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Agriculture and Natural Resource Adequacy

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In this lecture I will (1) explain why agricultural economists tend to be Cornucopians rather than Malthusians; (2) examine how the availability of the natural resources of energy, water, and land will affect aggregate agricultural output in the United States for the remainder of this century; and (3) discuss public policies affecting natural resource use in agriculture.

Agricultural Economists as Cornucopians

Economists have contributed much to the intellectual tradition concerning resource adequacy that dates at least to the time of Malthus, almost two hundred years ago. Not surprisingly, economists, like other writers, have tended to become polarized into optimistic and pessimistic schools of thought--Cornucopians and Malthusians. The optimistic school includes such names as T. W. Schultz, Barnett and Morse, and Julian Simon, whereas Nicholas Georgescu-Roegen, Herman Daly, and Krutilla and Smith are economists of a more pessimistic persuasion. Strikingly, the more vocal of the pessimists have not been economists, as is illustrated by the work of Paul Erlich and Barry Commoner, as well as such studies as The Limits to Growth and Global 2000.

I believe more agricultural economists are to be found in the camp of the Cornucopians than with the followers of Malthus and I advance three reasons as an explanation:

1. Agricultural economists work with an industry where rapid technical change, particularly in the past three decades, has been

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the rule rather than the exception. The great expansion of agricultural output in this country has resulted from using new technology that has substituted capital for labor and natural resources. As a consequence, policy work of American agricultural economists since the 1920s has been more concerned with managing an abundance of agricultural commodities than with natural resource adequacy. No doubt this rapid technical change is a major reason agricultural economists have been among the pioneers in studying the causes of technical change and its returns. This is to the credit of the profession: if per capita food consumption is to continue to increase in the world, additional technical change in agriculture will be needed. Agricultural economists should continue to try to understand the causes of technical change and the incentives needed for its development and adoption.

2. Another reason agricultural economists have not been overly concerned with resource adequacy stems from their heavy reliance on the microeconomics of Hicks and Knight and substantial neglect of Marshall and Pigou. Since World War II, work on the economics of the firm in agricultural economics generally has denied any uniqueness of natural resources as these resources enter the production function for agricultural output. Agriculture has been linked to the remainder of the economy through the commodity markets on the output side and the labor and capital markets on the input side. Land, water, energy, and environmental quality have received relatively less attention on an industry level and such work often was considered outside the mainstream of agricultural economics.

To a degree, the work of the agricultural resource economists is considered an exception, for they have used externality and nonmarket valuation concepts in their research for more than two decades. Yet, this research has not significantly emphasized the contribution of natural resources to agricultural output, the generation of externalities in agricultural production, or the unique role of natural resources in farmer decision making. Rather, the research of agricultural resource economists has been virtually indistinguishable from that of resource economists generally (Castle, Kelso, Stevens, and Stoevener, 1981). This is unfortunate. Agriculture is the largest single user of natural resources and also one of the largest contributors to many forms of environmental degradation as in, for example, stream siltation. The problems associated with the ownership, acquisition, and use of natural resources and disposal of the residuals from natural resource use are such that they deserve special attention.

3. The methodology used by economists and agricultural economists to assemble evidence about the world also contributes to our Cornucopian tendencies. While not universally true, the optimists about future resource adequacy usually cite historical trends as evidence, with particular emphasis on the experience of the past century. The pessimists typically project future population growth, per capita consumption, and technical change. For example, contrast the methodology and conclusions of Schultz and Barnett and Morse with those of Limits to Growth and Global 2000. Economists rely heavily on historical data in assessing the

future. Other disciplines are more inclined to use projections for this purpose. And, even when economists do make projections they are less likely to ignore the determinants of technical change and the role of institutions in their models.¹

Whether natural resources in the future will be sufficiently constraining to cause costs to rise or whether the cost of natural resource services will continue to decline as they have during the past century is, of course, answerable only with a large degree of uncertainty. Neither a study of the past nor a projection into the future can yield a definitive answer. The fundamental deficiency of both approaches is the same: no one can know or predict the state of future knowledge. This knowledge will govern the relative importance of natural resources in production and consumption, as well as in the design and application of those incentive systems which determine individual choices and group responses. Yet, even if the fundamental question is unanswerable, it is important that we apply as much intelligence as we can muster to the study of such evidence as is available. As we shall see, a number of public policies are affected by our expectations about natural resource availability.

