

THE BENEFITS OF IMPROVED TECHNOLOGIES IN AGRICULTURAL AVIATION

NASW-2781



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FOREWORD

This report presents the results of a 14-month study of the economic benefits attributable to a variety of potential technological improvements in agricultural aviation. It represents an update and extension of an earlier report issued July 1977.

PART I gives a summary description of the ag-air industry, the data base used to estimate the potential benefits and a summary of the potential benefits from technological improvements.

PART II provides a detailed description of ag-air activities in the United States.

PART III provides an overview of foreign ag-air activities.

PART IV gives a description of the major ag-air aircraft in use with a discussion of manufacturers' sales and distribution networks.

PART V provides estimates of the benefits to the United States of proposed technological improvements to the aircraft and dispersal equipment.

PART VI is a bibliography of references relating to this study.

The format of this report is such that the text on the left-hand page complements the graphics on the right-hand page.



ACKNOWLEDGEMENTS

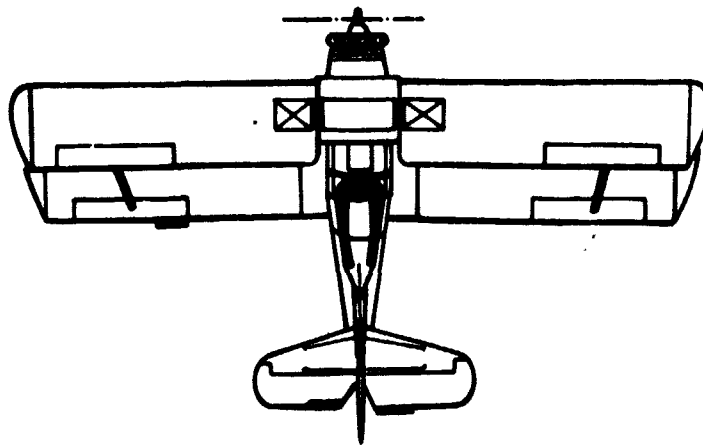
This study was managed by Dr. George A. Hazelrigg, Jr. Other members of the ECON staff contributing to the study include Mr. Fred Clyne, Drs. Robert Fish and Francis Sand, Messers. Keith Lietzke, Philip Abram, David Pike and David Lawson, and Ms. Chris Braen and Ms. Sandy Givens.

This study was performed for the NASA Office of Aeronautics and Space Technology under Contract No. NASW-2781. Mr. Roger Winblade was the NASA COTR.

The photographs presented in this volume were taken by Mr. Fred Clyne of ECON unless otherwise noted. They show a variety of agricultural aircraft in actual operation. ECON wishes to thank the operators who made these pictures possible. The individuals involved are cited in the picture captions.

ECON wishes to express its deep gratitude to Mr. Farrell Higbee, executive director of the National Agricultural Aviation Association, his staff and the entire NAAA membership for their extensive cooperation and for the data which they provided to make this study possible. We thank also the General Aviation Manufacturers Association and the individual aircraft manufacturers and equipment manufacturers, the International Agricultural Aviation Centre, Mr. Alan Stephen of the Federal Aviation Association, numerous individuals associated with the USDA extension services and the Economic Research Service, the Environmental Protection Agency, numerous foreign Ministries of Aviation, and the hundreds of ag-air operators around the world who contributed to the data collection effort.

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PHOTO: A CESSNA AGWAGON OPERATED BY GUDGEL'S
AERO-AG OF CHOWCHILLA, CALIFORNIA APPLIES
A DEFOLIANT TO COTTON.

PART I INTRODUCTION AND OVERVIEW



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Over the period of November 1976 through January 1978, ECON, Inc. performed an assessment of benefits attributable to a variety of potential agricultural aviation technology improvements. Potential areas of technology were identified by NASA as candidates for research programs. These technology areas are identified in the left-hand column. The impact that each technology improvement could have on the economics of ag-air operations is identified in the right-hand column. Some of the impacts of new technologies are to increase the productivity of ag-air operations or, equivalently, to reduce the cost of these operations. Other impacts lie in the area of potentially improved safety. The benefits which are checked here have been addressed by this study and a quantitative basis for the monetary value of cost savings in these areas is provided.

POTENTIAL AG-AIR TECHNOLOGY IMPROVEMENTS

<u>TECHNOLOGY</u>	<u>BENEFITS</u>
● IMPROVED/AUTOMATED GUIDANCE	✓ REDUCED FLAGMEN COSTS ✓ IMPROVED UNIFORMITY OF APPLICATION
● SPRAY DROPLET SIZE CONTROL	REDUCED DRIFT ✓ REDUCED APPLICATION RATE
● IMPROVED SPRAY BOOM AND SPREADER DESIGN	✓ INCREASED FERRY SPEED
● IMPROVED AERODYNAMICS	REDUCED STALL SPEED ✓ REDUCED TURN TIME IMPROVED SAFETY ✓ INCREASED PAYLOAD
● NIGHT FLYING VISIBILITY AIDS	INCREASED UTILIZATION OF AIRCRAFT
● APPLICATION RATE CONTROL WITH GROUND SPEED	✓ IMPROVED UNIFORMITY OF APPLICATION
● IMPROVED LOADING SYSTEMS	INCREASED PRODUCTIVITY OF AIRCRAFT

Despite common misconceptions, the agricultural aircraft business is an important component of the modern, mechanized agricultural society. First, at least two crops, cotton and rice, are simply too labor intensive to be grown in the United States without agricultural aviation. Second, agricultural aviation permits substantial increases in productivity in other crops, such as vegetables, where the investment in ground equipment to achieve the same level of productivity would be prohibitive. Agricultural aircraft can react quickly to problems and can generally treat problems before major damage is done, something which ground equipment cannot always accomplish. In many instances, aircraft provide the only means of treating a crop, at least without causing substantial damage. This is true of wheat, which is not a row crop, and corn after it is about three feet tall. It is also true that aircraft can usually apply materials to a crop more fuel-efficiently than ground equipment. This is the case so long as the application rates do not exceed about 200 pounds per acre and the field is sufficiently large, say 20 acres, to accommodate aircraft. The industry is important especially since both aircraft and agricultural products are major U.S. export items. Improving the technology base for agricultural aircraft helps to assure continuing competitiveness in this important export market.

WHY AGRICULTURAL AIRCRAFT?

- WHY ARE AG AIRCRAFT IMPORTANT?
 - TWO MAJOR CROPS (COTTON AND RICE) COULD NOT BE PRODUCED ECONOMICALLY WITHOUT AG-AIR
 - AG-AIR ENABLES LARGE INCREASES IN PRODUCTIVITY FOR SOME CROPS, E.G., LETTUCE -- INVESTMENT IN GROUND EQUIPMENT FOR THE SAME RESULT WOULD BE PROHIBITIVE
 - AG-AIR CAN REACT QUICKLY TO PROBLEMS, EVEN WHEN GROUND EQUIPMENT CANNOT, E.G., AFTER HEAVY RAIN
 - SOMETIMES AG-AIR IS THE ONLY WAY TO TREAT A CROP WITHOUT CAUSING SUBSTANTIAL DAMAGE
 - AG-AIR IS FUEL EFFICIENT COMPARED TO GROUND EQUIPMENT
- WHY IS THE INDUSTRY IMPORTANT?
 - TWO KEY EXPORTS THAT CONTRIBUTE TO THE BALANCE OF TRADE ARE AIRCRAFT AND AGRICULTURE

The current world fleet of agricultural aircraft consists of over 24,000 aircraft located predominantly in the U.S.S.R. and the United States. About 900 new agricultural aircraft are built each year in the United States and an unknown number of Russian design are built annually in Poland. Well over 500 million acres are treated each year; about 180 million acres in the United States alone. The U.S.S.R. has the largest fleet and sprays the largest acreage annually, closely followed by the United States. A number of countries have fleets that number over 100 aircraft and the aircraft takes on special importance in tropical areas where uncontrolled insects would quickly destroy crops. The U.S. industry presently exceeds \$1 billion gross revenues annually (including materials costs) and has been growing at about 12 percent annually for the past several years.

INDUSTRY OVERVIEW

- WORLD AG-AIR FLEET ABOUT 24,553 AIRCRAFT (8,649 IN U.S.)
- ABOUT 900 AG-AIR AIRCRAFT ARE BUILT IN THE U.S. EACH YEAR
- ABOUT 575 MILLION ACRES TREATED ANNUALLY (130 MILLION IN U.S.)
- NATIONS RELYING MOST ON AG-AIR ARE

<u>NATION</u>	<u>ACRES TREATED</u>	<u>AIRCRAFT FLEET</u>
U.S.S.R.	223,000,000	10,000
U.S.	180,000,000	8,649
NEW ZEALAND	14,465,000	451
CUBA	12,730,000	184
ARGENTINA	12,360,000	539

- U.S. INDUSTRY IS GROWING ABOUT 12 PERCENT PER YEAR--CURRENTLY EXCEEDS \$1 BILLION ANNUALLY INCLUDING COST OF MATERIALS APPLIED

The seven major U.S. crops treated by agricultural aviation include cotton, rice, wheat, vegetables, corn, soybeans and sorghum. Together, these crops account for about 70 percent of the agricultural aviation activities in the nation. The major applications to these crops include insecticides, herbicides and fertilizer. Rice is almost entirely seeded from the air. It is, in fact, the technology of aerial seeding that enables rice to be grown without being prohibitively labor intensive.

MAJOR U.S. AG-AIR CROPS

CROP	AREA TREATED (1,000 ACRES)	FLIGHT HOURS	% OF CROP TREATED BY AIR	PRIMARY TREATMENT
COTTON	46,500	645,500	60	INSECTICIDE
RICE	14,100	316,800	95	FERTILIZER
WHEAT	18,400	265,200	5-20	HERBICIDE
VEGETABLES	8,700	174,400	30-50	INSECTICIDE
CORN	11,800	166,800	10	INSECTICIDE
SOYBEANS	8,500	162,700	10	INSECTICIDE
SORGHUM	3,800	109,900	40	INSECTICIDE

A breakdown of U.S. ag-air activities for all crops is presented here. Again, it becomes clear that the aircraft is an important means of controlling insect damage. Without the standing capability to combat problems as they arise, with a minimal delay, many crops could not be economically produced in the United States. The importance of this capability is not captured in statistics reflecting reactive applications only, but one can get a feel for this importance by noting the extensive preventive activities on crops such as cotton and vegetables.

U.S. AG-AIR ACTIVITIES

APPLICATION	% OF TOTAL	FLIGHT HOURS
INSECTICIDE	51.6	1,364,800
HERBICIDE	22.1	584,500
FERTILIZER	10.8	285,700
FUNGICIDE	6.8	179,900
SEED	4.4	116,400
DEFOLIANT	4.3	113,700
TOTAL	100.0	2,645,000

The potential benefits of various ag-air technology improvements are presented in detail later in this report. Two technology mixes were provided by NASA. These are presented here. In Case I, a conservative mix of technology improvements was analyzed. These technology goals appear to be readily achievable. Case II adds to the technology mix of Case I a capability for maintaining improved droplet size control that enables a 25 percent reduction in insecticide application rates.

TWO POSSIBLE AG-AIR TECHNOLOGY MIXES

CASE I: CONSERVATIVE TECHNOLOGY BASE

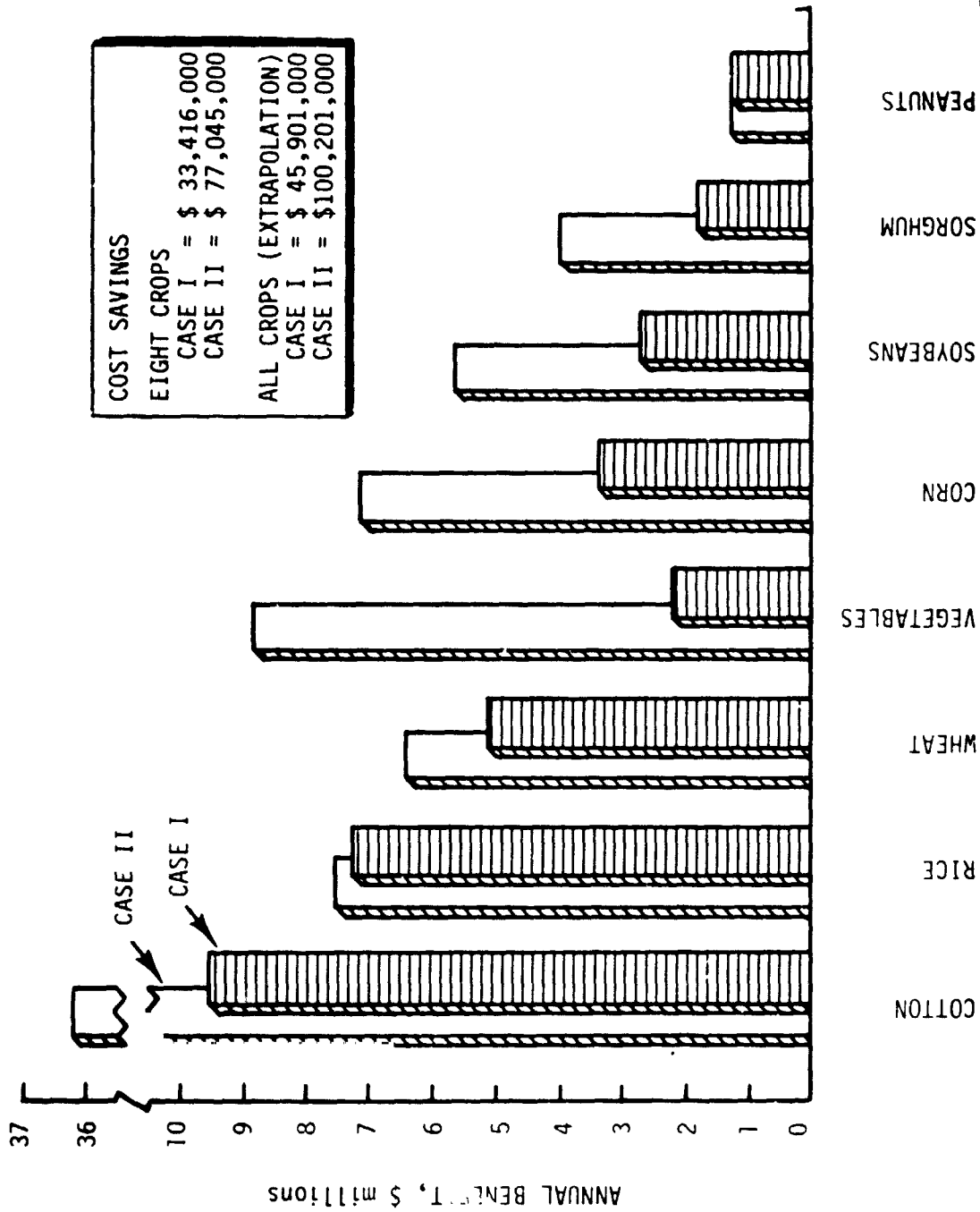
- TURN TIME REDUCED 25%
- FERRY AND SPRAY SPEED INCREASED 20%
- FLAGMEN ELIMINATED

CASE II: PROBABLE TECHNOLOGY BASE

- TURN TIME REDUCED 25%
- FERRY AND SPRAY SPEED INCREASED 20%
- FLAGMEN ELIMINATED
- INSECTICIDE APPLICATION RATE REDUCED 25%

The potential cost savings for the two technology mixes provided by NASA are shown here. Implementation of Case I, the conservative technology base, across the entire fleet could result in annual cost savings of \$45.9 million. If Case II, the probable technology base, were fully implemented, annual cost savings over \$100 million could result. The cost savings are only part of the benefits that would result. There would also be reduced material losses, increased aircraft productivity, improved safety and an increased export market; these benefits have not been quantified.

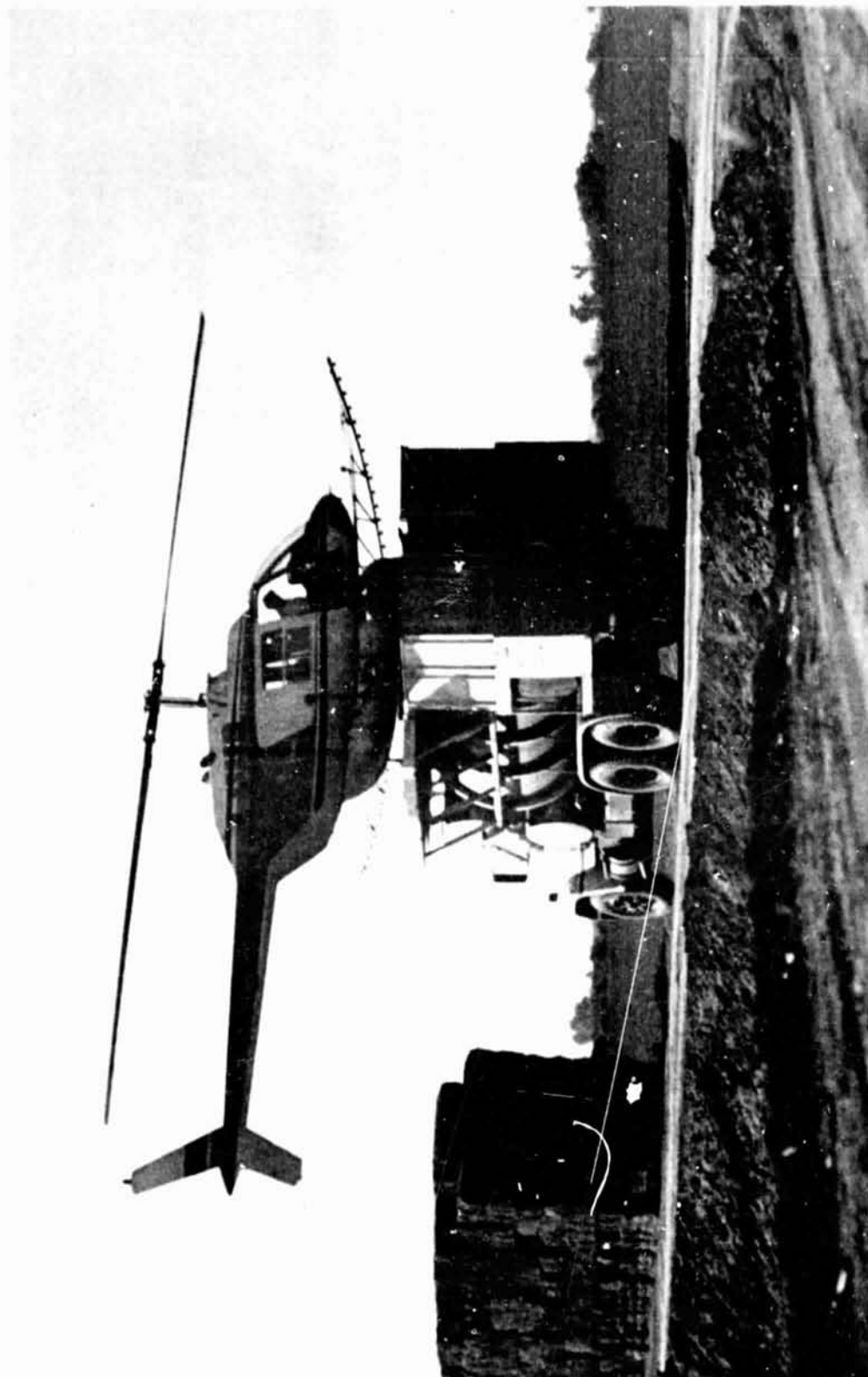
POTENTIAL U.S. COST SAVINGS FROM TWO PROPOSED TECHNOLOGY MIXES



U.S.

PHOTO: A BELL JETRANGER OPERATED BY VISCO
FLYING COMPANY, INC. OF IMPERIAL,
CALIFORNIA RELOADS BEFORE ANOTHER RUN.
(BLADE IS IN MOTION.)

PART II
THE U.S. AG-AIR INDUSTRY



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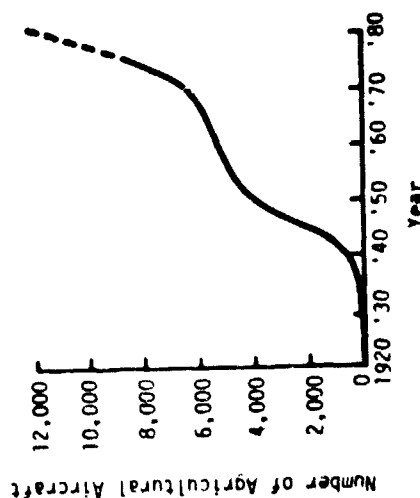
To set the stage for the analysis that follows, it is helpful to first obtain a feel for the general magnitude of the ag-air industry. As of 1976, there were approximately 8,600 fixed and rotary winged aircraft in service primarily used for agricultural purposes. These aircraft flew about 2.5 million hours over some 180 million acres during that year. In so doing, gross revenues somewhat in excess of a billion dollars were generated, including the cost of materials applied. Finally, over the past five or so years, the industry has experienced an annual growth rate of about 12 percent. One possible cause for this substantial growth rate may be the increased cost of fuel which tends to favor aircraft over ground based application as a more fuel-efficient means of applying various materials to crops. Much of the growth in the ag-air industry presently appears to derive from increased market penetration in areas and for crops where the current use of ag-air is quite low, rather than from increased acreage of the crops presently largely treated by air. This may, to some extent, bear evidence that aerial application is becoming a more economical means of treating crops than ground-based application. The cost savings benefits discussed later should be compared to the gross annual revenue figure sited insofar as both reduced operating costs and material savings are involved. It is also helpful to keep in mind that this base is growing rapidly.

THE AG-AIR INDUSTRY

- NUMBER OF AIRCRAFT
FIXED WING 7,841
ROTARY WING 808
TOTAL 8,649
- ANNUAL HOURS REPORTED
2,645,000
- NUMBER OF ACRES TREATED
180,000,000
- GROSS ANNUAL REVENUES (INCLUDING MATERIAL COSTS)
\$1,100,000,000 (APPROXIMATE)
- ANNUAL GROWTH
ABOUT 12%

The number of aircraft used for agricultural aviation has been increasing since they were first used in the 1920s. During the past 25 years, this number has increased 89 percent with the largest increase occurring in this decade. If this growth rate continues, there will be nearly 12,000 aircraft in agricultural use by 1980. The national distribution of aircraft used for agricultural

purposes in 1976 can be seen in the map at the right.* The two states with the most aircraft are Texas (1120) and California (932), and combined, account for some 25 percent of the nation's ag-air fleet. These states are followed by Arkansas, Louisiana, Mississippi, Florida and Oklahoma, which brings the total to about 50 percent of the fleet. The Midwest, Northern Plains and Pacific states follow in importance by number of aircraft. Only about 10 percent of the fleet is located in the New England, Appalachian, and Corn Belt states.

