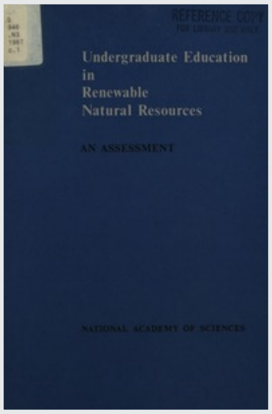

Undergraduate Education in Renewable Natural Resources: An Assessment

DETAILS

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Undergraduate Education in Renewable Natural Resources

AN ASSESSMENT

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Commission on Education in Agriculture
and Natural Resources
Agricultural Board
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Preface

Having been concerned about undergraduate education in renewable natural resources for some time, the Commission on Education in Agriculture and Natural Resources formed the Panel on Natural Resource Science late in 1965.

The Commission asked the Panel to submit a report containing recommendations for improving undergraduate education of scientists, managers, and other persons professionally engaged in developing, managing, and protecting the renewable natural resources of the United States.

After making an extensive study of existing and proposed courses and curricula, reports, articles, recommendations by professional societies, and standards of employing agencies, the Panel submitted the report published here.

The Commission endorses the report and commends it to the attention of all persons interested in education in the area with which it is concerned. Institutions are encouraged to begin planning programs that will implement the recommendations, even though immediate implementation of certain features may not be feasible. Firms and agencies that employ natural resources personnel are encouraged to consult with colleges and universities, professional societies, and other interested groups concerning academic standards for employment.

The Commission on Education in Agriculture and Natural Resources was established in 1961 by the Agricultural Board and functions within the Division of Biology and Agriculture of the National Research Council. Its major purposes are to review trends in undergraduate teaching in agriculture and natural resources; to stimulate discussion, re-evaluation, and improvement of courses and curricula; and to make recommendations for the future development of academic programs.

The Commission and the Panel express their appreciation to the many persons who offered comments on preliminary drafts of this report.

R. E. Larson, Chairman
Commission on Education in Agriculture
and Natural Resources

Contents

Definition and Scope

The term "renewable natural resources" may be defined as those parts of man's environment that are useful to him and that, though used, have the potential of being maintained or improved in quantity or quality or both. This concept encompasses resources associated with conventional agriculture (e.g., cultivated land, crops, and domestic livestock); all other flora and fauna; soil; forests, range land, and wild land; air; and water in any form and wherever it is found (e.g., in lakes, rivers, and estuaries).

Traditionally the terms "renewable natural resources" and "agriculture" have divided what is, in fact, a continuum. Although the distinction is artificial, it is expedient, for purposes of this report, to give attention primarily to renewable natural resources.

Similarly, the problem of distinguishing renewable from non-renewable natural resources can be minimized pragmatically if one accepts the fact that here, too, we deal with a continuum.

Undergraduate curricula in renewable natural resources, as treated in this report, include forestry, fisheries and wildlife biology and management, range management, watershed management, soil and water conservation, parks management, and outdoor recreation.

Other curricular areas will undoubtedly emerge as additional experience is gained in fitting various disciplines into the broadening field of natural resource science and management.

The renewable natural resource scientist of the future will, in most instances, be a specialist in a discipline such as pathology, ecology, genetics, sociology, or statistics. His research efforts may tend to focus on a single resource, such as timber or wildlife, or to range more or less widely over several resources. (Even though he may concentrate on a single resource, a scientist will probably be concerned with an entire habitat or environment.) As a student he may or may not have been enrolled in renewable natural resources programs *per se*; in any event, his professional efforts will be enhanced if he understands the interdisciplinary relations that are characteristic of the renewable natural resources field.

The resource *manager*, on the other hand, should, under most circumstances, have completed an undergraduate curriculum specifically designed to prepare him for his work.

Although they are somewhat outside the central theme of this report, certain matters related to undergraduate curricula for resource scientists and managers of the future should be mentioned.

