Proceedings

1976
CALIFORNIA PLANT
and
SOIL CONFERENCE

Sponsored by the

CALIFORNIA CHAPTER–A.S.A.

Quality Inn Woodlake
Sacramento, California
January 28, 29, and 30, 1976

1976

CALIFORNIA PLANT AND SOIL CONFERENCE

Sponsored by the

CALIFORNIA CHAPTER

AMERICAN SOCIETY OF AGRONOMY

January 28, 29 and 30, 1976

Quality Inn Woodlake

Sacramento, California

ELECTED OFFICERS OF THE CALIFORNIA CHAPTER

OF THE AMERICAN SOCIETY OF AGRONOMY

FOR 1976

THE EXECUTIVE COMMITTEE:

President:	Donald L. Smith Cal/West Seeds, Woodland
First Vice President:	R. Merton Love University of California, Davis
Second Vice President:	Stephen T. Cockerham Scientific Turfgrass Services, Ventura
Past President:	Oscar A. Lorenz University of California, Davis
Executive Secretary-Treasurer:	George R. Hawkes Chevron Chemical Company, Richmond

COUNCIL OF REPRESENTATIVES:

One-Year Term:	Luther B. Hughes California State Polytechnic University San Luis Obispo
	Luther B. Grass Imperial Valley Conservation Research Center, Brawley
	David J. Thompson Ferry-Morse Seed Company San Juan Bautista
Two-Year Term:	Warren S. Barham Basic Vegetable Producers, Inc. Vacaville
	Roy L. Branson Cooperative Extension University of California, Riverside
	Gaylord P. Patten California State Polytechnic University Pomona
Three-Year Term:	Roy S. Rauschkolb University of California, Davis
	Paul Rogers Kellogg Supply Company Carson
	Richard M. Thorup Chevron Chemical Company San Francisco

CONFERENCE REPORTS

WATER USE IN THE FUTURE

Dr. Gerald H. Meral
Deputy Director
Department of Water Resources
The Resources Agency
State of California

I. Introduction.

A. Today, I have been asked to discuss "Water Use in the Future."

B. The truth is, predicting the future is a risky business.

1. Consider the words of a soothsayer of the early twentieth century: "By replacing horses, which dirty city streets, the automobile will put an end to pollution."

2. Prime Minister Chamberlain upon returning from Munich: "This conference will result in peace in our time."

3. An MGM executive to an office flunky: "People will never sit at home and watch a 6-inch screen when they can go to the corner movie house."

4. A philosophy of the 1960's: "The United States will ALWAYS have access to cheap Arab oil."

II. Energy Prediction.

A. That last example typifies the inability of "experts" to predict the energy "crunch."

1. In spite of all the sophisticated forecasting tools we have, the nation was dramatically short-sighted about the energy crisis.

2. There were a few voices crying in the wilderness, but they generally were regarded as crackpots.

3. For the most part, long-range planners just didn't foresee the problems that beset us at the beginning of this decade.

B. This is not the first time knowledgeable people have "goofed" when it comes to energy prediction.

1. After the Federal Central Valley Project was approved, the U. S. Bureau of Reclamation assembled a blue-ribbon committee to establish committees to develop the Central Valley Project Studies.

a. 24 problems were posed and 24 committees established to find solutions.

b. The problems concerned post-war readjustments, costs allocations, acreage limitations, etc.

c. One of the problem studies, known as Problem 7, concerned the need and future source of power for the CVP.

2. The Problem 7 Committee worked from 1944-1946 and published their results in 1947.

3. What the Committee said:

   a. The Committee assembled historical power loads and prepared forecasts of the future need for power.

   b. The Committee reasoned that the rate of growth for power had been accelerated because of the increased demand for plants producing materials for war and the expected increases in load would not continue. Therefore, there would not be a large increase in the demand for power.

   c. The Committee also reasoned that there would be a readjustment in cost because cost had been fixed during the war years; and after the war was over, costs would accelerate, which also would lessen the demand for power.

4. What actually happened:

   a. The cost of power remained relatively fixed.

      1) Oil in the State was in abundance, natural gas was available, and power was being produced at low cost.

      2) These low costs continued for some period exceeding the 15-year time span (1945-1960) the Committee was concerned about.

   b. The 1950 loads exceeded the Committee's forecasted amount for 1960!

   c. The Committee of well-informed, knowledgeable people - probably the best available in California at the time - were wrong on two counts.

      1) That the cost of power would accelerate.

      2) That demand would slacken or decrease for a number of years.

C. Prediction of energy use in the future is just as risky today.

1. The current oil supply/demand situation is obviously dynamic, and whether oil prices will stabilize cannot be estimated accurately.

2. Nuclear energy faces not only cost uncertainties (allocation of "storage cost," price/supply curve for uranium), but also environmental and safety ones.

3. The cost of fossil fuel power plants also has been rising rapidly and costs of meeting stringent pollution standards are uncertain. Furthermore, supplies of oil and gas are dwindling.

D. I have devoted so much time on energy prediction, because energy, of course, today is a major factor in discussing water use in the future.

1. The Department of Water Resources' Energy Division falls under my jurisdiction as Deputy Director.

2. We are actively considering a number of alternatives to providing power for the State Water Project.

a. Favorable-rate contracts expire in 1983.

b. Alternatives we are looking at include:

1) Coal.

2) Geothermal.

3) Nuclear.

4) Other thermal plants (oil).

5) Power from the Pacific Northwest and BPA surplus energy.

6) Project recovery plants and Hyatt-Thermalito power.

7) Hydroelectric plants.

8) New generating methods (solar and wind).

III. Accuracy of water prediction.

A. Predicting energy use is not the only area in which long-range planners have encountered difficulties.

B. There is a built-in conflict in making long-range water planning projections.

1. It takes about 20-25 years to plan, build, and put into operation a major water project.

2. On the other hand, 20-25 years is at the outside range of our realistic planning period.

3. Since demand for water is now less than it was in the 1960's, it is even harder to plan for major new water projects, since the time scale for their need has been even further extended.

C. The Department of Water Resources is aware of the need for flexibility in long-range water planning.

1. In California Water Plan Bulletins 160-70 and 160-74, the Department projected conditions for both 1990 and 2020.

a. The 1990 projections were geared to decisions that should be made imminently because of the time frame involved in making water projects operational.

b. The 2020 projections were to illustrate a general future condition, rather than a situation against which a definite construction timetable should be set.

2. Just how successful have the Department's planning projections been?

D. Dan Ray, of our Department's Projects Analysis Office has made a brief analysis of the success of projections included in past State Water Plans.

1. The report was based on a review of 11 DWR bulletins, ranging in publication dates from 1923 to 1974, and one memorandum report issued in 1975.

2. This report was not put together as a "hatchet job" to discredit past work done by the Department. Let me quote from its introduction:

> "To avoid the accusation that I'm kicking a man while he's down - or in some cases after he's dead - I thought I'd start off with this quote from Bulletin No. 35 ('permissible Economic Rate of Irrigation Development in California.' published in 1930):
>
> > 'All that is asked is clemency on the part of those who in future years compare the results of this investigation with past events. It is hoped they will remember they are looking back and this report is looking forward through a telescope with lenses none too perfect making use of such materials as are at hand.'"

E. I'd like to read some of the comparisons from the Projects Analysis Office report.

NOTE: GHM will ad lib this section, working with a copy of the report.

F. The report drew the following conclusions:

1. Projections are not dependable as accurate predictions of future trends and events. (Only 40 percent of all the projections fall within five percent of actual data or recent projections.)

2. Projections for "ultimate conditions" are useless in preparing for specific plans for the next 25 to 50 years.

3. Projections are useful as indicators of probable trends under specified sets of public policies and other conditions. However, they should not be used as the <u>basis</u> for such policies. (Self-fulfilling prophecy, circular logic.)

4. Medium- and long-range projections are both about equally reliable and could be used reasonably as indicators of probable trends.

   a. Statewide projections are more reliable than regional or industry-specific projections.

   b. Their generality, however, probably limits their usefulness somewhat.

5. De-emphasizing the importance of projections in planning studies might help to shift the topic of water policy debates from theoretical points to the real issues.

IV. With these points made, I would like to use the time I have remaining to discuss water use in the future.

A. DWR's planning for water use in the future will be based on the goals enumerated in Water Management Policy adopted last May.

1. Water resources already developed shall be used to the maximum extent before new sources are developed.

2. <u>All</u> alternative sources of supply shall be considered.

3. Water conservation shall be implemented.

4. Water shall be reused to the maximum extent feasible.

5. Instream uses shall be balanced with other uses.

6. Water quality objectives and beneficial uses adopted by the SWRCB shall be the basis for water quality management.

7. Flood control shall include consideration of nontraditional, as well as traditional, measures.

8. The least expensive alternative will not necessarily be selected.

V. DWR's approach to meeting those goals is typified by the Water Action Plan.

A. Through the Water Action Plan we hope to bring together interests with diverse viewpoints and work toward solving specific problems in the near-term future.

B. The plan will reexamine significant water issues and suggest ways of resolving them in line with today's social and environmental goals.

C. The area studies portion focuses on ten specific areas within California with critical water problems which can be resolved in the near future.

1. We are working out water allocation and management actions for specific areas by reconsidering water needs, sources to meet those needs, and required implementation measures.

2. We are working closely with local agencies and holding dozens of public meetings to encourage full public involvement in the process.

3. We hope that any of you here today who are interested in becoming more involved will get in touch with the appropriate Department District Office or with our Statewide Planning Branch in Sacramento.

D. We have chosen the year 2000 as a reasonable time scale for our Water Action Plan effort.

1. Because of time frames involved, we must be thinking now about meeting our water needs in the year 2000.

2. We have to identify the decisions that must be made now and separate them from the decisions that are not needed yet.

3. This way, we are able to preserve as many options as possible. while still meeting basic needs.

VI. Conclusion.

A. I guess the main conclusion of my remarks here today would be: While the accuracy of projection techniques may be improving, our ability to make assumptions about long-range conditions is eroding.

B. This is one of the major tenets of K.E.F. Watt's The Titanic Effect, in which he details several recent cases of projections gone awry when underlying assumptions failed to hold up.

C. While long range projections may be useful for evaluating the potential impacts of alternate sets of development assumptions and public policies, it is not wise to then assume the impacts and begin long range, inflexible capital improvement programs to meet these expected impacts.

A GROWER LOOKS AT THE FUTURE IN AGRICULTURAL RESEARCH

Lester S. Heringer
Grower, Clarksburg

I am a California farmer. I have been a farmer all my life; and since I am also a Cal Aggie and our land lies nearby, I have been intimately associated with many agricultural research projects carried out by the staff of the Davis campus of University of California. I believe I know the value and importance of agricultural research not only to me, as a farmer, but to the population of the United States and the world as a whole.

Without treading on the toes of Dr. Shideler who is going to talk to you about 200 years of California agriculture, and since I don't go back quite that far, I am going to take the liberty of telling you something about what's happened in California since the turn of the century and of the important role that research has played in these events.

Probably all of you know that this is the third largest state in the nation with a total of 100.2 million acres. In 1974, 36.1 million of these acres were being farmed and these acres produced 9 percent of the national agricultural gross cash receipts. This production came from 63,000 farms, or 2 percent of the nation's farm total. California produces some 200 crops commercially and leads the nation in 47 of these crops, ranging from alfalfa seed to walnuts. California is also the leading producer of processed fruits and vegetables. Since the season is so long in this state, we don't yet have the figures for 1975, but in 1974, it supplied national and world markets with 146,891,728 cases of these commodities.

Actually, it was the California gold rush of '49, with its demand for compactly preserved foods, that gave impetus to the national canning industry. The California canning industry began in 1860, and in 1863, about 7,000 cases of California production was canned.

For purposes of gaining insight, I would like to quote to you from the Cyclopedia of American Agriculture, published in 1912. "California, having the climate favoring the widest range of products and a location best suited for marketing them, has shown the largest development in the canning industry. It has been to the canners' interest to see that only the most improved varieties of fruit are grown; that the orchard is properly pruned, plowed, cultivated and protected against pests of every kind; that the crop is thinned when necessary and that it is harvested properly. Operating under such contracts, orchardists have been brought to see the benefit of intelligent and business-like farming. Information from the best authorities, relating to preferred varieties of fruits, methods of cultivation, pruning and fighting of pests, harvesting and the like, has been distributed to the grower through the agency of the canners, and the latter have frequently pioneered some suggestion of the State College of Agriculture or of the United States Department of Agriculture, looking to improved conditions of horticulture."

Research had begun filling its role in California agriculture.

In 1905, the California canning industry was using the production from about 15,000 acres of fruit, and 10,000 bearing acres of vegetables, and the comment was made in the Cyclopedia that it was generally thought that the industry would not show the rapid growth in the future that it had in the past.

In 1974, bearing acreages of fruit and nuts in California, exceeded 1.5 million acres, and vegetables took up 859,000 acres. More important, however, has been the increase in production per acre which has taken place almost entirely as a result of research in better varieties and better cultural methods. As one example, in 1959, yield per acre in processing tomatoes was 15.4 tons. In 1974, just fifteen years later, that yield had risen to 23.4 tons per acre. Naturally, this means more dollars per acre returned to the farmer although he is essentially a middleman for their funds since costs of production have eroded most of this increased return. Meanwhile, the consumer is getting a better quality product at a cost of approximately 17 percent of her disposable income in 1974, as compared to 24 percent in 1959. I am sure you are as aware of these figures as I, but when agriculture and agricultural research is being beset by every do-gooder or self-appointed consumer spokesperson or by state and federal agencies or legislators who should know better, I tend to become upset.

The following item appeared last month in the Washington Food Report of the American Institute of Food Distribution. "The House this week rejected a compromise bill to enable cattle producers to finance and carry out a beef research and promotion program. The measure was sent back to Senate-House conferees after a number of Congressmen expressed concern that the estimated $60 million-a-year cost of the proposed program would raise retail beef prices by at least that amount. Several House members also called on the conference committee to restore to the bill a provision to require consumer representation on the board that would coordinate the industry-financed beef program." Please note that this was to be an industry-financed program. The beef industry is not alone in being attacked by consumer groups. Our California market order programs have been subjected to the same type of action on the state level.

In California, growers have picked up increasing amounts of the cost of research for many years. During 1974, 41 commodities operating under state marketing programs contributed more than $2.3 million toward research, with the citrus industry contributing some $416 thousand, and rice $348 thousand, for example. Total costs for the 41 programs, which also include inspection and market development, came to almost $32 million. But along with the $2.3 million spent on research, the programs were charged $2.8 million by the state for administration. The grower, who is taking this money from his declining net returns, is paying for a lot of bureaucrats and a lot of clerks and a lot of administration; and he certainly is not getting a return comparable to what he gets for his research dollar.

To focus on one commodity with which I am very familiar and which owes much of its dominance of national production to research, let's look at processing tomatoes. I know you are all familiar with the great success story of the mechanization of the California tomato industry, a story which never could have been told without the financial support of the industry, the cooperation of the University of California, the contribution by growers of time and acreage for experimentation, and the work of some very dedicated people who not only developed the machines, but the varieties that could be harvested by machines. It was a team effort that resulted in a billion dollar industry in this state; and since it is the state's primary processing crop, it provides a lot of employment for the state's residents.

In 1975, the Tomato Advisory Board contributed $149,328 to research on such projects as mechanical grading tables and dirt in loads going to the cannery. Under the Processing Tomato Advisory Board, an additional $275,000 was contributed for control of branched broom rape, and $193,000 to research on mold and varieties. $83,000 was spent on administering the market order. For state inspection of tomatoes, to make sure the consumer gets only the most wholesome of products, the industry contributed 34¢ per ton (one-half by growers and one-half by processors) for a total of $2,570,821.26. Of this figure, $250,000 was spent for administration - not for inspectors - but for administrators. I might add that last year there were only 825 processing tomato growers in the state, and 28 canners, to pay the bill for these programs.

Agriculture faces a very real dilemma. Our members are decreasing, out net returns are dwindling in the face of increased costs of production, we are being called upon to furnish more and more of the funds for research and for administration of programs, yet our hands are being tied by consumers who fear they may have to pay some share of the cost even though that same research is responsible for keeping food costs in relation to disposable income at the lowest level in the world. I would say to the consumer spokes persons that profit is not a four-letter word, nor is it a dirty word in agriculture. The agricultural industry must have profit to survive; and our ability to maintain some level of profit has come about through research that has allowed us to become more efficient. Rejecting a beef industry research program because of fear that it might raise retail prices is just plain stupid. If our past experience is any criterion, the ultimate result undoubtedly would allow the currently hard pressed cattle producer to stay in the business of producing beef; and if this is not accomplished soon, we will see astronomical prices accompanied by shortages.

When you ask about the future of agricultural research, I'm afraid agriculture and the present political atmosphere are at opposite poles. I know that farmers are strong believers in research and are quick to adopt new methods that come about through research. I know that the California farmer is particularly proud of the University network and the farm advisors who have been willing and eager to assist the number one industry in this state. I know that we are willing to pay our share of the research required to keep us in business and the U. S. consumer well fed. What I don't know is how much longer we are going to be allowed by the do-gooders, the consumer spokespersons and the bureaucrats to try to improve our production and our skills through research. And I don't know how much longer we can continue to pay the price tag for administration of the industry programs that make much of our research possible.

Yet, possibly never has the need for research and its application been more necessary to promoting peace and staving off world hunber. In a recent report from the Agency for International Development, it was stated, "We have led the world in applying science to the problems of agriculture and in doing so, have developed an unmatched set of federal and state agricultural research and development institutions. We are in a dominant position to help the hungry nations produce the food they need."

But until they are in a position of producing the food they need, and that would now appear to be a long way in the future, developed countries must continue to produce food surpluses to cover the deficits of these developing nations. While our land, water and other necessary resources are not without limit, we are faced with the necessity of continuing to increase our efficiency and our productivity if we are to be able to help feed a world population that is expected to double in the next 35 years, when our present total of some 4 billion mouths to feed will become 8 billion, if projections are correct. The proverbial two blades of grass where one grew before that has come about through the research and skill of American agriculture, will scarcely suffice under these circumstances.

This is the challenge to the United States farmer and to those engaged in agricultural research and its application in the years ahead. As we look back on the 1912 Cyclopedia of Agriculture, we become aware of the great strides we have made; and I am sure the agricultural industry will continue to support research both with money and skills, if it is allowed to do so. I believe that in order to minimize criticism and irresponsible attacks, we must objectively evaluate research projects on the basis of their practical application in serving the highest use of our resources, of increasing production, improving quality and lowering costs. Projects must be coordinated and duplication eliminated.

As you all know, the day is passed of the little old dusty researcher pursuing some private goal of his own and dying with never having attained it. There is neither time nor funds for such pursuits. Every research dollar must be put to its maximum use for the maximum benefit of the world population. Our time is short, our task is large, but I have great faith in your dedication as researchers and the ability of the United States farmer to put your results to work.

A LOOK TO THE FUTURE FROM THE STUDENT ACTIVITIES SUBDIVISION OF THE AMERICAN SOCIETY OF AGRONOMY

Shane Kramer
National President-ASA-SAS
Cal Poly, San Luis Obispo

It is with great pleasure that I extend to the California Chapter of the American Society of Agronomy the greetings of the Student Activities Subdivision. In representing some 4,000 undergraduate students from 70 universities throughout the nation, I am indeed appreciative of the opportunity to offer you a view of tomorrow, a glimpse of the results of our actions or inactions of today.

Today, agronomy is faced with a very real challenge - feeding an ever increasing world population. On a world-wide scale population, increasing yields per acre, new food sources, and improved crop strains have all been mentioned as components in either heading-off or at least cushioning the world food shortage. A most optimistic note out of studies at Berkeley indicate that through planning, frugality and a measure of luck, we may be able to keep pace until the mid 1980's. My question to you is: What happens after this?

