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LACIE EVALUATION AND OUTLOOK PANEL TRANSCRIPT

THE LACIE SYMPOSIUM

OCTOBER 1978

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Lyndon B. Johnson Space Center
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LACIE Symposium
LACIE Evaluation and Outlook Panel
Johnson Space Center
Houston, Texas
October 23, 1978

Panel Members:

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International Maize and Wheat Improvement Center
William F. Brooks, President and General Counsel
National Grain Trade Council
Anthony J. Calio, Associate Administrator for Space and Terrestrial Applications, National Aeronautics and Space Administration
Ludwig Eisgruber, Head, Agricultural Economics Department, Oregon State University—Panel Moderator
Frank G. Lamb, President, Eastern Oregon Farming Company
Don Paarlberg, Professor Emeritus, Purdue University
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Milling and Baking News
Harold Strickland, USDA Remote Sensing Service Coordinator, Office of the Secretary, USDA
Sylvan Wittwer, Director, Michigan Agricultural Experiment Station

FOREWORD

The LACIE Evaluation and Outlook Panel was composed of technical and managerial leaders holding key positions in the agricultural community, the research community, the U.S. Department of Agriculture, and the National Aeronautics and Space Administration.

The panel discussion concluded the opening session of the 4-day LACIE Symposium, October 23, 1978, after the comprehensive Plenary Session presentation and the Independent Peer Evaluation of LACIE. This discussion responded to the following questions:

- What is the status of today's technology in satisfying agricultural information needs?
- What should be the primary thrust of technology development/application in the 1980's?
- Who should be the key preponents of this thrust, and why?

This transcript was prepared from a recording made during the panel discussion. Minimal editing has been done in order to provide the reader with essential information available to those present at the symposium.

MACDONALD Professor Ludwig Eisgruber, head of the Agricultural Economics Department at Oregon State University, chaired a study sponsored by the National Academy of Sciences to examine the need for improved information in agriculture and has been acquainted with the subject for a considerable length of time. For these reasons, he has been selected moderator of this LACIE Evaluation and Outlook Panel.

EISGRUBER The paper by Don Paarlberg, entitled "An Independent Evaluation by the Plenary Peer Review Team," is a summary of the peer group's technical evaluation of the Large Area Crop Inventory Experiment (LACIE). This panel will present a different dimension of the peer group's evaluation of, and outlook on, LACIE; namely, the future role of LACIE-type technology in serving the needs of agriculture.

To address this complex topic, the following individuals have been assembled as members of the LACIE Evaluation and Outlook Panel: (1) Harold L. Stickland, Remote Sensing Coordinator for the Office of the Secretary of the U.S. Department of Agriculture (USDA); (2) Sylvan H. Wittwer, Director of the Michigan Agricultural Experiment Station; (3) Morton I. Sosland, Editor and Publisher of *Milling and Baking News*; (4) Norman E. Borlaug, Director of the Wheat and Triticale Program for the International Maize and Wheat Improvement Center; (5)William F. Brooks, President and General Counsel for the National Grain Trade Council; (6) Anthony J. Calio, Associate Administrator for Space and Terrestrial Applications for the National Aeronautics and Space Administration (NASA); (7) Frank G. Lamb, President of Eastern Oregon Farming Company; and (8) Thomas D. Potter, Deputy Director of the Environmental Data Service of the National Oceanic and Atmospheric Administration (NOAA).

The discussion by the LACIE Evaluation and Outlook Panel begins with comments made for the Federal Government, for the state agricultural experiment stations, for grain producers and the grain trade, and for the academic and research environment on three major questions: What is the status of today's technology in satisfying agricultural information needs? What should be the primary thrust of technology development and its application in the 1980's? Who should be the key proponents of this thrust, and why?

STRICKLAND The USDA has many responsibilities that relate to the Earth and its resources. It has programs to enhance the environment and to maintain the Nation's food and fiber production capability by assisting in the protection of the soil, water, forest, and other natural resources. It works to maintain an improved farm income, develop and expand export markets for farm products, and increase the efficiency of the agricultural sector. In carrying out these broad responsibilities just within the department, USDA personnel must collect, analyze, maintain, evaluate, and disseminate timely and reliable resource commodity data and related economic information. Rapidly changing conditions in the world have pointed to the need for better means of obtaining information. In the past, information requirements for specific programs have generally been satisfied by unique surveys or systems addressing a very narrow set of requirements. However, recent remote sensing technological changes show promise of broadening the ability of systems to provide these same data. Therefore, the most obvious question that the USDA is asked is the following: What is the status of remote sensing technology to meet agriculture's need?

The answer to this question lies in a report recently completed by the USDA's Remote Sensing User Requirements Task Force, which was established by the USDA's Office of the Secretary. The task force included representatives of eight USDA agencies, representatives from NASA, other government agencies, and universities. The task force represented the first coordinated effort to document USDA agency requirements that could be met by remote sensing. Identification of a need for additional study was also part of its responsibility. More than 3000 agency requirements for resource data were cataloged, analyzed, and evaluated. Involving the actual data user in this activity was a key to its success. Having other government agencies, universities, and NASA scientists assist was valuable in resolving questions and discussing technical capabilities. Accurate identification of all Earth resources data requirements with a full description of key parameters was probably the most important task.

The task force completed an analysis of whether or not remote sensing could be used to acquire the Earth resource data. Experts in both the optical and electronic technologies assisted the task force in this analysis. The requirements were categorized into four broad classifications. The first one was operational: That is, the technology is well established, known, and understood by a cadre of USDA staff; required hardware and communications facilities are in place and are available; and software is developed and available for routine use. The second classification was developmental: research is complete, testing is carried out, and the results are published; conclusions have been tried in a research/academic environment and found successful but have not been used for operational projects. The third classification was research, defined in the classical sense: The status of technology is as yet unknown or unproven, technology is beyond the state of the art, or the need for new knowledge is not yet available in the academic or advanced commercial communities. The fourth category was considered unfeasible for doing this particular work with remote sensing.