- For professional reasons some students enrolled in other curricula—for example, students in meteorology, civil engineering, bioengineering, and journalism—need an appreciation of the problems and opportunities involved in developing, managing, protecting, and using renewable natural resources.
- Students in general should have a sharper awareness of the role of renewable natural resources in their lives and of how they as individuals and members of society can influence the use of these resources.
- Technician training in renewable natural resources, normally accomplished in 1- or 2-year post-high school programs, is becoming increasingly important and thus merits critical study by educators and employers.
- Because the desired level of formal and informal education continues to rise, advanced study will be an obvious necessity for the scientist and will be most helpful to the manager. Thus graduate study and continuing education deserve attention.

Changes Bearing on Education in Renewable Natural Resources

Recent and imminent changes related to renewable natural resources signal a need to re-examine undergraduate education. Some of these changes are noted below.

Increasing emphasis is being placed on aspects of the environment that are related to health, recreation, and aesthetics and on ways in which the quality of the environment is affected by scientific and technological developments in industry and agriculture.

Graduates in this field are increasingly involved in planning and decision-making. These are responsibilities for which many are inadequately prepared.

Patterns of land and water use are changing at an accelerated pace. This acceleration is especially critical in rural-urban fringe areas, where population pressures and economic growth have often frustrated attempts to manage land and water resources.

In certain areas, adjustment in land use should be accelerated to offset decline in economic activity, or to assist communities in developing land and water resources, or to accomplish both purposes.

Some farmers, ranchers, and other property owners are beginning to consider fish, wildlife, and campsites as primary "crops." They need encouragement and assistance.

We need to prevent further misuse of unoccupied and undeveloped lands. Some of these lands should remain as they are. We should have trained personnel to identify them and arrange for preserving them.

Some of the land that has been retired may be returned to agricultural production, because U.S. agricultural surpluses are declining and world food requirements are increasing. Such a reversal in land use would not lessen the need for trained personnel to survey our land resources in search of those that have unfulfilled scenic or recreational possibilities.

Increasingly we have the power to reshape the landscape to suit almost any need or whim. But how can we be assured that this power will be exercised in ways that are consistent with efforts to make our environment efficient, safe, and pleasant? Economic, political, or sociological considerations often override sound principles of "best use" or "resource capability."

Persons who are aware of the ecological consequences of man-made change are urgently needed. They must be adequately prepared and should participate in planning resource use. As participants they would have an opportunity to discern long-term ecological dangers in actions having short-term goals. They could explain those dangers and propose desirable alternatives.

The concept of "multiple use" of forest, range, and other lands, and of watersheds and water courses, is being endorsed and adopted at an increasing rate. For example, forest lands once devoted almost exclusively to producing commercial timber can now be used for additional purposes such as game production, recreation, watershed protection, and water yield. Although timber production may be retained as a primary objective, an area can still provide corollary values.

The demand for outdoor recreation is increasing. Increased recreational use of land and water has intensified our problems in erosion control, land protection, water quality, and so on.

The national beautification effort provides new opportunities for resource professionals. Formally sponsored efforts at the national level and at state and community levels have made protection and enhancement of natural beauty a widely accepted goal in the United States. The White House Conference on Natural Beauty, held in May 1965, stimulated interest in beautification of urban areas, highways, and the countryside. Today many of our states have beautification programs.

Pressure of use makes it desirable to protect and manage many scenic, fragile, and aesthetic resources. Support for protecting endangered species of flora and fauna is increasing.

Because of the close association between natural beauty and natural resources, emphasis on beauty has opened new opportunities for resource professionals. Detailed knowledge of the relations between soils, plants, animals, and water must undergird our cultural and aesthetic sensibility if our beautification goals are to be achieved. The beauty and bounty of the countryside usually go hand in hand.

Sociological and economic aspects of renewable natural resources are coming to be recognized. These aspects of renewable natural resources need additional study. Efforts are being made to assess public preferences for outdoor recreation and to evaluate the aesthetic values of natural features.

Current Curricular Problems

A number of colleges are correcting deficiencies in their natural resources curricula, and more employers are assuming responsibility for skill training. Nevertheless, undergraduate curricula in the area considered here need strengthening. Most have one or more of the following deficiencies:

1. Excessive emphasis on narrow vocational training.

After they graduate, students in renewable natural resources will be obliged to face problems having complex biological, sociological, and economic attributes and to apply the methodologies of diverse substantive fields. They will have to synthesize information from many areas of knowledge, apply the information to solving problems, and adapt to change.