Energy, Water, and Land and Aggregate Agricultural Output

The evidence that has come to my attention on worldwide income and population growth and on the poor performance of agriculture in the centrally managed economies leads me to conclude that the welfare of many people, both inside and outside the United States, will be improved if U.S. agricultural output continues to grow. It is appropriate that we assess as best we can how energy, water, and land enter the

agricultural response function and to what extent, if at all, these resources will constrain future agricultural output. Although I am familiar with the major quantitative studies on availability of these resources, my treatment will be nonquantitative.

Energy

Spreng and Weinberg have argued that the three fundamental resources are energy, time, and information. Even if one stops short of adopting their framework, the importance of energy both in production and consumption activities is hardly debatable.

I believe that the social historians of the future will assign great importance to the energy problems of the 1970s. While the term "energy crisis" was misleading, uncertain energy supplies and rising real prices for energy with resulting shifts in income and global balance of power have contributed to many of the political, social, and economic problems now facing both the industrialized and developing worlds. Because the problem mistakenly was thought to be one of physical shortage it was called a "crisis." Now that the physical shortage seemingly no longer exists, many believe there no longer are any energy problems. I was never among those who believed we were "running out of energy," but neither do I now believe we have solved all of our energy problems.

One of the complications of managing natural resources is that they are seldom evenly distributed over the face of the globe. The liquid fossil fuels are the most economically satisfactory form of energy for many of the needs of the industrialized and developing societies, and in the early 1970s economic production of these fuels was concentrated in a

relatively small number of geographic areas. Since that time several other producing areas have assumed importance in response to higher prices, and higher prices have stimulated many efficiencies in their use. Even so, the United States continues to import a great deal of the fossil fuel it uses and continues to depend on others for much of its energy supply.

But I believe we are less vulnerable than we were in the early 1970s for a number of reasons. We now have a much more sensible energy policy with far greater reliance on the market and this greatly improves our capacity to adjust both production and consumption. Further, many new producers now want to sell oil, which makes it increasingly difficult for an international cartel to control prices. Additionally, I sense there is a growing international awareness of mutual dependency among nations with respect to trade and global resources. Nevertheless, there is little question but that an interruption of fossil fuel imports would disrupt our economy seriously. This would be true either of a temporary disruption, for whatever reason, or a more permanent diminution of imports stemming, let us say, from a major war in some part of the globe.

Because energy is so widely used in both production and consumption, the income distribution effects of different policy options are often the principal focus of policy debates about energy. For the time being, at least, we seem to have resolved the issue but it is likely to reemerge should there be a supply interruption. Nor, in my judgment, should income distribution be ignored even if controlled energy prices do not seem to be an efficient or an effective way of addressing the problem (Landsberg and Dukert, 1982).

Any serious discussion of energy policy must consider the enormous use of the unpriced resources used to create the supply of energy necessary for an industrial society. While environmental problems may command fewer headlines than they did in the late Sixties and early Seventies, some current trends cause me to have even more concern about the environment than I had at that time. The enormous use of the fossil fuels is changing our environment in ways that no one can predict. Both the climate and the landscape are being altered by carbon dioxide accumulation and acid rain. Yet, the institutional mechanisms are virtually nonexistent for affecting the behavior that causes such conditions.

Thus, major energy policy problems remain. These stem basically from the unequal global distribution of the liquid fossil fuels, from the unequal impact of energy shortages on different segments of society, and from the heavy use of the unpriced, open-access resources associated with fossil fuel combustion. With this as background, I now turn to energy use in agriculture.

