

Applied and Basic Research in Mediterranean-Climate Ecosystems¹

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Of all of the world's ecosystems those of mediterranean-climate regions offers the greatest management challenge. In these regions high human populations often abut natural systems which are unusually prone to fire and flood. Rational management policies are hindered by social and political constraints as well as a lack of basic ecological information. It is this latter deficiency which is addressed here.

APPLIED VERSUS BASIC ECOLOGICAL RESEARCH

At present the distinction between applied and basic ecology is rather blurred. Although this merging of approaches has accelerated in recent times it has been true that historically leaders in ecology often have been engaged in research which falls within both realms.

The Ecological Society of America has recently utilized as a working definition of applied ecology, "the study of ecological systems (organisms, populations, communities, ecosystems) influenced by human activity". Such a definition would of course encompass virtually all of ecological research since there are essentially no ecosystems on earth which have not been influenced by the activities of man. This is becoming increasingly so as the impact of man's activities are becoming more pervasive and more global as evidenced by the increase in atmospheric CO₂ concentration, the wide-scale dispersion of toxic compounds such as radioactive nuclides, DDT, and PCB's and the large regional influences of acid rain.

It has only been within the past few decades that man has become aware of the global nature of his impact. Basic ecologists traditionally have been interested in unravelling the interrelationships of organisms with their environment as they have been molded through evolutionary time. Man's activities were viewed as disruptions of these relationships which resulted in disequilibrium conditions.

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Abstract: Man's impact on ecosystems has become so pervasive that there is now little distinction between basic and applied ecological research. Still, the available research results are often inadequate to translate into management policy. The use of an international network of ecosystem study sites in which researchers and managers collaborate should hasten the development of rational programs to manage the difficult mediterranean-climate ecosystems.

A major thrust of the International Biological Program (IBP) in the United States in the late 1960's and early 1970's was the study of ecosystem function. For these studies a great effort was made to find study sites which had been impacted little by human activities. The finding that virtually all ecosystems have been influenced by man to one degree or another and that these impacts are becoming increasingly greater has been a key factor in the design of the successor to the IBP, UNESCO's Man and the Biosphere Program (MAB). The MAB program has been characterized by the collaborative efforts of basic and applied scientists. Specifically the MAB program attempts not only to determine the structure and functioning of the biosphere but the changes induced by man and in turn their effects on human populations. MAB is an international interdisciplinary effort.

There have been other factors which have led to the convergence in the realms of basic and applied scientists. One is the finding that evolutionary adjustments can occur in relatively short time spans, as evidenced by the evolution of pesticide-resistant insects (Ehrlich, et al., 1977) and heavy metal tolerant grasses on mine tailings (Bradshaw, et al., 1965). Another was the realization that certain factors which were disruptive to equilibrium conditions, such as fire, often played a large role in molding the structure and functioning of these ecosystems. Thus, factors, which in the past received little attention by basic ecologists, all of a sudden were receiving considerable attention. Also, there was the increasing awareness that catastrophes of one sort or another, other than fire, such as hurricanes, droughts, etc., played a large role in structuring ecosystems (Sprugel and Bormann, 1981) and that an equilibrium ecosystem was more of an abstraction than a reality. There was also the realization that many human disturbances were often not too different from those resulting from natural disruptions (Mooney and Godron, 1982). The differences were often more a matter of scale and intensity.

Even though I have presented a picture of a general convergence of the spheres of activity of basic and applied ecologists I would like to note also that even in earlier times the divergence was not great. This can be appreciated by the background and publications of some of the pio-

neer ecologists who worked in the Californian mediterranean vegetation.