An understanding of the biotic, physical, and human environment is essential to successful performance of these duties. Obtaining such an understanding through broad, liberal education is clearly more desirable than obtaining it as a remedial measure at the graduate level.

Professional baccalaureate programs in renewable natural resource fields will be needed in the future. They should emphasize the natural and social sciences, mathematics, humanities, and communications. A substantial part of the responsibility for "how-to" training should be shifted to subsequent employers.

There is, above all, a need to develop in the undergraduate a sense of responsibility for the sum total of renewable natural resources, not just for isolated segments.

Admittedly there are too few employment opportunities at the baccalaureate level for the graduate who is broadly trained, partly because of narrow job specifications and partly because of strict accreditation practices.

2. Barriers that make it necessary to offer specialized courses in professional areas.

Such barriers often exist between university departments and colleges. The result is seen, for example, when one encounters courses in <u>forest</u> economics and <u>forest</u> pathology in forestry schools and departments. Such courses are probably more useful when properly taught in departments of economics and plant pathology.

3. Too much emphasis on practices, too little on principles.

This tendency is aggravated by a similar imbalance in textbooks, although, in general, instructional materials are adequate in quantity and quality.

4. Insufficient progress in revising academic programs to reflect newly emerging areas for professional employment.

5. Excessive proliferation of curricula and courses.

Recommended Program

An undergraduate program for future managers and scientists in the field of renewable natural resources is offered here as a model. (See Table 1.) In preparing it, the Panel looked perhaps two decades ahead, recognizing that employment needs will change, new areas of specialization will develop, and some current specialties will decline in importance.

A student in the recommended program would take (a) courses in the basic core curriculum, (b) courses in one of four areas of emphasis, (c) professional courses, and (d) electives. If possible, he should take core, area, and professional courses in the order named. This is especially desirable in view of the increasing importance of community and junior colleges. Most of these colleges should be prepared to offer courses in the basic core curriculum that would be well suited to a student planning continued study in natural resource science and management, but few are likely to offer area and professional courses adequate for such a student.

Outlines of suggested courses are given in Appendix A (page 19). This is done to clarify course content, which is often inaccurately described by titles. (As explained later, the term "course" is used in this report with the understanding that the subject matter included in a course may be covered in less than 1 semester.)

TABLE 1 Recommended Undergraduate Program for Managers and Scientists in Renewable Natural Resources

Component	Number of Courses	Semester Credits in Each Course (Average)	Total Semester Credits
Basic core	23	3-1/2	81
Areas of emphasis	4-5	3	12-15[a]
Professional courses	7	3	21
Electives	5-6	3	15-18[a]

[a]Total of 30 hours in areas of emphasis and electives.

BASIC CORE CURRICULUM

If they are to be liberally educated citizens, future scientists and managers in renewable natural resources need a fairly extensive core curriculum, whether they subsequently specialize in forestry, range management, soil and water conservation, outdoor recreation, or some other area. The basic core recommended by the Panel is given in Table 2.

The need for the courses under the headings "Biological Sciences," "Physical Sciences and Mathematics," and "Integrating Courses" will be obvious to most. The need for those under "Social Sciences and Humanities" may not be so clear. These courses are included because a student in the field of renewable

TABLE 2 Recommended Basic Core

Areas of Study	Number of Courses
Biological Sciences	
Fundamentals of biology	2
Ecology	1
Physical Sciences and Mathematics	
Mathematics, probability, and statistics	3
General chemistry	2
Physics	1
Meteorology and climatology	1
Geology	1
Soils	1
Social Sciences and Humanities	
Principles of economics	1
Resource economics	1
Political science	1
Sociology	1
Philosophy or logic	1
Literature	1
Communications	2
Integrating Courses	
Man and his environment	1
Integrated resource analysis and planning	2

natural resources urgently needs education that will prepare him for dealing effectively not only with traditional rural situations but also with a variety of urban situations. For example, he must be prepared to work with government agencies at all levels, civic organizations, and pressure groups. Such work requires thorough, practical awareness of the social sciences and humanities; more specifically, it requires knowledge of pertinent legal, institutional, economic, historical, and cultural factors that affect decision-making.