The results of this analysis indicated that approximately 15 to 25 percent of the data requirements (information requirements) are being fulfilled today by remote sensing. About 25 to 30 percent are in the developmental stage, about 30 percent need additional research, and about 28 to 30 percent were not considered feasible. These figures indicate that the status of remote sensing to satisfy agricultural needs is somewhere around 40 percent available; that is, either it is operational or it is developmental by the USDA definition. Approximately 30 percent of USDA's needs that have been described must still be researched. Of the USDA's requirements, 91 percent are for domestic resource data. More than half of the requirements, or 68 percent, require updating at least annually; and a sufficient number of that percentage requires updating more frequently, about 31 percent. No single remote sensing technology is capable of satisfying all, or even a majority, of USDA data requirements. However, this report notes that high-resolution photography has a maximum potential of satisfying 41 percent of all USDA requirements; NASA's existing multispectral scanner, about 8 percent. The thematic mapper has a potential of about 20 percent; in-place sensors, about 6 percent. The analyses show that apparently few, if any, alternatives exist which are lower in cost than the current USDA method of using conventional aircraft for obtaining timely coverage to meet domestic requirements. In dealing with the question of remote sensing's capability to meet agriculture's needs, the USDA found that the potential for its use is widespread but that in many areas its use requires additional development and research.

In the fall of 1978, the Secretary of Agriculture proposed an expanded multi-agency program, referred to here as the Initiative, or the Secretary's Initiative. The USDA has been working with NASA, with the Departments of Interior and of Commerce, and with the Agency for International Development (AID). Within the USDA, the Initiative built upon the experience and expertise gained in such programs and activities as the previously mentioned Remote Sensing User Requirements Task Force; LACIE; the research of the Economics, Statistics, and Cooperatives Service (ESCS); the Forest Service; and the Science and Education Administration. The Initiative identifies seven categories of importance in order of priority. These categories will be the USDA's thrust of technology development in the 1980's.

1. Early warning of changes affecting production and quality of commodities and renewable resources, such as a flood, heavy frost, or disease which may affect crops or yield.

2. Commodity production forecasts. Commodity production information is essential to agencies with responsibilities in commodities marketing, natural resources management, international trade, and supply management.

3. Inventory and assessment of renewable resources, including timber, range, water, wilderness, and wildlife.

4. Land-use classification and measurement data. Information from change monitoring and detection is used to update baseline production information to reflect land shifts from rural areas, shifts between agricultural crops, and shifts in cultural practices.

5. Land productivity estimates. As the world demand for food and fiber products has increased, it has become more evident that better procedures are needed to accurately estimate and quantify land productivity and potential.

6. Assessment of conservation practices. Conservation practices for which better information is needed include, among others, cultural practices for protection against wind and water erosion, flood control systems, irrigation, and application of fertilizers and herbicides.

7. Pollution detection and impact evaluation. The detection, location, and identification of pollution sources related to agriculture and forestry are essential to understanding and controlling the effects of pollution on agriculture.

These seven areas offer a high potential for remote sensing use in enabling the USDA to meet the data requirements. The first two categories, early warning and commodity production forecasts, will receive the first attention. Since these types of activities will be tied to operating program needs, the USDA expects that as methodologies are developed, tested, and determined to be cost effective, they will, in fact, be phased into the operating programs. In its description of the user requirement task force in the Initiative, the USDA has stressed the close relationship of user needs and the development of specific remote sensing techniques and procedures to satisfy those needs. The use of aerial photography from aircraft as a commonplace tool for domestic management and information within the USDA is evidence of this fact. New forms of remote sensing, such as those based on satellites, will also become commonplace, provided that user needs can be satisfied. It is in fact established that remote sensing has a widespread capability, within the foreseeable future, to significantly benefit identified agricultural information needs, then the third question arises: Who should be the key proponents of this thrust, and why?

To date, remote sensing activities have been primarily a Federal function. Several private sector companies and groups have expressed interest in commercial exploitation of Earth resources satellites. However, in May 1978, President Carter reaffirmed existing or established new national space policy when he stated,

> The United States shall encourage domestic commercial exploitation of space capabilities and systems for economic benefits and to promote the technological position of the United States, except that all United States Earth-oriented remote sensing satellites will require United States Government authorization and supervision or regulation.

Implementing this policy in the broad context of government will be very complex, but it must be dealt with in the early stages on a case-by-case basis. The involvement of the commercial sector with the USDA would be in areas of (1) contracted research and development, system design and construction, and operation; (2) data analysis and interpretation and information generation services; and (3) information communication services. Involvement of nonprofit institutions and universities will be more effective in basic and applied research, requirement analysis, and critical concept design reviews. A contractor/contractee relationship would be most effective until a system has been in operation long enough to have built up a substantial customer volume. Until this happened, private industry would probably be reluctant to invest heavily. Remote sensing is still a young technology but it is growing rapidly. Private investment at this period of its growth would have to be recovered quickly or become beset with antiquity. Data collection by remote sensing techniques should not be viewed as a replacement or exclusive data collection means. Remote sensing is only one of many of the USDA's data sources; and to be properly utilized, it must be incorporated with other data collection and analysis methods. During the 1980 budget process, the USDA will present a coordinated, thorough program to develop and apply aerospace technology to agriculture.

WITTWER Thirteen years ago, the Michigan Agricultural Experiment Station participated in the initiation of a joint effort in the remote-sensing area with the Willow Run Laboratories [now known as the Environmental Research Institute of Michigan (ERIM)]. ERIM had the hardware and the physical facilities, and the Michigan Agricultural Experiment Station had the biological and the crop production expertise. It was and remains a very viable team effort. This is an example of a cooperative effort that will be referred to later. Three areas will now be addressed. What is the status of today's technology in satisfying the information needs of agriculture?