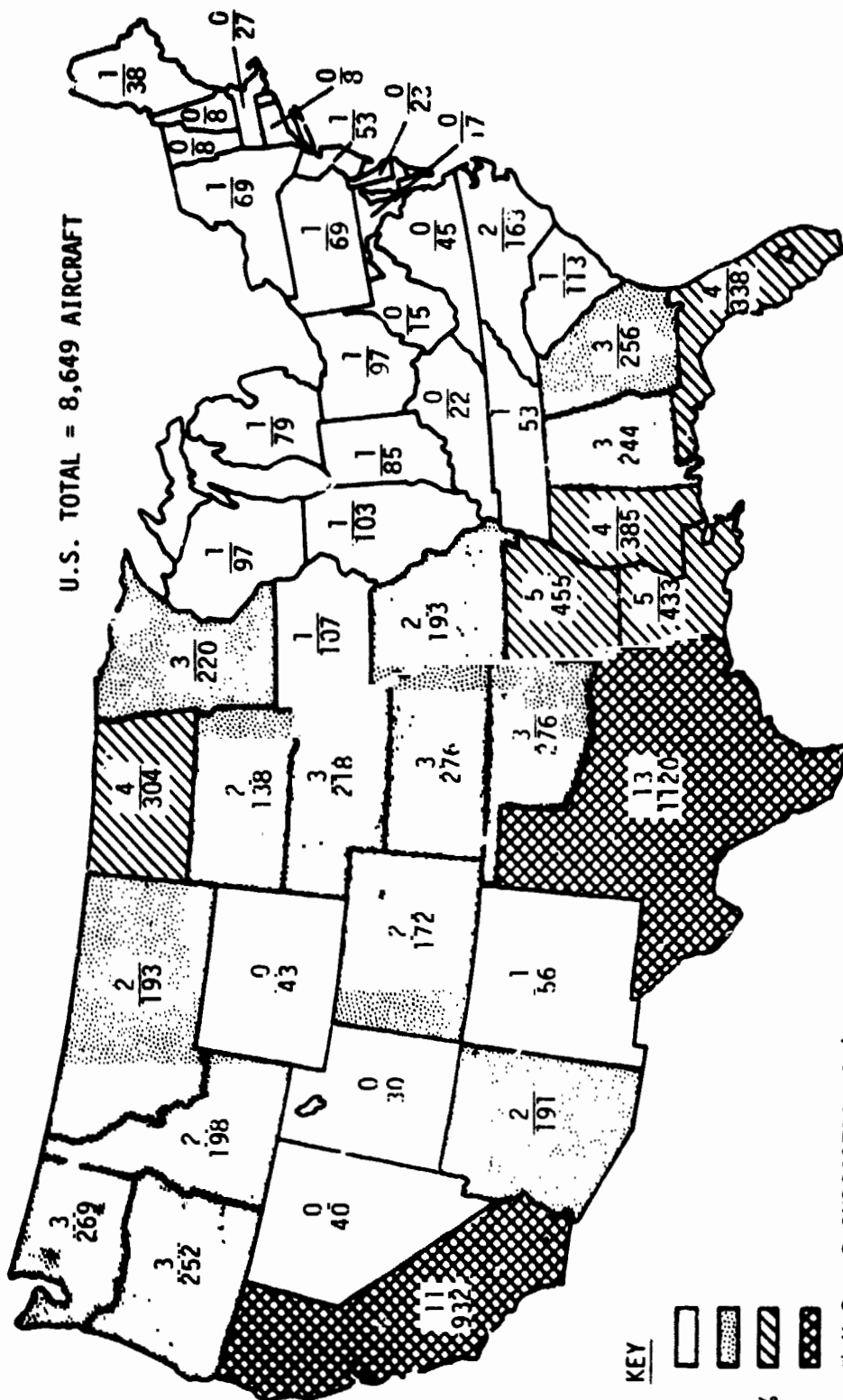


Growth Pattern for Number of Agricultural Aircraft (Source: Merrill (1969); Akesson and Yates (1974); FAA Records (1970-75))

*These data and those for flight hours are estimates obtained after analyzing the FAA Aircraft Registration Master File released in November 1977.

NUMBER OF AGRICULTURAL AIRCRAFT BY STATE

U.S. TOTAL = 8,649 AIRCRAFT



KEY

- 0-1%
- 2-3%
- 4-10%
- 11+%

% U.S. (0 INDICATES <1%)
NUMBER OF AIRCRAFT

ALASKA - 1/96
HAWAII - 0/22

The fleet mix of aircraft used in agricultural aviation is shown in the next two tables. There are nearly equal numbers of the Piper Pawnee D (1111), Cessna Ag-Wagon (1076), the Stearman (1210) and the Grumman Ag-Cat (1133). Piper aircraft of all makes and years account for about 32 percent of the entire aircraft fleet. Cessna aircraft follow with 19 percent. The Stearman make up about 15 percent of the fleet, Grumman aircraft 14 percent, and Rockwell International about 9 percent. The remainder are various other aircrafts. The average gross weight of all fixed wing aircraft is 3,431 pounds and the average cruise speed is 94 miles per hour. Of particular interest is the fact that the Stearman make up as sizeable a fraction of the fleet as they do despite the fact that they have been out of production for over 30 years. The table also shows, however, that this fraction is now rapidly declining. With a major portion of the fleet as old as can be inferred from this chart, there should be a growing market for new agricultural aircraft using advanced technologies.

TYPE OF AIRCRAFT (FIXED WING) USED IN AGRICULTURAL AVIATION

MANUFACTURER NAME AND MODEL NUMBER	NUMBER IN FLEET FOR 1976	NUMBER IN FLEET FOR 1975	GROSS WEIGHT (LBS.)	CRUISE SPEED (MPH.)
PIPER (PAWEE, CUB)	2508	2720		
PA-25-235	1111	1259	2900	93
PA-18(A)-150	298	358	1625	97
PA-36-285	186	207	3800	113
PA-25-260	174	201	2900	93
J3C-65	160	193	1220	67
PA-25	135	162	3300	81
PA-18(A)	53	129	1500	97
PA-11	44	70	1220	67
PA-18(A)-135	15	53	1500	97
PA-18-125	144	22	1500	97
OTHERS		46	-	-
CESSNA (AG-TRUCK, WAGON)	1529	1478		
1888	1076	1138	3300	108
1888(A)	257	298	3300	96
OTHERS	196	42	-	-
BOEING (STEARMAN)	1210	1377	2717	93
GRUMMAN (AG-CAT)	1133	1134		
G-164(A) (B)	663	602	6075	81
G-164(A)	470	532	3725	98
ROCKWELL (THRUST)	738	737		
AERO-COMMANDER	245	271	6000	119
S-2R	249	250	7000	82
AERO-COMMANDER	121	133	3000	82
CALLAIR	53	60	2350	93
OTHERS	69	23	-	-
OTHERS	723	309		
M3M-3 (NAVAL)	99	115	3200	94
S2C (SNOW)	96	49	4800	112
7AC (AERONCA)	103	43	-	-
2018 (HEATHERLY)	43	34	3500	96
AT301 (AIR TRACTOR)	41	29	1500	71
OTHERS	341	39	-	-
TOTAL AIRCRAFT	7841	7755		

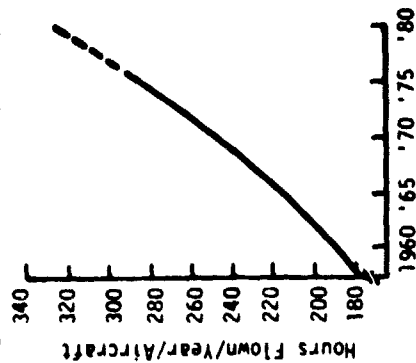
Rotary wing aircraft make up about 9 percent of the total ag-air fleet. Bell helicopters account for about 57 percent of all rotary wing aircraft, Hiller about 16 percent, Hughes about 15 percent, Continental Copter about 4 percent, Sikorsky about 4 percent and various others about 3 percent. The average weight of rotary wing aircraft is 2,638 pounds and the average cruise speed is 87 miles per hour. Rotary wing aircraft are typically two-to-ter times more expensive to buy and operate as fixed wing aircraft. Nonetheless, their special capabilities to take off and land vertically, hover, make tight turns, maneuver in small fields, and to force the chemicals down into foliage, make them useful for certain applications.

TYPE OF AIRCRAFT (ROTO WING) USED IN AGRICULTURAL AVIATION

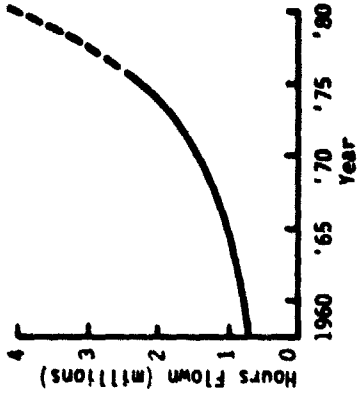
MANUFACTURER NAME AND MODEL NUMBER	NUMBER IN FLEET FOR 1976	NUMBER IN FLEET FOR 1975	GROSS WEIGHT (LBS.)	CRUISE SPEED (MPH.)
BELL 47G, 47D	464	460	2200-2950	78
HUGHES 269	121	124	1575-1670	64-65
HILLER UH-12	127	112	2400-3100	63-80
CONTINENTAL COPTERS CH-13H TOM CAT	36	17	--	51
SIKORSKY	31	16	7300-7500	71
OTHERS	59	11	1600-7200	71-90
TOTAL AIRCRAFT	808	740		

A rapid increase can be seen in the total flight hours reported for agricultural purposes during the last ten years. This increase can be explained not only by increased number of aircraft, but also by the number of hours flown per year per aircraft. Over the last six years the average hours flown per year per aircraft has increased by 20 percent. By 1980 each ag-plane could be flying on the average about 330 hours a year. In 1976 most of the hours flown were concentrated in the South and the West as the map at the right shows. Again, the two top states are California (391 hours) and Texas (356) which account for about 25 percent of the total hours flown in the nation. These states are followed by Louisiana, Arkansas, Mississippi, and Florida which brings the total

hours to about 50 percent of all hours flown. The average hours flown per aircraft in 1976 ranges from 699 in Hawaii to 61 in Connecticut. The higher rates of 400 to 500 hours per aircraft are found in Louisiana, Tennessee, California and Arkansas. Slightly above average rates of about 300 to 400 hours per aircraft are found in the Southeast and Texas. The remaining states fall below the national average of 306 hours per aircraft per year.

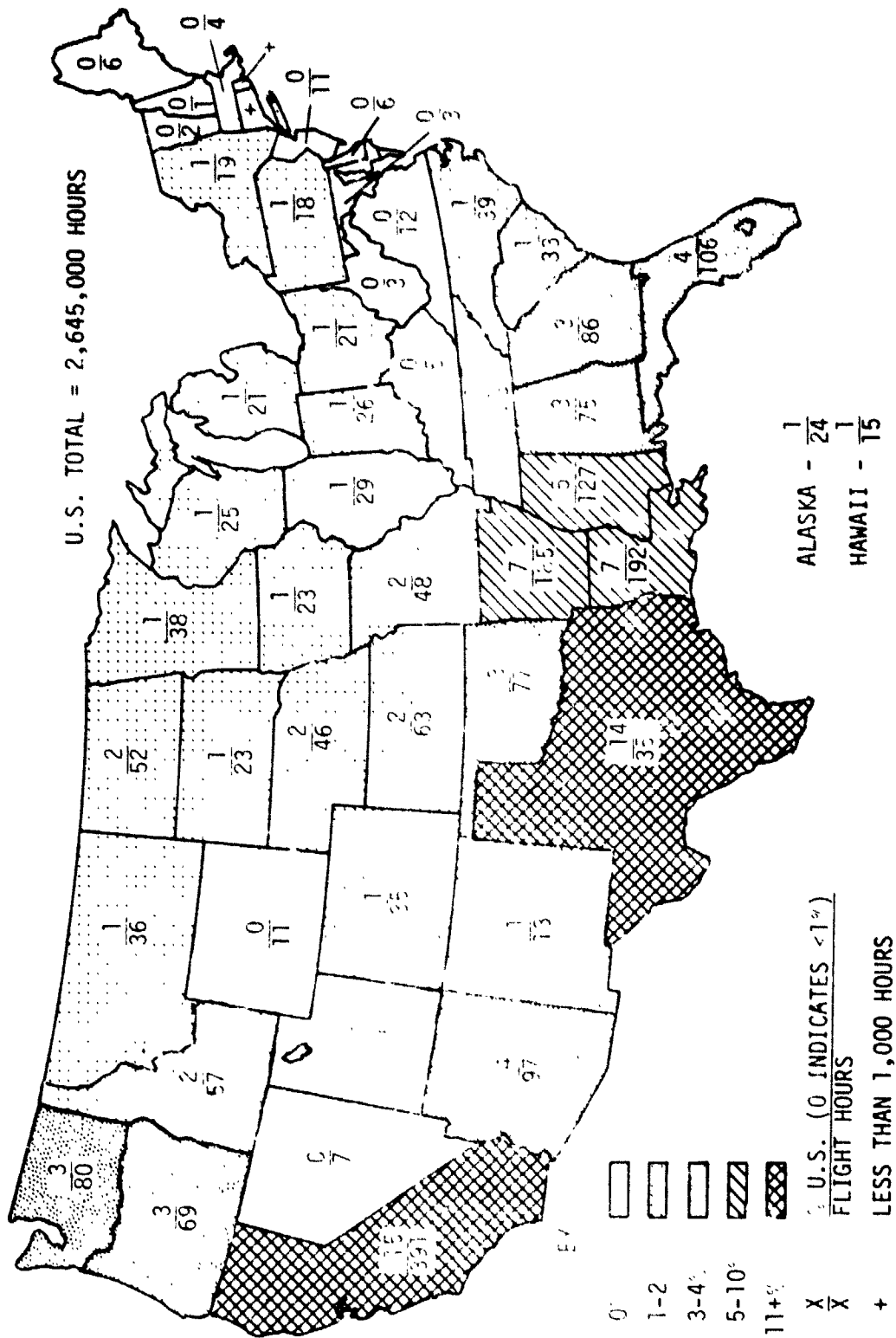


Growth Pattern for Hours Flown Per Aircraft (Source: Merrill (1966); FAA Records (1970-75)).



Growth Pattern for Hours Flown By Entire Ag-Air Fleet (Source: Merrill (1966); FAA Records (1970-75)).

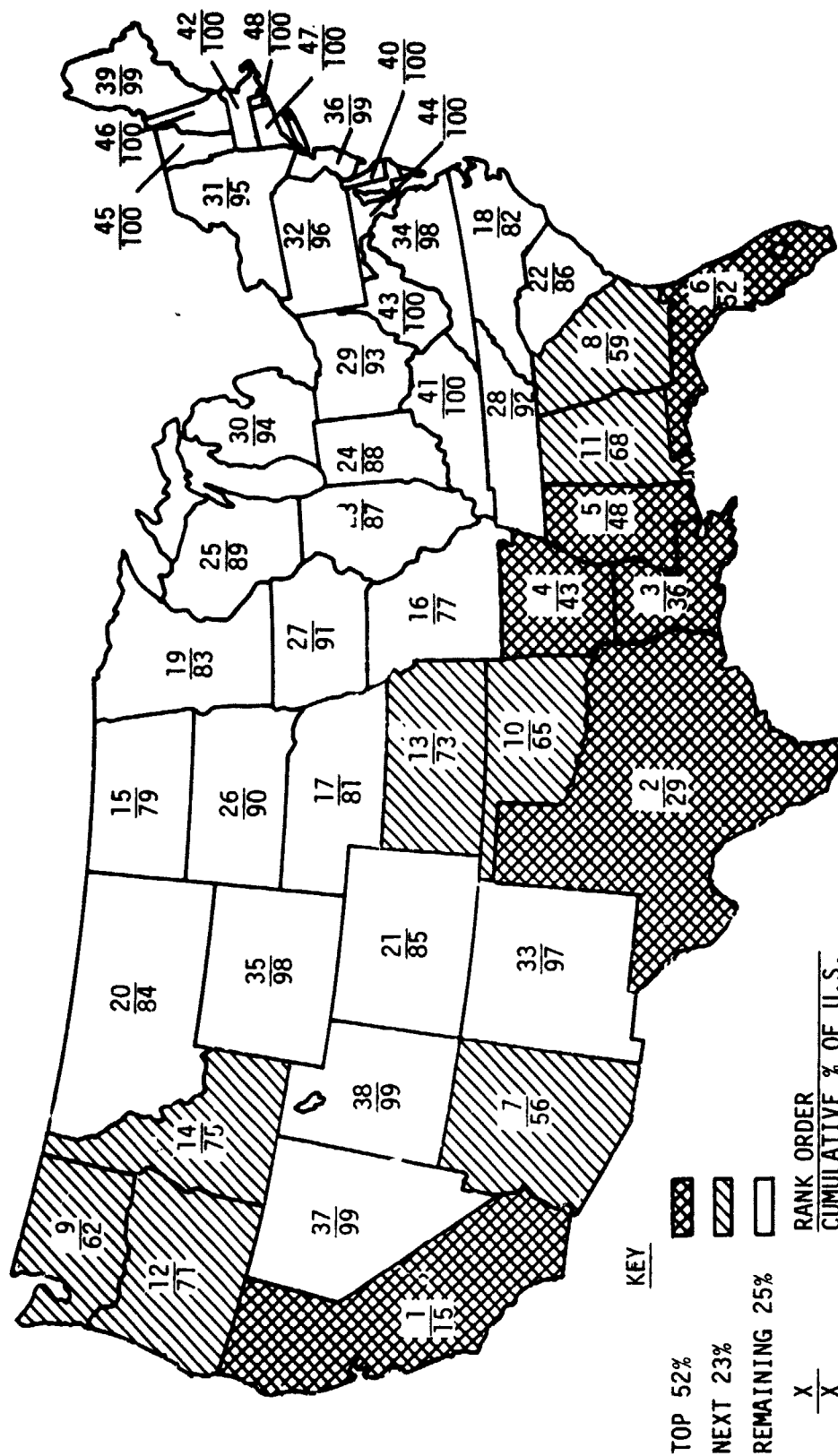
FLIGHT HOURS FOR AGRICULTURAL AIRCRAFT BY STATE (1,000 HOURS)



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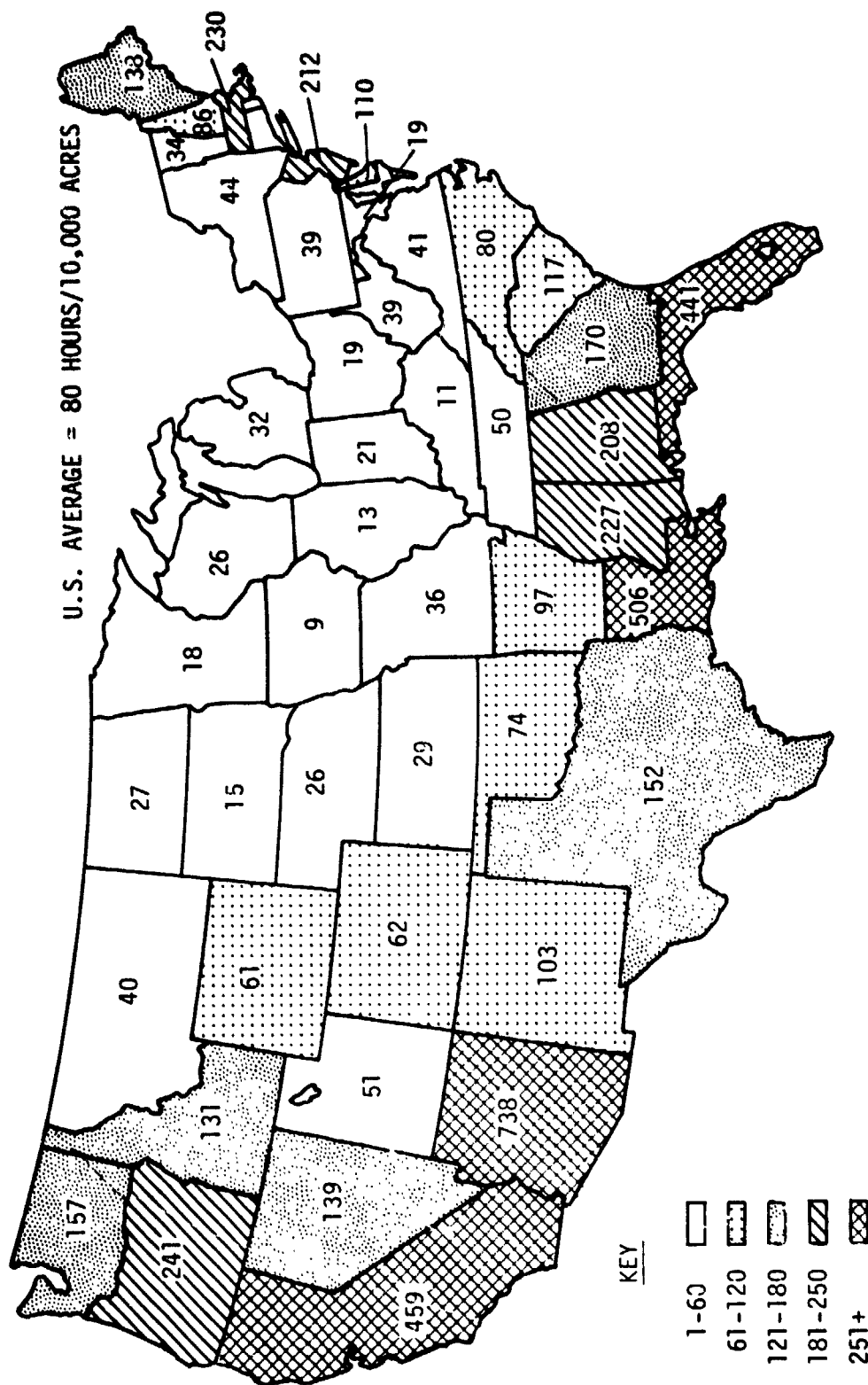
Rank ordering each state by the total hours flown clearly shows where most of the ag-air activities are located. California heads the list and accounted for 15 percent of the nation's ag-air hours in 1976. By adding Texas, Louisiana, Arkansas, Mississippi, and Florida, 52 percent of the nation's hours are accounted for. By looking at the top 14 states, 75 percent of all hours flown are accounted for. Considering, then, the number of aircraft and the hours flown, the most important areas in ag-air are California, Texas, the Delta states, and the Southeast. Important fringe states include Arizona, Oklahoma, Kansas, Missouri, Washington, Oregon and Idaho.

FLIGHT HOURS FOR AGRICULTURAL AIRCRAFT RANK ORDERED BY STATE



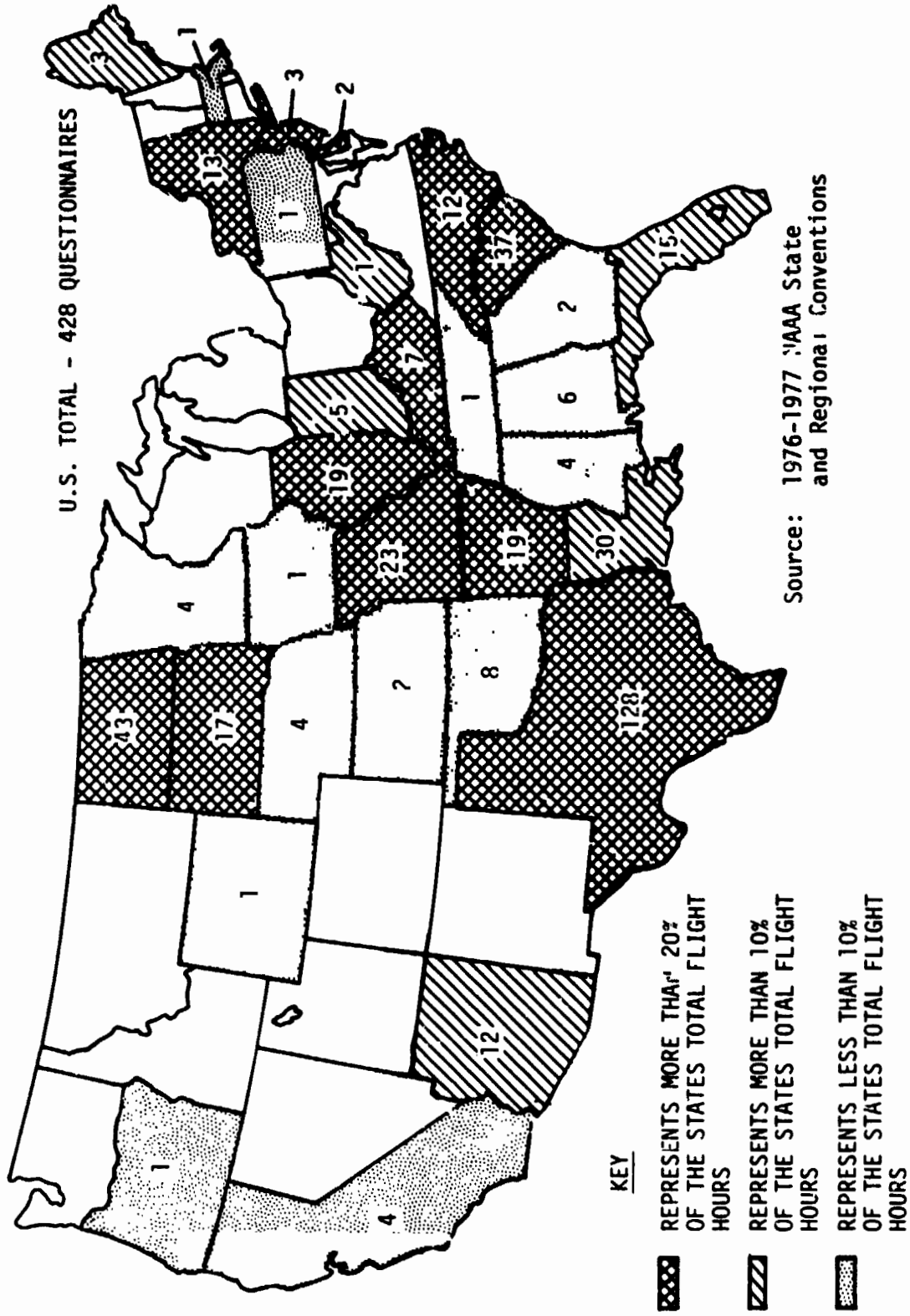
The extent to which farmers utilize agricultural aviation can be seen in the map at the right. Arizona, Louisiana, California, and Florida are areas of heavy use of ag-air for all cultivated land. Oregon, Massachusetts, Mississippi, and New Jersey follow in the density of ag-air use. Texas, an important ag-air state by fleet size, hours flown and area treated, becomes less important when all cultivated land is considered.