All students should be required to obtain at least one summer of on-the-job training in their chosen fields of specialization in order to develop specific skills. Appropriate experience can be gained in college-operated summer camp programs or with organizations engaged in the kind of work in which trainees wish to develop skills. The latter type of experience has the advantage of establishing early employer - employee contacts.

The Panel's views on certain components of the basic core are given in the following paragraphs.

Fundamentals of Biology

All students in renewable natural resource science should have a 1-year (2-semester) sequence in biology. It should be interdisciplinary within the biological sciences and should emphasize basic principles.

Ecology

All students in this field must have a good understanding of basic ecological principles; environmental interrelations; competition and other factors limiting the kinds, numbers, and distribution of plants and animals; population dynamics; structure and organization of communities; and effects of organisms on the environment.

Though the instructor may be a specialist by training, he should have a multidisciplinary philosophy.

Mathematics, Probability, and Statistics

At least nine semester credits and at least one course in calculus are recommended for this area. Study beyond this minimum, particularly in calculus, is highly desirable.

Knowledge of basic statistical concepts, frequency distributions, and sampling design and variation is needed to solve many problems encountered in natural resource science.

The student should be made aware of the usefulness of the computer, but not necessarily in a separate "computer course." The subject may be introduced more effectively in the courses in mathematics, probability, and statistics.

General Chemistry

Two courses, carrying three to five credits each, are recommended. Students with outstanding records in high school chemistry could omit the first course.

Study of organic compounds should be introduced early in freshman chemistry (first course), and should make up a large part of the second course.

Resource Economics

Resource development and use have economic and social aspects that are as important as the technical aspects. This course should include field assignments in which students are required to solve problems and prepare written reports.

Political Science

Political considerations have a bearing on most resource-development and resource-use programs. As competition for natural resources becomes keener, a knowledge of political science (government) will become increasingly valuable to resource managers and scientists.

The course should center on U.S. government and should relate the functioning of government agencies (local, state, and national) to resource-management problems. Term papers or case studies on governmental aspects of resource management could well be made a requirement.

Sociology

Most programs for conserving, developing, or using natural resources are influenced by sociological factors. Especially useful to resource professionals is an understanding of the institutional arrangements that permeate our society. Study of these arrangements should include study of power structures, pressure groups, and governmental jurisdictions.

Philosophy or Logic

The resource professional's involvement with ethical, economic, and political considerations brings him into situations where he must reason out the long-range effects that man's activities have on his natural environment. Philosophy or logic will help prepare him for these situations.

Literature

A knowledge of literature is an essential ingredient of the broad education that a resource scientist or manager must have in order to be fully effective in his profession. The course should seek to engender an appreciation of literature and to make of reading a form of cultural and educational enrichment that will continue beyond formal education.

Communications

Ability to communicate effectively, both orally and in writing, is necessary to success in resource management. Without it, the manager is unable to gain the cooperation that is necessary to carry out his program.

Skill in communications is also essential to success as a resource scientist, for the scientist must be able to present his findings clearly and forcefully.

The outline in Appendix A (page 19) stresses training in expression, not grammar. Instruction in grammar is considered to be the responsibility of primary and secondary schools.

Man and His Environment

This is an elementary, integrating course dealing with the man-resource relation as seen in culture and technology. It reveals the scope of natural resource problems and explains how different disciplines contribute to solving those problems. It would be useful to all undergraduates.

Integrated Resource Analysis and Planning

This 2-semester integrating seminar should be required of all seniors in natural resource science. Participants are exposed to ecosystem problems of increasing complexity.

AREAS OF EMPHASIS

Beyond the basic core, students would take courses in one of several areas of emphasis, four of which are identified here.

The plant science area would direct a student toward professional specialization in such fields as forestry and range management; the animal science area, toward fisheries, wildlife, and the like; the social science area, toward outdoor recreation, resource planning and economics, and similar fields; and the soil and water science area, toward such career fields as soil conservation and hydrology.

Flexibility would be assured by the core curriculum itself, with the result, for example, that students who had placed emphasis on plant science during their undergraduate years might be suitably employed in some phase of wildlife management or soils work after a moderate amount of additional training.

Obviously these suggestions do not include all fields of employment or all areas of specialization. It is very likely that new needs and opportunities will emerge, and educational institutions must remain alert to this likelihood. For example, atmospheric science may become an area of undergraduate emphasis within renewable natural resources in the near future.

