering a one-year period and a comparative study of fire suppression costs of 513 wildfires. Results of the study showed that the cost averaged $3.65 per acre for controlled burns of 40 acres, only $0.60 per acre for burns of 440 acres, and $1.20 per acre for those of 640 acres. The researchers found that legalized controlled burning has made an important contribution toward reducing the acreage burned by incendiary fires each year, although on the basis of savings in fire-suppression cost alone it appeared highly questionable whether controlled burning could be advocated for fire-hazard reduction on large areas. All evidence pointed toward the fact that controlled burning is likely to be wasteful of time and money unless there is careful planning and effort to provide proper management of the area after the burning has been accomplished.

Needed Research—Recommended are expanded studies in cost-and-returns of timber growing, range forage production, and vegetative type conversion; in economic institutions such as marketing arrangements, taxation practices, and public programs for resource protection and development; in the economics of wildland conservation; and in physical output and economic returns from recreation, watershed management, and other extra-market uses of the land.
The demand for water spurs a special interest in wildland problems for nearly every city dweller and a good many farmers throughout California. The runoff patterns in the Tuolumne Basin become a subject of concern to every resident of San Francisco. Erosion on an Owens Valley hillside is a vital matter in Los Angeles. A forest fire in the northern Coast Range threatens the late summer supply of irrigation water for a Glenn County farmer.

The reason is that more than ninety-five per cent of California's available water supply flows from wildland watersheds—and water, it is often said, is the "lifeblood of California."

The extraction of maximum water flows during dry summer and fall seasons is an essential feature of watershed research. We need more fundamental knowledge of watershed behavior and a better analysis of watershed management practices.

INCREASING USABLE WATER YIELDS involves different approaches for each watershed vegetative type: woodland-brush zone, forest belt below the snow line, forest belt above the snow line, and alpine zone. In many areas, there are possibilities of increased water yield through reducing evapotranspirational losses on watersheds—that is, through taking water away from brush and other low value plants and sending it down the slopes to enter the available water supply. Such projects may be especially valuable where dams are constructed downstream to store water for future use.

Of equal importance may be the possibility of changing the timing of runoff in certain areas through modification of the plant cover. If this proves feasible, runoff may be shifted to later months when there is less danger of floods and a greater need for water on irrigated croplands and in municipal water supply systems.

UNIVERSITY RESEARCH activity in the field of watershed management includes studies of the various influences on disposition of precipitation and yield of water. On experimental watersheds located throughout the state, researchers are collecting basic data on soil type, vegetative cover, precipitation patterns, and related variables as these affect rates of streamflow, infiltration, and erosion. One project has demonstrated water flow increase after removal of oak trees. Another project is investigating the effects of range management practices and other aspects of
land management to find influences on infiltration, runoff, and erosion. Related information on watershed management is also being obtained through work on the improvement of brushlands and in a study on the influence of forest trees on such soil properties as permeability and infiltration rate. Previous studies in the central Sierra have clearly established that water runoff is increased when deep-rooted shrub and scrub trees are removed from watersheds and supplanted by more shallow-rooted range grass species.

**Needed Research**—With a multi-billion-dollar plan for water development under consideration in the state, Californians cannot afford to ignore the sources of that water—the wildland watersheds. Expanded studies are recommended on the factors influencing rain and snow disposition and water yield; the rainfall-runoff relationship on watersheds; the influences of different plant covers on water losses, soil erosion, and soil properties; and the effects of various land management practices on water yield, erosion, and the timing of runoff.

In watershed research, a topic for study is the influence of trees on snow cover manipulation and the resulting effects on evaporation and runoff. This scene shows snowclad lodgepole pines on Mt. San Antonio, Los Angeles County.
Field day visitors inspect a water measuring station located below an experimental watershed on Piney Creek, Mariposa County.

