VALUES AND CHOICES IN THE DEVELOPMENT OF AN ARID LAND BASIN - THE ROLE OF AGRICULTURE

Gerald W. Thomas*

There is no doubt that competition for resources in the Colorado River Basin is increasing. This competition results from pressures within the area as residents seek to satisfy their own objectives for livelihood and well-being but, more importantly perhaps, competition results from pressures without as the U. S. and World population grows and the demands increase for Basin resources and services. It is this outside pressure that complicates the situation and makes choices difficult--or even reduces the alternatives.

Since my topic is agriculture and grazing, I cannot examine the problems within this arid land basin without some discussion of the world-wide food and fiber problem--pressures largely external to the basin. I will keep this brief in order to get back more specifically to the alternatives for development of the region.

I know that it is dangerous to make sweeping generalizations because "no generalization is absolutely true including this one" or, in other words, "a generalization that is unquestionable is certainly questionable." Nevertheless, generalizations can serve to stimulate discussion so here is my first broad generalization:

Yesterday and Today - An Environmental Crisis

Today and Tomorrow - An Energy Crisis

Tomorrow and Day-after-Tomorrow - A Food and Fiber Crisis

We move from crisis to crisis. Perhaps a "crisis" is necessary for Americans to recognize a serious problem--to initiate action programs. I'm convinced that the Arabs did us a favor by closing the oil spigot. They alerted us to an energy problem that would have been really serious with another lapse of 5-10 years of lethargy. We now have an unprecedented

*President, New Mexico State University, Las Cruces, New Mexico. Presented to the Committee on Arid Land Symposium, AAAS Meeting, San Francisco, California, Thursday, February 28, 1974.

opportunity to examine our life styles--to plan for the future with a deeper economic, social and environmental understanding.

The reason I am concerned about food and fiber is partly because of the energy crisis (we use vast amounts of energy to produce, process, package and transport food and fiber), but more appropriately because of my concern about all resources involved in agricultural production, particularly land and water. It is likely that world-wide demands for food and fiber in the near future will place resources for agricultural purposes in a much higher priority than is now the case. Even a doubling of food production in the next three decades would only maintain the world's population at present dietary levels (1).

As Lester Brown stated recently, there are two major reasons for the increased demand for food. "During the 1970's, rapid global population growth continues to generate demands for more food; but, in addition, rising affluence is emerging as a major new claimant on world food resources." (2) Dr. W. Robert Parks, President of the National Association of State Universities and Land-Grant Colleges added a third factor to the "new circumstances" facing agriculture (3). He stated that our "bank account" of food technology has been drawn down to a very low level and there is a special need for new breakthroughs in agricultural research. When the U. S. decided to open up trade with the Communist Nations, another 2 billion people became potential customers for U. S. agricultural products. The Colorado River Basin, where a wide variety of crops are produced, will be involved in this increased demand for food and fiber. Thus, priorities for resource allocation in the Basin may change.

Competition for Farm Land - The "Cultivated" Land Base.

It is estimated that, with the present technology of the developed countries, nearly one acre of cultivated land is needed on the average to provide an "adequate" standard of living for each person. This takes into consideration some variation in land productivity as well as some variation in level of affluence. With the present population in the U.S., we have about 1.2 acres of cultivated land per capita and a potential of about two acres per capita if we expand acreage to the maximum. We do not as yet know the effects of the recent farm programs to enlarge the acreage under cultivation nor we know the new per acre yields. The experience of many countries has shown that most efforts to expand culti-

vated acreage have resulted in reduced per acre yields. We are already using the very best lands for cultivation.

The U. S. is now exporting the production of about one acre out of every four--leaving about 0.9 of an acre per capita for home use. The Far East has less than 0.8 acre of cultivated land per capita with Communist Asia at about 0.4 acre per capita. Latin America with 1.3 acres per person, and Africa with about 2.3 acres per person still have a good cultivated land resource base.

For the world, the cultivated acreage now stands at about 3.5 billion acres, or 11 per cent of the earth's land surface. The area actually harvested for crops in a given year is considerably less (due to fallow practices and crop failures)--usually about 2.4 billion acres. This means that we now have only about 0.6 acres of usable cultivated land per person in the world compared with an estimated need of one acre per person. By the year 2000, the cultivated land base will likely be reduced to about 0.3 acre per capita. World-wide yields will have to be doubled to maintain our present position of food availability.