DENSITY OF AG-AIR USE FOR ALL CULTIVATED LAND (HOURS PER 10,000 ACRES)



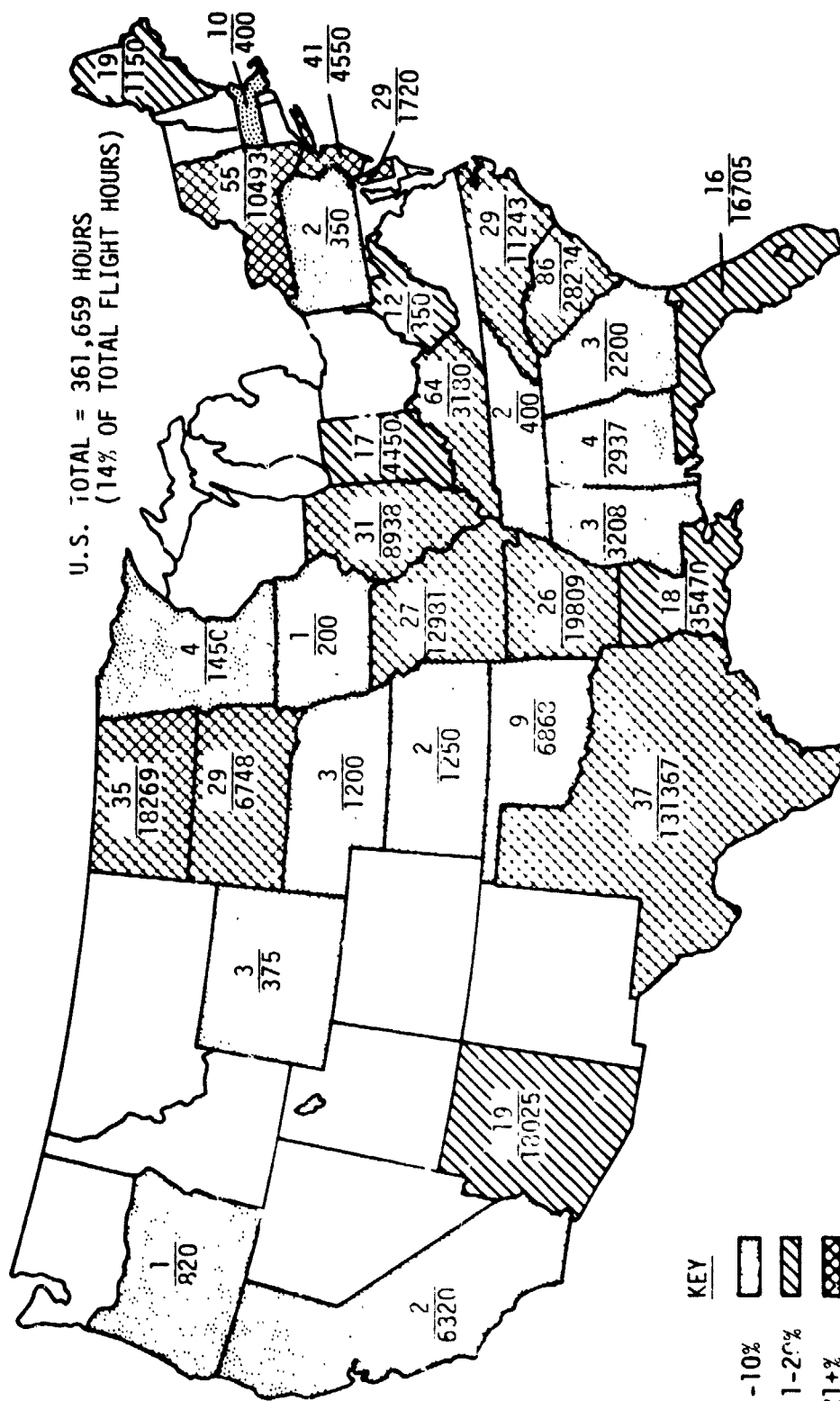
During the 1976-1977 regional and state conventions of the National Agricultural Aviation Association (NAAA), pilots and operators were asked to fill out a questionnaire about their own ag-air activities. Information received from the 428 respondents covered 32 states. Part of this information includes the number of hours flown per aircraft per year. Twelve states reported on at least 20 percent of the state's total flight hours, 6 states reported on at least 10 percent of the state's total flight hours, and the remaining 14 states reported on less than 10 percent of the state's total hours. (The total flight hours for each state is based on information from FAA records.)

NUMBER OF USABLE NAAA QUESTIONNAIRES BY STATE



A closer look at the flight hours reported on the NAAA Questionnaires is shown on the map at the right. In Texas, 37 percent of the state's total flight hours were accounted for by the questionnaires. In South Carolina nearly all of the state's flight hours were accounted for. The Southeast and California, important ag-air regions, were not well represented by the NAAA Questionnaires. Respondents from California and Mississippi accounted for 2 and 3 percent of each state's flight hours respectively. Georgia and Alabama are similar with 3 and 4 percent, respectively, of the state's flight hours. In total the NAAA Questionnaires accounted for 14 percent of the nation's flight hours.

FLIGHT HOURS REPORTED ON NAAA QUESTIONNAIRES BY STATE



KEY

1-10%

11-20%

21+%

X / X

% OF STATE'S TOTAL FLIGHT HOURS
REPORTED FLIGHT HOURS

Source: 1976-1977 NAAA State
and Regional Conventions

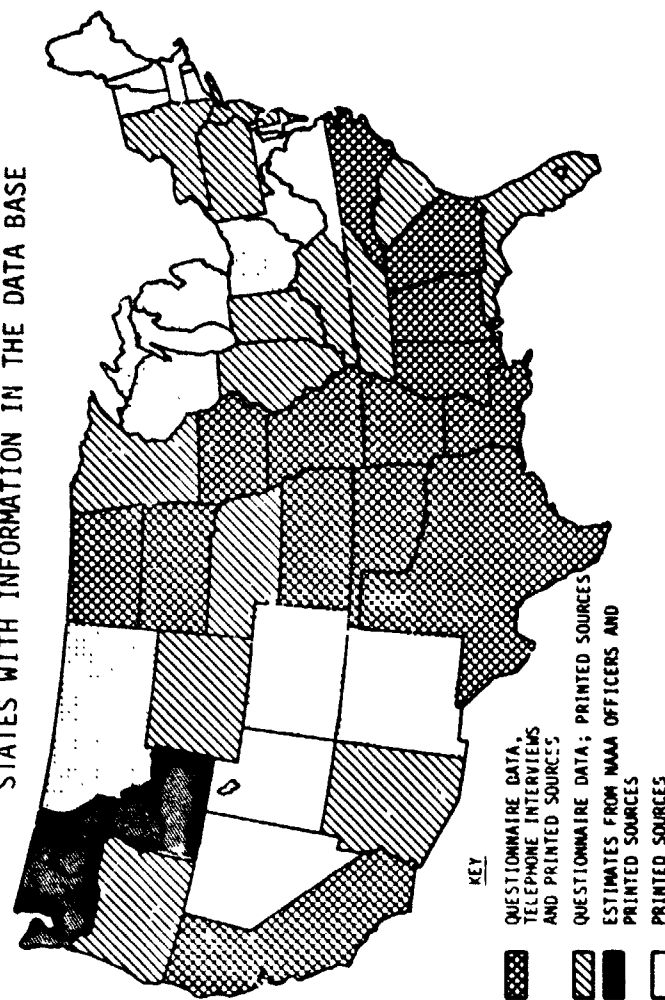
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In addition to the NAAA Questionnaire, information was obtained through telephone interviews, field trips, written communications and various printed sources. The telephone interviews were conducted with the ag-air operators themselves in order to get information not covered by the questionnaire and to get information from states that were not well represented by the questionnaires. Over 200 telephone calls were made to operators, pilots, NAAA officers, and government organizations such as the Environmental Protection Agency, Federal Aviation Administration and State Agricultural Extension personnel. Information from various USDA publications and journal articles was used. Contacts were made with many aircraft manufacturers and the General Aviation Manufacturers Association. More than 50 Foreign Ministries of Aviation and Agriculture contributed information to the foreign data base. The map at the right shows what information is used for each state included in the U.S. data base. With very few exceptions, the individuals contacted were eager to participate in the study and cooperated extensively. A few individuals went to great lengths to make substantive contributions to the study and to identify technology areas which they felt were most in need of research and development work.

THE AG-AIR DATA BASE

- ABOUT 900 PEOPLE AND ORGANIZATIONS CONTRIBUTED TO THE DATA BASE
 - OPERATORS
 - MANUFACTURERS
 - NAAA AND GAMA
 - DOA, EPA, FAA
 - FOREIGN SOURCES
- GREAT ENTHUSIASM SHOWN FOR STUDY AND EXTREME COOPERATION OBTAINED FROM NEARLY EVERYONE CONTACTED

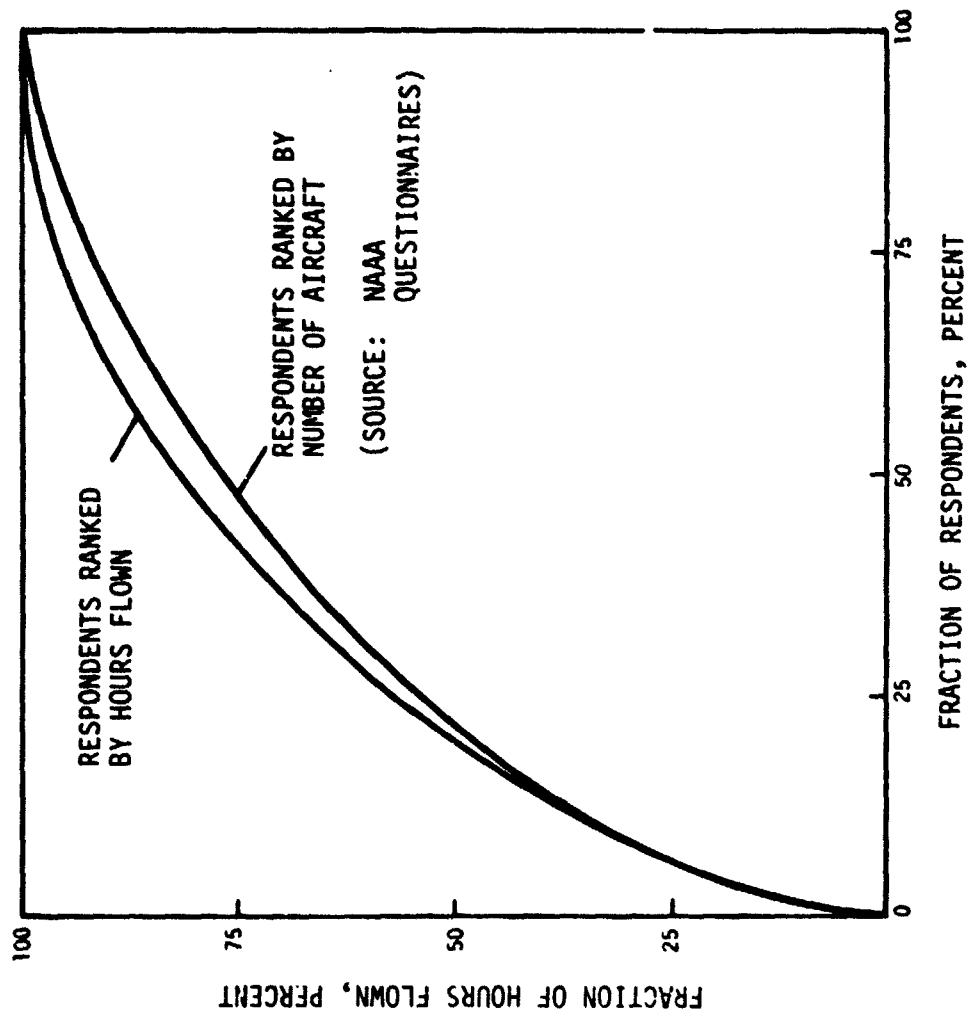
STATES WITH INFORMATION IN THE DATA BASE



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OF POOR QUALITY

During the course of the telephone interviews, the question arose of what fraction of the industry could be sampled by talking only with the larger operators. By ordering respondents on the NAAA Questionnaire by number of hours flown per respondent and by the number of aircraft per respondent, the graph at the right is obtained. It shows that 50 percent of the respondents account for some 75 percent of the hours if that 50 percent includes the larger operators. The same is true for the number of aircraft.

SIZE DISTRIBUTION OF AG-AIR OPERATORS



Part of the information from the NAAA Questionnaire includes the number of hours spent flying over each crop. The table at the right shows the results after tabulating the 428 questionnaires. These tabulations indicate that the most important ag-air crops are cotton and rice. These data, however, do not account for all areas of the nation equally, for over a third of the hours reported here are from Texas, which accounts for only 13 percent of the nation's hours. Similarly, California, which accounts for 14 percent of the nation's hours, accounts for only 2 percent of the data here.

By augmenting the NAAA Questionnaire data with telephone interviews, estimates from NAAA officials and USDA printed sources, an estimate was made state by state of the hours flown for each crop. Tabulation of these data is shown on the following two pages. A comparison of these estimated hours with the actual reported hours of the questionnaires shows only slight changes. The NAAA Questionnaire data seem to represent the national average fairly well. Cotton and rice are the two most important ag-air crops. By looking at cotton, rice, wheat, vegetables, corn, soybean, sorghum and peanuts, over 70 percent of all ag-air hours are accounted for. (Peanuts is included in the data base so that comparisons could be made with other NASA projects associated with that crop.)

USE OF AG-AIR FOR VARIOUS CROPS

STATISTICS FROM NAAA QUESTIONNAIRES		
Crop Grouping	Total Hours	% of Total
Cotton	96211	26.60
Rice	62925	17.40
Wheat	29141	8.06
Soybeans	25427	7.03
Vegetables	23314	6.45
Corn	22793	6.30
Sorghum	22498	6.22
Grains	14592	4.03
Potatoes	9206	2.55
Rangeland & Brush	8651	2.39
Beans and Peas	7791	2.15
Citrus	6813	1.88
Peanuts	6080	1.68
Grass	5097	1.41
Sugarcane	3182	0.88
Field Crops	2838	0.78
Alfalfa	2643	0.73
Other	2296	0.63
Orchards	2259	0.62
Mosquito Control	2027	0.56
Timber	1678	0.46
Tobacco	1586	0.44
Fruits	1405	0.39
Right-of-Way	942	0.26
Nuts	267	0.07
Total All Crops	361660	

ESTIMATED HOURS FLOWN FOR VARIOUS CROPS BY STATE (1,000 HOURS)

STATE	COTTON	RICE	WHEAT	VEGETABLES	CORN	SOYBEANS	GRAINS	SORGHUM	SUGAR CROPS	POTATOES	RANGELAND	ORCHARDS	CITRUS	ALFALFA	PEANUTS	FRUIT	OTHER	TOTAL HOURS
CALIFORNIA	84.9	69.6	22.5	60.0	4.2		24.4	2.0	25.4	2.7	0.4	8.4	19.3	57.6	1.6	3.4	4.4	390.8
TEXAS	97.3	71.4	16.8	17.7	25.3	4.0	20.4	44.3	1.1	2.3	41.7	0.3	2.3	1.1	6.4		3.6	356.0
LOUISIANA	45.4	70.6	0.5		0.1	27.2	9.0	1.0	35.1	0.3	1.5	0.3					1.4	192.4
ARKANSAS	56.4	82.3	7.5	0.5	0.5	16.0	5.8	2.0									13.6	184.6
MISSISSIPPI	118.5	20.4	1.4	0.5	0.5	6.9	0.1	2.5		0.1	0.3	0.1					2.1	127.4
FLORIDA	3.1		0.3	30.0	0.3	6.0	0.3		2.2	0.4	3.5	3.1	41.8		1.1		14.1	106.4
ARIZONA	50.0		1.8	3.1	0.1		5.6	0.1	0.2	0.2	1.5	0.8	1.2	7.4			24.7	96.7
GEORGIA	51.3		0.1	4.0	0.5	16.0	0.1	0.1		0.1		0.3			21.0		0.2	86.5
WASHINGTON			33.8	6.4	0.7		8.9		1.4	6.2	0.5	19.8				0.7	1.9	80.3
OKLAHOMA	15.0		20.0	1.0	8.5	12.0	1.9	13.8		4.5	11.3				6.8		0.6	77.0
ALABAMA	61.2		0.1	0.3	0.3	9.7	0.1	0.1		0.1	0.1	0.2			5.8		0.3	74.7
OREGON			14.1	5.7	0.5		11.6		2.2	3.9	1.7	17.4					11.7	68.8
KANSAS			7.3		24.9	0.6	0.7	17.8	3.8		7.1						0.7	62.9
IDAH0			13.5	2.0	0.6		9.6		1.3	7.5	0.2	15.4					7.0	57.1
NORTH DAKOTA			24.7	2.8	0.3	2.0	13.8		0.1	4.9	0.6			0.3			2.7	52.2
MISSOURI	8.0	2.5	8.0	1.0	6.9	14.3		7.5			0.3			0.1			0.1	48.1
NEBRASKA			3.5		18.0	0.5	0.5	14.8	2.2	1.0	4.9						0.1	45.5
NORTH CAROLINA	15.3		0.5	0.2	0.5	9.1	0.5	0.1		0.3	0.3				8.0	0.4	3.5	38.7
MINNESOTA			18.0	2.2	5.0	0.9	7.0		2.0	2.5	0.2						0.2	38.0
MONTANA			21.9		0.5		7.2		3.2	2.2	0.7						0.2	35.9
COLORADO			9.5	1.0	5.0		2.5	1.7	2.1	2.0	1.5						9.8	35.1
SOUTH CAROLINA	15.4		0.1	0.6	0.8	6.3	0.4	0.1			0.3	0.5			0.6	0.5	7.0	32.6
ILLINOIS			2.3	0.7	10.0	5.7	0.5			0.4	0.5			0.3			8.9	29.3
INDIANA			2.4	2.2	6.2	3.4				1.5				0.6			9.2	25.5

ESTIMATED HOURS FLOWN FOR VARIOUS CROPS BY STATE (1,000 HOURS)

STATE	COTTON	RICE	WHEAT	VEGETABLES	CORN	SOYBEANS	GRAINS	SORGHUM	SUGAR CROPS	POTATOES	RANGELAND	ORCHARDS	CITRUS	ALFALFA	PEANUTS	FRUIT	OTHER	TOTAL HOURS
WISCONSIN			0.3	8.1	2.2		2.1			5.6		0.5				1.7	4.3	24.8
SOUTH DAKOTA			21.3	0.3	2.0		3.1	0.6			1.1			0.3			0.1	23.1
IOWA				21.3	2.4		0.1	0.1				0.1					0.1	23.0
TENNESSEE	7.0		0.3	0.7	0.2	6.9		0.5								0.5	6.5	22.6
OHIO			2.5	2.5	11.8	5.1	0.2		0.1	0.2							0.1	21.5
MICHIGAN			0.8	4.0	3.0	3.0	1.0			4.9		2.0				2.0	0.1	20.8
NEW YORK			1.4	4.8	2.9	0.6				9.1		0.1				0.1	0.2	19.2
PENNSYLVANIA				2.2	2.2	0.8				6.5				0.5			5.8	18.0
NEW MEXICO	12.0		0.9	0.7	0.1		0.1	0.9									0.1	12.7
VIRGINIA	2.0		0.2	0.9	0.3	1.5				1.0					5.0		1.4	12.3
NEW JERSEY				3.3			1.5			0.8						2.1	3.3	11.0
WYOMING			2.1		0.2		2.3	0.5		0.3						5.1		10.5
NEVADA			0.5				1.5										2.3	7.3
MAINE					0.3		0.8			4.2		0.1				0.5	0.1	6.0
UTAH			2.7	0.4	0.1	1.5				1.0							0.1	5.8
DELAWARE			0.2	3.0	0.2	0.4	1.2										0.6	5.6
KENTUCKY	0.1		1.0		1.3	2.1											0.4	4.9
MASSACHUSETTS				0.3	0.3		0.1			0.1		0.1				3.0	0.5	4.4
WEST VIRGINIA							0.2										1.4	3.1
MARYLAND			0.1	1.3	0.3	0.7	0.1			0.1		1.0		0.3			0.3	3.0
VERMONT												0.1					2.2	2.2
NH, CN, RI																	1.4	1.4
UNITED STATES	645.5	316.8	265.2	174.4	166.8	162.7	122.1	109.9	79.5	76.8	74.7	65.1	62.2	61.8	54.4	14.5	153.4	2604.8
%	24.8	12.2	10.2	6.7	6.4	6.2	4.7	4.2	3.1	2.9	2.9	2.5	2.4	2.4	2.1	0.6	5.9	100.0

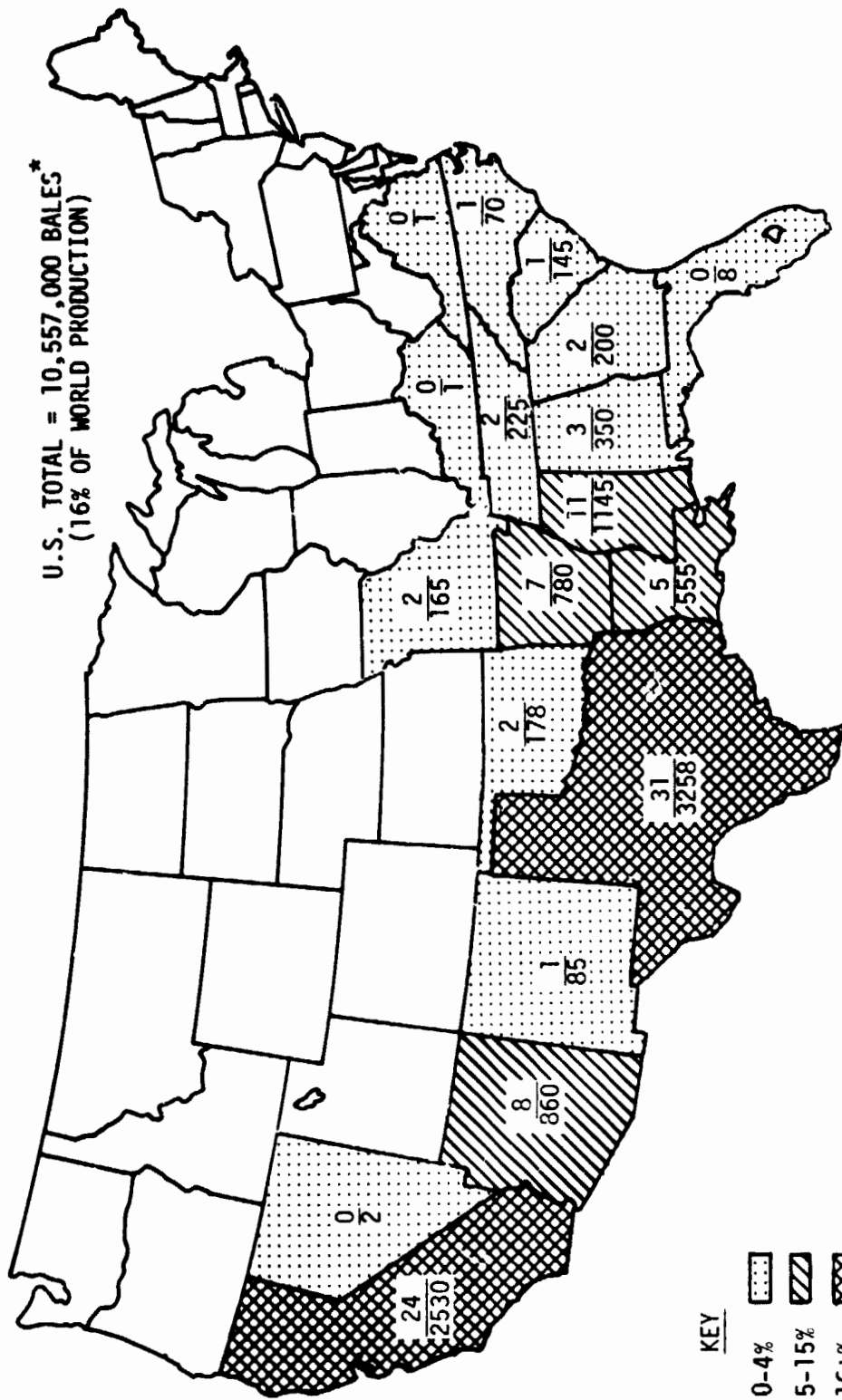
On the next several pages, some general information is discussed for each of the crops included in the data base for which benefit estimates are made. Following discussion of the eight crops, there is a summary table for their easy comparison.