Litter on the forest floor—in this case pine needles and oak leaves—is highly important as a protective cover against raindrop splash erosion, also as a regulating factor in runoff and evaporation. Studies on the kind, amount, and distribution of litter are keys to improved watershed management.
CALIFORNIA'S GROWING NEED FOR WATER

An important key in meeting requirements is **GOOD WILDLAND MANAGEMENT**

These are the major water yield areas

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**OUR WATER NEEDS**

<table>
<thead>
<tr>
<th>MILLION ACRE FEET (ANNUAL)</th>
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<tbody>
<tr>
<td>50</td>
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<tr>
<td>40</td>
</tr>
<tr>
<td>30</td>
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<td>10</td>
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</tbody>
</table>

Estimated present requirements

Probable ultimate requirements

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Forest belt below snowline

Woodland, brush, grass

Alpine snow areas

Forest belt above snowline

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Total mean annual run-off — million acre feet

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only 3% of our water comes from areas other than wildlands

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Sources: State Water Resources Board and California Division of Forests.
There's an axiom that says: "A nation is as strong as its forests."

In other words, where a people and a government have learned to treat forests with respect, to use them wisely, and to maintain a balance in growth and cutting to assure a perpetual timber supply, that nation has achieved a measure of self-reliance far above the nation whose resources have been abused and plundered.

Where does California stand in this picture?

California forests furnish the raw material for a lumber industry that supplies 14 per cent (almost one-sixth) of the national lumber output, as well as a major plywood industry and an expanding pulp and paper industry.

Yet these great industries still thrive on stored resources, the rate of timber cutting today is nearly double the comparable rate of timber growth.

We know that the potential timber supply is not inadequate; in fact, under ideal conditions, California forests could supply a much larger lumber and wood products industry without a danger of resource depletion. The potential for increased timber growth in California is at least three billion board feet annually.

While timber growth is one key to a stable forest "bank account," log utilization is another of equal importance. In this area there has been encouraging progress in recent years. But we still use less than half the wood that is cut from the forest. Low quality wood, bark, and little-used tree species handicap good forest practices and create vast quantities of unused residues. In an age of rising consumer demands and stiffening international competition, such waste cannot be slighted or ignored.

One problem in the restoration of severely cutover lands is the high cost of site preparation and planting, particularly for small forest landowners, with an ensuing long period before returns can be realized. California contains 4 million acres of land needing tree restocking (nearly 25 per cent of the total commercial forest lands).

THE CHALLENGE OF OUR FORESTS can be clearly defined. First, more fundamental knowledge of California's unique forest conditions—climate, soils, tree species—must be developed. Then, modern advancements in science and technology must be applied to forest problems and tested thoroughly. To do these jobs, we need a big boost in our forestry research efforts. Finally, given the results of research, management can move ahead rapidly with new techniques and greater efficiency toward a program of full and balanced forest utilization.

FORESTRY RESEARCH in the Wildland Research Center is conducted by a staff of scientists skilled in such fields as botany, silviculture, soils, ecology, entomology, pathology, zoology, forest economics, forest management, and forest engineering. The Forest Products Laboratory provides the most
yield a variety of important softwood timbers
The behavior of young seedlings can make or break the future productivity of forestlands. Here an instructor and students are checking pine seedlings grown in a laboratory tank on the Berkeley campus under controlled conditions of temperature, moisture, and soil fertility.
modern means for investigation in the vital fields of wood chemistry, timber physics, and wood technology. Blodgett Forest is a superb site for field studies in silviculture, ecology, forest management, and related subjects. Controlled environment chambers, recently completed on the Berkeley campus, are providing powerful new tools for tree physiology research. And the University’s Computer Center makes available for forestry problems highly advanced equipment and permits fruitful attack on projects that would have been hopeless a few years ago.