These world-wide and national statistics on farm land are presented for the purpose of indicating that pressure from outside the Colorado River Basin will influence priorities of land use within the basin. The basin itself now has a surplus land base for farming--about 8 acres of cultivated land per capita in the Upper Colorado (4) and about seven acres per capita in the Lower Colorado (5).

Water and Agriculture

Water is probably the most important--and most limiting factor--in the growth and development of the Colorado River Basin. A high percentage of the cropland in the Basin is irrigated and the potential for irrigation is still greater. However, in view of the National Water Commission Report, it is unlikely that irrigated cropland acreage will be expanded. One conclusion from the Report is as follows (6):

> "Land will not be scarce by 2000.... Output from U. S. farm and range lands, including lands now set aside in government programs, will be adequate to meet projected food demands even at the high level that would be expected if population increases to 325 million persons and some food exports grow to about twice their 1967-69 levels."

Furthermore, the report concluded that "Expansion of irrigation is not needed to meet future food needs. Quite to the contrary. The most efficient

pattern of production at most projected demand levels would be achieved with a reduction in the acreage of irrigated land used for annual crops."

Needless to say, I do not agree with these statements. A good review of the National Water Commission Report was prepared by the Western Agricultural Economics Research Council (7). This Council challenged some assumptions of the "Heady Report" on which the Commission conclusions were based. In addition, the world outlook has changed with the energy crisis and the opening of markets for our food and fiber in the Communist Nations. U. S. Agricultural exports in 1973 were about $12.9 billion. The USDA Economic Research Service estimates that total agricultural exports could reach $20 billion by 1975 (8). Food has indeed become a potent factor in foreign policy (9).

Reports by the Colorado River Basin Inter-Agency Study groups (released in 1971) on land use, project the need for cropland to increase from 1,816,000 in 1965 to 1,852,000 by the year 2020 in the Lower Colorado River Basin (15) and for the Upper Colorado Region increases from 1,621,500 in 1965 to 2,625,000 in 2020 (4). Most of the increases were projected for irrigated lands.

At the Colorado River Basin Environmental Management Conferences held in Salt Lake City in October 1973 (10), several concerns were expressed about irrigated farming in the Basin: (1) There is a serious problem of ground water mining (some aquifers now being tapped for irrigation water are not being recharged to offset withdrawals, and the "closed basin" approach has not been adopted), (2) Increased salinity and other pollution problems--partly associated with irrigation--present both a regional and international challenge, (3) The status of Indian water rights continues to be unsettled, and (4) Transfers of water rights to summer home development, to industries, and other uses is continuing to reduce irrigation in the agricultural sector.

Thus, while the debate over world-wide requirements for cultivated land and for irrigation continues, and while certain groups are projecting increased food and fiber needs, we are actually experiencing continued losses of farm land in the Colorado River Basin to other uses--usually to some form of urban or industrial development. These transfer decisions are being made piecemeal, under economic pressure, and without adequate consideration of land-range needs or systematic planning for optimum land use. No part of

the Basin has so far been able to successfully zone or build in the necessary legal and economic incentives for the protection of good farm land.

Impact of the Energy Crisis on Agriculture.

The Colorado River Basin is an energy rich area--that is, rich in basic energy sources. The story is somewhat different for the finished consumer product. Here again the ties to the outside areas--and to the world situation--become important. Energy shortages and increased energy costs will have a substantial impact on all development in the Colorado Basin. We can anticipate increased pressure for exploitation and mining of petroleum and mineral resources. We can anticipate increased research and development activity for alternate sources of energy--geothermal, nuclear, hydropower, wind, and solar energy. We can expect economic and political pressure to compromise standards on environmental pollution. Furthermore, we can anticipate changes in expenditure patterns and consumer demands--that is, food, clothing, forestry and housing, may increase in priority while tourism, recreation and energy luxury activities may diminish. Perhaps, the long overdue reconsideration of life styles of the affluent American may change. All of these factors could impact on development and decision-making in the Colorado River Basin.