The F.E. Clements-J.E. Weaver Nebraska School of Ecology produced a large number of first generation California ecologists most of whom were associated with range and forestry programs. H.L. Shantz was a Clements PhD and A.W. Sampson was influenced by Clements as an undergraduate at Nebraska. H.H. Biswell, A.M. Schultz, and H. Heady were all students of Weaver. The publications of these scientists often were both basic and applied. W.S. Cooper of the University of Minnesota, who was a product of the Chicago School of Ecology (H.C. Cowles), and who did the classic study of the California chaparral, directed the PhD thesis of Joseph Kittredge a Californian forester who did both basic and applied work in the chaparral. W.C. Lowdermilk, who was important in the San Dimas lysimeter design, was a student of Sampson.

Thus it can be seen that all of these ecologists, although often having positions in applied schools, received their training in basic ecological programs.

RESEARCH VERSUS MANAGEMENT OBJECTIVES

Deriving information from research results, either basic or applied, for management purposes generally offers difficulties for a number of reasons. One, the technological approaches utilized in research are often not appropriate for management. Two, the research results are generally not gathered to answer specific management problems. Three, research information on specific sites is often difficult to transfer to another site without new research.

As Johnson and Bossort (1980) recently noted managers find the research approaches of basic scientists to be "faddish, speculative, and lacking in substance; in other words not practical". Basic scientists who work at the forefront of their trade feel that applied scientists do not avail themselves of the latest approaches and concepts. Managers, as Johnson and Bossort note cannot "use methods which are new and consequently potentially controversial. This is a result of the social and political implications of their projects". Thus independent of the ecological questions involved there is a fundamental difference in the way a research investigator and a manager may approach the problem. The manager needs methods which are "tried and true" whereas the researcher is looking for new approaches.

Then there is the matter of how research programs are formulated. Most often they are not designed to answer specific management questions, but rather questions of a more general nature. For example, research on the impact of fire on nutrient flow in an ecosystem will generally not be comprehensive enough to tell how intense, how often, and when controlled burns should be utilized and further how these variables will impact

such ecosystem components as large herbivores. Closer interaction between managers and researchers is essential to insure that research leads to knowledge which can be applied directly in management.

Unfortunately, management needs often arise in response to a crisis which in turn has arisen from a research breakthrough. Management plans evolve in response to our understanding of how ecosystems operate. New knowledge may bring the question of how management is taking into account the problem which the research has just uncovered, eg., nutrient loss from ecosystems through fire. Obviously management plans cannot involve issues for which knowledge is lacking.

Even if we have a general understanding of the knowledge required to evolve comprehensive management plans it may be difficult to evolve specific management plans. Ecology is a developing discipline encompassing complex issues. The data base is slim even for the most fundamental issues. Textbooks in this area are often filled with "general principles" many of which have been derived from a few isolated studies. This is hardly the information base needed to design specific management plans. Then too, there are research areas which are just developing in ecology from which specific knowledge is needed for management. For example, as Keeley (1977), Noble and Slatyer (1977), and Zedler (1977) have shown so clearly for mediterranean-type ecosystems, knowledge of the life-history attributes of the resident species of an ecosystem is essential to predict the long term consequences of a particular fire management scheme. Yet practical knowledge of the population biology of even the commonest dominant species of an ecosystem is often lacking. The study of plant population biology is in itself a relatively new endeavor (Harper, 1977). We have very little information of how different species respond in distinctive ways to dissimilar thermal, moisture, and nutrient regimes, and yet this information is necessary to make predictions as to the outcomes of any management scheme. We do not know in detail how water and minerals move through various ecosystem types and yet again this information is vital to assessing the impact of diverse management practices.

Finally, there is the problem mentioned above of extrapolation of the results from one region to another. One need only recall the lively discussions which evolved around the proposals to convert chaparral to grassland in different regions of California. The success of programs on gentle topography were questioned for areas of high erodible steep terrain.

How can one approach these problems? For one, we can pool our efforts and concentrate our resources. We are already doing both to a certain extent.

