STRATEGIC ANALYSIS & IMPLEMENTATION PLAN for TEXAS' CORN INDUSTRY

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Executive Summary

The Corn Advisory Committee was appointed by the Texas Agricultural Experiment Station in 2002. The Committee is comprised of research and extension unit heads and selected faculty, together with members of the Texas Corn Producers Board. The charge was to develop a 5-year corn strategic plan that addresses all the major issues for Texas Corn Production and recommends actions that position the research and extension corn programs among the nation's best. The committee has identified issues and constraints to the corn industry in Texas and has recommended six (6) **Major Program Areas** below (unranked). Within each Major Program Area, the highest-ranked* Program Elements are also shown below:

CORN PRODUCTION AND MANAGEMENT
- System for mycotoxin management/BMPs (H)
- Ground and surface water protection (H)
- Irrigation efficiency (H)
- Cropping systems (H)
- Integrated Pest Management/IPM (H)
- Hybrid selection (H)

TARGETED STRATEGIC LIVESTOCK FEEDING APPLICATIONS
- Evaluate the feeding value & economics of distillers dried grains, DDG (H)

ALTERNATIVE USES OF CORN
- Developing new products & uses of corn (VH)

ECONOMIC & POLICY ANALYSIS
- Implications of the Farm Bill and its policies (VH)
- Impacts of alternative uses of corn (VH)
- Master Marketing/risk management (H)
- NRCS rules & regulations (H)

BREEDING AND GENETIC IMPROVEMENT
- Drought tolerance (VH)
- Mycotoxin resistance (VH)
- Heat tolerance (H)
- Insect resistance (H)
- Disease resistance (H)
- Better-yielding short season varieties (H)

RESOURCE COORDINATION AND LEADERSHIP DEVELOPMENT
- Congressional internships (VH)
- TALL program (H)

An analysis and discussion of current issues, Program Elements, and recommended Program Actions for each of the above six Major Program Areas is provided in this report. A Recommended Action Plan that will address needs of the Texas corn industry is provided in Table 1.

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*Note: VH=very high and H=high priority.

Table 1. A Recommended Action Plan for Texas, Corn Advisory Committee, 2003.

Recommended Actions	Timeline: Short Range	Timeline: Long Range	Relative Cost: Inexpensive	Relative Cost: Expensive	Status: Who
Aflatoxin/mycotoxin:					
• State aflatoxin task force	X		X		TAES & TCE
• Develop multi-university task force*	X		X		TAES & TCE
• Congressional Initiative on Mycotoxin		X		X	TAES, TCE, TCPB
• I.D. losses due to Aflatoxins/Mycotoxin	X		X		TAES & TCE
State Legislative Initiative(s) (2005-2007):					
• Cropping systems, including corn		X	X		TAES & TCE
• Irrigation water management		X	X		TAES & TCE
Capital equipment replacement plan:		X		X	TAES
Focus on highest priority research needs:					
• Farm bill implications/economics (continual ongoing analysis)	X		X		TCE
• Alternative uses—new products/uses of corn economic impacts		X		X	TAES, IFSE, ARS
• Mycotoxins		X		X	TAES, ARS, TCE
• Water stress		X		X	TAES & ARS
• Pest Management		X		X	TAES, TCE, TAMU
Enhance Technology Transfer to Seed Industry:					
• Improve value of Texas Corn variety tests--					
▪ Breeders workshop	X		X		TAES & TCE
▪ Multidisciplinary evaluation of tests.	X		X		TAES & TCE
▪ Include commercial hybrids.	X			X	TAES & TCE
Engage TAMU—Institute for Food Science and Engineering (IFSE):					
• Liaison	X		X		TAES & ISFE
• Seed money, TAES		X		X	TAES
• State legislative initiatives on cropping systems (see above)		X	X		TAES, TCE, ISFE
• Mycotoxin initiative/multistate (above)	X		X		TAES, TCE, TCPB
Improve collaborations with USDA-ARS on Alternative Uses:					
• Liaison	X		X		TAES, TCE, ISFE, ARS
• Workshops	X		X		TAES, TCE, ISFE, ARS

*Includes: GA, MS, SD, KY, TN, NC, SC, LA, MO

Table 1. - Continued

	Timeline:		Relative Cost:		Status:
Recommended Actions	Short Range	Long Range	Inexpensive	Expensive	Who
Improve coordination of Corn R & E Programs:					
• TCPB research funding priorities and projects	X		X		TCPB, TAES, TCE
• Access TCPB research reports	X		X		TCPB, TAES, TCE, ARS
Compilation of all corn R & E in Texas (One-stop shopping):					
• Access existing report/data bases: TARD, CRIS, TAES and TCE Impact Statements, etc.	X		X		TAES, TCE, TCPB
• Interpretative summaries of the above reports		X		X	TAES, TCE, TCPB
• Compile consolidated research progress report in Texas		X		X	TAES, TCE-Soil & Crop
Extension Priority positions/coordination:					
• State corn specialist—Coordinate various agencies		X		X	TCE & TAES
• Regional corn specialists—High Plains, Blacklands, Upper Coast/Coastal Bend, Low Coast, Valley, & Winter Garden		X		X	TCE
• Corn workers group, inter-disciplinary	X		X		TAES & TCE
Research Position:					
• Research/Extension entomologist/corn—High Plains or statewide		X		X	TAES & TCE
Continued Involvement of Corn Advisory Committee:					
• Guide & monitor Strategic Plan implementation.	X		X		TAES & TCE
• Interact with Corn Workers Group, including Strategic Plan Implementation.	X		X		TAES, TCE, TCPB

Introduction

Texas Corn Production

Annually 2 million of acres of corn are planted in Texas. An average of 190 million bushels of corn is harvested with a net value of approximately $400−575 million to Texas producers. Corn producers are represented by Texas Corn Producers Board, which administers the check off funds for the state, and by the Corn Producers Association of Texas.

Conditions including natural resource constraints, management practices, and biotic/abiotic stress factors vary considerably among these major production areas. Corn planting begins in far south Texas in February and concludes in the northern panhandle in early May. Harvest season is normally from late July through November as it progresses from the south to the north. The distance from south to north presents corn producers many varied concerns such as insects, diseases, and weeds, and with moisture and heat stress being common across the whole state in most years. Water availability is a main factor in corn production, whether irrigated or dryland. Energy costs are a concern for irrigation.

Most of the corn that is produced in Texas is used for livestock feed with other uses including human food products or export. There is growing interest in alternative uses such as ethanol production or expanded food or industrial usage of corn products.

Corn Advisory Committee

The Corn Advisory Committee was established by memorandum (January 17, 2002) the Associate Vice Chancellor and Deputy Director, Texas Agricultural Experiment Station, Texas A&M University System (TAMUS) Agriculture Program. The administrative Charge to the Corn Advisory Committee was stated as follows:

> *"The Committee charge is to develop and submit to me, at the earliest possible date, a Five-Year Corn Production and Improvement Strategy that addresses all major issues for corn production in all of Texas, meet as needed over the next three years to monitor progress on implementing the Strategy, and recommend to my office actions that position the Texas corn program among the best in the USA."*

Appointed committee members represented the following categories (Appendix A):

- Resident Directors, TAMUS Agricultural Research and Extension Centers (ARECs) in areas where corn is a significant part of a region's agricultural economy;
- Heads of TAMU Departments having significant disciplinary responsibility for corn;
- Selected members of the Board of Directors, Texas Corn Producers Board.
- Executive Director, Texas Corn Producers Board.

In fulfilling the administrative charge, the Committee met 7 times (March 7, 2002 through July 21, 2003), and has produced this consensus report. When adopted by the Committee, this report will be presented to TAMUS Agriculture Program Administration for further action.

The Corn Advisory Committee was organized and is well-positioned to ensure very strong linkages with leadership of the industry in identifying issues, challenges, needs, and opportunities and in developing recommendations that will help foster, develop, and accelerate corn research and extension programs that meet the identified priority needs. The discussions involving academia and corn industry representatives that have gone into this "**Strategic Analysis & Implementation Plan for Texas' Corn Industry**" have provided a forum for exchange of ideas which included developing and articulating a statewide vision and action plan for the corn industry. The report can be used also as a guide for review and prioritization of program requests involving corn research and extension programs across the TAMUS Agriculture Program, including TAES and TCE in accordance with the identified needs and vision of the state's corn industry.

Vision, Mission, and Major Program Areas

The Corn Advisory Committee has developed the following consensus vision, mission and identified six Major Program Areas, as follows:

1. Vision -- Interdisciplinary, multi-agency research and extension programs in corn production, management, and utilization shall be the premier source of new and applied knowledge that will help advance the corn industry in Texas.

2. Mission Statement -- Develop and deliver science-based information and knowledge related to improving corn production, management, and utilization in Texas, in accordance with the respective missions and program capacities of the Texas Agricultural Experiment Station, the Texas Cooperative Extension, and closely-partnering universities (e.g., West Texas A&M University, Texas Tech University, etc.), federal or state agencies (including USDA-ARS), and the corn industry.

3. Major Program Areas -- In fulfilling the vision and mission of the Corn Advisory Committee, six (6) Major Program Areas should be vigorously pursued in the next 5-8 years as resources permit to ensure strength of the corn industry in Texas:

   A. Corn Production and Management

   B. Targeted Strategic Livestock Feeding Applications

   C. Alternative Uses of Corn

   D. Economic and Policy Analysis

   E. Breeding and Genetic Improvement

   F. Resource Coordination and Leadership Development

The appropriate Program Elements and recommended Program Actions to substantially address these six Major Program Areas are provided in subsequent sections.