The gigantic food and fiber industry, taken in its entirety, uses more petroleum products than any other industry in this country. Large amounts of energy are consumed in the "supply sector" to provide the farmer and rancher with fertilizers, pesticides, machinery, and other inputs. Large amounts of energy are used in the "production sector" for planting, cultivation, irrigation, care and harvesting of crops and livestock. Large amounts of energy are also consumed by the "storage, processing, packaging and distribution sector" in order to place food on the table and clothes on the backs of 210 million Americans. Estimates of the petroleum products used by agriculture, in this broad sense, vary from 10 to 18 percent of total consumption of petroleum in the United States.

Through the years, farmers in the U.S. have steadily mechanized and have substituted over five million tractors and many other forms of power equipment for about 22 million horses and mules. As a measure of progress, we have released about 72 million acres of land that would have been required to feed the horses and mules and may now be used for direct food production for humans. In addition, we have increased efficiency and output per acre (11). Years ago, a man with a good team of horses would plow about 2 acres

a day. Today, mechanized power makes it possible for him to plow over 100 times that much. However, as a result of this increase in mechanization on croplands in the U. S., energy flow patterns have been significantly changed. Horsepower, mulepower, oxenpower, and manpower operate on the solar energy collected by vegetation--a continuing resource for all practical purposes. Tractors and machinery utilize fossil fuel--a finite and depletable resource.

The trend toward mechanization on farms is not confined to this country. In 1950, FAO estimated that there were about 6.1 million tractors in the world. By 1970, this number had exceeded 15.5 million (12). In addition, world fertilizer use, which is heavily tied to petroleum, increased from 15.2 million metric tons in 1950 to almost 68 million metric tons in 1970. As the technology associated with the "Green Revolution" spreads, more energy will be required. Thus, the world pressure on petroleum for the agricultural sector is increasing at an accelerated rate. Farmers in the Colorado River Basin will also feel these pressures on petrochemicals and fuel supplies.

One of the difficulties in arriving at accurate statistics on agriculture and energy relates to the definition of "agriculture." However, for the "production," or "on-farm" sector, we do have some fairly good studies which show that in the relatively primitive rice cultures of the Phillippines about 16 calories of digestible energy (food) resulted from each calorie of "cultural" energy input. In this case the "cultural" energy was hand labor. As mechanization developed, the ratio of "cultural" energy input to digestible energy output has increased and thus, the net caloric gain has decreased. According to Heichel (13) some modern cropping systems yield approximately 5 calories of digestible energy at the farm level per calorie of cultural energy (including fossil fuels). Pimentel et al (14) have calculated that only 2.8 K calories of corn are produced for each K calorie of fuel. However, one farm worker can now produce enough food for himself and 49 others compared with only 8 others in 1950 and the trend toward more mechanization is continuing.

Heichel (13) reports that "on-farm" corn production in the early 20th century derived about 17 per cent of its cultural energy from labor and 70 per cent from depreciation of machines and buildings. In comparison, corn production in 1970 derived about 0.7 per cent of its cultural energy from

labor, 50 per cent from fuel, 15 per cent from fertilizer, 4 per cent from pesticides, and 24 per cent from depreciation of machines and buildings.

Using U. S. Agricultural Technology, Pimentel (14) states that to feed the world population of 4 billion (projected for 1975) would require the energy equivalent of 488 billion gallons of fuel just for the "production" sector of agriculture.

As the concept of agriculture is enlarged to include the "supply" sector and to encompass "processing, storage and distribution," the net energy becomes negative and the outside energy subsidies increase. Hansen (15) recently stated that it has been estimated that about 12 per cent of total energy consumed in the U. S. goes to the food industry.

A task force at the University of Arizona, headed by Dr. Kenneth Barnes (16), reported that "In the overall energy picture which includes hydropower, nuclear energy, natural gas, coal and oil, the U. S. food system uses 12 to 15 per cent of the total." They report a breakdown of total energy use to put food on the U. S. dinner table as follows:

Farming	-	18%
Food Processing	-	33%
Transportation	-	3%
Wholesale & Retail Trade	-	16%
Household Preparation	-	30%

It is my belief that the Task Force figures on transportation are low, but data are not available to substantiate this assumption.