Suggested courses for each of the four areas of emphasis are listed in Table 3.

PROFESSIONAL COURSES

Seven courses, totaling approximately 21 semester credits, are recommended in addition to the basic core curriculum and the area courses. They should suffice for professional specialization at the undergraduate level.

TABLE 3 Recommended Courses in Four Areas of Emphasis

Areas of Emphasis and Recommended Courses	Number of Courses
Plant Science Area	
Genetics	1
Plant physiology	1
Entomology	1
Plant pathology	1
Plant classification	1
Animal Science Area	
Genetics	1
Animal physiology	1
Vertebrate zoology	1
Invertebrate zoology, including microbiology and entomology	1
Animal diseases and parasites	1
Soil and Water Science Area[a]	
Geomorphology	1
Hydrology	1
Sedimentation and water pollution	1
Soil morphology (classification and interpretation)	1
Social Science Area	
Economics[b]	1
Resource economics[b]	1
Public administration	1
Social structures and interaction	1
Resource policy and administration	1

[a]Several other courses, including physical chemistry and soil and water conservation, are highly recommended. Their desirability depends on students' objectives.

[b]In addition to the courses included in the basic core.

Specific professional courses are not recommended for each field, primarily because of differences in course arrangements (at different institutions) and in students' objectives. But, just as an illustration, the following courses would be sufficient for an undergraduate specializing in forestry: wood structures and properties, silvics, silviculture, mensuration, forest management, principles of wildlife management, and principles of range management.

Certain of the area courses might be considered professional specialization in some institutions. In forestry, for example, some or all of the courses in the plant science area could be so considered. Also, for many fields, the core courses in integrated resource analysis and planning, resource economics, and ecology could be considered professional.

ELECTIVES

At least five elective courses, totaling approximately 15 credits, should be made available so students may explore areas of special interest, prepare for a special field (such as foreign employment), or prepare for graduate study (e.g., additional science courses or a foreign language).

Some electives may be used to diversify the curriculum; for example, a student in the animal science area might choose courses in the plant science area.

Flexibility in the Curriculum

A major issue in higher education is the extent to which curricula should be prescribed. The amount of information to which students must be exposed if they are to acquire both professional competence and a general education is so great that educators often feel obliged to establish rigid curricula.

A 5-year baccalaureate or first-professional program has been suggested as a means of ensuring flexibility while providing for adequate training. However, the Panel does not recommend such a program. It would delay a student's entry into employment without assurance of a higher beginning salary to compensate for the delay. And if a student is to remain in school for a fifth year, his opportunity for financial support during that year would be greater if he moved to graduate student status.

The 4-year curriculum recommended in the previous section provides flexibility. The breadth of the student's basic preparation makes it possible for him to transfer (on the campus or to another campus) with negligible loss of credits. Specialization too early would only limit such flexibility. Other suggestions for increasing flexibility follow.

- The suggested courses need not be in full semester or quarter packages. Course titles may not coincide with present administrative units. The critical aim is to cover, in some effective way, the subject matter detailed in Appendix A (page 19). If imaginative experimentation with course arrangements leads to removal of obsolete and insignificant material, so much the better.

For example, consideration might be given to developing one or two courses that incorporate all the recommended basic-core material in resource economics, political science, and sociology. Similar combinations or reorganizations of area emphasis and professional courses could be undertaken.

- "How-to" training should be shifted to employers as much as possible. Fortunately, some employers are already assuming this responsibility. Further progress can be made as more technicians are trained in post-high school, subbaccalaureate programs; with these technicians on the job, scientists and managers will be relieved of a great deal of responsibility for performing tasks at the technician level.
- Finally, one must be aware of the contributions that high schools can make in preparing students for the baccalaureate program, and of the free time that high school training would make available in the college years. At present, some entering students have had a course in calculus; in the future, students with this preparation will surely enter in greater numbers. Similar possibilities exist in chemistry, physics, and biology.

Concluding Statements

Recommendations in this report are directed to college and university faculty members, administrators, curriculum committees, student advisors, and others concerned with undergraduate education.