STATISTICS ON EIGHT MAJOR AG-AIR CROPS

•	COTTON
•	RICE
•	WHEAT
•	VEGETABLES
•	CORN
•	SOYBEANS
•	SORGHUM
•	PEANUTS
•	SUMMARY TABLE

The production of cotton is shown in the map at the right. Texas produces 31 percent of the nation's cotton and is followed by California's 24 percent. The three states in the Mississippi Valley area account for 23 percent of the nation's cotton production. The United States as a whole produces 16 percent of the world's cotton.

COTTON CROP PRODUCTION (1,000 BALES)



KEY

- 0-4% [dotted pattern]
- 5-15% [diagonal lines]
- 16+% [cross-hatched pattern]

% U.S. (0 INDICATES <1% PRODUCTION)

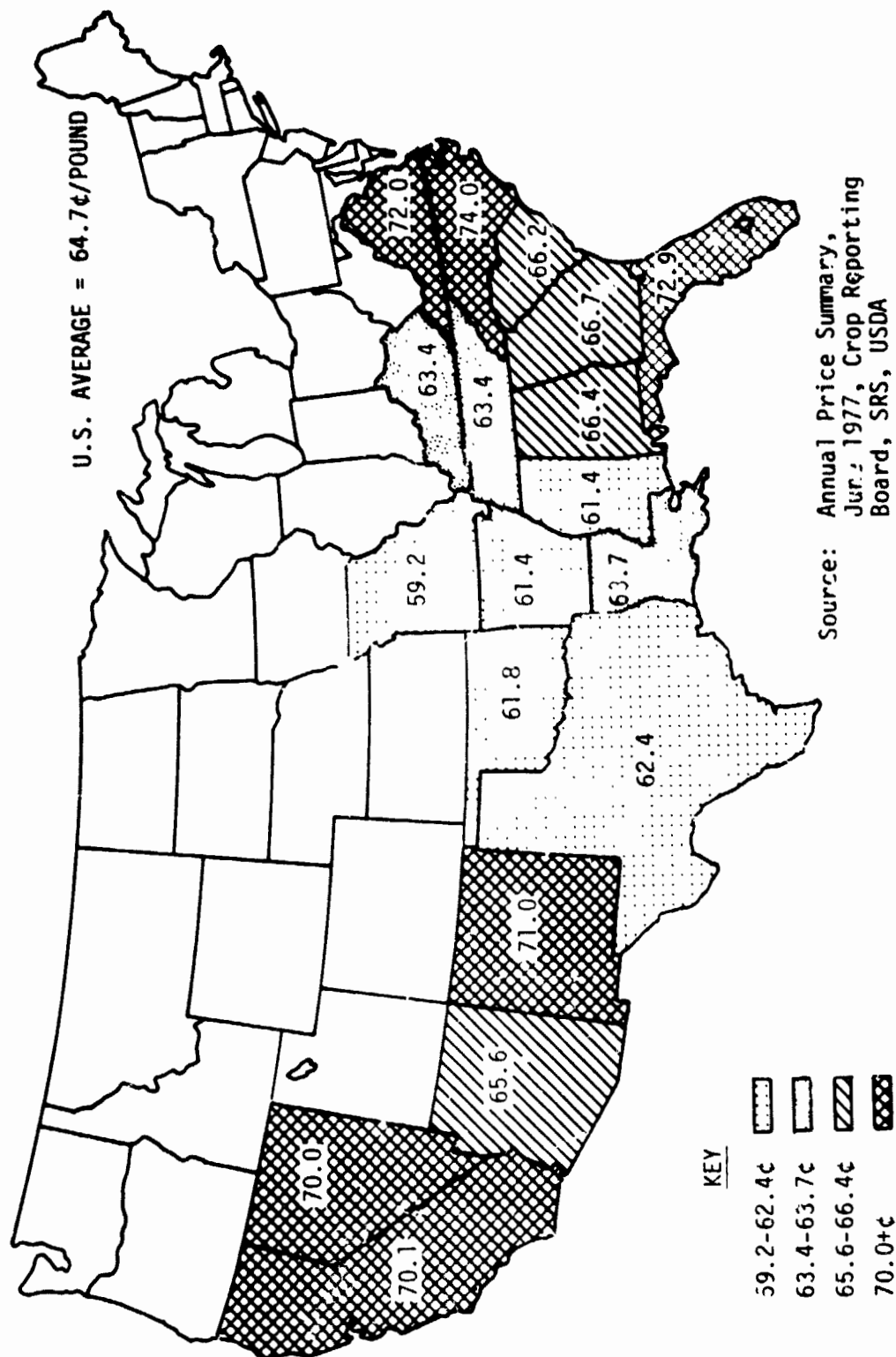
* 480 LB. NET WEIGHT BALES

Source: U.S. Crop Reporting Board,
Crop Production, Annual
Summary, January 1977

The average price of cotton received by farmers varies by state. The farmer in Texas, a high production region, receives a relatively low price for the cotton. The farmers in Georgia and Alabama receive a relatively high price for their cotton as do the growers in California. However, the value (price x production) of the cotton crop in Texas, California and in the Mississippi Valley area are all about equal. The value of the total U.S. crop is about \$3.3 billion. It is interesting to note that the revenue received per acre varies from \$760 in California to \$216 in Texas with the national average being \$300.

1976 SEASONAL AVERAGE PRICE OF COTTON LINT RECEIVED BY FARMERS (CENTS/POUND)

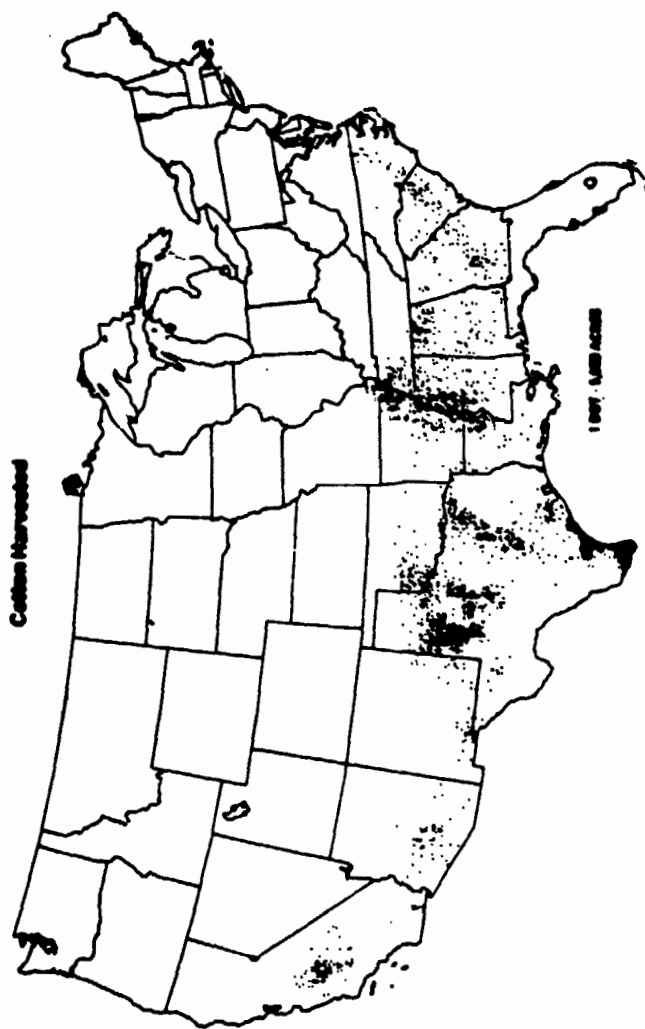
U.S. AVERAGE = 64.7¢/POUND



Source: Annual Price Summary,
 June 1977, Crop Reporting
 Board, SRS, USDA

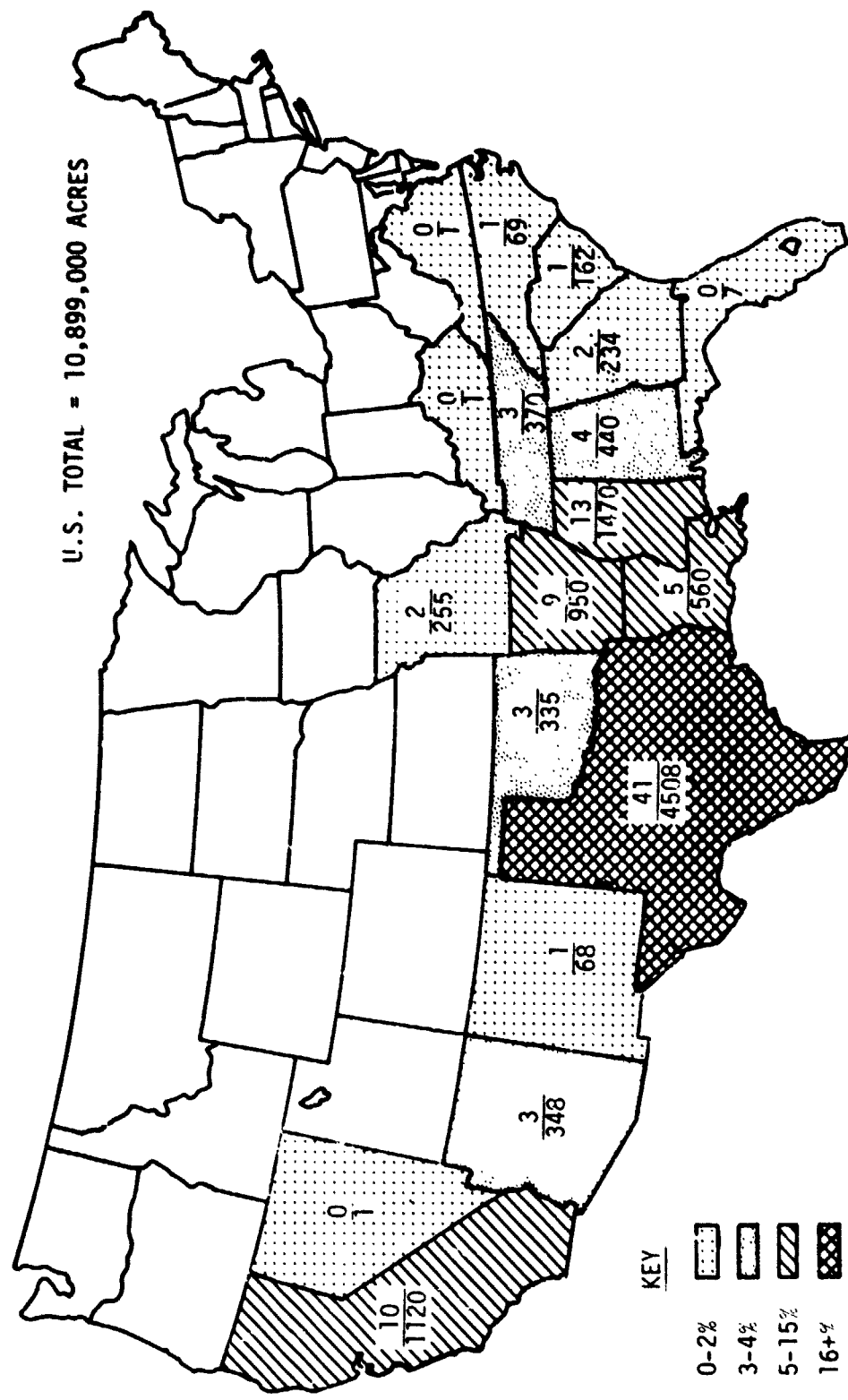
303

Cotton requires a long, frost-free season. Under tropical conditions, plants continue to grow each year and develop into trees. In the U. S., cotton is grown as an annual from seed planted after soils become sufficiently warm. Nearly 11 million acres of cotton were harvested in the U. S. in 1976. About 40 percent of this acreage is in Texas. Only 10 percent of the acreage is found in California which produces nearly as much cotton as Texas. About a third of the nation's cotton acreage is found in the Mississippi Valley. The map below shows the growing regions within each state. Approximately 60 percent of the acreage harvested is treated by air.



AREA OF COTTON HARVESTED (1,000 ACRES)

U.S. TOTAL = 10,899,000 ACRES



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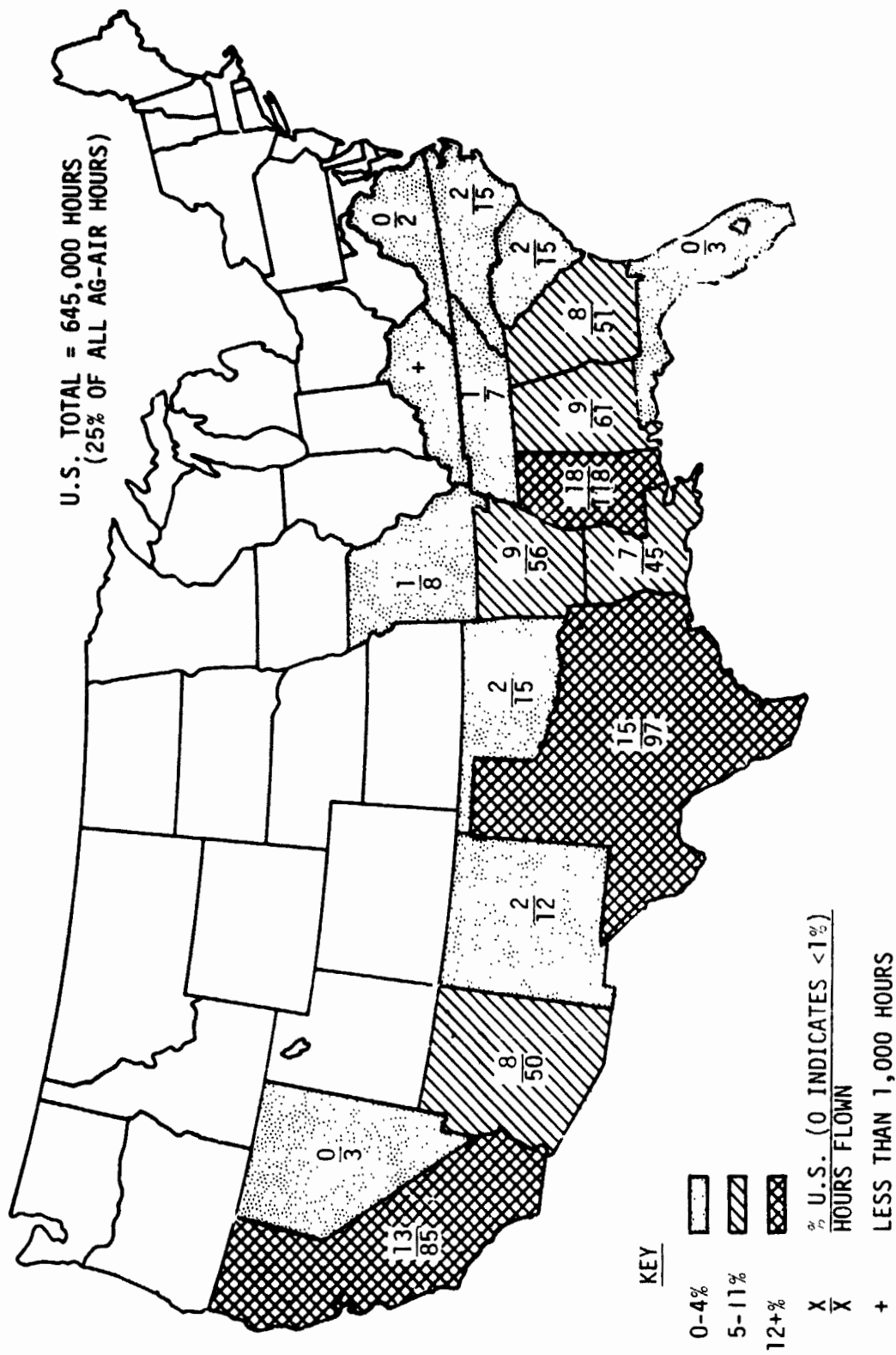
- 0-2%
- 3-4%
- 5-15%
- 16+%

% U.S. (0 INDICATES <1%)
AREA HARVESTED

Source: U.S. Crop Reporting Board,
Crop Production, Annual
Summary, January 1977

Estimates were made for the number of hours flown for cotton by each state. More hours are flown in Mississippi than are flown in all of Texas. This can be explained by the number of times the cotton crop is treated in the Mississippi Valley area. A grower in Mississippi will treat his cotton some 15 times, whereas in Texas the cotton is treated in some regions as little as 3 times, and in other regions up to 10 times. California has very stringent pesticide laws. The many chemicals that are used in the Mississippi area are restricted in California. Growers in California treat their crop about 5 times. The hours flown for cotton account for about 25 percent of all ag-air hours flown in the country.

ESTIMATED HOURS FLOWN FOR COTTON BY STATE (1,000 HOURS)



Data from the NAAA Questionnaires were tabulated by type of application for each crop. On a national average, the applications of insecticides account for over two thirds of all hours flown for cotton. The application of defoliants account for slightly over 10 percent of the hours. Very little time is spent applying herbicides. The miscellaneous applications include combinations such as herbicides and defoliants that cannot adequately be separated into the individual categories. Some respondents did not specify the type of applications but indicated only the hours flown per crop. These hours were classified as unattributed.

NATIONWIDE BREAKDOWN OF AG-AIR HOURS FOR COTTON

<u>APPLICATION</u>	<u>% OF TOTAL HOURS</u>
INSECTICIDE	69.7
DEFOLIANT/DESSICANT	11.3
HERBICIDE	3.0
FERTILIZER	0.6
MISCELLANEOUS	2.7
UNATTRIBUTED	<u>12.7</u>
	100.0

SOURCE: NAAA QUESTIONNAIRE DATA

Three states were chosen to show the variety of ag-air activities for cotton. In Mississippi about 80 percent of the hours flown are for the application of insecticides. In Texas about 77 percent of the hours are for insecticides. In California only 40 percent of the time is spent applying insecticides. However, for the application of defoliants, operators in Mississippi spend about 16 percent of their time, in Texas about 17 percent and in California about 53 percent. Trifluralin, an herbicide, is applied across the country. Toxaphene, an insecticide used extensively in the south, has been banned in California and Azodrin and Aldicarb are taking its place. Def and Folex, defoliants, are applied across the country; however, Paraquat, a rather expensive defoliant, is applied quite often in California and somewhat in Texas.