Limited studies have also been made of energy flow patterns for cotton and other fibers. Table 1 presents a comparison of energy (large fossil fuel) required for cotton and cellulosic and non-cellulosic fiber production (17). To produce and process a pound of cotton as a finished broadwoven fabric requires about 14,620 calories. Energy consumption for the synthetic fibers is more than double this amount. Wool places the lowest demand on fossil fuel. The raw materials for the non-cellulosic fibers are petrochemicals from petroleum and natural gas.

Table 1. Energy Consumption for Selected Fibers* - Raw Materials to Finished Broadwoven Fabric (Kilowatt hours per pound of fiber)

	Cotton	Cellulosic	Non-cellulosic
Consumed as Raw Materials	0.20	1.61	6.28
Consumed in Fiber Production	3.55	22.09	11.36
Consumed in Weaving & Spinning	6.30	7.03	7.03
Consumed in Finishing Mills	6.98	8.52	8.52
Cumulative Total	17.03	39.25	33.19

*Adapted from Gatewood, National Cotton Council of America

From an ecological viewpoint, the natural fibers (cotton, wool and mohair) have an advantage in that they place less pressure on the energy resource base than synthetic and highly-processed fibers. In spite of these ecological considerations, synthetic fibers have been capturing an increasing share of the fiber market. Each person in the United States is now consuming over 20 pounds of synthetic fiber per year. Just prior to the energy crunch, Resources For The Future predicted that synthetic fibers would capture over 54 per cent of the fiber market by the year 2000. In my opinion, these projections will not materialize due to the pressure on petroleum products. Japan and Western Europe are already placing more emphasis on natural fibers. It is safe to anticipate increased demands for natural fibers produced in the Basin--wool and cotton.

Uncultivated Lands - Competition for land use.

Uncultivated lands constitute the largest acreage of land in the Colorado River Basin. Management and land-use decisions on these lands is complicated by three major factors: (1) land ownership patterns, (2) extreme variability in climate, soils, vegetation, and topographic conditions, and (3) multiple-use possibilities.

Approximately 65 per cent of the total land area in the Basin is Public Land. Decisions on the use of public land are becoming more and more "everybody's business." Social welfare weighs heavily against economic value. Environmental concerns are more apt to be considered. The tradition for decision-making on private or corporation land is somewhat different. Right or wrong, the land owner still makes most of the decisions on land use and this prerogative is strongly established by American tradition.

Given this difference in management prerogatives and/or objectives on private vs. public lands, the situation is further complicated by the fact

that many ranch operators graze livestock on both public and private lands. Thus, the land-use decisions on federal or state lands has a significant effect on private lands. A change in the use of one has an immediate impact on the others. This dependence on public lands for forage supplies varies among the states--reaching a high in Nevada where 49 per cent of the livestock forage comes from public lands.

As many of you know, there is a national movement sponsored by the Natural Resources Defense Council to force the Public Land Agencies--primarily the Forest Service and the Bureau of Land Management--to close all Federal lands to grazing. I have been working with a Task Force of the Council for Agricultural Science and Technology to prepare a position paper on the effects of such a ban on our national economy and the environment. This Task Force, composed of 15 scientists from the Western U. S., is taking a very strong stand to oppose the elimination of all grazing by domestic livestock from federal lands (18). A quotation from the Task Force Report is as follows:

> "Eating of plant materials by animals is a natural process in terrestrial and aquatic systems. Thus, with the coming of European man to the West, the introduction of domestic livestock did not constitute an entirely new component in the environment. More realistically, the domestic livestock replaced, or were added to, the wild animals that were already there. Rangeland vegetation, especially grassland and shrubland, in the Western States evolved to withstand grazing to a moderate degree. Without grazing, different vegetational characteristics develop. The range forage that livestock utilize is a renewable natural resource because the forage regrows each year and has done so for many centuries.....
>
> .....The environmental effects of grazing depend upon the kind of range, the intensity of grazing, and the kind of management employed to control livestock on the range."

