Proceedings

1975
CALIFORNIA PLANT
and
SOIL CONFERENCE

Sponsored by the

CALIFORNIA CHAPTER–A.S.A.

Sheraton Anaheim Motor Hotel
Anaheim, California
January 29, 30, and 31, 1975

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AMERICAN SOCIETY OF AGRONOMY

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CONFERENCE REPORTS

SOIL CONSERVATION AND MANAGEMENT

George E. Goodall
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Food production in California and elsewhere in the world can be increased significantly by using improved management techniques and soil conservation practices. Granted, additional increments of production from our finite resources are harder to come by, but they are possible. And, what's more, the public is expecting us to do it.

In accepting this discussion, I did so on the grounds as a past president of the California Chapter of the Soil Conservation Society of America, I could bring you the ideas of that group of fellow professionals. And, secondly, I accepted because I think we are learning some lessons on natural resource conservation in our Santa Barbara area that make us a leading edge.

You have all heard of GOO - "Get Oil Out" - a militant group of citizens that was formed after our Santa Barbara oil spill several years ago. The typical news portrayal is the contention between GOO and the oil companies. Now, with our critical petroleum shortage, it's too bad that the "environmentalists" won't let the oil companies expand their production using new safety equipment.

As we approach shortages of food, are the desires of the farmer to increase production going to be stopped by environmentalists and others concerned about the safety, both of the food itself and to those who live nearby production areas? My optimistic view is that if we learn from a few experiences and enter into this new position of agriculture with an enlightened attitude, we will be able to feed more of this world's burgeoning population.

In addition to our GOO experiences in Santa Barbara, we have had two other happenings that illustrate that in spite of old precepts and organizations, there is continued need for new approaches in soil conservation to expand agricultural production.

The first example is a rather traditional problem, particularly when one uses the term, "Soil Conservation." After several early, heavy rainstorms, many local urban residents insisted that the County pass a Grading Ordinance to control clearing and grading of new agricultural land. The steep hillsides were being prepared for new avocado orchard plantings.

This occurred without benefit of, and in spite of, existing Soil Conservation Service efforts and Agricultural Stabilization and Conservation Service payments. What is different here can be characterized in three ways.

First, the offending land developers were not those who had experience in our local area. They were from outside or were business investment groups or others whom, as an educator, I had failed to reach with the right kind of information.

Second, the "carrot-on-the-stick" approach and volunteer cooperation are not enough. I'm not criticizing the SCS and ASCS. They are doing a fine job. But their budgets limit their funds and staff engineering time; so eager investment groups can't wait. What is needed in a critical limited resource, such as our land, is that all land developers will be required to develop the land in an acceptible manner; thus, a County Grading Ordinance that enforces compliance to acceptible standards and prevents abuses.

Third, the public's environmental concern, as expressed in Environmental Impact Statement requirements and similar expressions, does extend to agricultural operations. "No one can get away with anything, anymore." Just like, "There ain't no more free lunch." Operation of one's land is scrutinized by neighbors, others in the community, and even by satellites, such as ERTS - Earth Resources Technology Scanner.

There are many other examples. You can probably think of others from your experience. I would like to cite another program that we have been working on in Santa Barbara County that is a part of the improved management techniques involving soil conservation. It is what has been termed Land Conservation, specifically, the Williamson Act of 1965 that provides for Agricultural Preserves.

Santa Barbara County was one of the early participants in this program in 1967. Currently, we have about 80% of our privately owned, rural lands under contract. The program has been both a good land-use planning tool to preserve agricultural land and a satisfactory farmland taxing policy that relates assessments to productive capacity.

On the pro-side, one of our farmers has stated that this program has conserved more agriculture by saving land from urbanization and reducing the tax burden on farmers than all other programs combined.

But, in spite of our success so far, the program is criticized because it doesn't go far enough. Often, some of the best land is not in the program because the landowner hasn't applied for a contract under a permissive program. It is also criticized for not preserving other types of open space, recreation and natural areas, which it was authorized to do. Of course, it is criticized for shifting tax burdens.

Many feel that the direction for California is toward mandated agriculture preserves by boards, somewhat like the Coastal Commission that will designate certain lands for agriculture. Others object. But, underlying this issue is the public concern for its agricultural production resource - the prime land.

What does this have to do with the management to increase food production? Modern farm managers have many things to consider. In addition to the traditional factors of production - land, water, labor, capital, and equipment - they must now include land-use zoning, taxation policy, special districts and permits, and even public opinion.

This more complex view of the entrepreneur's purview of enlightened management suggests a very high level of knowledge. Using the traditional definition of conservation as "wise use of natural resources", we need to expand and redefine "wise." Not only must a high degree of technical knowledge be available, but it must be put together in an efficient, economical plan of work, to obtain a profit. But, it must also be in the public interest and not injure or adversely affect anyone else. What I'm suggesting is that farm operations that are in both the private interest and public interest are the ones that will survive.

I'm not one of the "doom's day boys." We have those in Santa Barbara, also. Just as Karl Marx was wrong, in that corporations did not maximize profit by exploiting labor, but have improved their labor-management relations. Also, U. S. agricultural production expansion disproved Malthus' theory of population control by starvation due to limited food production.

Agri-Business of the future can and will use enlightened management that will not exploit the land, but will use conserving practices to sustain production indefinitely. While he is working hard at this, the public will be looking over his shoulders to see that he is using his resources properly and that their foodstuffs are not polluted. This is what I mean by "both the private and public interests."

As our food supply becomes more scarce with world population increases, the public pressure on the relatively few farmers to use their land "wisely" will increase even more. It's no longer whether a given proposal is in the public interest or in the private interest. Thy both have to occur to have good prospects. The problem for many farmers is to change to consider the public's interest. I'm suggesting if he understands the stakes in the future and considers the public's interest along with his own inputs, that we can make the production advances that will keep us the best-fed, best-housed, best-clothed people everywhere. It will not be easy, but it is a goal. The basic building block is our land; and we must use it conservatively to sustain and improve production to better feed the world.

WATER CONSERVATION AND MANAGEMENT

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Water management for conservation is hardly a new topic; some among us have made a career out of promoting the concept and attempting to develop technological improvements to further the cause. Sometimes we have waxed evangelical, but our audience betimes failed to share our enthusiasm.

In recent years, water management for conservation has gained new significance and attracted new supporters on several fronts. The amount of water available is, after all, finite; and the less expensive new sources have been developed, if not exhaustively, then certainly extensively. Increased pressure for municipal and industrial use, together with a reduction in the percentage of the voting public engaged in agriculture (and thus, of the Congressmen from rural districts), makes just the retention of water rights for irrigation a sometimes tenuous matter - not to speak of expanding the supply. Consider, for example, the recommendations of the National Water Commission.[1]

The Amendments to the Water Quality Control Act of 1972 illustrate the national concern with water quality, and irrigation, by its very nature, does tend to increase the salt concentration in river water. It is estimated by EPA, for example, that 37% of the salt contributed to the Colorado above Hoover Dam originates from irrigation.[2] With or without the Federal Water Quality Act, the water users in Orange County appear quite concerned about the effect upstream water users have on the quality of the Santa Ana. Whereas it is recognized that irrigation agriculture cannot survive for long unless salts are carried out in the drainage water, that doesn't exclude a possible benefit in terms of downstream water quality from improved irrigation water conservation.

It has always seemed obvious that an increase in irrigation efficiency would make more water available for other purposes, including possibly an expansion of irrigated acreage and thus, of food supply. Obvious as it seems, this is not always true: the water "wasted" by inefficient irrigation may well find its way back into a water supply where it can be reused. Nevertheless, the more likely result is one of a loss - a waste of a natural resource - either in terms of quantity, of quality, or in expenditure of energy. The recent World Food Conference in Rome is a forceful reminder that, even if you and I do not necessarily need the potential additional production of food, there are many in the world who do. Thinking back to an earlier study, in connection with the late President Johnson's Panel on the World Food Supply, the Sub-Panel on Water and Land concluded that the world's potential supply of water and land were still far from exhausted if we could find the capital and the will to bring them together and develop them.[3]

Most urgent and recent of the new stimuli is energy conservation. Whether the energy crisis is behind us, as former President Nixon declaimed, or just beginning, we all are painfully reminded of it whenever we buy a tank of gas. Irrigation agriculture produces substantially more food per unit of land, of greater variety and possibly higher quality, than nonirrigated agriculture - but at a considerable cost in terms of energy. Pimentel, et al.,[4] developed statistics on the energy consumption in the production of grain. Using their basic numbers and applying them to a corn field irrigated with three feet of water, it appears that 55% of the total energy required to produce the crop is used for irrigation.

The foregoing enumeration - or harangue - explains the renewed interest, often from unexpected quarters, in water conservation in agriculture and, expressly, irrigation. The problem isn't new, but the interest is, and, with it, the emphasis has shifted. Whereas it used to be necessary to justify irrigation efficiency, like erosion-control measures, in terms of net dollar return, one now begins to hear the question: what is the cost of desirable resource conservation?

Before we address ourselves to some technological innovations and opportunities, I wish to dampen any excessive enthusiasm. I quote from Lou Striegel:[5]

"1. The present approaches to salinity control in the Colorado River Basin are based on a too simplistic understanding of the legal and institutional structures which exist at present.

2. The existing legal and institutional structures are dysfunctional to any comprehensive solution to the salinity problem of the Colorado River Basin.

3. Technology seems to exist for maximization of our water resources and minimization of pollution resultant from the use of water."

No doubt the institutional problems will drastically restrain the adoption of many technologically feasible conservation measures. Yet, it is the area of technology that most of us consider our primary responsibility and expertise.

The range of measures that show promise of enhanced water management is broad. A full discussion should, among other items, address groundwater recharge, reuse of secondary sewage effluent, prevention of saline seeps by more intensive cropping, breeding crop plants for tolerance to higher levels of salinity, as well as irrigation management. It is the latter we shall discuss in some detail, but first a few remarks about two other important, indirect factors that affect water-use efficiency.

Air pollution is normally considered separately from water resources and discussed primarily with reference to human health. But substantial documentation exists that air pollution drastically reduces crop yields - and thus, production per unit of water. In November, 1974, Dr. Ray Thompson, Statewide Air Pollution Research Center at UCR, was quoted in the Riverside paper as estimating a 40% reduction in alfalfa yield in the San Bernardino Valley due to air pollution. Work at our Laboratory[6] confirms this estimate and also identifies a strong salinity-ozone interaction.[7,8,9] Thus, air-pollution control indirectly affects water-use efficiency.

Secondly, utilization of organic wastes, be they sewage sludge or manure, is most often discussed in terms of a disposal problem, rather than as an opportunity for better resource utilization. Whereas a meaningful discussion of this type is beyond our scope, it should be pointed out that optimal use of organic byproducts can lead to improved soil physical conditions and increased fertility, and in turn, to significantly higher water-use efficiency.

Turning now to irrigation management and, inseparately intertwined therewith, salinity management, let us explore some of the potential for increased conservation in light of recent research findings.

For present purposes, we shall define irrigation efficiency (E) as the ratio between the amount of water utilized by the crop in evapotranspiration, V_{cu}, and the amount of water delivered to the field, V_{iw}. This in turn permits the definition of leaching fraction (LF) as that fraction of the irrigation water that passes below the rootzone as drainage water. Leaving out of consideration any tail water or surface runoff, we then have: $LF = (V_{iw} - V_{cu})/V_{iw} = 1 - E$. In order to maintain a level of salinity in the soil water that is not excessive for adequate crop growth, a certain amount of drainage must be provided for. This required amount of drainage (V_{dw}) is generally expressed in terms of the leaching requirement (LR): $LR = V^*_{dw}/V^*_{iw} = EC_{iw}/EC^*_{dw}$.

Here we introduced the electrical conductivity of the irrigation and drainage waters, EC_{iw} and EC_{dw}, and starred the various parameters to distinguish required from actual. To determine the LR, one must establish the level of salinity to be obtained in the drainage water.

It has often been recommended that the value inserted for EC^*_{dw} be taken as the EC_{e-50}, i.e., the salinity in the saturation extract that results in a 50% crop-yield reduction under conditions of a salinity profile uniform with depth. Recent data, however, indicate that with the type of salinity distribution more likely encountered in the field, essentially full yields can be obtained when salt levels far exceed $EC^*_{dw} = EC_{e-50}$.[10,11]

Figure 1 shows steady-state salinity profiles obtained when alfalfa was irrigated in lysimeters with irrigation waters of 1 and 2 mmho-cm and at the leaching percentages shown. Note that the salinity is expressed in terms of EC_{sw}, the electrical conductivity of the soil solution at the water content <u>in situ</u>. Crop yield differences between leaching fraction treatments for a given water were less than those due to change in waters. At LF's below those shown in Fig. 1, salts accumulated in the rootzone over time and yields declined substantially.

As the roots absorb water, the salt concentration in the water remaining increases, leading to the S-type profile of Fig. 1. The limit beyond which the roots cannot absorb water may be estimated from earlier plant tolerance data[12] by extrapolating the yield response curves to zero yield (Fig. 2). Note that in Fig. 2 the salinity is expressed in terms of the electrical conductivity of the saturation extract, EC_e. For alfalfa, the zero yield value obtained in this manner is $EC_e = 14.5$ mmho/cm. To express this value in terms of the conductivity at field moisture content (EC_{sw}) requires a knowledge of the field water content and the water saturation percentage. Accepting a ratio of two between saturation and field capacity as a reasonable approximation, one obtains $EC_{sw} = 29$ mmho/cm. This value is reasonably close to the $EC_{sw} = 25$ mmho/cm read from Fig. 1 for the lowest LF's and lends support to the concept that existing yield response data can be reinterpreted as here suggested by extrapolation to zero yield. For beans and cotton, the EC_{e-50}-values of 3.5 and 16 mmho/cm compare with EC_{sw}-values of 12 and 45 mmho/cm. Thus, the LR is greatly reduced if the EC_{sw} at zero yield is used for EC^*_{dw} in its determination instead of $EC^*_{dw} = EC_{e-50}$.

The above observations on plant tolerance are important by themselves, but they gain additional significance when one considers their consequences in terms of a salt balance. Whereas the general observation is obviously correct that a favorable salt balance need be maintained, it is a serious oversimplification to evaluate this salt balance strictly on the basis of the total amount of salt added in the irrigation water and the total amount removed in the drainage water, especially on a project-wide basis.[13] Of primary interest in the present context are the precipitation and solution reactions that take place in the soil-water complex as a function of mineralogy, ionic composition, concentration, P_{CO_2}, and related parameters. At low concentrations, one expects the solution of certain salt species from the minerals in the soil; at high concentrations, one expects precipitation first of $CaCO_3$ and then of $CaSO_4$ and $MgSO_4$. Detailed experiments with alfalfa grown in lysimeters filled with Pachappa fine sandy loam have provided quantitative data on the various components of the salt balance when these lysimeters were irrigated at LF's of 0.1, 0.2, and 0.3 with a range of 8 waters simulating river waters from the Feather River ($EC_{iw} = 0.1$) to the Pecos River ($EC_{iw} = 3.3$).[14,11]

The results verified that irrigation water with a low salt content dissolved substantial amounts of salts by mineral weathering while initially saline waters precipitated salts. A higher LF increased the amount dissolved or decreased the amount precipitated (Table 1). Expressed in tons/acre-year of salt in the drainage water, the data also show a substantial effect of LF (Table 2).

Table 1. Net effect of LF on salts dissolved (+) or precipitated (-) for six river waters expressed as percentage of salt input (on milliequivalent basis).

	$100(S_m - S_p)/V_{iw}C_{iw}$		
River	0.1 LF	0.2 LF	0.3 LF
Feather	+158	+243	+344
Missouri	-11	+4	+12
Colorado	-23	-2	+5
Salt	-10	+6	+12
Sevier	-22	-8	-3
Pecos	-35	-20	-10

Table 2. Effect of leaching fraction on salt load in drainage water, T/A-yr (based on three feet of consumptive use).

River	Leaching Fraction 0.1	0.2	0.3
Feather	0.77	1.17	1.73
Mississippi	2.34	3.08	3.80
Colorado	2.85	4.08	5.00
Salt	4.08	5.41	6.53
Sevier	4.59	6.11	7.36
Pecos	6.15	8.52	10.96

Independently, a steady-state model has been developed based on theoretical physical chemistry for the prediction of the composition of the drainage water.[15] The results obtained with this model agree extremely well with the experimental data just referred to. Thus, predictions can be made with reasonable confidence beyond the exact conditions of the experiments.

Thus, decreasing the LF can significantly decrease the salt burden of the drainage waters by the harmless precipitation of carbonate and gypsum salts and the extent of such reactions can be predicted. Since the LR as determined from recent plant tolerance data is apparently substantially lower than previously thought - in many instances by a factor of four - and, in absolute terms, seldom as high as 0.10, there is an excellent opportunity to reduce the salt load contributed by drainage water through better irrigation management. At the same time, such improved management would increase the water-use efficiency substantially.

In practice, the degree to which the foregoing concepts can be applied in irrigation management depends on the ability to control water application accurately and to determine the amount of water needed. The traditional irrigation cycle results in alternating dry and wet periods; during the dry period, osmotic stress in the upper part of the rootzone would reduce the availability of water to roots. Thus, a relatively short irrigation interval is indicated, with essentially continuous water application as practiced with trickle irrigation the ideal. Traditional irrigation methods, especially gravity irrigation, also tend to apply water at a rate that exceeds the infiltration capacity of the soil; this causes a nonuniform distribution of amount of water replenished, because soils are notoriously nonuniform. If the water is applied at a rate less than the infiltration capacity of the soil, then the infiltration rate depends on the application rate and not on the soil properties. Again, frequent irrigation is indicated.

Determination of the amount of water needed requires knowledge of the evapotranspiration rate (ET) or, as an alternative, some feedback system that depends on the drainage rate. Average annual ET can be estimated reasonably closely, but daily, or short-term, rates are generally not known accurately. Clearly, an error in ET of, say, 10% would be excessive if used to control a LF of 0.05 or 0.10. The alternative of a feedback system depends on identifying a measurable parameter with short response time. Soil matric potential, such as measured with a tensiometer, suffers the drawback that, at steady state, wide fluctuations in LF would cause very limited changes in the measured water potential. Salinity, as measured with a salt sensor, is wanting in that the changes in salinity at or near the bottom of the rootzone occur too long after changes in water application rate must be made.