The recommended curriculum is not to be used as a basis for standardization or accreditation, but should be used as a guide in the light of circumstances existing on each campus. It is very important, however, that the subject matter of the basic core be somehow included in the student's undergraduate experience; that, so far as possible, the student take core, area, and professional courses in the order named; and that the courses themselves be of the level and quality indicated by the suggested prerequisites.

Course outlines in Appendix A (page 19) are not intended to standardize course content. On the contrary, innovation is encouraged. The outlines are intended only to clarify what is meant by a given course title, and to indicate subject areas that are considered important.

In establishing curricula, colleges and universities should be aware of criteria and eligibility requirements used by employers, and employers should consult with educators as they establish academic requirements for employment.

APPENDIXES

Course Outlines

The following outlines can serve as a basis for preparing detailed course descriptions. Prerequisites are indicated in certain instances, but are generally held to a minimum, the chief purpose being to give a better characterization of the courses and to suggest the desired level of rigor and sophistication.

BASIC CORE

Fundamentals of Biology (two courses)*

1. The nature of science; chemical and physical properties of life; the cell as the basic unit of life; cellular and tissue organization; physiology; regulation and coordination; behavior; growth and development.
2. Reproduction; heredity; evolution; taxonomy; survey of plant and animal kingdoms.

*Adapted from an outline prepared by a committee selected in 1965 by the Commission on Education in Agriculture and Natural Resources and the Commission on Undergraduate Education in the Biological Sciences to recommend instruction desirable for undergraduates majoring in natural resources. Copies of the committee's outline may be obtained from the Commission on Education in Agriculture and Natural Resources, National Research Council, 2101 Constitution Avenue, Washington, D.C. 20418.

Ecology*

1. Ecosystem concepts and operation: definition, interdisciplinary nature, kinds, boundaries; controlling factors; dependent factors.
2. Ecosystem change.
3. Responses of organisms to environment: microclimate, organism climate, local climate, macroclimate; environmental factors.
4. Classification and description: community classification; habitat; ecosystems.
5. Man in the ecosystem.

Prerequisites: Fundamentals of biology; general chemistry.

Mathematics, Probability, and Statistics†

Outlines of representative courses follow.

Elementary Functions and Coordinate Geometry (Mathematics 0). A study of elementary functions, their graphs and applications, including polynomials, rational and algebraic functions, exponential, logarithmic, and trigonometric functions; an introduction to three-dimensional analytic geometry.

Prerequisite: Three years of secondary school mathematics. May be completed in advanced high school work.

Introductory Calculus (Mathematics 1). Differential and integral calculus of the elementary functions with associated analytic geometry.

Prerequisite: Mathematics 0.

Mathematical Analysis (Mathematics 2). Techniques of one-variable calculus, limits, series, multivariable calculus, differential equations.

Prerequisite: Mathematics 1.

Probability (Mathematics 2P). An introduction to probability and statistical inference making use of the calculus developed in Mathematics 1.

Prerequisite: Mathematics 1.

*See footnote on page 19.

†Outlines taken from A General Curriculum in Mathematics for Colleges (1965), a report to the Mathematical Association of America by the Committee on the Undergraduate Program in Mathematics (CUPM). Copies of the report may be obtained from CUPM, P.O. Box 1024, Berkeley, California 94701.

General Chemistry (two courses)

1. Principles of chemistry; properties of metallic and nonmetallic elements; qualitative analysis.
2. Fundamental principles of organic chemistry.

Physics

Basic principles and their relation to other physical sciences; standard topics in traditional physics, including motion, dynamics, conservation laws, kinetic theory, gravitational and electromagnetic forces and fields, and wave motion and light; relativity; introduction to atomic physics, structure of matter, and nuclear physics; laboratory.

Prerequisite: Mathematics 0.

Meteorology and Climatology*

Climate-forming processes and how the atmosphere functions; climate as an ecological factor; the biota-climate relation; microclimate and macroclimate; applied climatology and forecast interpretation; data handling.

Geology

Structure of the earth; origin of minerals, rocks, and soil; genesis of the landscape; geologic eras; water resources.

Soils

Introduction to soil science; nature and properties of soils; principles of identification and classification of soil units; basis for soils interpretation; parent material; morphology; soil physics; clay minerals; soil chemistry; soil water; microbiology; organic matter and nitrogen; fertility.