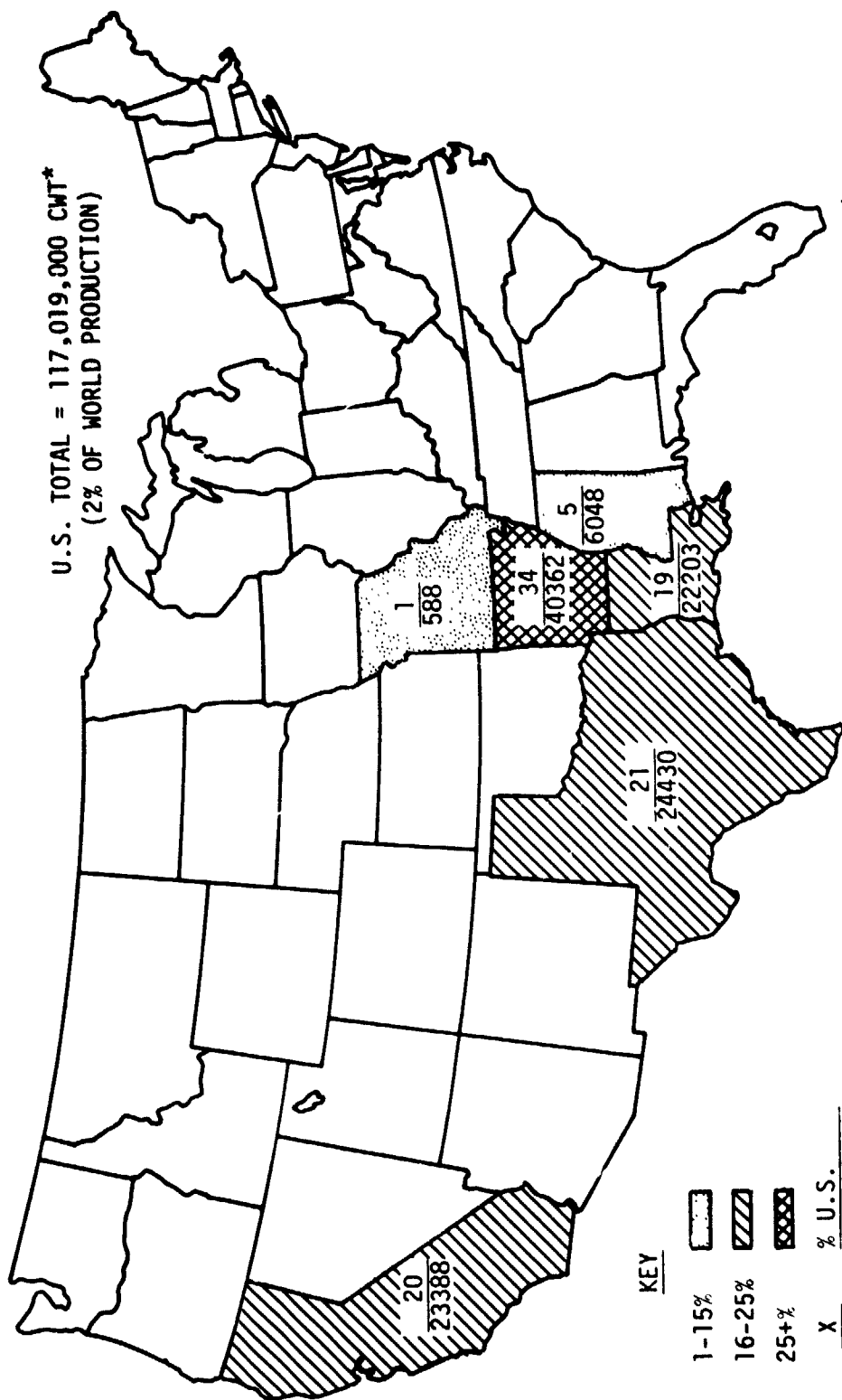
TYPICAL AG-AIR ACTIVITIES FOR COTTON

STATE	DATE	MATERIAL*	CHEMICAL NAME	AMOUNT OF CHEMICAL/ACRE	APPLICATION RATE OF TOTAL MIX/ACRE	NUMBER OF APPLICATIONS	REMARKS
MISSISSIPPI	MAY	HB	TRIFLURALIN MSMA; OSMA	1/4 GAL. 2/3 GAL.	5 - 10 GAL.	1	EITHER PRE OR POST IS USED
	JULY- OCTOBER	IN	6-3 TOXAPHENE- METHYL PARATHION 3-3 METHYL PARA- THION-EPN	1/3 - 1/2 GAL. 1/6 - 1/3 GAL.	1 - 2 GAL.	9 - 12	APPLIED EVERY 5 TO 7 DAYS FOR 10 TO 12 WEEKS
	OCTOBER- NOVEMBER	DF	DEF FOLEX	1/5 - 1/4 GAL.	5 GAL.	1	
TEXAS	APRIL- JUNE	HB	TRIFLURALIN MSMA; OSMA	1/4 - 1/3 GAL. 1/4 GAL.	3 GAL.	1 - 2	
	JUNE- OCTOBER	IN	6-3 TOXAPHENE- METHYL PARA- THION 3-3 METHYL PARA- THION-EPN	1/4 GAL. 1/8 - 1/4 GAL.	1 - 2 GAL.	5 - 12	NUMBER OF APPLICATIONS VARY BY REGION
	AUGUST- DECEMBER	DF	DEF; FOLEX ARSENIC ACID PARAQUAT	1/5 - 1/4 GAL. 1/8 - 1/2 GAL. 1/4 GAL.	1 - 2 GAL.	1	
CALIFORNIA	MARCH- MAY	HB	TRIFLURALIN SODIUM CHLORATE CACODYLIC ACID	1/4 GAL. 3 - 4 # 1/10 #	3 GAL.	1	
	MAY- NOVEMBER	IN	AZODRIN ALDICARB PARATHION	2/3 # 1 # 1/8 GAL.	1 GAL.	2	
	OCTOBER- NOVEMBER	DF	PARAQUAT DEF FOLEX	1/5 GAL. 1/4 - 1/3 GAL. 1/4 - 1/3 GAL.	1 - 2 GAL.	2	ACCOUNTS FOR ABOUT 53 OF HOURS

* HB-HERBICIDE, IN-INSECTICIDE, DF-DEFOLIANT

About one third of the nation's production of rice is centered in Arkansas. The other two thirds are shared equally by Louisiana, Texas and California. The total U.S. production of 11.7 billion pounds of rice represented just 2 percent of the world's production in 1976.

RICE CROP PRODUCTION (1,000 CWT)



KEY

1-15%

16-25%

25+%

X

% U.S. PRODUCTION

*

CWT (HUNDREDWEIGHT) = 100 LBS.

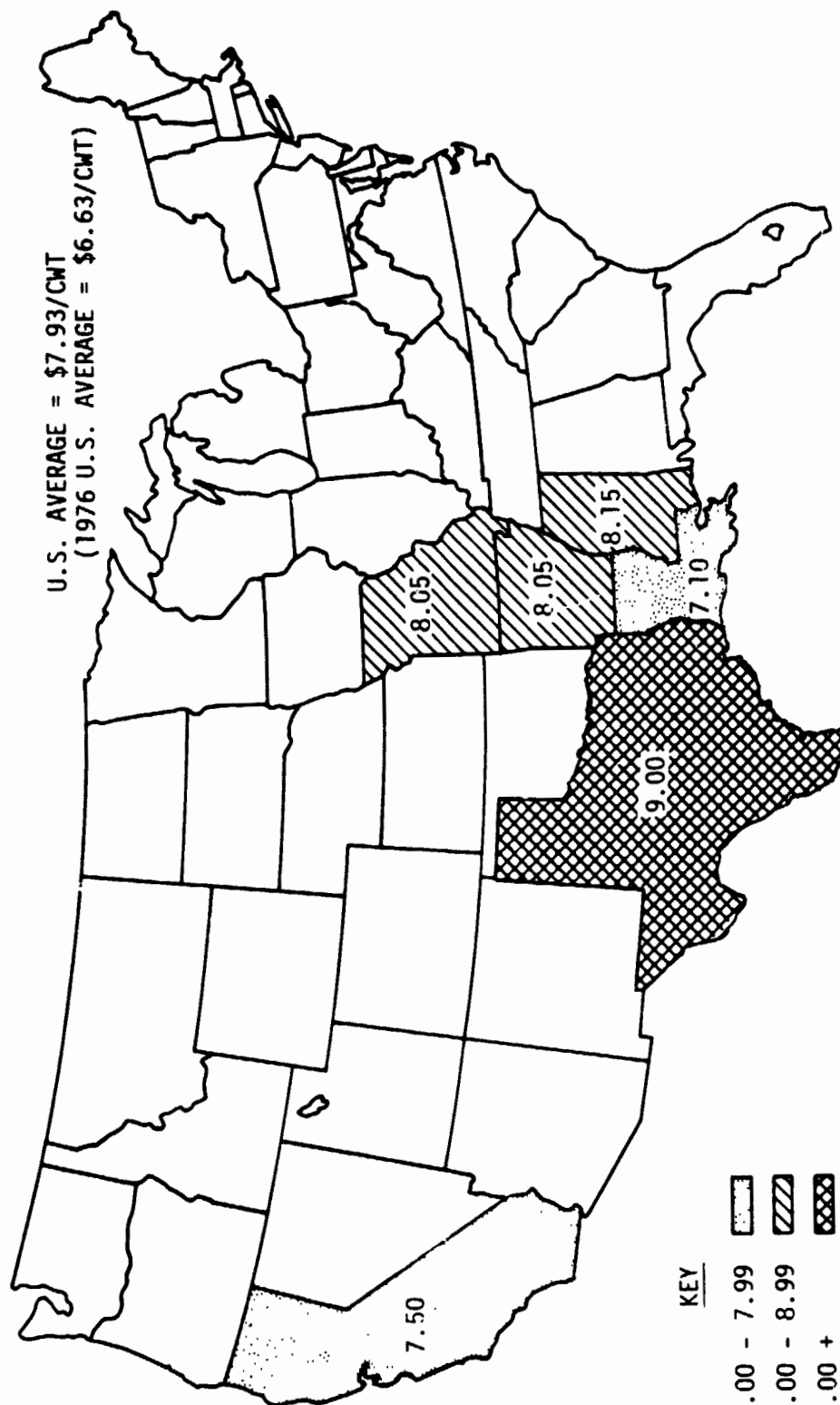
Source: U.S. Crop Reporting Board,
Crop Production, Annual
Summary, January 1977

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The average price of rice received by farmers in 1976 was \$6.63/Cwt. making the total value of the crop for that year to be nearly \$776 million. In 1975* Arkansas accounted for slightly over a third the value of the rice crop. However, because of the higher price received by farmers for rice in Texas, that state accounted for about 25 percent of the nation's total value of the crop. The value of the crop in California and Louisiana was almost equal, at 19 percent and 17 percent of the total value.

_____* USDA discontinued publishing the seasonal average price by state for rice in September 1976. Figures shown at the right are for the 1975 season.

1975 SEASONAL AVERAGE PRICE OF RICE RECEIVED BY FARMERS (DOLLARS/CWT)



KEY

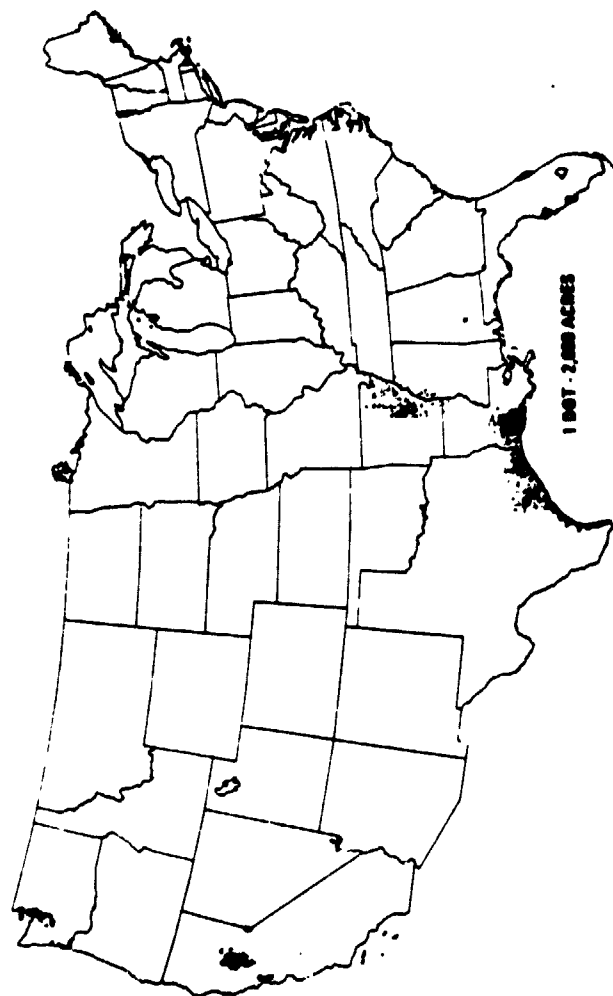
\$7.00 - 7.99	
\$8.00 - 8.99	
\$9.00 +	

Source: Annual Price Summary,
June 1976, Crop Reporting
Board, SRS, USDA

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Successful rice culture depends upon high temperatures during the growing season, a dependable fresh water supply for the irrigation period, soils that are comparatively level and underlaid with impervious subsoil, and good drainage. Areas which meet these requirements are the Coastal Prairie region of southwestern Louisiana and southeastern Texas, eastern Arkansas and northwest Mississippi, and the central valleys of California (particularly the Sacramento Valley). Production in the U. S. is confined mainly to these three regions. About 2.5 million acres of rice were harvested in 1976. Once again Arkansas accounts for about one-third of the total acreage. California, Texas and Louisiana are again about equal. The map below shows the three principal regions where rice is grown. Over 95 percent of all rice acreage is treated by air.

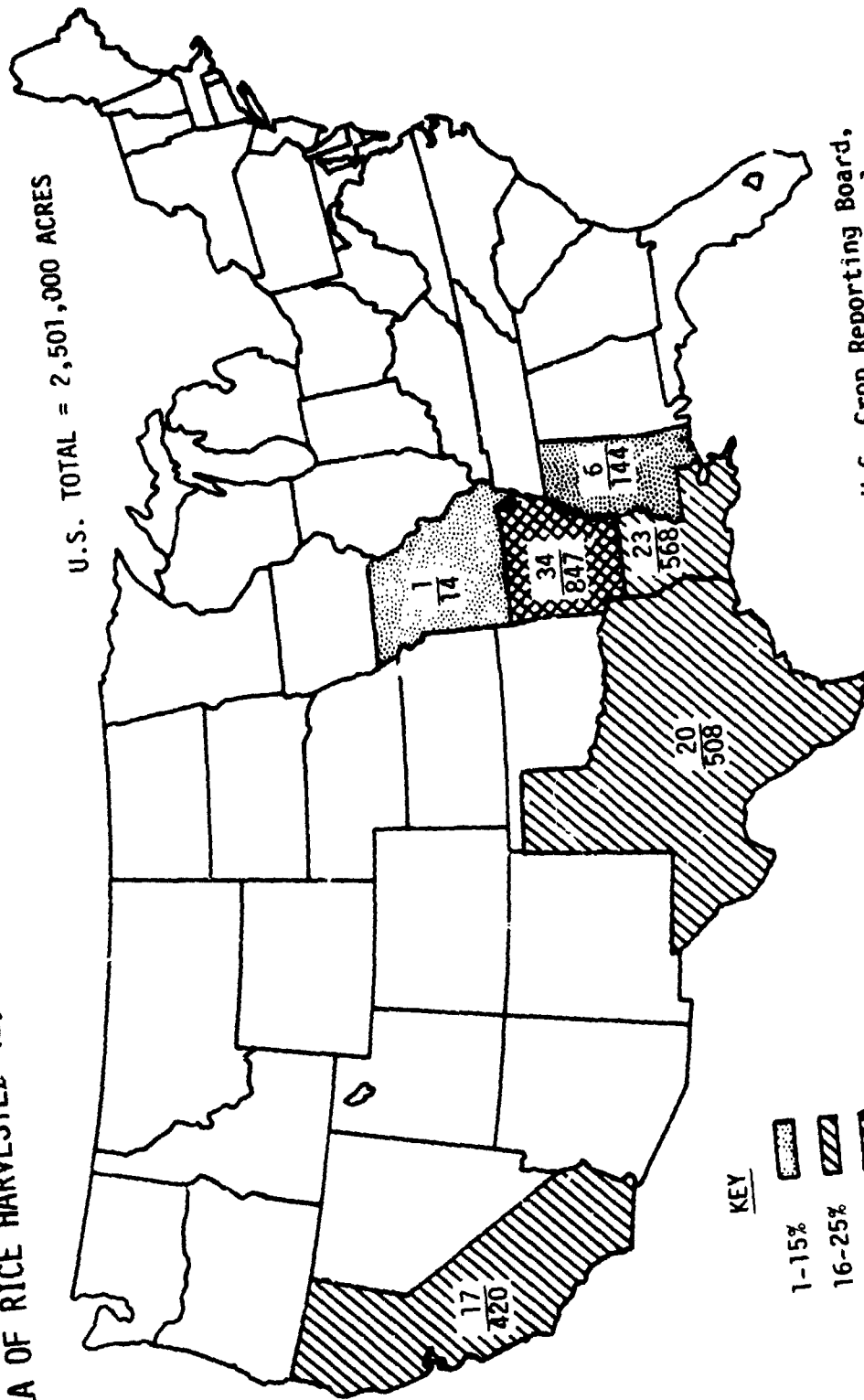
Rice Harvested



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AREA OF RICE HARVESTED (1,000 ACRES)

U.S. TOTAL = 2,501,000 ACRES



KEY

- 1-15%
- 16-25%
- 26+%
- $\frac{X}{X}$

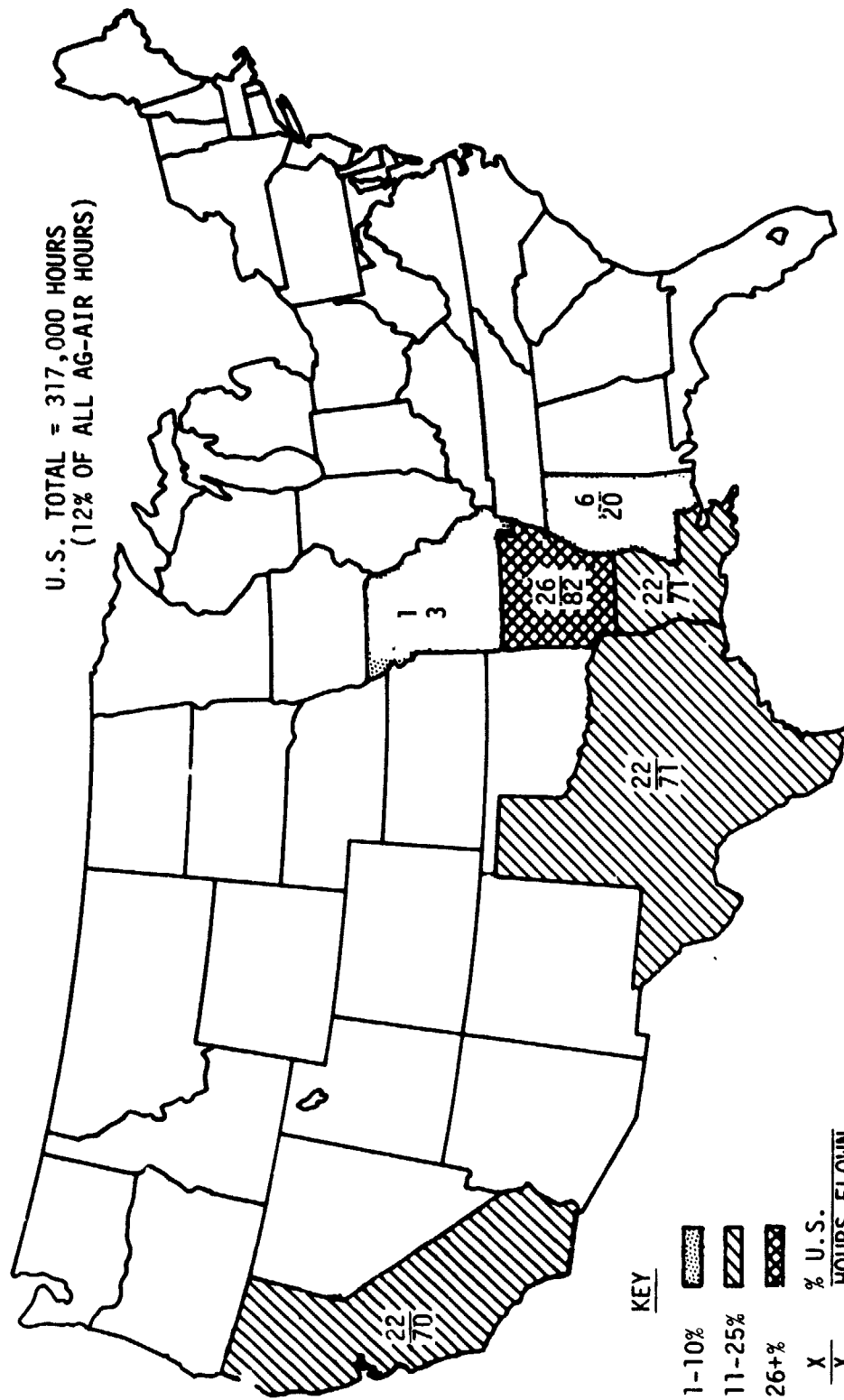
% U.S.
AREA HARVESTED

Source: U.S. Crop Reporting Board,
Crop Production, Annual
Summary, January 1977

econ

Estimated hours flown for rice in each state are shown on the map at the right. California, Texas and Louisiana are about equal in the number of hours flown. Arkansas accounts for slightly over one-fourth of the nation's hours. Differences in number of applications and percent of acreage treated accounts for the equality in hours flown for these four states in which acreage varies by over 100,000 acres. Rice accounts for 12 percent of the nation's ag-air hours.

ESTIMATED HOURS FLOWN FOR RICE BY STATE (1,000 HOURS)



Tabulation of the data from the NAAA Questionnaires shows that nearly half of the time spent flying over rice is for application of fertilizers. The other half is divided between applying herbicides and seeds. Although most of the acreage is treated with insecticides, the high productivity of the aircraft associated with low application rates accounts for the small number of hours attributed to this activity.

NATIONWIDE BREAKDOWN OF AG-AIR HOURS FOR RICE

<u>APPLICATION</u>	<u>% OF TOTAL HOURS</u>
FERTILIZER	40.2
HERBICIDE	19.9
SEED	14.9
INSECTICIDE	5.0
FUNGICIDE	0.7
UNATTRIBUTED	19.3
	<u>100.0</u>

SOURCE: NAHA QUESTIONNAIRE DATA

The rice farmers use aerial applications extensively for seeding, fertilization, and pest control. The ag-air activities for the various states are nearly identical. The basic difference occurs in the type of chemical used, percent of acreage treated and application rates. For example, in California virtually all of the acres are seeded by air, in Louisiana about 70 percent, and in Arkansas, less than 50 percent. The herbicide propanil is used for broadleaf weed control in all states except California where MCPA is used instead. A detailed breakdown of ag-air activities over rice in California is shown here.