To evaluate the potential of increasing irrigation efficiency under the field conditions, the USSL has initiated three field experiments. One, in cooperation with ARS personnel from Fort Collins, Colorado and with financial support from Bureau of Reclamation, involves irrigating corn in the Grand Valley of Colorado. The most pertinent part of this experiment consists of a 180-meter radius electric-drive pivot sprinkler system, arranged such that three LF's are obtained in two replications on each of the 60-degree segments. The LF's of 0, 0.05, and 0.15 are approximated in this instance by calculating the ET using the Jensen-Haise procedure.[16] Conditions are monitored by means of numerous salt sensors and tensiometers read at frequent intervals, by means of one weighing and several non-weighing lysimters, with a series of vacuum extractors, and by metering the amount of water applied to each segment. After only two seasons, it is not yet possible to make any definitive statements on salt balance. Crop yields have compared favorably with those on adjacent areas and the salinity profiles are indicative of adequate, if minimal, leaching.

The second field experiment is located on the Mesa near Tacna, Arizona, in the Wellton-Mohawk Irrigation District. It consists of a trickle irrigation system on mature Valencia oranges, on soil classified as Dateland fine sandy loam - a typic haplargid, coarse loamy, mixed hyperthermic. The basic experimental design consists of nine replications of three LF treatments (0.05, 0.10 and 0.20), each containing a block of nine trees. Each tree is irrigated through its own flow control valve using 35 meters of Anjac twin-wall tubing spiralled around the tree. The water applied to each block is metered. Extensive instrumentation provides frequent information on the salinity status and soil water potential with depth and on the volume of drainage water.

The third field experiment, also near Tacna, Arizona, is on alluvial soil (Indio fine sandy loam - typic torrisluvents, coarse silty, mixed (calcareous) hyperthermic) rather than on the Mesa. In this case, alfalfa is the test crop and the irrigation system used is a lateral-move spray irrigation system. Five replications of three LF's are used on strips 12 m wide by 100 m long. The corn experiment in Grand Valley was initiated in March, 1972, the citrus experiment in December, 1973, and the alfalfa experiment in October, 1974. In each case, comparisons are made with gravity systems similar to those used locally.

Of special pertinence is the control system used to schedule irrigations on the alfalfa and citrus experiments. We shall describe it in some detail, using a block of nine trees as an example.

Four tensiometers under one tree of each treatment block, all at 30-cm depth, are equipped with electric sensors that provide an off-on signal when the water potential exceeds or is less than a predetermined level. A time-clock signal interrogates each of these sensors several times daily. When any two of the four tensiometers indicate that the tension exceeds the setpoint, a solenoid is activated that permits 120 liters of water to be delivered to each tree in the block; alternatively, when fewer than two tensiometers "call" for water, no water is delivered. The selection of the setpoint depends on the salinity in the soil profile. Ideally, the value considered should be the salinity just below the rootzone. From the desired LF, and the known EC_{iw}, one can calculate EC^*_{dw} by an equation like $LF = EC_{iw}/EC_{dw}$, but corrected for salt precipitation. Since the time required to obtain an equilibrium salt distribution is too long, it is necessary to select a shallower reference depth. This, in turn, requires an adjustment in EC^*_{dw}, because one no longer has a measurement at the bottom of the rootzone, but somewhere within (Fig. 1). Lack of knowledge of the actual rootzone depth and of the water uptake distribution makes, for the time being, the selection of the working value of EC^*_{dw} (rather, EC^*_{sw}) a matter of judgment.

Having selected the control depth as 30 cm and the desired value of EC at that depth, the time trend of EC at that depth is monitored. When either the absolute level or the direction of change is not as desired, the setpoint on the tensiometer is adjusted. Such adjustments are required at first to bring the system to some desired state of quasi-equilibrium. Later, adjustments continue to be required because the ET changes as the season progresses.

Experience to date has indicated that the above logic can be used effectively. It also has verified the anticipation that the matric potential setpoint would be relatively high - around 70-90 cm of water for a LF of 0.05. Figure 3 illustrates the time course of salinity at various depths, together with the setpoints chosen, for three treatment blocks with a planned LF of 0.05.

Our objective has been to outline the reasons why we are convinced of the potential for improved irrigation management to reduce the adverse effects of irrigation on downstream water quality and to indicate our commitment to verify this conviction through extensive field scale experimentation.

That the present level of irrigation efficiency, on the average, is deplorably low, few will argue. It is my understanding that a fairly recent survey conducted by the U. S. Bureau of Reclamation of 231 irrigated fields showed that only 44% of the water applied was used consumptively.* Substantial improvement is no doubt possible by better on-farm practices. Further improvement may often depend on expensive modification of the water distribution system. Here we do not address ourselves to either the engineering aspects of modifying the water distribution system or to the economics of irrigation efficiency improvement. We restrict ourselves to the implications in terms of the conservative and beneficial use of our natural resources.

We have demonstrated that irrigation agriculture can be maintained satisfactorily with efficiencies above 90% - LF's below 0.10 - without adverse effects in terms of salinity. Such high efficiencies would result in substantial reductions in the mass of salt discharged in the drainage water, in the volume of water applied for irrigation, and in the volume of drainage water; in an appreciable increase in salt concentration in the drainage water and in a change in drainage water composition to a higher SAR. To be feasible of attainment, however, such low LF's require very close control over water application to obtain high uniformity; uniformity of application and of infiltration is most easily obtained with pressurized irrigation systems.

Aside from the primary benefit in terms of reduced salt loading in the drainage water, one also should take account of probably major reductions in fertilizer needs - especially nitrogen - and of drastic changes in total energy consumption as the amount of water delivered is reduced.

Whatever the short-term economics, it seems eminently desirable to work towards conservative resource utilization in the first instance in contrast to searching for corrective measures after the fact.

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*Personal communication from John T. Maletic.

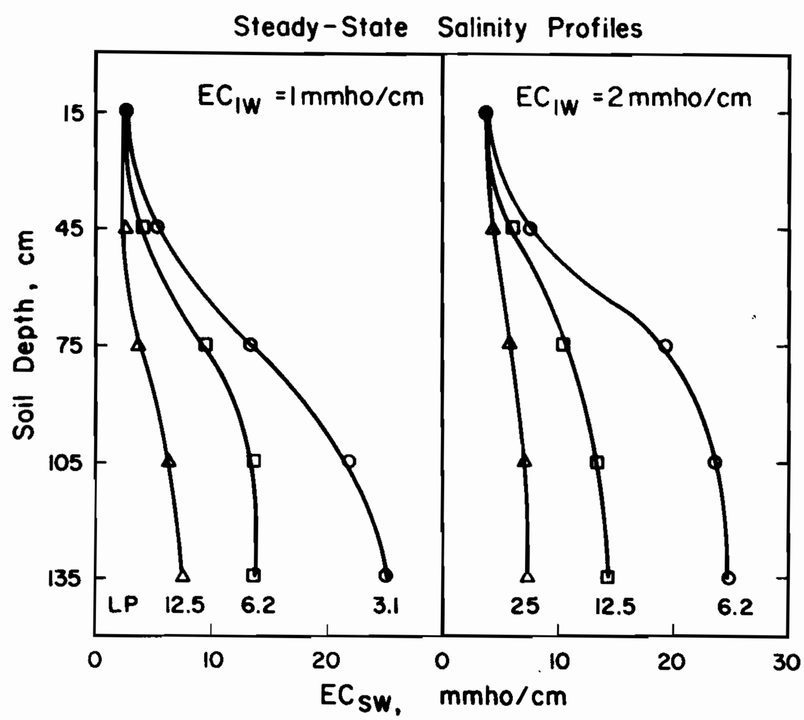

Figure 1. Steady-state soil water salinity profiles obtained with alfalfa irrigated with irrigation waters shown at indicated leaching percentages.

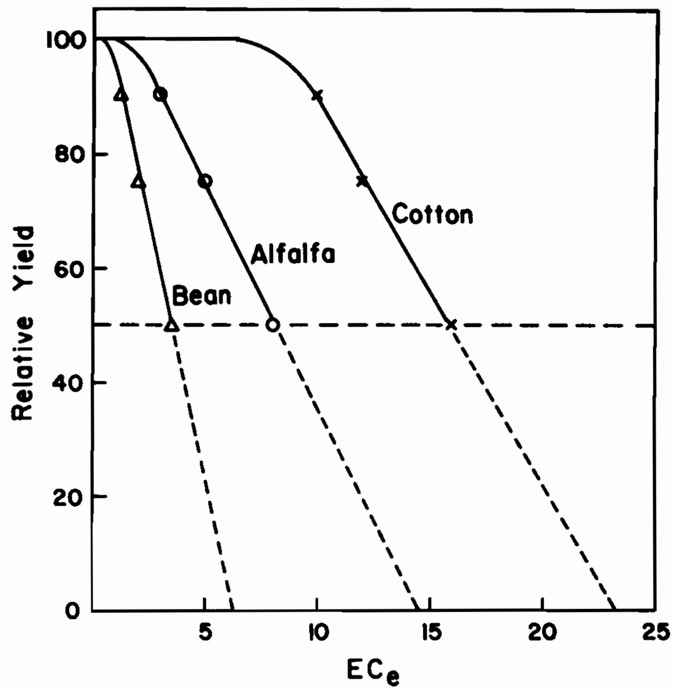

Figure 2. Extrapolation of yield response curves to establish zero yield soil water salinity.

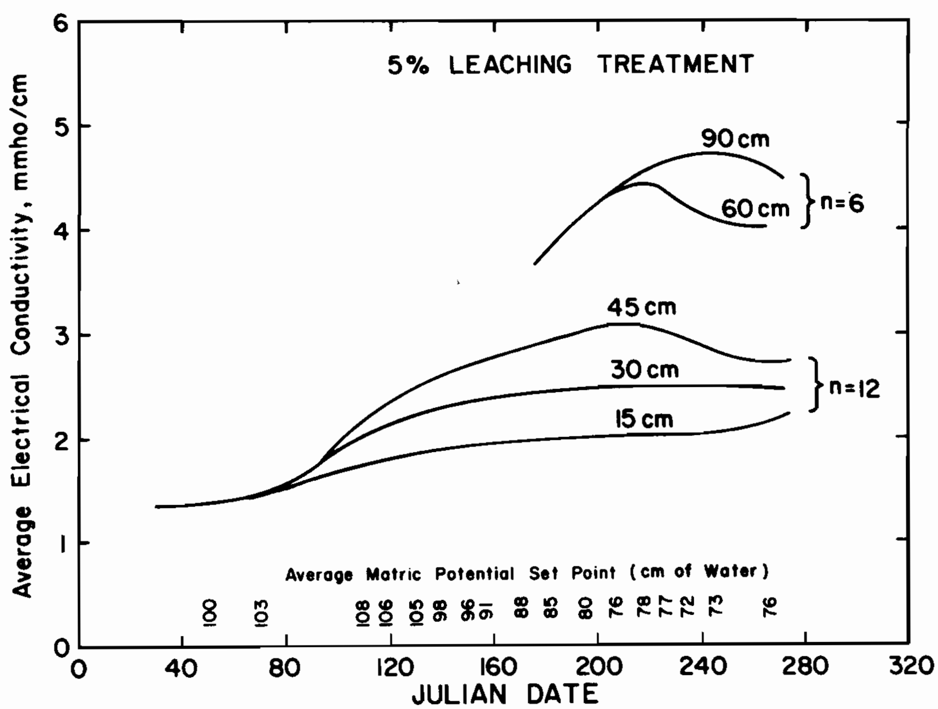

Figure 3. Time course of the change in soil salinity at various soil depths for the 5% leaching treatment in the citrus experiment. Average of three plots; n indicates number of sensors averaged.

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A HUNGRY WORLD: THE CHALLENGE TO AGRICULTURE*

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The present world food problem, triggered by a sudden decline in world food output in 1973 and by continuing upsurge in world food demand, has various causes. Some, such as poor weather, may well be temporary influences; but others, such as rising population and the energy shortage, are longer range in nature.

A crucial question is: Will the primary factors behind this latest dramatic development in the world food situation be permanently significant, or will they disappear in two or three years?

Of course, no unqualified answer is possible at this time. But, it is imperative that an attempt be made to assess the available evidence in order to provide an independent, objective judgment of the long-term prospects for the world food situation.

The University of California Food Task Force report, therefore, has these objectives:

1. To evaluate expected world food supply-demand conditions in 1985 and beyond;
2. To identify the basic factors which may lead to shortfalls in food supply;
3. To identify alternative solutions; and
4. To assess the implications for the world, for California, and for research and education.

World Food Needs

Three basic factors determine the demand for food by humans:

1. Population,
2. Per capita market demand, which in turn is influenced by
3. Income levels and distribution.

Population. The world population, estimated at 3.86 billion in mid-1973, is growing at a rate of two percent per year. There appears to be little chance of much drop in that overall rate by 1985. In the developed world, the problem appears to be manageable; but in Asia, Latin America, and Africa, growth rates remain excessively high. The problem is particularly serious in Asia, where population density is already high.

Income. Worldwide income averages have been climbing faster than population, but that fact reflects affluence in the developed world. The problems are (1) the income gap between the "have" and the "have-not" nations, and (2) income gaps among individuals and households within nations.

Demand. It appears that until 1985 at least, effective per capita demand for almost all crops and animal products will grow even faster than population. Per capita consumption demand trends differ in developed and developing countries, but the overall projected increases in total population indicate much larger total food needs in 1985 and beyond.

Individual nutritional requirements, of course, may be different than per capita market demand. One question is that of protein needs versus energy (calorie) needs. Despite worldwide concern about protein shortages, the evidence indicates that future shortages of calories to satisfy nutritional requirements will be more crucial than shortages of protein.

The extent of the future world problem will depend on the balance between (1) gross food demand (allowing not only for food, but also for non-food uses and losses) and (2) effective supply (the amount that actually will be produced and marketed).

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*Highlights of University of California Food Task Force Study.

World Food Production Potential

Crops, including those fed to animals, furnish nearly all of the world's human food supply - whether the output is measured in terms of tonnage, food energy, or protein. Animal products and fish provide about 35 percent of man's protein.

Cereal grains are the most important crops, accounting for about 75 percent of both the world's cropland area and the total calories produced. Wheat and rice are the two most important single crops.

Crop production has been projected to 1985. Among the cereals, wheat yields should continue to increase as they have since 1950, so that little increased cropland will be required. Rice yields are projected to increase at a somewhat slower rate than wheat. For maize, substantial increases in both yield and cropland are needed and appear achievable. For soybeans and dry beans, potential yield increases are limited, so that substantial increases in area will be needed.

The outlook for supply of animal products (meat, milk, eggs) is less predictable because livestock productivity so far is very low in many areas for various reasons - low genetic potential, poor disease control and management, etc. However, there have been dramatic increases in animal product output in the developed countries during the past two decades.

Future gains in aquatic food production will be limited by both biological and institutional factors. Aquaculture is generally believed to have limited potential to increase total food output under presently prevailing conditions.

Limiting Factors

Future food output will be limited and/or increased by the renewable natural resource base, by development of technology, by energy, and by other environmental, economic and institutional forces.

Some of the more significant factors are availability of arable and irrigable land; climate; inputs of fertilizer, pest and disease control, irrigation, mechanization and plant improvement; livestock breeding, management, and disease control; environmental quality; fossil fuels and other energy sources; and such human factors as poverty and institutional constraints.

Food Balance in 1985

On a worldwide basis - and allowing for various assumptions and unknowns - 1985 human food production from crops and animals is projected to balance reasonably well with the gross amounts required at present levels and composition of food ingestion. There will be an overall shortage of oilseeds, and also some possible shortfalls in market supply of certain animal products - primarily, a reflection of affluence in developed countries.

These points are clearly indicated:

1. Effective demand and production may be about equal on a world basis, but there will be wide imbalances among regions.

2. Calories are projected to be in shorter supply than protein.

3. Regional shortages will have vastly different implications for areas which can afford to buy on the world market (Europe) and for those which cannot (Asia, Latin America).

Projected food energy and/or protein deficits which appear relatively small on a percentage basis in Asia, Latin America, and Africa are actually critical because they are expected to occur in areas where population pressures are high, productivity and per capita incomes are low, and the sheer volume of projected deficits is almost overwhelming.

Two regions - North America and Oceania - show projected surpluses of both food energy and protein not only well above the levels required for their own nutritional needs, but also well above internal effective demand. Combined potential surpluses in these regions could make up all the world's food deficits in 1985 if:

1. Economic incentives to producers are sufficient.

2. Developed countries are able and willing to assist or subsidize the transfer of food to whatever degree is necessary.

Patterns of international trade, including economic forces, governmental policies, and the effects of the energy shortage, will have a large influence on the outcome.

Worldwide Implications

There are both short-run and long-run aspects of the world food situation as projected to 1985 and beyond. In several regions, population growth rates in excess of food production increases, expected to continue at least to 1985, will compound food supply problems over the long run. Meanwhile, short-run market surpluses - i.e., actual supplies in excess of effective demand - are likely to recur in those countries capable of producing food in excess of their consumption requirements. Thus, the distribution of world food supplies will remain a more serious problem than total world crop and animal production. Given the limited purchasing power of many consumers in less developed nations, the world food dilemma will continue: malnutrition and starvation in some areas, while food surpluses accumulate in other regions.

The world's food shortages will continue to be centered in the developing regions of Asia, Africa, and Latin America, but the problem is worldwide. Effects of human suffering and unrest in the developing regions inevitably will be felt elsewhere. In addition, potential solutions to the world's food problem have their origins in industrialized nations, or at least will require their cooperation.

Outlook Beyond 1985

The food situation beyond 1985 is more uncertain. While no attempt was made in this study to assess food balances after 1985, certain key issues need emphasis. World population is projected to increase by another one or two billion from 1985 to 2000. At the upper population variant, this means feeding about twice as many people in 2000 as existed in 1968. At the lower variant, the world population in 2000 would still be 50 percent larger than it is today.

The amount and quality of the world's undeveloped arable land creates further uncertainty for food production beyond 1985. For obvious reasons, the best and easiest land was developed first. It will be increasingly difficult to mobilize the necessary human, institutional, and economic resources rapidly enough to keep pace with food demand in countries where the need will continue to be most critical.