The LACIE technology has provided estimates of nonirrigated winter wheat acreage in two of the major areas (the southern Great Plains of the United States and the U.S.S.R.) and of spring wheat in the U.S.S.R. There are, however, very special spectral problems with spring wheat, small grains, as Don Paarlberg indicated, and small fields because of the size of the sensor resolution elements. It is not clear how these problems will be resolved, if they will be. Global analysis of wheat yields may not yet be accurate enough for economic feasibility. A debate on the economic issue of this whole matter would be interesting. There are still, however, real problems with field size versus spectral resolution for wheat which suggest that it may be premature to think of remotely sensing in a large scale other crops such as corn, rice, soybeans, sorghum, and potatoes, which have even greater complexities in distribution, field size, production practices, and spectral characteristics than has wheat. Yield models have been designed that are thus far somewhat crude regression models derived from meteorological data. They fail under the severe climatic stresses or changes or as a result of extreme departures in yield caused by pests. This is very clearly pointed out in a report on the LACIE program published in August 1978. Yet, these are the times in which information is needed the most and would be the most valuable. In other words, physiologically accurate yield models have not yet been developed for any of the major crops. The classical example is 1974, in terms of the drought year, when the estimates were off by about 4.6 bushels per acre.

In terms of the thrust for the 1980's, the current or past LACIE program has been almost entirely based on information derived from agrometeorological data. There has been little spectral data input. There is a need to determine how spectral information can best be utilized with respect to predicting the yield component. The small-field problem must be resolved. Spectral separability may possibly be achieved with finer and different spectral bands, greater frequency of observations, and more observations during critical periods — coupled with field work in the ground-related companion crops, field densities, irrigation, and other cultural practices. Higher resolution satellites are critical for accurate crop assessment programs. There is a need for signature extension and optical crop canopy analyses. Existing Land Satellite (Landsat) technology should be used to identify severe crop abnormalities rather than to focus entirely on estimating global crop yields. This will require the extensive calibration of existing imagery and future imagery yet to be designed. Such calibrations should be based on continuation or combinations of precise yield information and spectral information gathered on a field-by-field basis. One of the interesting things that could be done would be samplings of specific crops that are easily manipulated and could further define essential requirements for data interpretation. A primary deficiency in programs to now has been the emphasis on the crop acreage component rather than on crop conditions and yield potential. A major cooperative effort for the past 10 years has been under way with the station's personnel at Michigan State University and those with ERIM to further define optical properties of crops and crops under stress to optimize the use of current sensors and to develop new sensor capabilities.

The critical issue is determining who should be the key proponents of these thrusts and why. The triagency effort — NASA, NOAA, USDA effort — should be continued and extended to include the scientific expertise and resource of the state agricultural experiment stations. The continued inputs and upgrading of hardware and software from NASA should continue to constitute the core of the program, but they should not take over. The meteorological inputs at NOAA are very obvious and essential. The existing crop yield estimating and forecasting program, which has been highly developed within the USDA, should be combined with the latest remote sensing procedures with NASA. The expertise and resources of a fourth component should now be added: that of the state agricultural experiment stations with an accompanying emphasis on ground observations and field work. The capabilities residing primarily in the agricultural experiment stations and many of the USDA field laboratories within the states heretofore have been largely ignored. Local research on the optical properties of plants, computer software packages, and sampling procedures will be essential for any LACIE-like program to be launched in the 1980's for forecasting yield of the major crops. Models for crop yields must be further developed; this development could be a responsibility to which the state stations could make a major contribution. Many people today know a lot about equipment and remote sensing but not about crops. Even more important than these people are those who know about crops and the components that go into crop productivity but who have seldom related to remote sensing programs; there is a need to bring them together. The past is reflected by good emphasis on space, satellite observations, and the potentials for the acquisition of more reliable measurements from space by remote sensing technologies. More emphasis is called for in making use of what is now available on the ground at much less cost. Improvement of the reliability of simple ground measurements should hold equal priority to the haste often witnessed in developing new technologies from space satellites. This could be done with considerably less cost, perhaps, in sophistication of instrumentation than that accomplished from satellites. Finally, it must be recognized at the Federal level that agricultural research and extension programs for the future must constitute more than the Federal system — and more than a multiple Federal agency complex. The state agricultural experiment stations are going to play an increasingly important role. Already, the partnership between the Federal and the state system in agricultural research is one in which the state is a dominant partner and in which the ultimate utilization of the results of satellite research will reside.

Remote sensing technology is scarcely more than 15 years old. It has been a major-success program and the LACIE program is a success, in terms of what it was designed to do — in terms of winter wheat and spring wheat in the Soviet Union. Yet, it may be a little bit premature to think of a lot of other crops. More ground observations and good solid field work will be essential in the future. Major research investments for the future must extend beyond the NASA satellite hardware component for acreage assessments, and the NOAA weather data from the World Meteorological Organization network, and USDA's ESCS. Yield variations for most crops exceed the variations in acreage. In addition, a vast reserve of crop productivity data is available from scientists, from the state agricultural experiment stations, and from the USDA laboratories spread across the Nation. They must become an essential part of any successful remote sensing system for the 1980's. There must be a solid recognition by the Federal agencies that agriculture extension programs are more than a Federal system and that often the real action for implementation occurs at the state and county levels. Finally, the value of information including that derived from research and satellite data on assessing crop production is unknown until the information is obtained and used. There must be more frequent conversation with potential users in the language that they can understand. For agriculture, the ultimate might be the individual farmer.