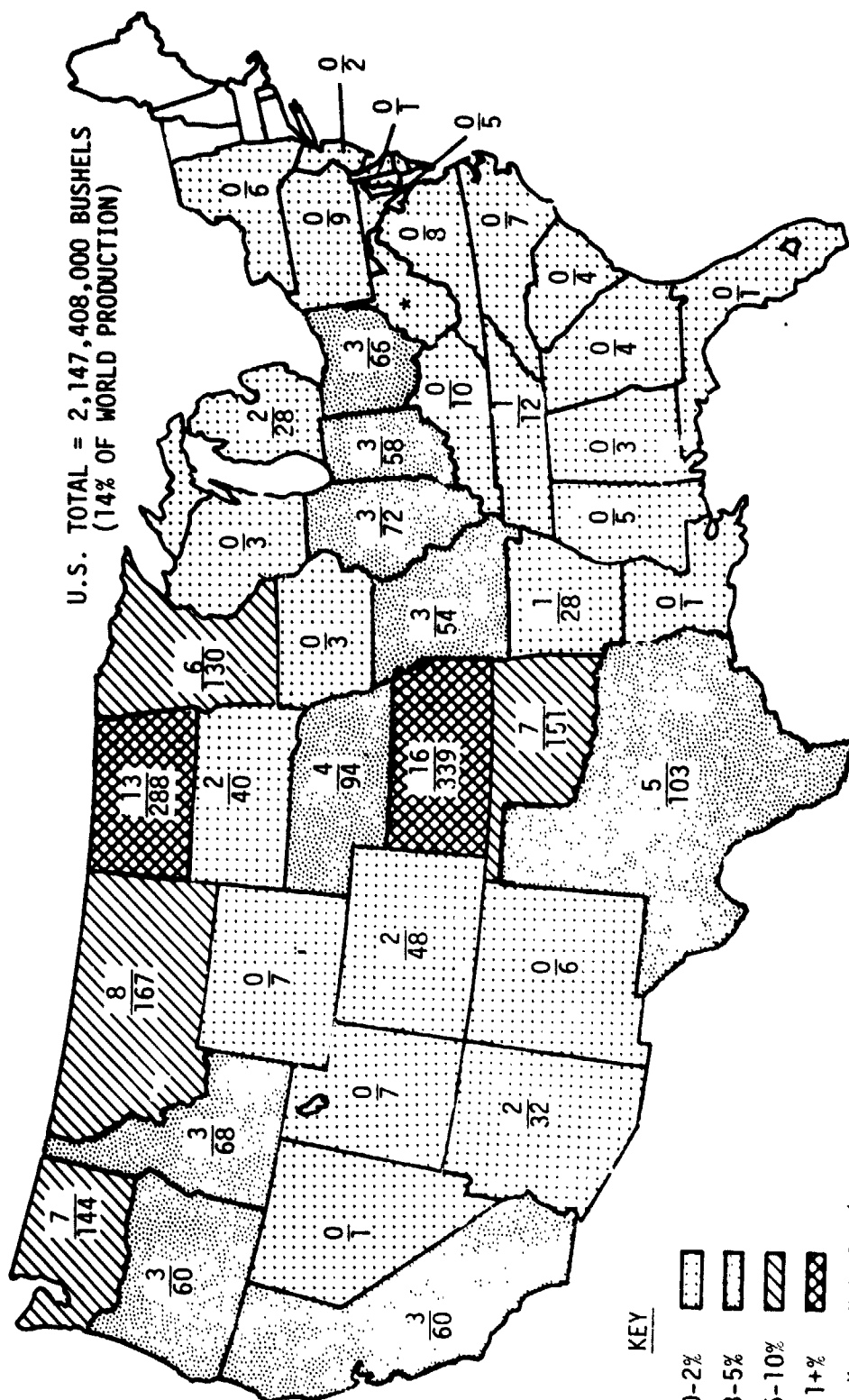
TYPICAL AG-AIR ACTIVITIES OVER RICE FOR CALIFORNIA

MONTH	TYPICAL FIELD ACTIVITY	RICE GROWTH STAGE	% ACRES TREATED BY AIR	NUMBER OF APPLICATIONS	MATERIALS* USED	AMOUNT OF TECHNICAL MATERIALS	TOTAL MIX APPLICATION RATE
MARCH	SEEDBED PREPARATION--PLOW, DISC LEVELING WITH LANDPLANE (PLOW), SURVEY, MARK, AND MAKE LEVELS						
APRIL	THREE-WHEEL PLANE (PLOW) FERTILIZE BARNYARDGRASS CONTROL RICE WATER WEEVIL CONTROL DISC OR HARBOR CLOSE LEVELS FLOOD FIELD TREAT AND SOAK SEED SOW		60 60 40 80 35	2 1 1 1 1	FL-NITROGEN FL-PHOSPHOROUS FL-ZINC HB-MOLINATE IN-CARBOTURAN	30-60# 18-26# 8-16# 3# 1/2# 1#	150-300# 150-250# 25-50# 30# 10# 10#
		SEEDED	100	1	SD-SHORT AND MEDIUM GRAIN	125-150#	150-200#
MAY	RICE STAND ESTABLISHED CONTINUE IRRIGATION TADPOLE SHRIMP CONTROL ALGAE CONTROL	SEEDLING EMERGENCE	75	1	2N-PARATHION	1/5-1 PT. (1-5#)	1/2-2 GAL.
JUNE	RICE LEAFMINER CONTROL CONTINUE WATER MANAGEMENT	TILLERING					
JULY	BROADLEAF WEED CONTROL (WATER GRASS) TOP DRESSING RAISE WATER LEVEL	INTERNODE ELONGATION BOOT	80 60	1 1	HB-MCPA FL-NITROGEN	1-2 PT. (1#) 30-50#	10 GAL. 150-250#
AUGUST	CONTINUE WATER MANAGEMENT	HEADING AND FLOWERING					
SEPTEMBER	GRAIN FIELDS	GRAIN FORMATION					
OCTOBER	HARVEST	MATURITY					

* FL-FERTILIZER, HB-HERBICIDE, IN-INSECTICIDE, SD- SEED

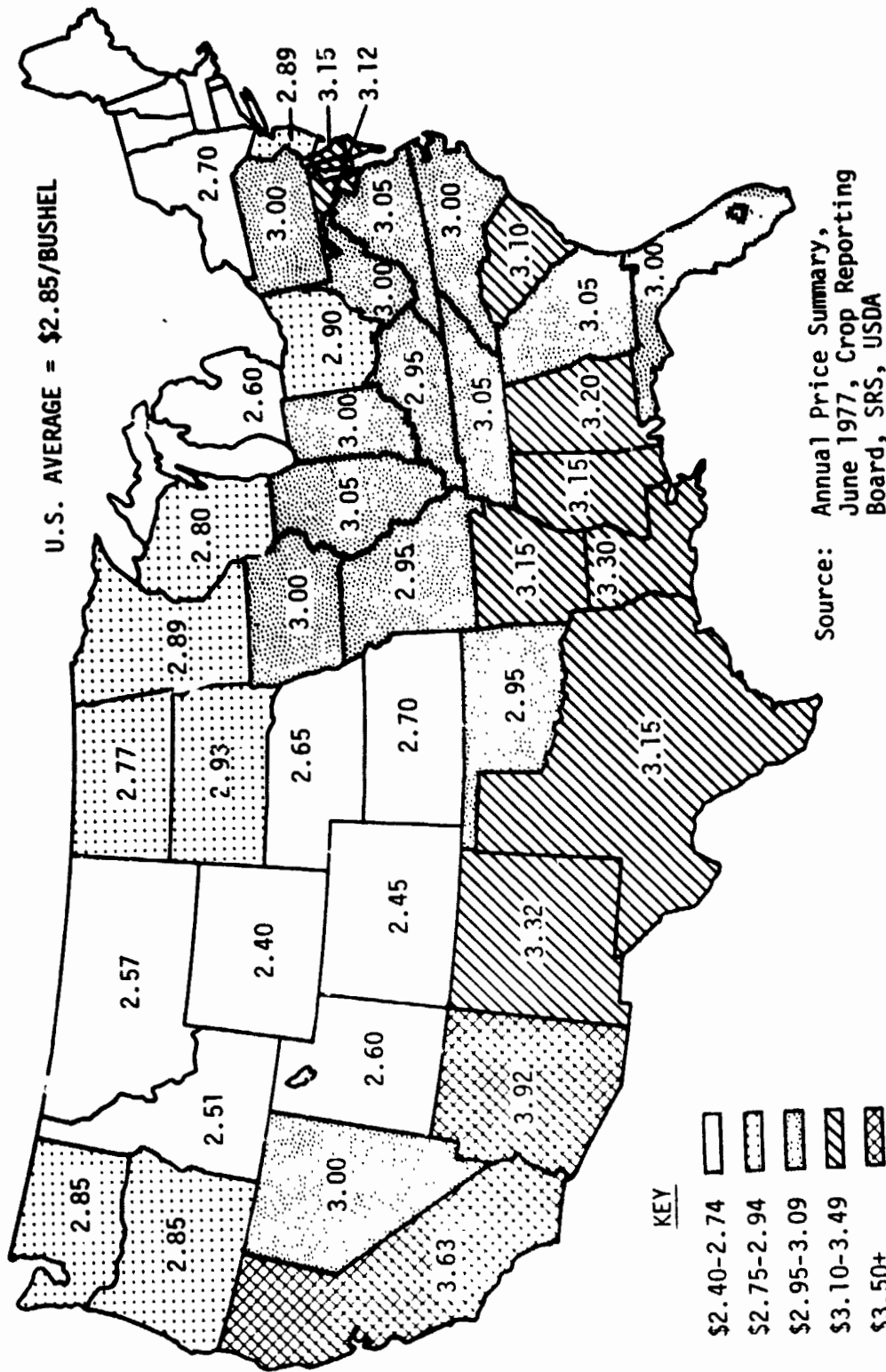
The United States produced over 2 billion bushels of wheat in 1976, which was 14 percent of the world's production. Just under a third of this production is centered in Kansas and North Dakota. Another third is shared between Montana, Washington, Minnesota, Oklahoma, and Texas. The remaining third is divided among the other states. Winter wheat predominates in the more southern regions whereas spring wheat is planted in the north.

WHEAT CROP PRODUCTION (1,000,000 BUSHELS)

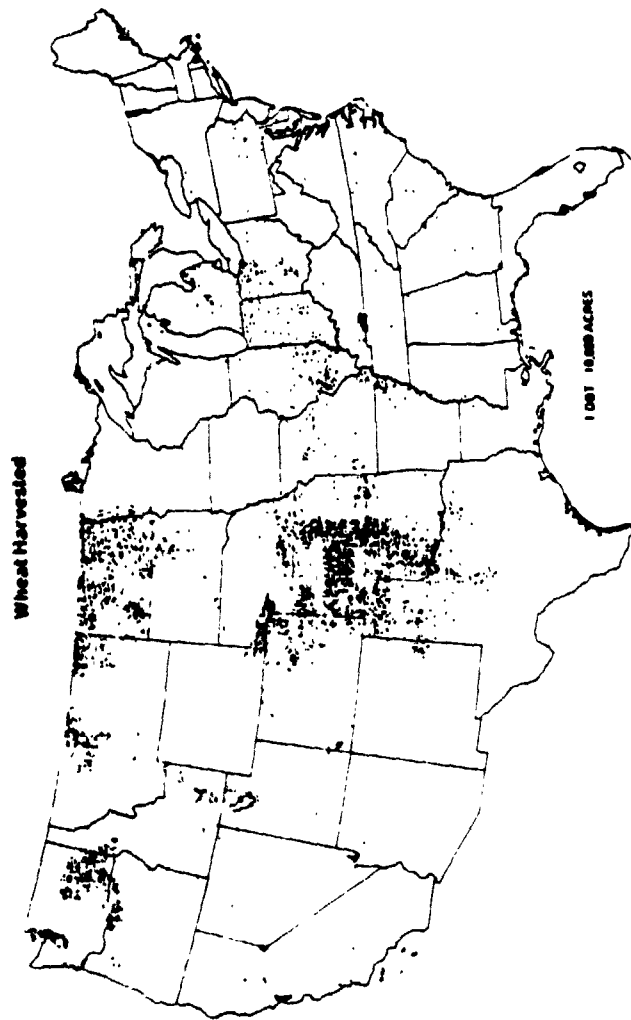


Higher prices are received for wheat in areas where the production is low than are received in areas where the production is high. The national value of the wheat crop for 1976 was slightly over \$6.1 billion. Again, Kansas and North Dakota account for just under a third of the value. Montana, Washington, Minnesota and Oklahoma also account for a third of the value.

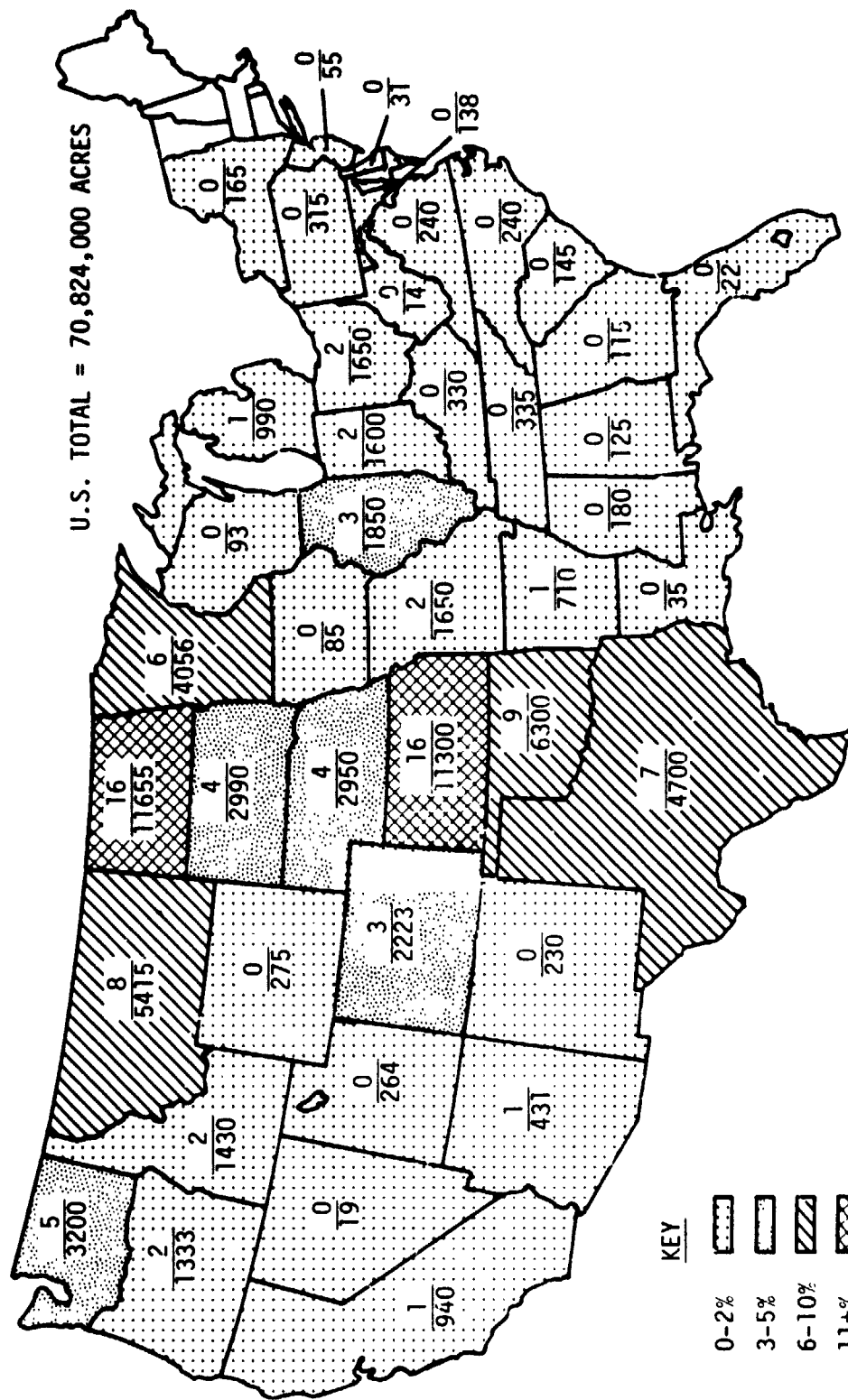
1976 SEASONAL AVERAGE PRICE OF WHEAT RECEIVED BY FARMERS (DOLLARS/BUSHEL)



Spring wheat is planted in the late spring and harvested late in the summer. Spring wheat is primarily grown in the West North Central and Northwestern States. Winter wheat is planted in the fall of the year. When weather conditions are favorable for early fall growth, much of the winter wheat in the Great Plains area is grazed in the fall prior to going into dormancy and again in the late winter and early spring when new growth starts. The United States harvested slightly over 70 million acres of wheat in 1976. A third of this wheat was grown in Kansas and North Dakota. Another third was grown in Oklahoma, Montana, Texas and Minnesota. Winter wheat is grown primarily in Kansas and spring wheat mainly in North Dakota. The map below shows the growing regions within each state of both winter and spring wheat. About 20 percent of the acres of wheat harvested are treated by air.

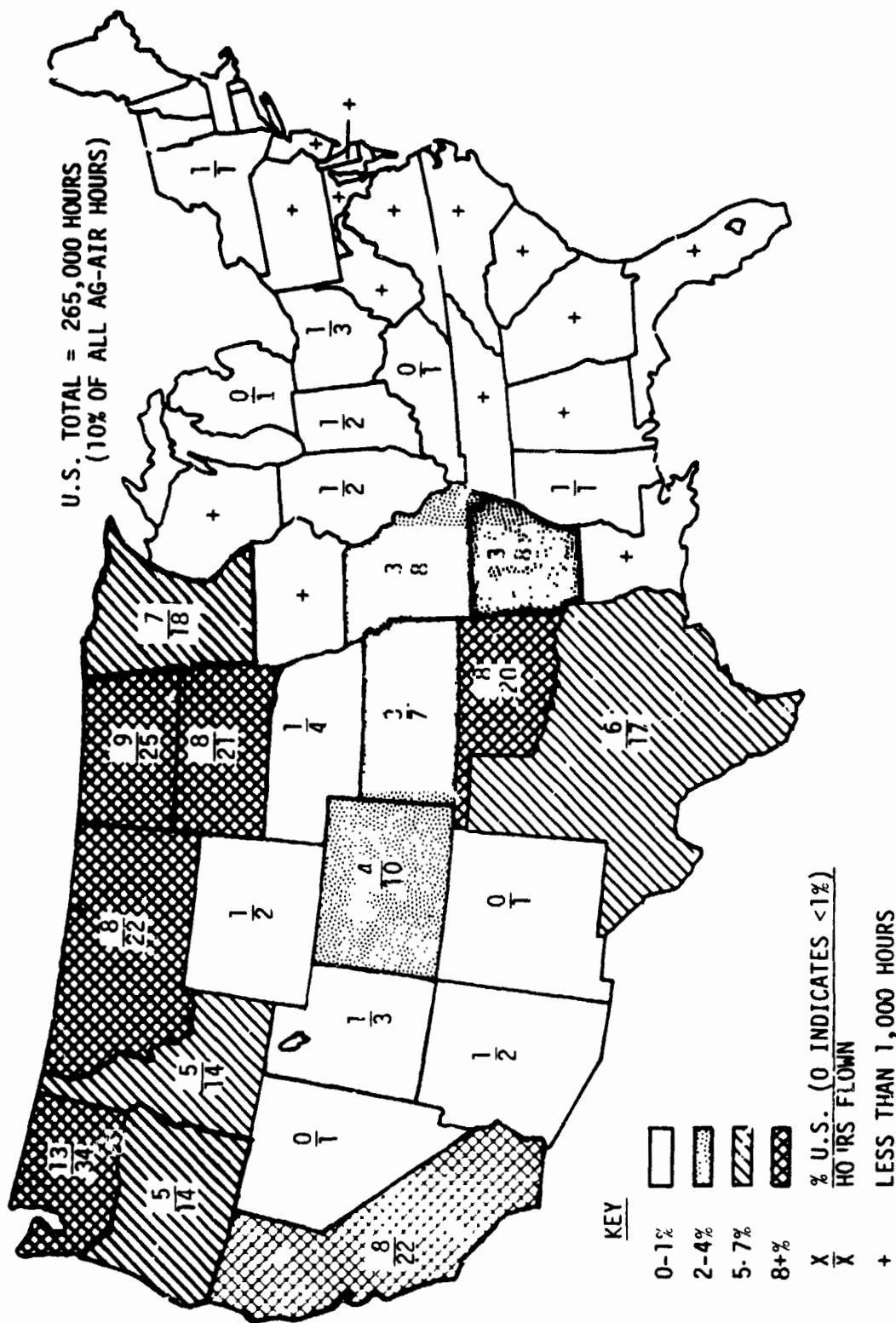


AREA OF WHEAT HARVESTED (1,000 ACRES)



The estimates for the number of hours flown for each state for wheat are shown at the right. Kansas, the largest wheat-producing state, is not an important wheat state for ag-air. Over half of the hours flown on wheat in the country are centered in the north. California, Oklahoma and Texas follow in importance. The reasons why so few hours are flown in Kansas is explained later in this report. The total hours flown for wheat account for about 10 percent of all ag-air hours and are quite variable from year to year.

ESTIMATED HOURS FLOWN FOR WHEAT BY STATE (1,000 HOURS)



The national breakdown of ag-air hours for wheat shows that over half of the time is spent applying herbicides. Because some respondents reported seeding as a general activity by itself not associated with any specific crop, the hours reported here for seeding may be less than what is actually done. However, seeding by air is still of minor importance in wheat.

NATIONWIDE BREAKDOWN OF AG-AIR HOURS FOR WHEAT

<u>APPLICATION</u>	<u>% OF TOTAL HOURS</u>
HERBICIDE	53.0
INSECTICIDE	22.1
FERTILIZER	9.2
SEED	2.6
FUNGICIDE	1.7
MISCELLANEOUS	4.4
UNATTRIBUTED	<u>7.0</u>
	100.0

SOURCE: NAAA QUESTIONNAIRE DATA

Four states were chosen to show the variety of ag-air activities for wheat. Applications in the northern states appear to be very similar. Most of the time is spent applying the herbicide 2,4-D. However in the south, Oklahoma and Texas, most of the activity is in applying insecticides.

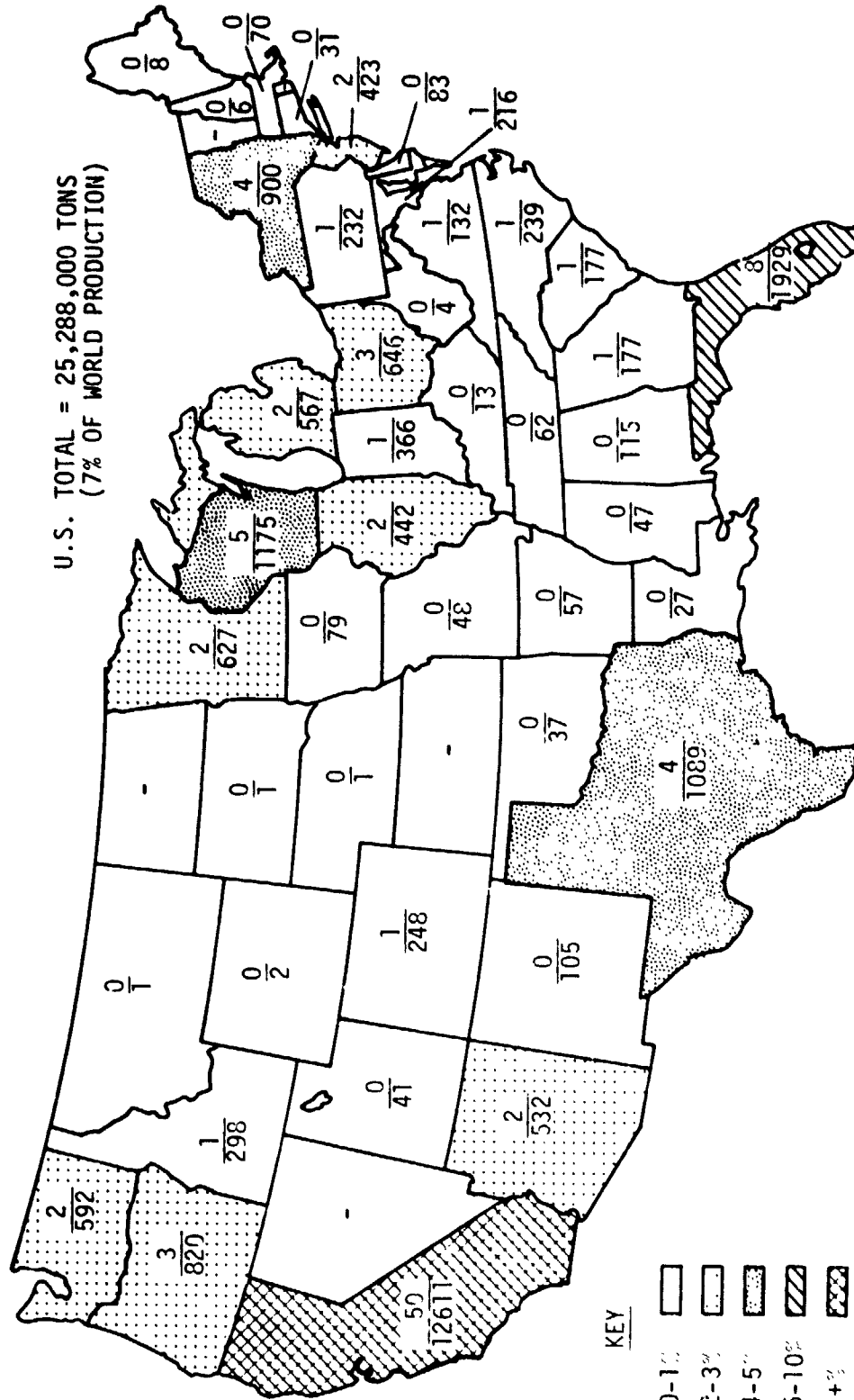
TYPICAL AG-AIR ACTIVITIES FOR WHEAT

STATE	DATE	MATERIAL*	CHEMICAL NAME	AMOUNT OF CHEMICAL/ACRE	APPLICATION RATE OF TOTAL MIX/ACRE	NUMBER OF APPLICATIONS	REMARKS
NORTH DAKOTA	APRIL-JULY	HB	2,4-D	1/2 - 1 PT.	1 - 2 GAL.	1	OVER 90% OF HOURS
	FEBRUARY-MARCH	FL	NITROGEN	-	100 - 200#	1	TOP DRESSING
		IN	PARATHION	1 - 2 PT.	1 - 2 GAL.	1	ABOUT 80% OF HOURS
OKLAHOMA	FEBRUARY-JUNE	HB	2,4-D	1/2 - 1 1/4 PT.	1 - 3 GAL.	1	
	FEBRUARY-MARCH	FL	NITROGEN	-	100#	1	TOP DRESSING
		IN	PARATHION	1 - 2 PT.	1 GAL.	1	ABOUT 60% OF HOURS
TEXAS	FEBRUARY-JUNE	HB	2,4-D	1/2 - 1 PT.	1 - 2 GAL.	1	
	APRIL-JULY	HB	2,4-D	1/2 - 1 PT.	2 - 3 GAL.	1	OVER 90% OF HOURS
		HB	2,4-D	1/2 - 1 PT.	2 - 3 GAL.	1	OVER 90% OF HOURS