By 1985, today's college student will have graduated, stepped out into the world and be fairly well established in his or her profession. Many of the ideals acquired in the university will become evident in his behavior and actions. If his training and profession is outside of the realm of agriculture, many of his misconceptions about agronomics will be quite rigidly implanted. He will be part of the 95% of our population whose only link to agricultural production will be the price tag on a grocery counter; he will be a person who can approve of a labor union's ability to shut-off exports of grains to overseas countries; he will be a person who sees price controls on the consumer end as a desirable and justifiable action; and he will be a person who sees nothing wrong with placing prime agricultural lands under pavement and concrete. If his training is in agronomy, he may be one of two personalities - passive or active. The passive type will be a person who saw only books during his college career. In the business world, he will see only what the system has to offer him rather than what he may offer others. If he is active, then he will have been a participant in agronomic activities during his college years. In the business, he will be constantly aware and active in promoting agronomy and seeking solutions to the age-old struggle of agriculture.

In these opening comments, I have tried to outline some of the problems that will plague the agronomist of the next decade - namely, a worsening food situation, a vast majority of the people who do not have even a basic understanding of agriculture, and a segment of those who are in our own field who take no active interest in promoting agronomy. Alleviation of these situations rests upon the professional of today. Somewhere in a student's education, he must be exposed to agriculture, its difficulties, how production works and why we must maintain a viable agricultural program in the United States. Whether he agrees or not with the agricultural point of view, he must at least be aware of it and hopefully, understand it.

To this end, the American Society of Agronomy is especially well suited. The Society is designed to deal with the problem of agronomy and the world food crisis. By the nature of its membership, it is designed to promote research, improve education and promote agronomy. It was with this in mind that the Society moved to guarantee its continuing effectiveness by establishing a Student Activities Subdivision. To reflect this, the SAS functions are to promote and educate others in agronomy; to instill in the agronomy student an enthusiasm and desire to promote agronomy; and to build and train leaders in agronomy.

By the nature of the SAS, it could play a very important role in helping to reshape some of the thoughts and ideals that many college students have about agriculture. The necessity for this kind of SAS activity can be seen by taking a look at the college situation today. On today's college campus, there is an ever growing schism between agriculture and students of other curriculums as fields of study are specialized. In addition, the fads and scares of the past few years concerning ag. chemicals, agricultural practices and the so-called evils of agribusiness have compounded the misunderstandings and misrepresentations about agriculture. More unfortunate yet is the fact that these ideas will be carried out and maintained in the business world. Even more disastrous is the fact that many of these same young people will become the leaders, policy makers and planners of tomorrow. With this in mind, it becomes exceedingly clear why the SAS must be much more involved in education.

As far as SAS involvement is concerned, how does California fare and what is her potential? Currently, there are four chapters affiliated with SAS. Of these, only one has been prominent on a national level and only two are currently considered active. In a state that is number one in agronomy, this is a poor reflection. The mechanisms are available for a very viable local organization.

Circumstances on a national and regional level are quite favorable to the development of the SAS in California. (1) Nationally, the western states are playing a more important role. Two national officers are from the West - Vice President from Brigham Young and President from Cal Poly, San Luis Obispo. In addition, there are committee chairmen from the western regions. (2) Through the appointment of a committee by the California ASA, you have expressed an interest in the student organization and encourage participation on a state level. (3) The regional soils contest for next year will be held at Cal Poly, San Luis Obispo. By extending these events, it becomes apparent that the revival of the SAS in California should be the next step.

Before I move on, let me reiterate the importance of a strong SAS in the future. It is one of the truly effective tools in reshaping ideals on the college level outside of the agriculture curriculum. To give you an idea of what we are faced with, consider the enrollment of the 19 campuses of the California State Universities and Colleges system based on 1974 enrollment. Of a total enrollment of 231,800, only 6,600 are in Agriculture and Natural Resources. This compared with 35,000 in Business and Management; 28,000 in Social Sciences; 12,000 in Psychology; 11,000 in Public Affairs; 16,000 in Fine and Applied Arts; 15,000 in Education; and 14,500 in Biological Sciences; is a pitifully few. Consider also that by current trends, only 3,000 of those enrolled in Agriculture are actively involved in student organizations, it becomes evident what a monumental task we have before us.

If the SAS is to thrive in California, it is necessary for it to be supported through cooperation by the California Chapter of the American Society of Agronomy. A working California association cannot survive without the aid, promotion and support of the professional society. In spite of the fact that students will be the voice, students will operate their own programs, and students will be the vehicle of expounding the agronomic point of view; students will also be moving on after graduation. In the long run, students are not, by the nature of the educational system, a body of stability and continuity. Because of this, it is necessary for a State Association to have the provision for participation, in an advisory capacity, of those from the professional society. In this way, there are people who can note the operation of the student organization from one year to the next and offer sound advice. This would instill the stability of experience which any long-term effort or organization must have to survive.

In conclusion, there are several ideals that must be remembered. (1) That the future will see the agronomist plagued by the world food crisis. This crisis will be complicated through the demands of those who do not have even a basic understanding of agriculture. (2) That hand-in-hand the Student Activities Subdivision and the California chapter of the American Society of Agronomy can, through mutual cooperation, reshape the ideals or at least make those in non-agricultural areas of study aware of the problems of agriculture, as well as build agricultural leadership for the future. (3) That the time to begin such an alliance is now.

Again, thank you for the opportunity to speak here today and please keep in mind that the SAS of today is the ASA of tomorrow.

AGRICULTURAL INSTRUCTION AND RESEARCH IN THE FUTURE

Charles E. Hess
Dean, College of Agricultural and Environmental Sciences
University of California, Davis

It is a pleasure to participate in the 1976 California Soil Conference of the California Chapter of the American Society of Agronomy. This morning I'd like to expand the topic which was given to me to include extension along with a consideration of research and teaching since it is essential to have all components of this tripartite organization in order to make it really successful. I'll touch on each of the three areas, teaching, research and extension, and share with you my thoughts of where we are and where we're going or should be going. As many of you know from personal experience, undergraduate enrollment in the colleges of agriculture throughout the United States has grown dramatically in the past five years. For example, at Davis in 1970, there were 2119 undergraduates in the College of Agricultural and Environmental Sciences. This past fall, in 1975, there were 4395 undergraduate students. The largest enrollment in some of 48 majors at Davis include animal science, 516 students; biological science, 322; plant science, 261; agricultural economics and management, 236; and environmental planning and management, 205 students. A smaller major, but one of interest to you, would be soil and water science which has had a three-fold increase in students going from 21 in 1970 to 63 in 1975. We greet this influx of students with mixed emotions.

On one hand, it is great to have the tremendous student interest in the programs offered by the College. I think it reflects a concern of the students for basic values in life and, through our programs, an opportunity to serve society. I also feel that the U. S. economic situation has had substantial influence in that the programs in colleges of agricultural and environmental sciences provide a sound liberal education, but at the same time provide a career orientation which enhances a student's opportunities for employment after graduation. It was not too many years ago when colleges of agricultural and environmental sciences were actively recruiting students for their programs. On the other hand, the great influx of students has placed a tremendous stress upon the faculty and the resources of the College. I do have some concerns that we maintain a proper balance among the teaching and research and extension responsibilities of our College. I feel that in the past few years, some of our research capability has been eroded by faculty members redirecting their efforts from research to working with students. This is a natural thing because our faculty are very concerned with the students and want to see them have the best possible educational experience. At times, it is necessary to postpone doing an experiment in order to counsel a student or to be sure that the lectures and laboratories are in their best possible form. However, we do have a responsibility to generate new knowledge and to be concerned with applying that knowledge to the solution of the problems facing agriculture and the environment in our State. It is essential that we do not undermine our efforts in the latter area. Toward that end, we are beginning to take some steps within the College to ensure a good balance and there are external forces which will also help prevent what could develop into a serious problem. We are beginning to redirect students from majors which are particularly heavily enrolled. We are asking the students to consider other areas of study or to go to other institutions of higher education. This has been particularly true in the case of animal science which is our largest major and an area which attracts a number of students who are hoping to enter the School of Veterinary Medicine. Since the students can enter a college of veterinary medicine with degrees in fields other than animal science, we are trying to give some preference to those students who are truly interested in production aspects of animal science. Another concern I have and one which may influence the rate of enrollment applications is the placement of the large numbers of students which have entered colleges of agricultural and environmental sciences throughout the United States. As I indicated earlier, the phenomenon which has been experienced at Davis is by no means unique; almost every college of agriculture throughout the U. S. has experienced substantial increases in enrollment. If after a few years, students find it difficult to obtain employment in their chosen fields, there may be a decline in the number of applications as has been experienced in recent years in the humanities and some of the social sciences. Fortunately, however, the education which students obtain in most colleges of agricultural and environmental sciences is one which gives them many options in terms of seeking employment. I think it is critical that we keep this factor in mind and when we are reviewing curricula, we are sure that we do not make them so structured or more narrow that the student is locked into one particular career choice.

In California, the action of the Governor may also play a role in the enrollment picture. When the Governor presented his budget to the legislature, he stated that the funding for the instructional programs would be based on the number of students which appeared in the University budget request and not on actual enrollment. It turns out that since the enrollment pressures were very high, there are more students on Campus already than what had been projected for the 1976-77 budget. In the past, the funding had been tied to the actual student numbers. If this position is not changed by the legislature and the Governor in his final action in approving the budget, there will be a number of students on Campus whose educational support will not be funded by the State and it will be necessary to spread the resources of all the students a little more thinly. This will put the pressure on the Campuses to be more careful in terms of not exceeding the enrollment projections. It is a very difficult type of game to play because there are a number of factors over which the Campus or the College has little control. One in particular is what the students are thinking and what is it that influences them in terms of either coming to college or staying in college. The very large enrollments and return of students in the past year may be due to the economic situation in which there was a shortage of job opportunities. There are some indications already that the return to a more favorable economic environment with increased numbers of jobs, fewer students will enroll and more students who are presently in college will not be back next fall. But there's no way to project or predict those types of figures - we just have to wait and see what will happen.

Another factor which places admissions offices into a game of Russian Roulette is the fact that you do not know what the acceptance rate will be of students who have been admitted to the College. It's always necessary to accept more students than actually we intend to enroll because roughly half will decide to go to other colleges. However, in programs which are very popular, such as agricultural and environmental sciences, the percentage can be higher and the averages do not have validity. In terms of the future, the demographic information shows that there will be an actual decline in the number of college-age students during the period of the 1980's to early 1990's. You just have to count the number of people who are already here and from the census, you can see that there will be a decline. It will be a difficult period, for some colleges are not in a position to offer quality programs. However, for U. C. Davis, I believe the outlook is fairly optimistic. We will be limited essentially to a steady state situation because of the size of our physical plant and an attempt to maintain a balance between students in agricultural and biological sciences with those in the humanities and social sciences. However, the programs that are offered in our College are areas which have been and will remain major concerns to society. Food production, environmental quality and energy are issues which affect the quality of life here in the U. S. and throughout the world. Although society's interests may rise and fall in these areas, the basic problems underlying them will be there and will need an adequately trained corps of people to be producing, teaching and extending in these areas.

There is also potential for growth in graduate programs at Davis and I would feel that a good proportion of the students would be in the area of the basic sciences which underlie the programs in A&ES. Also, there is a possibility that there will be a growth in the number of foreign students, particularly if the legislation known as the Title XII Amendment to the Foreign Assistance Act is adequately funded by Congress. This legislation, originally known as the Findley-Humphrey Famine Prevention Act, was incorporated into the U. S. Agency for International Development Foreign Assistance Act and the enabling legislation has been passed and signed by the President. Funding is anticipated later this fiscal year.

Now I'd like to turn our attention to the area of research. We have gone through a period in which there was tremendous pressures for discipline-oriented research. This was brought about in part by the period of very substantial funding by foundations, such as the National Science Foundation, the National Institutes of Health and the Atomic Energy Commission. These agencies were interested in supporting basic research endeavors; and when proposals which were mission oriented were submitted, they were usually returned with a suggestion that funding be obtained from other sources, such as in the U. S. Department of Agriculture. In the University of California, another factor played and continues to play a major role in influencing the direction of research activities and that is the peer review system. Of the three components used in judging a faculty member's accomplishments, namely, teaching, research and public service, certainly research, and specifically publications in peer-reviewed journals, play a major role in the judgmental process. While there is no question that it is essential for our College to have substantial investment in programs which are considered basic and are providing the fundamental answers to questions of production and environmental concern, we must also recognize that we do have a responsibility in problem-oriented research. It was for this reason that colleges of agriculture with a combination of teaching, research and extension were established and we must not lose sight of this responsibility. I do have some concerns, as I do with the balance between teaching and research, that we may need a little better balance within our College between basic research and problem-oriented research. I feel this is particularly important at this time when we may be looking towards the support of our constituencies in agriculture and in the environmental area - either for direct support or for support of the University research budget. If these constituencies feel that the University is not interested in the solutions to their problems or is not delivering, then certainly their support will be very difficult to obtain. And, given all the pressures that are placed on the legislature for the distribution of tax dollars, there will be problems obtaining funding for new programs, let alone maintaining the current areas of research.

In this current year for example, the Governor has provided no increase at all for University research budget, including the Agricultural Experiment Station; though, in relationship to what has been experienced in other states, such as New York and New Jersey, this might be looked upon as a fair action. However, it really does in fact represent a cut because of the eroding effect of inflation. In a way, it is ironic. We are in a period in which there has been expressed major concern for food production, both nationally and internationally. We have a Secretary of State who is concerned about wheat and soy bean production and a Secretary of Commerce who is pointing to a balance of payments which is favorable for the first time in many years because of agricultural exports. Numerous conferences establishing research priorities for food and nutrition research have been held and yet we see many states actually decreasing their support or at best holding a steady state situation for agricultural research. I feel this presents us with a challenge. Obviously, we have not done a good job in convincing legislators that the type of research that we do does not represent an expenditure, but really an investment in the future - an investment which is returned manyfold by new information, new products, better nutrition and improved quality of life. I came from a state which is described as being the most urbanized in the United States and there too, we had substantial challenge to provide the legislators with the necessary information so that it would be possible to make sound decisions when it came to agricultural legislation or appropriations. I feel in a state such as California, where agriculture is the number one industry, that this job should be a little bit easier, but it's one which must be done because here too, the legislature is primarily urban oriented and their constituents get little closer to agriculture than the supermarket. In addition to seeking continued and, hopefully, additional support from the legislature, I feel we also have an opportunity to seek increased support from the agricultural industries who utilize much of the research information which is generated in the University of California and other land grant colleges. I fully support the concept of marketing orders which have become the subject of some debate in this past year. They provide funds to help develop more stable markets for the commodity which is of interest to both the grower and the consumer. They also provide money which is invested in research programs that lead to improved quality and improved production efficiencies which benefit both the producer and the consumer. The marketing orders and the research advisory boards, which are normally associated with them, also provide an excellent means of communications between agriculture and the scientists at the University. They are able to sit down and discuss needs and priorities and the research funds provide some operating dollars which is often a limiting factor in conducting research.

Finally, I believe we also need to have greater cooperation between extension and research; and I know Vice President Kendrick is and has been working in this direction. I believe the Pomology Continuing Conference, with which many of you may be familiar, is an excellent mechanism that provides a forum for researchers and the extension staff meet annually to identify problems, set priorities and to decide who is going to do what and how. It is an exercise that is beneficial both to the research faculty and to the extension staff. I would like to see such programs conducted in other areas in the College. We have a tremendous opportunity both now and in the future. We are living in a state in which agriculture is number one - as Tim Wallace refers to it, the sixth largest good producing country in the world. It represents an eight million dollar industry supplying some twenty-five percent of the food for the United States as well as substantial exports overseas. We are living in a time when food is a major concern of our government and of the people both here and internationally. We have a great faculty and staff in teaching, research and extension. If we can work together as a complete team, we can contribute to science, to agriculture and to the consumer in such a way that the level of support which has been the tradition in the past will continue with enthusiasm in the future.

TWO HUNDRED YEARS OF CALIFORNIA AGRICULTURE

James Shideler
Department of History
University of California, Davis

In 1776 on different parts of the globe, three things happened that relate to California's agricultural history. First, the Mission Dolores and Presidio of San Francisco were founded as outposts of colonial Spain in a remote northern corner of Alta California far away from headquarters of the colony in Mexico. Second, 3,000 miles away, on the East Coast of North America, at Philadelphia, a Continental Congress representing 13 distant colonies of the British Empire declared for national independence. Third, that same year, another 3,000 miles across the Atlantic, in Britain, Adam Smith published The Wealth of Nations, in which he persuasively argued that economic growth proceeded most happily at the hands of individual entrepreneurs in the absence of governmental controls, or under a policy of laissez faire. And this became a guide and inspiration for American growth and development.

These three unrelated events were representative of larger trends that were to converge in California in the course of the next two centuries.

The founding of San Francisco was one step in the Spanish thrust northward from New Spain or Mexico. Little was known about California except that it was there. It was believed to be an island ruled by Califa, Queen of the Amazons. Fanciful, yes, but not entirely wrong. Separated as it was from everything else by space, deserts and mountains, California was very much a sort of island.

The Spanish had been in Mexico since 1520 and Cabrillo explored the coast of California as early as 1542, but they did not get around to starting occupation until more than two centuries later at San Diego in 1769. At the end of the Spanish period, in 1822, a string of 21 Franciscan missions and few presidios and pueblos represented the extent of Spanish occupation; and agriculture had been established.

California's native Indians had only a rudimentary agriculture to transfer to the Hispanic European newcomer. The missionaries, mainly, brought it all - domesticated plants and animals, tools of cultivation and some knowledge of irrigation, and weeds that radically replaced the native flora over much of the landscape (notably, wild oats). They introduced the European heritage of small grains, many vegetables, stoned fruits and citrus. The Mission Olive, the Mission Fig, the Mission Grape, are directly traceable to the Spanish missions. The Mission Grape made a so-so wine, but it served its principal purpose. This agronomic and horticultural variety demonstrated something about the receptivity of California to numerous agricultural products. As for livestock, the Spanish brought poultry, sheep, goats, and cattle. In a benign environment, the rangy cattle multiplied like jackrabbits and were about as meaty.

At its peak, mission agriculture "employed" about 18,000 Indian neophytes, had around 400,000 head of livestock and a few thousand acres under a sort of cultivation, producing mainly small grains.

The revolution which brought independence to Mexico in 1821-22 was followed by secularization of the missions in 1833. They quickly fell into decay as their resources were acquired by Spanish-Mexican-Californian cattle ranchers. A free and easy cattle ranching era lasted 26 years, trading hides and tallow for manufactures from New England with more money made by the merchants than the rancheros. This romantic, easy-going and improvident life of the Californios, exploiting natural resources in a skimming sort of way, is neatly described by the firsthand observations of Richard Henry Dana in his classic Two Years Before the Mast.

A carry-over imprint from the Mexican period was large landholding, based on land grants more or less casually conferred. Fewer than 20 Spanish grants were made and several hundred more under a relaxed Mexican regime. Among the grants was one in 1840 to John Sutter of eleven square leagues. Sutter's fantasy of a great agricultural empire was a-building when events overtook him. He is remembered mainly by the city of Sacramento which he founded and Sutter's Fort, a historical relic. War between the United States and Mexico ended in 1848 with United States possession of California, then populated by about 15,000 people of European descent - Spanish-Mexicans, some Anglo-American agricultural settlers and a mixed bag of European hide, tallow and fur merchants at Monterey, San Francisco, or Yerba Buena, and Santa Barbara. That is fewer people than there are now students on the Davis campus. That same year, 1848, James Marshall discovered gold in the millrace of John Sutter's sawmill on the American River. California's Spanish-Mexican character was mostly erased, trampled in the rush for gold.

This brief sketch dwells overlong on the Spanish-Mexican side for this short paper. What about the other two events of 1776?

America's Declaration of Independence began a governmental system that was relatively stable and tranquil, enabling citizens to devote their energies to development.

The economic freedom extolled by Adam Smith in 1776 was adopted in America as a national policy which stimulated vast productive activity by enterprising speculative individuals.

As it happened, American independence and adherence to Smithian economic doctrine came at an early stage of the industrial revolution in Europe and America. The markets and the tools and the transportation facilities were made ready for the exploitation and development of America's vast continental resources of soils, timber and minerals.

American national growth was like a vast powerful harvester chugging across the continent, making farms, building cities, digging mines, constructing steamboats and railroads and factories, and rearing up irrigation works.