Prerequisites: General chemistry; geology.

*A detailed outline is available from the Commission on Education in Agriculture and Natural Resources.

Principles of Economics

Fundamental economic concepts; supply - demand relations; production; pricing; allocation of resources; labor and capital in the economic processes.

Resource Economics

Theories of land use; relation of systems of land classification to physical factors; land capability as a measure of suitability for various agricultural and nonagricultural uses; patterns of change in land use; the effect of institutional arrangements on land management; land and water policy formation; tangible and intangible values.

Prerequisite: Principles of economics.

Political Science

Political process; public policy formation; influence of organized groups (pressure groups); elements of government administration; government agencies concerned with resource management.

Sociology

Principles and basic concepts of sociology; groups and cultures; classes and castes; communities; collective behavior.

Philosophy or Logic

Philosophy: Introduction to philosophical ideas and problems; study of the writings of several major philosophers.

Logic: Principles and techniques of traditional and symbolic logic.

Literature

Forms of literature; masterworks of Western literature; works of a small number of selected modern writers.

Communications (two courses)

1. Fundamentals of English composition; writing technical and popular papers, to be corrected or rewritten after criticism by the instructor; oral reporting on a variety of assigned subjects, with evaluation and criticism by the instructor and members of the class.

2. Training in effective expression; training in interpretation of literature studied and in accurate reporting on situations observed and experiments conducted; practical use of graphic materials.

Man and His Environment

Qualitative aspects of natural resource science; quantitative resource situations; demographic trends; consequences of man's manipulation of the environment; the conservation movement and selected conservation "issues."

Integrated Resource Analysis and Planning (two courses)

1. Forces and disciplines (biological, physical, sociological, political, economic, and legal) affecting ecosystems; introduction to methods of analyzing systems; use of computers, teams of specialists, and simulation models in problem-solving; philosophical and ecological background; organization theory; information theory; cybernetics; ecosystem structure; evolution of ecosystems; ecosystem management.

2. Case studies in which seminar participants analyze specific natural resource ecosystems, work on problems of quantification, and attempt to merge various forces and disciplines into a management plan.

PLANT SCIENCE AREA OF EMPHASIS

Genetics*

Mendelism; chromosomes; the gene; life cycles and modes of reproduction; mutation; population genetics.

Prerequisite: Fundamentals of biology.

*A detailed outline is available from the Commission on Education in Agriculture and Natural Resources.

Plant Physiology

Photosynthesis; absorption of nutrients; mineral nutrition; respiration; translocation; carbohydrates; nitrogen relations in plants; lipids; plant products; interlocking metabolic pathways; growth and development; physiology of reproduction; differentiation; physiology and environment.

Prerequisites: Fundamentals of biology; general chemistry.

Entomology

Structure, biology, and classification of insects; introduction to the study of insects as a major segment of the biological community; laboratory.

Prerequisite: Fundamentals of biology.

Plant Pathology

Nature, cause, and control of diseases in plants; laboratory.

Prerequisite: Fundamentals of biology.

Plant Classification

Taxonomy of vascular plants; survey of major groups of seed plants and ferns; methods of identification; laboratory.

Prerequisite: Fundamentals of biology.

ANIMAL SCIENCE AREA OF EMPHASIS

Genetics

Mendelism; chromosomes; the gene; life cycles and modes of reproduction; mutation; population genetics.

Prerequisite: Fundamentals of biology. (Course in statistics desirable.)

Animal Physiology

Physiological functions in various phyla, with emphasis on vertebrates and with interpretation based primarily on morphology,

ecology, and evolution; blood; circulation; digestion; respiration; metabolism; excretion; endocrinology; physiology of reproduction.
Prerequisites: Fundamentals of biology; general chemistry.

Vertebrate Zoology

Classification, phylogeny, morphology, biology, ecology, and natural history of vertebrates, with emphasis on wild species; impacts of water developments and other alterations of the environment on fish and wildlife populations.
Prerequisite: Fundamentals of biology. (Course in plant classification desirable.)

Invertebrate Zoology

Classification, phylogeny, morphology, and natural history of invertebrates; study of insects, nematodes, and microorganisms important in food chains and degradation of waste products.
Prerequisite: Fundamentals of biology.