* HB-HERBICIDE, FL-FERTILIZER, IN-INSECTICIDE

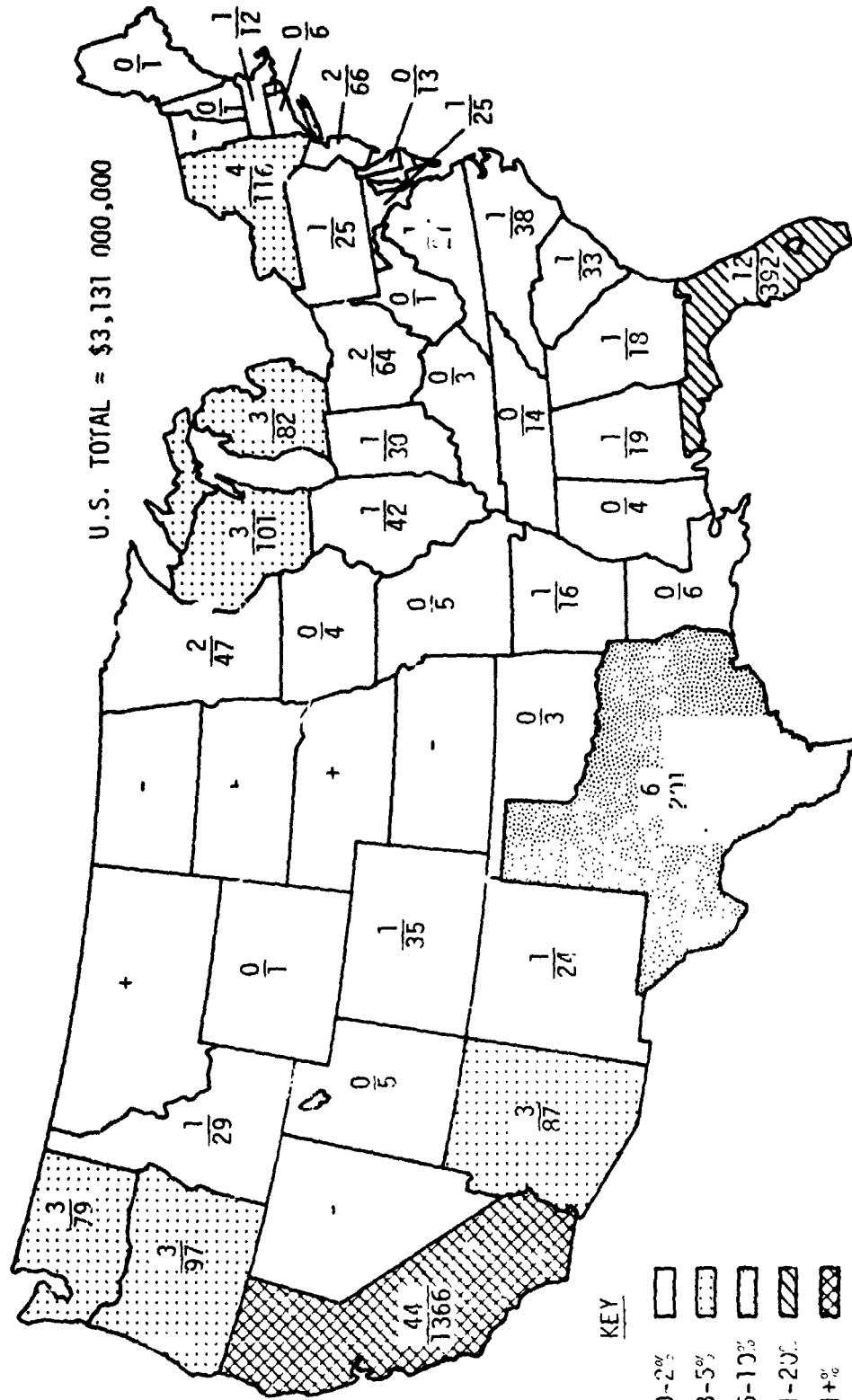
About 50 percent of the nation's vegetable production is centered in California. Florida produces about 8 percent of the nation's vegetable crop. Wisconsin, Texas and New York together produce about 13 percent. These five states account for over 70 percent of the nation's vegetable production. The United States accounts for over 7 percent of the world vegetable production. Vegetables for both fresh market and processing are included in these figures.

VEGETABLE CROP PRODUCTION (1,000 TONS)



With such a wide range of prices for different vegetable crops, the total value of all vegetable crops is shown at the right instead of individual crop prices. California accounts for 44 percent of the total U.S. vegetable crop value. Florida follows with 12 percent. Texas, New York and Wisconsin account for 13 percent of the crop value. These five states together account for about 70 percent of the nation's vegetable crop value.

VALUE OF PRINCIPAL VEGETABLE CROPS (1,000,000 DOLLARS)



Source: Agricultural Statistics
1976, USDA

U.S. (0 INDICATES <1%)

VALUE

LESS THAN \$1,000,000

NO DATA GIVEN

KEY

- 0-2%
- 3-5%
- 6-10%
- 11-20%
- 21+%

X
X

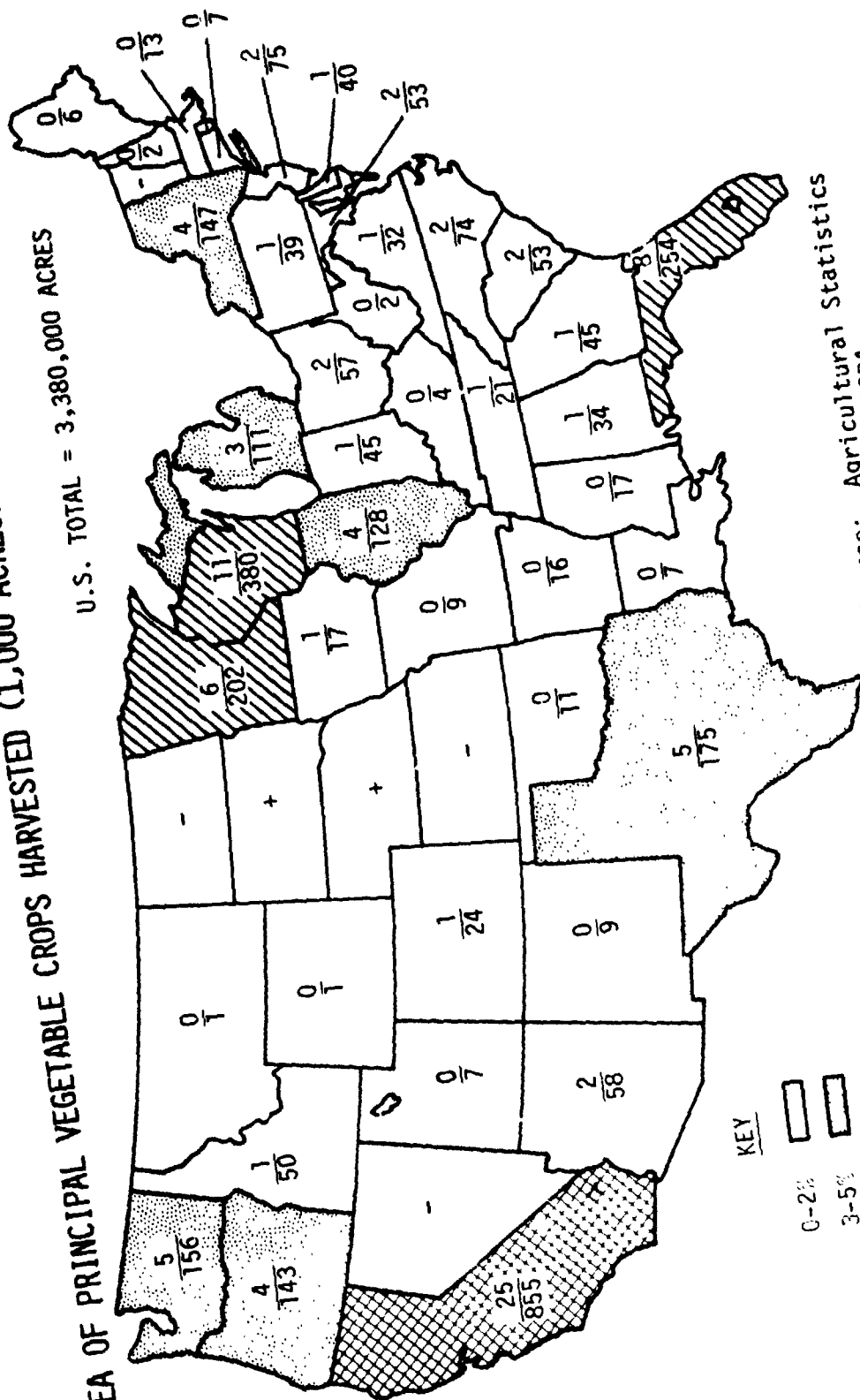
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Over 3 million acres of principal vegetables were harvested in 1975. This acreage does not include home gardens. About 25 percent of the nation's acreage is located in California. All types of vegetables are grown in California but the two principal crops are tomatoes and lettuce. Over 50 percent of California's vegetable acreage is devoted to these two crops alone. Wisconsin grows sweet corn, peas and snapbeans and accounts for 11 percent of the nation's vegetable acreage. Most vegetable crop types are grown in Florida but the most important are sweet corn, watermelons, snapbeans and tomatoes. Florida accounts for 8 percent of the nation's acreage. Minnesota accounts for 6 percent of the nation's vegetable acreage. The principal vegetable crops in Minnesota are sweet corn and peas. Important vegetable crops are: in Texas, melons and onions; in Washington, peas and sweet corn; in New York, beans and sweet corn; in Oregon, peas and sweet corn; and in Illinois, sweet corn. Only about 53 percent of the nation's acreage is found in the five principal states of vegetable production and crop value. Between 30 and 50 percent of the nation's vegetable acreage is treated by air.

AREA OF PRINCIPAL VEGETABLE CROPS HARVESTED (1,000 ACRES)

U.S. TOTAL = 3,380,000 ACRES



KEY

- 0-2%
- 3-5%
- 6-15%
- 16+%

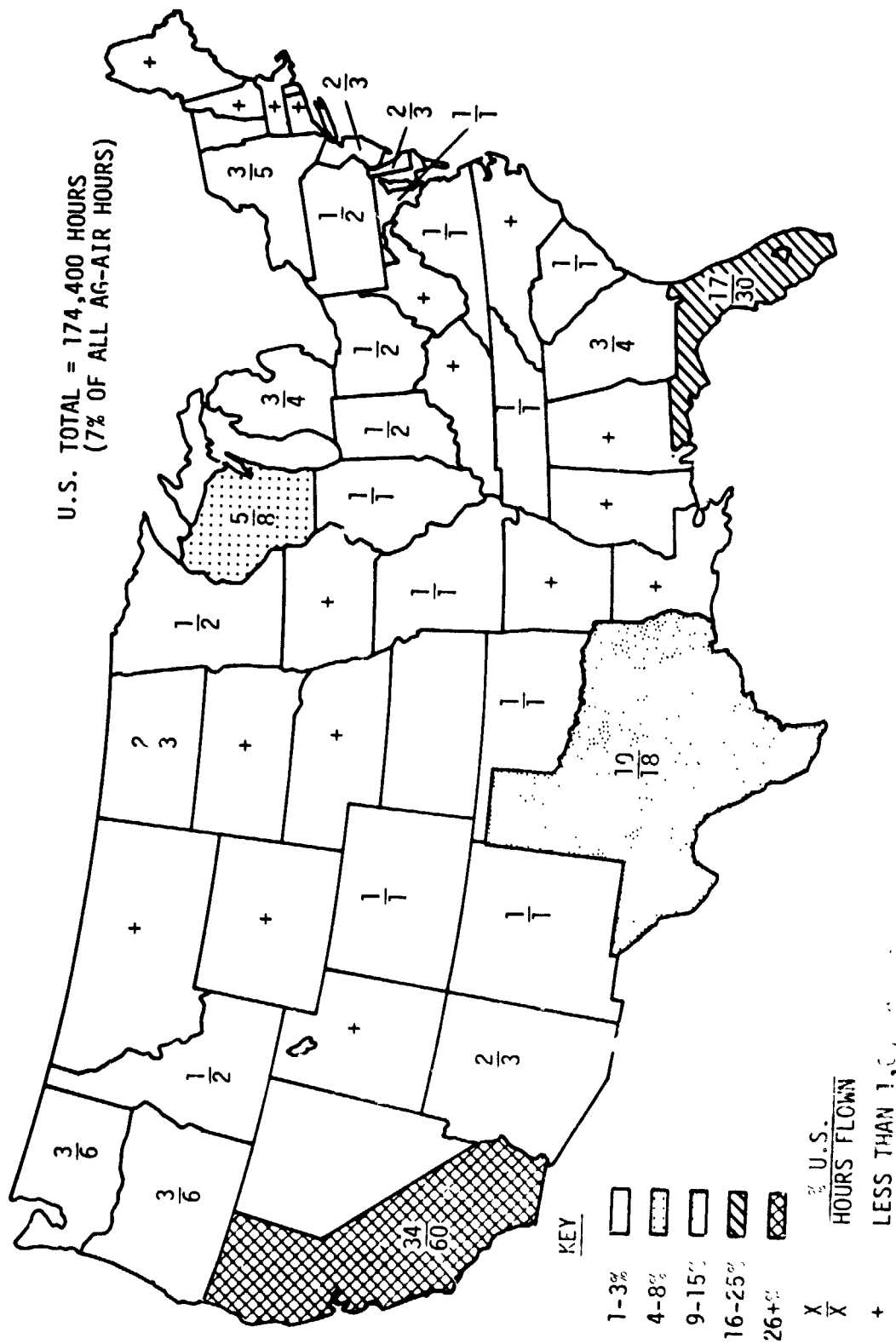
% U.S. (0 INDICATES < 1%)
 AREA HARVESTED
 LESS THAN 1,000 ACRES
 NO DATA GIVEN

Source: Agricultural Statistics
 1976, USDA

88

Estimates were made for the number of hours flown for vegetables by each state. California accounts for 34 percent of the nation's hours followed by Florida with 17 percent and Texas with 10 percent. Wisconsin and New York account for 8 percent of the nation's hours. These five areas account for about 70 percent of all hours flown for vegetables. About 7 percent of all ag-air hours are for applications to vegetables.

ESTIMATED HOURS FLOWN FOR VEGETABLES BY STATE (1,000 HOURS)



A breakdown of ag-air hours for vegetables is shown at the right. Most of the applications are for control of insects. A fungicide is often added to the spray mix and applied along with one or more insecticide applications. Most weed control is done either by ground rigg at the time of soil preparation or by hand during the growing season.

NATIONWIDE BREAKDOWN OF AG-AIR HOURS FOR VEGETABLES

<u>APPLICATION</u>	<u>% OF TOTAL HOURS</u>
INSECTICIDE	43.7
FUNGICIDE/INSECTICIDE	22.7
FUNGICIDE	12.9
HERBICIDE	2.1
MISCELLANEOUS	10.6
UNATTRIBUTED	8.0
	<u>100.0</u>

SOURCE: NAAA QUESTIONNAIRE DATA

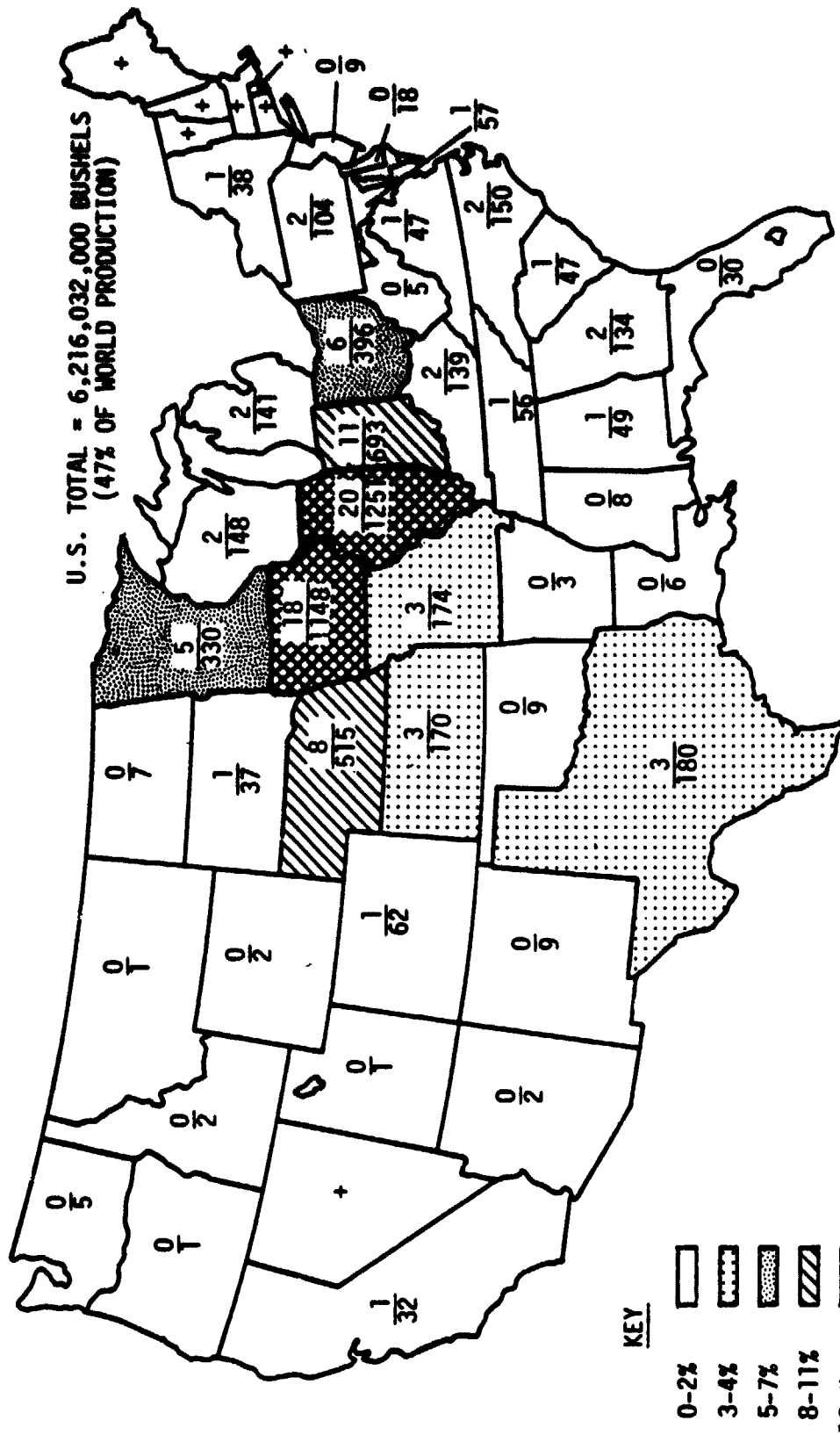
Two states were chosen to show the large variety of ag-air activities for vegetables. In California an application rate of 10 gallons per acre is fairly consistent for all applications. However, in Texas the average application rate is 3.5 gallons for insecticides, 7.4 gallons for fungicides and 4.1 gallons for an insecticide/fungicide mix. The number of applications will vary in a season by the severity of insect and disease problems, heavily dependent on rains, and also by the use of irrigation. Typically, fungicides are mixed with insecticides for several of the applications.

TYPICAL AG-AIR ACTIVITIES FOR VEGETABLES

STATE	VEGETABLE	MATERIAL	APPLICATION RATE OF TOTAL MIX/ACRE	NUMBER OF APPLICATIONS	REMARKS
CALIFORNIA	TOMATOES	INSECTICIDE FUNGICIDE	10 GAL. 40#/10 GAL.	3-6 1-8	SULFUR DUST IS SOMETIMES USED AS A FUNGICIDE TYPES OF INSECTICIDES VARY GREATLY; COMMON ONES ARE LANNATE, GUTHION, PARATHION, AND DIAZINON FUNGICIDES ARE OFTEN MIXED WITH SEVERAL INSECTICIDE APPLICATIONS NUMBER OF APPLICATIONS MAY VARY GREATLY BY SEVERITY OF PROBLEM AND USE OF IRRIGATION MELON CROPS ARE SOMETIMES DEFOLIATED
	LETTUCE	INSECTICIDE FUNGICIDE	10 GAL. 10 GAL.	6-8 2-3	
	SUGAR BEETS	INSECTICIDE FUNGICIDE	10 GAL. 40#	1-3 2-3	
	CARROTS	HERBICIDE INSECTICIDE FUNGICIDE	10 GAL. 10 GAL. 10 GAL.	1 1-5 1-2	
	ONIONS	FERTILIZER INSECTICIDE FUNGICIDE	150-200# 10 GAL. 10 GAL.	2-5 2-4 2-4	
	MELONS	INSECTICIDE	10 GAL.	1-3	
	TOMATOES	INSECTICIDE FUNGICIDE	1-5 GAL. 5-10 GAL.	8 5	
	CABBAGE	INSECTICIDE FUNGICIDE	2-6 GAL. 4-5 GAL.	15-20 1-12	
	LETTUCE	INSECTICIDE FUNGICIDE	1-5 GAL. 5-10 GAL.	12-15 4-10	
	CARROTS	HERBICIDE INSECTICIDE FUNGICIDE	2 GAL. 1-5 GAL. 4-5 GAL.	1 2-4 4-6	
TEXAS	ONIONS	INSECTICIDE FUNGICIDE	5 GAL. 10 GAL.	4-6 8-15	
	CANTALOUPS	INSECTICIDE FUNGICIDE	3 GAL. 3 GAL.	5-6 5-10	
	WATERMELONS	INSECTICIDE FUNGICIDE	3 GAL. 5 GAL.	2-4 2-4	
	BELL PEPPERS	INSECTICIDE FUNGICIDE	1-5 GAL. 5-10 GAL.	15 12	

The United States accounts for nearly half of the world's production of corn. Of the 6 billion bushels produced in the United States, 20 percent is found in Illinois, 18 percent in Iowa, 11 percent in Indiana, 8 percent in Nebraska, and 6 percent in Ohio.