It was a unique society and geography that produced so much development so quickly. And, it got to the West Coast and California in the mid-nineteenth century along with the gold rush.

Here was a convergence of Anglo-American profit-seeking and industry and California's barely explored resources.

As significant and dramatic as the gold rush surely was, it recedes when we turn to California's economic growth, especially to its agriculture, which, like mining, was a speculative money-making enterprise free of romantic ideas about founding a country of small yeomen farmers. There was some of that, but it was usually the rhetoric of developers with land for sale.

Early Easterners were pessimistic about California's agricultural potential. Here was a strange environment, an unlikely place for farming with a hostile desert climate. Well, if not desert, then subhumid or semi-arid by eastern standards. The average annual rainfall here in Sacramento is about 17 inches a year, all bunched in the winter months, leaving a long dry season. "Averages" are not usual. More usual are alternate drouths and floods. In recent years, the Davis station recorded a low of 5.9 inches (1939) followed the next year by a high of 29.4 inches (1940). The land offered early settlers either excessive wetness, sticky soils and swamps, or excessive dryness with hard-baked ground. Coping with an unfriendly environment and turning liabilities into assets is a large part of the California story.

This belief in a narrow agricultural potential was reversed by the gold rush. California was suddenly a food-deficit area. Population had increased nearly 20 times, standing at 255,000 by the end of 1852. Food was imported from Oregon, Hawaii, Chile, even Australia.

Hungry miners bid high for necessities and delicacies. The price of skinny native cattle leaped from 5 dollars to 300 dollars a head, even to 500 dollars in the right place. Tall tales, such as miners told of miraculous strikes, recounted killings near Sacramento of 40,000 dollars paid for 40 acres of potatoes. In 1849 a German farmer close by here sold 30,000 dollars' worth of melons. And in 1851 two acres of onions from Napa brought 2,000 dollars. But in 1850, there were still only about 870 farms in the state.

The state's agricultural potential suddenly boomed. Boosters were now talking about oats growing 8 feet high with stalks a half-inch in diameter suitable for walking sticks and wheat alleged to produce 120 bushels to the acre. A bit more believable were giant ten-pound carrots, 26-pound turnips, 53-pound cabbages, a 118-pound beet and a 260-pound squash.

Whether the result of fantastic productions or fantastic profitability, shortages even more quickly became surpluses. And natural disaster, the great drouth of 1862-65, finished off the ranching era.

Here was an early example of the many radical changes in production patterns, rapid rise, then sharp decline, boom and sometimes bust, that became a distinctive feature of California's commercial agriculture.

Maybe the greatest of the great swings was the wheat bonanza of about 1860 to 1900. The wheat boom provides an example of early agricultural adjustment to a hostile environment and of the convergence of the industrial revolution and California's resources.

Finally, huge wheat production and export made a great contribution to California's economic growth, greater than the more dramatic gold bonanza.

We start with the vast level acreages of the Central Valley - alluvial soils, rainfall concentrated in the winter and spring sufficient to mature a crop of winter wheat, and a dry summer for harvest with wheat bone dry and suited to long-distance shipping. Next, add in large landholdings to start with and cheap land available for more big operations. Add also the industrial and technological revolution with iron and steel and steam-powered machinery underlaying a new industrialized agriculture - gang plows, harvesters and headers, threshing machines, steam traction engines, combines - then combines with side-hill leveling gizmos and, in time, gas engine crawler tractors. A larger industrial revolution, centered in England, produced great urban consuming populations drawing their food from long distances - markets for California's wheat.

To operate profitably on the distant fringes of the world market, California agriculture had to be efficient in terms of capital and labor inputs.

A final element in this rare combination of favorable circumstances for a wheat boom was transportation - the natural waterways, the San Joaquin and Sacramento Rivers and San Francisco Bay, where river steamboats and railroads and ocean-going steel-hulled vessels could all come together to drain and transfer the flood of grain from Central Valley fields. For several miles along the south bank of Suisun Bay, from Port Costa to Crockett, immense wharfs and warehouses filled an average of 300 ships a year from 1870 to 1900 to carry away the grain. In the season 1881-82, 500 loaded ships sailed away.

Meanwhile, back on the farm, operations were large-scaled, immensely productive and profitable for some. There was a get-rich-quick speculative fever, like the mining rush, to exploit the easily available virgin soil resources. And, like mining, wheat growing was an extractive industry.

As to scale, one example will do. Dr. Hugh Glenn had 42,000 acres in wheat (in what is now Glenn and Colusa counties) that produced in one year a harvest of one million bushels.

All together, some stupendous total of wheat was produced in the 40-year period of the boom, somewhere around a billion bushels. Income from wheat was a prime stimulus to economic growth, bringing the state to the stage of a matured economy. There were spin-offs or multiplication factors at work spreading benefits to machinery manufacturers like Holt and Best, bankers, steamboatmen, railroaders, warehousemen, insurance companies, commission merchants, flour mills, a horde of clerks and stenographers and stevedores, but no agronomists that I know about.

A sharp decline in wheat production came about at the end of the century just as California was ready to move on to other and more varied enterprises. Gains from economies of scale ran out. Despite loss of soil fertility from a rip-off type of agriculture, increased land values from encroaching irrigated cropland crowded out lower-value wheat in a classic example of the cost-price squeeze.

A technological revolution in flour milling from revolving stones to spinning rollers, plus a shift in the bakers' market to stronger hard wheats, plus new competitive wheat land in Canada, Australia and Argentina all combined to reduce the price of California's soft white winter wheat. Plant diseases and pests were the last straw.

There is, of course, much more to the story, but by 1900, the basic persisting elements of California's agriculture had emerged:

1. A peculiar set of geographic conditions modified and exploited by the agency of man - meaning the large-scale management of water resources until just about every drop of rain that fell on the State was planned before it dropped. But, lurking in the background is a solid ceiling on available water - and, in some years, less than that.

2. A highly commercialized capital-intensive form of agricultural operation, so highly commercialized, it won the name "Agribusiness."

3. Specialization within an extraordinary diversity of crop and livestock options.

4. Large operations in terms of acreage and/or investment and gross return.

5. Bursts of greater efficiency and productivity in terms of land and labor inputs (especially since World War II).

6. An ever-closer dependence of agricultural operations upon technological and scientific innovation and highly trained expert personnel produced by research and educational institutions, both public and private. (This is a large and important unwritten piece of history.) In 1900 there was no science of genetics. Mendelism was just then being rediscovered.

7. Rapid change, swings, ups and downs of crop patterns and profitability, responses to external pressures like rice acreage limitation, or crises like drouth years or pink bollworm driving cotton out of the Imperial Valley.

Two hundred years of experience with California agriculture did not result in fixed patterns or stability beyond these persisting general characteristics.

Whoever might think the final stage has been reached surely has another think coming.

NEW SOCIETAL ATTITUDES AFFECTING WATER SUPPLY AND USE - OVERVIEW

Robert M. Hagan
University of California, Davis

Today's farmers must manage water to obtain both favorable yields and profits. Less well known are the effects on water management of new societal attitudes on the environment and resource conservation. These new attitudes have already shaped important legislation, influenced the actions of water agencies (for both agricultural and urban areas), and will substantially affect water management at the farm level.

Water is an essential resource. Man has found no substitute for water in supporting all life forms and in producing our food and fiber. Foreseeable demands on water will increase in both diversity and magnitude. Water demands for energy technologies alone will be substantial and will necessarily compete with water for agriculture and other uses where water supplies are already over-committed, as in the Colorado River Basin. Not only are our water resources physically limited in quantity, quality and occurrence, water use is further constrained by legal and numerous institutional arrangements. The essential character of water resource management in the future will not be the development of new supplies. Instead it will be more intensive management of relatively fixed water supplies and, possibly also, reallocation of existing water supplies among competitive uses and users. Supply problems will no longer be mainly a matter of finding reservoir sites and suitable canal alignment. A mix of water uses must be developed that will support the varied goals of society.

The changing value systems of today's society are reflected in new water management policies announced in June, 1975 by the California State Department of Water Resources.

Developments in the last several years clearly indicate that water management, both in agriculture and in the cities, is going to be shaped by a host of new societal attitudes, new legislation and regulations, changing water pricing and institutional structures and other socio-economic considerations. Agriculture will no longer be able to deal with on-farm water management independent of other segments of society. In addition to managing water to achieve favorable crop yields and profits, farmers will now also have to be concerned about conserving water (even in regions of apparently abundant and cheap water), protecting surface and groundwater quality, protecting other beneficial uses of water, including fish and wildlife, providing for land disposal and/or use of urban wastewaters and reducing energy consumption in obtaining and applying irrigation water.

The dependence of irrigated agriculture on the very large amount of energy required to develop, convey, and distribute irrigation water is now becoming recognized by responsible officials, especially in California where the major aqueduct systems require very large amounts of power. The energy requirements of alternatives in water supply, use, and wastewater reclamation and re-use are summarized in a report recently issued by the University of California Water Resources Center. Attention is now being given to the energy requirements of different irrigation systems and to the energy used to irrigate principal crops in California.

It is clear that major challenges to agriculture are the development of water management and other agronomic practices which will achieve more crop-per-drop of available water while conserving energy and other resources. Of all the steps involved in converting precipitation which falls on some distant watershed into crops - many of which have low efficiency because of substantial water losses involved - the least efficient in conversion occurs at the farm in crop production. For some years ahead, water management and other agronomic practices which will increase water use efficiency at the farm level and deal with new societal pressures - such as land disposal or re-use of wastewaters - will be where the "action is."

WATER CONSERVATION IN IRRIGATION AGRICULTURE - EVALUATION OF OPPORTUNITIES AND CONSEQUENCES

James L. Welsh
Department of Water Resources
State of California, Sacramento

The California Department of Water Resources has undertaken a Water Action Plan to look at significant water issues facing California over the next 25 years. We will make decisions where we must and preserve options where we can. A major thrust is water conservation, which means stretching our available supplies to make them go farther and do more.

Our water conservation ethic includes reclamation and reuse of waste waters, better coordination of surface and ground water use, water exchanges, institutional rearrangements, more efficient use of urban and agricultural water.

This discussion centers on agricultural water conservation. The Department has a three-pronged water conservation program. The first, Bulletin No. 198, "Water Conservation in California", to be released in March, which covers both urban and agricultural uses. It presents water-saving measures; analyzes their effects, favorable and unfavorable; estimates the potential water savings; and discusses possible implementation.

The second phase will include development of a water conservation policy which will be the set of practical principles to guide our efforts in achieving maximum water conservation. The third phase will include implementation of these principles throughout the State.

On January 16 and 17 in Los Angeles, we held an Urban Water Conservation Conference. We found wide support for water savings. Many local agencies have already undertaken water conservation measures. We are planning a similar agricultural water conservation conference jointly with the University of California Agricultural Extension Service at the Red Lion Inn in Sacramento on June 23 and 24.

Two guiding principles we have adopted are: (1) the State will take appropriate action to prevent and eliminate waste and unreasonable use of water, and (2) effective water conservation will be a condition of state approval of water-related actions.

Where water, after use, flows to the ocean without further beneficial use, reduction in the amount of water applied to the land results in a direct water saving. But much of the State's agriculture is located in the Central Valley, where the only drainage to the ocean is through the Delta. Here, excess water applied to irrigated land eventually supplements Delta outflow. However, better management of water can save some water, better meet environmental needs and require less energy.

A second means of conserving agricultural water is to reduce evapotranspiration. Reducing weeds, phreatophytes and evaporation in open ditches and canals will reduce losses in distribution systems, but may impair environmental conditions. Recent experimental work at the University of California at Davis suggests that for some crops, less water than optimum amounts will produce nearly the same yield. Water application may be reduced as much as 20 percent in some instances. Irrigation method, land leveling, and water application duration may also reduce evapotranspiration through limiting saturation and volume of soil wetted. Drainage systems changes can reduce evapotranspiration.

There are many factors which determine efficiency of water use. These include water costs, labor, present system of irrigation, timing and amounts of water available, water quality, and soil conditions and resulting leaching requirements.

Opportunities for water savings must be examined on a case-by-case basi Because each situation is different, water conservation must result from car ful individual farm management. Also, the farmer has only partial control over water use. The source and timing of water supplies to the farm may dictate use. Institutional arrangements for supplying water, including not only timing and amounts, but most importantly, water costs and pricing, must be examined and optimized to provide better opportunities and incentives for saving water.

And water serves consumptive requirements of crops, it also must leach the root zone and transport harmful salt concentrations from the agricultura area.

These thoughts suggest two things: (1) a conservation ethic must be applied to the development, use and disposal of water; and (2) water manage ment must include the total concept of water supply, use and disposal.

The better the quality of water, the more efficient can its use be. Water management and water quality are inseparable elements; and it is only through achieving water quality objectives that we can obtain the most efficient water use.

Water conservation must be economically viable. Nor can major changes be made overnight. However, the cost of existing water supplies can be expected to increase, particularly as the cost of energy rises. The costs of developing new supplies are spiraling and public sentiment for achieving better environmental conditions continues to mount. We must conserve; and we think conservation is good business. Waste of water means future legitimate demands may not be met; unnecessary use of energy, which we can ill affort to do; and excessive costs to meet future water demands.

IRRIGATION AND WATER QUALITY DEGRADATION - PROBLEMS OF COMPLIANCE WITH WATER QUALITY CONTROL REGULATIONS

Robert S. Ayers
Cooperative Extension
University of California, Davis

Present pollution control regulations require monitoring of return-flow waters from irrigated agriculture. Monitoring for the next one to two years includes volume of the flow, its salinity and total suspended solids.

Public law 92-500 requires "best practicable control technology currently available" be adopted by July 1, 1977 and "best available technology economically achievable" by July 1, 1983. Agricultural waste waters (return-flows) come under the law; and it can be anticipated that regulations of agricultural discharge to both surface and sub-surface waters will be agreed upon and implemented at some time in the near future.

As background, the following should be considered -

1. World water supply is distributed about as follows:

   Oceans- - - -97.2%
   Land Areas- - 2.8%
      Ice caps and glaciers- - 2.1%
      Groundwater- - - - - - - 0.6%
      Lakes, streams, etc. - - 0.1%

2. Detention times of water (time to completely replace present water):

   Freshwater Lakes- -100 years
   Salt Water Lakes- - 10 years

Stream Channels - -.03 years
Groundwater
Shallow- - - - -200 years
Deep - - - - - -10,000 years
Soil Moisture - - -0.2 years
Atmosphere- - - - -.03 years
Oceans- - - - - - -???

Salts in irrigation waters and waste waters are now going someplace. Can more acceptable places be found where these salts can be directed and allowed to accumulate in relative safety?

Salts degrade the water supply and salinity is considered as one of the main quality parameters in evaluating a waters suitability for use. The salinity is usually a concern to many of the beneficial users of a given water supply, and reduction of the salt contribution or pollution of the water resource is one of the objectives of any water quality control program.

Three water management alternatives are sometimes proposed to reduce degradation of receiving waters. (1) Dilution of return flows to reduce salt concentration and meet a discharge requirement. (2) Decrease the efficiency of irrigation to obtain more dilute return flows. (3) Improve the efficiency of irrigation to save water.

Return-flows mix with the receiving waters and usually degrade them. Their effect depends upon the volumes and quality (salinity) of both the return-flow and the receiving waters. The relative effect of such return-flow can be evaluated in terms of the dilution water (of some assigned quality) that might be needed to restore the quality of the return flow to a desired or agreed-upon value. The following equation can be used:

$$Vdil = \frac{ViwCiw - (Viw-ET)\ Cal}{Cal - Cdil}$$

Where Vdil = volume of diltion water required to restore quality of percolating water.

Viw = Volume of applied water (assumes no run-off and uniform application).

Ciw = Concentration of applied water.

Viw-ET = Volume of percolating water.

Cal = Concentration of percolating water to be permitted (discharge requirement).

Cdil = Assigned or assumed concentration of diluting water.

Vdil can be termed the "degradation potential." This is a method of evaluation of degradation and is not a recommendation to dilute the discharge.

The effect of water management (changing leaching fraction, LF) on the "degradation potential" can be evaluated by use of the above formula under three different situations -

Case 1: Discharge requirement allows appreciable degradation of receiving water and applied water is also used for dilution.

(ET = 30 inches, Cal = 1000 mg/l, Cap = Cdil - 500 mg/l)

Leaching Fraction	Water Applied	Degradation Potential	Total Resource Water Use	% Change
LF.1	33.3 inches	27 inches	60 inches	0
LF.2	37.5 "	22.5 "	60 "	0
LF.3	42.9 "	17.1 "	60 "	0
LF.4	50.0 "	10.0 "	60 "	0

Conclusion: Increasing the leaching fraction (decreased efficiency) reduces the degradation potential, but total change in the water resource-used water applied plus water degraded - is the same at all leaching efficiencies.

Case 2: Discharge requirement allows no degradation of receiving water and water better than applied water must be used for dilution (ET = 30 inches, Cap = 500 mg/1, Cal = 500 mg/1, Cdil = 400 mg/1).

Leaching Fraction	Water Applied	Degradation Potential	Total Resource Water Use	% Change
LF.1	33.3 inches	150 inches	183 inches	0
LF.2	37.5 "	150 "	188 "	2.7
LF.3	42.9 "	150 "	193 "	5.5
LF.4	50.0 "	150 "	200 "	9.3

Conclusions: Increasing the leaching fractions (decreased efficiency) has no effect on "degradation potential", but more total resource water is used because of additional salts added in the applied water under less efficient management. Total resource water saved $\frac{(LF.4 - LF.1)}{LF.1}$ = 9.29%.

Case 3: Discharge to be allowed is of better quality than quality of water applied. This would require dilution with much better water than the applied. (ET = 30, Cap = 500 mg/1, Cal = 400 mg/1, Cdil = 200 mg/1).

Leaching Fraction	Water Applied	Degradation Potential	Total Resource Water Use	% Change
LF.1	33.3 inches	76.7 inches	110 inches	0
LF.2	37.5 "	78.8 "	116 "	5.5
LF.3	42.9 "	81.4 "	124 "	12.7
LF.4	50.0 "	85.0 "	135 "	22.7

Conclusions: Increasing the leaching fraction (decreased efficiency) increases both the degradation potential and total resource water used due to additional salt applied under inefficient management.

This concept of "degradation potential" may be useful for comparison of various water management procedures or various discharge requirements that might be placed on irrigation return flows.

The above suggests that some degree of degradation or reduction in over-all quality of the water resource must be accepted due to irrigated agriculture or steps must be taken to obtain adequate dilution water of good quality to maintain or restore the quality of the water resource.

Some of the alternatives of management to improve or maintain the water resource include -

1. Increased recharge of underground basins using run-off and surplus waters when available.

2. Increased export of low quality waters from a basin.

3. Importation of waters of better quality.

4. Restrict imports of water of low quality.

5. Recovery and export of excessively degraded water.

6. Improved efficiency of use to be better able to place the saved water where it will do the most good.

ADVANTAGES AND DISADVANTAGES OF DRIP IRRIGATION

Albert W. Marsh
Cooperative Extension
University of California, Riverside

Advantages:

The advantages of drip irrigation are listed by name. A few comments will be made about each. The order of their occurrence in this list does not necessarily reflect my view of their order of importance. The list and brief comments follow.

1. Water saving. This point has probably created the greatest interest. On a mature crop, it may be no greater than 20%; but on a newly planted crop, around which there is much bare soil, it may be 50 to 75%.

2. Labor saving. An installed drip irrigation system that is free from trouble may take very little labor for irrigation and even less where time clocks are used. Systems which have clogging problems and are otherwise not reliable may take as much labor as any other method of irrigation.

Fertilizer injection in the irrigation water is readily accomplished with drip irrigation and, in fact, is the only way that satisfactory fertilization can take place in arid climates. Injection through the irrigation system eliminates the labor associated with broadcast applications. With drip irrigation, the weed growth between emitters is much less than with other methods of irrigation and the cost and labor of controlling weeds is thereby reduced considerably.

3. Power saving. Water pressures needed for drip irrigation vary from 5 to 35 psi, but 15 is about average. It takes much less power to provide water at 15 psi than it does at 40 to 60 psi for sprinkler systems.