The November 1978 issue of *Scientific American* (page 94A) carries this IBM advertisement: "Prices keep going up. Information costs keep going down." The statement is somewhat misleading. Information costs are not going down but rather the costs of information technology and data accumulations. However, it takes more than that; besides satellite imagery being used for crop yield estimates, early warnings, and commodity production forecasts, valuable satellite information is presently available far in excess of the existing ability to use it. Future focus should be on the applications technology already known. This could be extended beyond the capability of estimating crop production in various parts of the world. It could include resource, land, water, forest, biomass inventories, assessments, land-use classification, pollution detection, etc. It could provide information for more effective resource management, planning, and use. This emphasis on applications could be greatly implemented at the state level in concert with the Federal agencies. Finally, the success of the original LACIE effort should be given more visibility. It did work. Projections for the Soviet wheat production and its grain inventory are economically and strategically important. The Soviets are the most important wheat producers in the world. No area is more prone to yield fluctuations from year to year because drought is prevalent and because millions of hectares of land in the Soviet Union are marginally cold and marginally dry.

SOSLAND The use of remote sensing systems between two parts of the grain industry, the market (which determines prices) and the planning process (by both producers and the industry), is differentiated in the following discussion. No part of this economy has a more direct tie to weather, weather observation, and crop forecasting than does that represented by grain farming, processing, and trading. Obversely, if there is any sector of this Nation that knows less about the capabilities of the LACIE program, it is the grain industry Thus, for this sector, the desirability of improvements over present crop forecasting systems can hardly be exaggerated. The greatest obvious need is for inprovement in the analysis of crop acreage and development in foreign lands, specifically those countries which buy significant quantities on the world market but which are unwilling or unable to offer generally acceptable crop forecasts.

In 1974, a panel met in New York because of a concern about the world's running out of food. There, an expert in weather forecasting and crop forecasting stated that the technology was so quickly progressing that forecasters would be able to pinpoint with some accuracy county-by-county or even farm-by-farm moisture and crop conditions. He then posed the question, would not the availability of that kind of knowledge mean the doom of the futures markets? The answer, of course, is no. Because the main focus when that panel met was almost exclusively on whether the United States, India, the People's Republic of China (PRC), and the U.S.S.R. would have good crops, he assumed that ending the uncertainty about their crop prospects would mean the death knell of the markets. Elimination of the uncertainty of weather for the market, however, would result in the two new concerns filling the gap. The point, simply, is that LACIE or any other new technology will not have an effect on price that is the least bit different from the impact of current weather and crop forecasting. This is especially the case when the information is made generally available in the public domain. A single market participant having something like LACIE available only to him would cause the information to be extremely valuable, even priceless. However, since that will not be the case and since information having an impact on the market has a value inversely related to its availability or scarcity, it is difficult, from the narrow viewpoint of price determination alone, to state that some exactitude in weather crop forecasting really would be a significant contribution.

Some nonweather, non-crop-forecasting forces might replace weather and crop size as market movers. The most important of these unpredictables is, of course, the government decisionmaking process. One of the most striking examples of this type of unpredictable is what the U.S.S.R. did in 1972. The surprise that year was not that the U.S.S.R. had a poor crop but that the Kremlin elected to buy its deficit overseas. LACIE or any other system could not have forecast the Kremlin's buying decision even though it was definitely weather- and crop-related. The same could be said of the PRC's grain-buying policies. The markets follow with a great deal of interest weather developments in the PRC, but the most difficult question of all is what the leaders of the PRC will do in response to a specific level of production or in response to political developments, which are certainly outside the ken of either LACIE or the markets. It is worthwhile to know how the PRC's growing season is faring, but that provides only a small part of the answer as far as eventual impact upon market actions and prices is concerned.

There are a great many other forces at work. That list includes farmer decisions on a wide range of matters from acreage to selling their grains, from a compliance of governmental programs to farm bin construction. Logistics, harking back to the horrors caused by last winter's severity, loom very large. Transportation, foreign exchange fluctuation, global politics, labor negotiations, burdensome government-imposed rules, and trade negotiations — all can, and do, exert as powerful an influence on market prices as weather prognostications. It can be maintained that better crop forecasting would serve to moderate price fluctuations and then would be of value. This is a favored theme of politicians, but it is an accomplishment that has little benefit from the viewpoint of either the producer or the grain trade. For markets to perform effectively, price broadcasting has to be very loud and very clear.

Thus, the performance of grain prices in the wake of the U.S.S.R's massive buying in 1972 served very effectively to stimulate dramatic increases in acreage and in production in our country particularly and in a few other lands. The result was that the concerns then ruling about world food supplies quickly have turned into renewed worries about surpluses. Taking steps to diminish the price broadcasting power of the market only lessens the important benefit stemming from markets as a consensus of thousands and thousands of traders with their own opinions. The plea for recognition of the value of the American market system should not be interpreted as a reverse suggestion that LACIE is counterproductive. Having good information, reliable information, is essential to a properly functioning marketplace. Since the market price mechanism has extreme sensitivity, though, one cannot exaggerate the need for a high standard of accuracy. The 90/90 level mentioned for LACIE must be the very minimum. Crop forecasting or weather forecasting that is accurate at some level below that has really the inherent threat of doing a great deal more damage than good. Take the example of a farmer deciding on his winter wheat acreage or, better yet, of a government official who has to make a decision on the level of acreage set aside. A decision based on less than accurate weather observations by winter wheat farmers or by the government itself could hardly be more dangerous in a world where the difference between shortage and surplus is a few percentage points. Nothing would be more disadvantageous for grain farmers or the grain trade than making available a system of crop forecasting that would not be nearly perfect.