Some titles of current projects:

- Forest Regeneration
- Natural Reproduction Survival
- Methods of Measuring and Improving Restocking on Cutover Forests of the Sierra Nevada
- Predicting the Yields of Young Growth Stands in the Redwood Region
- Technical Properties of California Woods
- Influence of Site on Mechanical Properties of Red Fir
- Strength and Related Properties of California Wood Species
- Bird and Mammal Influence on Reforestation
- Effect of Early Stocking on Volume and Quality in Douglas Fir Stands
- Role of Brush in Ponderosa Pine Management
- Kiln and Air Drying of California Hardwoods
- Solvent Seasoning of Tanoak
- Influence of Forest Tree Species on Soil Properties

Useful new knowledge developed in these projects is shown by three examples from recent reports:

1) Studies of seedling physiology are helping to brighten the picture of forest planting in California. Survival of pine seedlings is found to be closely associated with their ability to produce roots, and rooting is influenced by the physiological condition of the seedlings and the season of the year when they are planted. One hundred per cent rooting was obtained on ponderosa pine seedlings transplanted in the spring, only 40 to 60 per cent rooting on the fall-planted ones. Through further studies may come a better understanding of seedling behavior and a sound basis for improved nursery and planting practices to speed up restocking of cut-over and burned-over lands.
Stepping up growth through forestry practices and reduction of losses will help bring growth and cut into balance.

*Sawtimber trees are commercial species over 11" in diameter and containing at least one merchantable log.

Source: U.S. Forest Service

2) Another study is concentrating on natural forest regeneration—the survival of seedlings as influenced by weather and ground conditions. Results of this project may enable foresters to rate the restocking potential of each forest area and to determine whether nature can do the whole job or whether man must lend a hand through site preparation or actual planting. Under very good ground conditions, the report shows, pine seedlings develop a deep root system during their first year and are able to tap soil moisture and continue to flourish even in very hot open areas. Under poor conditions, root growth is slower and roots may lose contact with soil moisture during dry months. Even these less fortunate seedlings may survive in an inactive state, however, if they are sheltered from extreme heat and dryness.

3) Much better utilization of California's sizable crop of native hardwoods may be possible as a result of research on seasoning problems conducted at the U.C. Forest Products Laboratory. Warping, checking, and other seasoning defects have blocked nearly all commercial use of these hardwoods in the past. But a series of tests at the Laboratory showed that California black oak could be kiln-dried successfully from the green condition by the proper regulation of temperature and humidity. A newer method of processing called solvent seasoning has also produced encouraging results in preliminary tests conducted on tanoak.

Needed Research—Better use of California timberlands depends on the rapid development of more fundamental knowledge. Additional work in the Wildland Research Center is recommended on forest regeneration by natural and artificial means; in improving timber growth through genetic means or through treatment of the stand; on alternate methods of managing forest types, including methods of coordinating timber production with other kinds of forest land use; on forest fertilization; and on wood utilization. Studies are also needed on methods of producing income from small forest ownerships while waiting for young tree crops to mature.
FOREST PLANTING IS INCREASING

... but costly plantation failures must be eliminated

... if our plantable acreage is to be made fully productive

Source: U.S. Forest Service
California tanoak and other native hardwoods, now largely discarded because of seasoning problems, may achieve wider utilization as a result of tests under way with this new experimental solvent seasoning apparatus at the U.C. Forest Products Laboratory in Richmond.

A U.C. forester makes an increment boring on a second-growth redwood in Santa Cruz County, part of studies to develop new volume tables as an aid in effective management and harvesting of second-growth timber.
...we grow twice the volume of hardwoods that we use each year.

HARDWOOD INVENTORY BY SPECIES

Inventory of hardwoods
TOTALS:
6 BILLION BOARD FEET
Tree pruning to improve future log quality is one of the silvicultural techniques studied at the University's Blodgett Forest in El Dorado County.
RECREATION is exploding across California wildlands in a way that couldn’t have been foreseen a few years ago. Recreational activities are accelerating at a far greater rate than any other wildland use. And in some wildland areas, dollar returns for recreational uses are exceeding any previous commodity production values.

By the millions every year, Californians “head for the hills” seeking a new and refreshing environment and a change from the chores of everyday life. Reflecting dozens of varying tastes, they move en masse and enthusiastically into the wildlands in larger proportion than in any other state. Each new outdoor development is nearly overwhelmed with boaters, campers, sightseers, summer homes, or winter sportsmen—and even wilderness areas are getting crowded.

Expenditures in the wildlands are matched or exceeded back home by the costs of preparation—for camping equipment, hunting and fishing gear, winter sports equipment, boats, transportation, and special clothing. It all adds up to a booming business affecting the economy in every part of the state, and a flood of new problems for those who manage and set policies for wildland development.