Technology and research requirements for the 1985-2000 period present even greater challenges. Much of the yield-increasing technology assumed in our projections for the 1970-1985 period is currently available for adoption or is in the advanced stages of development. But, meeting food production needs during the last 15 years of the 20th century will depend upon accelerated adoption of known methods, development of new technology, and, indeed, some real "breakthroughs". Broad planning, basic and adaptive research and the development of effective vehicles for international cooperation are imperative if food production technology is to be available when and where needed. Improved methods for monitoring of world food production and utilization will be required for effective planning.

A final word of caution for the 1985-2000 period relates to those parameters over which man has the least control. The more intensive the food system becomes, the more vulnerable it is to unexpected adverse dynamics from physical and biological factors. Possibilities of genetic failures, diseases, global weather disturbances and sudden crucial input shortages make the world food system more precarious. It behooves both developed and developing countries to allow for a margin of safety. Technological development and food reserves are two ways to provide that margin.

Implications for California

California, as an important producer of many crops (specific production projections to 1985 are given), will play a significant role.

Important considerations within the state are:

1. The diversion of agricultural land to other uses.
2. More efficient use of the water resources.
3. Conservation of energy in food output operations.
4. The shift toward intensification of crop production.

Implications for Research and Education

Worldwide research and education needs are particularly urgent in the areas of:

1. Population growth.
2. Nutrition.
3. Crop production, particularly the use of tropical soils; productivity of water use; pest control; fertilization; and genetic resources.
4. Animal production, particularly the underutilized range resources and the underexploited genetic potential of livestock.
5. Energy in food production-consumption systems.
6. The environment, particularly management of pollutants and analysis of trade-offs between environmental and food production goals.
7. Human and economic institutions, particularly the problems of income disparity and research delivery systems.

PROFESSIONAL CERTIFICATION AND THE AGRONOMIST

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The basic objective of a professional society and the principal service to its members will be the "communication" of new scientific discoveries and ideas and the elimination of "error." There are many who now believe that a "member service" should also include. . ."some kind of certification, registration, or creditation," as noted recently in a personal communication from Dean B. R. Bertramson of the Washington State University, Pullman.

The question of professionalism within the American Society of Agronomy was suggested by Dr. L. A. Richards in 1965 in his presidential address:

> "At present, membership in our associated societies is composed of friends of agronomy, crop science, and soil science who are willing annually to contribute the subscription price for one of our major periodicals. At some state in our maturation process, I have no doubt, we shall become professional societies and require a certain level of technical preparation for full membership as is done by (some other) professional societies. It may not be too soon to start thinking about this."

The SSSA has provided certificates for students completing the B. S. degree with adequate training in soil science and related fields for many years; and, in 1965 as president-elect of SSSA, I had the pleasure of appointing an ad hoc "professional standards and status" committee with Dr. W. E. Raney, as chairman, to study the matter. This became a standing committee (S-502) in 1967; and in 1968 Dr. C. A. Black became chairman. In 1974 this committee was superseded by S-573, a committee on the "Certification of Soil Scientists", with Dr. R. B. Grossman as chairman. There is much activity on the state level in the "registration" and "certification" of soil classifiers. The North Dakota and Maine legislatures, for example, in 1973, established an official registry of soil classifiers. Registration is being seriously considered in Arizona, Nebraska, California, Idaho, Illinois, Minnesota, and Wisconsin. . .and probably others.

In 1968 the question of "professionalism" for members of the American Society of Agronomy was debated within the "Organization, Policy and By-Laws" committee (A-201), Dr. L. B. Nelson, chairman, and in 1970 an ad hoc committee on "certification of agronomists" (A-591) was appointed with Dr. Malcolm McVickar as chairman. This was authorized to become a standing committee in 1973, relabelled, "Professionalism in Agronomy" (A-591), with Dr. J. C. Engibous as chairman. A report from this committee recommending the establishment of an "American Registry of Professionals in Agronomy, Crops and Soils" (ARPACS) together with criteria and procedures and a "code of ethics" statement was presented to the Board of Directors meeting in Chicago, Illinois, on November 15, 1974. The proposal was approved in principle; and the Executive Committee was directed to work with the committee on suggested revisions of the outline. The establishment of a certification program was made as indicated. This is a notable achievement.

Other professional societies comparable to ours are also moving rapidly in this direction or have established "certification" so as not to be disadvantaged in comparison with the veterinarians, foresters, and engineers who have supported professional certification for some time. These include the geologists, entomologists, plant pathologists, and animal scientists, among others.

The real purpose of "certification" is not only to protect the integrity of the profession, and thus, the public, from the "self-styled" experts who are flooding the media with irresponsible misinformation, but also to serve the interests of the members by certifying only those with technical competence based on training and experience within a professional speciality. "Accountability" comes from the acceptance of a "code of ethics" which has traditionally defined. . ."a professional's highest ideals of conduct. He accepts the obligation to exercise critical self-discipline and judgment in gathering information, in using it, and in transmitting it." (From a "statement on professional ethics", AAUP Bul. LIL302-3, June, 1965.)

Certification, an Optional Membership Service

There are, of course, many members who do not wish to be "certified", as such. These will include many who feel that they have adequate "credentials" through their academic, State or Federal employments, and those who do not wish to function as "professionals", but who are supportive of the objectives of the Society. Certification will most appropriately be by request, will require a "registration fee" to defray the costs engendered by a "certification board or committee", and could well be administered through a profession-wide organization, such as. . ."The American Institute of Professionals in Agronomy, Crops and Soils." The certification panels would be appointed by the Executive Committees of the associated societies; they would undoubtedly require an acceptable education with appropriate degrees, professional experience, and, if necessary, knowledge of the speciality area by examination.

Members in commerce or industry, consultants, or those in regulatory or control programs on the local, State, or Federal level, and others, surely need the support of a certification program. To quote directly from the committee (ASA-591) report presented to the Board of Directors by Dr. J. C. Engibous, Chairman:

> "New laws governing crop production and quality practices; air, water, and soils quality standards; disposal of industrial as well as agricultural wastes; and the use of agricultural chemicals are examples of new situations that require the services of specialists in agronomy, crops or soils. Many regulatory and control programs require inputs from those professionals. This requirement in turn generates a requirement for a means of identifying persons who are qualified professionals. . .and that (they) be able to show evidence of their training, experience and special abilities."

Testimony in court of "certified" individuals carries considerably more weight than testimony from "concerned" individuals. A realistic certification program. . ."is clearly in the public interest."

MILTON D. MILLER
RECIPIENT OF THE CALIFORNIA CHAPTER ASA
DISTINGUISHED SERVICE AWARD
Annual Meeting - January 30, 1975

On June 7, 1974, Milton Miller completed a career with the Extension Service of the University of California which he began more than 38 years ago when he became field crops farm advisor in Ventura County in 1936. Except for the five years he spent in military service from 1941-1946 where he entered service as a second lieutenant and emerged as a lieutenant colonel, he has devoted his entire professional career in the interests of serving his profession of agronomy through the University Extension Service.

After his discharge from the armed forces in 1946, he became Extension Agronomist on the Davis Campus from 1946-1949; Farm Advisor, Glenn County, 1949-1955; again returned to Davis as Extension Agronomist from 1955-1964; Assistant State Director of Agricultural Extension from 1964-1966; and, again, Extension Agronomist, Davis Campus, from 1966-1974.

During his tenure with the Extension Service, Milton Miller has been responsible for organizing and conducting programs on oilseeds, which resulted in the establishment of safflower as a major crop in California, on small-seeded legumes, on seed certification, genetic improvement, rangeland management, cotton mechanization and in rice. His effectiveness as a leader and organizer in rice earned for him the award of "Rice Man of the Year" in 1970 and the "Distinguished Service Award" of the U. S. Rice Technical Working Group in 1974.

In addition to his distinguished service as an Extension Agronomist, Milt also has given unselfishly of his time and efforts to the American Society of Agronomy. He has served on the Editorial Board of Crops and Soils; as Associate Editor, Journal of Agronomic Education; Chairman, California ASA Membership Committee; member of the ASA Variety Registration Committee; member of the Awards Committee; Chairman of the Publicity Committee for Crops and Soils and a member of the Executive Committee and Vice President, California Chapter, American Society of Agronomy. Milton was recognized for his service to the ASA by election as a Fellow in 1972.

Milton Miller also has made valuable contributions through his research on the effects of organic compounds on seed yields and quality of wheat, barley, field beans, Ladino clover and alfalfa, leading to 25 technical publications in this field. As a rice and oilseeds extension specialist, he has published over 125 technical and semi-technical papers, a large number of popular publications and extensive radio and television performances.

And, finally, Milt Miller also has served his profession abroad. In 1966 he was a member of a team of scientists which assisted Kasetsart University in Thailand in a review to develop its agricultural research and education. For three years, he helped train Peace Corps volunteers. During World War II, he was technical advisor to the U. S. Army and to the Australian Government on food production.

To Milton Miller, a gentleman, a scholar, a dedicated agronomist, a scientist, an organizer of support for programs, a statesman in our profession, we present to you in public recognition of your many contributions this award from the California Chapter. . . an award which we hope represents the affection and admiration we have for you and for your career of service to your profession.

FERTILIZER USE BY CROPS IN CALIFORNIA

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In 1973 a survey was conducted within Cooperative Extension to obtain information regarding the use of fertilizers supplying the three major plant nutrients on 70 major crops representing a large majority of the cropped acreage in California. Information was obtained on the range of rates applied, the common rate of application, and the percentage of the acreage fertilized for each crop on a county basis. The California Crop and Livestock Reporting Service was the source for crop acreages within the counties. The counties were divided into six regions on the basis of similarity of cropping systems. The estimated total amount of each nutrient applied is the sum of the common rate for each crop times the acreage times the percent acreage fertilized. The totals in tons are approximately 424,000 of N; 117,000 of P_2O_5 and 49,000 of K_2O; these values represent 97, 76 and 96 percent, respectively, of the tonnage of those nutrients sold in California in 1972 according to the State Department of Food and Agriculture fertilizer reports.

Common rates of N, P_2O_5 and K_2O averaged statewide for several representative crops are given as follows: wheat, irrigated, 104, 33, 3; cotton, 109, 42, 100; rice, 86, 37, 10; alfalfa, 20, 76, 19; almonds, 127, 14, 79; peach, 129, 21, 78; wine grapes, 53, 20, 112; grapefruit, 154, 43, 29; lettuce, 159, 93, 48; tomato, 142, 80, 55; turf, 200, 75, 55. Regional differences do exist which can account for the discrepancy between the average value and the actual rate commonly used by growers. Because of the closeness of the estimate to the actual amount of plant nutrients sold in the state, these estimates are considered to be reasonable estimates of rates of fertilizer usage by growers in California.

SYMPOSIUM: APPROACHES FOR MAXIMIZING FERTILIZER EFFICIENCY ON CALIFORNIA CROPS:

EFFICIENT USE OF NITROGEN - CITRUS

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Use of leaf analysis as a guide to fertilization has proved to be the best method in achieving an overall increase in N efficiency for citrus. For example, the history of N usage on oranges in California shows that prior to about 1960 many growers were using more N than was needed to produce the crop. In many areas the pounds of N applied per acre is now less than half of what it was prior to 1960; yields have been maintained and fruit quality has improved. The reduction in N rate was associated with increased commercial usage of leaf analysis as a guide to N fertilization. Also, since 1960, as a result of the decrease in fertilizer applied, the annual per-acre amounts of fertilizer N that were subject to leaching in the Santa Ana Watershed were reduced by an estimated 50% in Riverside County and about 80% in San Bernardino County.

Fifty-six "experiment years" of orange, lemon and grapefruit data show that, pound-for-pound, foliar-applied N (urea, containing less than 0.25% biuret) was as efficient as soil-applied N (from urea, ammonium nitrate, calcium nitrate, or anhydrous ammonia) for fruit production. However, while one annual soil application supplied adequate N, three to six or more annual sprays were required. The total yearly amount of N applied per tree to the foliage depended upon tree size, foliage density, spray solution concentration, and the number of sprays per year. At or near the maximum nutritionally-attainable yield, from 11 to 75% of the applied N was removed from the orchard in the fruit; and fruit produced per pound of applied N varied from 97 to 484 pounds. Under N-deficient conditions, more N was removed in the fruit than was applied; and as much as a ton of fruit was produced per pound of applied N. Orchards that produce larger crops, for reasons other than nutrition, have greater N efficiencies.

Experiments in progress show that a lower potential to pollute groundwaters with nitrate is associated with foliar-applied N than with soil-applied N.

FERTILIZER PLACEMENT MAXIMIZES FERTILIZER USE EFFICIENCY

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Drilled placement of seed and fertilizer for many field crops is often twice as effective on phosphorus deficient soils as broadcast applications. Likewise, a given yield is often attained by using only half as much phosphorus applied by drill as is needed if seed and fertilizer are broadcast.

Adequate amounts of available plant nutrients must be present in the root zone of plants at the time of high nutrient demand if high crop yields and efficient use of fertilizer is to be obtained. A large portion of the total nitrogen and phosphorus required by many field crops is taken up during the first two months of growth when several important crop yield components are determined. Proper placement insures accessibility of nutrients, enhances the solubility of phosphate fertilizers in many soils, stimulates plants to their optimum performance assuring earliness of maturity and reduces weed competition. For these reasons, fertilizers for cereal crops, sorghum, safflower, corn and others are normally applied slighly before, or at the time of planting. Numerous California studies have shown that nitrogen-phosphorus fertilizers drilled with a split boot opener at the time a crop is seeded are more efficient in increasing yields and fertilizer uptake than other seeding and fertilizing methods. A comparison of methods of seeding and fertilization on non-irrigated barley is shown below.

Fertilizer lbs/acre	Method of Seeding and Fertilization: Seed Broadcast Fertilizer Broadcast lbs/acre	Seed Drilled Fertilizer Broadcast lbs/acre	Seed Drilled Fertilizer Drilled lbs/acre	Increase Due To Fertilizer lbs/acre
None	1917	2043	2043	---
N_{40}	2173	2266	2454	297
P_{40}	2110	2227	2332	222
$N_{40}P_{40}$	2461	2659	2930	682
Increase Due to Method	--	134	275	

Crops grown in rotation with rice have received very large benefits from banded nitrogen and phosphorus. While rice on these soils ordinarily does not respond to phosphorus, succeeding crops are often seriously affected by phosphorus deficiency. Phosphates which are released to rice in flooded soils by several mechanisms, including the reduction and hydrolysis of insoluble ferric phosphate to more soluble ferrous phosphate, the release of occluded phosphate by reduction of hydrated iron coatings and exchange reactions with clay, organic matter and organic ions are reversed when the soil is dried. This leads to enhanced reactivity of the soil sesquioxide fraction resulting in decreased solubility and availability of phosphorus. Highly significant yield responses to banded phosphorus applications have been obtained in crops following rice.

EFFICIENT USE OF FERTILIZER FOR VEGETABLE CROPS

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There is abundant opportunity for increased efficiency in vegetable crops fertilization. As a class, vegetables are probably the most heavily fertilized crops that we produce. Surveys have clearly indicated that in our more intensive vegetable production areas of California, the availability of certain nutrients has been built up by fertilizer application over the years to very high levels.

Until very recently, vegetable growers have shown very little interest or inclination to make changes which result in increased fertilizer efficiencies. With the escalation of fertilizer prices and the shortages of some materials, the vegetable industry will be forced to adopt more efficient fertilizer programs and practices. Fertilizer management on the basis of sound knowledge and using scientifically proven tools and techniques is gradually replacing management based on past practice and tradition.

One important aspect of vegetable fertilization which requires attention is fertilizer timing. Generally, all P, K and Zn, if required for the crop, should be pre-positioned before or at planting time since these nutrients are relatively immobile in soils and need to be where crop roots will encounter them early. Nitrogen, on the other hand, because of its vulnerability in the soil to oxidation, reduction, movement and loss to the system, should usually be applied by installments with half or less at planting time and the remainder following stand establishment. Late N applications (beyond the midgrowth stage) are often wasteful, having little or no effect on yield or quality.

Methods of application and fertilizer placement are also areas wherein efficiencies can be achieved. Broadcasting fertilizer was and is an effective method when heavy application rates are used. With present high levels of available P and K in many districts, the need for heavy rates is diminished. With lesser rates, soil injection becomes a more efficient method. Placement must consider the nutrient source or material, crop, soil, irrigation method, and season of the year. The rule-of-thumb is: "Near enough for plant roots to reach early, deep enough to remain moist, and far enough from seed or plant to avoid injury." With some crops and under certain conditions, this means fertilizer in close proximity to seed or plants while in other instances fertilizer is considerably removed.

Fertilizer sources should be carefully selected to fit the needs and conditions of the crop. Where N is the only fertilizer nutrient needed, it is wasteful to apply fertilizers which also supply P, K or Zn. Soil analyses can tell the grower well in advance whether or not there is any likelihood of crop response to P, K or Zn application. Plant tissue analysis, when used to monitor a crop's nutrient status, can indicate the adequacy of N in the crop, sometimes allowing deferment or elimination of N application when there is great sufficiency or permitting extra application when deficiency is indicated. Although plant analysis reliably indicates the nutrient status of P and K, there is seldom time with vegetables to take corrective action when P and K deficiencies are detected by plant analysis.

EFFICIENCY OF FERTILIZER APPLICATIONS TO GRAPES

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Contrary to many other California crops, the grape vine does not require a high level of fertility. It thrives best with a deep, unobstructed root zone and a relatively low mineral nutrition level. So far, in California we have found only four mineral elements to be deficient in vineyards - nitrogen, potassium, boron, and zinc. For efficient use of fertilizer, the recommendation is that each nutrient deficiency be treated singly, i.e., not with a mixed fertilizer.

Nitrogen. Many vineyards receive nitrogen applications when they do not need any; others are fertilized at the wrong time. Most frequently in California, the results have been best in terms of yield response to amount applied when rates of about 50-60 pounds of nitrogen per acre have been banded, i.e., applied in a two-foot band, each side of row, during January and February. In some situations, there may be volatilization losses from surface applications. The cost of these must be weighed against the cost of drilling or immediate discing.

Potassium. Grapevines rarely, if ever, show a measurable response to potash applications unless the vines show visual symptoms of deficiency. These symptom areas are spotty in California, often not more than an acre or so in size; and since heavy application is required for response, spot treatment with rates of 2 to 5 pounds of potassium sulfate in deep furrows close to the vine row is usually the most effective and efficient use of potash.