A. Corn Production and Management Systems

Regional Differences

The key corn growing areas of Texas, as defined by the Texas Agricultural Statistics Service (TASS)*, are: the Northern High Plains (656,000 acres), Blacklands (650,000 acres), South Central (225,000 acres), and Upper Gulf Coast (217,000 acres). These regions accounted for 85% of the Texas corn. The environmental conditions for growing corn vary considerably in these four regions. As such, farming practices have been developed to address regional corn production issues.

Major Production Influences

The major factor in successfully producing corn is water availability during the season. Most of the corn grown in south and central Texas is produced under dryland conditions. In the Texas High Plains close to 100% of the corn acreage is irrigated. Cultural practices that improve water use efficiency in both dryland and irrigated production systems will have a major impact on yield and profitability. Those farming practices that impact water use efficiency are:

- Irrigation efficiency
- Integrated pest management (IPM) of diseases, weeds, and insects
- Cropping systems
- Hybrid selection
- Soil fertility
- Tillage
- Seeding rate, row spacing, and planting date.

The interaction of all these components greatly impacts the profitability of corn. The fundamentals of each factor should continue to be studied with particular interest in how they interact and fit into and overall corn production system.

1. Water Management for Conservation and Ground and Surface Water Protection

Water management and utilization are major factors in successfully growing corn in Texas. All of the components of a cropping system impact corn water use. Increasing corn water use efficiency (amount of grain produced per inch of water) should be the goal of all research and extension efforts, either directly or indirectly. With good management and efficient irrigation systems, growers are producing 600 lbs (10.7 bu) or more per inch of irrigation water. Production should be 400 lb (7.1 bu) or more from seasonal irrigation, rainfall, and soil water. Great strides have been made in recent years to improve irrigation water use efficiency. Developments of Low Energy Precision Application (LEPA) and Low Elevation Spray Application (LISA) technologies have greatly increased the efficiency of getting water to the corn crop. Subsurface Drip Irrigation holds similar promise in improving irrigation water use efficiency over furrow and other systems. Educational efforts need to continue in encouraging adoption and improving management of these high efficiency systems. Site-specific irrigation technologies are currently being developed and tested to identify their effectiveness and feasibility. Educational emphasis should be placed on utilization of irrigation scheduling tools such as evapotranspiration models, soil moisture monitoring, as well as cultural practices that affect crop water demand.

* Regions as defined by TASS designation; planted acreage data from 2002.

The issue of off-target losses of pesticides and fertilizers is a major issue facing corn producers. The Texas Commission on Environmental Quality (TCEQ) has listed six surface water impoundments and one river threatened by atrazine contamination from surface runoff of agricultural and urban landscapes. Further, Lake Aquilla in Hill County is listed as impaired associated with atrazine contamination and a Total Maximum Daily Load for atrazine has been set for this reservoir. Alachlor has also been detected in Lake Aquilla at the threatened level. All of these water bodies serve to provide drinking water for each one's surrounding communities.

The TCEQ has also documented atrazine detections of public water supply wells for 6 or more cities in the Texas High Plains in counties with significant corn production. The United States Geologic Survey (USGS) surveyed 48 sites covering 29,000 square miles of the Texas High Plains to analyze drinking water wells in the Ogallala Formation. Preliminary results presented by USGS from this water quality study revealed pesticide detections in 15 of the 48 wells sampled (USGS WRI Report 02-4112, 2002).

Work must be done to develop strategies for effective and sustainable corn growth and protection to reduce off-target losses of pesticides and nutrients. This effort must include on-site applied research projects that evaluate the use of best management practices (BMPs) that reduce off-target losses of pesticides and nutrients with minimal adverse impact on yield and net return per acre. A concerted effort must then be undertaken to transfer the results to the producer via field days, tours, CEU meetings, news releases, websites, news articles, videos, etc.

2. Disease Management (IPM)

Corn diseases occur in all production areas of Texas, and several of these diseases can cause devastating losses. The greatest threat is from fungi that produce mycotoxins, which contaminate grain. For example, recurring droughts in Texas have predisposed most corn production areas of the state to aflatoxin contamination, even affecting irrigated corn. The increasing use of Bt corn and other transgenics has altered production and disease management practices. Consequently, there is greater need for interdisciplinary efforts to develop new disease management systems in the field as well as to develop innovative methods for improving disease resistance or pathogen suppression. Corn is an important rotational crop in Texas; its use in a farming system allows for economical and effective management of diseases, weeds, and insects of other agricultural crops. Consequently, the loss of corn as a viable crop, as a result of an unsolved disease problem, limits the cropping options of growers. Major disease problems that continue to be the focus of research and extension programs are described below.

Mycotoxins

Aflatoxin contamination of corn is the major problem for producers in Texas. It consistently results in annual losses across all Texas corn growing areas in the tens of millions of dollars, with losses exceeding $100 million during drought years. Aflatoxin is especially a problem in years when drought and heat stress occur during pollination or kernel maturation, even affecting irrigated corn. Because of the nature of contamination, controlling it has been difficult. Coordination of efforts between pathologists and breeders has led to some progress in breeding as a control approach, but this is not likely to be the sole solution. There is a need for additional, coordinated research on other management practices.

Another important and emerging mycotoxin problem is fumonisin, produced by the fungus, *Fusarium verticillioides*. Factors affecting the preharvest accumulation of fumonisin in corn are not well understood. FDA has only recently established action levels for fumonisins in grain, and additional federal regulations are expected in the future because of the high toxicity of fumonisins to humans and animals.

Other Diseases
There are other diseases that reduce corn productivity. There is no coordinated, intensive research effort on these diseases. These diseases are: charcoal rot, caused by the soilborne fungus *Macrophomina phaseolina;* head smut, caused by *Sporisorium reilianum*, and common smut, caused by *Ustilago maydis*, which can be found throughout the state, although serious problems occur mostly in the High Plains region of Texas; southern rust, caused by *Puccinia polysora*, and common rust, caused by *Puccinia sorghi*, which occur primarily in coastal and southern corn-producing regions of Texas; and viruses such as maize dwarf mosaic and the newly-recognized High Plains Disease. There is a need for epidemiological studies of these diseases, particularly smuts, in which the influence of weather and crop management practices is unclear, and High Plains Disease, which has a broad host range that, includes wheat, barley and several weedy grasses.

The corn pathology research and extension team should have expertise in mycology and mycotoxins, virology, disease resistance and breeding, and epidemiology. The team will address both applied and basic aspects of diseases, screening germplasm for performance in the field, and an educational program to ensure technology transfer to producers. To address these disease problems in Texas, the following research and extension activities are identified:

a. Develop new approaches to identify resistance to aflatoxin-producing fungi, and support conventional breeding efforts aimed at incorporating aflatoxin resistance into corn germplasm.
b. Further investigate the potential use of non-toxigenic strains of fungi that suppress aflatoxin-producing fungi on corn.
c. Develop educational programs and publications that address the educational needs of growers, processors, and others potentially affected by aflatoxin.
d. Evaluate the prevalence of fumonisins in the major production areas.
e. Develop hybrids resistant or tolerant to fungal and viral diseases.
f. Determine how drought and other environmental stresses induce host susceptibility to charcoal stalk rot and mycotoxin-producing fungi.
g. Develop molecular gene markers to assist in selecting disease resistance genes for use in corn breeding programs.
h. Use molecular tools to understand resistance responses to pathogens and the strategies pathogens use to overcome field resistance.
i. Continue studies on cultural practices for managing corn diseases.
j. Increase support and incentives for collaborative multidisciplinary research teams to enhance crop and disease management practices.

3. Weed Management (IPM)

Weeds are a major challenge for corn producers in Texas. Weed management research and educational efforts are ongoing at Bushland, Lubbock, College Station, and Corpus Christi. Continued efforts are needed to respond to weed species shifts, changes in tillage and cropping systems, and introduction of new herbicides. Staying ahead of weed resistance is an ongoing issue. For example, Johnsongrass resistance to popular sulfonylurea herbicides has been confirmed on farms in the High Plains. In addition, intense pressure is being exerted on weed populations with the growing use of glyphosate in tolerant hybrids and varieties in a number of crops. Development of glyphosate resistance could be a major setback in reduced tillage systems. More effort must be made in developing the most economical strategies for weed control and developing and integrating strategies to prevent the development of weed resistance to herbicides.

4. Insect Management (IPM)

Transgenic Corn

Transgenic hybrids currently seek to provide protection against stalk borers, corn earworm, fall armyworm, and other lepidopteron species. Transgenic hybrids that protect roots against corn rootworm damage entered the market in 2003. These products work well and have eliminated the need in many instances to treat fields for target pests.

Transgenic hybrids that control Lepidoptera can provide significant economic returns to Panhandle growers through near-complete protection against southwestern and European corn borers. Growers in the northern two tiers of Panhandle counties plant up to 80% of their crop to transgenic hybrids (maintain a 20% refuge) as mandated by the EPA. Some of these counties have insect infestations that warrant the extensive use of Bt hybrids, but the current requirement of 50% refuge in the South Plains substantially limits the potential economic benefit to corn farmers that could be realized by this technology. As the new rootworm Bt event is stacked in hybrids with the corn borer Bt, growers will have less opportunity to benefit financially from technical advances if the restrictive refuge requirements are maintained. Efforts to inform federal regulators of the scientific merit of reduced refuge requirement should be enhanced.