4. Problem solving. A strong point for drip irrigation is its ability to accomplish irrigation under unfavorable conditions. Very steep lands can be irrigated with drip irrigation, also soils that have extremely poor permeability and cause severe ponding or run-off with other irrigation methods. Sandy soils that cause maldistribution of water and excessive use with surface methods of irrigation can be irrigated satisfactorily with drip, as they also can with properly designed and operated sprinklers. Cultural operations are easier because much of the soil surface remains dry even though irrigations have been in progress. Cultural operations requiring machine traffic can be accomplished without miring in the mud or causing severe soil compaction.

5. Drip irrigation permits high frequency irrigation and the accompanying maintenance of low soil suction values. This may be the strongest advantage of drip irrigation from a crop production standpoint, but is often overlooked. The nature of drip irrigation is to have a high frequency and many research studies of recent years have pointed out the advantages in crop production to be associated with high frequency irrigation.

Disadvantages or Problems:

Drip irrigation has some advantages, but it also has a number of problems that may or may not be classed as a disadvantage, but rather they are points still in need of solution.

1. Cost. Drip irrigation systems are expensive, but about equal in many cases to the cost of permanent, solid-set sprinklers. Because of the cost, they probably cannot be used to produce low value crops.

2. Clogging. One of the principal problems of drip irrigation is clogging of the emitters by debris carried in the water. When emitters clog, much labor is required to remedy the situation. If clogging is only partial or not remedied, it has a detrimental effect on the uniformity of distribution of the water and much of the efficiency gains to be expected with drip irrigation may be lost.

3. Reliability. Drip irrigation is new and various problems have shown up so that growers often are unable to rely on the performance of the system. This causes the use of excess labor and eliminates the ability to operate the systems on time clock and remote valve basis. Reliability can be improved by following proper recommended procedures, but many growers insist they do not have the confidence to irrigate without having labor patrol the lines.

4. External damage. Drip irrigation systems are subject to a certain type and amount of external damage. Mostly this is caused by wild animals that chew and gnaw on the pipes and by field workers during harvest or other cultural operations. Drip irrigation systems may get in the way of certain cultural operations, particularly harvesting and some growers remove the laterals from the field before harvesting. This will reduce the external damage, but also increases the cost.

5. Pressure control on rolling land. If uniform distribution of water is to be obtained, it is essential that the system is designed so that pressure at all of the emitters is nearly the same. This takes considerable engineering skill and the use of extra accessories.

6. Line drainage. At the end of each irrigation, the lines tend to drain at the lowest point in the line. Depending on the position of the valves, this could involve a moderate quantity of water. When the line drainage at each irrigation is multiplied by the number of irrigations, it can amount to a considerable quantity of water. This drainage may also provide far too much water at the point or points of drainage.

7. Clay soils. Clay soils that shrink and swell have created some severe problems in drip irrigation. The high frequency of drip irrigation may give rise to soil water conditions that are too wet for the plant roots because the hydraulic conductivity of the clay is slow and the water will not move away from the emitter at a sufficiently rapid rate. If the irrigation interval is extended to help dry out the soils, they tend to crack and the next irrigation application cannot move across these cracks by capillary flow and a confined volume of soil is all that is wetted and it becomes wetter than ever.

8. Schedules. Traditional irrigation has meant irrigating from one to four times a month during an irrigation season. Drip irrigation should be applied daily or alternate days, a schedule difficult for many people to accept and perform. Without this high frequency of irrigation, many of the advantages of drip irrigation on plant performance are lost and soils may crack as indicated above.

9. Fertilizer timing. With drip irrigation, the fertilizer is injected through the irrigation system. Some crops have a one-time-a-year requirement or recommendation for fertilization that applies a rather large amount of fertilizer in a short period of time. With drip irrigation in a limited soil volume, this cannot be done without applying a concentra-

tion of fertilizer that is too great for the plant roots. It is, therefore, necessary to stretch the application of fertilizers through drip irrigation over a longer interval. The exact timing and effect of this is not adequately known at present.

OPPORTUNITIES AND PROBLEMS OF IRRIGATION WITH URBAN WASTEWATER

Archie Matthews
Senior Engineer
State Water Resources Control Board, Sacramento

Until recently, there has been very little interest expressed in taking advantage of these opportunities. We now think we see a slight change in attitude - in part due to the wastewater treatment facilities construction program and in part due to projected water shortages and the estimated costs of developing the State's remaining water resources. Large scale reuse of wastewater for irrigation is being seriously studied in several locations throughout the State. The studies are looking at reuse of wastewater for the purpose of augmenting existing water supplies, not, as in the past, as alternative means of disposal to avoid more costly treatment. In other words, wastewater is being considered an important part of the available water resources.

Before talking about opportunities, we need to consider geographical constraints on the reuse of wastewater. Municipal wastewater is the product of population. Large populations produce large quantities of wastewater. We believe, therefore, that if the use of wastewater is to increase measurably, it will have to be in the Bay Area and the South Coastal Area. This doesn't mean that we have ruled out the possibility of reusing wastewater elsewhere in the State. Agricultural reuse of wastewater is currently being studied in the South Monterey Bay area; studies are also looking at the possibility of reusing wastewater from the proposed Sacramento regional treatment facility for irrigation purposes in adjoining counties. However, we believe that the greatest opportunities exist in the areas where there are water shortages and abundant wastewater supplies.

Agriculture is considered to offer the best opportunity for reusing wastewater because it is the largest water user in the State. I'm sure you're aware that 85% of all water used in California is used by agriculture. Those of us working for the State Board assume that if there is to be a substantial increase in the use of wastewater, there will have to be a substantial increase in its use for agricultural purposes. Our definition of agriculture is broad and includes landscape irrigation and irrigation of golf courses, as well as the more traditional agricultural crops grown for animal and human consumption.

The major opportunities in reusing wastewater can be summarized as quantity and quality. Urban wastewaters are a firm supply of water. Our projections indicate wastewater will increase with time as population and municipal water use increases. At the present time, wastewater is literally available for the asking. The availability of wastewater is extremely important if you consider the problems involved in developing water resources today.

You may be surprised to find that, in some areas of the State, urban wastewaters are of better quality than groundwater or surface water supplies. Surface and groundwaters have been degraded through many cycles of use and reuse causing communities to seek good quality State Water Project water for their raw water supply. In these instances, the switch from in-basin supplies to imported State Water Project water has brought an improvement in the quality of wastewater. The Santa Clara River basin in Ventura County is an example of this. Groundwater quality has been deteriorating. As State Water Project water becomes available, municipal wastewater has improved. Water resources developers in this area are studying a plan to recharge the groundwater with M&I wastewater. Use of the groundwater would then be restricted to agricultural purposes. This makes it possible to reuse municipal wastewater and, at the same time, improve groundwater quality.

There are several potential technical problems associated with using wastewater for irrigation purposes. These include possible over application of plant nutrients, concentration of heavy metals in plant tissues and varying quality of treatment plant effluents. These are by no means the only problems associated with the reuse of wastewater. These may even be the problems of least concern since they can be overcome through the application of existing technology. Nitrogen, the plant nutrient of greatest concern in wastewater, can be reduced in concentration either through treatment or dilution. Heavy metals concentrations are likewise reduced either through source control, treatment, or dilution. Treatment plants can be designed to perform reliably; many are doing so today.

Public health is another of the concerns in using wastewater for irrigation. Questions arise as to how reliable the disinfection process is and whether the criteria for reusing reclaimed wastewater is adequate. As with so many questions dealing with treatment processes, the reliability of the disinfection process has to be dealt with case-by-case. We know it can be made reliable. Turning to criteria, the Department of Health criteria may pose the biggest problem to the irrigator who wants to use wastewater. The criteria can effect several aspects of a farming operation, including the crop grown, the method of irrigation used and how the end product is used.

Would the public eat the fruit of crops grown with treated wastewater? Attempts have been made to find out. So far, there doesn't appear to be a good answer. Polls indicate that the public thinks wastewater should be reused and that someday, it will have to be reused. One of the speakers at a recent groundwater conference in Ventura concluded that public acceptance depended largely on what was termed the perceptive quality of the wastewater; that is, taste, odor and appearance. Supposedly, people are more likely to accept wastewater if it doesn't smell, foam, or have a yellow color. Public acceptance of the use of wastewater for irrigation has no doubt been conditioned by past waste disposal practices involving almost continuous application of wastewater to land. It appears, however, that the public accepts the idea that we should be making more use of wastewater as a means of solving our water supply problems. Further, they seem willing to accept the judgment of professionals as to whether a particular project provides sufficient safeguards.

The irrigator usually wants to know what happens when he doesn't need anymore water. If you've seen many land disposal operations, you know that there is often no way to turn off the water. Wastewater is applied to the land, rain or shine, sleet or hail. This problem can be overcome by either providing an alternative means of disposal or storing water when it's not needed. Since many of these projects are situated in the water short coastal basins, using the wastewater to create a seawater intrusion barrier is a favored means of disposing of wastewater when it is not needed for irrigation.

The biggest obstacle to reusing wastewater is cost. Technical solutions generally increase costs. Removing nitrogen, increasing plant reliability, building storage reservoirs, or providing alternative disposal systems, all add substantially to project costs. When these costs are added to a treatment project, we find that the cost of wastewater doesn't compare favorably with alternative water supplies. However, the economics of water supply, like everything else, is undergoing change. So, we're not discouraged. When we compare the opportunities and problems of using wastewater for irrigation, we feel the opportunities outweigh the problems. We believe that as time goes on and we gain more experience in applying wastewater, the reluctance to use wastewater for irrigation purposes will diminish, our ability to practice total water resources management will increase and economics will favor more extensive reuse of wastewater.

ENERGY REQUIREMENTS OF ALTERNATIVES FOR WATER SUPPLY, USE AND RECLAMATION - A FACTOR IN DECISION-MAKING

Edwin B. Roberts
Staff Research Associate
University of California, Davis

Introduction

Since widespread concerns over water shortages, water pollution and other water problems preceded the "energy crisis", recommendations made by agencies, environmental groups and others calling for various water supply and management approaches have given little or no attention to energy requirements. However, rapidly increasing prices for energy are making many earlier planning decisions obsolete and new decisions based only on dollar costs will also be quickly outdated. A more rational decision-making process should take into consideration the energy units as well as dollars - and not just direct energy consumption, but the total energy impact on society.

Most of the energy used directly by water projects, either as electricity or refined fuels, comes originally from coal, oil, or natural gas. Total energy requirements include conversion losses, ancillary energy (energy from external sources used to power conversion processes), energy for construction of facilities and energy subsidies from natural ecosystems. It is important that planners, decision-makers, special interest groups and others have a general understanding of these categories so they can determine which alternatives actually have the lowest overall energy cost to society. In many cases, certain categories make up such a small fraction of the total energy cost that they can be safely ignored when comparing alternatives, but there is a danger that incomplete understanding of the range of possible energy requirements could lead to the selection of alternatives which, on the surface, appear to conserve energy, but which actually have the highest overall energy impacts.

Examples of Total Energy Calculations

1. Comparison of total energy requirements for irrigation pumps operating at Nebraska Standard Performance levels with different energy types is difficult because electric pumps operated around the clock will tend to draw power from base load power plants with conversion efficiencies up to about 38%. Pumps operated only during hours of peak electrical demand will tend to draw power from peaking-type power plants having efficiencies down to about 25%. Therefore, electric pumps are the least energy intensive for around the clock operation while diesel-powered pumps may use less energy overall than electric pumps for irrigating only in the daytime.

2. A recent study at the University of Arizona calculated the dollar costs of pumping groundwater with different forms of energy and found natural gas-powered pumps to be the most economical. Calculation of annual total energy requirements corresponding to the University of Arizona annual dollar costs showed that, for the specific examples, diesel power was 22% more costly and used 18% more total energy than electric power. Natural gas power had a dollar cost only 79% as high as electric power, but

the total energy required was 35% higher than for electric power. Obviously, deregulation of gas prices could wipe out overnight the dollar advantage of natural gas power.

3. The energy requirements for land treatment of wastewater depend on so many variables that generalization is not possible. However, the sample calculations presented at least indicate that large energy savings are possible under certain circumstances. Simple land disposal of wastewater after secondary treatment, compared with the alternative of tertiary treatment and river disposal was found to save 1,124 KWH per acre-foot of wastewater. Crop irrigation with the wastewater, in another sample calculation, was found to save 2,371 KWH/AF compared with tertiary treatment, river disposal and alternative supply of fresh irrigation water and taking into account the energy valve of nutrients present in the wastewater. The energy benefits of irrigating with wastewater from large Southern California coastal cities might be very small, however, because adequate crop land might be many miles inland and at considerably higher elevations.

4. A research group at Utah State University recently calculated total energy requirements for several irrigation systems. For example, they found that drip irrigation required less than 2/3 the pumping energy of hand-moved sprinklers, mainly because of lower operating pressures. However, the installation energy was so much higher than the sprinkler system that the two systems had nearly equal total energy requirements. The study assumed that water was available to the pump intakes energy-free and, therefore, simple surface irrigation was by far the least energy-intensive despite much lower irrigation efficiency. In California, where some irrigation water is delivered at an energy cost of more than 3,000 KWH/AF, the energy savings from reduced water use may more than make up for the higher installation and operation energy of the more efficient systems.

Conclusions

Although calculation methods need considerable refinement, it appears that the preliminary calculations of total energy requirements now possible provide a very useful tool to be used along with more traditional methods in evaluating water management alternatives.

A NEW LOOK AT OPPORTUNITIES FOR REVAMPING CALIFORNIA'S WATER SUPPLY AND USE PLANNING - SOME INSTITUTIONAL CHALLENGES

Robin R. Reynolds
Deputy Director, Department of Water Resources
The State of California Resources Agency

It's a new "ballgame" in the area of water supply and use planning. . . due to the energy crunch, increased environmental awareness, economics and the realization that water and other resources have finite limits.

There always have been many institutional constraints which bear on planning. . .now more than ever.

In discussing institutional challenges, begin by defining agency policy. Department of Water Resources policy redefined May, 1975, as follows:

1. Water resources developed shall be used to maximum extent before new sources are developed.

2. Water resources of California managed for greatest long-term benefit to people of State.

3. Consider all sources of supply, including water exchanges and conjunctive use of surface and groundwater supplies.

4. Implement water conservation.

5. Reuse water to maximum extent possible.

6. Balance instream uses (recreation, fish, wildlife)

7. Water quality management based on objectives and beneficial uses adopted by State Water Resources Control Board.

8. Flood control methods will include flood plain zoning, flood proofing, flood warnings and other nonstructural approaches.

9. Water management will include consideration of costs, economic and social benefits, environment and ecology and energy. Least cost will not be principal consideration.

10. Water management based on existing laws with consideration of new legislation as needed.

Department of Water Resources policy is not necessarily everyone's policy. . .forums for resolution of policy differences include "Water Action Plan" and public hearings, 4-Agency group and other less-structured mediums.

Examples of issues and areas of planning and implementation activities include:

1. Transfer of SWP Water Contractor entitlements study.

2. Conjunctive use.

3. Water Conservation activities.

4. Delta Facilities review process and Delta Levees program.

5. Coordinated operation CVP and SWP.

PHYSIOLOGICAL DETERMINANTS OF YIELD AND QUALITY

D. W. Rains
Department of Agronomy and Range Science
University of California, Davis

Much of the work of both plant breeders and crop physiologists is concerned with the factors limiting the yield and/or quality of the desired product. When environmental factors are optimized through management and the maximum amount of resources that a grower or the environment can provide is approached, only then are the biological limits expressed and the ultimate potential for productivity observed.

Many biological limits have been identified and described in terms of physiological processes. An example of one such process is photosynthesis. In most highly productive systems, the limit for further increased photosynthesis is the concentration of CO_2 in the atmosphere. Although experimentally, CO_2 levels above atmospheric concentrations can be used to increase productivity, it is quite apparent that this is not practical at the field level.

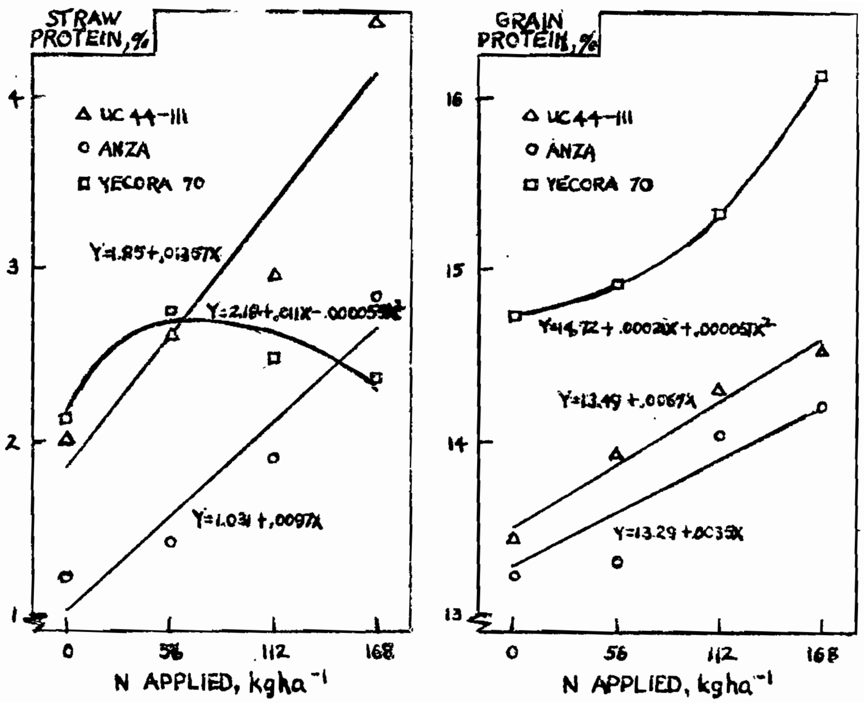
Another common observation is the negative correlation between yield and protein content of seed. This is very obvious in the productivity of large seeded legumes (3) but is also recognized in cereal crops. The plant is required to channel large amounts of energy into protein which reduces the accumulation of starch and other carbohydrates in the seed, hence reduced production of seed. It is also observed that many crops become nitrogen deficient when protein is translocated to the seed in large amounts which in turn causes premature senescence of leaves and of immature reproductive parts.

If this is in fact contributing to the lower productivity of high nitrogen, high protein crops, then physiological processes which could alter these responses should be studied. We have selected two such processes to study.

One process is the ability of plants to take up nitrogen from the soil during this high demand period of seed filling. If the plant can accumulate enough nitrogen both before and during seed filling so as to reduce the nitrogen deficiency resulting from this high demand, then senescence might be delayed and seed filling prolonged. We investigated the variability in nitrogen uptake by wheat varieties and found this to vary by as much as 10-fold. However, the protein content of the seed or the yield were not significantly different (2). This suggested a second process by which protein content and productivity might be influenced.

If the protein content of two varieties was not altered even though uptake and assimilation were significantly different, then the nitrogen was still to be accounted for. Further studies indicated that the plants with higher uptake and assimilation of nitrogen were inefficient in mobilizing and translocating stored protein into the seed (1,2). In response to applied nitrogen, the protein content of the straw of the variety with greater potential for uptake and assimilation of nitrogen increased relative to the variety with lower uptake and assimilation. The net result was the same protein content in the seed. One could propose that if this protein could be remobilized, then a seed with higher protein content might be obtained without repression of yield.

The figure below illustrates this situation in wheat. The variety Yecora shows the ideal characteristics for response to nitrogen. As nitrogen is applied, straw protein reaches a maximum while seed protein increases. This suggests that the straw does not retain large amounts of protein, but readily translocates this protein to the seed (1). This character, along with positive responses of uptake and assimilation of nitrogen, may produce a wheat variety with excellent yielding potential and high productivity.



<u>Literature Cited</u>

1. Galagher, L. 1976. Genetic variation in nitrate reductase activity and its relationship to protein in common wheat. Ph.D. Thesis, University of California, Davis.

2. Rao, K. P., D. W. Rains, C. O. Qualset and R. C. Huffaker. 1976. Nitrogen nutrition and grain protein in two spring wheat genotypes differing in nitrate reductase activity. (Submitted to <u>Crop Science</u>).