Boron. Boron excess is far more common, more widespread, than is deficiency, but crop level is reduced much, much greater by deficiency. Like potassium, boron deficiency is spotty, but treatment is relatively inexpensive - about 10 pounds of actual boron per acre, applied about every third year.

Several soluble forms are available. The low, per-acre rate is most economically applied by spraying on the soil during the dormant season.

Zinc. In total vineyard acres subject to deficiency, zinc ranks second to nitrogen. Soil applications are not practical. For spur-pruned varieties, the painting, (daubing) of pruning cuts within a few hours with a solution of one pound of zinc sulfate per gallon has been by far the most effective and sure control. For cane-pruned varieties, foliar sprays applied two to three weeks before bloom seem to be the only remedy, but because the grape leaf does not readily absorb mineral nutrients, the results with this approach are often erratic. More work must be done.

General Comments: As just stated, the grape leaf is very inefficient at absorbing mineral nutrients. Thus, the various concoctions on the market for foliar application, are of little real benefit. Several intensive trials with both urea and with potassium nitrate sprays adequately prove the ineffectiveness of this approach. As yet, there have been no beneficial results to our vineyards from applications of phosphate, applied in any form, by any method; one reason for avoiding formula mixes containing P. Organic sources of nitrogen are either so low in N that supplementary inorganic N must be added, or what N they do provide comes at a bad time - too late to be of most worth. As fertilizer costs continue to increase, more and more importance should be placed on tissue analysis and correct diagnosis of visual symptoms.

DECIDUOUS FRUITS

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Current recommendations for rates of nitrogen application to deciduous orchards are not excessive for currently used timing and methods of applications. Actual application in the field often exceeds the recommended rates. Excessive nitrogen is detrimental to quality and yield of fruit crops. Recovery of applied nitrogen by tree crops has been estimated to be from 25 to 35% so that efficiency of nitrogen use leaves much to be desired. As with other crops, improvements in efficiency will come from improvements in timing and method of application.

Except in very rare cases, deciduous tree crops in California have not responded to the application of phosphorus. The application of any phosphorus in deciduous orchards is inefficient.

Potassium deficiency in deciduous orchards growing on sandy soils is best controlled by application of modest amounts of fertilizer at regular intervals. Use of excessive amounts in this situation can lead to leaching losses. With loam to clay textured soils, leaching loss is not a problem; applied potassium is held near the soil surface by clay particles. In this situation, obtaining penetration of adequate amounts of potassium into the root zone is the problem. Current recommendations are to apply large amounts of potassium (i.e., about 25 lb. K_2SO_4/tree) in concentrated bands to bring about correction of deficiencies for a several-year period. An alternative used in recent years is the foliar application of potassium nitrate several times each season. A computer model that predicts penetration of soil-applied potassium as a function of type and amount of fertilizer applied, irrigation water composition and amount of water applied and the amount of annual rainfall has been developed. This model is useful in determining whether soil or foliar application potassium would be more efficient.

THE MEANING OF FERTILIZER EFFICIENCY

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Fertilizer efficiency means different things to different people. It may mean the dollars earned per unit of fertilizer applied or it might mean the bushels or pounds of product produced per unit of fertilizer applied. On the other hand, it could be considered in relation to the ability of fertilizer to substitute for other inputs which may be limiting, such as land, water, labor, energy, etc.

All of these ways of looking at fertilizer efficiency are valid and useful. The data in Table 1 comes from the recent experiment performed at the Kearney Field Station under the supervision of Dr. Perry Stout within the framework of the RANN Project.

Table 1. Energy Use and Water Use Efficiency of Irrigated Corn - Kearney: 1973.

Fertilizer Applied lbs/N/A	Yield bu/A	Ratio Energy Recovered / Energy Expended	Relative Energy Use Efficiency %	Relative Water Use Efficiency %
0	16.5	.53	100	100
50	88	2.40	455	534
100	141	3.38	640	854
200	194	3.81	725	1180
300	194	3.05	575	1180

With the same input of land, water, labor and energy, the check plots receiving no nitrogen yielded 16.5 bushels per acre while those receiving increments of fertilizer increased in yield up to a maximum of 194 bushels at an application rate of 200 pounds of nitrogen per acre. Thus, there was a 725% increase in energy use efficiency, a 1180% increase in water use efficiency and equivalent increases in land and labor use efficiencies. That is real fertilizer efficiency.

However, there is a more direct meaning of fertilizer efficiency which is less often used, but which is of considerable importance, namely fertilizer use efficiency; that is, the proportion of the applied fertilizer taken up by the plant. When fertilizer and energy were cheap and we didn't worry about excess nitrates in our water supply, this was not as important an efficiency criterion as some of the other criteria mentioned previously. However, as soon as fertilizer supply becomes limiting or excesses become an environmental consideration, as is happening today, we must consider fertilizer use efficiency.

At the level of developing countries, this has always been the case. In developing countries, the supply of fertilizer has always been limiting. The cost is high. It may represent the only cash cost of production to the farmer. It represents an important commodity requiring hard currency payment which is in short supply. Maximizing fertilizer use efficiency is the main fertilizer problem over and above obtaining the fertilizer itself.

To maximize fertilizer use efficiency, it is necessary to know how much of the fertilizer is taken up by the actively growing plant when the amount, source, placement and timing of the fertilizer is varied and how this amount is affected by other cultural practices and the environment. Only after knowing this information can the most efficient fertilizer practice be recommended that will maximize yield response and at the same time maximize use of the nutrient by the actively growing plant and minimize nutrient losses. Fortunately, by using isotope-labelled fertilizers, we can get quantitative evaluations of fertilizer nutrient uptake as a function of the factors of interest. Extensive field experiments using isotope-labelled fertilizers are going on at the Kearney Field Station and at Davis. The data coming from these experiments and similar experiments in the future will go a long way toward gathering the knowledge necessary to maximize fertilizer use efficiency.

IRRIGATION PRACTICES FOR THE PRODUCTION OF CONTAINER GROWN ORNAMENTALS

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In Southern California, the production of ornamentals in containers presents many unique irrigation problems. Since the volume of soil used in the container is a compromise between minimum shipping weight and reasonable physical stability, the development of specialized soil mixes and irrigation practices are important factors in the success of the production system used in most modern-day wholesale nurseries.

Recently, the irrigation method has shifted from mass application by sprinklers to water conserving discrete application through small tubes or drip emitters to each container. This new approach has many advantages. Besides saving precious water and soluble fertilizer, the detrimental effects of excessive run-off so often associated with sprinklers can be virtually eliminated.

With drip irrigation, the application of moisture is not dictated by assembly schedules, maintenance programs, and other production activities requiring a dry working area. Instead, the needed moisture can be applied many times daily and at the proper time directly to the container. Since the soil mix can be maintained near field capacity at all times, the effects of salinity can be minimized on many salt-sensitive plants. Also, the foliar absorption of sodium and other detrimental salts can be reduced measurably.

With the use of modern electronic irrigation controllers, mini-computers, tensiometers, and salinity monitors, the progressive grower of ornamentals has the opportunity to accurately manage the application of water to produce the highest quality product for the consumer at a reasonable production cost.

THE CURRENT STATUS OF RECOGNIZED NEMATODE DISEASES OF CALIFORNIA TURFGRASS

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Many different plant parasitic nematodes are found in the soil around the roots of various turfgrasses in California. Only one of these, the root-knot nematode (*Meloidogyne* sp.), has been *proven* to be pathogenic (that is, cause a turf disease). Several others are suspect, such as the lesion nematode (*Pratylenchus* sp.), the stunt nematode (*Tylenchorhynchus* sp.), the ring nematode (*Criconemoides* sp.), the pin nematode (*Paratylenchus* sp.), the dagger nematode (*Xiphinema* sp.), and the stubby root nematode (*Trichodorus* sp.). In other parts of the United States, especially the southeastern seaboard, nematologists have found nematodes, especially the sting nematode (*Belonolaimus* sp.), to be devastating to turf. This nematode, to the best of our knowledge, does not exist in California.

When we find suspect plant pathogenic nematodes, such as previously mentioned, we can only speculate as to their importance to turf grasses until appropriate studies can be conducted under controlled conditions which either prove or disprove their potential importance to turfgrass species. Until such time as these studies have been carried out, the only evidence we really have is "guilt by association", which is meaningless with regard to their importance to turf species.

Dichondra. Root-knot, *Meloidogyne incognita*, is widespread throughout the state and is extremely important as a disease of dichondra. This nematode has been proven to be a cause of a devastating disease of this sod and without proper control measures can destroy a stand of dichondra in a relatively short period of time. Infected plants at first appear stunted, then become chlorotic and continually are wilting in comparison to noninfected areas. Examination of the roots reveals galls and egg masses of the nematodes. Investigations on the control of this nematode on established sod and potential tolerant or resistant varieties were discussed.

VEGETATIVE PROPAGATION OF MONTEREY PINE

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The Monterey Pine (Pinus radiata) seedling tree is used extensively in Southern California landscaping and is also the major tree used for choose-and-cut Christmas tree farms in this area. These seedlings differ considerably in their growth habits, appearance, and resistance to air pollution. After a severe air pollution attack, the trees will vary from no apparent damage to slightly yellow tips on the needles to branches and entire trees which have turned yellow. Trees have occasionally turned completely brown and died. Apparently, the trees have different degrees of susceptibility to different types of air pollution. The search for trees with good vigorous growth habits and a beautiful appearance that are resistant to air pollution led to the interest in producing Monterey Pine trees from cuttings.

Fred Dorman, whose Christmas tree farm is located in Highland, California, has been a leading grower in the search for better trees and the best methods to produce the cuttings.

Over 200 different trees were tested in the propagation beds for rooting ability. These were selected from over 30,000 seedlings. The first criteria for selection was vigor. Cuttings from a potential Mama Tree must root at least 50 percent, and up to 80 percent under ideal conditions. Rooted cuttings must not show damage from air pollution until they are at least five years of age. The trees must have good color and needle density. Trees are preferred that have upright growth habits and that branch or bifurcate frequently. The tree must have apical dominance. Severe hot dry winds during the late fall make it essential that the tree be resistant to twisting. Over the years, two different "gene banks" were established where tagged rooted cuttings from the best Mama Trees were grown. Their development into saleable Christmas trees was evaluated.

Propagation beds were filled only once a year, in January, because that was when the wood and the weather were best. The beds had about five inches of sand and vermiculite over fiberglass screen and heating cables. The beds were open at the top for ventilation, and the mist was on for two seconds every 2½ or five minutes, depending upon the weather. Rooting procedures favor large cuttings, a fast draining rooting media, frequent mist, good air movement and bottom heat.

The branches for the cuttings were kept damp and cool until they were processed. The preferred wood was about the size of a pencil, showing quite a little brown color. The cuttings were from three to six inches long, depending upon the wood. Large cuttings were preferred, as they were soon large vigorous plants. Needles were stripped from the lower 1½ inches and old cuts were recut before dipping in 4000 ppm IBA solution.

Cuttings with the terminal buds were preferred because: they continued to grow while in the propagation bed; they got off to a very fast start; and they required a minimum of hand pruning to develop a single leader. Cuttings with side branches or buds also got a fast start, but they required more hand work to develop the single leader. Other cuttings rooted just as well, but were much slower developing as the buds took from two to three months to break. They also required hand pruning to develop the single leader.

Cuttings were normally lifted in 90 to 100 days. They were rooted, pruned and planted in a sandy planting mix in quart cans. After hardening off, they were held for three or four months before transplanting into gallon containers. The largest of these were used as replacements after Christmas sales; and the smaller ones were later transplanted into containers 16 inches tall for planting the following year.

Using these procedures, culling was reduced from about 20 percent for yearling seedlings to almost nothing for the rooted cuttings. Loss of trees due to air pollution damage was much less due to the high percentage of trees propagated from trees resistant to air pollution. Less time was spent trying to salvage trees that lack apical dominance because cuttings were not taken from that type of tree.

Mr. Dorman selected 17 of his best "Mama" trees for a trial which began at the Monrovia Nursery in Azusa on May 19, 1972. Results of that trial are shown in Table 1. Nine trees that rooted the best, which included some that Mr. Dorman thought were his very best "Mama trees, were transplanted into gallon cans in January, 1973, for further evaluation.

We kept a record of height measurements, made notes regarding necessary pruning for Christmas trees, and kept a record of the trees' appearances and reactions to air pollution. We had beautiful, three-foot-tall trees within two years after starting our cuttings. By July, 1974, after the spring flush of growth, many of the trees were over six feet tall.

For landscaping, tree 109-84 is a beautiful open tree with practically no pruning necessary; however, it might not be first choice for a Christmas tree farm even though it was the fastest grower. Tree 55-76 was rated best overall for Christmas tree farms. It had the darkest green color, but did require considerable pruning. Tree 96-89 was not quite as good in color and also required a good deal of pruning for a Christmas tree. There are two other good trees: 113-96 and 92-56. However, although the cuttings showed no air pollution damage, the parent trees did show damage by the time they were five years old. They might warrant further study for Christmas trees, which are normally harvested when three years old, but would not be satisfactory as landscape trees. It should be noted that it takes about one year from the time the cutting is started until it is about one-foot tall in a gallon can. Normally, the cuttings would be made in January, ready to set out in the farm or to sell to retail nurseries one year later.

In January, 1974, we started a trial with the top three Monterey Pine cuttings at the K & Y Nursery in Gardena. The flats of cuttings were placed in a greenhouse with some flats over heating cables maintained at 72° F. and other flats with no cable. To help with the rooting, the lower ends of some of the cuttings were dipped in a three percent IBA solution; and all others were dipped in a 1.6 percent IBA solution. The results are shown in Table 2.

We checked the temperatures in the greenhouse during the daytime and found they were averaging about the same as the heating cable - 72° F. Of course, at night, it was cooler than the cable. The results show that tree 55-76 had a higher percentage of rooting with no cable than with the heating cable. Tree 96-89 was about the same. There was no good comparison for tree 109-84 since only one flat had a cable. As far as the IBA treatment was concerned, the higher dosage substantially lowered the percent of rooting for tree 55-76 and raised it slightly for tree 109-84. There was no comparison for tree 96-89. Results from other trials have shown that high concentrations of IBA either had no effect or reduced the amount of rooting. This trial was lifted too early - after just 11 weeks. We had good results, but many of the cuttings were just ready to root when we lifted them. We replaced those cuttings and lifted them again in four weeks, thereby getting more roots which brought the overall averages up to very good percentages.

The trials emphasize that Monterey Pine cuttings need frequent mist and excellent drainage. The heating cable or greenhouse produces roots much faster than without added heat. While succulent cuttings did root, we had less trouble with wood that was more mature and pencil-size. Cuttings larger in diameter had more rotting and did not have as high a percentage of rooting. We feel we have selected three excellent trees as sources for cuttings that will root with high percentages under good conditions.

We are proposing a large-scale, one-half acre plot or more at the University of California South Coast Field Station to compare cuttings from trees 55-76 and 109-84 with Monterey Pine seedlings and Pinus brutia seedlings. Also, space is being allotted for selections from Dr. Libby's work at Berkeley.

Table 1. Rooting of Selected Monterey Pine Cuttings From Dorman Farm in Highland.

Tree No.	Rooted Cuttings	Cuttings Not Rooted	Total Cuttings	Percent Rooted
104-105	42	11	53	79.2
110-104	54	21	75	72.0
113-96	37	19	56	66.0
96-89	52	27	79	65.8
109-84	20	16	36	55.6
92-56	39	33	72	54.2
97-98	32	33	65	49.2
104-118	28	34	62	45.2
55-76	32	43	75	42.7 *

*Nine trees above the center line transplanted in January, 1973, into gallon cans for observation at the Research Center at Monrovia Nursery.

Tree No.	Rooted Cuttings	Cuttings Not Rooted	Total Cuttings	Percent Rooted
112-71	20	34	54	37.0
105-113	25	43	68	36.8
110-118	19	39	58	32.8
111-69	17	41	58	29.3
107-124	20	64	84	23.8
12-28	14	65	79	17.7
101-113	3	72	75	4.0
101-75	1	58	59	1.7
TOTAL	455	653	1,108	41.1

Cuttings made May 19, 1972, placed outdoors under mist fairly frequently - bottom heat, 72° F. Cuttings moved August 24, 1972, for hardening off under saran with mist about every half hour from 9:00 to 3:00 p.m., depending on weather. Cuttings lifted September 13, 1972, and planted in four-inch pots.

Table 2. First Trial of Top Three Monterey Pine Cuttings From Dorman Farm Showing Percent Rooted Cuttings Out of 32 Cuttings in One-half of a Flat.

Tree Numbers		
55-76	109-84	96-89
3% IBA - No Cable	3% IBA - No Cable	
34.4%	46.9%	
37.5%	53.1%	
43.8%	65.6%	
59.4%	68.8%	
Av. 43.8%	Av. 58.6%	
1.6% IBA - 72° F Cable	1.6% IBA - 72° F Cable	1.6% IBA - 72° F Cable
43.8%	43.8%	40.6%
43.8%		50.0%
46.9%		59.4%
53.1%		62.5%
59.4%		81.3%
59.4%		
Av. 51.1%		Av. 58.8%
1.6% IBA - No Cable	1.6% IBA - No Cable	1.6% IBA - No Cable
46.9%	40.6%	43.8%
53.1%	46.9%	50.0%
56.3%	46 9%	56.3%
65.6%	53.1%	56.3%
71.9%	56.3%	56.3%
75.0%	56.3%	56.3%
75.0%	59.4%	62.5%
	71.9%	65.6%
		68.8%
Av. 63.4%	Av. 53.9%	Av. 57.3%
Total av. 54.4%-1st lift	Total av. 54.6%-1st lift	Total av. 57.8%-1st lift
Plus 7.7%-2nd lift	Plus 21.8%-2nd lift	Plus 3.6%-2nd lift
Overall av. 62.1%	Overall av. 76.4%	Overall av. 61.4%

Cuttings made January 21, 1974; first lifting 11 weeks later, April 9, 1974; second lifting 4 weeks later, May 7, 1974.

AIR POLLUTION EFFECTS ON TURFGRASSES

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Plant damage from air pollutants, industrial fumes and dusts, has been known for over 100 years. Photochemical air pollutants (smog) were recognized and plant injury symptoms described in the late 1940's. Of this group of gasses, ozone, nitrogen oxides and peroxyacetyl nitrate (PAN) caused the most widespread and serious injury.