Transgenic technology will soon allow the introduction of corn that produces precursor molecules that can be used in drug development, industrial processes, etc. These corn hybrids will require strict isolation from any other corn in order to prevent pollen transfer. Because of their exceedingly high value and need for isolation, it is probable that growers in areas that do not grow corn to any great extent will be able to grow these specialty corn hybrids under strict contract. This will expand corn production to areas of the state where corn is not normally produced. Because of its high value, this corn will need insect control thresholds that are far more conservative than those for field or food corn. It will probably also require the use of a different set of insecticides than is commonly used in field corn. The issue of thresholds and insecticide selection will have to be addressed in the near future.

It is essential that TAMUS personnel continue to serve on NC 205 and NCR 46, both of which serve research exchanges and as advisory groups to EPA on matters of transgenic corn regulation. Texas is well represented within these groups and has significant impact on policy as it concerns Texas growers. Without Texas representation, it is likely that EPA would make regulatory decisions more appropriate for the midwestern corn belt and then impose the regulations on Texas growers. For example, Texas, Kansas, and Colorado representatives to NC 205 have formed a subgroup that advances regional interests in areas where the southwestern corn borer (rather than the European corn borer) is the dominant stalk-boring pest. This subgroup operates within NC 205 and influences recommendations from that group to EPA.

Insecticide Resistance

The Food Quality Protection Act has eliminated some organophosphate insecticides, and will probably eliminate others from this class and the carbamate class. Newer insecticide chemistries are coming to the market, but in many cases they are more expensive to use than older products. Also, these newer products may not work as well, last as long, or provide the broad spectrum activity of older products. The dilemma is to find economically feasible methods to control corn pests, and to avoid over-reliance on one or a few modes of action (and thus delay or prevent insect resistance to these products). Current example of this dilemma is in spider mite control.

There are very few spider mite pesticides registered for use on corn. The most economically attractive miticide has been used extensively for control of southwestern corn borer, adult corn rootworm, and spider mites. However, there have been indications in the past few years that this product may be losing its effectiveness as a miticide. It is essential that Texas A&M University

System personnel assist in the development and registration of new miticides. Continued reliance on one or a few products will hasten insecticide resistance and eliminate any ability to control spider mites.

Additionally, 2002 bioassay data indicate high levels of insecticide tolerance in corn earworm for pyrethroid insecticides, the most frequently used class for control of many corn pests. The scope and extent of this tolerance (or resistance) should be quantified and mitigation strategies should be developed. The corn earworm has been implicated in elevated aflatoxin levels, and is also a major pest of cotton and vegetable crops.

Corn Breeding to Improve Insect Resistance
TAMUS corn breeders and entomologists have developed drought tolerant and corn earworm and spider mite resistant corn lines. These lines are nearing commercialization and need to be evaluated locally by TAMUS personnel. If successful, these lines have the ability to expand the area where corn can be grown economically, and they will increase net profit per acre. Successful introduction of these lines may also necessitate revision of economic thresholds for spider mites.

Economic Thresholds Need Modernization
Most of our economic thresholds were written 20 or more years ago and are "static" in that they do not reflect the introduction of transgenic, host plant resistant hybrids, changing market prices or costs of control. A few "dynamic" thresholds have been developed. These alter the action threshold according to insect numbers, value of the crop, and the cost of control. More dynamic thresholds need to be developed, in part to help growers and consultants make reasonable control decisions with high-cost inputs and high-value corn (or low-value corn).

More Regulation of On-farm practices
USDA-NRCS appears to be developing a framework wherein most management actions will receive a "score" in a matrix program, and growers will be compensated according to how high their score is in the management tactics preferred by NRCS. Regardless of one's opinion as to the merits of this approach, it might be wise to develop thresholds and techniques that could be recommended for Texas production. Otherwise, Texas growers might be forced to adopt thresholds and techniques from other states.

5. Cropping Systems
A cropping system is the sum total of all of the production practices on a particular field or farm. This may include the types of crops grown, their planting sequence, time, rate and pattern of planting, tillage, nutrient, irrigation, and pest control management strategies. For any cropping system to be successful it must be profitable and sustainable both in the short and long term. Much research in the past has been narrowly focused on refining individual production practices within a single crop, with little effort expended on developing profitable, whole farm cropping systems. In recent years economists, scientists and specialists across the state have made efforts to examine entire cropping systems. This effort must be encouraged to continue and expand, reaching across traditional commodity lines.

6. Hybrid Selection
Corn hybrids are constantly improving as new releases are developed by university and industry plant breeding programs. TAES and TCE personnel conduct uniform corn hybrid trials around the state to provide seed companies and growers a fair assessment of current and newly released corn hybrids. Seed companies are invited each year to enter hybrids for a fee into these trials. The number of hybrids submitted by commercial companies has declined in recent years. Those submitted are often experimental and do not include the hybrids currently being sold in the local area. This reduces the value of TAES and TCE trials. A plan needs to be developed to improve the relevancy and dissemination of information from hybrid performance trials.

Currently the Texas Corn Variety Test is primarily focused on yield. In the future, the Variety Test should include additional traits to help the corn producers in different regions to choose the most suitable hybrids. These additional traits include yield performance under different water treatments, husk coverage and tightness, physical and chemical characteristics of the seed pericarp, corn earworm, and grain molds or possibly the aflatoxin contamination level. Apparently, the Variety Test requires the collaboration of the scientists with different expertise to collect these data.

7. Soil Fertility

Soil fertility research on corn production in Texas has been limited in recent years. Nutrient management practices must be evaluated from both economical and environmental perspectives.

Amounts of N, P, and K required to optimize production is well documented however; research is needed on how to best deliver nutrients with the least possible loss and to develop soil test procedures that accurately quantify nutrient carryover.

There has been much debate on the reliability and accuracy of soil test values for phosphorus. Regulatory thresholds for phosphorus are based on extractable P levels, but have not been correlated with the environmental impact. This is compounded by the use of different extractants by soil labs, which give different soil test values. The TAMUS extractant gives different values in some soils for extractable phosphorus than the Mehlich III extractant used by many other labs. Studies are needed to identify the best extractant for the major soils in the state and test values correlated with phosphorus fertilization.

Micronutrients or trace elements such as sulfur, iron, zinc, boron, and magnesium differ from the macronutrients in that they are needed in much smaller amounts and spatial distribution of these elements between and within fields appear to be less uniform than that of macronutrients. Studies are needed to determine when, where, and how to apply these micronutrients to obtain a positive economic return.

8. Tillage

Tillage practices strongly influence the condition of the seedbed at planting. Good seed to soil contact is critical for obtaining uniform stand emergence. Tillage systems that promote seed germination and seedling vigor, enhance weed control, and preserve and improve water infiltration and storage are desirable. Optimum tillage practices will vary based on soil type, annual precipitation, crop rotations, the presence of weed, disease, and insect pests, and available equipment. Tillage practices vary considerably between regions of the state and even between neighboring farms. The development of new herbicide and weed control methods has enabled Texas farmers to rely on less tillage than was common even in the recent past. While some producers have adopted no-tillage, most rely on a wide range of tillage methods and equipment. Research to develop profitable reduced tillage systems that address regional concerns are needed.

9. Seeding Rate, Row Spacing, and Planting Date

Response of corn yield to seeding rate, row spacing, and planting date vary considerably depending on the region of the state. For example, recent studies on row spacing suggested a strong advantage in 20-inch rows over conventional 30 and 40-inch rows in central Texas. The advantage of 20-inch rows under the irrigated conditions of the Texas High Plains was much less. Although Texas agronomists have studied these cultural practices in recent years continued studies will need to be done as new hybrids are released and other farming practices such as tillage and irrigation efficiency change. Interaction of these cultural practices with the incidence of disease, insect, and weed pests need further study

Program Elements and Recommended Program Actions

Program Elements were identified within the Major Program Area of *Corn Production and Management Systems.* These Program Elements represent broad program directions or targets for statewide corn research and extension programs. Recommended Program Actions for each Program Element are more specific, tangible and measurable activities that should be considered.

Program Element 1. Develop and disseminate best management practices that enhance or protect surface and ground water quality and optimize water use efficiency.

Action 1. Develop strategies for effective and sustainable corn production while protecting surface and ground water from off-target movement of pesticides and nutrients.

Action 2. Develop cropping systems and management practices that optimize water conservation and management by:

a. Expanding research and educational efforts to encourage the adoption of high efficient irrigation equipment, management, and cropping systems.
b. Determining optimum cropping systems that result in water conservation and efficiency.

Program Element 2. Developing new strategies and disseminating information on IPM- based control of aflatoxin/mycotoxins and other diseases, weeds, insects, and pests.

Action 1. Characterize and mitigate effects of important corn diseases with a particular focus on mycotoxins, using interdisciplinary teams to:

a. Develop new methods for suppressing mycotoxin-producing fungi.
b. Develop new disease management systems in the field;
c. Develop innovative methods for improving disease resistance or pathogen suppression.

Action 2. Characterize effects of weeds on corn and develop IPM solutions by:

a. Developing economical specific weed control recommendations based on tillage practices and crop rotation considerations.
b. Developing and disseminating information on weed control strategies that minimize development of weed resistance.