In addressing the question, it is important to recognize that a world market for energy exists. While this world energy market is far from perfect, an increase in real energy prices is likely to affect the United States and other principal grain-exporting countries in comparable ways. The energy intensity of agricultural production is not identical for all regions, but the differences probably are not large and are unlikely to be to the marked disadvantage of the United States. This leads to the more general issue of energy intensity in agriculture. During the 1970s, allegations of the vulnerability of U.S. agriculture

were made because of its heavy reliance on energy. Specifically, questions were raised whether agriculture's performance could be sustained in the face of curtailed energy supplies or rising energy prices. An analysis of the experience of the 1970s permits some generalizations (Castle, 1981b).

1. U.S. agriculture has demonstrated great capacity to adjust to changing energy conditions. That economic man, the farmer, has responded to higher energy prices in many ways. The rapid adoption of conservation tillage, for example, no doubt has been motivated in an important way by higher energy prices. U.S. farm output increased far more in the 1970s than it did in the 1960s even though energy prices fell during the Sixties and rose during the Seventies.² I recognize too much could be made of this simple relationship because of the excess capacity of the 1960s disappeared during the 1970s. However, this leads to point #2 which follows.
2. The productivity of most energy-intensive practices in agriculture is sufficiently high to permit agriculture to compete with alternative uses of energy if the market is the allocator.
3. The agricultural sector in the United States has about the same energy intensity as does the economy generally.
4. The preparation, transportation, preservation, and packaging of food uses far more energy than does its on-farm production.

In summary, I am less concerned about the negative effect of high energy prices on agricultural output than I am about the effect on output of policies that might be adopted to correct the income distribution effects of high energy prices (see Landsberg and Dukert, *ibid.*) Also, the continued heavy use of fossil fuels will increase pressure on open-access, unpriced resources. This, for me, is the major concern about the present pattern of energy use; we know neither the effects of such developments nor how to cope with them efficiently and well.

Water

Major problems plague agricultural water management in the United States on both a micro and macro basis. Unfortunately, economists are falling far short of their potential in helping to solve these problems. Let me state first what some of these problems are and then explain why I do not believe economists are making as much of a contribution to their solution as they could. I conclude with a judgment about the probable contribution of water to increased agricultural output.

First, a basic fact: most of the low-cost opportunities for irrigation in the United States already have been exploited. Public subsidy for massive irrigation projects in the United States probably are a thing of the past (however, this administration has found a place for numerous water projects in the tight federal budget, despite considerable rhetoric about the importance of markets and economic considerations in water development and allocation). Private development of both surface and ground water to increase agricultural output will occur only with greater economic and environmental costs.

Salinity is a problem in many parts of the West and nonagricultural water uses have been growing in importance for several decades.

Under such circumstances one logically looks to ways that might make more effective use of existing water supplies. We now know that improved efficiency of energy use in production and consumption, stimulated by realistic prices, was a major factor in improving the energy situation. Why not something comparable with water?

Historically, on-farm agricultural water use has been in a favored position both with respect to public investment and in state water law. No doubt many of these policies made good sense at the time they were adopted, but social needs have changed and water institutions have not changed in a comparable and responsive way. I do not believe that appropriate intellectual effort is under way to provide the base for such change. If it does come, it probably will be because of pragmatic need and trial-and-error experimentation. There are two reasons for this sad state of affairs.

Almost every national magazine during the past two years has had a major story predicting a massive water shortage during the 1980s or at least before the end of the century. I know of little empirical data that would support such a judgment, but a great deal of evidence does indicate that water is being mismanaged and used inefficiently. The parallel with energy problems of a decade earlier is striking. It seems we again are destined to confuse inadequate incentives and obsolete institutions with physical scarcity. But the parallel should not be overdrawn: the problem of bringing about needed institutional change for water is far more deepseated and complex than for energy.

Water institutions have deep historic roots and the physical characteristics of the resource--water, are far different than those of the resource--energy.

These news stories and other discussions have attracted considerable interest on the part of the social awareness people in foundations and in government. But most of the resulting effort that they are supporting is being undertaken in apparent ignorance of the extensive literature on water resources of the 1950s, 1960s, and early 1970s (National Water Commission, 1973). As a result, we seem destined to cover the same ground with many of the studies, conferences, and workshops that are being funded--a tragic waste of resources at a time when funds for research are so limited.