A recent statistical study completed at the School of Forestry shows the “standing-room-only” shape of things to come on federal forest areas in California.

If past trends continue, the report predicts, ten-year increases in forest recreation may range from 38 to 106 per cent, depending upon the type and location of the facilities. In the four national parks, this would boost attendance from 1½ million visitor-days in 1955 to nearly 7 million visitor-days in 1965 (with “visitor-days” figured as the total attendance multiplied by the average number of days each visitor stays in the forest area). Use of the national forests is expected to increase from 17 million visitor-days in 1955 to more than 29 million in 1965.

Accurate information on forest recreation is scarce, but experts have already noted several trends:

1) Greater use of facilities in more remote areas and deterioration of recreation environment in some heavily used areas.

2) More interest in the question of fees for the use of public camp and picnic facilities.
WILDLAND RECREATION

Fastest Growing Use

Indexes of Use on California National Forest — 1950 = 100

FOREST HIGHWAYS

WINTER SPORTS

PICNICKING

CAMPING

Index curves for various uses of wildland recreation, showing forest highways, winter sports, picnicking, and camping.
3) Increased emphasis on the present and potential use of private lands for outdoor recreation in order to shift some of the demand from overcrowded public areas.

Recreation use is posing new questions each day which must be answered with only a meager scientific background available. How much and what kind of lands should be devoted exclusively to recreation? What are the effects of recreation use on soil, plant cover, and other elements of the resource, and how can such effects be minimized? Can the "carrying capacity" of the land for recreational use be increased by modification of the plant cover or by other means? Recreation is a fledgling in the wildland research field, often involving interrelated aspects of ecology, economics, sociology, esthetics, and psychology. Its complexity only emphasizes the obvious need for more extensive scientific study.

WILDLIFE is a vital part of the biotic resource on our wildlands—important as game for fishermen and hunters, important economically, important esthetically to all who visit wildland areas, and important to science. Over two million hunting and fishing licenses are sold annually in California. Pressures of recreational use and changes in land management can produce immediate effects on the numbers and condition of wildlife. Questions of public interest in the field of wildlife management include: How can we secure the maximum useful production of deer with the minimum interference with other land uses? What effects can be expected from the competition for food between deer and domestic livestock on the same ranges? What are the best ways to maintain an abundant fish population in mountain streams? How can we improve California marshlands for waterfowl? What can we do about predators, diseases, and food shortages that affect California wildlife? More factual research information is essential in setting public wildlife policies and in guiding management practices.

THE UNIVERSITY has been conducting an active and expanding program in wildlife research for many years and is beginning to introduce experimental work on the economic interpretation and management of wildlands for recreation—an area scarcely touched by any research in the past. In one current project, the Wildland Research Center is examining a virgin redwood forest where recreational use is heavy, seeking to determine how soil properties and tree vigor are affected by such influences as soil compaction, excessive sedimentation, wind damage, and highway clearing.

Some current project titles in the field of wildlife management include:
- A Survey of the Effects of Animal Control Methods on the Biotic Environment
- Brush Removal Effects on Game Ranges
- Game Browse Establishment
- Ecology of Black-Tailed Deer on Sheep Ranges
- Aquatic Insects in Fishery Management and Pollution Evaluation
- Distribution and Abundance of Fish Population in Sagehen Creek
- Winter Factors Causing Fish Mortality
- Management of California Marshlands for Waterfowl
- Effects of Beaver Dams on Trout Streams and Trout Populations
- General Biology of California Quail

Results from three wildlife projects were reported recently:
1) During recent years, scientists at the Museum of Vertebrate Zoology on the Berkeley campus have conducted extensive surveys of deer in California. One three-year field study made on the Jawbone deer herd in Tuolumne County showed that the harvest by hunters is approximately one-fourth of the annual herd production. In other words, while the annual production within the herd is about 32 per cent, hunters are making an annual kill of only about 7 per cent. Studies have shown that in some areas there is actually a problem of deer over-abundance, that the animals have a tendency to outgrow their food supply, and that deer do best on lands that have been cleared and settled by man.