Action 3. Characterize effects of insects on corn and develop IPM solutions by:

a. Finding economically feasible methods to control corn pests, and to avoid over-reliance on one or two modes of action.
b. Assisting in the development and registration of new miticides.
c. Developing and disseminating information on economic thresholds that

take into account the insect numbers, value of the crop, and cost of control.

Program Element 3. Develop and encourage adoption of cropping systems and management practices that maximize the economic return of corn production.

Action 1. Develop and encourage the adoption of cropping systems and best management practices by:

a. Developing extension activities that improve the quality and quantity of unbiased information on hybrid selection that maximize yield potential under local environmental and cultural conditions.
b. Determine soil fertility management practices that reduce nutrient loss; better quantify nutrient carryover; utilize the best identified phosphorus extractant for the major soils in the state with respect to phosphorus fertilization; and identify when, where, and how to apply micronutrients to obtain a positive economic return.
c. Developing profitable reduced tillage systems that address regional concerns.
d. Expanding research and extension activities to provide knowledge on soil management, tillage, row spacing, seedbed preparation, optimum plant population and spacing, and planting date and rates.

B. Targeted Strategic Livestock Feeding Applications

Livestock Use

Corn has been a major feedstuff for U.S. livestock for many years. It is the most widely-used component in finishing diets for cattle and swine. Therefore, we often take for granted that the volumes of research that have been reported on corn as a feedstuff is sufficient for present and future understanding of its value. But, corn is a dynamic cereal and livestock feeding systems are ever-changing. New hybrids are being developed, new feeding roles are evolving, and new factors need to be considered in its use as a feed, especially those concerning the environmental effects of feeding rations high in corn to animals concentrated in feedlots.

Research and extension faculty involved in animal nutrition for livestock production and wildlife management have considered the current state of knowledge available to the industry. Corn has been shown to have negative associative effects when fed to cattle consuming protein deficient, high forage diets. But, its value in high forage, high protein diets is not well understood.

In most corn hybrids, phosphorus in kernels is largely tied up as phytate. Phytate is poorly digested by swine and poultry (nonruminants). The phosphorus level in corn is about 0.3%. Phosphorus requirements of cattle have recently been shown to be 0.2%. Phosphate-related water pollution from manure or effluent from concentrated animal feeding operations is a nonpoint source water pollution problem in some watersheds. If phosphorus or phytate in the diet can be reduced, for ruminants or nonruminants, respectively, the potential for phosphate-related nonpoint source water pollution can be reduced also, and the number of acres needed for environmentally-sustainable land application can be maintained at practical levels.

Some work has been done evaluating new hybrids such as high oil corn and high lysine corn. But many new corn hybrids are being developed and their feeding value must be assessed.

Corn has become a staple supplement for white tailed deer, but many other species consume the corn fed to these animals. Several reports indicate that the effects of supplementation of non-target species are often surprising and deleterious to the goals of the producer.

Program Elements and Recommended Program Actions

The Corn Advisory Committee has developed five (5) Program Elements and specific recommended Program Actions to meet identified industry needs. The fulfillment of these research and extension needs will help maintain corn's prominent role as an animal feedstuff in Texas and neighboring states.

Program Element 1. Evaluate the feeding value and economics of ethanol by-products including distillers dry grain with solubles (DDGS).

Action 1. Determine the proper level of DDGS in livestock diets.

Action 2. Determine the nutrient availability of DDGS.

Program Element 2. Determine the feeding value of corn as a supplement to high protein, high forage diets.

Action 1. Evaluate the associative effects of corn when cattle graze high protein forages (e.g. small grains).

Action 2. Compare the associative effects of feeding corn to cattle fed diets containing the most commonly fed high protein forages.

Action 3. Determine the site of digestion and rate of passage of corn fed as a supplement to animals consuming high protein, high fiber diets.

Action 4. Compare the associative effects of feeding corn to cattle, deer, goats, and sheep fed high protein, high fiber diets (including animals grazing or browsing rangeland).

Program Element 3. Develop low phosphorus and low phytate corn varieties for animal feeding purposes consistent with environmental nutrient management requirements for concentrated animal feeding operations.

Action 1. Determine the optimum phosphorus requirement for livestock at different stages of growth, considering environmental quality goals.

Action 2. Determine the minimum phosphorus level attainable in high-yield corn.

Action 3. Identify new parental lines with potential to develop hybrids of corn that are low in phosphorus and phytate.

Action 4. Determine the effect of the new corn varieties in livestock diets on comprehensive nutrient management plans for typical concentrated animal feeding operations.

Program Element 4. Evaluate the feeding value of recently developed corn varieties.

Action 1. Determine the energy value of new corn hybrids processed by steam flaking.

Action 2. Determine the protein characteristics (including site of digestion and rate of passage) of new corn hybrids processed by steam flaking.

Program Element 5. Determine the effects on target and non-target species when corn is fed to white tailed deer on rangeland.

Action 1. Determine the distribution of corn consumption among animals of the targeted specie (e.g. what proportion of the white tailed deer population actually consumes the corn?).

Action 2. Determine the non-target species consuming corn as fed as supplement to deer, and the effect on the behavior of these species.

C. Alternative Uses of Corn

Opportunities and Issues

Corn is used domestically as human food (cereals, meal, cooking oil, starches, syrups, sweeteners, etc.) and animal feeds in swine, poultry, beef and dairy production. A major portion of the U.S. corn production is exported as raw grain or prepared animal feeds.

Opportunities exist to develop new and more competitive products from corn and new uses for corn. These new products would include pharmaceuticals; designer foods; and plant-based renewable resources for biofuels, bioplastics, biofibers, and other non-food uses such as industrial feedstock, lubricants and other industrial applications.

Certain key issues and/or problems must be addressed through research and development for these alternative uses of corn to become an economic reality. Increases in production and processing efficiencies will be required for corn to replace fossil fuel-based products as biofuel and bioplastics. New niche markets will have to emerge in response to the availability of new products. Industrial processing technologies that rely on physical or chemical methods to remove components or change physical or inherent characteristics of the product will have to give way to new bioprocessing systems such as enzymatic conversion, bioextraction, biofiltering, and bioremediation. Functional foods with nutritional benefits and health-promoting properties for humans and animals (e.g. domestic pets) will require new technologies to enhance the desired properties. These opportunities and issues provide the basis for focusing the scientific inquiry.

Major differences exist between academic resources vs. industrial commitment and capability in processing/utilization research and development directed at developing functional foods with nutritional and health-promoting properties for human and animals and new and more competitive nonfood products from corn. Product quality laboratories and molecular research capability will be needed. The Agriculture Program of the Texas A&M University System has developed an Institute of Food Science and Engineering, and also is currently developing a Department of Nutrition and Food Sciences. The USDA Agricultural Research Service has a strong presence in agricultural utilization research at its national center in Peoria, Illinois. The expertise and resources present in these entities could be engaged to provide stronger support for increased efforts to develop new and more competitive products from corn, new uses of corn and develop stronger industrial partnerships in foods, biofuels, manufactured products, and industrial chemicals.

New Products/New Uses

Corn has potential uses as bioplastics, biofuels, and biofibers (i.e., plastic, fuels, and fibers made from living matter), as well as other non-food uses. Additionally, corn may have uses as functional foods with nutritional benefits and health-promoting properties. Other uses include industrial feedstock (e.g., bio-degradable plastics), lubricants, and in other industrial applications. All these alternative uses of corn will require new technologies that enhance commercial properties, improve the processing efficiency of harvested corn crops, and support expanded and new market infrastructures.

Quality Characteristics

Each of the alternative end-processed products will require certain quality characteristics of the raw corn product. Research must be conducted to determine the quality characteristics associated with each type of end-product and the quality characteristics of existing corn genotypes to meet the end-product needs. Better understanding of genetic variability of existing hybrids and potentials for improved germplasm development are essential.

Genetic Improvement and Breeding
Access to many of the desired genes associated with the end-processed product quality requirements and a vigorous program in fundamental genetic research to support an applied germplasm development program will be required. Biotechnology related research to use genetic markers to Atag@ traits of interest and to facilitate their incorporation through marker-assisted selection into commercial corn hybrids is essential. Plant breeders will then need to recognize phenotypes of the desired genetic traits to develop and combine new and improved traits into adapted varieties.

New Markets/New Uses
Many new processes and products never succeed in the market place due to inadequate marketing systems and inadequate investigations into the future social, economic, ethical, and environmental implications related to the consequences of creating those products. The development of sustained and productive markets for new bioproducts from corn will require substantial investment in social market research prior to product development.

Marketing Infrastructure for Special Uses and Bioproducts
Once the dynamics of social, economic, ethical, and environmental components are assessed and incorporated into product development, access to and investment in transportation and advertisement infrastructure will be essential to product marketability. Development of a significant technical information base for use by producers, shippers, exporters, rural communities, government agencies, and universities for informed decision-marking will be crucial for their success. This information resource must include data and models in social and economic consequences, economic profitability, suitable production areas, production potential and variability, market potential, geographic dynamics, transportation, processing costs, pricing limits, and global regulatory constraints. The acquisition and development of this information base will necessarily precede the development of a more formal marketing infrastructure, but it will be a critical component of the future research infrastructure and institutional decision-making that has the greatest potential to contribute to the profitability and economic success of these new products. Creation and maintenance of such an information resource is appropriately within the domain of universities and government agencies, and it will require state and federal investments. But much of the coordinated development of the marketing infrastructure will rely on private investment or public-private partnerships, as most of the implementation of these new technologies will occur in the private sector.