3. Sinclair, T. R. and C. T. DeWitt. 1975. Photosynthate and nitrogen requirements for seed production by various crops. <u>Science</u> 189: 565-67.

BREEDING FOR IMPROVED QUALITY IN FORAGE CROPS

Iver J. Johnson
Cal/West Seeds, Woodland

Promising potentials exist to develop cultivars that have a higher protein content and digestibility are less subject to hazards from pasture bloat, are lower in saponins and other anti-quality components and have better balance of certain mineral elements. Some of the desired nutritional qualities are related in positive correlations, others have little association with other desired attributes and, unfortunately, some are negatively associated. Higher leaf percentage generally is associated with higher digestibility with higher protein content and with higher carotene content. Because most of the soluble proteins associated with pasture bloat are found in the leaf tissue, there is a negative relationship between leaf percentage and bloat hazard.

Negative associations between yields and digestibility are due to changes in stem structure that reduce lignified plant cells, a component of weight.

Directed changes in nutritive value largely must depend on the importance of each component of quality to the livestock producer. The value of breeding for lower bloat hazard ranks high when legumes constitute a major pasture herbage. If legume hay - rather than pasture - constitutes the major feed, priority should be for high protein content and digestibility. For monogastric animals, lower saponin content has important values. Thus, it will be necessary to develop cultivars with specific attributes most important for the kind of animals to which forage is fed.

Research on genetic components of variance and on progress from recurrent selection show quality components can be modified by breeding. Generally, the additive components of variance have been greater than non-additive. Because character expression generally is conditioned by several genes, the rate of progress from directional selection may be slower than desired.

QUALITY AND THE CONSUMER

Christine M. Bruhn
Department of Food Science and Technology
University of California, Davis

Food quality is an elusive term, difficult to define, measure and interpret. It could be considered as the composite response derived from all sensory properties of a specific food that cause it to be judged superior by users who have been exposed to a random selection of the product over a period of time. It is any attribute of economic value. A consumer would say, "It has good quality because I like it, and I like it because it has good quality."

We must carefully distinguish between consumer preference, consumer acceptance and consumer practice; the first two relate to what the consumer says he wants and the latter to what he does. The consumer can accept certain products or products of a given quality, but he may not prefer them when presented with improved alternatives. A consumer expects to be favorably impressed with the food he selects and expresses displeasure if the product does not measure up to his anticipations. Adverse impressions have a much greater influence on the consumer's reaction than do pleasant ones.

Many factors, of which food quality is only one, influence the consumer's acceptance and selection of a food. Attributes of the consumer, such as nationality, race, regional preferences, age, sex, religion, educational background, socio-economic status, psychological motivation and physiological motivation, all influence the way products are evaluated and accepted.

Characteristics of the food must also be considered. Of importance to consumers are convenience, cost, uniformity and dependability, safety, and sensory properties. Appearance is the most important initial sensory property as it influences the selection of one item among the thousands displayed in the grocery store shelf. However, once the product has been tasted, flavor is the most important characteristic influencing consumer's preference and continued use of a product.

Nutritional value appears to be of less concern in selection of food than most nutritionists would like. Consumers do have some nutritional information on products and on human needs and they want more. Although consumers buy what they wish on the basis of taste, their awareness of nutrition and the potential impact of nutrition on their food choice is increasing. Consumers may increase their consumption of some foods if they have a complete picture of the food's nutritional value. Even some standard animal foods might become food supplements for humans due to their high nutritional value.

Quality is not solely an attribute of the food; it is also in the eyes of the consumer. Today, and in the future, good taste is the most important factor which determines preference. Concern for nutrition is becoming increasingly important to consumers. I think that this interest in nutrition can be used to modify food practices.

TOMATO QUALITY

Adel A. Kader
Department of Vegetable Crops
University of California, Davis

Fresh tomato quality is determined by appearance, texture, flavor and nutritive value. Consumers buy fresh tomatoes primarily because of appearance and flavor. Although purchases are usually made on the basis of appearance, especially color, the frequency and magnitude of subsequent purchases depend largely on consumer assessment of flavor.

Although no clear relationship exists between fruit size and shape and flavor, large and round fruits are preferred. Quality-wise, size is most important with fruits harvested green since smaller sizes for any one cultivar would usually be less mature at harvest. While most consumers like deep-red-colored cultivars, some prefer pink.

Minor defects are acceptable - since they do not detract from eating quality - but more serious defects and presence of decay influence salability. Defects originating before harvest include: puffiness, catfaces and other scars, growth cracks, insect and bird damage, sun scald, injuries from freezing and/or chilling, excessive softening and irregular ripening. Physical damage can occur during harvesting and/or postharvest handling. It influences not only appearance, but also flavor and can provide entry for decay organisms.

Firmness is dependent upon skin toughness, flesh texture and fruit structure, i.e., the ratio between locular tissue and pericarp. Firm, but not hard fruits without tough skin are preferred by most consumers.

Tomato flavor is judged by both the olfaction (smell) and gustation (taste) sensations. Aroma is a result of the presence of trace amounts of 125 or more volatile compounds with a total concentration of about 0.5 μg/100 gm fr. wt. Acids and sugars are the main constituents that influence taste. Varieties differ quantitatively in their content of 16 volatiles, reducing sugars, acids and ascorbic acid. Correlating these biochemical differences with sensory evaluation is not easy due to variations in personal preferences among taste-panel members. However, most people like a tomato that is high in acids and high in sugars.

Studies were initiated in 1974 (in cooperation with Dr. M. A. Stevens and Dr. L. L. Morris) to investigate the influence of stage of maturity and ripeness at harvest, simulated transit temperature and duration, use of ethylene or ethephon to promote ripening and use of low oxygen to retard ripening on 'Cal Ace' tomato flavor. Parameters evaluated included: appearance, firmness, sugars, acids, ascorbic acid and volatile compounds. Sensory evaluation using the multiple comparison tests was conducted by a trained panel of 14 judges during the 1975 season. The sensory evaluation data indicate that picking tomatoes at less than fully-ripe is a major problem with tomato flavor. There is an increase in sweetness and a decrease in tartness with ripening and the panel members consistently detected an 'off flavor', especially in fruits harvested at the green stage and ripened at 20° C. Preliminary evaluation indicates that differences in 10 volatile components may explain, in part, these flavor differences. Other components, such as amino acids and alkaloids, may also be involved in 'off-flavor' development.

The effects of postharvest factors included in this study were much less important than ripeness-stage at harvest on tomato flavor.

Our research program will continue to define good tomato flavor as determined by sensory evaluation and is measurable in biochemical terms. Such information is prerequisite for developing new varieties with better flavor and for evaluating the impact of pre- and postharvest factors on flavor quality of fresh-market tomatoes.

WINE QUALITY

Ann C. Noble
Department of Viticulture and Enology
University of California, Davis

In the assessment of wine quality, within a given category or type of wine, several specific attributes must be assessed. Use of scorecards which will standardize the evaluation of wines was discussed. The important attributes in wine evaluations are: appearance, aroma, flavor by mouth, balance of acid, astringency and sweetness, "body", and aftertaste.

Whereas, instrumental evaluation of the color is rather easy to accomplish as was demonstrated in wines which had undergone browning, flavor is extremely difficult to approach by objective means. Techniques for the descriptive analysis of wine flavor by sensory means and for the collection and analysis of the volatile compounds of the wine flavor by instrumental means were discussed. Although some flavors are a function of only a few components, most systems are complex; the ratios and amounts of many of the 300 to 500 compounds present in the flavor influence the quality and intensity of the flavor. Consequently, in interpretation of instrumental flavor data, pattern recognition techniques must be used. Some general examples or discriminant analysis and multiple regression analysis as applied to interpretation of the Riesling or "floral" aromas of several white wines were shown.

A BRUSHLAND PERSPECTIVE

Theodore E. Adams, Jr.
Extension Wildlands Specialist
University of California, Davis

Two hundred years of occupation by European man have had a profound impact on the vegetation of California. Abuse and misuse of our vegetation resource, beginning in the 18th Century, is reflected in most plant communities, including brushlands.

Today, brushlands occupy about 23 million acres. There is much diversity in these brushlands, but the majority is a type called chaparral. The many species of shrubs present in chaparral represent a single ecological type well adapted to California's Mediterranean-like climate.

Our brushlands are perceived in several ways. The view of many people is influenced by the most dramatic feature of brushlands, wildfire. A distinct public concern is treatment of brushlands to insure maintenance of water production and quality. Brushlands are valued in a limited way as a source of food and fiber. There is a great deal of interest in wildlife resources and brushlands are recognized as important wildlife habitat. A social value is given to brushlands through use of these communities for recreation.

The present situation presents environmental and economic problems that have become political issues. During the past decade, 215,000 acres have been burned on the average each year by wildfire. The many direct and indirect costs resulting from wildfire total about $1,000 for each acre burned. Loss of vegetation on vast areas often results in accelerated soil erosion and flooding during winter storms. People pay for these losses directly in taxes, increased insurance premiums and disruption of personal, economic, and business activities.

More effective management of California's brushlands might be encouraged by selecting a related issue or value widely recognized and for which support now exists. The widespread interest in wildlife in California and the concern for brushland habitat might provide the needed base for influencing brushlands management policy.

Habitat improvement, reduction of fuel volume and other purposes can be achieved through reintroduction of fire in management of brushlands. This does not imply indiscriminate burning; fire should be used only under carefully specified fuel and weather conditions so that control is possible. This type of fire is referred to as prescribed fire.

A modification of the approach to brushlands management might consider utilization of the brush resource. Brushlands represent a storehouse of solar energy. Harvest of this concentration could partially offset the worldwide shortages of food, fuel and cellulose. Perhaps the most obvious method of harvest is through animals. Animals, a biological tool, could make use of a wasted resource, reduce dependence on feed grains, enhance habitat and in the process, reduce the fire hazard.

MECHANICAL PROCESSING OF BRUSH

Boone Y. Richardson
Director, Equipment Development Center
USDA Forest Service, San Dimas

The USDA Forest Service Equipment Development Center at San Dimas, California, has developed and tested equipment for rangeland improvement since 1945. Much of this equipment was developed to treat or remove undesirable species of brush and convert the site to producing desirable grasses or browse. "Vegetative manipulation" is one term used to describe the process.

Dragging an anchor chain between two large crawler tractors was one of the early methods that was used very effectively. The chains had links weighing 40 pounds or more and various modifications and attachments were used with the links.

Various types of pull-behind brush cutters have been tested and used. One early machine tested - the Tree Eater - could be considered the precursor of several front-mounted machines available today. Root plows, crushers, rolling choppers, harrows and cultivators of various types have been tested and used.

Machines suitable for farm row-crop and pasture application have generally been found unsuitable for forest and range applications. This has been proven repeatedly at considerable expense. On the other hand, engineers at San Dimas have successfully designed and developed a number of machines that operate effectively in the forest or range environment.

Some of the machines suitable for treating forest residues may be effective in treating brush. The front-mounted cutters can generally be divided into horizontal-shaft and vertical-shaft machine types. A new machine incorporating the advantages of both types (while minimizing their disadvantages) has been designed at San Dimas. Field tests are now under way with the machine; and preliminary results indicate it may also be suitable for mechanical processing of brush.

BRUSH AS A SOURCE OF WOOD FIBER

William A. Dost
Extension Forest Products Specialist
University of California, Berkeley

Decisions on the use of fiber derived from California brushlands by the wood-products industry will be made on the basis of utility, alternate or competing sources and price. With present processes and attitudes, the preferred material is softwood fiber free from leaves and bark. Substantial quantities of relatively high-quality softwood residues are presently unrecovered at mills and in harvesting. These will undoubtedly be the first materials utilized as production capacity expands. Further, additional quantities of relatively uniform agricultural wastes are presumably available and could also be utilized. A particular problem is contamination with bark, dirt and leaves. They reduce utility by raising the cost per pound of usable raw material purchased and by reducing the throughput of product.

In a general sense, there is still a buyer's market for most wood residues in California. Brush must compete with these alternate sources; and prices will likely remain low relative to harvest costs until "full" utilization of wood fiber is achieved. An anticipated rapid increase in wood-residue fuel consumption by the industry, along with expansion in the production of residue-based products, can be expected to convert the present oversupply to a shortage over the next 10 to 15 years.

BRUSH AS A SOURCE OF ENERGY

Brian C. Horsfield
Assistant Professor of Agricultural Engineering
University of California, Davis

As the price of imported oil continues to rise, along with realization that the domestic supply of oil is limited, serious attention is being given to alternative forms of energy. Could brushlands provide a source of renewable natural fuel? Brushland has the advantage over such concepts as cultivated crops for energy in that brushlands occur naturally, require no real management and are very extensive.

Wood, as a fuel, has several desirable features. It is generally low in ash, ranging from 13% to slightly over 2% of dry matter. It is low on sulfur and has a heating value of 8000 to 9000 Btu per pound. Compared with oil, at $17 per barrel, the equivalent fuel value of brush is approximately $49 per dry ton.

Wood is no stranger as an energy source, for many mills today still utilize wood wastes for generating heat and electricity. Sawdust and bark have the obvious appeal that they are already at the mill site and must be disposed of if not used in some way. However, in the past, because of cheap fuel supplies, it has often been more economical for smaller mills to burn sawdust in teepee burners and purchase electricity and natural gas. This situation is changing with the rapid changes in the price of oil and their effect on other fuels.

Can brushland be economically harvested and the product transported and processed economically enough to compete with fuels, such as coal and oil? That is the essential question if brushlands can seriously be considered as a source of fuel. Innovative harvest concepts will undoubtedly have to be developed; and other credits, such as seedbed preparation, must be included if brush can be seriously considered. If harvest systems could cope with the terrain and operate essentially 24 hours per day nearly the year around, they may justify the necessary return on capital, provided that transport costs are reasonable and that capital investment for converting wood wastes to usable forms of energy is not excessive. One such concept would be the augmentation of coal supplies in a coal-fired electric generating plant. In this context, of course, wood would compete with the price of coal, but such a use would have nearly a limitless market.

On a smaller scale, such concepts as incineration and gasification can extract usable energy from wood in the form of heat or power. Gasification, in particular, has been used successfully in many parts of the world, particularly Sweden, for operating internal combustion engines in automobiles and trucks as well as in stationary applications. Under certain circumstances, such a concept may be feasible in light of current economics.

BRUSH AS A RUMINANT FEED: DOMESTIC LIVESTOCK

W. C. Weir, E. Sergio Lailhacar-Kind, and R. M. Love
Chairman, Department of Nutrition, Graduate Student in Ecology,
and Professor of Agronomy and Range Science
University of California, Davis

The range manager and/or livestock producer who wishes to utilize an area primarily as a site to produce livestock feed is faced with three fundamental questions: (1) Assuming the area has a brush cover, should he attempt partial or total removal and conversion or utilize brush as the main source of feed? (2) Assuming that the decision is to utilize brush for domestic livestock, should he accept what nature provides or attempt to improve the productivity of the brush area? (3) If confronted with an area which has lost its brush through mismanagement, fire, or other causes, should he attempt to restore the native vegetation or introduce exotic brush species? This paper suggests some of the criteria the manager should use in answering these questions.

Where edaphic and climatic conditions permit any crop at all, conversion has been the usual approach. We suggest that this decision should not be made lightly, but only after careful consideration. In the arid and semiarid areas, which constitute over 50% of the continental surface of the world, typical brushland vegetation constitutes the natural cover of a considerable proportion, especially in regions with a Mediterranean type of climate. Much of this woody vegetation consists of unpalatable species which have been able to survive grazing pressure. The polystratified plant community permits a more efficient utilization of water, nutrients and light and thereby maintains a larger standing crop than a single-stratum community. The more diverse plant communities also provide more variety and seasonal availability of nutrients for the animal population. Thus, there is less likelihood of nutrient deficiencies, consumption of toxic plants, or a loss of all vegetation through disease or insect infestations. The species currently occupying the site have demonstrated their adaptability to the soil and climate of the ecosystem, as well as their ability to survive and reproduce in spite of insects, diseases, drought, or other influences which might eliminate introduced species.

Shrubs are often referred to as sources of browse or forage for both domestic livestock and game in the great variety of ecotypes found on the various continents (McKell, et al., 1972). Observation of grazing habits of animals, analyses of stomach contents and the condition of the plants before and after exposure to the animals all document that animals eat brush. However, quantitative values as to intake, carrying capacity and nutritive value are difficult to obtain. Experimentation is further complicated when more than one brush species coexist on the same site. Wilson (1969), reviewing the world literature, was unable to document "that browse makes a major contribution as to the nutrition of domestic or most game animals." He further suggests that arid and tropical browse plants have more potential as ruminant feeds than those from semiarid to rainy temperature zones. This latter conclusion may well relate to our proven ability to convert to more productive forage-producing systems in the temperate zones, whereas our conversion in tropical areas has been less successful in many areas and moisture is so limiting in the arid zones that disturbance of the existing vegetation may well be contraindicated.

Before opting for conversion, consideration should be given to the possibilities of increasing the forage yield of existing brushlands through various established management procedures, such as controlled season and intensity of grazing, fertilization, selective use of fire or chemicals to favor the most desirable species, control of rodents and insects, as well as wind and water erosion, and the use of other techniques adapted to the ecotype. Consideration should also be given to secondary effects, such as adaptability of wildlife to the habitat change and recreational and esthetic values.

Finally, if conversion to grasses and legumes is chosen, the conversion should be attempted only on a limited pilot scale unless the methods and animal and economic results have been well proven in the same or similar ecotype for several seasons.

If, on the other hand, the prudent decision is to maintain the site in shrubby vegetation, should the manager be satisfied to let his animals harvest what "nature" provides or should he manage the shrubs and perhaps even convert from the native shrubs to introduced shrubs which are more productive in quantity or provide a more nutritious fodder. Unfortunately, most brush areas of the world have been overexploited and overgrazed by both domestic livestock and wild animals to the extent that the more palatable species may be found only as remnants or in areas without grazing animals because water is lacking. Fortunately, efforts are now being made by plant scientists in Australia, Northern Africa, Chile and Israel to identify the more desirable species and ecotypes and to multiply the seed supply through nurseries in favorable sites. Useful exploitation of such species for domestic livestock is still in a primitive state in this country. The establishment of an exotic brush species for forage production is at least as complicated and vexing as selecting and growing any new crop or orchard species in a new environment. Generally considered for such brush sites are only sites that are less favored in terms of soil fertility, topography, temperature, and moisture extremes. In addition, rodents, insects and diseases may well destroy even well established species in a new ecotype.

Before attempting to introduce any new species as a source of animal feed, it should be tested for the following characteristics:

1. Is it free of toxic properties for the animal?

2. Can the productivity of the plant be maintained and the production kept accessible to the animals through a system of mechanical mowing?

3. Is the introduced species sufficiently more productive than proven native species to justify economically the expense of testing to find the correct species to introduce to a particular ecotype?

4. Is it palatable to the animal at the season when it is needed in the animal management scheme?

5. Will the plants survive under grazing pressure?

6. What is the relationship between season of grazing, resprouting and survival of the plant?

7. Will the plants require protection against game animals, rodents and/or insects?

One such species that has shown sufficient promise in the Mediterranean zone of Chile to warrant further testing is Atriplex repanda. Several California species have provided forage for sheep, goats and, to a lesser extent, cattle and horses in the past. Research - particularly yielding quantitative information - is needed on the most desirable species to use in the many varied sites in the western United States that may be needed in the future to produce forage for meat-producing animals.

IMPLICATIONS OF BRUSHLAND MANAGEMENT FOR DEER

Hal Salwasser
Graduate Student, College of Natural Resources
University of California, Berkeley

Broad-scale changes in California's brushland ecosystems underlie our dramatic deer decline. Whether we consider California mule deer on the Sierra west slope, muleys in the great basin, or the blacktails of the chaparral, deer are mid-successional brushland species. High deer production depends upon high yearly recruitment of young into the herd. Recruitment in turn depends upon forage and cover quality during all seasons of the year. Brushlands play the dominant role in meeting these food and cover needs. Management activities that enhance critical components of deer habitat (potential limiting factors) can thus rely on increased deer numbers as one of their benefits.