As far as the second sector is concerned, any and all progress in crop projecting is highly welcome. It would be difficult to guess how much is currently being invested by the major grain-trading companies in sharpening their skills in weather and crop observing, mainly to enhance the planting process and not to let them make a good trade. Decisions on allocations of resources, manpower, transportation, storage, and handling are closely tied to knowledge about crop production potential. This knowledge becomes particularly important when related to the rapid expansion in livestock and poultry production around the world, which provides the best reason for the extension of the LACIE system to these crops. For instance, knowing production in an area immediately tributary to a cattle feedlot could facilitate more efficient allocation of resources than would be possible now without such information. From a global point of view, knowing that one area of the world will have a poor crop or a good one would allow assignment of shipping capacity and other resources in a way that could significantly reduce costs of transportation and distribution. An official of a major grain-trading company has made the point that his company's business is primarily that of moving grain into positions where its use is transformed from the general to the specific. The transformation process ranges from gathering wheat in Kansas for grinding by a mill in Pennsylvania to erecting inland terminal elevators in Iowa and Illinois to move corn through an export elevator at the Gulf. While a great deal of money has been invested in making this a very efficient and effective system, its imperfections beyond those caused by government are more often than not related to lack of good knowledge about crop size and production in one or another part of the world.

From the viewpoint of the grain farmer, crop forecasting knowledge is important and desirable in so many obvious ways that one can pass over such areas as acreage and harvesting decisions in quick fashion. However, there is one new development — new, that is, in recent years — that makes accurate crop forecasting into the foreseeable future assume even greater importance: the tremendous expansion in farm storage capacity in recent years and the accompanying truly massive rise in ownership of grain stored on farms by farmers. The first survey of national grain farm storage ever conducted, issued in 1978, estimates total on-farm grain storage capacity as of April 1 at 9.9 billion bushels. That is nearly enough to hold this year's combined crops of corn, wheat, and soybeans (and it is nearly full), which is a phenomenal fact when you consider that off-farm commercial storage capacity adds another 7 billion bushels to the total. While data are not available to show how much of the farm storage capacity was added in recent years, it is certain that the fastest expansion has been in the past couple of years in response to two new governmental programs: a sweetened farm storage facility loan program and a 3-year reserve under which growers commit to hold the grain off the market for that period in return for an annual storage payment of 25 cents a bushel. It is important to note that a significant influence on the willingness of farmers to participate in that program can be directly tied to the expectation that market prices will advance before the end of the 3-year period in response to a significant crop shortfall. If that does not happen, the Government in less than 3 years faces a monumental task, either extending the program or allowing what is rapidly approaching a billion bushels of grain to be either released into the market or delivered into the ownership of the Commodity Credit Corporation. In other words, a farmer-held reserve absolutely demands a large enough deficit in either American or world production to draw out that grain. The remote sensing capability of LACIE does not necessarily answer that crop forecasting need.

Would farmers have gone into the program if they were assured that the next 3 years would be abundant crop growing years? Any input about crop prospects would be helpful in what has literally become an open-ended commitment to encourage farmers to hold grain off the market through financing and storage provided by the Federal treasury. It is not good enough in those circumstances simply to declare that the probability of such a world's crop shortfall is within the realm of realistic expectation. There is an alternative policy that this Administration now seems anxious to avoid. It is the alternative of doing everything possible to maximize use. The Carter Administration has made the choice that favorable weather, such as that experienced for the last 3 or 4 years running, is best accompanied by unilateral actions on the part of the United States to cut back on its production. That is a gamble so far as having enough grain to feed the world is concerned, but it has not been lost in either 1977 or 1978. On the other hand, single-minded pursuit of acreage curtailment by the United States obviously serves to chill countries that do offer the greatest potential for market expansion. One can speculate only on the resort of a different U.S. policy: one that could be soundly based on accurate crop projections and that would tell the world, "Come and get it. We will grow all we can and make it available to you at a price in line with real supply-demand conditions." For both the grain farmer and the grain trade, it can be said that improved crop forecasting tools are very urgently needed — not for market price judgments which are important, but in two other areas: for individual entrepreneurial guidance in making investment and distribution decisions and for provision of urgently needed input to the Government's decisionmaking process. The role that LACIE can plan and should play toward achieving those ends merits immediate and urgent consideration.

EISGRUBER With respect to the question on the status of technology to satisfy information needs for agriculture, comments made so far, including those by Dr. Paarlberg who spoke for the peer review team, are very complimentary toward what has been accomplished and are very optimistic with respect to what can be accomplished in related areas (moisture, other crops, etc.).

The second question (what should be the primary thrust of technology development and application) can be answered by providing highlights of recommendations made on this topic by the six peer review teams. Some of the peer review recommendations applicable at this point include the following: improved sample estimates (removing possible bias due to cloud cover, redesigning of ground observations that increase subsamples, etc.) and improved yield modeling (improving the crop calendar models); increasing the role of machine-oriented procedures to reduce analyst labeling errors; emphasizing technology transfer more heavily; and designing reliable, dedicated systems which are operational. A few additional recommendations that are much broader and that have not been addressed by the peer review group are the following: We have a much better handle on the technological capabilities than on the question of what to do with this capability. There are many areas in which improvements are still possible, if not needed. If one goes back into history, and it need only be a few decades, and at most a century, one will find that an introduction of a truly significant technology did not simply consist of replacing it with a somewhat better one. It consisted of a change in entire institutions and the creation of new ones. This is what is so painful for developing countries. It becomes more noticeable when we go to developing countries because we are transplanted into a new environment. We think we know what is going on and what great things would happen if new technology were introduced. Developing countries do not always see it that way; closer to home, the introduction of a technology like remote sensing results in the same kind of problem. When the telephone was adopted, it was adopted not because of what the existing mail service already could do, but because of what it would do in addition to that and because of the things that the existing mail service could not do. When air travel came into being, there was no attempt to duplicate the dining cars, the club cars, and the like. Air traffic simply was instituted because of a different need, because of a different service; and it changed our institutions. The same could be said about computers. We are not very good about predicting successful technologies, like the technologies with a great deal of impact. To date, the only kind of question asked about LACIE-type technology is whether it is better than existing technologies — whether it is significant enough to ask what kinds of new institutions are needed to facilitate the use of the technology in the best interest of society