The other reason that progress is likely to be slow stems from water's physical characteristics. These characteristics explain in part the nature of the institutions that have arisen for the social control of water, and of professional specializations for the management and study of water resources. Especially in the West, engineers and lawyers have been of great importance in water's development and management; it was natural that this interest would carry over into academic practice in those fields. For obvious reasons, academic economists and political scientists also have devoted considerable attention to water. But it is my contention that this specialization is at the seat of much of the difficulty. Few lawyers understand markets even though several do understand a good bit of hydrology and engineering; engineers often know a great deal about water law or economics, but seldom about both. Economists, on the other hand, often

assume the law means what it says, which is not the case, and frequently fail to take hydrology into consideration in their suggestions for institutional reform.

Successful institutional innovations need to provide for economic influences to play a role, to reflect the facts of hydrology, to be realistic in the context of our basic systems of laws, and to be politically feasible. The principal flaw in the present system is its failure to reflect economic forces, but the incorporation of economics into water law and other water institutions involves the contribution of all of the disciplines mentioned. Sadly, we are not very good at such integrated efforts these days, in part because the people who are funding academic work on water are interested in immediate results and this kind of effort is not likely to have a quick payoff. Thus, I believe economic pressure eventually will build to the point that policymakers will force changes over the resistance of tradition and vested interests. But, as I indicated, that is likely to result from pragmatic action, probably without great help from the academic community. I hope I am proved to be wrong.³

Let me now return to water adequacy and agriculture. The work of Frederick (1982) leads me to believe that increased irrigation cannot be expected to contribute to greater agricultural output in the future to the extent that it has in the past. On balance, irrigated acreage will increase, but at a slower rate, and the increases will occur in less hospitable environments, for example, the Sand Hills of Nebraska, and costs correspondingly will be higher. I do expect greater economic incentives for the better utilization of water both in irrigated and

rain-fed areas, but this would be much greater, of course, if water markets are reformed. The consumptive nonagricultural water uses now on the horizon are not large enough to affect aggregate agricultural output significantly if water were put to more efficient use in agriculture.

Higher energy prices are affecting water for irrigation in many areas. This is especially true for ground water, where pumping lifts are increasing as water tables are dropping. Thus, even though it is hard to visualize a national water shortage, water allocation and management will be major resource problems for many areas and agriculture will be at the center of the conflicts that will occur. It should not be concluded, however, that only agriculture will be forced to adjust if more realistic pricing and allocation policies are adopted. Many municipalities, as well as other users, already have been forced to reexamine their water use programs and practices.

Land

We live in a time of much dissatisfaction with the way land is held in this country. Some would return the public lands to private hands, while others are very unhappy with private land use and believe substantial government intervention in the private land market is necessary.

My remarks will be confined to privately held lands, with particular reference to the way land availability influences agricultural output. For at least three decades the literature in agricultural economics has held that new technology has substituted capital for labor and land in agricultural production. But recently the orthodoxy of our profession on agricultural land has been challenged.

One challenge comes from those who point to the loss of rural land to urban uses and conclude that such a trend eventually will depress agricultural output. Indeed, it was this point of view that was advanced as a rationale for the National Agricultural Lands Study (U.S. Department of Agriculture, 1981). The NALS in turn stimulated several pieces of literature (Crosson, Fischel, Raup, Brewer and Boxley) that, on balance, upheld the orthodox view of the profession while extending our understanding of the role of land in agricultural production. Philip Raup, in an excellent article in the May 1982 issue of Land Economics entitled "An Agricultural Critique of the National Agricultural Lands Study," captures the essence of the conceptual contribution of this recent literature. Crosson and others have given us a much better understanding of the empirical dimensions of the problem.

Another challenge arises from the behavior of land prices relative to the general price level since World War II. If land was declining in economic importance in agricultural production, why did agricultural land prices rise more rapidly than other input prices from, say, 1950 to 1980? Doesn't this suggest scarcity rather than abundance?