In a paper presented to the 1973 annual meeting of the Society for Range Management, I made the following concluding statement: "A careful examination of long-range research can only lead to the conclusion that: (1) on vast areas of public lands, livestock grazing, under proper management, is compatible with other uses, (2) on a limited number of sites, grazing by domestic livestock is detrimental to the resources and competitive with other uses, and (3) on other sites, grazing by livestock can be the most beneficial use to society for economic, social and ecological reasons." (19)

The concept of multiple use of the western range resources has been accepted and practiced for many years. That is, these lands have value to the individual and to society for more than one purpose. Although the primary income may be from livestock or forest products, the lands also are important from the standpoint of mineral production, wildlife, recreation, and water yield. Recently, another dimension has been added--that of "total environmental enhancement"--particularly air and water quality as well as aesthetic or wilderness values.

The pressure from individual interest groups is often so great that commitments are made excluding other uses. This trend is of special concern--particularly when political and legal restraints are imposed during a period of emotionalism or under one of the "crisis situations" which appear to develop frequently in the United States. Let's examine briefly some of these pressures on uncultivated lands.

Timber production has been increasing in relative importance because of the high demands for lumber, pulp, and paper products. This situation has become more critical with the energy crisis--and even the most extreme environmental groups are recognizing the need for more forest products. From a recent report by the National Commission on Materials Policy the following statements are pertinent to our discussion of land-use alternatives (20):

> "Three-fourths of the Nation's softwood is in the west.... Projections to the year 2000 for softwood sawtimber demand, at current prices and the present level of management, would require almost doubling the 1970 domestic production...Even with intensified management, prospects for balancing future supply and demand at 1970 process appear remote. However, stepped up investment in a variety of forestry activities could produce significant increases in timber production by the turn of the century."

From a recorded high of 507 million acres in 1962 in the U. S. the area of "commercial forest" land is projected by the Materials Policy Commission to drop to 475 million acres in the year 2020. They state that "quite possibly, additional areas on National Forest lands will be removed from the timber supply base for recreation and environmental protection." Nevertheless, forest production will remain a strong competitor as a major-use or as a concurrent use of uncultivated land in the Basin.

Recreation use on all of the range and forest lands in the Colorado River Basin has continued to rise at a more rapid pace than population

numbers would indicate. Increased mobility and affluence of the people contribute to this pressure on the resource.

In 1957 the Forest Service estimated that the total recreation visits by 1975 would reach 135 million, but this estimate was reached in 1965. Dr. Marion Clawson, of Resources For The Future, estimates that the recreation visits on National Forests could reach 400 million by 1980 and more than 1 billion by the year 2000. The amount of use on BLM lands is increasing at an even more rapid rate. It is clear that the National Park Service, like most other public agencies and private observers, has also greatly underestimated the continued growth in recreation demand in the West.

A Forest-Range Task Force, in December 1972 (21), projected outdoor recreation requirements on U. S. uncultivated lands to increase, in terms of 1965 uses, as follows: Camping-560 per cent, picnicking-400 per cent, horseback riding-370 per cent, and hiking-300 per cent. Their projections for requirements for fishing and hunting were much lower. The National Commission on Population Growth and the American Future states as follows (22):

> "During the postwar years, participation in outdoor recreation in the United States has grown by an average annual rate of 10 to 15 per cent. During more recent years, a slowdown in this rate has been observed for some specific recreational activities; however, the overall annual rate of growth may still be close to 10 per cent."

The increased importance of wildlife production and management on the Western range can also be readily illustrated. While livestock numbers on Federal lands have been reduced substantially since 1935, the number of big game animals has increased. At the present time, estimates indicate that there are more than five million big game animals on the Nation's forest-range lands (21). On BLM lands big game animals increased from an estimated 600,000 in 1945 to about 1.8 million in 1970 (23). Pressure by the public for hunting and other outdoor recreational opportunities has also opened up new possibilities for economic returns to many private ranching enterprises in the Colorado River Basin. Bird watching and nature photography, while not reported in wildlife-use statistics, also constitute an important part of the use of uncultivated lands.

The two Comprehensive Framework Studies of the Colorado River Basin, from which I have drawn much basic material, estimate that the acreage of

land set aside for Wilderness Areas in 1965 was about 2.2 million acres. This acreage has already been increased substantially and hearings are continuing in many parts of the basin to add to our Wilderness and Primitive Area base. Naturally, the ranching industry is concerned about this trend since livestock will be excluded from an increasing acreage of Federal land.