In 1955 Bobrov and coworkers described the injury symptoms of photochemical air pollutants on (Poa annua L.) annual blue grass. Later similar symptoms were recognized on other common cool-season turfgrasses.

Bobrov showed that necrotic areas on annual bluegrass leaves following exposure to smog resulted from disintegration of chloroplasts and plasmolysis of mesophyll cells in the vicinity of the substomatal chambers. The amount of tissue damaged depended upon the concentration of the photochemical air pollutants in the air. Greatest damage occurred in areas of mature, but no senescent cells. Therefore, cell necrosis would usually appear in distinct bands across the leaf. The location of these bands - at the tip, in the middle, or at the base of the leaf - would depend upon the age of any given leaf.

Air pollution damage to bermudagrass, Cynodon spp., was observed about 1960. Injury was greatest on Cynodon transvaalensis Burtt-Davy and many hybrids in which this species was a parent. Common bermudagrass, Cynodon dactylon (L.) Pers., appeared to be highly tolerant. Tifgreen, Tifway and Tifdwarf hybrid bermudagrasses have been shown to be very susceptible to air pollutants. In 1966 Santa Ana, a similar hybrid that was highly smog tolerant was introduced by the California Agricultural Experiment Station.

Recent studies at Riverside where different turfgrasses were exposed to known concentrations of ozone and PAN have shown a wide range in susceptibility among species and among cultivars of a species. Cultivars highly susceptible to one of the pollutants would not necessarily be equally susceptible to the other. Although Poa pratensis L., Kentucky bluegrass is considered to be moderately susceptible to air pollutants, some cultivars were observed to be quite tolerant to both ozone and PAN. Therefore, it is possible to select cultivars or to breed new strains that are better adapted to urban areas where air pollution is common.

However, it is not known as yet to what extent turfgrass growth of strains which show little acute toxicity symptoms may be reduced. Air pollution-induced growth reduction and loss of vigor could be an important factor in turfgrass disease or other management problems.

SYNOPSIS OF FUSARIUM ROSEUM IN SOUTHERN CALIFORNIA

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In relatively recent years, the turfgrass industry, including both production and maintenance, has fully emerged as a major agricultural enterprise. Specialized grasses have been selected and developed for utility, beautification and recreational purposes.

The establishment and care of turfgrasses has been a topic of increased interest as materials and techniques have become more and more sophisticated. Along with the improvements in turfgrass varieties and specialized maintenance programs have come new management and cultural problems. Several new and at least potentially destructive diseases have emerged.

A disease of Merion Kentucky bluegrass of unknown cause was first observed in 1959 in Pennsylvania. Since that time, the disease has been reported in most eastern and midwestern states. This disease, which has since been identified as Fusarium blight (Fusarium roseum and F. tricinctum), was first recognized in Southern and Central California in 1972. In the dozen or so years since its recognition, the disease has been quite extensively studied, particularly in the eastern and midwestern states. Attempts to correlate the incidence of *F. roseum* to grass species, soil conditions, temperature and humidity, nematodes, nutritional and irrigation practices and methods of dissemination have produced some consistencies and many conflicting opinions as to what is actually happening as the disease becomes evident and destructive in turf. Potentially promising methods of chemical control plus specialized management practiees indicate that Fusarium blight control can become a reality.

AN OVERVIEW OF THE ANNUAL GRASSLAND ECOSYSTEM SYNTHESIS EFFORT

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In 1968 the Grassland Biome, US/IBP, began an intensive multidisciplinary study of grasslands in the Western United States. 'Intensive' means that uniform types of information about energy flow and nutrient cycling were to be gathered on abiotic, producer, consumer, and decomposer components of the ecosystem in seven different grassland ecosystems. The representative of the annual grassland type is the U. S. Forest Service San Joaquin Experimental Range near Fresno, California. The concept of multidisciplinary studies means that scientists with backgrounds not only in the classical biological and agricultural sciences, but also in mathematics, computer science, statistics, engineering, meteorology, etc., were mobilized (using the systems approach) to attack the extremely complex puzzle of interactions of ecosystem components.

The systems approach as defined by George Van Dyne entails:

1. Compiling, condensing, and synthesizing a great amount of information concerning the components of the system;

2. Examining in detail the structure of the system;

3. Translating this knowledge of systems components, function, and structure into models (conceptual and mathematical) of the system; and

4. Using the models to derive new insights about management and utilization of grassland ecosystems.

The arsenal of tools used to gain this new insight includes detailed examination of the literature, well-designed field and laboratory studies, conceptual, statistical, and mathematical models, and, most importantly, the experience and understanding of knowledgeable field scientists.

The means chosen to convey information to the public at large about each of the seven grassland ecosystems within the Grassland Biome network is through development of individual comprehensive treatments in the form of "type volumes" or manuals. These volumes will be "state-of-the-art" reference manuals with special emphasis on "state-of-the-ignorance." The objective of this synthesis effort is to present information that is pertinent and relevant about ecosystems and to define what is unknown, but should be studied in light of the nation's new emphasis on increased utilization of grasslands.

The synthesis effort of interest, specifically in California, will produce a volume called, "<u>Structure, Function, and Utilization of an Annual Grassland Ecosystem</u>." Emphasis of the volume is on processes and controls of processes operating on and in the ecosystem. We recognize that understanding of the processes will require thorough knowledge of the ecosystem history and structure. Completion is anticipated to be in 1976.

The volume has several characteristics and purposes:

1. It is to be an integrated synthesis of information rather than a collection of individual articles.

2. IBP data sets collected at the San Joaquin Experimental Range will be related to specific information from non-IBP studies.

3. Information will be included from experimental projects in the field and laboratory, as well as conceptual and simulation modeling studies. Example sites will be the San Joaquin Experimental Range, the Hopland Field Station, and the Sierra Foothill Range Field Station.

The relationship of scientific journal articles and individual projects to a comprehensive synthesis is important. The synthesis volume does not have as its main intent the reporting of original results except where unpublished material must be used to fill in gaps of information. That is, the synthesis volume is not to replace papers for scientific journals. The synthesis volume will tend to cross individual projects and compare ecosystem components rather than to elaborate on detailed findings within individual projects.

Included in the synthesis effort are scientists from the Agricultural Research Service, Reno, Nevada; California Division of Forestry; California State University, Fresno; Naval Post Graduate School; Bureau of Sports, Fisheries, and Wildlife; University of California at Berkeley and Davis; U. S. Forest Service at Fresno; and Colorado State University. Details of what is being attempted by those scientists in specific areas of activity will be given in the following papers.

SAN JOAQUIN SITE OF THE GRASSLAND BIOME; ITS RELATION TO ANNUAL GRASSLAND ECOSYSTEM SYNTHESIS

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The Annual Grassland Site of the Grassland Biome, US/IBP, was established at the U. S. Forest Service's San Joaquin Experimental Range in 1972. The Experimental Range, located in Madera County, is representative of lower foothill annual grasslands in the granitic soil area of central California. Information throughout the 1973 and 1974 growing seasons was collected for the abiotic, producer, consumer and decomposer components of the grassland ecosystem in the same form as has been followed in six other grassland ecosystems. This paper reports some preliminary results for inclusion in the annual grassland ecosystem synthesis effort.

Both 1973 and 1974 were years of above-average precipitation, with resultant relatively high herbage production. Gravimetric soil water declined rapidly from about 10 percent during the period of rapid plant growth in March or April to 1 or 2 percent in May or June.

Total aboveground live biomass each season rose from a few grams per square meter early in the growing season to well over 400 when it peaked in late spring. Litter accumulation peaked about a month later. Belowground biomass was consistently greater than the aboveground, but did not follow a pronounced seasonal trend. Most of the belowground material was in the top ten centimeters.

Information on the consumer component included cattle-weight responses during each season. Cows and calves grazing the study plots gained two to three pounds per day during the green forage period, with cow gains dropping off far more rapidly than calf gains as the vegetation matured and dried.

CLIMATE, STRUCTURE, AND HISTORY OF CALIFORNIA'S ANNUAL GRASSLAND ECOSYSTEM

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Geographically and physiographically, the California annual grassland ecosystem includes the Central Valley and adjacent foothills of the Sierra Nevada and Coast Ranges; the low hot interior valleys of the inner Coast Ranges; and coastal areas from San Luis Obispo County southward. Also a part of this plant community as thus delimited are the coastal grasslands of the middle and outer North Coast Ranges from San Francisco Bay northward. Elevationally, it extends from sea level to about 3,000 feet, ascending to 5,000 feet in Southern California and on warm slopes in the north. Physiognomically, it includes both the grassland and the adjacent and commingled open woodland where the dominant vegetation is herbaceous, but the associated trees give a marked aspect.

The Central Valley, the surrounding foothills, and the South Coast Ranges have a dry-summer subtropical climate: the so-called "Mediterranean" climate. It is characterized by warm-to-hot rainless summers; mild rainy winters; and a high proportion of sunshine in all seasons. The middle and outer North Coast Ranges, from San Francisco Bay northward, have a mesothermal marine climate with mild winters, cool summers, and high rainfall, differing from the Mediterranean type in more equable temperatures and higher annual rainfall.

The great geographical extent and differences in elevation are reflected in large variations in climatic elements. Average annual precipitation is from six inches, in the south, to more than 75 inches, in the north. Mean maximum temperatures are from 63° to 102° F. in summer, while winter minima range from 29° to 45° F. The growing season varies from six months, in the northerly portions and at higher elevations, to the entire year, in the south. The frost-free period may be as short as 175 days or as long as 365 days.

Throughout the grassland ecosystem, annual plants are the dominant life form even where aspect dominance is maintained by open woodlands. The original perennial bunchgrass dominants have been superseded by annual bromegrasses, fescues, wild oats, and wild barleys. Associated with the grasses are a host of forbs, both native and introduced, the most constant and most abundant being filarees, legumes (bur clover, lupines, and trefoils), and tarweeds. The abundance and variety of forbs create marked seasonal differences in appearance of these grasslands, probably without parallel in any other plant community. At certain seasons, the forbs may be so conspicuous as to obscure the grasses, creating the illusion of being the dominant vegetation.

Grazing and agricultural development began on California grasslands with the founding of the Spanish settlement at San Diego. More than two centuries of settlement, grazing use, agricultural development, and the vicissitudes of climate have wrought significant changes. Three great waves of alien plants have swept across these grasslands; a fourth is in progress. Ecologically adapted to a wide range of habitat factors, resistant to grazing, having a high biotic potential, and being specialized for dispersal by seed, these aliens have transformed the essential character of the grasslands from dominance by perennials to dominance by annuals. The changes in composition and vegetation structure have been accompanied by a lower productivity and reduced nutritional efficiency, resulting in ecologically significant shifts in relationships of the plant-soil-animal complex.

ANNUAL GRASSLAND ECOSYSTEM PROCESSES: ABIOTIC AND AUTOTROPHIC COMPONENTS

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In using a systematic approach to analyze ecosystems, it is logical and useful to subdivide knowledge concerning the systems into structural characteristics of the ecosystem components and functional processes through which the ecosystem operates. One might compare this approach with traditional organizations of knowledge by equivalencing broad definitions of anatomy and morphology with ecosystem structure and equating knowledge in the subject areas, genetics and physiology, with ecosystem processes. This procedure is used throughout the analysis of individuals, populations, and communities of organisms under the control and influence of the abiotic components of the ecosystem.

Primary production of autotrophic organisms in an annual grassland ecosystem and the subsequent transfer of organic materials is a complex linkage of a host of functional processes under the control of numerous biotic and abiotic factors. One can conveniently categorize these processes into gross primary production, net primary production, and fluxes of net primary production. Taking the breakdown of information one step further, gross primary production is made up of two rather different groupings of processes, one being phenology and the other being the production and partial use of metabolically active carbon compounds. Finally, an example of one process within the second grouping of processes is photosynthesis, which is under the control of such factors as soil, water, temperature, nutrients, phenology, insolation, photosynthetic pathway, biomass, leaf area, disease, and others.

The bulk of our knowledge lies in the area of net primary production, or the rates of accumulation of biomass over time for a number of important plant associations in annual grasslands. Probably, the strongest link in our understanding of net production in annual grassland ecosystems is the effect of soil nutrient status on herbage production. The independent effects of nitrogen, phosphorus, and sulfur and the interaction and interrelation of these soil nutrients are well documented for many grass and legume species.

The major important gaps in knowledge of the system lie in the area of fluxes of net primary production. Rather unknown quantities are the effects of processes such as fire, shoot mortality, root mortality, litterfall, leaching, seed production, and seedling dynamics. Only recently have there been research efforts in a few of these areas. It is hoped that a detailed analysis and synthesis of knowledge concerning abiotic, autotrophic, and heterotrophic processes will redirect efforts into areas of needed research.

ANNUAL GRASSLAND ECOSYSTEM PROCESSES: HETEROTROPHIC COMPONENTS

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Processes involving heterotrophs in an ecosystem can be divided into six functional classes: energy flow circuits, food webs, diversity patterns, nutrient cycles, evolution, and controlling factors. These subdivisions are arbitrary, and some have received no attention in the study of annual grassland ecosystems.

Structurally, the heterotrophic component of grasslands can be subdivided into herbivores, carnivores, and decomposers. The herbivore component comprises livestock, small mammals (rodents and lagomorphs), birds, and insects. While much attention has been given ecological processes involving vertebrates, little evaluation has been made of processes involving the invertebrate fauna. Invertebrates are difficult to study because of the diversification and specialization of life stages of the various taxa and because of the large number of taxa present. Although some invertebrates are carnivores or decomposers, most are herbivores.

The California ground squirrel (Spermophilus beecheyi) has received attention because of its herbivorous habits and because it has been considered a competitor with livestock for annual plant forage. Yet, this species apparently consumes less than 1% of the annual forage production on native annual rangeland.

The decomposer component of the system consists of organisms that break down dead primary producers and consumers into chemical elements which are returned to the soil or atmosphere. As much as 75% of the energy captured annually by plants enters the decomposer portion of the food web. Carrion, feces, litter, and belowground parts of plants are partially decomposed by earthworms, mollusks, isopods, diplopods, dipterans, coleopterans, nematodes, collembolans, mites, and ants. The most important group in the turnover of energy trapped by photosynthesis, however, is the microflora, which consists of bacteria, actinomycetes, fungi, and algae. Although not all bacteria are active at any one time, the live-weight biomass in the upper 15 cm of grassland soil has been estimated to be as high as 4 kg/m^2. Decomposers are vital to the function of the grassland ecosystem even though they utilize a very high percentage of the available energy produced by primary production. Loss of the decomposers in the system would result in a build-up of litter and carrion, with a resulting accumulation of nutrients aboveground and an increase of trapped energy in the system. As nutrients became tied up in undecomposed material, there would be a decrease in primary production and a resulting decline in secondary production.

Carnivores, aside from man, consume a relatively small percentage of the energy available in annual grasslands.

UTILIZATION PROBLEMS AND POTENTIAL OF THE CALIFORNIA ANNUAL GRASSLAND ECOSYSTEM

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"Annual grassland" is defined to include areas where biological products directly or indirectly useful to man are necessarily harvested by grazing and/or browsing animals. The plant communities consist of some combination of native, resident, and deliberately introduced herbaceous and woody species and are grazed by some combination of domesticated livestock (principally cattle and sheep) and wild game. The lands, occupying roughly one-third of the state, consist of widely differing complexes of climates, soils, relief, and vegetational communities, resulting in an almost infinite array of constraint combinations and management-utilization opportunities. Total livestock meat production in California - from breeding herds, stocker cattle, and sheep - has been valued at more than 200 million dollars. These lands interface, in one direction, with intensive agriculture through opportunities for use of supplemental irrigation and intensive management of introduced annual legumes on dry-farmed edge-of-valley lands; and interface in another direction with wildlands and desert where the fragility of the system, fuel management problems, and watershed stability are illustrative of management problems of non-food resources.

One of the first management decisions made is whether to accept the inherent level of productivity, i.e., to maintain an equilibrium condition which is an integration of all constraints, or whether to alter and/or manipulate the system, moving it in the direction of maximum plant and animal export product. In California, we have witnessed an era of management emphasis based on concepts and procedures derived from intensive agriculture. In this approach, vegetation-type conversion, achieved through the use of fire, mechanical, and chemical methods, is followed by revegetation, often with exotic plant species, control of competitive woody and herbaceous resident vegetation, fertilization with nutrients considered to be deficient, and grazing management designed to enhance the stability of the new plant communities. Despite considerable success, the past three or four decades have also seen consistently increasing economic and regulatory constraints, refinements in plant and soil management, and an increasing awareness that an understanding of ecosystem structure and function does not necessarily lead easily to its successful manipulation.

Management of the plant-soil-climate complex is currently evolving toward the two alternatives of short-term (one-to-three-year cycles) intensive management on selected high-potential sites vs. long-term (over decades) management aimed at equilibrium stability and small increments of additional export productivity gained from small economic inputs and slight disturbances to the system. Management of the animal-product multiple-use complex is evolving toward a greater emphasis on the animal reproductive unit and intensive calf management. The long-fought controversy around comparative efficiencies in food production is far from over, but current trends suggest proportionately more range-finished red meat in the future as modified supplementation practices aimed at year-around use of the annual grasslands and consumer acceptance of "grass-fed" meat occur.

"Utilization" is nearly synonymous with "export." Given a growing season of adequate length, the principal constraints on plant production are nutrients and water. A thorough understanding of climate, soil, and plant growth processes has enabled more perceptive and precise management of fertilizers Similarly, work with annual legumes and rhizosphere ecology has improved grasslands nitrogen economy and the nutritive value of range forage. Research conducted in an ecosystem framework and formulation of hypotheses and organization of currently known facts through modeling should result in new advances in nutrient ecology and water management as they relate to the export of appropriate and useful products from a reasonably stable grasslands system.

SIMULATION MODELING OF THE ANNUAL GRASSLAND ECOSYSTEMS

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Until recently, efforts to model annual grassland behavior have been confined to a few studies of the association of yield with weather and other environmental variables, using correlation and regression, because most of the phenomena occurring in grasslands involve highly interactive systems and nonlinear functions with thresholds and other difficult response functions. The availability of high-speed digital computers now makes it possible to deal more effectively with these phenomena. Thus, we can model such complex processes as production and competition at the community level, or photosynthesis, respiration, and ion absorption by roots at the individual plant or organ level. Moreover, a worker with even limited mathematical facility can learn to use a modeling language in a reasonably short time and can then concentrate on relational concepts and problem conceptualization.