The motivations that move farmers to acquire land are not always clear. Land is an investment opportunity as well as a productive input in farming. Given the changes during the Sixties and Seventies in the general price level, prevailing land prices, the availability of credit for the purchase of land, interest rates and inflation rates, land was judged by many to be a good investment over and above its contribution to agricultural production. For many it was a good investment, although

many bubbles have burst during the past two years for numerous aggressive investors. No doubt the demand for land as an investment during the past two decades became a significant component of the total demand for land and contributed significantly to the increase in land prices that we have observed during that period. Irving Hoch and I have demonstrated that increased real land prices do not necessarily mean land is becoming more scarce (Castle and Hoch). While I am not at all confident of our empirical estimates of land price components, I believe we have demonstrated that a capital gains component has existed for many years.

The following data illustrate the point:

Index of Prices Paid by Farmers (1967=100)

<u>Land</u>	<u>All Commodities</u>	<u>Land</u>	<u>Land, Adjusted^a</u>
1967	100	100	100
1978	216	308	247

^a adjusted by the capital gains component, V_{3t} , in Castle and Hoch.

When land prices are adjusted for the 1967-78 period by those components of land prices not explained by agricultural earnings, the increase in land prices is less than prices paid for all commodities according to the work Hoch and I have done. As I indicated, I am not sufficiently confident of our empirical estimates to feel comfortable in using them for this kind of adjustment. But I do believe an adjustment is necessary if land prices are to be used as a proxy for scarcity in agricultural production.

The recent swell of concern about the adequacy of agricultural land has created an educational opportunity for agricultural economists.

It is obvious there is great concern outside the farming community--probably much more than there is inside--about the adequacy of agricultural land. I believe the tools of economics can help the layperson to a better understanding of the essentials of the problem. Too frequently economists have accepted the implicit assumptions in the question "Are we in danger of running out of farmland?" No one knows how many acres could be farmed in this vast country under certain circumstances. Other inputs are combined in many ways with land to bring about agricultural production. As agriculturists, we know these things but the nonagriculturalist is inclined to believe that land enters the production function in fixed combination with other inputs and that a change in acreage has a proportional effect on output.

Would a serious problem exist if all of the land the Soil Conservation Service says is suitable for cropping were used for that purpose? Not necessarily. It would mean pressure on farm land the SCS says is not suitable, and erosion probably would increase. But it certainly would not mean that output could no longer be increased and there is no reason to believe it would place the domestic food supply in jeopardy, although it is possible production costs would rise. Increased exports might then be at a competitive disadvantage with other parts of the globe but, of course, that does not follow automatically. But this does lead us to an important question that has not been addressed systematically in recent years. That is, is agriculture likely to move from a decreasing- to an increasing-cost industry? But this important question cannot be answered by focusing primarily on agricultural land.

The retention of agricultural lands may be a non-issue with respect to aggregate agricultural output, but it certainly is an issue at the state and local level. Land use control is the principal, albeit often crude, tool local areas use to control their destiny. The land market has many imperfections in solving rural urban fringe problems. But it is not just the market that fails. Local and state governments often contribute to such problems by unwise zoning or land use control policies, and by the location of public facilities, including highways. I am pleased that a number of agricultural economists are working on these problems. They are our profession's best hope in helping noneconomists and nonagriculturalists to acquire a better appreciation of agricultural lands and the role these lands play in agricultural production and in community development.

Soil erosion constitutes another dimension of agricultural land adequacy, but I will not develop this subject in this paper. This is not because I consider it unimportant; rather it is because it is highly complex and I do not believe I can do it justice in the time available to me. Crosson and Brubaker have just completed a comprehensive assessment of the environmental effects of the increased agricultural output that has and likely will result from greater exports. They give particular attention to soil erosion, soil salinity, fertilizers, insecticides, and herbicides and conclude that, of these possible environmental threats, soil erosion is by far the most serious because of its possible effect on soil productivity as well as its off-farm effects. Several highly competent people now are working in this problem area and our understanding undoubtedly will be substantially

greater in two or three years than it is currently. At the risk of eventually being proved wrong, I hypothesize that erosion is not diminishing our aggregate capacity to produce agricultural products significantly, but it may be harming the comparative advantage of some areas, and it certainly is causing off-farm environmental costs. If this is true, it justifies the attention of those who are devoting their time to its study.