Most of us recognize the need for wilderness and primitive areas, but the management of Wilderness Areas is of special concern to ecologists. Dr. D. W. Hedrick (24) stated recently that, "Many of the wilderness and National Park areas are occupied by fragile ecosystems where human and animal impacts are more crucial and significant than on the bulk of public ranges grazed by livestock." He expressed special concern over the effects of horses--both riding and beasts of burden. Dr. Hedrick also stated that, "It is only a matter of time before our policy on use of wilderness and remote recreational areas is attacked by minority and low-income groups. Our present policies on the use of wilderness areas is among the most discriminatory followed by public officials."

Watershed values of the western range are difficult to evaluate. The concern here is both water yield and water quality. On forest lands, a review of 39 watershed experiments throughout the world concluded that when timber stands are harvested, or sufficiently reduced in density, water yield is increased (21). The magnitide of change varies over a wide range of climates, forest cover types, and geomorphic situations. The role of vegetation management cannot be underestimated. On many brush-infested range areas there may be as much as 100 tons of water associated with the production of each pound of beef. But, even water expenditures for "undesirable" vegetation may not be wasted in terms of oxygen production or environmental enhancement.

Mineral production in the Colorado River Basin, particularly on the Federal lands, is subject to much controversy. The total acreage under petroleum leases or mineral claims may have stabilized somewhat, but the volume of production and the value of production of many minerals is still rising (21). Increasing concern about the total environment has reduced some of the speculative and haphazard exploration and/or exploitation, but many problems remain to be faced by this and future generations. Land-use policies, as they relate to mineral production, often have a heavy economic impact on small communities in the West. The energy crisis may force us

to comprise our standards on environmental protection--at least for the short term.

For purposes of economic analysis, Gray (25) has classified multiple use of range resources into three categories: competitive, supplementary, and complementary. The traditional viewpoint of the rancher is that all other uses tend to compete with livestock production. This is certainly true for many ranching enterprises. But, for others, it may be both economically advisable and ecologically sound to consider supplementary or complementary activities such as grazing two or more classes of livestock, producing game, and managing the resource for recreational purposes.

Furthermore, while the rancher, as an individual with a direct economic interest in the range resource, may desire single-use management, the public must always consider multiple-use as the most desirable approach. As we come more and more to realize the impact of man's land-use practices on the total environment, we become even more heavily involved in the ecology of multiple-use management.

Some Ecological Considerations

Uncultivated lands present a complicated ecosystem for study involving the interrelationships among plants, animals and environment. Basic and applied studies are needed in many fields. But because of the need for correlating and analyzing the many variables, ecology has become the dominant science to bring the purpose of man in harmony with the forces of nature on range areas. Plant physiology, soil science, climatology, hydrology, genetics, forestry, entomology, taxonomy, wildlife biology, recreation management, and animal science are all complementary to ecology. And, while the economist is needed for determining managerial alternatives and other economic considerations, the ecologist must provide the essential service for analysis of interrelationships.

In any ecological analysis, vegetation is the key, since Plants are the first step in energy capture, and are the major factor in eco-system stability. The traditional approach to vegetation surveys on rangelands is often described as "dynamic ecology," the central concepts of which are succession and the climax as developed by Cowles, Clements, and Cooper in the early part of this century. Figure 1 is a schematic diagram of this concept (26).

Climate is shown as the overall controlling factor in vegetation and soil development. On any particular area, vegetation changes with time in