2) Well-fed deer with plenty of "elbow room" produce more young than half-starved deer on overstocked ranges. The increased fertility can apparently result from a reduction in deer numbers that relieves the competition for forage and from a favorable growing season for browse and acorns. A study at the Hopland Field Station showed that well-nourished does on a good range can produce up to 180 fawns per 100 does, while under poor conditions
the average can be as low as 107 fawns per 100 does in the same coastal area.

3) University of California zoologists at Berkeley, engaged in a long-term study of Sagehen Creek in the Tahoe National Forest, have found that the stream’s trout are capable of maintaining their numbers against the onslaught of anglers, without annual stocking from hatcheries. The average catch of all species of trout in this creek has amounted to less than 38 per cent of available trout over the past five years. Since hatchery stocking was suspended in 1951, the highest exploitation of any single species of trout has never exceeded 50 per cent of the available fish. Each summer the scientists cut off ten sections of the stream and pump them dry. The fish found are counted, weighed, identified as to species, and then replaced in the same section. An annual census of catches made by anglers in the area provides an accurate idea of the percentage of fish that are taken. Eventually, the information obtained at Sagehen may be applied to western trout fishing in general. Through habitat improvement, it may be possible to better the fishing in many areas by improving the survival of naturally spawned fish.

**Needed Research**—Recommended are studies on how to measure and predict levels of recreational use, how to determine the amount of use an area can support, how to maintain or improve existing vegetation for recreational purposes, how to minimize site deterioration, and how to correlate recreation with other important wildland uses. In the field of wildlife management, additional research is needed on deer physiology and management, relationships of plant cover to game carrying capacity, study of upland game birds, effects of predation on game species, population dynamics of fish, and effects of timber or forage management on productivity of fish and game.

PROBLEMS IN A PARADISE . . . are calling the attention of U.C. wildland researchers to California’s famed High Sierra wilderness region. Pictured above on the next page is the South Fork Basin of the Kings River (Kings Canyon National Park), a typical High Sierra scene of lakes, meadows, forests, and alpine rockland. Nature here is in delicate balance, and the impact of recreational use can result in serious problems. Researchers must consider the conditions for maintenance of natural vegetation and wildlife, the lack of natural repair, and the tendencies toward erosion and stream pollution.

Specific problems occurring in mountain meadows are shown below. At lower left is a group of multiple-trails worn by hikers and pack animals, a form of gradual deterioration that can lead to drying and eventual barrenness. At lower right is a meadow where over-grazing, possibly by pack animals, is aiding the invasion by corn lilies, an undesirable (non-forage) species.
• Motor Touring
• Picnicking
• Family Camping
• Water Sports
• Fishing
• Hunting
• Skiing
• Wilderness Travel
• Nature Study
• Outdoor Photography
• Mountain Climbing
• Summer Home and Resort Living
• Organization Camping

3½ MILLION PEOPLE

6½ MILLION PEOPLE

MORE PEOPLE
+ HIGHER INCOMES
+ MORE LEISURE TIME
+ BETTER ROADS
+ OUTDOOR EMPHASIS IN THE "CALIFORNIA WAY OF LIFE"

BOOMING RECREATIONAL USE OF CALIFORNIA WILDLANDS

2 Hours — Average driving time from metropolitan centers
Swarms of vacationers crowding into California's popular outdoor playgrounds create serious economic and biological problems. Research efforts must be intensified in these areas in order to provide for future needs in outdoor recreation and to safeguard natural wildland values.
Heavy recreational use can also be a hazard to the natural beauty of an old-growth redwood forest, like this one near Smith River, Del Norte County. In a current study in such an area, U.C. scientists are analyzing the impact of recreation and other uses on soil properties and tree vigor.

An icy environment doesn't prevent U.C. zoologists from taking winter fish samples in a seining operation conducted near the Sagehen Creek Experimental Wildlife and Fisheries Station, Nevada County.
Ear and antler markers will help U.C. scientists from the Museum of Vertebrate Zoology, Berkeley, follow the movements of this buck trapped on Jawbone Ridge, Tuolumne County.