Research has shown that the following factors are important to neonatal fawn survival: (1) Winter fat reserves of pregnant does - this is provided by high-energy young browses the previous summer and fall and maintained by winter range cover that minimizes energy losses during the winter. Mature brush that provides winter cover is also a staple food. (2) Spring nutrition - high-protein spring herbage (forbs and grasses) provides nutrition for fetal growth and prepares the doe for lactation. Early to mid-seral brushfields provide the most nutritious forage at this time. Summer fawn survival is enhanced by dense brush that provides protective cover to fawns and by forbs, grasses and young browses for lactating does and weaning fawns. Fall habitats provide a shot of energy and protein. This nutrition boost influences ovulation rates and fertility. It also adds to doe fat reserves and to fawn growth, both of which affect winter survival. Early to mid-successional brushfields, again, are the best habitats.

Years of work on deer nutrition have illustrated the relative nutritive values of brushland plants. Browses are most productive and nutritious during the middle years of their life. Certain browses are always more nutritious than others; they are the key plants during some seasons, but by no means are they alone the key to deer production. The herbaceous component of young brushfields is universally a key to good spring and early-summer habitat quality.

Man has played an active role in changing deer habitats. Early disturbances created much favorable habitat. Recent fire suppression has resulted in succession to mature and decadent brushlands and/or forests. This trend is not beneficial to deer. Overgrazing by deer and domestic stock has altered plant communities to unpalatable brush species on many sites. On potential forest sites, mechanical and chemical brush removal, followed by artificial return to forest, is eliminating thousands of acres of productive deer habitat. Many acres of brush have been, and still are being, artificially replaced by grasslands, to the theoretical benefit of livestock. This is often facilitated by the use of herbicides, which have yet to be shown to benefit wildlife. Finally, the California sportsmen and politicians, ignorant of efficient animal management, have precluded optimum use and regulation of deer production. A consequence has been that excess deer damaged future production. Also, underuse of deer resources led land managers to discount their potential value when making land use decisions.

Recent deer declines reflect poor fawn survival, a natural response to deteriorating habitats. Reversing recent trends will thus require changes in land use practices. Interspersion of diverse natural habitat types with maximum edge effect is still the key to good wildlife habitat. Large monoculture or wholly artificial conversions are least beneficial.

If we are to stay in the deer business, we must look to a combination of approaches. Optimum use of deer resources would go far toward justifying brushland management designed to produce deer as well as other resources. Private landowners must see deer habitat management as a profitable venture. Land use planning must preserve habitat acreage from residential development. Allowances must be made for natural brushland successions in timber management. Controlled use of fire is needed for periodic rejuvenation of selected mature brush fields. Superior grazing systems should be used to maintain highly productive diverse plant communities. Emphasis should be placed on management methods that most closely mimic natural disturbances. Deer will continue to be a brushland resource if we give them a chance.

REHABILITATION OF A FLOOD DAMAGED GOLF COURSE

R. L. Baldwin
Cooperative Extension, Ventura

In 1969 the Ventura River broke its banks and swept through a seaside municipal golf course, destroying the facilities and leaving a residue of one to two feet of fine sand, silt and clay on the course.

The course was reconstructed and seeded to seaside bentgrass. Poor germination was obtained in some areas and only weak growth in other areas. Investigation revealed salinity levels at or above 7mmhos/cm, slow water infiltration, a water table at about 30 inches and low fertility levels.

Field trials gave a marked response to nitrogen and some response to phosphorus. Attempts to leach the salts were unsuccessful. Additional fertilizers were applied and the course kept as wet as possible consistent with play, to dilute the salts. Muddy areas were roped off.

Trials with different thicknesses of mulch, using washed dairy waste, established that mulch 1/2 to 1-inch thick permitted germination under highly saline conditions. This proved of only partial benefit as the grass tended to die out as the mulch dissipated.

Holes dug through to the water table and backfilled with gravel helped to drain off the surface water. French drains to lakes in the course also helped drain excess water. Additional lakes were established in low areas where nothing would grow.

A constant breeze from the ocean kept temperatures too low for good growth of bermudagrass and disrupted normal sprinkler irrigation patterns.

Sodding with Tifway bermudagrass was successful on better drained areas, but failed in the low areas where salinity levels were from 20 to 40 mmhos/cm. Greens were all raised and constructed of a porous mix, but, even so, salinity levels of up to 8 mmhos/cm were found.

The turf that existed prior to the flood is still intact and has formed a thin interface of peat underlaid with soil of a different texture from the flood deposit. In one fairway, trenches were cut through the underlying soil and backfilled with the mixed soil which improved grass establishment and growth. More recently, extensive trenching and backfilling with sand permitted growth in bare areas.

The course is irrigated with sewage effluent water high in sodium (SAR of 14); and soil tests now indicate a need for calcium. Gypsum has been used on the greens and in particular areas periodically. Application of gypsum, as soil tests indicate the need, is planned for the whole course.

HOW MANAGEMENT OF GROUND COVERS DIFFERS FROM TURF AREAS

Paul A. Rogers
Kellogg Supply Company, Carson

Before an attempt is made to answer the title question, I believe that it is important to look at philosophies regarding the management of turf and ground cover areas. Generally, turf receives a high degree of management. We pay careful attention to proper planting procedures, irrigation, mowing and thatch removal, aeration, fertilization and pest control. What about the ground cover?

Although ground cover plant breeders have been busy over the years and have developed a number of excellent plants, our attitudes towards the maintenance of ground covers has not kept pace. Ground covers are almost always used where very little management will be employed. They are fortunate to receive proper irrigation and an occasional fertilization. Yet, we demand almost as much from them as we do of our turf areas. While ground covers are generally more robust than turf, they still have specific needs.

The landscape industry generally lacks available information on the management of ground covers. While this paper will not answer all of the questions concerning ground covers, it will attempt to outline some considerations regarding ground cover management.

Surprisingly, few realize that ground covers are classified, as are turfgrasses, into cool season and warm season plants.

<u>Cool Season Plants</u>		<u>Warm Season Plants</u>	
Arenaria Verna	Ophiopogon	Ajuga	Hypericum
Camomile	Osteospermum	Arctotheca	Korean Grass
Campanula	Potentilla	Armeria	Lantana
Cerastium	Sagina	Baccharis	Lippia
Clover	Sedum	Clover	Myoporum
Festuca	Verbena	Dichondra	Petunia
Fragaria		Euonymus	Rosemary
Gazania		Geranium	Santolina
Helexine		Herniaria	Trefoil
Ice Plant		Ivy	Trachelospermum
Juniper		Honeysuckle	Vinca

Cool season plants are most vigorous during the fall and the spring. During periods of summer heat, they have a slight decline and become quite susceptible to summer root rot diseases. Cool season ground covers often tend to be very herbaceous in nature.

Warm season plants are usually woody and produce their greatest growth during late spring, summer and the early fall. Diseases are usually not a problem on these plants.

The accompanying chart shows the growth pattern for both the cool season and the warm season ground covers. Additionally, since the cool season plants tend to be susceptible to diseases, a disease pattern for them is also illustrated.

Based upon these growth patterns, I have suggested some timing of the various ground cover cultural practices. These are: vegetative removal, fertilization and planting. Since these items are so important to good ground cover management, some comments on each of these categories follows. Additionally, a discussion on irrigation and pest control is provided.

GROUND COVER GROWTH CURVES AND TIMING OF CULTURAL PRACTICES

SOUTHERN CALIFORNIA	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
ACTIVE GROWTH												
cool season		-----	-----	-----	-----	-----			-----	-----	-----	
warm season				-----	-----	-----	-----	-----	-----	-----		
DISEASE												
cool season					-----	-----	-----	-----	-----			
VEGETATIVE REMOVAL												
cool season		-----	-----	-----	-----	-----			-----	-----	-----	
warm season				-----	-----	-----	-----	-----	-----			

GROUND COVER GROWTH CURVES AND TIMING OF CULTURAL PRACTICES (Cont.)

SOUTHERN CALIFORNIA	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
FERTILIZATION												
cool season		----	----	----	----				----	----	----	
warm season				----	----	----	----	----				
PLANTING												
cool season		----	----	----	----	----			----	----	----	
warm season				----	----	----	----	----	----			

MANAGEMENT OF GROUND COVERS

Vegetative Removal

Vegetative removal is a broad description that covers the areas of dethatching, mowing, thinning out and pruning or cutting back. Most importantly, all of these operations should be performed during or just prior to periods of active growth. Otherwise, regrowth will be slow and weeds will predominate.

Following any plant removal, it would be wise to fertilize with fast action nitrogen in order to promote rapid regrowth. Some examples of the plants that require various vegetative removal operations are listed below.

DETHATCH	MOW	THINOUT	PRUNE BACK
Osteospermum	Arctotheca	Gazania	Hypericum
Ivy	Potentilla	Festuca	Lantana
Vinca	Fragaria	Ajuga	Myoporum
Ice Plant	Lippia		Rosemary
	Trefoil, Clover		Baccharis
	Helexine		Euonymus
	Dichondra		Geranium
	Cerastium		Juniper

Fertilization

Ground covers, like most ornamentals, require annual applications of nitrogen, phosphorus and potassium, and occassionally, other nutrients. Their actual needs will be best dictated through use of soil testing.

New plantings, particularly ivy, are very slow to establish. To enhance this establishment, apply soluble nitrogen each month until coverage is obtained.

Established ground cover plantings are best fertilized twice annually, at the rate of one to two pounds of actual nitrogen per application. On flowering species, excellent results have been reported from fertilizers that contain equal parts of nitrogen and phosphorus and half as much potassium. Non-flowering ground covers will benefit from fertilizers that contain more nitrogen than phosphorus and potassium. Furthermore, consider using slow-releasing materials, such as the natural organics or synthetic insoluble inorganics, as growth will not be forced nor is necessarily needed.

Iron is important to some species, such as juniper, trachelospermum, osteospermum and fragaria. When chlorosis occurs, apply iron chelate, especially in calcareous soils.

Planting

Like turf, ground covers should receive good soil preparation. Soils should be amended to a depth of 4" to 6" and receive a complete fertilizer containing slow-release nitrogen. Follow recommended plant spacing, but as a general rule, set plants at a distance that will enable them to grow together and provide coverage in a single growing season. Finally, never plant into a dry soil, use well-watered plants; and water planted areas as soon as practical while ensuring that they do not go into a stress for moisture.

Irrigation

Perhaps the biggest mismanagement problem in growing ground covers is irrigation. The problem is usually too frequent shallow watering rather than lack of water. This stems from the lack of a well-designed irrigation system, using turf heads for ground cover areas and applying water on a frequent and indiscriminate bases. Ideally, ground covers should be watered deeply (this also helps to flush out salts) and by systems that produce heavier droplets than for turf areas. The use of drip irrigation or low gallonage systems seemingly would meet the needs of most ground covers nicely.

Pest Control

Pest problems on ground covers are mainly those that occur from diseases. Insects are evident, but these are mainly the common garden types, such as snails and slugs, aphids, mites, mealy bug and caterpillar grubs.

Disease problems appear to be directly related to poor irrigation practices, vegetative build-up and poor soil preparation and the subsequent lack of drainage. Some of the most common disease problems are the water molds and crown and root rots. In particular, osteospermum is very susceptible to these disease organisms and requires careful management practices, especially irrigation.

Weed control on ground covers is best implemented on a preventative pre-emergent basis. Some of the commonly used materials are diphenimide, trifluralin, E.P.T.C., nitrofen and a host of others. Success on a post emergent basis is marginal as selectivity is quite limited. For specifics on pest control for ground covers you would be best advised to consult with a pest control advisor or the University of California farm advisors. Chemicals are excellent pest control aids, but can be very damaging when misused.

In summary, it is evident that the overall management of ground covers does not really differ from turf areas. Planting and vegetative removal must be performed as well as fertilization, irrigation and pest control. The details of these operations, however, do differ and it is necessary that we recognize and practice these differences. More and more ground covers will be used as economic substitutes for turf areas. Ground covers are more costly to establish than turf, but less costly to maintain once they are established.

EVALUATING TREES FOR DIFFICULT LANDSCAPE SITES IN 20 AREAS OF CALIFORNIA

W. B. Davis
Department of Environmental Horticulture
University of California, Davis

A great deal is known about thousands of tree species used by man for food, fiber shade and beautification. More by accident than by design, we know something about some tree species as to their adaptibility to the difficult landscape site. Many new landscape areas have never supported native stands of trees. In the development of new landscape areas, we may create soil-water relations that make growth and development of trees difficult. Shallow soils, poorly drained soils, flooded areas, high salinity and wind pockets are just a few of the problems we encounter when looking for the right tree in the right place.

The Department of Environmental Horticulture at U. C. Davis has been evaluating plants for special landscape areas for a number of years. As a spinoff on their program, 43 species of Eucalyptus were selected for statewide field evaluation. The selection of species for this study were based on reports from their native habitat. The species selected had one or more of the following characteristics: Tolerance to intermittent flooding, poor drainage, salt tolerance, drought tolerance, tolerance to coastal winds and an adaptibility to a wide range of soils and climates.

Seed for these trees was obtained from New Zealand and Australia, where it was collected from uniform natural stands of the individual species. All trees used for our field evaluation were produced at the University of California at Davis. Seed was sown in February, transplanted to peat pots and then to gallon cans. The young, vigorous growing trees were delivered to the field sites in June and field planted during the summer months. Plantings were made in 1972, 1973 and 1974.

In order to get the widest range of soil and climatic conditions throughout the state, completely independent projects were set up between our County Cooperative Extension and any suitable cooperator. At each planting site, 5 to 20 trees of each species requested were planted. At some sites, all 45 species have been planted while at others, only two or three species were selected. The size and scope of each planting was determined by the County Extension staff member and his cooperator. All surviving trees must remain in place for a minimum of 5 years.

Plantings have been made in 20 counties at a total of 36 planting sites from Redding to San Diego. These individual projects are located at city, county and regional parks, high school and Junior College campuses, county and state highways, golf courses, landfill areas and reservoir sites. At each planting and establishment and management varied according to the site and the cooperator. Some projects are highly managed while others received only first summer care. The variability between sites ranges from ideal to impossible.

During the first 5 years in the landscape, the trees are evaluated for survival and growth rate.

Once we have established trees growing at a site, soil, water and climatic information is developed to characterize that site. The information gained at each site may be quite meaningful for the local area, but collectively, the information gained from all sites should give a truer picture of what to expect from these species and their range of adaptability.

There are over 600 species of Eucalyptus. Most of them are well described as to flower, fruit, leaves and bark type. Description as to size and form is based primarily on observation of native stands. Hardiness is pretty well known for the most common species in the trade. While the descriptions as commonly given are of importance, they are generally based on their use in an ideal situation or a site well adapted to their genetic makeup. Presently, in the trade, our major nurseries are producing 25 species of Eucalyptus. The most common 10 are:

Eucalyptus camaldulensis
Eucalyptus citriodora
Eucalyptus ficifolia
Eucalyptus globulus 'compacta'
Eucalyptus maculata
Eucalyptus polyanthemos
Eucalyptus rudis
Eucalyptus sideroxylon 'rosea'
Eucalyptus torquata
Eucalyptus viminalis

The Eucalyptus species which we will be evaluating over the next five years are:

Eucalyptus aggregata
Eucalyptus albens
Eucalyptus ancept
Eucalyptus archeri
Eucalyptus bancroftii
Eucalyptus bicolor
Eucalyptus blakeleyi
Eucalyptus botryoides
Eucalyptus burdettiana
Eucalyptus caesia
Eucalyptus camaldulensis 'rostata'
Eucalyptus camphora
Eucalyptus cornuta
Eucalyptus cosmophylla
Eucalyptus diversifolia
Eucalyptus eremophila
Eucalyptus exserta
Eucalyptus falcata
Eucalyptus goniantha
Eucalyptus griffithsii
Eucalyptus gunnii
Eucalyptus incrassata
Eucalyptus kitsoniana
Eucalyptus longicornis
Eucalyptus maculata
Eucalyptus megacornuta
Eucalyptus microtheca
Eucalyptus morrisii
Eucalyptus occidentalis
Eucalyptus perriniana
Eucalyptus pileata
Eucalyptus platypus
Eucalyptus populifolia
Eucalyptus pyriformis
Eucalyptus rhodantha
Eucalyptus robusta
Eucalyptus rudis
Eucalyptus rugosa
Eucalyptus salmonophloa
Eucalyptus sargentii
Eucalyptus spathulata
Eucalyptus stricklandii
Eucalyptus tetraptera

We trust that the information gained will enable us to recommend trees which will enhance California landscapes where treescapes were previously difficult to establish and maintain.

DEVELOPMENTS IN THE TURFGRASS RESEARCH FACILITIES AT U. C. SOUTH COAST FIELD STATION

V. A. Gibeault
Cooperative Extension, Riverside

Turfgrass research has been conducted at the South Coast Field Station, El Toro, since the early 1960's. The research projects have heavily emphasized a breeding and selection program for bermudagrass, zoysiagrass, bentgrass, tall fescue and dichondra, as well as management programs on irrigation, overseeding and variety evaluation, to name a few.

Recently, the Southern California Turfgrass Council has been providing grants to assist with the expansion of the research efforts. To date, a new irrigation system has been installed on seven experimental blocks, which combined, total in excess of 35,000 square feet. The irrigation system has the capacity for individual block sprinkling, which will greatly enhance the research capability.

The seven blocks were seeded in the autumn of 1975 to cool season grasses. Heavy emphasis is being placed on Kentucky bluegrasses, perennial ryegrasses and tall fescue. Specifically, established trials include the following:

1. Kentucky bluegrass variety trial that has 33 varieties in plots 6' x 6' replicated three times. Experimental, new and standard varieties are represented.

2. Twelve varieties of perennial ryegrass, including Yorktown, Diplomat, Derby, Clipper, Pennfine, Manhattan and Lamora were seeded to 150 sq. ft. plots with four replications. The base plots will be split in the spring when two cutting heights and three fertility levels will be imposed.

3. Thirteen varieties of Kentucky bluegrass also will be observed under three fertility levels. Measurements will focus on varietal performance relative to general appearance, weed and disease incidence.

4. Kentucky bluegrass-perennial ryegrass mix study will evaluate ten different mixes of the two species from 5 percent perennial ryegrass to 50 percent perennial ryegrass. Observations will be made on time to percent cover, general appearance and disease resistance.

5. A tall fescue, perennial ryegrass, Kentucky bluegrass mix study will evaluate two- and three-way mixes with these species. Several percent mixes are being observed.

6. Large areas have been separately established to pure stands of Kentucky bluegrass, perennial ryegrass and tall fescue. These plots will be available on an as needed basis for short term projects.

REBUILDING A QUALITY SMALL COLLEGE FOOTBALL FIELD

R. Troy
Grounds Superintendent
California Lutheran College, Thousand Oaks

The limitations considered in this project were cost and time, namely the availability of a quality playing surface on a minimum budget by the first week in July.

The reasons prompting the rebuilding were grade problems - improper crown, irregular overall grade and sunken repair areas, inadequate irrigation system, highly compacted adobe soil covered with thin turf heavily infested with poa annua and weedy perennial grasses.

The alternatives were to rehabilitate the existing surface by aerating, fertilizing, resodding the sunken areas, topdressing to correct the improper crown and spraying out the weedy grasses. Secondly, to install a P.A.T. (Prescription Athletic Turf) field, excavating to a depth of 10 inches instead of the normal 18 inches, refilling with sand and covering with sod. Thirdly, to redo the old field, completely by removing the existing sod, repair the grade, add soil amendments, install an automatic irrigation system, place new sod the length of the field between the hash marks and complete the sodding using the salvaged sod. After considering the time available - two and one-half months - costs, expected life of the field and necessary compromises, the third option was selected.