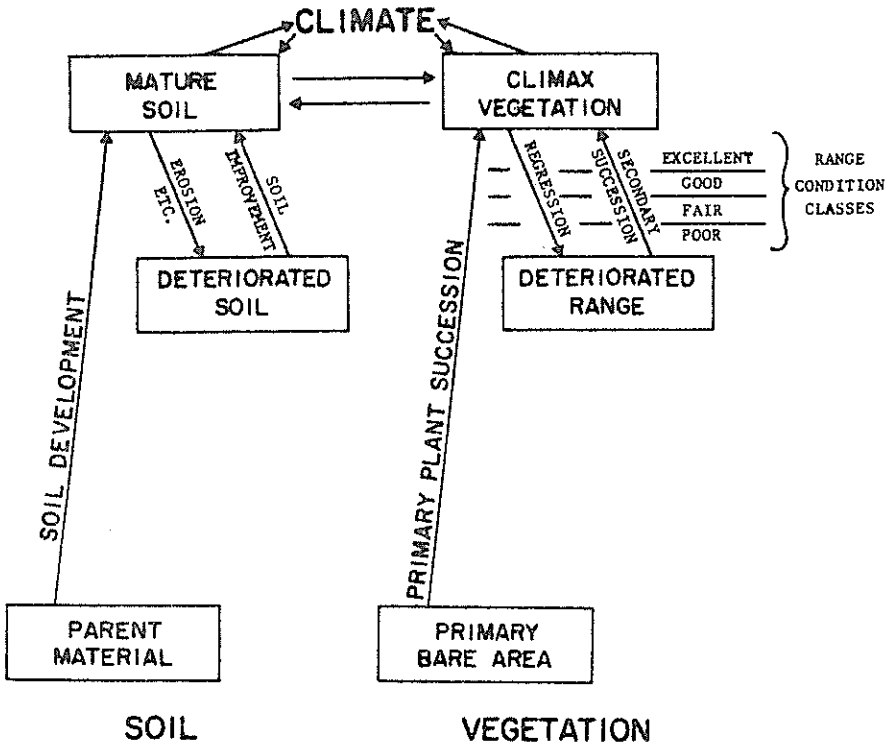

Figure 1. A concept of vegetation succession and regression patterns and the Range Condition Classification System.

a rather systematic pattern (primary plant succession) until a plant community (climax) ultimately appears in equilibrium with the environment. It might be more appropriate to call the terminal plant community an "Environmental Max" rather than a "Climatic Climax" since the total environment predetermines the outcome. This concept excludes the influence of civilized man, but includes other natural biotic factors. This climax condition is very dynamic and encompasses "normal" variation in climate. It means, also, that since geologic processes are still active on most areas, "Change is inevitable."

Man enters the picture and brings about vegetation change (regression or retrogression) through manipulation of livestock, harvesting of forests, cultivation, recreation, or other disturbance techniques. Man can also bring about improvement by controlled management to hasten "secondary succession." Corresponding changes such as deterioration in physical properties, or erosion, can take place in the soil depending upon the severity of the treatment imposed.

Attempts to quantify the succession-regression patterns were not very successful until the "Range Condition" method was developed following World War II. Ecologists first worked with the secondary succession sequence but found this rather frustrating because of the variation in developmental plant communities due to the extent of soil deterioration, availability and nature of seed source, short-run climatic adversity, size of the area, and other factors.

A major contribution was made by Dyksterhuis and others when a system of "Range Condition" classes was proposed, based primarily upon the regression sequence using livestock grazing as the disturbance factor (27). Most Federal agencies are now using a modification of this technique in evaluating the effects of grazing. Similar techniques could be used for other "disturbance factors." Unfortunately, little research data is available concerning such man-caused regression effects as the impact of recreational vehicles, uncontrolled hiking, camping, pack horses, etc. Some of the "substitutes" for livestock are probably more detrimental to the ecosystem and more difficult to evaluate and control than cattle or sheep.

Under this Ecological approach, vegetation classification "in time" is shown as "Range Condition," and classification "in space" is determined primarily by soil, topographic, and climatic conditions forming "Range Sites."

Once the boundaries of Sites are established, the succession-regression patterns are broken into Range Condition Classes: Excellent, Good, Fair, and Poor. These classes, therefore, represent departures from the so-called climax plant community, departures based upon grazing pressure or other disturbances over time. All plants on a particular range Site are identified as to their response to pressure and their probable place in the climax plant community. Thus, the vegetation survey establishes both present condition and potential productivity. It also reflects "stability" and "diversity" of biological populations.

Reliable soil or site surveys are vital to this system of classification. The spatial pattern of vegetation communities is complex, "a field of phenomena notably lacking in fixed points of reference, lines of division, invariable rules, and easy definitions" (28) and it is necessary to determine the role of soils in this distribution pattern. For the Colorado River Basin, with its extreme variability in rainfall, soils and topographic conditions, the proper identification of "Sites" and the proper analysis of vegetation change is critical--not only for evaluating the effects of grazing but to determine the effects of other man-caused or man-accelerated disturbance factors.