Animal-proof fences, like this one constructed in Modoc County, are employed by U.C. wildland researchers in several areas to protect experimental range or forest seedling plots and to show how grazing by deer and other animals affects the growth of vegetation.

This young buck is surprised to find himself in a deer holding pen, used for game management studies at the U.C. Hopland Field Station in Mendocino County.
Forage Yield and Grassland Production

As population pressure rises and the livestock industry expands to meet food demands, the need to get the best possible forage yields from our rangelands becomes more and more pressing.

"Man has assumed wrongly for hundreds of years that natural vegetation on ranges was best," said R. Merton Love, chairman of the Department of Agronomy, in a recent address.

"In past thousands of years, man has developed the tools and knowledge necessary to grow bigger and better agricultural crops; but over these same thousands of years, there has been little change on the rangelands of the world.

"Range improvement suffers in comparison with other crops in three ways: there is a smaller degree of success in overcoming the limitations of nature, research is many years behind that for other crops, and there is too often an unwillingness among both scientists and farmers to try to do anything about it..."

"Emphasis must be changed from management to improvement..."

"Grassland, natural or artificial, is a renewable resource...and facing the researcher is the problem of developing research programs that will insure not only the continuity but also the improvement of the resource."

In California, livestock consume range forage valued at over $30 million annually. Of the total California wildland area, more than one-fourth is covered with grass or woodland-grass, and another seven million acres of sagebrush are managed primarily for livestock production.

More research information can point the way toward achieving increased yields and values of grassland through fertilization, weed and rodent control, introduction of improved grasses, and better management practices. In addition, there are many possibilities for expanding grassland areas through brush removal.

UNIVERSITY RESEARCH in this field is firmly established, with more than twenty projects under way at several locations through the state. Project titles include:

- Physiology and Ecology of Range Plants
- Physiology and Ecology of Rangeland Legumes Related to their Use for Soil Improvement and Dry Land Forage
- Ecological Balance in Range Species as Influenced by Environment Manipulation
- Improvements of Range Grasses by Introduction, Selection, and Breeding: and Non-Irrigated Pasture Improvement by Seeding, Fertilization, and Livestock Use
• Control of Medusa Head and Other "Weedy" Forbs
• Identification and Nature of Poisonous Range Plants
• Control of Woody Species
• Control of Range Weeds by Imported Insects
• Nutritive Value of Specific Range Forage Species as Influenced by Seasons, Fertilization, and Management
• Fiber and Fibrous Feeds in Nutrition
• Effect of Nutrient Restriction on Growth and Body Composition of Sheep and Cattle
• Distribution and Control Factors of Herbaceous Range Weeds
• Improvement of Rangelands by Management Practices
• Production of Hybrid and Polyploid Strains of Forage Grasses
• Suitability of Dominant Range Soils for Grazing in Humboldt County
• Conversion of Brush Ranges to Grass Ranges
• Relation of Wildlife to Agriculture with Emphasis on Rodents and Rabbits
• The Integration of Pasture and Dryland Range for Beef Cattle Production

Results from these studies can be put to use in improved management practices, as shown by the following examples:

1) A rangeland drill under test by University range management specialists at Davis may lead the way to better pasture and more meat production from the state's 30 million acres of rough range. The machine tested is a heavy duty drill capable of negotiating the uneven rocky areas of the range to sink grass seed and fertilizer into dry soil. Researchers have found that the careful seed planting allowed by the machine produces good forage crops. Test plots were established in 21 counties on a variety of range types including control-burned brushland, cultivated seedbeds, sprayed sagebrush, burned and unburned medusahead range, and others. Best results on one plot showed a yield of 3,140 pounds of dry forage per acre.

2) Deciduous oak trees on California rangelands may cut the land's forage growing potential as much as 80 per cent. Grass that can be added to the range by getting rid of oaks may easily cover the cost of tree-killing chemicals. For the past few years, the competition of blue oaks with range grasses has been studied on the U.C. Hopland Field Station. A successful method of killing oaks by chemical treatment has been demonstrated, involving frilling, or surface cutting, of the oak trunk and inserting the chemical herbicide. As the oak canopy thins out, the grass response is rapid. If each acre of rangeland is to pay its own way in productivity, then reducing thick stands of oak trees is an essential practice in California's foothill grazing areas.