INTERNATIONAL APPROACH TO THE STUDY OF
MEDITERRANEAN-CLIMATE ECOSYSTEMS

It would certainly appear as if we are pooling our collective effort in the study of mediterranean-climate ecosystems. For no other ecosystem type is there such a high intensity of international cooperation in both applied and basic research. Further, it appears that the level of collaboration between managers and basic research workers in mediterranean-climate regions is unusual. This symposium certainly lends support to these assertions.

Ecologists from the various mediterranean-climate regions met together for the first time in March, 1971 in Valdivia, Chile. The objective of that conference was to summarize our knowledge about the environment and biota of these regions in order to lay the foundation for a new comparative in-depth study of the structural characteristics of Californian and Chilean mediterranean-climate ecosystems (di Castri and Mooney, 1973). It had been known for a long time that mediterranean-climate regions all had ecosystems which were quite similar in appearance. Studies by individuals in the late 1960's gave substance to the concept that these areas had evolutionarily converged to these similarities (Naveh, 1967, Specht, 1969a, b, Mooney and Dunn, 1970).

Determining the degree of convergence between these regions was an important task since from it would be derived the possibility of comparative ecosystem studies. As di Castri and Mooney (1973) noted, "One of the greatest barriers to understanding most ecosystems is the lack of repeatability. Hypotheses based on detailed studies of a particular ecosystem cannot be put in a context of generality because there are no standards of comparison, that is no precisely similar ecosystems built up from different starting points in which to test the principles involved. This question has major practical implications for the management of natural resources".

The Chile-California comparison, which was part of the International Biological Program, indicated that these ecosystem types were convergent in many structural (Mooney, 1977) and functional attributes (Miller, 1981). Differences were noted between these regions however some of which had management implications (Mooney, 1977).

The second international meeting of mediterranean-climate ecologists took place at Stanford, California in 1977. This was truly an international gathering which brought together basic and applied scientists to consider the dynamics of ecosystems where fire played a major role (Mooney and Conrad, 1977). The proceedings of that meeting made it clear that in all mediterranean-climate regions fire was a major consideration in management yet the approaches that were being utilized were often quite different. For example,

at that time controlled burns were being used extensively in management in South Africa but only to a limited extent in California. The reasons for many of the differences in management policy were historical rather than because of anything fundamentally different about fire in these regions.

The complexities of managing fire-prone ecosystems were highlighted at that conference. It became clear that some of the simplistic views that were prevalent relevant to the use or exclusion of fire in management needed considerable revision as new information became available. Intercontinental comparisons greatly accelerated the rate at which we were acquiring new knowledge.

This past year there has been an intensification of efforts to compare properties of mediterranean-type ecosystems. In Greece, in August 1980, a conference focused on the, "components of productivity of mediterranean-type ecosystems". The issues discussed ranged from the basic environmental features limiting productivity in mediterranean-climate ecosystems to the effects of pollutants on productivity. The possibilities of harvesting biomass for energy, which at the same time would reduce fire hazards, were also discussed. At the Greek conference the similarities among mediterranean-climate ecosystems were reinforced further, however significant differences again became apparent such as the evidently greater importance of temperature in controlling plant distributions in the Mediterranean Basin than in other mediterranean-climate regions.

In September of 1981 at Stellenbosch, South Africa an intensive conference focused on the role of nutrients in determining the structure and function of mediterranean-climate ecosystems. As intercontinental comparisons were made at all ecosystem levels it was becoming evident that South Africa and Australia differed from their northern hemisphere counterparts in a number of fundamental ways (Cody and Mooney, 1978). It appeared that the basis for this divergence was not climate but rather soil types. The southern hemisphere mediterranean-climate ecosystems are extremely nutrient deficient, particularly in phosphorus. This leads to great differences in such ecosystem properties as the diversity of the dominants. These findings give us the basis then of assessing the importance of substrate in molding ecosystem structure and function since in a sense climate is controlled in an experimental sense.