It is my hope that, to an increasing extent, we will base our values and choices in determining proper land and water use on ecological considerations. Under these conditions, agriculture and grazing will still remain competitive as a part of the economy and development potential in the Colorado River Basin.

LITERATURE CITED

1. Conservation Foundation Letter. How Far Can Man Push Nature In Search For Food. November, 1973.

2. Lester R. Brown. Population and Affluence: Growing Pressures on World Food Reserves. Population Reference Bureau, Inc. Vol. 29, No. 2, 1973.

3. W. Robert Parks. New Circumstances Facing America's Ability to Meet Expanding Domestic and Foreign Demand for Food and Fiber. A statement by the National Association of State Universities and Land-Grant Colleges, October, 1973.

4. Upper Colorado River Basin Group. Upper Colorado Region Comprehensive Framework Study. Water Resources Council, June, 1971.

5. Lower Colorado Region Group. Lower Colorado Region Comprehensive Framework Study. Pacific Southwest Interagency Committee Main Report, June, 1971.

6. E. O. Heady, et al. Agricultural and Water Policies and the Environment. Iowa State University, June, 1972.

7. Western Agricultural Economics Research Council. Review and Critique: Agricultural and Water Policies and the Environment. Undated.

8. Economic Research Service, U. S. Department of Agriculture, U. S. Agricultural Exports: Commercial and Under Government Programs, February, 1974.

9. Nicholas Wade. Agriculture: Rise to Prominence at Home and Abroad. Science Vol. 182, December 28, 1973.

10. Agricultural Workshop Report. Colorado River Basin Environmental Management Conference, Salt Lake City, Utah. October, 1973.

11. Gerald W. Thomas, Progress and Change in the Agricultural Industry. Kendall-Hunt Publishing Co., 1972.

12. Lester R. Brown. Population and Affluence: Growing Pressures on World Food Reserves. Population Reference Bureau, Vol. 29, No. 2, 1973.

13. G. H. Heichel. Comparative Efficiency of Energy Use in Crop Production. Conn. Agric. Expt. Sta. Bul. 739, November, 1973.

14. David Pimentel, et al. Food Production and The Energy Crisis. Science Vol. 182, November 2, 1973.

15. Edward H. Hansen. Agriculture Needs For Energy. Address to Extension Committee on Policy, October 24, 1973.

16. Kenneth K. Barnes, et al. Farms Poor Fuel Saving Prospects, Univ. of Arizona News Release, January 11, 1974.

17. L. B. Gatewood, Jr. The Energy Crisis: Can Cotton Help Meet It? National Cotton Council of America, January, 1973.

18. Report of a Task Force of the Council for Agricultural Science and Technology. Livestock Grazing on Federal Lands in the Eleven Western States. January, 1974.

19. Gerald W. Thomas. Livestock Grazing on Public Lands: Unity for Political, Economic, and Ecological Reasons. Journal of Range Management 26(4), July, 1973.

20. Edward P. Cliff. Timber: The Renewable Material. Prepared for the National Commission on Materials Policy, August, 1973.

21. Report of a Forest-Range Task Force. The Nation's Range Resources - A Forest-Range Environmental Study. USDA Forest Service Report No. 19, December, 1972.

22. Charles J. Cicchetti. Outdoor Recreation and Congestion in the United States. Report of the Commission on Population Growth and the American Future. Supt. of Documents, Washington, D. C. 1972.

23. Paul Howard. Public Attitudes on Public Land Grazing. Grazing System Symposium, Las Cruces, New Mexico, September 9, 1973.

24. D. W. Hedrick. Grazing on Public Lands. Rangeman's News. Society For Range Mgt., Vol. 5, No. 4. August, 1973.

25. J. R. Gray. Ranch Economics. Iowa State University Press, Ames, Iowa, 1968.

26. Gerald W. Thomas. The Western Range and the Livestock Industry It Supports. From Range Research and Range Problems, Crop Science Society of America, 1969.

27. E. J. Dyksterhuis. Condition and Management of Range Land Based on Quantitative Ecology. Journal of Range Mgt., Vol. 2, p. 104-115, 1949.

28. R. H. Whittaker. A Consideration of the Climax Theory: The Climax As a Population and a Theory. Ecol. Monog. 23:41-78, 1953.