Biomass and Bioproducts

Improved Processing Efficiency
Industrial processing technologies of corn and other agricultural commodities have traditionally relied on physical and chemical methods to remove components or change the physical or inherent characteristics of the product. In the future, technology will provide the means to efficiently process many agricultural commodities using bioprocessing systems such as enzymatic conversion, bioextraction, biofiltering, and bioremediation. The impact of these technologies and the ways by which they will transform the nature of manufacturing are not yet fully understood. Texas must be on the cutting edge of implementing these new technologies if we are to become competitive in new markets for conventional agricultural commodities and new products from corn and other plant species.

Improved Biomass Production
Crop biomass engineering is capable of providing an increasingly larger share of the materials and energy provided by the petrochemical industry to produce plastics, specialty chemicals, and the organic building materials currently extracted from timber logging in private and national forests. Texas must now plan for a transition to a greater use of crop-based renewable resources, especially

for those sectors of the state=s economy in the best position to make this transition. Crop production systems that increase biomass quantities and qualities and more efficiently utilize water, nutrients, and chemical inputs must be developed. Any significant shift toward the production and harvest of crop biomass for the energy, manufacturing, and building sectors to the state=s and nation=s economies will require more technological advances in methods that simultaneously keep these crops productive and healthy while protecting the environment and natural resources.

Program Elements and Recommended Program Actions

Following are recommended Program Elements and Program Actions identified by the Corn Advisory Committee to address the above issues and opportunities:

Program Element 1. Develop new and more competitive products and new uses for corn.

Action 1. Determine the quality characteristic of the raw corn product required of the end-processed product (e.g. high starch content for biofuel processing, or high anti-oxidants for human health properties).

Action 2. Develop corn genotypes and hybrids through genetic engineering and breeding programs that possess the desired characteristics.

Action 3. Conceive new markets for corn products and new uses for corn.

Action 4. Develop marketing infrastructure for corn hybrids designed for special uses and corn bioproducts.

Program Element 2. Develop new uses for corn biomass.

Action 1. Develop technologies to improve processing efficiency of corn bioproducts (e.g. biofuels, bioplastics, functional foods, industrial feedstock).

Action 2. Improve crop biomass quantities, qualities, and crop production efficiencies.

D. Economic and Policy Analysis

Corn is the second largest row crop in Texas with respect to cash receipts. Two-thirds of the production is irrigated and one-third is dryland. The major corn production areas in Texas are separated by more than 600 miles in distance, resulting in the need for different production and marketing approaches. These factors lead to a myriad of economic issues that need to be evaluated on a regional basis.

For example, dryland corn production systems account for the majority of corn produced in the Central Texas and Texas Coastal Bend areas. During the 1990s and early 2000s, these regions experienced fairly large variations in yields and prices due to drought and disease problems, including mycotoxins.

The Research and Extension educational response to the need for economic management of risk resulting from variations in yields must be addressed on several fronts. First, Research and Extension education should address the risk management issues related to dryland corn production on a whole-farm basis. Second, Research and Extension education efforts should evaluate the impact of variability of corn yields and alternative production systems with respect to the provisions of the 2002 Farm Bill. Third, Research and Extension education efforts should address land tenure (rental) issues related to corn production in light of alternative production systems. Fourth, Research and Extension education efforts should address marketing alternatives that capitalize on the early harvest and location advantages of corn producers in Texas.

More than eighty-five percent of the irrigated corn production is located in the Texas High Plains. Irrigation and the characteristics of this region give rise to some unique economic issues. First, declining water tables result in a need to evaluate several alternatives to economically maximize water including: irrigation technologies; irrigation scheduling such as using region-specific evapotranspiration (ET) data; cropping systems; hybrid selection; water conservation; production practices and water quality. Second, the increasing grain deficit characteristics of the region give rise to other issues that need to be evaluated such as: the impact of unit train facilities on local corn prices and the evaluation of alternative products, such as silage, for use in dairies. Third, issues surrounding volatility in irrigation fuel prices need to be addressed including: feasibility of alternative irrigation fuel sources; modification of crop lease agreements to combat the impacts of fuel prices volatility; and evaluation of methods to manage/control irrigation fuel prices.

A number of economic issues need to be addressed that cut across all corn production regions of the state. They include: the economic implications of the 2002 Farm Bill and subsequent changes to that bill; impact analysis of changes in EPA regulations; improvements in marketing education allowing Texas corn producers to capture increased profits; improved corn basis information to assist in marketing and risk management efforts; and feasibility studies that evaluate community and producer impacts of attracting alternative uses to Texas, such as ethanol plants and 'designer' corn products.

The overall goal of the economic strategic plan is to provide research and continuing education programs that enhance Texas corn producers' ability to make improved economic decisions and maximize their net returns.

Program Elements and Recommended Program Actions

The Program Elements and recommended Program Actions identified by the Corn Advisory Committee are:

Program Element 1. Provide regional and farm level economic analysis and interpretation of federal and state policies affecting Texas corn producers.

Action 1. Evaluate the economic implications of the various provisions of the 2002 Farm Bill and subsequent proposed modifications of the bill to Texas corn producers, by production region.

Action 2. Evaluate and provide Texas corn producers with information concerning the impacts of changes in USDA-NRCS and EPA rules affecting production practices and chemical use, by production region.

Action 3. Provide analysis and implications to Texas corn producers of changes in NAFTA, GATT and other international agreements.

Action 4. Evaluate potential policy changes that could enhance the comparative advantage of Texas corn producers.

Program Element 2. Evaluate alternative marketing possibilities and develop educational programs that give Texas corn producers the skills/alternatives to maximize profits.

Action 1. Conduct economic feasibility studies on alternative uses/products for corn, such as plastics, ethanol, and de-icers, in order to expand markets for Texas corn and to disseminate results to corn producers.

Action 2. Enhance the intensive marketing educational system (eg. Master Marketing) already initiated to expand the use of improved producer marketing skills

Action 3. Develop Research and Extension education programs that relate to the financial viability of on-farm grain storage and marketing strategies that utilize grain storage, both on-farm and commercial. These programs will help producers take advantage of strengthening basis levels after harvest and could increase value added opportunities through identity preservation.

Action 4. Develop Research and Extension education programs related to marketing strategies based on the early harvest capability of Texas corn producers and potential for strong basis levels that may be available at harvest.

Action 5. Develop, maintain, evaluate and disseminate corn basis information for the production regions of Texas to improve pre- and post-harvest marketing decisions.

Program Element 3. Develop research projects and extension programs that address the critical financial and production risk management issues of Texas corn producers.

Action 1. Develop Research and Extension education programs to examine how new risk management tools being developed by the USDA Risk Management Agency could be incorporated into the total risk management program for corn producers in Texas.

Action 2. Develop Research and Extension education programs related to changes in the total cost structure of alternative production systems under the 2002 Farm Bill, including secondary impacts on rental arrangements and land tenure.

Action 3. Develop Research and Extension education programs that evaluate the economic impact of alternative corn production technologies on the whole farm operation. For example, what are the impacts on fixed costs related to changes in the machinery complements due to the use of transgenic corn hybrids that offer alternatives to traditional pest management strategies. Another example could be the financial and capital impacts due to adoption of narrow row-spacing production technologies.

Action 4. Evaluate improved irrigation technologies to maximize the returns to irrigated corn producers.

Action 5. Conduct a feasibility study of alternative fuel sources for irrigation and identify methods to control fuel costs.

E. Corn Breeding and Genetic Improvement

Major environmental factors limiting Texas corn production include drought, heat, insects (corn earworm, spider mites, corn rootworm, and corn borers), and diseases (aflatoxins and fumonisins). Texas corn producers need hybrids with high yield potential, resistance to biotic and abiotic stresses, and good product quality. Development of the hybrids with a strong adaptation to Texas environments is crucial for sustainable and profitable corn production. The development of suitable hybrids is done through corn breeding, which is a science and art of genetic improvement of the crop plant. Breeding is a long and continuous process (Figure 1). Commercial corn hybrids are mostly single crosses between two elite inbred lines. Development of an inbred line starts creating a breeding population by crossing selected materials (lines, populations, testcrosses, hybrids, genetic stocks, etc.) with desirable traits. After five or more generations of selfing and selecting desirable plants, a pure and stable line is developed. The inbred lines are then crossed to produce experimental hybrids that are evaluated in multiple locations for 3-5 seasons. Superior experimental hybrids become commercial hybrids. Corn breeding goals and objectives are relatively constant; however, plant materials used in the program are continually evolving. In each crop season, new germplasm is introduced, new crosses are made, and promising materials (lines, hybrids, and populations) are advanced and selected. In this process only a small percentage of material screened meet the selection criteria.

Evaluation and selection of breeding materials are the most expensive and time-consuming part of a plant breeding program. Many important agronomic traits are complex in genetics and difficult to improve. Their physiological and genetic mechanisms are not well understood. To establish effective and economic evaluation and selection procedures, plant breeders rely on the expertise of interdisciplinary teams for scientific inputs (Figure 1). The recommended processes for release and licensing of new plant materials are discussed in Appendix B.