3) An insect attack is being launched against tansy ragwort, a toxic weed invader in the north coast region of California and in parts of Oregon. The cinnabar moth, a natural enemy of tansy ragwort in Europe, will be imported and released in California by specialists in biological control with the University and the U. S. Department of Agriculture. Proof that the moth has no liking for any useful plants in California has been established in feeding trials at the USDA Parasite Introduction Laboratory in Paris. Tansy ragwort, an unpopular member of the thistle family, spreads on ranges, pastures, and on cutover timber lands. It is known to poison livestock, especially cattle and horses.

4) Salina, a new variety of strawberry clover developed by University plant breeders at Davis, is now generally available for range plantings. The new certified selection, tested for nine years at Davis, is recommended for the same general areas as ladino clover. Salina is more alkali- and drought-tolerant than ladino, although the new variety is more susceptible to sclerotinia fungus, which is favored by wet weather. However, close grazing at the beginning of the cool season tends to reduce the amount of the disease. Salina is productive on poorly drained areas and will produce even more feed on well drained soils.

Needed Research—Expansion and acceleration is recommended for nearly all the current projects in this field including basic work on the life histories, physiology, and ecology of range plants; on preventing the spread of undesirable plant species; on establishing and maintaining desirable range plants in the grassland cover; on alternative practices for improving range quality; on the evaluation of range plants as animal forage; and on the role of insects in pollinating range plants.
Modoc County ranchers attending a field day near Likely look over a fertilizer trial on seeded wheat grasses. The fertilized plot yielded 10 times the check plot.

On a rugged brushfield in San Diego County, an area previously swept by wildfire, U.C. researchers test a new heavy-duty drill used to seed and fertilize range grasses. Early establishment of ground cover after fire is often necessary to prevent soil erosion.
A stovepipe nursery at Davis used to compare drought tolerance and rooting habits of range grasses is examined by an agronomist and a range management student.

Old man gopher squints at the world from an experimental trap used in U.C. rodent control studies in San Mateo County and other areas.

Meteorological devices record conditions inside this experimental plastic-covered range shelter developed at the U.C. Hopland Field Station by agricultural engineers and specialists in range management and animal husbandry.
INCREASING MEAT AND WOOL PRODUCTION
requires more
FORAGE • PASTURE • DRY LOT FEEDING

WILDLAND RANGES CONTRIBUTE VITAL FORAGE TO THE LIVESTOCK ECONOMY

CALIFORNIA BEEF, LAMB, AND SHEEP PRODUCTION
(Thousand pounds per year — live weight)

CALIFORNIA WOOL PRODUCTION
Thousand pounds per year

Sources: U.S.D.A.
A Better Break for Brushlands

More than 20 million acres of California wildlands are covered with brush. These areas, mostly of very low current productivity, present a direct challenge to the researcher and to the land manager. Many of these brush areas are suitable for conversion to grass. Others are potential sites for timber planting. Still others can be improved for wildlife and water yield. And even on those areas where brush is the only practical cover, there are opportunities for reducing erosion and fire hazards.

Brushland investigations are complicated by the large number of brush species, many of them little-known in botanical studies, and by the wide variety of soil and climatic conditions under which they grow. Before wise treatment can be prescribed for much of the California brushland area, research is needed to develop more information on the botanic characteristics of various species, on their plant-soil-water relations, and on the economic background of brush conversions.

UNIVERSITY RESEARCH projects in a number of areas have direct application in the field of brushland management:

1) Basic studies of soil characteristics including wildland soil analysis, suitability of dominant range soils for grazing, soil and forest-site quality investigations, and relations between soil fertility and brush seedling establishment.

2) Studies of basic ecology and physiology including the botanical characteristics of range plants, natural and artificial regeneration of forest and range plants, and game browse establishment.