The "payoff" comes in being able to model aspects of system behavior, especially under natural conditions in the field, which would be almost impossible to do in their entirety experimentally. In consequence, scarce research resources are conserved for the most incisive and relevant experiments; and process interactions can be brought into sharp focus that were formerly not perceived or only guessed at.

Among the several examples that will be cited is a dynamic model of deferred grazing systems on annual-type vegetation. The model represents a subterranean clover pasture in Western Australia, and use was made of the literature and a recent grazing experiment in its development. Herbage growth is estimated from known relationships with radiation received, leaf-area exposed, soil moisture, and herbage removed by grazing. Change in soil moisture is estimated from rainfall and pan evaporation data. Defoliation is based on stocking rate, pasture weight, and pasture height to account for the effects of animal numbers and availability of pasture. Liveweight change of the consuming animal is calculated as a function of intake, digestibility, and the partitioning of metabolizable energy between maintenance and weight change. Validation of the model by results observed in the grazing experiment is presented. The model is used to make postulates about grassland and livestock responses to the management variables, length of deferment and stocking rate, for various levels of initial plant population.

Such a working model requires a satisfactory balance in quality of information that it serves to simulate, and leads one during model development to an awareness of the weak areas. Hence, it can be a powerful aid in establishing research priorities.

VISUALIZE - YOU'LL LIKE IT

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Communication is not a "one-way street." In order that true understanding and learning take place, there needs be an exchange or "interchange" to allow for an adequate feedback process which completes the communications cycle, so a presentation of this type requires special attention to insure successful understanding.

Unfortunately, most scientists have been taught poor habits of visual presentation along with the scientific method. One can hardly come away from four to eight years of bad example unscathed. Furthermore, usually no training in proper design and methods has been taken to offset the ingrained misguidance. The problem is compounded by what I call 'scope' vision and the shrinking perameters of exclusivity so proper to the scientific method. Of course, a real passport to presentation excellence in many cases is natural talent.

These factors explain the frequent disregard by specialists for the meeting environment, the audience, the time allotted, planning, the equipment, future uses of the visuals, etc. Aside from the subject matter (which is naturally dear to the presenter) and his own career furtherance, the presenter should think the presentation important to the audience or it will be a waste of time for both him and those attending. The gross assumption here is that any professional audience is waiting breathlessly for his information and that they will understand it no matter how slipshod the talk.

It has been shown that people are more receptive and retain more longer when a presentation is well illustrated. Also, complex material is more understandable when graphically displayed. Material should be edited for a specific time allowance and audience. This exercise can be enhanced by averaging data not important in its extended raw form to this talk, dividing graphic representations into several separate ones, substracting information not germain to this briefing (and being barbarous in doing so), abbreviating, consolidating, and/or revealing in logical sequence the data of any one graphic. . .on a number of slides for instance. If visuals are simple, as they should be in a talk of less than one hour, people will grasp the step shown and be ready for the next in from seven (7) to twenty (20) seconds.

It is difficult for most to change and accept unfamiliar forms of thought; and attitudinal change accounts for some 90% of acceptance; but usually access to materials, facilities and opportunities for self-improvement are available to the persevering whereever they work. Literature, courses, media production units, talented student or clerical help, easy-to-use do-it-yourself kits, etc., are available.

We use no 'new' or magical equipment in our facility, only methods of effective teaching known for decades and equipment first brought into use on a mass scale in WW II, i.e., mainly slides from "diazo" transparencies for which artwork has been completed on tracing papers. But, even in our operation, the presenter must want to learn to communicate his wares, and learn to improve his method of presentation as consciencioualy as he pursues his research, in order to be successful.

WATER CONSERVATION MEANS ENERGY SAVED

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In a survey of agricultural pumping plants in the Central Valley of California, Pacific Gas and Electric Company found that overall pumping plant efficiencies were much higher than they expected. As a result of this, it was decided to emphasize irrigation efficiency in an effort to reduce power consumption during the energy crisis. Irrigation power accounts for 85 to 90 percent of PG&E's agricultural power deliveries. A brochure, "Saving Energy on the Farm", was prepared and distributed to agricultural customers to compliment the activities of the Company's pump test engineers and agricultural power consultants working in the field. Although the main emphasis of this program is on irrigation power conservation, the Company's effort also extends to poultry, dairy and other miscellaneous agricultural uses of power.

FERTILIZER INJECTION EFFICIENCY

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There are several purposes for injecting fertilizer through an irrigation system. There can be a substantial saving of labor compared to hand or machine application of solid materials directly to the ground. Without having to await suitable travel conditions through a field for machines or people, the applications can be timed better for plant needs. Multiple sequential applications of small amounts of fertilizer are economically feasible by injection and can reduce losses by volatilization and leaching compared to large, less frequent applications.

Various methods of injection can be used. They range from simple solution displacement from a fertilizer tank by flowing water to high pressure precision injection with a calibrated, externally powered pump. Most of the methods used can inject a previously measured amount of fertilizer into all or a fraction of the water used at a single irrigation.

Efficiency of fertilizer injection in irrigation water is dependent on the uniformity of its distribution to the land. This involves two requirements for control:

1. Uniformity of injection into the water and

2. Uniformity of distribution of water to the land.

Either the injection must be at uniform concentration to all the water used for an irrigation or water receiving variable concentrations must be uniformly divided among the final distributing elements of the irrigation system. The other requirement is the uniformity of distribution of water to the land. The latter is usually the more difficult to achieve. Unless irrigation water is distributed with reasonable uniformity, the chances for increased efficiency by fertilizer injection are poor.

SALT BALANCE IN IMPERIAL VALLEY, CALIFORNIA

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The irrigated area of Imperial Valley (I. V.) comprises some 440,000 acres of intensively cultivated truck and farm crops. The area occupies the northern arm of the Colorado River Delta at the extreme southern portion of California, north of the Mexican Border. The area is almost rainless and irrigation all year round depends entirely on Colorado River water. Irrigation was first introduced in the Valley in 1901.

As in all irrigated arid areas, salinity is a major concern in I. V. because salts in irrigation water accumulate in the soil. Colorado River water contains about 1.2 tons of soluble salts per acre-foot (about 900 parts per million). The concept of salt balance of irrigated projects was introduced in the early Thirties to indicate trends in salinity contents in the projects. Salt balance (SB) was defined by C. S. Schofield, an USDA research worker, as the relation between the quantity of dissolved salts delivered to an irrigated area with irrigation water and quantity removed from the drainage water. According to this relation, a favorable SB exists when the output of salts equals or exceeds the input. An adverse SB exists when the input exceeds the output.

Salt balance ($SB = V_{ew}C_{ew} - V_{iw}C_{iw}$) and salt balance index ($SBI = \frac{V_{ew}C_{ew}}{V_{iw}C_{iw}}$) of Imperial Valley (I. V.) have been determined annually since 1943 by the I. V. Irrigation District to assess salinity trend in the Valley as a whole by measuring, bi-weekly, the volume, V, (ac-ft) and concentrations, C, (tons/ac-ft) of influent, iw, and effluent, ew, waters. During 1973, V_{iw} and V_{ew} were 2.956 x 10^6 and 1.065 x 10^6 ac-ft; SBI was 1.14; and the weighted average concentrations of iw and ew in meq/1 were, respectively: total cations, 13.7, 43.8; Ca^{++}, 5.3, 10.6; Mg^{++}, 2.8, 8.6; $Na^+ + K^+$, 5.7, 24.6; HCO_3^-, 3.1, 4.2; $SO_4^=$, 7.0, 17.4; and Cl^-, 3.7, 22.5. Data such as these for past years have reflected cropping and water-use patterns in the Valley and give information about the total inputs of salt into the Valley and outputs to the Salton Sea.

Contrary to general postulates, salt balance evaluations are of little value in indicating trends in soil salinity. To properly interpret such data in the latter purpose requires additional information, such as volume of soil water, rootzone percolate, valley-wide consumptive use and composition of rootzone percolate. These data are not presently available. Reasonable deductions for the latter suggest that an appreciable fraction of salt in the Valley effluent comes from below the rootzone and drain tile depth. Scattered field observations substantiate this conclusion.

An alternative to the revised approach of evaluating salinity trends is to develop within the Valley an intensive soil sampling program that takes into account the soil series and cropping patterns. A four-probe, soil-resistivity monitoring program for the Valley is under investigation and may reduce greatly the time and cost of sampling program.

MAXIMIZING YIELDS WHEN SPRINKLER IRRIGATING WITH SALINE WATER*

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A comparison of yields of alfalfa, cabbage, carrots, lettuce, and sugar beets was made while utilizing five different leaching ratios of 1350 ppm water. The ditch water derived from the Colorado River contains approximately 880 ppm T. D. S. Appropriate amounts of solution of $NaHCO_3$, NaCl, $CaSO_4 \cdot 2H_2O$, and $MgSO_4 \cdot 7H_2O$ were added to bring the concentration in the sprinkler sump to 1350 ppm. The crops were planted by precision Stanhay planter on October 26, 1973, and irrigated at 2.8 mm/hr through the sprinklers.

The leaching ratios were established by applying 0.75, 0.79, 0.83, 0.90, or 1.05 times the amount of water which evaporated from a U. S. Weather Bureau pan. A split-plot design was used with one set of treatments on a clay soil and the other on a sandy, clay loam with three replications on each soil.

The first four cuttings of alfalfa showed no significant yield difference due to water application. The fifth cutting showed a significant decrease in yield with increasing water application. At the outset of the experiment, the clay soil was higher in salinity leading to a significantly lower yield in this soil as compared to the light soil. The first four months of irrigation reduced the salinity so that there was no significant difference in the top two feet, although the significant difference in the third and fourth feet remained. Subsequent harvests showed no yield difference associated with soil.

The carrots harvested on April 10, 1974, showed no significant differences in yield associated with soil, leaching ratio or water salinity. The lowest leaching ratio, 0.75 times pan, was apparently adequate to supply the plant and leaching needs.

The cabbage harvested on March 5, March 12 and March 18, 1974, showed a significantly higher yield on the lighter soil from the first harvest and a significantly higher yield

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on the heavier soil during the last harvest. The average head size was greater on the light soil. The total yield from the 0.83 and 0.90 treatments was significantly higher than the other three with the 1350 ppm water.

The 0.83 and 0.90 treatments in the lettuce produced the greatest total yields and the largest head sizes. These were significantly greater than the 0.75 treatment with the 1350 ppm water.

The sugar beets harvested on June 17, 1974, on the sandy, clay loam soil produced a higher sucrose percentage in the driest treatment and a higher dry matter production in the wettest treatment. This led to a significantly greater sucrose yield in the two extreme treatments as compared to the intermediates. The heavier clay soil did not exhibit this pattern. No differences in dry matter, sucrose percentage, top weight or total sucrose production were associated with soil type.

EFFECTS ON CARROTS OF DRIP IRRIGATION IN A SALINE SOIL*

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In the winter of 1973, an experiment was conducted to determine the response of carrots planted in a saline soil to drip irrigation. The objectives were to determine the effect on the plants as related to depth of installation of drip irrigation tubing.

Carrot seed was planted at right angles as well as directly over and parallel to the drip tubing. Root development was observed to determine if there was any lateral movement of the carrot roots towards the drip lines buried at various depths in the soil. Observations were also made to determine the response of carrots to different moisture conditions.

There was little or no movement of the carrot roots toward the drip irrigation tubing. There were, however, large differences in plant response to varying moisture conditions. The quality of the carrots varied widely through the experiment due to the effects of drip line depths. The effect of depth of drip tubing on carrot quality was quite apparent due to the distortion of the carrots around the drip lines. In some cases it was observed that the carrots closed off the flow of water through the drip tubing. Excessive soil wetness led to rot and splitting while excessive soil dryness led to non-uniform root expansion. The best yield and quality of carrots was obtained when drip lines were placed on the soil surface or beyond the carrot rootzone.

*Contributions from Imperial Valley Conservation Research Center, ARS, USDA, Brawley, California; and Agricultural Extension Service, University of California, El Centro.

FEEDBACK CONTROL OF DRIP IRRIGATION

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Close control of irrigation, with associated control of the leaching fraction, can have an important effect on the salt content of the drainage flow. Frequent application of small quantities of irrigation water by a pressurized water delivery system has the potential of uniformly applying water at rates closely matching those of evapotranspiration. The application of irrigation water can be set by irrigating whenever the soil water matric potential within the rootzone decreases below a prescribed value. This assures an optimum water content, but does not preclude buildup of adverse soil salinity due to inadequate leaching. Minimum leaching consistent with maintaining optimum crop growth can be obtained by maintaining the proper soil salinity level in the rootzone as estimated from crop tolerance data. Soil salinity can be measured in situ using salinity sensors. A control system that uses the salinity sensor output should assure optimum water content while controlling the salinity as well as the degree of leaching.

Experimental data obtained in lysimeters cropped with bromegrass will be discussed in terms of the interactions between water uptake distributions and the related interactions between depth of measurement and sensitivity of the control system. The optimum depth of measurement, 15 cm, corresponded to where 70 to 80% of the water uptake had occurred. A relatively stable and continuous leaching fraction in the range of 0.05 was achieved. Application of the feedback control system to a large scale field experiment will also be discussed.

GENE RESOURCES FOR QUALITY IN WHEAT

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The increasing need for optimum quality in wheat raises questions regarding:

1. The existence of gene resources for high protein content and a better balance of essential amino acids, also

2. Regarding the availability of such resources to the plant breeder.

The wild diploid wheats are widely dispersed from Greece to Transcaucasia, Lebanon and Iran. In the course of evolution and adaptation to a diversity of habitats, they presumably have accumulated considerable genetic variability. The wild prototype of the tetraploid wheats is largely confined to the western arc of the Fertile Crescent; and primitive types of the hexaploid wheats, which originated under cultivation, are rare. Virtually nothing is known about genes for protein quantity or quality in any of these wild and primitive types.

The tetraploid wheats (AABB) apparently originated by doubling of the chromosome number of a chance sterile hybrid between two wild diploid wheats (AA and BB). In the simplest case, this implies that the present tetraploid breeding stock traces back to a functionally homozygous primary amphiploid carrying the gene complement of one A-genome plant and one B-genome plant. It also suggests that the tetraploids became isolated by a sterility barrier from the genetic diversity of the parental diploid population. Thus, the genetic variability available for breeding of tetraploid wheats consists primarily of gene mutations accumulated since the origin of the primary amphiploid.

A second such evolutionary bottleneck occurred in late prehistoric times when the hexaploid wheats (AABBDD) originated from a hybrid between a tetraploid wheat and a third diploid species (DD). Theoretically, the short time since this origin has left the hexaploids with the least genetic variability of the various wheat types.

Experimental data showed that for all types of wheat (diploid, tetraploid and hexaploid) increase in seed size was correlated with a decrease in protein content as a percent of dry matter. All cultivated types had larger seeds and lower protein content than their wild or primitive progenitors. For the wild or primitive wheats, the mean protein percentages of the 2n, 4n and 6n types were 23.4, 20.7 and 15.3, respectively. Diploids and tetraploids showed considerable latitude for selection of high protein types within a given seed-size class. Such selections presumably could be used to increase the protein content of the cultivated tetraploids and hexaploids. However, high sterility would be expected in the required crosses.

The recent evident identification of the missing B-genome donor of wheat provides a more reliable method for using the gene resources of the wild diploids to improve the cultivated wheats. Thus, high protein types could be selected in both the A- and B-genome species. These could be crossed and polyploidized to give a synthetic AABB type which would be fertile in crosses with the cultivated tetraploids.

AMINO ACID SEQUENCING AS RELATED TO GENETICS IN WHEAT

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A more detailed understanding of the genetic relationships and control mechanisms that determine the types and amounts of the various protein components in bread wheats should be helpful to geneticists and breeders seeking to improve protein quantity and quality in wheat grain. Because of the hexaploid nature of common wheat, <u>Triticum aestivum</u>, three genomes are active simultaneously. These three genomes may have been derived from three separate diploid ancestors each of which had originated at an earlier stage of evolution by a process of divergence from some common ancestor. The complex mixture of storage proteins (more than 40 components) found in the endosperm of bread wheats has resulted in part from the recombination of these divergent species through the process of polyploid formation. However, since even wild diploid species, such as Triticum boeoticum (which may have contributed the A genome), appear to have as many protein components as the hexaploid wheats, the number of components in the hexaploids may be considerably less than would be expected on the basis of a simple addition of the components from each diploid ancestor. Control of gene expression in wheat is little understood; however, interest in this area of research is developing rapidly. A better definition is needed of the relationships among the proteins in hexaploid wheats along with a definition of their relationships to the equivalent proteins of wild diploid species that may have contributed genomes (and to rye, oats, barley, etc.). This information is desirable as an important step along the path to understanding the genetic control of protein synthesis.

Amino acid sequencing of wheat proteins should be an effective way to define these relationships; the evolutionary history of the wheat plant is written in these sequences. Proteins are polymers of amino acids linked by peptide bonds. The number of each type of the 20 different amino acids commonly found in proteins combined with the order of incorporation of these amino acids into the polypeptide chain (sequence) defines the primary structure of any given protein. We have begun the amino acid sequencing of A-gliadin recently and, eventually, expect to provide the first complete sequence of a wheat storage protein; this sequence will serve as the basis for comparison with many other wheat protein components. The wheat gliadins have been classified, for example, into components and groups on the basis of electrophoretic mobility. Furthermore, these components have been assigned to particular genomes and chromosomes. We do not know, however, how closely these various components are related in terms of their primary structures or their location in endosperm tissue at the subcellular level.

A-gliadin was chosen as the starting point largely because of the extensive characterization of this component carried out in our laboratory; this included study of the fibrillar aggregates formed by this protein. These fibrillar structures have been shown to exhibit dough-like viscoelastic properties when concentrated solutions are subjected to shear. In addition to our interest in the genetic relationships of gliadin proteins, sequencing of A-gliadin will define the toxic peptide (or peptides) responsible for celiac disease in susceptible individuals insofar as the toxicity of A-gliadin has recently been demonstrated.