The commercial hybrids currently grown in Texas are mostly developed for the Midwest Corn Belt. Texas will benefit by greater breeding efforts specifically targeting Texas growing areas. The state corn breeding program has 1.25 FTE's. A group of scientists with expertise in plant physiology, pathology, entomology, molecular biology, molecular genetics, agronomy, agricultural engineering, and food science are also located throughout the major production areas in Texas. This distribution of resources was designed for breeding regionally-adapted corn that will maximize sustainable production in the high diverse geographical areas, environments, and production systems present in Texas. Introgression of genes from exotic corn germplasm (e.g. tropical and subtropical) offers a great promise for new sources of genes that can benefit Texas corn production. Texas is located in the transition zone between temperate and tropical environments, which facilitates crossing and gene introgression between temperate and exotic gene pools.

In recent years, the Texas A&M University System, Texas Tech University, and USDA-ARS have made a significant investment in plant molecular biology and genomics. The advances in these areas can help to understand genetic mechanisms of major corn agronomic traits, provide new tools for transferring desirable genes into elite germplasm, and make breeding more efficient.

A strong support and commitment from the Texas Corn Producers Board is especially important for the sustained success of the TAES corn-breeding program.

Program Elements and Recommended Program Actions

Program Element 1. Develop germplasm with drought tolerance, heat tolerance, high yield potential and proper maturities for irrigated and rainfed areas of Texas.

Action 1. Evaluate and select corn material under controlled moisture regimes in several environments across Texas. State of the art screening facilities (e.g., sub-surface drip irrigation systems) will be used to control stress levels.

Action 2. Determine the genetic and physiological mechanisms of stress tolerance and major agronomic traits.

Action 3. Enhance collaboration among breeders, plant physiologists, molecular biologists, and geneticists in conducting basic research to understand the physiological and genetic mechanisms of stress tolerance and quality.

Action 4. Introgress genes from tropical and subtropical germplasm.

Program Element 2. Develop corn germplasm resistant to mycotoxin-producing fungi and other diseases and to insects (particularly corn earworm and spider mites). Currently there are no effective chemicals or resistant commercial hybrids to control these pests.

Action 1. Employ effective screening methodologies to select resistant material for disease and insects by inoculating with target pathogens and pests or by evaluating plant materials in pest prone environments.

Action 2. Introgress genes from exotic germplasm.

Action 3. Establish a High Plains Mite Control Consortium to develop more effective control methods for spider mites, a major problem in the High Plains. The Consortium should actively seek federal funding to support the research for improved host resistance, more effective chemical and other control methods.

Action 4. Establish a Southern Corn States Consortium for Reducing Aflatoxins Contamination and Sustaining Corn Production. The consortium should seek state and federal funds, facilitate research among multidisciplinary scientific teams to develop tools for reducing aflatoxins contamination in corn and sustaining corn production in the region, and provide a network of testing sites for aflatoxins resistant hybrids across the Southern states.

Program Element 3. Develop short-season corn with a good yield potential that can save water and irrigation cost and avoid drought stress in the late growing season.

Action 1. Select early- and photo-period insensitive plants.

Program Element 4. Develop corn lines and populations with value added traits, including improved nutritional or processing properties for foods, feeds, and industrial products.

Action 1. Collaborate with processors, food scientists, nutritionists and end users in defining desired characteristics in raw material and in selecting most suitable hybrids.

Program Element 5. Develop silage corn to meet the expanding dairy and beef cattle industries in Texas.

Program Element 6. Discover new genes from exotic materials to enhance productivity and quality.

Action 1. Integrate biotechnology into applied breeding programs to identify genes and gene functions that are important for Texas and to increase breeding efficiency.

Action 2. Introgress exotic material to increase the genetic base of germplasm used by U.S. corn-breeding programs. The characterization and combination of subtropical/tropical and temperate sources of germplasm will be emphasized.

Action 3. Preserve, characterize, and enhance the genetic diversity of corn.

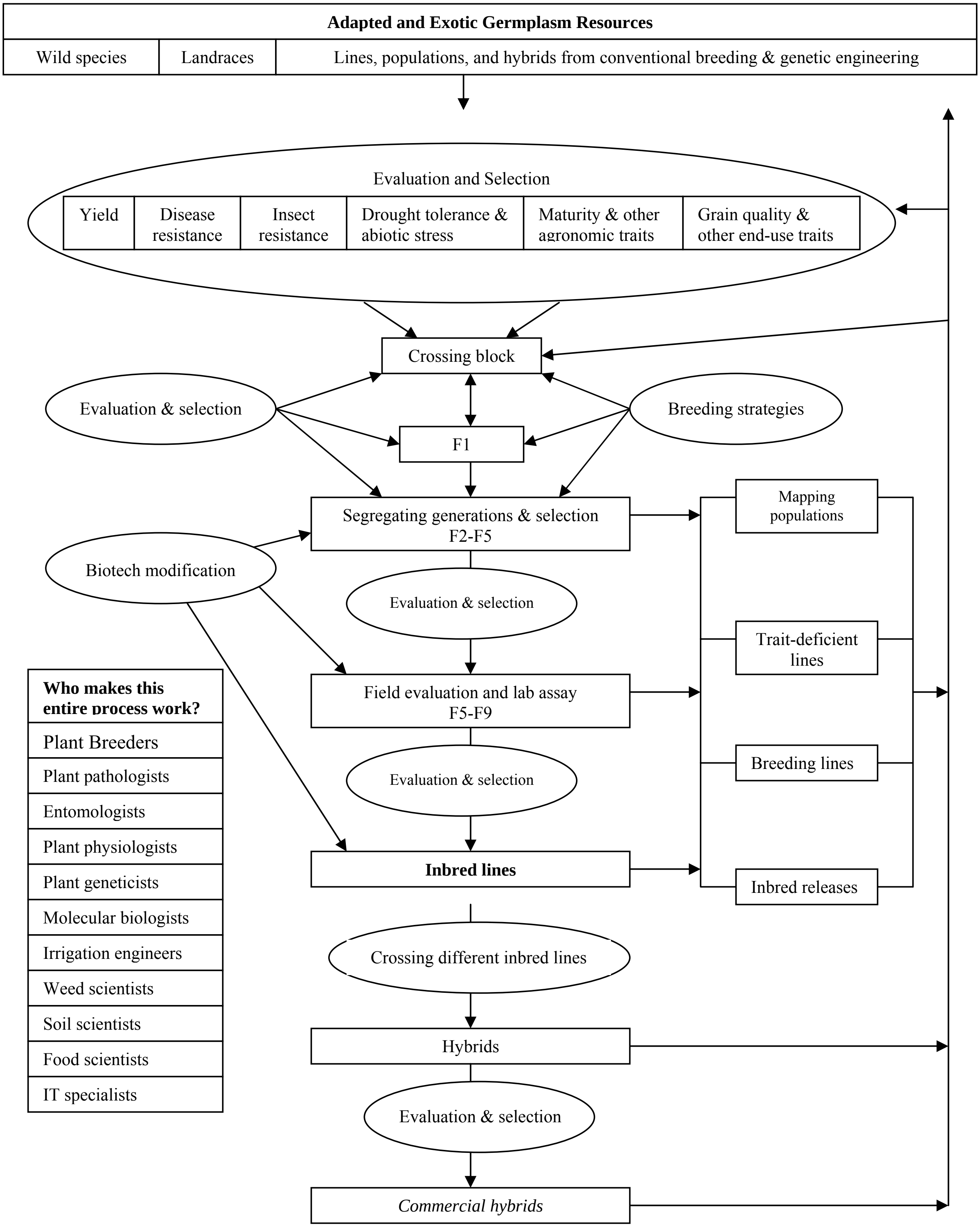
Program Element 7. Enhance technology transfer to the seed industry

Action 1. Establish and improve cooperation with seed companies; the TAES breeding program and TCE agronomists need to develop a closer relationship with the local seed companies to test new products under diverse environments.

Action 2. Establish a multi-location testing program across key Texas locations representing the main growing areas in the state; this will allow more accurate selection for regional adaptation, as the environments in Texas are highly diverse.

Action 3. Upgrade research equipment and facilities to handle larger numbers of research plots and to train students.

Figure 1. Components of a successful corn breeding program.



F. Resource Coordination & Leadership Development

Resource Benchmarks: TAMU Agriculture Program

An estimate of current resources devoted to corn programs in research (Texas Agricultural Experiment Station, TAES) and extension (Texas Cooperative Extension, TCE) within the Texas A&M University System's Agriculture Program, was obtained through a survey instrument developed by the respective Chairs of the Advisory Committees for corn, grain sorghum, and small grains. The survey instrument was patterned after an earlier 1999 survey conducted by the Small Grains Advisory Committee. The unified 2002 survey for these three commodities was mailed in May 2002 to all TAMUS Agriculture Program Department Heads; Resident Directors at Texas A&M University Agricultural Research and Extension Centers (ARECs); and to Colleges of Agriculture at West Texas A&M University, Tarleton State University, Texas A&M University-Commerce, and Texas A&M University-Kingsville. The results and ensuing follow up where necessary provided a reasonable estimate of resources of faculty, scientific support staff, special-use facilities, land, and equipment along with salaries/wages and operating costs that are identifiably targeted for research and extension education related to the corn industry. Specific categories for reporting purposes were: breeding, genetics, physiology, production and management, entomology, pathology, quality end-use, economics, and "other."

Corn Program Survey Results

Data on corn-related research and extension programs, personnel, and resources were provided by the following units:

- TAMU-ARECs -- Amarillo, Temple/Blacklands, Corpus Christi, Lubbock, and Uvalde.
- TAMU Departments -- Entomology, Forest Science, Plant Sciences (PLPM), Soil and Crop Sciences, and Biological and Agricultural Engineering.
- Other TAMUS Universities -- WTAMU Division of Agriculture.