The present conference is broad in its thematic coverage, again viewing all ecosystem levels. Further it continues the effort to forge links between scientists and managers. It does so by again calling upon the now large community of scientists and managers working in the world's mediterranean-climate ecosystems. This format has obviously been a highly successful one since there are already new international mediterranean-climate conferences in the planning stage. The

next comprehensive conference will be held in Perth, Australia in 1984. This conference will be devoted to a view of the maintenance of species and structural diversity in mediterranean-climate ecosystems and their resilience to environmental stress. International mediterranean region conferences with more limited themes will be held in Sydney, Australia in August and in Marseille in November of this year. The Sydney meeting organized by Professor R. Specht and held in conjunction with the International Botanical Congress, deals with drought tolerance mechanisms of mediterranean-climate plants. The Marseille conference, sponsored by NATO and organized by Professor P. Quezel, deals with the characterization of mediterranean-climate regions.

AN ECOSYSTEM APPROACH

These international efforts certainly represent a pooling of our collective efforts. What about the concentration of resources in the study of mediterranean-climate ecosystems? It is a truism of ecology that everything is connected to everything else. Understanding the totality of these connections is in essence the challenge of ecosystems science. Many management programs involve manipulation of a single property of an ecosystem such as numbers of game birds or large mammals, reduction of fire hazard, enhancing water yield, etc. Because of the interactions between ecosystem elements accomplishment of one particular research objective may actually have adverse effects on other ecosystem properties. For example, reduction in fire hazard by controlled burning may result in a decrease in species diversity and a loss of nutrient stores.

Thus in order to predict the consequences of any particular management program for a given area it is essential to have some understanding of how the total ecosystem operates. Unfortunately we have a limited understanding of ecosystem function in general and most certainly for any specific ecosystem. The argument can be made that such an understanding should be based, initially at least, on detailed studies of a single site. Since the biota of a region have co-evolved, and further since each habitat has to a certain extent unique environmental properties, any comprehensive understanding of ecosystem organization should come from site-specific studies. Extrapolation to comparable ecosystems, where species composition or habitat features vary to a certain extent, can then be made in a total system context--rather than in a case by case manner. Also, any new knowledge learned about a single site is greatly enhanced by the knowledge already gathered there. This is particularly important since ecosystem-level studies require the approaches of numerous disciplines and thus such studies are likely to be of a long-term duration.

The value of site-specific ecosystem studies can certainly be seen from the important ecosystem-level findings at such sites as the Hubbard Brook watershed in New England. There, for example,

the ecosystem impact of, and recovery from, timber harvesting was precisely documented (Likens, et al., 1970).

In mediterranean-climate regions there have been a number of site-specific ecosystem studies. Dark Island heath studies of Ray Specht and co-workers (see literature summary in Specht, 1973) was the forerunner of more comprehensive ecosystem studies elsewhere. In France, the production and nutrient studies at Le Rouquet and Le Puech du Juge (Lossaint, 1973) had an ecosystem character. The latter site included extensive manipulations including fire and grazing (Trabaud, 1973). In South Africa a comprehensive ecosystem study is now underway at a coastal site at Pella and an interior site at Jonkershoek. The International Biological Program study of California and Chile was centered at Boulder Creek and Fundo Santa Laura respectively (Thrower and Bradbury, 1977). Earlier intensive site studies in the California chaparral were focused at San Dimas (Mooney and Parsons, 1973).

Some, but not all, of these studies have involved landscape managers. Hopefully, in the future all such research efforts will involve not only basic and applied scientists but also managers who can provide an input into an experimental design which has meaning in terms of current management practices. At the research level, an obvious need is for the development of methods of extrapolation from the site-specific studies to regions.

CONCLUDING REMARKS

It would appear that our international network of mediterranean-climate ecosystem study sites offers a unique framework in which to make rapid advances in our understanding of how these systems function. Further effort is needed to extend these findings to determine the impact of various management treatments on ecosystem properties. In order to accomplish this there must be a closer collaboration between basic and applied scientists and resource managers.

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