BREEDING FOR INCREASED PROTEIN CONTENT IN RICE

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Quality of rice protein is high, but quantity of protein is low, averaging about seven percent for brown rice. Since rice is the principal food crop for at least half of the people of the world, even small increases in protein content could have tremendous impact on human nutrition. A desirable plant breeding goal is to increase protein content of rice by two percentage points while maintaining high yields. Attempts to increase rice protein content through plant breeding are underway in California, Arkansas and Texas, and in the Philippines, Japan and India.

Initially, several high protein rice varieties were identified by screening the USDA collections of 4400 varieties. In early studies at Davis, high protein Japanese varieties (9% protein) were crossed with California varieties (7% protein). Protein content was determined on part of the seed of random F_2 panicles. The remainder of each panicle was used to plant replicated F_3 hill plots. Standard unit heritabilities for the correlation of F_2 panicle values with F_3 hill-plot protein values were not significantly different from zero, indicating that single F_2-panicle selection for protein was ineffective. Variance component heritabilities for F_3 hill plots also were low. Significant genetic variation for protein content was observed in two of the six crosses studied. High protein content was significantly correlated with light kernels, early heading, and short plant height. In these early studies, the low protein heritabilities were attributed to genotype x year interactions, to environmental effects, and to within-line segregation due to early generation testings.

In subsequent row-plot studies conducted in the F_4, F_5 and F_6 generations, protein heritabilities of .60 and .71 were observed in two crosses between a high-protein Japanese variety and two California varieties. In these two populations, significant negative correlations (-.54 and -.38) were found between protein content and grain yield.

Further F_3 and F_4 studies involved a high-protein Hungarian rice variety (10% protein). Protein heritabilities of .37 and .62 were found in two crosses with the Hungarian parent. Small, non-significant negative correlations (-.01 and -.12) were observed between protein content and grain yield in these two populations. Some lines derived from one of these populations are about two percentage points higher in protein than the adapted check variety and yield 80 to 90% of the check variety. Progress in selecting good agronomic types in this population has been hampered by the weak straw contributed by the high protein Hungarian parent.

A more recent approach has been to examine protein content of lines included in the breeding program for other reasons. In this fashion, several short stature lines have been identified which are one percentage point higher in protein and nearly equal in grain yield to the adapted check variety. This approach is being explored in greater detail.

Protein heritability values obtained in these studies are of the same magnitude as heritability values for grain yield of rice. Hence, the rate of progress for increasing protein content should be comparable to that for increasing yield. Since it is unlikely that a high protein, but low yielding, variety would be acceptable, considerable attention must be given to possible negative relationships between protein and yield.

BREEDING FOR QUALITY IN DEHYDRATION CROPS

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Production of dehydrated foods in the United States expanded after World War II. About half of the dehydrated foods are used by remanufacturers whose principal customers are the food service outlets. The food dehydration industry also supplies food directly to food service outlets, as well as to retail markets. The Federal Government purchases dehydrated foods for the military and for the federal food distribution program.

Potatoes are produced in the largest volume of all the dehydrated vegetables. The second largest group is onion and garlic which, in the five years following 1965, doubled on a dry weight basis. In 1970, between 20 and 25% of the onion crop and more than 90% of the garlic crop were dehydrated. Other vegetables in lesser quantities that are dehydrated are chili peppers, carrots, bell peppers, tomatoes, asparagus, cabbage, celery, chives, corn, green beans, peas, pumpkins, green onion, shallots, parsley, lima beans, dill, mint, horseradish, and others.

Crops such as garlic reproduce only vegetatively; new potato varieties are produced by sexual reproduction, but the variety is maintained vegetatively. These crops create different and unique problems from those such as onion, tomatoes, and others that reproduce sexually.

It is not my intention to discuss plant breeding methods in detail or to outline the method used to produce new onion or garlic varieties for dehydration, but to show you the challenge and the responsibility of a plant breeder today as they pertain to breeding for quality in the dehydration crop. While the subject may be approached in different ways, inevitably, the basic product of plant breeding research is food supply. Processing techniques are excellent ways of carrying over from years of plenty to years of scarcity to effect a more stable supply throughout the year.

In breeding for quality in dehydration crops, all of the usual criteria apply - appearance, texture, consistency, flavor, aroma, etc. Under the pressure of inflation, the grower is faced with the economics of the growing of the variety. Government regulations exert their influence on the ultimate characteristics of the variety and on its nutritional quality. These new pressures, as well as others, have a great influence on the final product of the plant breeder.

The demands put upon a plant breeder differ according to the ultimate use of a variety. A fresh market variety may differ in many characteristics from that of one intended for canning or for dehydration. The plant breeder of today is not only responsible for the development of something "new and better", but in his hands rests the ultimate destiny of the world. In this day and age of food shortage throughout the world, the plant breeder is faced with the awesome challenge of creating new varieties that outproduce any ever known on this earth.

If we are to make contributions equal to or greater than those already made by primitive farmers, we must know our material intimately and thoroughly. We must learn how to introduce variability more efficiently, to evaluate rapidly and efficiently, and to select more effectively. Ultimately, we must develop a total plant breeding program. Considering the entire life cycle of the plant, as well as its ultimate use, we must consider its food value and effect upon man and his environment. We must study the variety thoroughly in the field in all its phases of development and growth and through all the stages of handling the crop until it is consumed.

The mechanization of agriculture made it possible for so many Americans to engage in commercial, industrial or service occupations and to make the United States the most advanced technological nation in the world. Breeding for quality in dehydration and processing crops has been a part of that technology.

SELECTING AVOCADO SITES

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The avocado is a subtropical evergreen plant. To be grown successfully, it requires exacting soil, water and climate conditions. In choosing a site for a proposed avocado orchard, remember, like a house, an avocado orchard can only be as good as its foundation. The three major components of the foundation are soil, water and climate. The most important is soil because, unlike water and climate, it cannot be modified as easily. Important considerations of soil include drainage, effective rooting depth, permeability and exchangeable sodium hazard as they relate to avocado root rot. Other important soil factors to consider include slope, texture, type, erosion and previous land use.

Climatic conditions to consider when choosing an avocado site should include winter frost hazard, spring temperatures at flowering, wind, and summer heat hazards.

Water conditions to consider when choosing a site should include the source and reliability of water, the quantity available, the quality of water and water costs.

The job of choosing the right site for an avocado orchard requires much time and effort. Seek out answers by observing successful operations, reading the available literature and talking with professional growers and managers.

NUTRITIONAL REQUIREMENTS AND FERTILIZATION OF CITRUS AND AVOCADOS

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This report is restricted to California conditions.

N and Zn are the nutrients that must be added for practically all citrus and avocado plantings. Fe deficiency affects about 5% of the citrus and avocado orchards. No other nutrient deficiencies are encountered in avocado, but P, K, Mg, Mn, Cu and B deficiencies have been encountered in citrus orchards.

Excesses of Cl and to a lesser extent Na are encountered in avocado. Excesses in citrus include B, S, Cl, Na and Li.

Because of variations in soil, contributions from reserve N in soil, amounts of N in irrigation water, types of culture, methods of applying irrigation water, etc., a general recommendation for rates of N may or may not be appropriate for a given orchard. Common appropriate rates of N in pounds per acre are 100 - 150 for oranges, low-vigor lemon selections and most avocados, and 200 - 300 for vigorous lemon selections and desert grapefruit. Leaf analysis integrates the effects of many factors that influence the N levels in trees into one figure - the concentration of N in the leaves. Leaf analysis is a very good guide to fertilization with N and other nutrients.

In the avocado, fertilizers have had little influence on fruit quality and size. Therefore, a leaf analysis guide calibrated against yield is very useful. In the case of the orange, within the range of nutrient levels for maximum production, N, P and K have important influences on fruit size and quality. In this case, a leaf analysis guide calibrated against yield only is limited in utility. Leaf analysis guides calibrated against yield, fruit size and quality are now available. Trade-offs among yield, size and numerous quality effects may be necessary to achieve greatest economic return. In some cases, quality can be improved by sacrificing some yield; however, from the overall economic point of view, it is usually advantageous to sustain maximum fruit yield even though there may be some sacrifice in fruit quality.

For citrus, external fruit appearance is of primary importance for fresh-fruit market, while quality and quantity of juice are of primary importance in fruit for processing.

Thus, fertilizer programs are influenced by the market outlet for the fruit.

With a properly calibrated leaf analysis guide, a year-by-year record of fertilizer applications and leaf analyses, and, in the case of some citrus varieties, a knowledge of specific quality problems, one can plan a proper fertilizer program.

SHAKE THEM OFF AT HARVEST
(A Report on Citrus Harvest Mechanization)

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Mechanical harvesting of citrus fruit is difficult and involves horticultural as well as engineering and economic problems. Numberous methods of complete mechanical harvest where fruit is removed from the tree without the use of human hands have been tried. Among these are vacuum and mechanical picking tubes and various devices which comb through the canopy of the tree, as well as limb and trunk shakers. Among these, only the limb shaker, coupled with the use of a catching frame, shows promise for commercial use.

The amount of injury to fruit harvested by shaking conventional trees is high. However, test work has shown that with proper pruning and tree training, the amount of injury sustained by the fruit can be reduced. Most of the injury to the fruit occurs as the fruit strikes twigs and branches during its detachment and fall through the tree to the catching frame. Among the criteria which have been listed to lessen the amount of injury to the fruit are:

1. Reduce sources of injury within the tree,
2. Reduce the distance the fruit falls through the tree, and
3. Reduce the velocity of the fruit as it comes into contact with branches and twigs.

These requirements can be partially met by producing a tree pruned free of dead and weak wood within the canopy and by training the main trunk and scaffold branch structure so that a low, open-centered, spreading tree is formed. With the branch and scaffold structure in our present unpruned trees, limbs are spaced one above the other in a random, haphazard fashion; and the inside of the tree is filled with dead and dying twigs.

Washington navel oranges allowed to free fall through trees where deadwood had been removed showed a marked decrease in the number of surface injuries compared with fruit which fell through trees from which the deadwood had not been removed. Similar results were encountered with shake-harvested grapefruit in the Coachella Valley. Sixty-seven percent of the fruit was free of surface injury where dead and weak wood had been removed from the tree, while only 45 percent of the fruit was free from similar injury where the trees were unpruned. Forty percent of these injuries were classified as large from non-pruned trees while only 8 percent were classified as large from pruned trees.

For the limb shaker, a tree where the trunk divides into three evenly spaced main scaffold branches seems the most practical. A low, open-centered, spreading canopy would give the fruit a freer fall to a catching frame with less chance of striking interfering branches. Also, since the height is less, the fruit will attain less velocity during its fall.

While the advantages of such a tree for shake-and-catch harvest are apparent, there are many unknown factors the principal of which is whether or not production can be maintained if severe pruning methods to produce such a tree are used.

FUTURE OF CITRUS AND AVOCADOS IN CALIFORNIA

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As producers of oranges, tangerines, lemons and grapefruit, California and Arizona growers now have close to 380,000 acres of citrus with an annual crop value of $225 million. Oranges produced in the two states provide approximately 60 percent of all oranges marketed in fresh form in the United States. The California-Arizona lemon industry grows practically the entire supply of U. S.-produced lemons and also provides substantial supplies of winter and summer grapefruit. Significant quantities of citrus are shipped from the two states into foreign trade. California is the major supplier of avocados for U. S. markets, producing 75 percent of the U. S. crop.

Navel and Valencia Oranges

During the last twenty years, the California-Arizona orange industry has undergone significant expansion with important shifts in acreage among producing districts. Total acreage in all districts increased from 176,484 acres in 1960 to 226,798 acres in 1974, a rise of 29 percent. Increases were greatest in Central California and the California-Arizona Desert Valleys and more than offset losses in Southern California.

Plantings of new orange acreage in California and Arizona reached a peak in 1965 and have since slowed as a result of unfavorable returns, increased interest in lemon and grapefruit plantings and other factors, including changes in Internal Revenue Service tax regulations. With at least ten years required to reach mature production, fruit from the heavy plantings in the mid-1960's will be felt in the mid-1970's and diminish in the late 1970's.

Lemons

California accounts for over 90 percent of U. S. lemon production. The remainder is produced in Arizona from plantings started in the mid-1950's. Following the development of frozen lemonade concentrate in 1950, increased demand led to improved grower returns and expanded acreage, followed by oversupply and lower returns in the late 1950's.

Since 1960 more favorable supply-and-demand relationships developed, largely as expanded export trade (particularly to Japan) more than offset declining shipments of fresh lemons to domestic markets. With favorable returns, acreage is currently increasing in all areas. Total acreage in California and Arizona on January 1, 1974, was reported at 86,145 acres, compared to 61,285 acres in 1960.

Grapefruit

The grapefruit industry of California and Arizona is divided into a winter and summer crop. The winter crop, grown from 16,413 bearing acres in the California-Arizona Desert Valley District, is marketed in direct competition with grapefruit grown in Florida and Texas. The summer crop, consisting of 5,490 bearing acres, is located in Southern California districts and is marketed in the summer months when U. S. grapefruit supplies are light. Currently, acreage is expanding, based largely on the prospects of expanded foreign trade and improved returns.

Avocados

Since the early 1960's, grower returns increased as a result of improved marketing procedures by growers and handlers, an extensive trade promotion program operating under a state marketing order, and more favorable supply-and-demand relationships in the industry. Currently, new plantings are at a record high rate; and higher levels of acreage and production are projected for the remainder of the 1970's and early 1980's. Projections also indicate a changing varietal composition in the crop with increases of the Hass variety relative to the Fuerte variety and proportionately larger spring, summer, and fall crops than in past years.

ODDS AND ENDS OF CITRUS AND AVOCADO PRODUCTION

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A number of practices and problems, not covered in the previous reports, are important in citrus and avocado production.

In citrus, it is estimated that 75 to 80 percent of the orchards are under a program of non-tillage with weeds controlled by herbicides. On sloping lands, strip cover crops, with growth controlled by mowing, are employed to reduce or prevent soil erosion. Non-tillage with herbicide weed control is used in avocado orchards. As trees mature, shading and a natural leaf mulch provide effective weed control.

Irrigation of avocados is primarily by sprinklers, low-head or overhead, dictated to a large extent by the sloping terrain on which they are planted. Recent plantings are relying heavily on drip irrigation. Citrus irrigation is by flood, furrow, sprinklers and, for recent plantings, drip. The type of irrigation employed depends on the climate, soil, topography, water requirement, and water quality of the area.

The selection of the proper rootstock for citrus in a particular area is an important aspect for a successful orchard. Rootstocks vary in their tolerance or resistance to virus and soil-borne fungus diseases and nematodes, their compatibility with the scion, their tolerance to salinity and poor drainage. They also have an effect on fruit quality and size, scion vigor and cold hardiness. Rootstock selection for avocados is less critical with one exception. This is a rootstock tolerant to the soil fungus <u>Phytophthora cinnamomi</u>; however, complete tolerance has not yet been found. Generally, rootstocks of Mexican-race varieties are preferred because of more tolerance to minor soil-borne fungi and lime-induced chlorosis.

Pest control costs in citrus are one of the highest cultural cost items a grower faces. While advances are being made in biological control of insects and mites, economic control of these pests is generally dependent on the use of pesticides. Programs of pest management, integrating chemical and biological control, are being more widely used. In contrast, avocado growers enjoy low pest control costs due to the effectiveness of natural biological control.

Disease prevention and control are major items of concern in both citrus and avocados. Citrus are subject to several viral, fungal, bacterial and mycoplasma-like diseases, some of which have caused extensive loss. The major disease of avocados is avocado root rot caused by the fungus <u>Phytophthora cinnamomi</u>. In part, prevention is dependent on the choice of a low-hazard root rot soil - one with good internal drainage - for orchard planting. Only one known virus disease affects avocados. Virus diseases in both citrus and avocados are now minimized by Certification and Registration programs for the production of virus-free nursery stock.

AGRICULTURAL CONSEQUENCES OF ENVIRONMENTAL TRACE ELEMENT CONTAMINATION

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Most episodes of trace element contamination affecting man and other biological systems have been traced to urban and industrial activities, mining and smelting operations, the use of agricultural chemicals, and contamination of foods during processing or storage. In the present brief account of trace element contamination, I will restrict examples to those related to production and consumption of agricultural commodities. Also, I will restrict my comments to the following trace elements: mercury, lead, cadmium, arsenic, selenium, zinc, copper, nickel, and boron.

Mercury, lead, cadmium, arsenic, and selenium where present at elevated concentrations have been shown to be toxic to humans, animals, aquatic life including fish, and plants. Zinc, copper, and nickel are toxic to aquatic organisms, fish, and plants, while with boron, toxicities are restricted to plants.

A large number of pesticides containing mercury are used or have been used to control seed and soil-borne fungus diseases. One of the major environmental consequences associated with the use of mercurial seed-dressings has been contamination of seed-eating birds and their predators. Reports from the USA, Canada, Sweden, Norway, and Finland all traced high levels of mercury in birds to this source. Accidental use of mercury-dressed seeds as poultry feed has caused high concentrations of mercury in eggs. Instances of consumption of mercury-dressed seeds by animals and subsequent poisoning of humans consuming the meat have been reported in the USA, Pakistan, and Guatamala. A number of cases of toxicity caused by direct consumption of treated seed occurred in Iraq.

Very high concentrations of lead occur on vegetation and in soil close to and downwind from certain lead industrial operations. Lead contamination of vegetation is caused primarily by the deposition of particulates onto plant surfaces. Cases of lead poisoning of horses and cattle have been traced to forage contaminated by stack particulates from smelters and certain industries which process lead ores. The degree and extent of lead contamination adjacent to industrial operations depends largely upon the efficiency of devices used to control stack effluents. Recent reports show that humans living close to certain smelters have ingested amounts of lead from food and air considerably in excess of normal levels. Although the combustion of leaded gasoline by motor vehicles is a major source of environmental lead contamination, no documented cases of lead poisoning from this source have been reported. Soils and vegetation, close to high traffic density highways, show, however, levels of lead considerably greater than those considered normal. Lead is used as a glaze in the pottery industry and where pottery has been improperly fired, cases of lead poisoning caused by contamination of foods stored or dispensed from these containers have occurred.