All indications are that there are trade-offs among timeliness of information, frequency of reporting, and accuracy. Articles in the *American Journal of Agricultural Economics* and in the *American Economic Review*, among others, show at least in a theoretical sense that a more accurate and final, but late, estimate is not necessarily a better one than the one which is less accurate but more timely. Of course, there is the question of what the trade-offs are. If there is merit to this observation, LACIE-type technology development might have to be redirected from a goal as old as 90/90 with a 14-day turnaround to perhaps a goal with about the same accuracy, or maybe even slightly less, and a more timely, more frequent turnaround. This theme could be expanded further to the need for a flexible sampling in our subsystem - flexible with respect to deciding on less frequent reporting and longer turnaround time but more accurate estimates when things are normal, but more frequent reporting and quicker turnaround when less accuracy is necessary and when things are abnormal.

The question of who should be the key proponents of the thrust of technology development will be interpreted here in the very broadest sense. First of all, it is evident that no one existing agency is likely to be successful if viewed as the sole proponent for three reasons. First, at least two review teams out of the six or seven in LACIE indicated that one of the great accomplishments of LACIE was the cooperation among various disciplines, various scientists, and various agencies and even the experiment stations here, although the latter's role was not as strong as it might have been. There is considerable agreement among those who reviewed the accomplishments of LACIE and their significance that this cooperation was necessary and that the accomplishments could not have been achieved otherwise. Second, new information systems will generate new institutions. In fact, to determine whether LACIE-type technology is useful for agriculture, one would first have to determine what kinds of new institutions could be established to capitalize on what LACIE technology can do. LACIE technology does not fit neatly into one agency or one industry group or the other but rather into a cross section of them. Third, it is evident that public institutions will continue to play a role in this area and should do so for a number of reasons.

1. Some of the research that would appear to be needed would not be forthcoming because its outcome would have no immediate value to private industry. However, it is the responsibility of the public if there is indeed social value to pursue this kind of research.

2. Some of the information generated by this technology needs to be made available to small and large firms alike. The income redistributional effects of information, if not equally accessible to all, can be substantial. This, incidentally, is the underlying philosophy behind the lockup that is now going on in Statistical Reporting Service (SRS). In a different sense, it is also the underlying philosophy that generates criticism of the agricultural experiment station because it generated information for commercial agriculture, thus giving the agricultural experiment station the "agribusiness bias." This is not to say, however, that private industry should not have access to anything but the final product of information produced by LACIE-type technology. The question, when can private industry tie into LACIE-type information, is totally different and deserves much attention.

3. Until very recently, research, development, and application of this technology were decided upon, planned, and carried out almost exclusively by Government and university-associated staff. The private sector (the user sector and particularly the agricultural producer/processor/supply handler) were involved at the fringes at best. Given the state of technology up to now, maybe this was appropriate; but its appropriateness from now on is doubtful.

4. The September 7, 1978, issue of the *Wall Street Journal* carried an article entitled "Controlling Global Information." The article reported on an upcoming conference in Paris in October 1978, in which the Soviets and the third-world nations were expected to press for a declaration on mass media that would strongly imply that each government has the right to control news generated and reported within its own borders. "Long ignored by top U.S. officials, the entire set of information issues has risen in their concern recently. An interagency committee is trying to develop answers and several influential members of Congress have begun to ride herd on the area." It appears, certain, then, that the proponent of this type of technology development in the 1980's will have to deal with this particular dimension of who owns information in the international arena and how this information can be used in the international arena.

BORLAUG Some complications exist as one moves into these densely crowded countries where the fields and plots are very small. Matters become even more complicated in the areas near the semitropics and tropics because of the diversity of crops that are growing at the same time. As has been indicated, it is difficult to separate spring barley from spring wheat in the spring wheat region. In an area such as the subcontinent of India, (which includes Pakistan, India, Bangladesh, and South China), this becomes ever more complicated because more than one crop (wheat, barley, oats, rye) is being grown. In addition, since the winter climate is not severe, a number of oil seeds, forage crops, and grain legumes are all growing. Sorting these crops out in a small plot becomes very complicated. Obviously, better techniques will be required. There are problems in these areas, and these are likely to be critical areas of the world when something goes wrong because of the population pressures and the amounts of food that will have to be imported.

The impact of change in technology as it is being applied occurs at different rates in different parts of the world. Some of the countries that used very little fertilizer up until 5 to 10 years ago are now increasing their output, and consequently their production potential, at a rapid rate. For example, India was consuming 400 000 tons of plant nutrients about 10 years ago, and today it is consuming 4 million tons. These changes have to be put into the formula some way or another in order to be able to project ahead. The same is true, of course, for changes in high yield dwarf varieties that have the potential to utilize these inputs of fertilizer. The rate of expansion of irrigation in a country such as India is tremendous. This, too, is another variable; and in some countries such as Pakistan and India, it is certainly one that remote sensing can bring out warnings for even more strongly than has been done in the past — for disasters in waterlogging and lack of drainage. Hopefully, in the next 10 years, there will be better remote sensing techniques worked out for identifying outbreaks of diseases, especially airborne diseases, such as rust fungi (a disease that affects wheat) or for identifying multiple cropping increases toward the semitropics. In the case of rice, some countries have been trying to grow three crops in the course of a year on the same land, even when they were attempting to use virus-resistant or disease-resistant varieties. They have had breakdowns: resistance to the virus and to the vectors, and there are all kinds of problems in the offing. If these can be spotted, they will give some additional information that will be valuable to those who are trying to see that food grain is fed into the right parts of the world and to anticipate the shortages that are likely to occur.