3) Studies of treatment and management of brush including control with herbicides, brush removal on game ranges, improvement of range lands by management practices, utilization of browse species, and watershed management factors influencing disposition of precipitation and yield of water.

4) Studies on the economics of brushland improvement.

Progress made in one aspect of brushland study is illustrated by the following report:

The conversion of properly selected brushy range to grassland through controlled burning offers enormous potential for increasing livestock forage, according to researchers at the U. C. Hopland Field Station. On one test area at Hopland, forage increased by five times the first season after treatment, and by 12 times the second season. A well-planned and carefully conducted burn followed by appropriate management measures will result in good vegetation removal as well as in good conditions for forage growth. The best burns at Hopland resulted when brush was crushed in place with a bulldozer about six months before burning, and trees were killed chemically not less than a year before the burn. This treatment assured a large amount of dry vegetation that burned easily and rapidly. Researchers emphasize the importance of examining the soil conditions, the most appropriate methods of conversion (either by bulldozing, chemical treatment, or controlled use of fire—or a combination of these), and the ways to establish range grasses, before proceeding in shrubland conversion. The possibility of certain shrub species resprouting should also be analyzed before land treatment is begun. Efficient seeding and proper use of livestock are the final essential steps in good rangeland conversion leading to a plentiful forage yield.

Needed Research—Expansion of current studies is recommended, with priority to basic investigations of major brush types on various soils: development of criteria for classifying brushland on the basis of suitability for conversion to more productive types such as forage or timber; and study of the physiology of brush species, particularly as it is related to control by fire, chemicals, or cover manipulation.
MAKING BRUSHLANDS MORE PRODUCTIVE

BRUSH... the dominant cover on over 20 million acres

CONVERSION to what? how?

- Clearing
- Seeding
- Careful grazing
- Protection

GRASS

- Clearing
- Animal control
- Tree planting and seeding
- Protection

LUMBER

- Manipulation
- Protection

For soil stabilization, improved water yield, and reduced fire hazard

BRUSH
Barren strips in this manzanita brushfield near Mt. Shasta (above) are mute evidence of a forest replanting project of the 1930's that has largely ended in failure—because of a lack of information on competition for moisture, seedling physiology, soil fertility, damage by jackrabbits, and other controlling influences. Natural regeneration (right), as illustrated by a 15-year-old pine seedling overtopping whiteleaf manzanita, can be encouraged in some areas by management practices guided by adequate research data.

A pot test set up at the University's Gill Tract in Albany measures brush seedling response to various levels of soil fertility.
EVOLUTION OF A WATERSHED ... is illustrated by an experimental project at the U.C. Hopland Field Station, Mendocino County. An aerial view (upper left) shows a small valley choked with brush and scrub oak before conversion treatments are begun. Another aerial view (upper right) shows the same watershed after it has been cleared of trees and brush, control-burned, and seeded to forage grasses. At a field day demonstration in the same area (next page, upper), smoke bombs are used to show visiting ranchers the techniques used in controlled burning. And during a winter period of heavy rainfall (next page, lower), runoff at the gauging station below the watershed is clear, showing that negligible erosion is resulting from the change in plant cover.
San Diego County ranchers attend an on-the-spot discussion of brush control during a range, watershed, and livestock tour conducted by U.C. range specialists and local farm advisors.

Mendocino County ranchers and timbermen gather near Ft. Bragg to learn about latest research in forest soils during one of the University's regular forest management schools conducted by U.C. foresters and Extension specialists.
CALIFORNIA WILDLANDS ARE . . .

. . . big (65 million acres)
. . . the source of valuable resources
. . . threatened with serious problems by increasing population pressures.

WILDLAND RESEARCH . . .

. . . provides the knowledge and new techniques needed to solve wildland problems
. . . can pay for itself many times over through increased wildland productivity
. . . should be sharply expanded if we are to realize the economic and social values potentially available on two-thirds of our land resource.

THE UNIVERSITY AND ITS WILDLAND RESEARCH CENTER . . .

. . . have active research programs conducted by competent scientists in all the fields basic to wildland research
. . . provide a broad foundation for increased wildland research to meet the challenges of the future.