Natural Resource Policy and Agriculture

By way of summarizing the previous section and to serve as a basis for the policy discussion to follow, I offer a hypothesis regarding natural resources and agricultural production. The term "hypothesis" is used advisedly because the empirical data that bear on it are fragmented and incomplete. Nevertheless, I believe my hypothesis represents the most logical conjecture that can be made on the basis of the evidence available. And it is essential that some hypothesis be advanced if there is to be any rational way of choosing among alternative public policies and research opportunities.

Hypothesis: Effective demand and institutional incentives will be the most important determinants of U.S. agricultural output for the remainder of this century. The availability of the natural resources of energy, water, and land will not be a major constraint on production. Energy is a possible exception if the United States should suffer from a major interruption of energy imports.

Irrigated agriculture will continue to grow but probably will not contribute relatively as much to increased agricultural production as it has in the past. Some environmental problems, such as soil

salinity and erosion, related to agricultural production will become more serious.

Should U.S. agricultural output fail to grow as much as it has in the past, I believe it will be either because of a dampening of the world demand for food or a slowdown in the rate of technical change because of inadequate incentives for the development and application of technology. The two, of course, are not independent, and a strong demand for agricultural products translated into favorable prices will stimulate the application of new technology. While prediction is hazardous, I believe that much new technology is being developed that will be applied if economic conditions are favorable. I include improved management techniques such as the collection and interpretation of information under the rubric of technology. Although I believe human capital is important in agricultural production, I do not think it is likely to become limiting for the remainder of this century.

Specific Policies Affecting Natural Resource Availability in Agriculture

If my hypothesis is correct, it is difficult to make a case for federal government intervention to increase the availability of energy, water, or land for agriculture even though global welfare probably would increase with expanded U.S. agricultural output. Some qualification to the above generalization is in order. In the event of an energy supply disruption and a return to energy allocation, the special needs of agriculture should be considered. In the case of water, government will need to modify the framework for the development and allocation of water if it is to be used more efficiently. But this will occur largely on a state-by-state basis with objectives other than increasing aggregate

food output. The problems of the rural-urban fringe and land use in development will continue to occupy the attention of local communities, but a better understanding of the role of land in aggregate food production should assist in simplifying this exceedingly complex problem.

General or Indirect Policies Affecting Natural Resource Availability in Agriculture

The modest role I assign to direct policies affecting natural resource availability is more than offset by the importance I attribute to the indirect agricultural resource effects of the following three sets of public policies.

1. Macroeconomic Policies

The macroeconomic policies adopted during the current administration have had the effect of shifting the economic advantage from debtors to creditors and have strengthened the dollar against other currencies, which makes exports more expensive. If this change in advantage should persist for any significant period of time the impact on agriculture will be enormous, as it affects both export demand and the market for agricultural land. Such policies may further accelerate structural changes in agriculture and exert further influence on the distribution of income and wealth in agriculture as well as the ownership pattern for natural resources. Economists generally, including agricultural economists, became so concerned with the evils of inflation that they failed to anticipate some of the adjustments that would be required by its control.

2. Research and Educational Policies

Research and educational policies in this country generally are in confusion and disarray. Increased competition for public funds and declining enrollments are contributing factors but by no means are the only cause. Agricultural research and education have been caught up in this general problem and, in addition, have problems that are unique to agriculture. Not the least of the difficulty in agriculture has been widespread concern with the organization and functioning of the agricultural research establishment (Castle, 1981). This concern threatens public support for an endeavor that has yielded a high rate of return on social investment. Research generally is not well understood and there is no reason to believe agricultural research is immune to this lack of understanding. People are far more likely to worry about the loss of agricultural land to urban growth or the loss of water from agriculture to a municipality than they are about a reduction in agricultural research support. Yet, the latter is far more important to a low-cost, abundant supply of food.