The rebuilding was begun on April 16, 1975. The first operation was to remove approximately 37,000 square feet of the best existing Tifway turf and stockpile it. The sod was stored in rolls stacked on each other. The entire pile was covered with black polyethelene plastic and kept constantly moist. Black was chosen over clear to minimize damage due to radiant heating. Next, the existing quick couplers were removed down to the feeder lines, plugged and staked. Using a John Deere elevator loader, approximately eight inches of soil was removed from the center area, tapering to three inches at the edges; along with the remaining sod, this was discarded. The removal was done to permit the addition of 360 yards of nitrolized redwood sawdust and 460 yards of imported sandy loam from the Malibu Lake area. The remaining adobe was highly compacted and extremely moist, posing problems for the incorporation of the new materials. To alleviate this condition, the surface of the field was "opened" to a depth of six inches, using the scarifier teeth on a road grader. The John Deere loader was now used to spread the loam and sawdust, keeping hand labor to a minimum and providing absolute control on spread depth. The entire area was gone over once more with scarifier teeth. Blending of the new materials with the adobe was completed, using a tractor-powered rototiller. About 960 pounds of ammounium phosphate was spread over prepared area and the surface rerototilled to a depth of eight inches. The field was rolled and graded with a resulting 11" crown in the center, tapering to flush at the edges.

In order to take advantage of the existing unvalved water system, 21 Toro individually valved sprinkler heads were installed on swing joints and coupled where the existing system had been plugged. Wires were trenched to the heads and connected to create a six station setup. These were hooked to an eleven station timer permitting irrigation at night and on weekends. The plumbing was tested and several repairs were necessary due to damage to the plastic pipe by the heavy equipment. The benefits were twofold, eliminating time-consuming hand watering and uneven irrigation caused by the strong prevailing daytime winds.

Starting on April 29th, the stockpiled sod was applied to the outer thirds of the field after applying 5 pounds of ammonium phosphate per thousand square feet. The sod had suffered extreme chlorosis during storage, but the stolons and roots remained viable. Damaged or weak areas were trimmed out during relaying. Upon exposure to sunlight, the chlorotic condition disappeared in about three weeks. Some 29,000 square feet of the old sod was re-laid. The remainder of the field was covered with 28,000 square feet of new Tifway sod from a local sod farm. Work was completed on May 8, 1975.

After one week, the old sod was treated with Kerb 50W at one pound actual per acre to eliminate the undesirable grasses. The playing surface was topdressed with a 50-50 mixture of screened sandy loam and plaster sand, where necessary, to correct minor depressions caused by settling.

All sod was well knit in one month. At this time the field was mowed to 3/4 inch and the old sod fertilized with ammonium nitrate at 1#N/1000; the new sod was left untreated at this time. Management of the field for the remainder of the season consisted of one inch of water weekly applied on weekends and the application of 1#N/1000 of ammonium nitrate monthly. The August fertilization was with a complete fertilizer at the same rate.

The field was used by the Dallas Cowboys during July and August and by the California Lutheran College team during their season. The appearance of the field at the end of this period was good; and sufficient thatch for safety and durability was maintained.

EFFICIENT USE OF WATER AND FERTILIZER IN NURSERIES

T. Furuta
Cooperative Extension
University of California, Riverside

Increasing the proportion used by the plant of all the water and fertilizer applied over a given area of nursery where container plants are being grown is important from the viewpoints of conserving vital resources and reducing the possibility of degradation of the environment. To some people, the solution is extremely simple - just place in the root zone the required amount of fertilizer and water for the desired type of growth to occur. In actual practice, however, because of the nature of the cropping system, the answer is extremely complex. All the possible solutions should be examined in detail for each location because each has unique limitations, and each requires an unique solution.

Place the water and the fertilizer in the root zone only. Here, the root zone is the soil mixture within the container; and each nursery has many isolated masses of soil that must be irrigated and fertilized. The soil volume is limited. The holding capacity for water and fertilizer is limited.

Frequent applications, often as much as twice a day, of accurately measured amounts of water and fertilizer is needed for the culture of crops in containers. Satisfactory equipment is not always available, especially for dry applications of fertilizer. From the operation of the business, trade-offs of capital and labor are needed.

Labor intensive methods are not always efficient in the use of these resources. Aljibury and associates reported that 8 acre feet of water per year, per acre was required when hand-watering methods were used. When a manually operated sprinkler system was used, the water requirement per acre, per year was 6 acre feet. Further reduction to 5 acre feet was found when a totally automated sprinkler system was used, but the question remained - was the added capital expenditure worthwhile?

By the use of drip and spitter irrigation systems, compared with sprinkling, as much as an 80 percent reduction of the water needed for irrigation was found. Unfortunately, associated with this savings were problems associated with soil salinity and wetting of the soil mass when drip irrigation was used.

A combination of controlled-release nitrogen incorporated in the soil before planting and supplemental liquid applications resulted in the most efficient use of fertilizer. With presently available fertilizers, it is not possible to incorporated before planting all the nitrogen needed by the crop.

The size of the plant and the plant species must be considered to determine daily need. Environment must also be considered. For daily needs for water, measures of evapotranspiration should be used to determine the amount of water to apply.

CROP RESIDUE MANAGEMENT IN PRODUCTION AGRICULTURE

Roy S. Rauschkolb
Cooperative Extension
University of California, Davis

Crop residues are managed under a wide range of soil and climatic conditions in California. In addition, great differences exist in loading rates and susceptibility of the residues to decomposition by soil organisms. The cultural practices employed to manage these residues vary from burning the material to moldboard plowing to achieve maximum soil incorporation. Due to winter rainfall, the performance of the practices used to manage residues of crops harvested in the fall may be delayed or prevented. During the late spring to late summer months, climatic conditions do not play a major role in determining the cultural practice used for residue incorporation. However, the time between harvest and planting a subsequent crop, as well as the amount of residue which can interfere with the planting operation, become factors regulating the cultural practice are employed and required to adapt to the prevailing soil and climatic conditions, as well as the diverse cropping patterns followed in the State. When soil incorporation of crop residues is possible, it may provide such benefits as improved soil structure and recycling of plant nutrients.

Improved soil structure is a benefit that is frequently attributed to soil incorporation of organic matter. If a soil has poor soil structure due to either chemical or physical destruction of soil aggregates, then the active decomposition of crop residues can facilitate development of soil aggregates. Active decomposition of relatively large quantities of organic matter are required to have this effect. Research results have shown that tanins, a by-product of decomposition, produces a very water stable soil aggregate, while another decomposition by-product, polysaccharides, produces the least water stable soil aggregate. The formation of stable soil aggregates reduces the susceptibility of the soil to compaction by mechanical means.

As crop residues decompose, plant nutrients, such as nitrogen (N), phosphorus (P) and sulfur (S), will be released to the soil. Some portion of these nutrients, as well as most of the other nutrients, are released without requiring decomposition. The release of the major portion of N, P and S requires the breakdown of the material by microorganisms. Consequently, factors which regulate biological activity also regulate the rate of decomposition of crop residues and release of these nutrients. The soil physical characteristics as it regulates water supply, aeration and temperature influences the rate of biological activity. Soil contact is important from the standpoint of supplying an inoculum of large numbers of organisms and preventing rapid drying of the crop residue. The result is greater decomposition as research results have shown. Soil temperatures common to California during the winter months in the Central Valley, coastal areas and Imperial Valley are sufficiently high to allow decomposition to proceed. Studies with rice straw have shown a 20 to 40 percent weight loss at 45^{o} F over a two month period, depending upon the soil type.

Perhaps the most frequently asked questions are: Do I need to put N with my crop residue in order to enhance decomposition or should I wait and fertilize for the next crop? In the short term, 30 to 60 days, and if a crop residue is low in N, less than one percent, then N additions can speed the rate of decomposition. However, even with N additions, the cumulative weight loss in 90 to 120 days is not different from the loss observed when no N is supplied under the same conditions. Numerous studies with rice and wheat straw have demonstrated these results. Also, when N has been applied at time of soil incorporation of straw in the fall rather than at time of planting in the spring, there has been a reduction in the yield response obtained to the added N.

For crop residues high in N, greater than two percent, N is released to the soil as soon as decomposition begins. Based on several years data where rice straw was incorporated into the soil in the fall and spring as compared with burning the straw, there was no difference in the amount of applied N required to achieve maximum yield of rice.

In summary, soil and environmental conditions regulate the rate of decomposition. Soil incorporation enhances the rate of decomposition which, at the same time, results in formation of soil aggregates and the release of plant nutrients to the soil environment. Finally, research has shown the often stated aphorism "fertilize the crop, not the residue" to be a sound crop residue management practice.

SEWAGE SLUDGE MANAGEMENT PROGRAM
SACRAMENTO REGIONAL COUNTY SANITATION DISTRICT

W. S. Hyde
Chief, Water Quality Division
Department of Public Works, County of Sacramento

The subject sanitation district is currently planning consolidation of the 22 existing sewage treatment plants in the Sacramento urban region to a single regional treatment plant. Flow capacity will be 130 mgd. Present plans for handling separated sludge streams involve 20 to 30 day anaerobic digestion followed by 1 to 2 year storage in earthen basins. Sludge flows will approximate 25,000 tons per year dry weight.

In view of the rural setting of the Sacramento community, reclamation of the liquid sewage sludge has been proposed on cropland at application rates approximating 7 tons (dry weight) per acre, per year. However, additional review has identified the following substantive questions regarding the reclamation mode:

1. Are regulatory, operational and technological constraints identified with disposal to sanitary landfills less onerous and more predictable?

2. Considering the extended (5 years) field and laboratory work required to better evaluate phytotoxic and disease or parasite constraints, is there any assurance that at program end, firm and tolerable regulatory controls would result?

3. Expected application rates may still yield only a 10 to 20 year period of application feasibility before "sterilization" of the land. A continuing land acquisition program would thus be required.

4. May not the problem be more one of land management than one of reclamation for agricultural purposes? For example, reclamation for the Sacramento sludge stream might consume 300 acres per year if sludge is "reclaimed," but only 7 acres per year if disposed of on dedicated sanitary landfill.

5. If the reclamation mode is to be considered, should this not be for crops outside the food chain?

6. Interested and affected regulatory agencies include: local Health Officer, Regional Water Quality Control Boards, State Solid Waste Management Board, State Water Resources Control Board, State Health Department, Environmental Protection Agency, Food and Drug Administration, U. S. Department of Agriculture. It will be difficult to achieve agreement among

these several agencies as to a risk-free procedure for application to edible or forage crops.

Preliminary conclusions indicate that a disposal mode to sanitary landfill is preferable; solutions that minimize committed land should be more heavily considered; and we should take a harder look at the use of solar heat for sludge drying, rather than mechanical dewatering methods.

ENERGY RELATIONSHIPS IN ORGANIC MATTER MANAGEMENT

W. C. Fairbank
Extension Agricultural Engineer, Cooperative Extension
University of California, Riverside

The FUNDAMENTAL COMBINED LAW OF PHYSICS states, "Neither energy, nor matter can be created or destroyed - only transformed." A second truism tells us that all energy derives from the sun. Engineers trap some solar energy, but agronomists collect that energy, convert it into useful forms, and package it through the fantastic chemical process we know as photosynthesis. Harvesting the sun is a topic with parallel opportunities for agronomists and ag engineers, depending on whether we want just to create food or the added convenience of being able to eat it elsewhere or at a much later time.

Four energy relationships need to be considered in the agronomic-engineering context: energy content of organic matter; energy extraction or conversion; energy/matter substitutions; energy conservation. Organic matter is a complex substance including fats, proteins and carbohydrates. These familiar food components all contain at least carbon, hydrogen and oxygen wherein lies chemical energy. Oxidation of carbon and hydrogen are highly exothermic reactions whether by direct combustion or by metabolysis. Energy can be extracted from organic matter by the direct routes of combustion or by feeding to some beneficial organism; or the indirect routes of thermochemical conversion into fuel or chemical feedstock, by anaerobic microbiological decomposition to biogas, or by biological fermentation either to alcohols or to single-cell protozoa which are then recycled as new feedstuff. Combustion of organic matter releases heat approximating the DULONG formula used by combustion engineers for solid fossil fuels:

$$\text{Btu/lb} = 14{,}000\ C = 62{,}000 \left[H - \frac{O}{8} \right] + 4{,}050\ S$$

where the elemental values are their percentage by weight. Most cellulosic matter burns with the release of 6000-8000 Btu/lb of dry matter. Bio-oxidation, the result of absorption of nutrients by microorganisms or ingestion by animals, releases energy directly to the surrounding media or converts it into the organism's activities. There are carbon, hydrogen and oxygen reactions brought about by microbes and enzymes acting either within the digestive system or within the microbial community harbored in any non-sterile moist organic mass.

Metabolizable net energy values for most organic wastes are now catalogued by livestock nutritionists. The energy extraction efficiency of livestock is up to near 60% of the calorific value of the feed, but in anaerobic biological systems, only about 30% of the energy in the raw waste reappears in new cellular material. Feeding of crop residues is common and the practice is simply a matter of TDN from organic waste as compared, costwise, to prime feed. Refeeding of manure, however, a topic of current investigation, needs some elaboration because it involves factors over and above simple plant trash and cull produce feeding. Manure is a competitive source of protein, but is low in net energy, the limiting quality of all modern production rations. Manure may be used as a protein source and fed in amounts up to about 15% of the ration before production suffers. The consuming animal utilizes the residual energy as efficiently as most of the engineers' thermal energy processes, but the real energy advantage is in not having to produce the equivalent amount of prime feed. Refeeding cattle manure to stockers or range cattle offers the maximum potential for energy conservation when compared to the alternatives of gasification for ammonia production, pyrolysis for low Btu gas production, or for biogas production by methane digestion.

Conversion of organic matter to pipeline fuels is possible through the biological processes of anaerobic digestion with methanobacters, or through fermentation to ethanol. Organic matter may also be fermented to new biomass for feed use and then recycled for energy saving as per the above discussion.

Pyrolysis of organic matter is receiving study by chemical and mechanical engineering groups and industries; by energy utilities; and, to a lesser extent, by agricultural engineers.

Biogas (alias manure methane, substitute natural gas, etc.) generation from organic matter by the process of anaerobic digestion continues to draw more attention than economics will justify. The most usual feedstock is manure, augmented with miscellaneous cellulosic garbage. The biogas that evolves is approximately 60-70% CH_4, 25-40% CO_2, and at least 5% unwanted "YECH!" (Yech = H_2 + N_2 + NH_3 + H_2S + CO + O_2 + $RCOOH$ + H_2O.) Fuel value is about 500-700 Btu/scf, which is adequate for most agricultural heat processes, but too low a temperature for good internal combustion engine performance. Biogas is loaded with impurities and the small quantities from any single producer would seldom justify the cost of scrubbing to commercial pipeline quality. Anaerobic digestion is under continuing study, but the technology is at hand. When economic feasibility of biogas production and utilization is reported, and when practicality is more certain, the process will sweep the livestock industry on simple economics.

Fermentation to ethanol remains a viable energy conversion possibility because of its direct potential as a gasoline extender. A method of producing glucose from enzymatic hydrolysis of cellulosic matter and then fermentation to ethanol has been developed. Present estimations are that the process may become competitive when gasoline approaches $2 per gallon.

The utilization of at-hand organic wastes to perform functions which normally consume primary fuel is an area of expanding notice. The motivation for implementation is only awaiting the proof of supply and demand economics. Examples include fertilization with manure, feeding of more wastes to reduce the acreage necessary for feed production, direct combustion and fermentation to new cell matter for feeding.

Better planning for farmland utilization, the selection of crops and the scheduling of operations can save energy. Examples: water pumped to hillside avocado groves; melon fields vs. beans or small grains which have a much better energy output-to-input ration; the availability of energy on demand, as well as its cost.

Better production management and equipment selection can save energy. Examples: strip-tillage or nontillage culture; water applied for frost protection; production systems best fitted to the local climate to preclude energy expenditures for environmental modification; integrated pest management to save the energy cost of several aerial applications; drip irrigation. The organic matter relationships are very real.

Energy conservation is its own reward. It is money not spent. It can provide a degree of production insurance by making certain operations less dependent on an unfailing energy supply at critical load times. The greatest return to producers, however, might just be the public relations benefit of demonstrated sensitivity for energy conservation.

TOMATO IMPROVEMENT - PAST AND PRESENT

Paul Thomas
Petoseed Company, Woodland

The tomato variety picture in the California processing crop is best illustrated as being at various plateaus.

In the 1920's, when the California tomato processing industry was in its infancy, the major varieties grown were large indeterminate types with large rough fruit. Yields were low, the crop was transplanted 1,000 to 2,000 plants per acre. All varieties were susceptible to root diseases; and the crop was hand harvested into 50# field boxes. The growing area was primarily in the cooler coastal areas of Alameda County and Santa Clara County. The varieties used were all very late maturing. This was important to the processors in order that they could complete their peach harvest and pack, which meant that they did not want tomatoes before September 15th.

The 1930's was the first major change in varieties with the release of the Pearson variety. Pearson was a more determinate variety; and the plant populations increased to 5,000 to 6,000 plants per acre. The Philipino labor found it much easier to pick these kind of plants; and by the early 1940's, when labor was scarce, Pearson became the dominant variety. The state average yield in California reached 10 tons per acre the first time in 1945. The tomato industry also moved inland; and the center became San Joaquin County with Alameda County second.

The 1950's saw the first introduction of disease-resistant varieties, such as Pearson B, Pearson XL and Pearson A-1, which were resistant to Verticillium wilts. In the late 1950's, both Verticillium and Fusarium wilt varieties were introduced with Pearson VF-6 and VF-11 and, eventually, CPC-2 or T-2 and VF-36. The latter 2 varieties also changed the industry again as they had smaller more compact plant types and were earlier than the Pearson types. VF-36 also was found to set better under higher temperatures; and the industry started to spread into the lower San Joaquin Valley and Bakersfield area, where the high temperatures during fruit-setting time limited previous production efforts.

The early 1960's became the age of mechanization for the harvest of the tomato crop. The release of VF-145A, VF-145B and VF-13L made mechanical harvesting a reality. The ability of these varieties to set under high temperatures and adaptable for mechanization opened up such areas as the Sutter Basin, Fresno County, Kern County, Blythe, El Centro and expanded Yolo County for increased production. Average yields per acre reached 20 tons in the mid-sixties and have continued to climb. Plant populations were increased to 20,000 to 25,000 plants per acre; the crop was harvested into 1,000 pound bins; and 100% of our processing crop was machine harvested.

The 1970's brought another change with the release of the first "square" or hard tomato for better handling and greater vine storage. The largest acreage in 1975 was planted in Fresno County with Yolo County in second place. The harvested crop is transported in 10-ton trailers. California, presently, produces about 85% of total U. S.-processed tomato crop. Fusarium Race II is now established in Yolo and Sutter Counties; and new resistant varieties to this disease are becoming available.

NATURALLY OCCURRING TOXICANTS IN PLANT FOODS

L. F. Bjeldanes
Department of Nutritional Sciences
University of California, Berkeley

Food is a wonderfully complex mixture of thousands of chemicals, the vast majority of which have not been identified. The toxicity of most foods has been evaluated based on readily observed effects of these foods on generations of consumers. If a food proved to be highly toxic, its use was discontinued immediately. It has been only in relatively recent times that any kind of systematic evaluations of the toxic effects of specific food chemicals have been undertaken. These evaluations will continue at increasing rates as more rapid and convenient methods for determining toxicity are developed. The potential hazard of several components of uncontaminated foods has been established. The food components to be discussed in this presentation are goitrogens, cyanogenic glycosides, hemagglutinins, cholinesterase inhibitors and sweet potato toxins. These topics and others concerning toxic components in foods have been reviewed.[1]

Goiter, which is not attributable to iodine deficiency, afflicts an estimated 8,000,000 people in the world. Antithyroid compounds, which are present in several common foods, are considered to be the cause of this non-iodine responsive goiter. The most active antithyroid compounds have been isolated from cabbage, cauliflower, brussels sprouts, kale, broccoli and other vegetables of this group.

Cyanogenic glycosides are compounds which liberate hydrogen cyanide on hydrolysis. Hydrogen cyanide is a highly toxic gas. Several foods and feeds contain these glycosides. The most important food sources of these compounds are cassava and lima beans. The hydrogen cyanide in these foods is liberated by enzymatic processes either in the plant or in the intestine. Studies of populations which consume large amounts of cassava suggest that certain visual and nervous disorders common in these groups may well be the result of chronic cyanide poisoning.

Hemagglutinins are proteins which agglutinate red blood cells. Their toxicity results, however, from their ability to inhibit nutrient absorption in the intestine. Some of these compounds are highly toxic and thorough heating is required to render safe the food which contains them. Hemagglutinins occur quite generally in legumes, such as soybean, black beans, red beans, castor bean, kidney bean, lima bean, etc.