In addition, several other Centers or Departments reported that no significant R&E efforts in Corn were being conducted currently, although they obviously have substantial efforts with respect to other program areas or commodities.

Faculty and technical staff resource levels and funding support from TAES, TCE, or grants were aggregated according to:

Program Statistical Estimates:	Faculty	Staff
• Number of individuals involved	X	X
• Scientific years or full time equivalents	X	X
• Prorated salaries or wages	X	X

In addition, significant, identifiable resource support of facilities, operating, and equipment costs were aggregated as follows:

- Operating funds provided by units
- Facilities, in terms of square feet of space for
    - greenhouses
    - seed processing
- Land, acres
- Major equipment, identifiable major dollar values

The results indicated that very significant resources are being devoted currently to Corn research and extension programs as follows (Table 2):

Table 2. Unit Survey Results, Estimated Faculty and Staff Resources Allocated to Corn Research and Extension Programs in Texas.

Resource Category	Totals
1. Faculty Involvement	
• No. Individuals	29
• Scientific Years, SY	*13.1*
• Salaries, prorated, $	$777,276
2. Support, Technical	
• No. Individuals	37
• Scientific Years (SY)/fulltime equivalents (FTE)	*14.03*
• Salaries, prorated, $	$389,322
3. Other Support	
• Operating Allocations	$323,986
• Facilities, ft^2	
o greenhouses	9,375 ft^2
o seed processing	1,686 ft^2
• Land, acres	260.65
• Major equipment, $	$338,995
4. Totals	
• Recurring support, $	$1,490,584
• Non-recurring support, not including land.	$338,955

Discussion of Survey Data

According to the survey, large differences exist among units in terms of personnel, programs, and identifiable resources devoted to corn research and extension programs. As expected, the greatest resources are being devoted in the major corn growing areas of Texas -- High Plains (Lubbock), Panhandle (Amarillo), Coastal Bend (Corpus Christi), Winter Garden (Uvalde), Blacklands (Temple), and central/southeast Texas (College Station). There are two Centers of Excellence established for the corn breeding program -- TAMU Soil and Crop Sciences Department and TAES-Lubbock -- and these appear to be well coordinated. The corn breeders and their scientific support staffs expend virtually 100% of their efforts on corn. However, essentially all other faculty and support staff statewide devote less than 100% of their efforts on corn, having direct responsibilities for other crops as well. This includes the extension state corn specialist (based in Amarillo) together with production-oriented faculty in agronomy, irrigation engineering/water management, entomology, integrated pest management, and economics -- many of these reside at the aforementioned ARECs. West Texas A&M University in partnership with Texas Cooperative Extension has developed integrated pest management (IPM) training and research programs dealing with grain production systems in the Texas High Plains. Value-added research is being conducted in the TAMU Soil and Crop Sciences Department, with modest efforts also in the Department of Biological and Agricultural Engineering. There is little or no acknowledged involvement to date identified with the TAMU Institute for Food Science and Engineering.

The survey data showed approximately 13 scientific years of faculty involvement in corn programs at an estimated dollar total of $777,000. About 14 FTEs technical support staff (approximately 37 individuals) is likewise involved representing an estimated $389,000 in salaries and wages. The reported faculty FTEs provided by TCE was slightly greater than provided by TAES. However, the majority of support staff is employed by TAES. Operating costs allocated to faculty from state or other sources for corn research and extension programs are about $324,000/year, while prorated equipment costs are $339,000 or greater. Facilities include 9,375 ft^2 of greenhouses and 1,686 ft^2 of seed processing. Over 260 acres of TAES-owned or operated farmland are used for experimental purposes for on-station corn research, and most of these acres are devoted to breeding or production research.

Total research grant requests approved by the Texas Corn Producers Board have averaged $245,000 per year for the last 5 years (Table 3). The amount is proportional to corn production in Texas. Accordingly, grant totals have ranged from a high of $353,000 for 1998 to a low of $171,000 in 1999.

Table 3. Texas Corn Producers Board, Total Research Grants Approved

Year	No. Grants	Amount $
1998	26	352,748
1999	16	171,000
2000	18	244,886
2001	26	235,175
2002	22	220,738
Totals	108	1,224,547
Average	22	244,909

The considerable investments being made in corn research and extension programs need to be properly coordinated and responsive to needs and opportunities of the corn industry in Texas. These needs and opportunities are identified in previous sections of this report.

Program Funding and Guidance for the Statewide Corn Strategic Plan

To fully implement the Major Program Elements and recommended Program Elements in this Strategic Plan, resources will need to be identified. Funding sources, resources, or opportunities that should be considered include the following:

- State Legislative Initiative—Corn research and extension programs could be included in broad-based cropping systems or natural resources Initiatives (exceptional items) for the 2005 or 2007 Legislative Session.
- Potential Congressional Initiative—Potential exists for development of aflatoxin initiative with other states.
- Partnerships with other institutions and agencies, e.g., USDA-ARS, West Texas A&M University Texas A&M University-Kingsville, Texas Tech University, University of Georgia, and other major institutions.
- Redirected resources within TAES, TCE, departments, agencies, and other specific units.
- Industry including the Texas Corn Producers Board.
- Contracts and grants from product user groups, private industry, and public sector.
- Royalties from intellectual property including releases of improved plant materials.

Significant new funding might occur through a proposed multi-state/multi-university Congressional Initiative on aflatoxin/mycotoxin, which is identified as a priority issue. Similar Congressional

Initiatives on water management have likewise generated some short-term resources that have relevance to corn production and management in the Rio Grande basin and the High Plains. As new or redirected funding becomes available within the Texas Agricultural Experiment Station or Texas Cooperative Extension, the recommendations of this Corn Strategic Plan should be considered

Future allocations of resources statewide should strongly consider Major Program Areas and Program Elements that are recommended in this Corn Strategic Plan. TAES policies regarding retention or distribution of royalties from corn industry-related intellectual properties should be reviewed as needed to determine potential revenue to help underwrite the state Corn Strategic Plan.

The Corn Advisory Committee should remain engaged with the industry and the TAMUS Agriculture Program administration as a coordinating mechanism in the development and review of project proposals and programs. The committee will be in a position to supply recommendations in program direction including resource allocation to balance cost and benefit while assuring that industry priorities articulated in this state Corn Strategic Plan are met and achieve consistency with the TAES Science Management Roadmap and equivalent TCE program plans. Another potential role is assisting the TCPB in annual proposal review vis a vis priorities articulated in this state Corn Strategic Plan.

Program Elements and Recommended Program Actions

Program Element 1. Improve coordination and cooperation of research and extension programs in concert with industry and partnering agencies.

Action 1. Develop methods that will optimize the efforts of university, industry, and partnering agency personnel by enhancing communication and encouraging interdisciplinary, multi-institution projects between individuals.

Action 2. Identify and prioritize key research and extension issues and address those issues in a coordinated effort.

Program Element 2. Allocate resources in substantial support of the statewide Corn Strategic Plan.

Action 1. Maintain corn program coordination through an ongoing Corn Advisory Committee.

Action 2. Provide a coordinated process for guiding research and extension grants toward achieving Program Elements and many of the recommended Program Actions established in the Corn Strategic Plan.

Program Element 3. Develop new resources where appropriate.

Action 1. Develop or encourage Congressional or State Legislative Initiatives that support new funding for priority Program Elements and Actions of the Strategic Plan.

Action 2. Guide resource allocation decisions that relate the corn industry toward priority Program Elements of the Corn Strategic Plan.

Summary and Action Plan

Corn is produced on 2 million acres annually in Texas. Four regions account for 90% of Texas' corn production—High Plains, Central/North Central, Coastal Bend/Upper Coast, and South Central about one-third of the total corn acreage is irrigated and two-thirds are non-irrigated. Production however is just the opposite: two-thirds from irrigated acreage and one-third from dryland. Net statewide value of the harvested crop is $ 400-575 million/year. Most of the corn is used for livestock feed, with human food usage and export also significant. Production challenges vary with region/subregion and include biotic and abiotic stress, resource limitations, and management practices.

The Corn Advisory Committee was organized by TAMUS Agricultural Program leadership to work with industry in addressing current and emerging issues and to provide recommendations that will position the corn research and extension program in Texas as among the leaders in the U. S. According to a 2002 survey, several research and extension centers and academic departments within the Texas A&M University System contribute significant resources to corn research and extension involvement—for instance, 13.1 scientific years faculty involvement, 14.0 FTE's technical support staff, $1.5 million recurring personnel and operating costs, and $ 0.33 million non-recurring costs not including research acreages. Likewise, the Texas Corn Producers Board has contributed another $245,000/year (5-year average) to corn research and extension projects. These recurring public and private investments are represented geographically at Research and Extension Centers in major corn production regions and likewise in appropriate academic departments on the TAMU campus. However, cohesion and statewide coordination within the TAMU System and with other universities and agencies outside the TAMU System appears to be lacking.

Major Program Areas together with key Program Elements identified by the Corn Advisory Committee are as follows:

A. Corn Production and Management

Develop and encourage the adoption of production and management systems for mycotoxins; protection and efficient use of groundwater and surface water resources; cropping systems; integrated pest management (IPM) strategies; hybrid selection; and best management practice for soil fertility, tillage, row spacing, and planting rates.