The International Maize and Wheat Improvement Center has been in the process of sending out international grain-yield tests. The grains consist of about 50 different varieties. Spring wheat is grown at 120 different locations. The Center also has a similar test with germ wheat and with triticaleum barley. There are about 300 collaborators throughout the world growing these varieties under a wide range of conditions. Up to now, there has been no way to feed this information into the system. The possibilities are now being explored. The data have been accumulated. The data are not very sophisticated, but they have been very useful for the purpose for which they were developed.

EISGRUBER Mr. Brooks, National Grain Trade Council.

BROOKS A question come with reference particularly to Dr. Paarlberg's observation about a user community for the results of this information. Will there be user fees involved in here by persons who might use the information that the LACIE projects and others have developed? The problems that the Government will have and that farmers particularly will have, such as determining the amounts of wheat, barley, corn, and sorghum that go into the reserve (strategic or otherwise), make it very essential that this be a marketing tool that farmers themselves can somehow take advantage of.

EISGRUBER Mr. Calio.

CALIO What would happen if there was a service charge for the data?

BROOKS Everything indicates that the data are of a great benefit to the public and to agencies of the Government, not only of the USDA, but also of the U.S. Department of Interior, perhaps the Department of Commerce, perhaps the Environmental Protection Agency, perhaps the Occupational Safety and Health Administration, and others who may be making some land-use plans. User fees, except in very selected instances (for instance, getting timber out of a national forest) just are not justified.

CALIO If there is an operational capability here, then, should private industry pick it up or should the Federal Government support it? Dr. Wittwer talked about state extension service being involved; so it is a multifaceted institutional problem.

BROOKS It is a multifaceted institutional problem.

CALIO From that standpoint, it is hard to see the role of the Federal Government. Mr. Sosland discussed getting down to the farmer himself and how that information should get to the farmer. Who should be the proponent, and how should that institutional setup be arranged? It seems as if all groups should try to move forward with Federal programs; solicit and incorporate the ideas that have been spoken about so far — taking into consideration state extension service, taking into consideration other federal agencies, taking into consideration the farmer, taking into consideration the private sector; and put them together in such a way that they can all use the data in a beneficial way.

BROOKS Who does not benefit from it?

EISGRUBER This is to be a very interesting question. Mr. Sosland would like to comment on it.

SOSLAND LACIE would be the supreme example of a program that would be federally paid for. There is not another research program that affects more people and more segments of the economy. If left to a user fee, the LACIE program might die. That is not necessarily the way that crop reporting should be provided — on the basis of whether people are willing to pay for it.

CALIO One question of clarification.

EISGRUBER One more question on this.

CALIO Over the next few years, when the research and development (some of that is done) and the technical problems that have arisen in LACIE are accomplished, benefits will be derived. In a day-to-day use sense, then, what is the best way to get that out for general use?

SOSLAND Again, it is like weather forecasting. It should not be made a service that only those who would be willing to pay for it could get it.

LAMB Production agriculture needs to be involved in the direction of two aspects of improved agricultural information; first, in the use and dissemination of the improved information; and second, in the direction of the continued development effort. To this point, the user defined by LACIE has been the USDA. During the development and the research effort, this is appropriate. However, at this point, this definition needs to be expanded in order to realize the full benefits of the technology.

POTTER The statement that soon all the uncertainty would be eliminated in weather and crop forecasting is not a very realistic view of what actually is the case. NOAA has developed some capabilities with respect to weather and crop-yield modeling, but it still has a long way to go. NOAA has other capabilities, particularly in the quantitative use of meteorological satellite data in frost warnings, the development of techniques for determining precipitation worldwide, flash-flood determination, snow extent, solar radiation, beginning capabilities along with NASA in soil moisture, and finally some capability for determining the effect of severe weather on crops. In 1980, NOAA certainly has a better need for operational data and information on a worldwide basis in a timely manner. There, the trade-off between timely information and precision is very applicable. NOAA has a need for better models. It has been mentioned several times that it is necessary to do a better job of combining the effects of weather and climate with agronomic factors and agrometeorological management practices in joint models. Finally, NOAA needs better short-range forecasting of episodic events which affect agriculture and better extended range in climatic outlooks. The primary thrusts then in the 1980's go along with these. The first three are being considered for development in the triagency program with USDA and NASA for remote sensing; more complete worldwide weather data and information in a timely manner considering all the appropriate weather variables; some other crop and country models for areas other than those that have been considered in LACIE, and some programs being developed within NOAA and other Federal agencies for providing a better capability for short-range forecasting. A program within NOAA, Prototype Regional Observing and Forecasting System (PROFS), is up for funding in 1980. This program will give a distinctly improved capability to handle those kinds of short-range events which affect the agricultural production to a considerable extent. A national climate program act was recently passed. Along with many other Federal agencies and with the cooperation of academia and some industries, NOAA hopes to develop a much better capability over the next few years for extended range and climate outlooks. There is some confidence that NOAA will be able to better estimate the effect of extended range forecasts on a seasonal basis. NOAA feels very strongly that the proponents are joint efforts of the Federal agencies, of academia, of industry, and of other countries because these are multidisciplinary problems which cannot be solved successfully by only one organization or one segment of the community or even one country.

HOLTER In reporting on the peer group review committee, Dr. Paarlberg commented that the single strongest positive conclusion of the committee was that the present existing LACIE technology was better than anything else available for estimating Soviet grain production. He also implied that the USDA is not going to implement that. Is it true that USDA is not going to implement it; and if so, why?

PAARLBERG The conclusion of the peer group is that this system is now available to producers and that information regarding the process for the wheat crop is better than information from other sources on which we have relied.