Although there is widespread concern over environmental contamination of cadmium, only a limited number of instances of poisonings from environmental sources have been reported. The most notable of these occurred in Japan where a number of cases of cadmium poisoning of humans were attributed to consumption of rice grown on cadmium-contaminated soil irrigated with cadmium-contaminated water. The source of the cadmium was a smelter upstream from the rice fields. A number of greenhouse studies have shown that cadmium is absorbed by many plant species in amounts sufficient to be of public health concern. The greenhouse studies have also shown that yields of many plant species are dramatically reduced by relatively low concentrations of cadmium in soil. Much of the concern over soil cadmium contamination is a consequence of the possible expanded use of sewage sludges as soil conditioners and fertilizers on agricultural soils. Many of these sludges, particularly those from urban and industrial areas, contain much more cadmium than is typically found in soils; and if applied in large quantities for a number of years, would cause soil cadmium enrichment. This may result in toxicities to plants and cadmium accumulations in foods sufficient to pose health hazards.

Use of arsenic compounds in agriculture in recent years has been declining. However, the use of these compounds as herbicides and pesticides has caused contamination of agricultural soils. Old orchard soils have been reported to be so highly contaminated with arsenic that many plant species will not grow. Compounds of arsenic have been applied to cotton for leaf desiccation or to vegetation as a general weed killer. Organic arsenicals also have been applied to soils as selective or post-emergence herbicides. Sprays to control weeds have been reported to damage crops in adjacent fields. Dusts emitted from gins which process cotton treated with arsenical defoliants have caused adverse effects on vegetation downwind from the gin. A recent report shows elevated, but non-toxic, levels of arsenic in the urine of workers employed in a forest treated with an arsenic-containing herbicide.

Forage grown on soils high in selenium will accumulate this element in amounts which are toxic to animals who consume the forage. It is an essential element for animals at low concentrations. The range between dietary deficiency and toxicity is narrow. All episodes of selenium poisoning of animals have been traced to natural causes and occur in regions where soils are naturally high in selenium. However, if wastes high in selenium are applied to agricultural soils, the potential for accumulation by forage and subsequent toxicity to animals exists.

Copper, nickel, and zinc are generally not thought to contaminate the environment in sufficient concentrations to be harmful to humans or animals. Recent concern over these elements pertains to their effects on the growth of plants in contaminated soils and on their adverse effects on aquatic organisms and fish in contaminated waters. Sewage sludges contain more copper, nickel, and zinc than are typically found in soils. Under conditions where large amounts of sewage sludge have been applied to soils, toxicities to plants caused by excessive levels of these elements in soil have been reported. These effects are usually more acute in acid than in neutral or calcareous soils.

Boron is an element which commonly occurs in sewage treatment plant effluents and sludges in high concentrations. The source of the boron in these wastes is household detergents. Certain plant species are quite sensitive to low concentrations of boron in soil or irrigation water. Therefore, certain crops grown on sludge-amended soils or irrigated with sewage treatment plant effluents may be adversely affected by excessive levels of boron.

THE SELENIUM AND ARSENIC SOIL-PLANT-ANIMAL CYCLES AND INTERACTIONS

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Selenium was recognized as an element of importance in agriculture in the 1930's because of its toxic effect in animals feeding on vegetation of certain areas of the Great Plains and Rocky Mountain foothills. About 20 years later, the element was assigned a new role - that of an essential micronutrient for animals.

Extensive investigations have been directed toward determining the geographical distribution of areas of high and low selenium in rocks, soils and plants.

Attention has also been given to the nature of selenium toxicity in animals and means for minimizing losses from selenosis in animal production.

Incidence of losses in livestock production due to selenium inadequacy, the so-called selenium responsive diseases, has been large in many countries of the world. Methods of safely supplementing Se in plants and the animals feeding thereon have occupied the attention of many researchers.

The principal sources of the element in the food chain are the rocks and the soils formed by weathering of these rocks. Selenium concentrations in soils range from 0.02 to 200 ppm. Except in a very few limited areas, industrial or other human-caused pollution does not contribute to Se excess. Likewise man's activities, such as agronomic manipulation, do not now appear to be causes of selenium inadequacy in the food chain.

Blind staggers and alkali-disease are terms applied to syndromes in cattle and horses resulting from toxic levels of Se in the diet. Concentrations of Se in excess of 2 ppm (dry basis) commonly lead to toxicity in grazing animals.

Animals on a diet providing less than 0.05 ppm Se (dry basis) exhibit symptoms of "selenium responsive" diseases.

Human diets, because of the varied sources of foods, do not appear to be either toxic or deficient in Se. However, populations in remote areas and subsisting on local produce may be so affected.

Soil, plant and management factors useful in alleviation of both Se excess and inadequacy will be discussed.

Selenium has not been shown to be essential for agronomic plants.

Arsenic is a natural constituent of rocks and soils. Arsenic concentrations in soils of 1 to 40 ppm have been reported. Arsenical pesticides and herbicides may give rise to locally higher soil As concentrations.

Soil grown plants derive their As from native soil As and in some areas, from pesticide and herbicide sprays and some industrial pollution. Soil grown foods usually contain less than 0.5 ppm As (dry basis). Foods of marine origin invariably are higher in As - from 2 to 200 ppm on dry basis.

Arsenic has not been shown to be essential for either animal or plant life. Some organic arsenicals are used as coccidiostats and as growth stimulators for swine and poultry.

Arsenic has been reported to have some beneficial effects in counteracting mild Se toxicity.

BIOAVAILABILITY OF CADMIUM TO IMPORTANT FOOD AND FORAGE CROPS

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Corn, wheat, rice, field bean, soybean, cabbage, spinach, lettuce, curlycress, carrot, turnip, radish, tomato, and squash plants were grown to commercial harvest stage with a neutral soil treated with municipal sewage sludge (1% addition) containing variable amounts of Cd added as $CdSO_4$. By testing these plants under controlled conditions of low to excessive substrate levels of Cd, we were able to associate symptoms, yield decrements, Cd content of diagnostic leaf tissue and edible tissue with known substrate levels. "Available" soil Cd was measured as water soluble and DTPA extractable; available Cd was correlated with plant response. Spinach, soybean, curlycress, and lettuce crops were sensitive to soil Cd (as little as 12 μg Cd/g soil was excessive), whereas tomato, cabbage, and wheat were able to tolerate 10-fold higher soil Cd concentrations. And, in general, leaf plants accumulate Cd, especially in the leaf blade. In contrast, seed and fruit tissue from plants under comparable substrate levels of Cd accumulated much less Cd of the seed crops, soybean accumulated 20-30 μg Cd/g seed under substrate treatments of Cd which led to only 1 to 2 μg Cd/g seed of wheat and rice. Rice, under paddy conditions, is tolerant to soil Cd additions ranging up to 640 μg Cd/g soil and little accumulation occurs in the seed. Upland rice management results in Cd injury and yield decrements comparable to wheat.

Alfalfa, white clover, sudan grass, tall fescue grass, and bermuda grass were also tested under comparable conditions prevailing for the experiments with vegetable and field crops. Cuttings were obtained every 3 to 6 weeks over a 12 months' period to have an indication of yield effects throughout the test and to have plant tissue for chemical analysis for Cd. Yield decrements of 25% were associated with soil Cd concentrations of 20, 30, 30, 80, and 120 μg Cd/g soil, respectively, for sudan grass, alfalfa, white clover, tall fescue, and bermuda. Plant tissue from these forage species contained on an average basis 9, 22, 11, 42, and 48 μg Cd/g tissue, respectively, from sudan, alfalfa, clover, fescue, and bermuda showing a 25% yield depression. As with the vegetable species, the forage species exhibit marked plant species effects regarding sensitivity to soil Cd, uptake and accumulation of Cd. The most conspicuous interaction noted was for plant Zn with soil Cd reducing Zn uptake and accumulation.

Current research is focused upon Cd bioavailability compared to that for Zn, Cu, and Ni (the zinc equivalent concept).

The vegetable-, field-, and forage species are listed in the following table in order of increasing tolerance to substrate Cd. This tabulation lists the minimum soil Cd concentration leading to a 25% decrease in yield and the Cd content of leaf tissue collected from these plants.

Table 2 indicates the Cd content of seed from bean, soybean, corn, wheat, and rice of plants harvested from the Domino soil ± 5 µg Cd/g.

Table 1. Soil and Leaf Cd levels @ 25% yield decrement.

Crop Species	µg Cd/g Soil	µg Cd/g Leaf	Crop Species	µg Cd/g Soil	µg Cd/g Leaf
Spinach	4	75	F. Bean	40	15
Soybean	5	7	Wheat	50	33
Curlycress	8	70	TALL FESCUE	80	42
R. Lettuce	13	48	Radish	96	75
Sw. Corn	18	35	BERMUDA GRASS	120	48
Carrot	20	32	Tomato	160	125
SUDAN GRASS	20	9	Z. Squash	160	68
Turnip	28	121	Cabbage	120	160
ALFALFA	30	22	Rice (Paddy)	>640	3
W. CLOVER	30	11			

Table 2. Cd Content of Seed From Plants Receiving 0 and 5 g Cd/g Soil

Plant Species	µg Cd/g Seed: No Cd addition	µg Cd/g Seed: 5 µg Cd/g soil
Field Bean	0.05	0.40
Soybean	0.6	6.8
Corn	0.005	0.5
Wheat	0.1	2.8
Rice	0.1	0.2

A PILOT PROJECT IN COORDINATED MONITORING OF ENVIRONMENTALLY HARMFUL SUBSTANCES

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In 1971 a novel interagency effort was undertaken to plan, execute, and evaluate a pilot monitoring project to be centered in the lower Salinas Valley and the contiguous Monterey Bay. The pilot project was to provide experience for planning and conducting total environment monitoring and was thought to be a forerunner of a statewide environmental monitoring system for California.

It was recognized from existing programs that there was a need to develop and employ an integrated monitoring effort which would be capable of tracing source, movement, and fate of harmful substances in the environment, particularly across the traditional boundaries established for existing monitoring programs.

A pilot project was proposed which would:

1. Design such a monitoring program and
2. Determine the extent to which a number of agencies working together could plan and implement the program.

Approval for the project was obtained from the Governor's Cabinet in March, 1971. A four-member Project Committee was established in June, 1971, to direct the project; it was made up of representatives of the Resources Agency, the Agriculture and Services Agency, the Health and Welfare Agency, and the University of California at Davis. The group was headed by the University representative.

The Project Committee's activities included identifying working committees, identifying a review and advisory group, preparing the organizational structure, identifying agencies with responsibilities and interests in monitoring, developing objectives and guiding principles for the project, preparing an activity plan, and seeking systematic means for disseminating information about the project. The planning for the monitoring project was given to several committees whose composition and role was established by the Project Committee; the committees were the Substances to be Monitored Committee, the Sampling and Analysis Committee, the Site Selection Committee, the Data Management Committee, and the Community Relations Committee.

Sampling began with the collection of first samples on March 20, 1972. Final samples were collected in April of 1973. In this interval, a great many difficulties in the original plan were discovered and successfully overcome. In general, most of the samples which were requested in the final monitoring plan were taken and were submitted to the laboratories.

One of the more interesting aspects of the project was the discovery of elevated levels of cadmium in some parts of the basin. It was found necessary to create several sub-projects to adequately define and measure the extent of the anomaly.

TRACE ELEMENT INTERACTIONS IN THE PLANT-ANIMAL FOOD CHAIN

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Trace elements are those that comprise less than 0.01% of the mass of an organism, although their concentration in an organ or tissue may be very much greater than that amount. Trace elements have been divided into three categories:

1. Essential or micronutrient elements,

2. Possible essentials, and

3. Nonessentials.

Essentiality is not well defined in field study because deficiency syndromes are compounded by a multitude of environmental factors. The criteria that have been employed for elemental deficiency include specific biochemical changes, physiologic and clinical syndromes, epidemiologic evaluation of elemental concentration within a population, and quality-of-life endpoints. As Stout has pointed out, an element cannot be considered essential if its only function is to ameliorate a disease or abnormal physiologic state that is not a primary effect of the elemental deficiency, as in the case of cobalt in amelioration of the ruminant disease phalaris staggers.

The elements presently classified as micronutrients for mammals are iron, iodine, copper, zinc, manganese, cobalt, molybdenum, selenium, chromium, and possibly tin. The possible essentials are those elements with poorly defined biochemical or physiologic roles, relatively low toxicity, and wide distribution throughout tissues and organ systems at relatively constant levels. They include fluorine, vanadium, aluminum, nickel, strontium, barium and pentavalent arsenic. The nonessentials are considered to be environmental contaminants, either toxic or nontoxic. The toxic elements are hazardous at relatively low or trace concentrations. Those of particular interest include all radionuclides, cadmium, mercury, lead, boron, antimony, arsenic and fluorine, as well as the essential elements selenium and molybdenum. Thus, a micronutrient may be essential over a relatively small tolerance range, as is the case for Se. In diets with Se concentrations below 0.05 ppm, white muscle disease has been reported in calves and lambs, exudative diathesis in chicks, and hepatosis diateticia in pigs. The borderline toxic level for Se, around 10 ppm, is responsible for alkali disease in horses, blind staggers in livestock, and selenosis associated with cirrhosis and anemia in laboratory animals. Selenium, an essential trace element is, therefore, also toxic at trace concentrations. Similarly, trace amounts of the micronutrient molybdenum may induce copper deficiency, as described in a case report of molybdenosis in young Charolais-Brahman cross beef cattle from Turlock, California.

The toxic nonessential elements having physicochemical properties similar to those of the essential elements may affect an organism by poisoning or by reacting with active sites on enzymes. This appears to be the case in lead interactions with porphyrin synthesis and in cadmium's mimicry of zinc. The latter leads to enzyme activity changes in liver, kidney, and testes. The effects of the toxic nonessentials may often be reversed by using micronutrients as absorption antagonists or as excretion accelerators that replace absorbed toxic elements.

Changes in tissue concentration of the essential trace elements in a variety of disease states are undoubtedly of clinical significance, as indicated by changes in serum copper and zinc levels in neoplastic disorders. Serum copper levels are useful indicators of the activity of leukemias, Hodgkin's disease, and osteogenic sarcoma and are valuable aids in prognosis and therapy evaluation. Tumorous rats and mice fed Zn-deficient diets have had retarded tumor growth. Continued research is required to characterize the role of trace elements and their significance in disease processes.

TRACE ELEMENT CONTAMINATION OF MARINE ORGANISMS OFF SOUTHERN CALIFORNIA

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The Southern California coastal basin is a major contributor of contaminants to the adjacent marine ecosystem. Municipal and industrial effluents, harbor inputs, surface runoff, and aerial fallout all are important sources of certain waste materials, such as trace elements, synthetic organic compounds, and petroleum hydrocarbons to the coastal waters. One area of concern is the degree to which marine organisms living in such waters accumulate potentially harmful trace elements released as a result of man's activities. To date, we have determined that the following elements have significant anthropogenic inputs to certain sectors of the offshore region between Point Conception and the U. S. - Mexico Border, known as the Southern California Bight: Ag, As, Cd, Cr, Cu, Hg, Ni, Pb, Sb, Se, Zn.

Investigations have been conducted on two scales, regional and local. The former utilized the ubiquitous intertidal mussel Mytitus as a bioindicator of metallic contamination of the near-shore biota. Specimens 5 cm in length were collected during Summer, 1971, from coastal and island stations throughout the Bight. Digestive glands, gonads, and flesh were dissected from three males and three females selected randomly from each collection. Composites for each sex were then freeze-dried and analyzed at the University of California, Los Angeles, by George Alexander, utilizing a specialized emission spectrometer. Application of this technique to reference samples (NBS Orchard Leaves) has produced excellent agreement with certified values for those elements detected.

The digestive tissue contained the highest concentrations of the nonvolatile elements measured; and these data proved to be the most useful in making comparisons. No important differences attributable to sex were observed for the seven potentially toxic metals considered (Ag, Cd, Cr, Cu, Ni, Pb, Zn). Therefore, the collections were separated into three groups. The first (termed "urban") contained the five stations off the Los Angeles-Orange County Basin and the City of San Diego lying closest to the major known sources of metallic wastes. The second (termed "rural") contained the remaining five coastal sites; the third (termed "island") contained the five island stations judged by independent DDT data to be least affected by coastal anthropogenic inputs.

Utilizing a statistical approach developed by Tukey, for each metal, the mean concentrations for the three station groups were compared. For Pb, both the urban and rural mean concentrations (18 and 21 ppm dry weights, respectively) were significantly higher at the 95% level than the island mean (6 ppm). This appears to reflect a widespread coastal source of lead; automotive emissions are strongly suspected. For the remaining six metals studied, submarine municipal wastewater discharges into the urban zone are believed to be the dominant coastal source. However, there is no clear pattern of resultant contamination. Although Ag and Cu urban mean concentrations (26 and 38 ppm, respectively) were significantly higher than corresponding island means (10 and 20 ppm, respectively), for Cd the urban mean (14ppm) was significantly lower than both the rural and island means (26 and 21 ppm, respectively); for Cr the urban mean (5 ppm) was significantly lower than the rural mean (15 ppm) and not significantly different from the island mean (2 ppm). No significant differences between urban, rural or island mean values were observed for Ni (6, 8, and 10, respectively) or Zn (79, 79, and 70, respectively).

On the local scale, metallic contamination of flatfish trawled from highly contaminated sediments around the submarine outfall system and from an island control station were investigated. Utilizing neutron activation analysis at the University of California, Irvine, Drs. J. de Goeij and V. P. Guinn measured concentrations of As, Cd, Cu, Hg, Sb, Se, and Zn in wet liver tissue of specimens collected by Dr. A. Mearns of this Project. (Again, excellent agreement with reference tissue samples was obtained.) Estimated surface sediment contamination factors for the discharge area ranged from 13-160. However, no significant enhancements over control levels were observed in the flatfish known by their high DDT levels to have lived in the most contaminated region. In fact, for As, Cd, and Se, the concentrations in the outfall specimens were significantly lower, averaging only one-half to one-third those measured in the island specimens. Subsequent analysis by emission spectroscopy on flatfish liver, gonads, and flesh from the two regions confirmed the general lack of contamination. Only for Cr was there any indication of higher levels in the outfall specimens. In this case, the enrichment factor in liver and gonadal tissues was about a factor of two.

These results suggest that contamination of coastal marine waters and sediments by trace elements does not invariably lead to a corresponding contamination of resident organisms. In no case was an enrichment of more than a factor of two to three observed, and corresponding metallic depressions in exposed organisms were just as common. We are continuing our research in order to discover the reasons behind these differences and their ecological significance.