B. Targeted Strategic Livestock Feeding Applications

Accelerated research to evaluate ethanol by-product (DDG) utilization; adapt to changing livestock feeding programs, uses and requirements including supplemental feeding of livestock (high forage/high protein) and wildlife; environmental nutrient management (especially phosphorus); and feeding values of recently-developed corn varieties.

C. Alternative Uses of Corn

Determine corn quality requirements for new or nontraditional uses (food, fuel, industrial products); develop production and management strategies that will meet these criteria; and develop new uses for corn stover.

D. Economic and Policy Analysis

Determine implications of the Farm Bill and its changing polices; develop economic analysis, and marketing strategies for alternative uses of corn; manage risks to assure viability of corn production in Texas; and help farmers interpret and take advantage of USDA-NRCS rules and policies for implementing conservation practices.

E. Breeding and Genetic Improvement

Develop superior plant materials including traditional breeding and biotechnology that maintains an emphasis on drought and heat tolerance, mycotoxins, insect and disease resistance, short-season varieties that are better yielding, end-user quality/value added traits, and silage production.

F. Resource Coordination and Leadership Development

Provide in-depth training and education to develop future industry leaders through programs such as Congressional internships and the Texas Agricultural Lifetime Leadership (TALL) program; provide closer cooperation, resource coordination, and leadership development among research, extension, and industry and other partnering agencies and organizations; and focus limited resources on the highest priority needs and develop new resources.

The Prioritized Program Elements and recommended Program Actions were provided within the report sections describing each Major Program Area. A summary of prioritized Program Elements is shown in Appendix C.

Appendix A

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Appendix B

PROCESSES FOR RELEASE/LICENSING OF NEW PLANT MATERIALS

Processes for Release/Licensing of New Plant Materials

Types of Releases Made in Corn

Four main types of releases are considered for corn material: germplasm, parental inbreds, genetic stocks, and mapping populations.

1. ***Germplasm***: This type of releases includes populations and synthetics with specific distinct characteristics (e.g. resistant/tolerance to abiotic and biotic stresses, exotic material adapted to temperate areas, grain quality attributes, etc.) created by recombining corn genotypes selected for those traits. Inbred lines are those that have shown potential for specific traits, or have performed well in preliminary hybrid evaluations, but have not been extensively tested over environments and/or testers could be included in this category.

2. ***Parental Inbred Lines***: Highly homozygous uniform inbred lines that can be used directly as parental lines in corn hybrid combinations. These lines have been extensively tested as lines per se and in hybrid combination potentially having direct commercial value.

3. ***Genetic Stocks***: Genotypes with one or more morphologic or physiologic traits whose inheritance is described (isogenetic lines, aneuploid lines, etc.). Genetic stocks are useful to determine the mode of inheritance or specific traits, transferring genes and gene mapping. They are not normally used directly as source of genes for breeding improved cultivars.

4. ***Mapping populations***: Groups of reproducible genotypes obtained from common parents that segregate for the expression of one or several trait(s) of interest. This set of genotypes can be used to map genomic regions known as Quantitative Trait Loci (QTL) or genes regulating the expression of the trait(s).

TAES corn releases use the prefix 'Tx' for parental inbreds. The corn breeding program at College Station uses 100, 600, 700 and 800 series: 100 series are white grained inbreds, 600 & 700 series are yellow grained inbreds, 800 series are high-lysine inbreds with even number being yellow and odd numbers being white. The corn breeding program at Lubbock uses 200-500 series. We do not have a designation system for germplasm (synthetics and populations), genetic stocks and mapping populations.

Evaluation of Release

The ultimate contribution of TAES corn material in farmer's fields relies on use of these materials by the private seed industry either directly as hybrid parents or indirectly as parents of new breeding populations to derive new improved proprietary lines. Evaluation of potential releases by interested private seed companies facilities identification of the most promising material.

A multistage process of evaluation across different locations is as follows: Initial evaluation and selection is conducted by the TAES corn breeding programs. The most promising material is considered for advance testing with involvement by other public institutions and private companies. TAES breeders invite private industry to observe and test this material. Material Transfer Agreements (MTA) will be used to share breeding materials with potential industry partners. MTAs will be developed as needed between TAES and interested companies to allow commercial evaluation or breeding activities prior to release.

Release Documentation and Distribution

- ***Documentation.*** TAES breeder develops a release proposal and registration, and submits this documentation to the TAES Plant Release Committee for recommendation to release. At the time of submission, the breeder notifies the Technology Licensing Office (TLO) and Texas Foundation Seed Service (TFSS) of the potential for a licensing and royalty agreement. At release TAES and TFSS notify public and private corn breeders of the availability of the material. Information about available material will be posted on the TFSS web-site.

- ***Seed Handling.*** Requests for seed will go directly to the appropriate plant breeder who then is responsible for distribution seed to public workers, or to companies. Prior to seed distribution, appropriate MTAs and financial arrangements must complete. Breeder seed will be maintained by the originating breeding program for distribution to interested parties in small amounts. A small quantity of breeders seed will be deposited at the TFSS for storage and germplasm preservation. The most likely use of corn material released by TAES will be as parent lines for use in breeding crosses. The originating breeding program should be responsible for this material, assuring proper seed increase and distribution by sharing providing small quantities of seed to interested parties. The TFSS will be informed of all distributions to the seed companies, and available to facilitate transfer and licensing. Some corn materials released could be used directly for commercial products (i.e., hybrids) increasing substantially the potential commercial demand. TFSS would have the option to increased and distribute seed for these latter materials.

- ***TLO and Royalty issues.*** TLO and TFSS will cooperatively develop licensing agreements with interested parties for all releases. Unless otherwise specified, breeders employed by public agencies and institutions will be allowed unrestricted use of TAES releases. However, TAES will reserve the right to restrict use of its products consistent with the need to achieve maximum utilization of the product, or to prevent other public agencies from restricting use of genes identified, isolated, or characterized by TAES through subsequent royalty agreements.

Appendix C

PRIORITIZED RANKINGS OF MAJOR PROGRAM AREAS AND PROGRAM ELEMENTS

Texas Corn Producers Board
May, 2003

Table C-1. Corn Advisory Committee's Major Program Areas* and Program Elements as ranked within the 6 Major Program Areas by the Texas Corn Producers Board.**

ECONOMIC & POLICY ANALYSIS
- Implications of the Farm Bill and its policies (VH)
- Impacts of alternative uses of corn (VH)
- Master Marketing/risk management (H)
- NRCS rules & regulations (H)
- Basis studies (L)

ALTERNATIVE USES OF CORN
- Developing new products & uses of corn (VH)
- Developing new uses for stover (L)

CORN PRODUCTION AND MANAGEMENT
- System for mycotoxin management/BMPs (H)
- Ground and surface water protection (H)
- Irrigation efficiency (H)
- Cropping systems (H)
- Integrated Pest Management/IPM (H)
- Hybrid selection (H)
- Soil fertility (M)
- Tillage (M)
- Row spacing (L)
- Planting rates (L)

BREEDING AND GENETIC IMPROVEMENT
- Drought tolerance (VH)
- Mycotoxins (VH)
- Heat tolerance (H)
- Insect resistance (H)
- Disease resistance (H)
- Better-yielding short season varieties (H)
- Value-added traits, pharmaceutical industries (L)
- Value-added traits, high lysine, high oil, etc. (L)
- Silage hybrids (L)

TARGETED STRATEGIC LIVESTOCK FEEDING APPLICATIONS
- Evaluate the feeding value & economics of DDG (H)
- Determine feeding value of corn to supplement high protein/high forage diets (M)
- Low phosphorus varieties for environmental purposes (M)
- Evaluate feeding values of recently developed corn varieties (M)
- Determine value and effect on feeding to wildlife (L)

RESOURCE COORDINATION AND LEADERSHIP DEVELOPMENT
- Congressional internships (VH)
- TALL program (H)

***Assumes a 5-8 year planning horizon.**
**Ranking Notation: VH=very high; H=high; M=medium; and L=low

Table C-2. Corn Advisory Committee's Recommended Program Elements, as Prioritized* by the Texas Corn Producers Board—May, 2003

Very High**

- Congressional interns
- Implications of the farm bill and its policies
- Drought tolerance
- Developing new products and uses of corn (PLA, DDG, co-products)
- Impacts of alternative uses of corn
- Mycotoxin

High

- Heat tolerance
- TALL
- Ground and surface water protection
- Evaluate the feeding value and economics of DDGs
- Irrigation efficiency
- Insect resistance
- Master marketing (risk management)
- System for mycotoxin management
- Disease resistance
- Better yielding short season hybrids
- NRCS rules and regulations
- Cropping systems
- Integrated pest management (IPM)

Medium

- Determining the feeding value of corn as supplement to high protein/high forage diets
- Low phosphorus varieties for environmental purposes
- Hybrid selection
- Soil fertility
- Tillage
- Evaluating feeding varieties of recently developed corn values

Low

- Value added traits (pharmaceutical industries)
- Basis studies
- Row spacing
- Value added traits (high lysine, high oil, etc.)
- Determining value and effects on feeding to wildlife
- Developing new uses for Stover
- Planting rates
- Silage hybrids

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*Priority determinations on a scale of 1-5, with 1 being most important. Categories were: Very High < 2.0; High 2.0 - 2.9; Medium 3.0 - 3.4; and Low 3.5 - 4.0.
** Not ranked within categories.