Cholinesterase inhibitors are substances which disrupt nervous function and are widely used in the pesticide industry. Some of these inhibitors have been shown to occur in certain foods, most notably potatoes. They are also present in lesser quantities in egg plant and broccoli. Solanine, the active compound in potato, has caused poisoning in humans and farm animals who consumed large amounts of the toxic potato.

Under normal conditions, sweet potato has not been shown to be toxic. However, when this crop is damaged in a variety of ways, such as by chemicals, fungal infection, or mechanical damage, certain stress metabolites are produced. Several of these stress metabolites have been shown to be toxic and have been implicated in poisoning in cattle. The roll of these metabolites in certain lung disorders, which occur frequently in parts of the world where sweet potatoes are a major part of the diet, is also a possibility.

---

[1]Committee on Food Protection: "Toxicants Occurring Naturally in Foods" Second Edition, National Academy of Sciences Publication No. 73: 8968, Washington, D. C., 1973.

FLOWER IMPROVEMENT

Scott C. Trees
Ferry-Morse Seed Company, San Juan Bautista

Flower improvement is more than understanding and manipulating the genetic material of a plant through contemporary plant breeding schemes - it is also an art. Historically, flower improvement began with the selection and cultivation of the desirable flowering species from the wild. After the rediscovery of Mendel's Laws, many early experiments in genetics utilized ornamental flowering species. Nevertheless, due to difficulties encountered in studying the genetics of ornamentals, such as high polyploidy and unknown reproductive mechanisms, much of the flower improvement for the first half of the Twentieth Century depended on plant introductions, mass selection and inbreeding of single plant selections from existing varieties or segregating populations. The objective of flower breeders at the turn of the century must have been relatively simple, and that was to produce a unique item which could be easily and inexpensively produced for packet houses and retail catalog sales.

By contrast, flower improvement today involves the cooperation of at least three highly trained specialists, the breeder, the production manager and the person in charge of quality control. All three must be knowledgeable of the application of new techniques in their respective fields. The breeder must not only be aware of the genetics of the crop he is working with, but must also understand and utilize the newest and most efficient plant breeding tools, such as male sterility, self-incompatibility, tissue culture and growth regulators. In addition, the breeder must be able to discern what the buying public will consider aesthetic.

The flower breeder is faced with a new set of objectives mainly evoked by changing markets for flower seeds in the last twenty years, the greatest change being the phenomenal growth in the bedding plant industry. The bedding plant industry has helped pay the way for expensive research programs which have produced exciting new hybrid flowers in many species.

The result of utilizing better trained individuals, as well as the new technology of all plant science disciplines, has been an improved flower product for the consumer.

WESTERN SUNFLOWER POTENTIAL

S. E. Shein
Northrup, King & Company, Woodland

The cultivated sunflower (Helianthus annuus L.) is a native North American plant that is presently attracting attention as a potential oilseed crop in the Western United States. Commercial production has previously been centered in the Red River Valley of North Dakota and Minnesota, but the introduction of high yielding hybrids is making the crop more profitable; and new areas of production are beginning to appear. Approximately 600 ha. were grown in California in 1975; and it is estimated that 4000 ha. will be sown in the spring of 1976. This dramatic increase can be attributed to a strong world market for vegetable oil and the availability of dwarf hybrids with multiple disease resistance. Sunflowers are similar in a number of respects to maize and most maize breeding techniques are quite appropriate. Some unique aspects of sunflowers, including flower morphology (perfect), self-incompatibility and pollen transfer by insects, pose special problems. As a result, traditional breeding schemes have been modified and experimentation is still going on.

GENETICS OF BIOLOGICAL NITROGEN FIXATION

R. C. Valentine
Plant Growth Laboratory
Department of Agronomy and Range Science
University of California, Davis

The supply of available nitrogen is a limiting factor in world food production. Certain bacteria and blue-green algae are the only organisms known to convert atmospheric nitrogen gas into a form suitable for plant growth, a process called biological nitrogen fixation. Man has learned to harness N_2-fixing microorganisms through the domestication and culture of soybeans and other leguminous crops which produce root nodules filled with symbiotic, N_2-fixing bacteria. In order to increase world food production, it may be necessary to further exploit these highly beneficial microorganisms.

Recently, it has been possible to genetically manipulate N_2-fixing bacteria: (1) derepressed mutant strains have been constructed which yield an excess of ammonium ion, (2) nitrogen fixation (Nif) genes have been transferred from the bacterium *Klebsiella* to *E. coli*, yielding a new N_2-fixing hybrid, (3) these studies have led to a model of symbiotic N_2-fixation in leguminous crops, such as alfalfa, soybeans, etc., in which root nodule bacteria (*Rhizobia*) export an excess of fixed N_2 as NH_4^+ by simultaneously derepressing their Nif genes while repressing genes of NH_4^+ utilization.

A COMPARISON OF SINGLE-SEED DESCENT AND RANDOM BULK METHODS IN WHEAT BREEDING

C. O. Qualset
Department of Agronomy and Range Science
University of California, Davis

Breeding methods for self-pollinated crop plants have not been radically changed during the past 40 years. However, there still are questions of which method of population development is most efficient in terms of rate of genetic gain per generation or per unit time. Two breeding goals are apparent in breeding so-called pureline varieties: homozygosity and genetic change toward a breeding objective. If these goals are approached simultaneously, the results are sometimes counterproductive because heterozygote advantage for the selected character or related fitness characters can slow the approach to homozygosity and result in non-permanent genetic gains.

The management of breeding populations can be viewed either as *selective* or *nonselective*. The former includes direct selection by the breeder for certain characters and also the effects of natural selection. Nonselective population development implies that all genes have equal opportunity to appear generation after generation, although gene combinations are rearranged by recombination while heterozygosity still exists. This condition probably only rarely occurs because of natural selection which operates throughout the life cycle of the plant. If natural selection operates in ways desirable to the breeder, then this is of no concern. Unfortunately, there are several important instances where this is not the case, as with tall wheats having selective advantage over dwarf wheats, when dwarfness is desired.

Bulk population breeding has been widely accepted as an inexpensive way to develop homozygous, but heterogenous, populations. These populations are usually "selective" populations because changes in gene frequencies have been demonstrated many times with many different crop plants as they are perpetuated as bulk populations under field conditions. Thus, there are motives to reevaluate the bulk population method of breeding. Interestingly enough, though, the motive mentioned above has not been the primary one. Breeders have been more concerned with rapid development of populations and have investigated ways to speed up the generation cycle time. Goulden was one of the first proponents of using controlled environment chambers to cause rapid generation turnover with small grains. He also was the first to suggest the selection of a single seed from each plant to use for the next generation. His method has come to be called single-seed descent; and it is intended for use in developing homozygous, heterogeneous populations by nonselective means.

It is becoming more obvious that nonselective population development is important in plant breeding because: (1) it is a means of genetic conservation and (2) breeding populations intended for one kind of environment can be developed in another, as in off-season nurseries, 24-hour photoperiods growth chambers or greenhouses, or nurseries at alternate latitudes. The second item is concerned with genotype-environment interaction. A plant breeder must also decide whether his method of population development will maximize genotype-environment interaction, as in a controlled disease epiphytotic, or minimize interaction. Minimizing the effects of genotype-environment interaction is important because it aids in retaining desirable genes in the population.

We have done one small study comparing single-seed descent (SSD) and random bulk (RB) methods of population development. F_2 to F_6 populations were grown in a greenhouse with minimal nutrients and 24-hour photoperiod. Two crosses were studied and both were handled by SSD and RB methods. Some differences in generation means and genetic variance were detected when lines from all generations were evaluated in field conditions, but, in general, there was little difference in the two methods. Therefore, with the greenhouse conditions we used, the RB method is preferred because it was less time-consuming than SSD. We also showed that selection for certain characters was effective; so for highly heritable traits, the two breeding goals mentioned earlier can be realized. Apparently, the RB method can be transferred to field conditions if noncompetitive conditions are used, as with wide spacing between plants. We have completed an experiment in which single plants were taken from F_3 lines at random and by selection for high yield. Little or no gain was obtained by selection of single plants even though considerable genetic variability was present in the population.

There still is no single method that can be recommended, but we do now recognize a number of options to the breeder, depending on his genetic materials, the selection criteria, the urgency of meeting the breeding objective, his budget and available labor. These considerations have resulted in some modifications of wheat breeding procedures at Davis. Hopefully, these modifications will be justified by the efficient development of superior germplasm.

AN OVERVIEW OF SOIL COMPACTION IN CALIFORNIA

W. J. Flocker
Department of Vegetable Crops
University of California, Davis

Soil compaction has long been recognized as one of California's pressing agricultural problems. Reports have indicated that approximately 2×10^6 acres of cropland has been compacted to the point where crop yields are reduced. The problem manifests itself by poor water infiltration, poor aeration, restricted root development, increased tillage cost and reduced yield. Symptoms of the problem are found in orchards, vineyards, vegetable and field crops and pastures. The problem has been found statewide and is not associated with any particular soil class or series.

Causes: Soil deformation occurs whenever the soil is subjected to compression, shear, or vibration forces; and the magnitude depends upon the intensity and duration the forces act. The compressibility of a soil varies with its moisture content, attaining a maximum compression at close to field capacity. Farm machinery has grown considerably heavier during the past few years, thereby increasing the load pressure placed on the soil as it moves over the field. Because of the economics of crop production, often it is necessary to perform harvest operations when soil moisture content is optimum for compaction. This is especially true for vegetable crops.

Mechanism for: Whenever a soil is compacted, a reduction in soil porosity results, which, in turn, impedes water and air movement. The process is accompanied by an increase in the bulk density, thus restricting root penetration and enlargement.

Symptoms: Easily detectible symptoms of soil compaction are not often available because the problem is insidiously sneaky, progressive and accumulative. Plant symptoms include reduced growth and yields, restricted root development, deformed roots, reduced seedling emergence, nutrient deficiencies and, sometimes, pathogenic maladies. Soil symptoms include reduced water infiltration, aeration, porosity, increased cloddiness and bulk density.

Measurement: Soils are variable and the interaction of soil properties with plants are complicated, thus, no single method will measure the extent of the problem satisfactorily. The multitude of methods proposed can be divided into four classes: (1) testing for soil hardness, soil strength and penetrability, (2) porosity measurements, bulk density and pore size distribution, (3) transmission and diffusion of air and water infiltration, and (4) aggregation stability and size distribution.

Prevention and amelioration: Prevention, the best approach, includes good soil management practices. Unnecessary tillage operations should be avoided. Tillage, when soil moisture content is high, severly increases the likelihood of compaction. Deep tillage is often recommended to break up compacted layers. Plowing under green manure crops, residues, manures, cover cropping, are all old practices, but have good consequences. Some soil ammendments have been used successfully on a limited scale.

SOIL IMPEDANCE AND ROOT GROWTH OF CORN AND COTTON

D. W. Grimes
Department of Land, Air and Water Resources
University of California, Davis

Many soil areas in the San Joaquin Valley are compact and may pose special water management problems. A higher than normal irrigation frequency is often required to meet evapotranspiration demands, suggesting a restricted plant root development. This study was conducted to evaluate a relation between high penetrometer soil strength, found naturally occurring in the field, and root development of cotton (*Gossypium hirsutum* L.) and corn (*Zea mays* L.).

Cotton and corn were grown in plots (1971 and 1972) established on a Panoche clay loam and Hanford sandy loam known to differ markedly in penetrometer strength. Both crops were grown in two row widths (51 and 102 cm), each with two plant density levels to determine if root distribution could be influenced by planting geometry and density. During the growing season, irrigation frequency varied for the crops and locations, but was frequent enough to meet the maximum ET demands of the crops. Soil strength was measured in the field with a recording soil penetrometer after the downward movement of water was megligible following a uniform irrigation. Plant root densities were determined at intervals starting in June.

Root densities (RD) observed in 1971 for cotton and corn were characterized with regression models having penetrometer soil strength (S), soil depth (D) and time after planting (t) as independent variables. The expression for cotton was $\widehat{RD} = 1.43 + 0.0691S - 0.00203D + 0.00488t - 0.001921S^2 - 0.00137SD + 0.0000166Dt$ ($R^2 = 0.952^{**}$) and for corn $\widehat{RD} = 0.194 + 0.454S - 0.0584D + 0.0244t - 0.0111S^2 + 0.000420D^2 - 0.003235D$ ($R^2 = 0.866^{**}$). In the equation, S is in bars (1 bar = 14.5 psi), D is cm of soil depth and t is days after planting.

Penetrometer soil-strength profiles show the Panoche soil to increase in resistance through a 30-cm depth, but achieves a strength of only 8 to 12 bars, which extends through the remaining profile depth. The Hanford soil strength profile increases rapidly to a strength in excess of 30 bars near a 30 cm depth with high strength extending to a depth of 75-cm.

Root densities for both cotton and corn increased rapidly in the low-strength Panoche soil, but the fibrous roots of corn increased in density at a given depth and continued downward extension throughout the season, achieving a maximum depth of 244 cm. In contrast, the tap-root system of cotton was complete by mid-july, with significant development to a maximum depth of 183 cm. A penetrometer soil strength of 25 bars (Hanford soil) at a 45 cm soil depth reduced the root density of both crops by 50 percent.

Narrow rows and higher cotton plant populations resulted in higher root densities observed at lower profile depths in the low-strength soil. This trend was not observed with corn.

Average water uptake/unit length of root for complete profiles was determined by relating soil water depletion to root density. With near-constant ET, average water uptake rate/unit root length declined with an expanding root system. An average of all extraction periods gave respective rates of 2.33×10^{-3} and 7.86×10^{-3} cm^3/cm/day for corn and cotton.

Understanding the extent and density of a plant root system, as it occurs in the field, is essential for sound water management decisions. The results presented show field measured soil strength to be effective for diagnosing or predicting mechanical root growth limiting conditions. Cotton root density was incorporated, as an independent parameter, into an irrigation termination model.

INFLUENCE OF WHEEL TRAFFIC ON YIELD AND STAND LONGEVITY OF ALFALFA

R. Sheesley[1]
Farm Advisor, Cooperative Extension
University of California, Fresno

Equipment wheels cover up to 75% of alfalfa hay fields during each harvest. Most haying implements have four wheels, few of which trail one behind another. This extensive traffic results in most alfalfa plants being run over one or more times each harvest and up to 20 times a season.

Experiments conducted from 1972 to 1974 at the San Joaquin Valley Research and Extension Center in Parlier measured the effects of wheel traffic on alfalfa plants and soil. Three treatments, simulated harvest (swather), post-harvest (bale wagon), and harvest plus post-harvest traffic were applied to the varieties Moapa, Lahontan, and Team at each cutting. An area receiving no traffic was used as a control. A seven-day interval separated swather and bale wagon traffic.

The study analyzed the effects of wheel traffic on stand life, forage productivity, root development, physical injury and relationship to diseases in alfalfa. Soil compaction within the top two feet of the soil profile was measured with a penetrometer. Wheel traffic was confined to narrow paths by using a tractor with trailing wheels.

Plant Survival and Damage

No significant reduction in plant population resulted from wheel traffic during normal cutting time, when regrowth buds are short. Survival of plants exposed to wheel traffic seven days after harvest was about half that of plants in the control plots. Mechanical damage was common on crowns and longer regrowth shoots, which were more subject to crushing and pinching when run over by a wheel.

Disease development in plant crowns was secondary to the mechanical damage. *Fusarium* spp., *Alternaria* spp., and *Cephalosporium* spp. were isolated from plants in both wheel traffic and control areas, but played a minimal role in stand losses and in reduced vigor of plants in these experiments.

Hay Yields

Yield was reduced in the immediate area of the wheel tracks, where traffic was applied seven days after harvest. Since traffic was confined to narrow lanes in these experiments, there was a "border effect" growth adjacent to the wheel path. This border effect sparks hope for minimal forage losses if traffic can be confined to narrow lanes within alfalfa fields.

Yields from the swather traffic lanes were not significantly different from the control plot yields. Fewer and weaker alfalfa plants survived in the treatments involving traffic seven days after harvest. These post-harvest traffic treatments also produced less than half the forage of the control plots.

Soil Strength and Root Development

Penetrometer soil strength measurements were made after each season's wheel traffic treatments. A uniform irrigation was applied and time was allowed for water to be uniformly distributed through the two-foot-deep measured zone before strength measurements were taken. This procedure was necessary because soil strength is influenced by soil water content. Soil moisture samples verified that soil water content was uniform.

Soil samples were collected by 6-inch increments to two feet on all treatments and replications. At approximately the same time, strength measurements were made and root length per unit volume of soil (root density: cm/cm^3) was determined. Average root density for the two-foot soil depth was reduced 57% by wheel traffic. A 37% reduction in root density of the 6- to 12-inch zone was observed for the traffic plots. Some of the roots in this zone likely came from lateral roots of plants growing adjacent to the traffic lanes.

Penetrometer soil strength values documented the degrading influences of wheel traffic compared with a no-traffic strength profile. The zone of maximum increased strength in the 6- to 12-inch depth zone corresponds with a high reduction in root density. That the increased strength from compaction extends to a depth of about 14 to 18 inches agrees with previous results.

A severe restriction was imposed by increased soil strength on alfalfa root extension. Each 100 lbs. per square inch increase in soil strength gave a 15 to 20% reduction in root density for a given depth increment. Rooting densities at each depth were appreciably higher in the spring of 1974 than in the fall of 1973. However, the relative effects of treatments did not change during the winter and early spring.

Greenhouse experiments were conducted in 1975 to determine alfalfa root growth with this same Hanford Sandy Loam soil compacted to varying degrees.[2] The bulk density for this soil in a moist drained condition is about 1.6 when under normal field cultural practices for alfalfa hay production. The development of alfalfa roots in the greenhouse studies was severely impeded by soil strengths at a bulk density of 1.6 or more. After a 110-day growing period alfalfa roots extended well into soil with a bulk density of 1.5, but were severely limited in 1.6 bulk density soil regardless of the length of growing period.

Root extension was measured in these tests after 48, 80, 110 and 141 day growing periods in soil with bulk densities ranging from 1.32 to 1.77. These results support the need for root extension to a soil depth below the level of traffic - induced soil compaction before harvesting equipment enters a hay field.

Timing First Harvest

Much of the stand loss in the field test occurred as a result of wheel traffic during the first and second harvest. Most of the root-restricting soil compaction took place during the first three passes of wheel traffic over the soil, emphasizing the importance of a large, healthy root system before the first cutting of a new alfalfa planting.

In sandy loam soil, the alfalfa taproot should be down 14 to 18 inches before the first harvest. This will permit additional root growth below the compacted soil area. Root-stored carbohydrates are needed for shoot growth following harvest. If regrowth shoots are damaged by wheel traffic, additional root reserves will be required for shoot growth and plant survival. Plants growing on light-textured soil with small root systems at the time of first harvest will be generally weakened and many will not survive the double blow of root-inhibiting soil compaction and mechanical damage to regrowth. Fall planting will give more time for proper root development before the summer harvest season begins.

Minimizing Traffic Damage

Extending the stand life of alfalfa plantings in California one year beyond the present three-year average could mean savings of over $20 million per year to alfalfa producers. This study demonstrates the significant effects of wheel traffic and makes imperative the further development of techniques to minimize traffic damage. Possible ways of reducing traffic effects and extending the production life of a stand include standardizing wheel traffic patterns, establishing designated traffic lanes in alfalfa fields and bed plantings with shallow furrows to be used as lanes for standardized wheel traffic. In designing alfalfa seedbeds, a grower needs to consider soil type, irrigation system and weed populations, in addition to standardizing wheel traffic patterns.

---

[1]This project is a cooperative effort of the following people: R. Sheesley, Fresno County Farm Advisor; D. W. Grimes, Associate Water Scientist, U. C. Davis; W. D. McClellan, Tulare County Farm Advisor; C. G. Summers, Assistant Entomologist, U. C. Berkeley; and Vern Marble, Extension Agronomist, U. C. Davis.

[2]Unpublished results from greenhouse studies (D. W. Grimes & P. L. Wiley, 1975)