Animal Diseases and Parasites

Nature, cause, and control of diseases in wild animals; parasites of wild animals; diseases and parasites as limiting factors in fish and wildlife populations and in relation to food supply and other environmental factors; wild animals as reservoirs and vectors of diseases and parasites affecting man.
Prerequisite: Fundamentals of biology. (Invertebrate zoology desirable.)

SOIL AND WATER SCIENCE AREA OF EMPHASIS

Geomorphology

Description and interpretation of land forms as they relate to structure, process, and stage.
Prerequisite: Geology.

Hydrology

Hydrometeorology; evapotranspiration and vegetative influences; groundwater; surface runoff; floods; unit hydrograph procedures.
Prerequisites: Physics; introductory calculus.

Sedimentation and Water Pollution

Water quality; source and effects of water contaminants and their fate in the environment; assimilation of wastes in water; biological parameters of water quality and their measurement.
Prerequisite: General chemistry.

Soil Morphology (Classification and Interpretation)

Principles of identification and classification of geographic units of soil; interpretation of such units for applied objectives; field practice in characterizing, mapping, and interpreting for planning purposes.
Prerequisites: Geology; soils.

SOCIAL SCIENCE AREA OF EMPHASIS

Economics

Nature of the American economy; capitalistic production; money and its use; economic instability; markets; value and price; functional distribution of income.
Prerequisite: Principles of economics.

Resource Economics

Production economics; theory of the firm; resource allocation; input analysis; welfare conditions; institutional arrangements; regional and national growth.
Prerequisite: Resource economics (core).

Public Administration

Legal and institutional setting of the administrative system; dynamics of organization and processes of public management; problems and techniques of administration illustrated by case materials and field investigation.

Social Structures and Interaction

Study of the structure of modern urban-industrial society, with emphasis on large, complex organizations and their influence on individual and group relations; agency - community relations; supervisor - worker relations; developing effective interpersonal relations.

Resource Policy and Administration

Processes of resource policy formulation and modification; review of major public resource policies; principles of resource administration; case studies in administrative behavior.
Prerequisite: Public administration.

APPENDIX B

Panel on Natural Resource Science

LLOYD E. PARTAIN (Chairman), Assistant to the Administrator on Recreation, Soil Conservation Service, U.S. Department of Agriculture, Washington, D.C.
A. W. BOLLE, Dean, School of Forestry, The University of Montana, Missoula, Montana
LAWRENCE S. HAMILTON, Professor of Forestry, Cornell University, Ithaca, New York

DANIEL L. LEEDY, Office of Water Resources Research, U.S. Department of the Interior, Washington, D.C.
R. M. LOVE, Chairman, Agronomy Department, University of California, Davis, California
R. J. PRESTON, Dean, School of Forestry, North Carolina State University, Raleigh, North Carolina
R. H. SHAW, Professor of Climatology, Iowa State University, Ames, Iowa

APPENDIX C

Commission on Education in Agriculture and Natural Resources

R. E. LARSON (Chairman), Dean, College of Agriculture, Pennsylvania State University, University Park, Pennsylvania
HAL B. BARKER, Dean, School of Agriculture and Forestry, Louisiana Polytechnic Institute, Ruston, Louisiana
GEORGE A. GRIES, Head, Department of Biological Sciences, University of Arizona, Tucson, Arizona
CARROLL V. HESS, Dean, College of Agriculture, Kansas State University, Manhattan, Kansas
A. R. HILST, Professor, Department of Agronomy, Purdue University, Lafayette, Indiana
ROY M. KOTTMAN, Dean, College of Agriculture and Home Economics, The Ohio State University; Director, Ohio Agricultural Research and Development Center; and Director, Ohio Cooperative Extension Service, Columbus, Ohio
DARRELL S. METCALFE, Director of Resident Instruction, College of Agriculture, University of Arizona, Tucson, Arizona
LLOYD E. PARTAIN, Assistant to the Administrator on Recreation, Soil Conservation Service, U.S. Department of Agriculture, Washington, D.C.
RICHARD H. WELLMAN, Vice President and General Manager, Process Chemical Division, Union Carbide Corporation, New York, New York