One need only compare the natural resource policy issues in forestry and fisheries with those in agriculture to be impressed with the difference technical change makes in the use of natural resources. Agricultural economists can take pride in the contributions they have made to the understanding of technical change and the role they have played in formulating research and educational policy. Yet, much remains to be done. We need to understand far better than we do the source of the agricultural

productivity of the recent past to guide future research policy.

We also need to continue to direct our talents to understanding the performance of both public and private sector research efforts. We measure inputs and outputs, but I doubt that we know much about how the two are related.

3. Energy and Environmental Policies

The essentials of an energy policy seem to me to be:

(1) reliance on the market to solve many of the complex problems of energy allocation and to stimulate efficiency of use both in production and consumption; (2) recognition that the market alone is not sufficient to meet emergencies that might result from interruptions in imports; (3) avoidance of costly measures such as gasohol and synthetic fuels to achieve an impractical goal, as implied by the term "energy independence"; (4) public support of basic research that might lead to more environmentally benign energy sources, such as solar; and (5) income redistribution measures to redress massive windfall gains or losses and to alleviate the hardship of the unfortunate who suffer from high energy prices.

The experience of the 1960s and 1970s permits us to evaluate environmental issues in a broader perspective. Global economic development results in the massive transformation of materials requiring enormous amounts of energy. Many nonpriced elements of the environment are used in this process. But public environmental concerns vary all the way from those that affect the quality of our lives in only a marginal or incremental way--littering of public

places or excess noise that affects our enjoyment of life but not our health--to those that may affect our lives in fundamental and irreversible ways--the accumulation of carbon dioxide in the atmosphere and the loss of plant and animal species. I join the optimists, the Cornucopians if you will, if asked to predict the availability of those natural resources that are priced in the market, including the availability of agricultural energy, water, and land. But I am much less sanguine about the continued availability of the open-access environmental resources that carry few market costs on their use or abuse, even though the real social costs may be significant. Little incentive now exists for their conservation and the development of technology to provide substitutes. To say the same thing another way, the price of the market-valued resources such as energy, often are less than their full social cost because they use the unpriced open access resources.

Summary

I believe agricultural economists have been justified in their past optimistic outlook. Furthermore, the prospects are reasonably good that continued optimism will be justified if the natural resources for agriculture--energy, water, and land--are viewed in an industry context and, therefore, I see little need for public policies designed to "protect" these resources in order to ensure an expanded agricultural output. I do believe, however, that natural resources and the agricultural industry should be taken into consideration in the formulation of macroeconomic policy, research and educational policy,

and energy and environmental policy. Agricultural economists may wish to reexamine their Cornucopian tendencies as they broaden their intellectual horizons to include the unpriced, open-access, environment within their definition of natural resources.

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FOOTNOTES

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1. Julian Simon has made much of this distinction in his recent book The Ultimate Resource. I have made the same point in some of my writing but reflection will show that too much can be made of it. The reason the past shows improvement is because of the growth and application of knowledge, especially during the last century. Projections of the future yield pessimistic conclusions unless an assumption is built into the projection that knowledge will grow and be applied more rapidly than the obstacles to be overcome as has been the case during the past century. But, because it happened during the past century certainly is not conclusive evidence that it will always be so.

2. Index number of farm output and gasoline prices paid by farmers

<u>Year</u>	<u>Farm Output</u>	Gasoline Prices
		<u>(bulk purchasers)</u>
1960	90	92
1969	102	104
1970	101	108
1979	129	248

Percentage change in output and real gasoline prices^a

Farm Output	1960-1969	+12.0%
	1970-1979	+29.0%
Gasoline Prices	1960-1969	- 5.9%
	1970-1979	+35.8%

^aReal gasoline prices are prices paid by farmers for bulk gasoline deflated by all prices paid by farmers.

3. My comments on water institutions and water policy are influenced both by my ten years' service on the State Water Resource Board and the Water Policy Board of Oregon as well as my work as an academic resource economist. While I believe economists have made major contributions to the general understanding of water policy and water institutions, their work on institutional reform is much less impressive. It is the literature on general water policy and water institutions that we seem to be ignoring in the current spate of water efforts.