KIBLER What is surprising is that technicians will take a sample of one, which is what USDA has from the Soviet Union for 1977, and assume that those results are repeatable and that they might hold true for 1978 or 1979 or years to follow on. Those technicians who have followed this technology actually saw considerably better results than those for the Soviet Union and for the winter wheat area in the United States in Phase II and Phase III. It is very difficult to explain some of the numbers that are coming out of the LACIE follow-on results in relation to the technology or in relation to the accuracy that was illustrated quite earlier and the repeatability. Many of those numbers were not available to the USDA when it made its July 1 forecast or its August 1 forecast. Those forecasts have been reworked after the data were really finalized from the standpoint of the standing at harvest. Two other aspects of it, too, are that the program is only looking at one crop when it is interested in about 60 crops and that it is studying 7 countries when there are more than 100 countries for which crops have to be estimated. It seems as if a better approach would be to broaden the program to include other crops and other countries so as to address a larger part of the total program.

EISGRUBER Would some of the panel members, particularly those that come from industry, care to comment on their assessment of the usefulness of the data, particularly from the U.S.S.R., regardless of what USDA plans to do and at this point perhaps also regardless of cost, recognizing that this is a discussion about an experiment?

SOSLAND Very brief reference was made to 1977, but the preceding is some difference. It was my impression LACIE was making those figures available; even the adjusted figures were much lower than what the Foreign Agricultural Service (FAS) stated in June-July of that year. Decisions were made on the likelihood of Soviets' buying. The surprise came when the United States learned in October that instead of buying minimum quantities of 6 million tons, the U.S.S.R. was going to buy 15 million tons of grain. Everybody was considering the FAS figures to be accurate. It was inconceivable to all who were helping people make decisions about flour purchasing and grain distribution and technology that those figures were not available. What is evident now is that LACIE was telling the FAS that its figures were way high and that the FAS was not doing anything about it. It would be very important to have figures like those if they are available and are accurate.

CALIO An interesting point about the availability of the data is that they are about 30 to 60 days behind the time of acquisition.

SOSLAND Those were figures that were made available to the USDA a week or so, or a few days before, and were mailed ahead of the release of the FAS figures.

MACDONALD It was agreed in LACIE that since it was experimental and was subject to the kind of uncertainty present in an experimental program, it would not be made available, published, or used in any kind of operational fashion. It was not to be released, in fact, for 120 days (the sensitive period). This was very simply just not to perturb the markets with a lot of experimental information that might or might not prove out.

BROOKS I might add that they were going to be announced — you'd have the same kind of uncertainty as they'd have now with the crop reporting board, people are waiting out in the corridors.

MACDONALD They were released, and they were made available before any of the baseline systems; so the problem of contamination between LACIE results and baseline systems did not exist.

One more comment about using remote sensing data for agricultural statistics in some underdeveloped countries is that the emphasis should be put, not on crop identification, or certainly not on yield forecast, but on improving existing area frame for collecting these statistics due to the small fields in general. The unavailability of accurate maps is a limiting factor even for training fields if you want to make a crop classification. Most of the work will be done by the field surveyors rather than through remote sensing, and remote sensing data should be used just to improve an area frame for collecting these statistics.

EISGRUBER A case is being made for having such things as a crop inventory rather than a crop estimate, soil inventory, assessment of the water, moisture conditions, etc.

MACDONALD The LACIE transition results will corroborate what has been seen in the first 3 years. As far as the numbers changing, there are small changes (backlogs of segments). Comparisons to the final USDA releases are made; as those numbers change, an end-of-season final analysis is made. A close review of those results shows that those are rather minor changes.

HALL A brief summary of the technology evaluations in the five foreign countries reveals that the technology seems to be generally applicable in Australia, Argentina, and Brazil for acreage, where the larger fields are located. Improvements in the technology for PRC and India, which have the very small field sizes for acreage, is needed. Production estimates were not made in these foreign countries, but the 10-year test of the yield models was conducted. Exploratory segments from those countries were analyzed, just as they were for this country. The crop calendar models were operated in those countries. The 10-year test of the yield models showed that they appeared to satisfy the 90/90 criterion in Australia and India. However, the historic data that are required to develop these models were just not of sufficient quality to get a good development of those models in Brazil, Argentina, and particularly the PRC. The crop calendar appears to work best in Canada where it was developed, not quite as well in the United States and particularly in areas where some of the dwarf and intermediate varieties of wheat are grown at the more southerly latitudes. They have had a different development situation than the Northern Hemisphere varieties do, and they simply just do not function for those Northern Hemisphere varieties.

HARTLEY There is much concern about how agricultural information enters the community. Whatever agricultural information is already available to the existing system is adequately handled. If LACIE makes information more accurate or if LACIE adds some other information that is not at the present time available, there are no real essential difficulties. Can we not learn on what and how the matter has been handled in the past?

EISGRUBER The questions of what LACIE-type technology might provide and to whom are real issues. It is the same kind of issue as to what experiment stations and extension services provide free; there are some charges for the publications, for services that are being provided, and for activities by USDA. With the coming of new technology, the balance will be changed as to who benefits relative to who loses. Even now, the same question exists: should there be a charge or not? Whether it is an extension service, the USDA, or the experiment station, these questions periodically arise; and they will be more important questions in the future as people look more carefully at who benefits from government programs and have been in the past. Would any of the other panel members comment on that? Mr. Sosland.

SOSLAND There is a perfect example of this going on right now. The Chicago Board of Trade is suing an organization called the Commodity News Service (CNS), which is one of the main providers of ticker-tape service. The suit simply involves the fact that the CNS has a computer to which one can dial in and for a time-sharing fee get quotations and a whole range of information.

EISGRUBER At this time, I would like to thank the panel and return the meeting to the symposium moderator for the next item on the agendum.

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