CORN CROP PRODUCTION (1,000,000 BUSHELS)

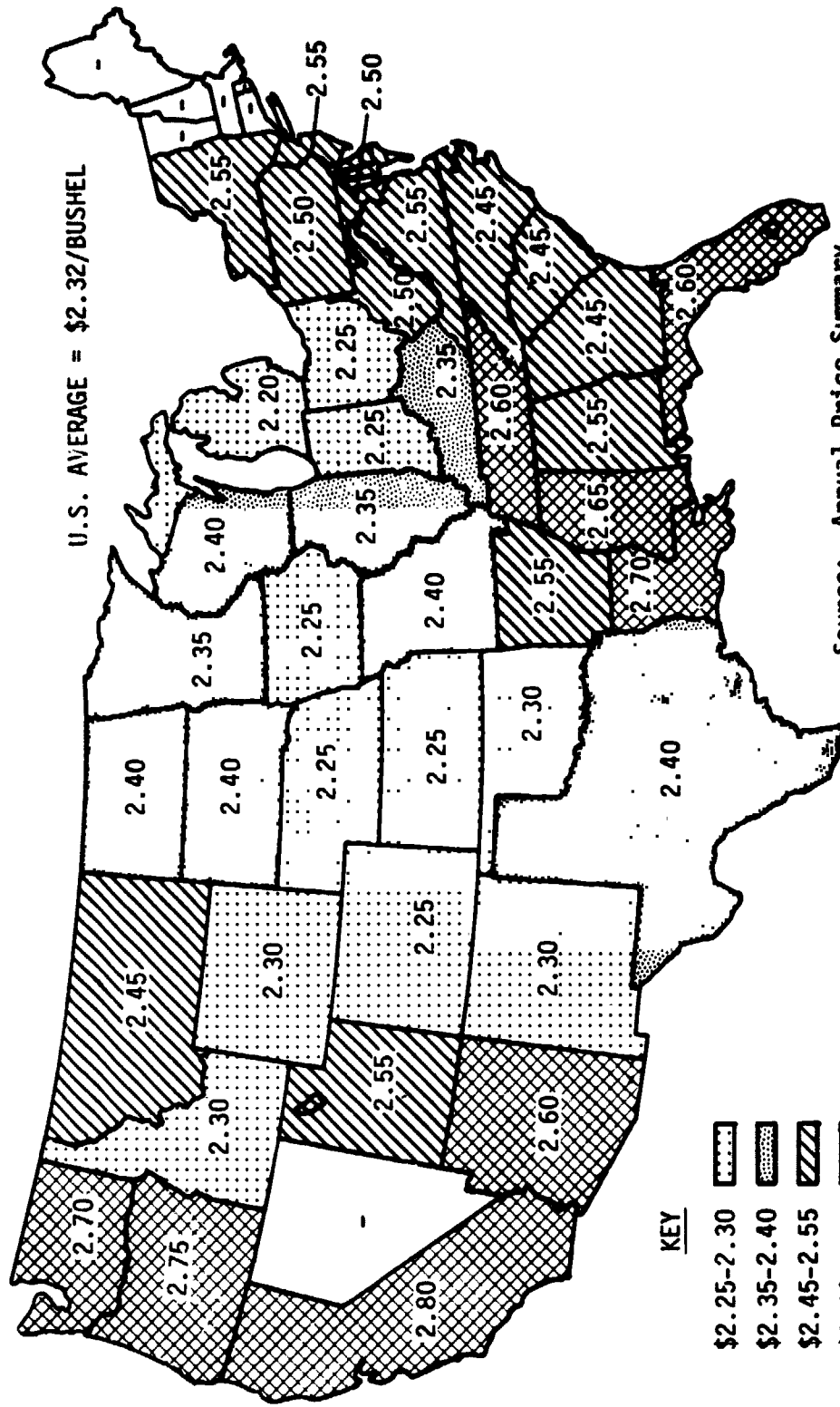


Source: U.S. Crop Reporting Board,
Crop Production, Annual
Summary, January 1977

LESS THAN 1,000,000 BUSHELS

The value of the corn crop is slightly over \$14.4 billion. Since the average price received by farmers per bushel of corn is very similar throughout the Corn Belt states, the distribution of gross revenue from corn is very similar to the distribution of the production of corn. Illinois accounts for 20 percent of the value of the crop, Iowa for 18 percent, Indiana for 11 percent, Nebraska for 8 percent, and Ohio for 6 percent.

1976 SEASONAL AVERAGE PRICE OF CORN RECEIVED BY FARMERS (DOLLARS/BUSHEL)



KEY

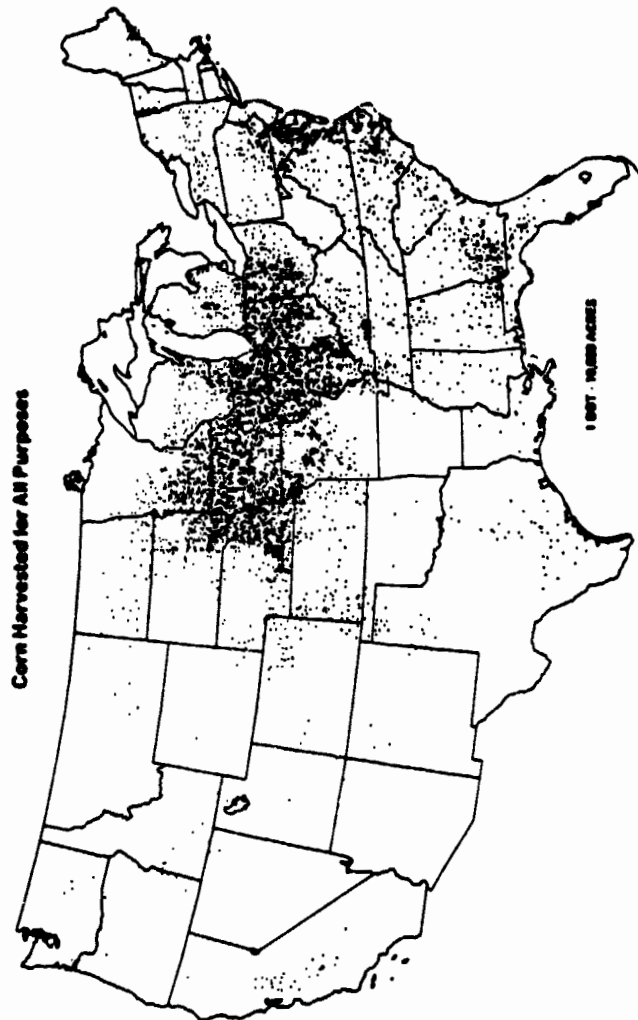
- \$2.25-2.30
- \$2.35-2.40
- \$2.45-2.55
- \$2.60+

- NO DATA GIVEN

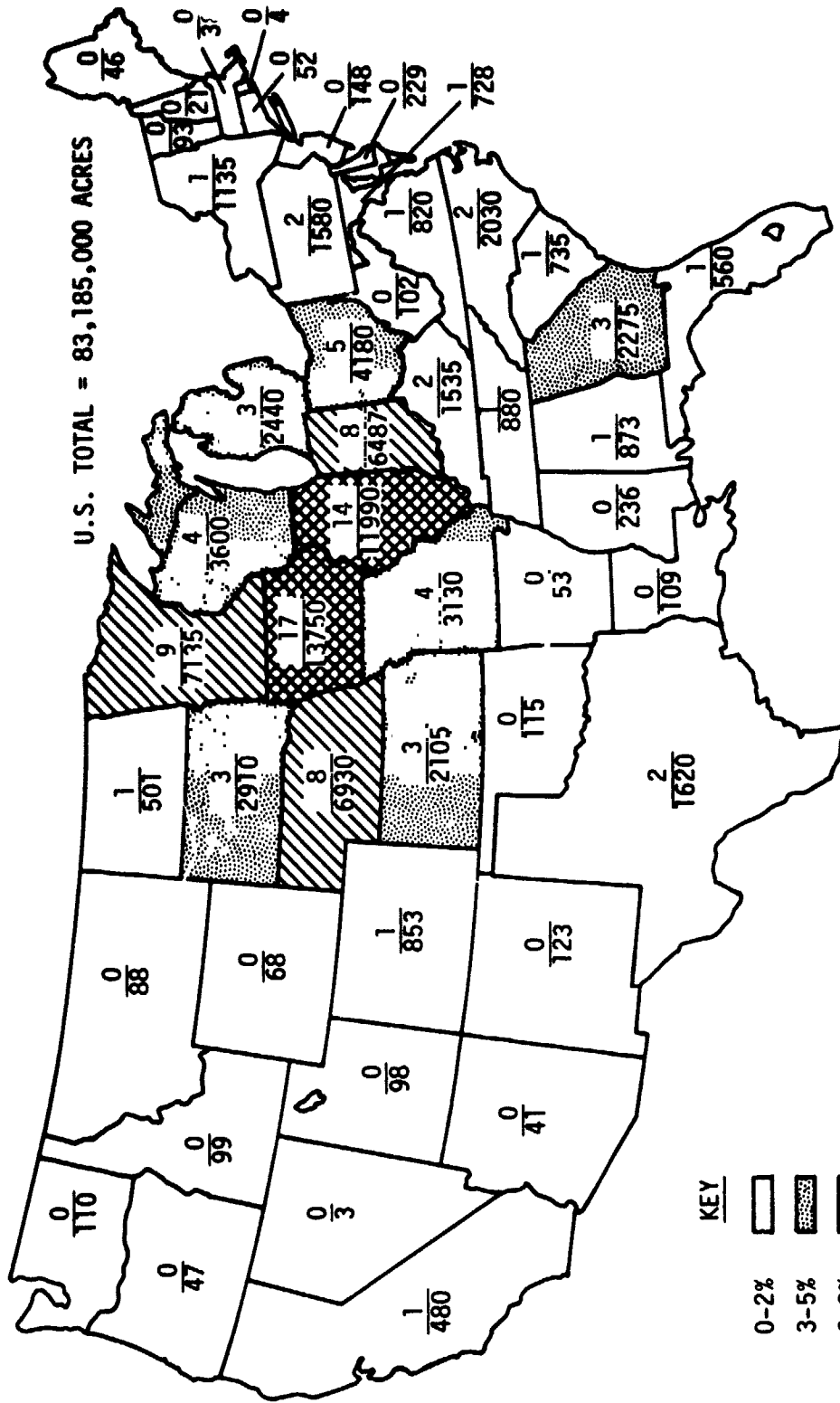
Source: Annual Price Summary,
June 1977, Crop Reporting
Board, SRS, USDA

97

The area harvested for corn in the United States is centered in Illinois, Iowa, Indiana and Ohio--the Corn Belt. Nearly two-thirds of the 83 million acres of corn harvested in 1976 are located in the Corn Belt states and Minnesota and Nebraska. The map below shows the area in each state where corn is grown. About 10 percent of the acres harvested are treated by air.



AREA OF CORN HARVESTED (1,000 ACRES)



KEY

- 0-2%
- 3-5%
- 6-9%
- 10+ %

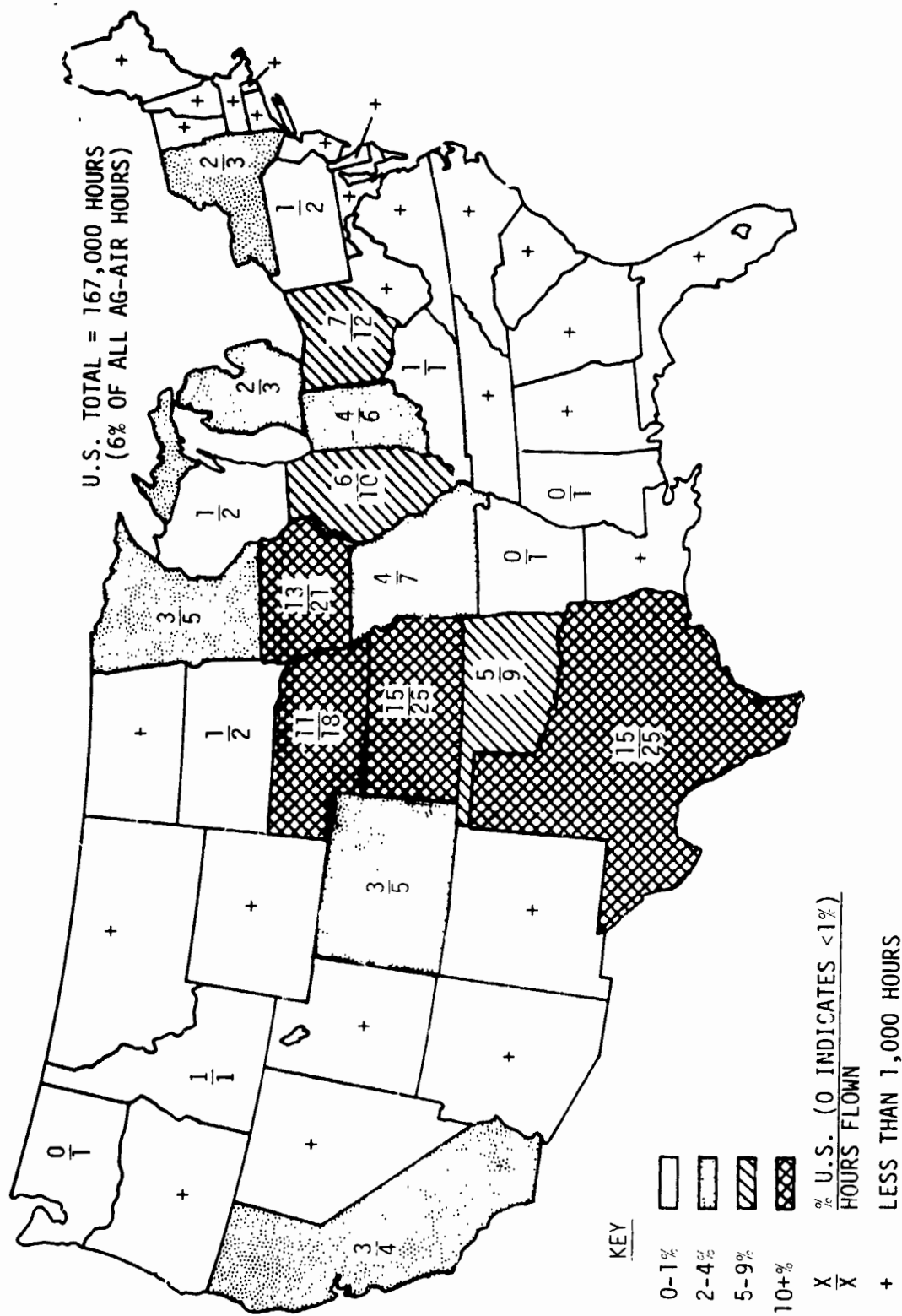
X % U.S. (0 INDICATES < 1%)
X AREA HARVESTED

Source: U.S. Crop Reporting Board,
Crop Production, Annual
Summary, January 1977

8300

Estimates were made for the number of hours flown over corn for each state. More hours are flown in Texas, Kansas and Nebraska than in the Corn Belt states. The 167,000 hours flown for corn accounts for about 6 percent of all ag-air hours.

ESTIMATED HOURS FLOWN FOR CORN BY STATE (1,000 HOURS)



A breakdown of ag-air hours spent treating corn is given at the right. The application of insecticides accounts for 60 percent of all hours flown over corn. Some experimenting is being done applying seed by air, but since the harvesting machines are constructed for row crops, harvesting aerially seeded corn is difficult.

NATIONWIDE BREAKDOWN OF AG-AIR HOURS FOR CORN

<u>APPLICATION</u>	<u>% OF TOTAL HOURS</u>
INSECTICIDE	59.3
HERBICIDE	24.7
FERTILIZER	5.4
MISCELLANEOUS	4.4
UNATTRIBUTED	6.2
	<u>100.0</u>

SOURCE: NAAA QUESTIONNAIRE DATA

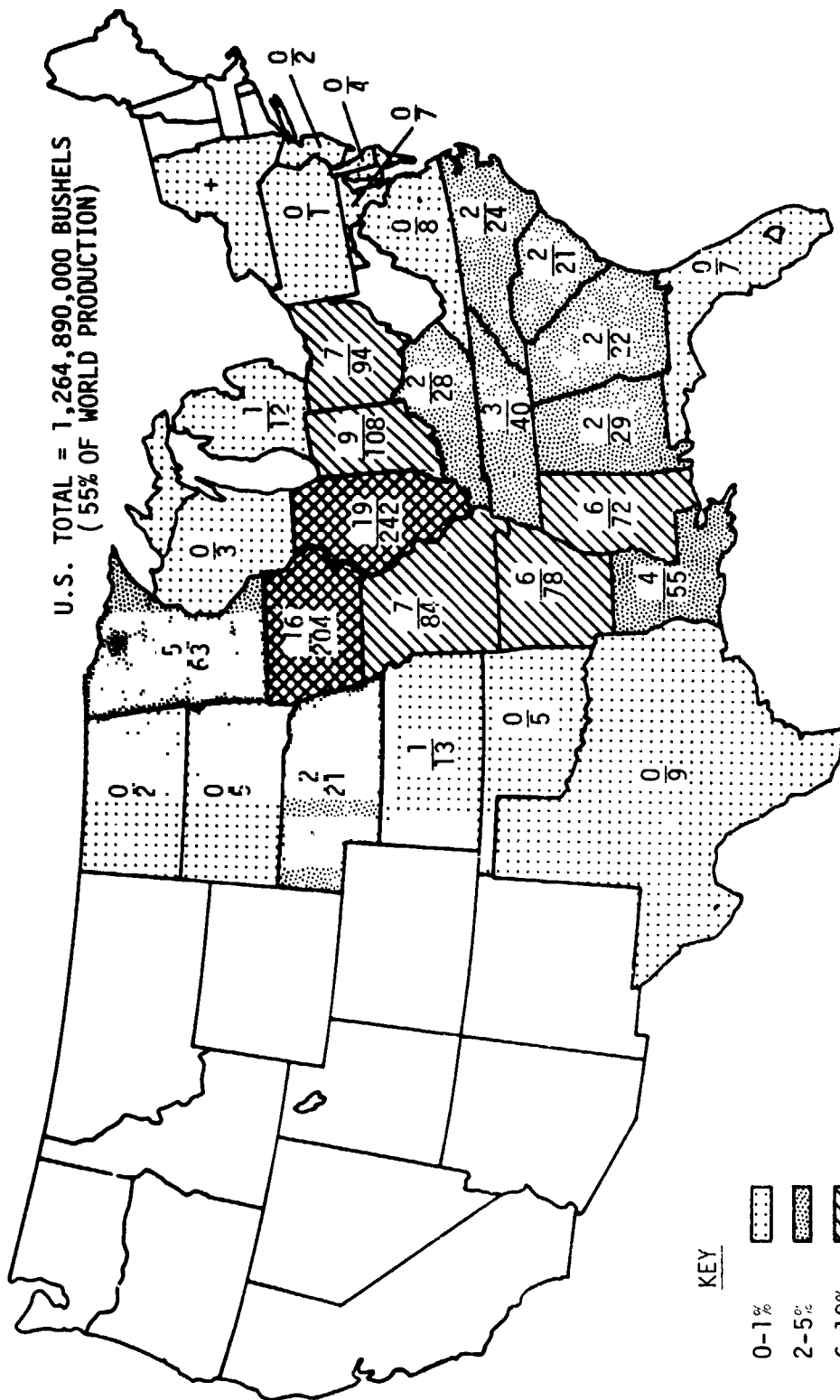
As with wheat, cropping practices vary from the North to the South. In the Corn Belt states, most of the hours flown are for the application of herbicides, mainly Atrazine. In the South, in Texas and Kansas, most of the hours are for applying insecticides.

TYPICAL AG-AIR ACTIVITIES FOR CORN

STATE	DATE	MATERIAL *	CHEMICAL NAME	AMOUNT OF CHEMICAL/ACRE	APPLICATION RATE OF TOTAL MIX/ACRE	NUMBER OF APPLICATIONS	REMARKS
TEXAS	MARCH- JUNE	HB	ATRAZINE	1 - 2 #	2 - 3 GAL.	1	
	MAY- SEPTEMBER	IN	CARBARYL PARATHION	1/4 - 1/4 GAL. 1/5 - 1/4 GAL.	2 - 3 GAL.	2	ABOUT 85% OF HOURS
KANSAS	APRIL- JUNE	HB	ATRAZINE	1 - 2 #	2 GAL.	1	
	MAY- OCTOBER	IN	CARBARYL PARATHION 7,4 OIL	1/4 - 1/3 GAL. 1/5 - 1/4 GAL. 1/4 GAL.	5 GAL.	2	ABOUT 60% OF HOURS
IOWA	MAY- JULY	HB	ALACHLOR ATRAZINE BLADEX	1/4 - 3/4 GAL. 2 - 3 # 2 #	3 GAL	1	OVER 90% OF HOURS
	JULY- SEPTEMBER	IN	CARBARYL 7,4 OIL	1/4 GAL. 1/4 GAL.	2 GAL.	1	
* HB-HERBICIDE, IN-INSECTICIDE							

Most of the soybean crop is produced in the Corn Belt area and the Mississippi Valley area. Over 50 percent of the production is located in Illinois, Iowa, Indiana, and Ohio. Another 20 percent is produced in Missouri, Arkansas, and Mississippi. The United States' production of 1.2 billion bushels accounts for 55 percent of the world's production of soybeans.

SOYBEAN CROP PRODUCTION (1,000,000 BUSHELS)



KEY

- 0-1%
- 2-5%
- 6-10%
- 11+%

% U.S. (0 INDICATES <1%)
PRODUCTION

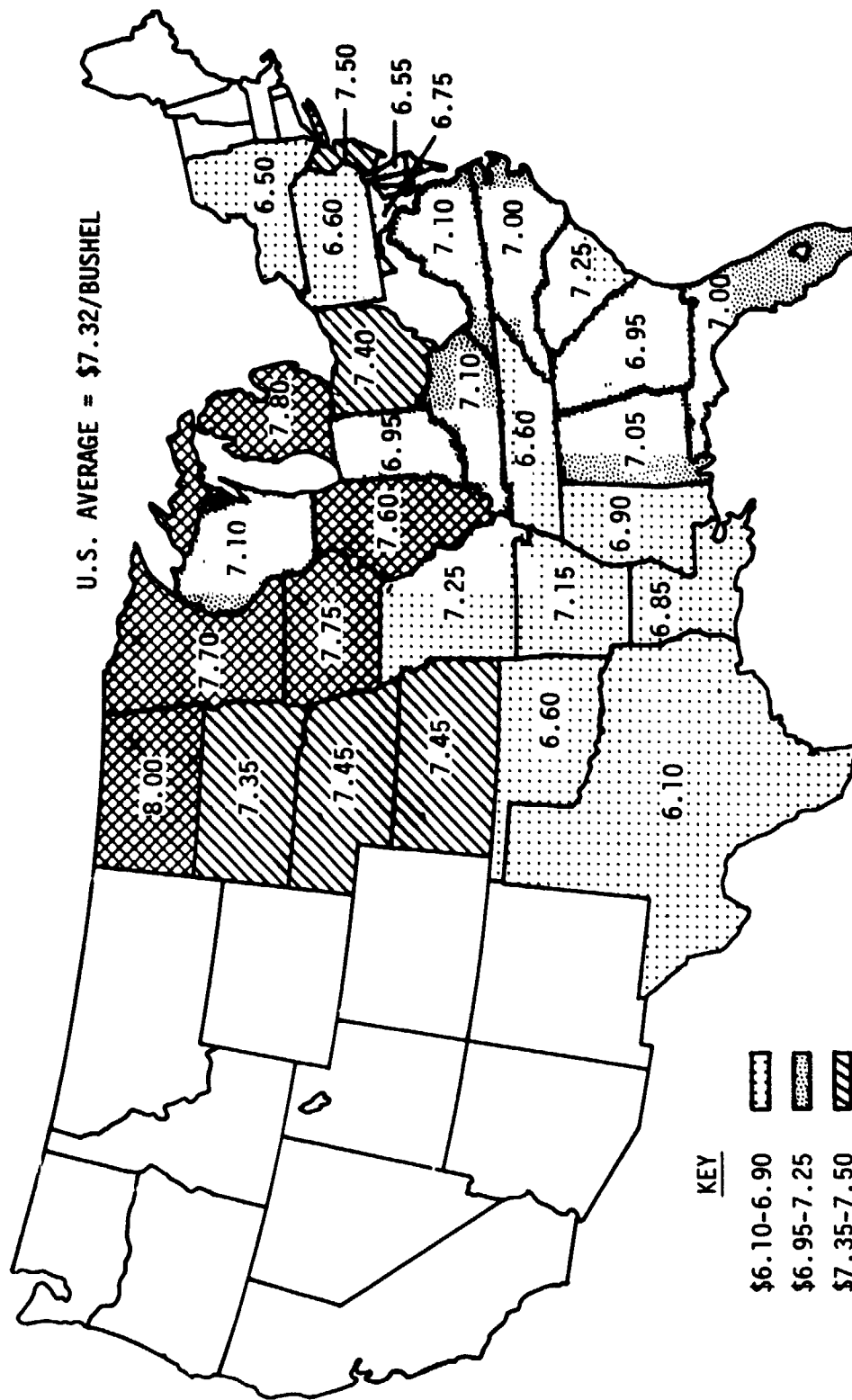
LESS THAN 1,000,000 BUSHELS

Source: U.S. Crop Reporting Board,
Crop Production, Annual
Summary, January 1977

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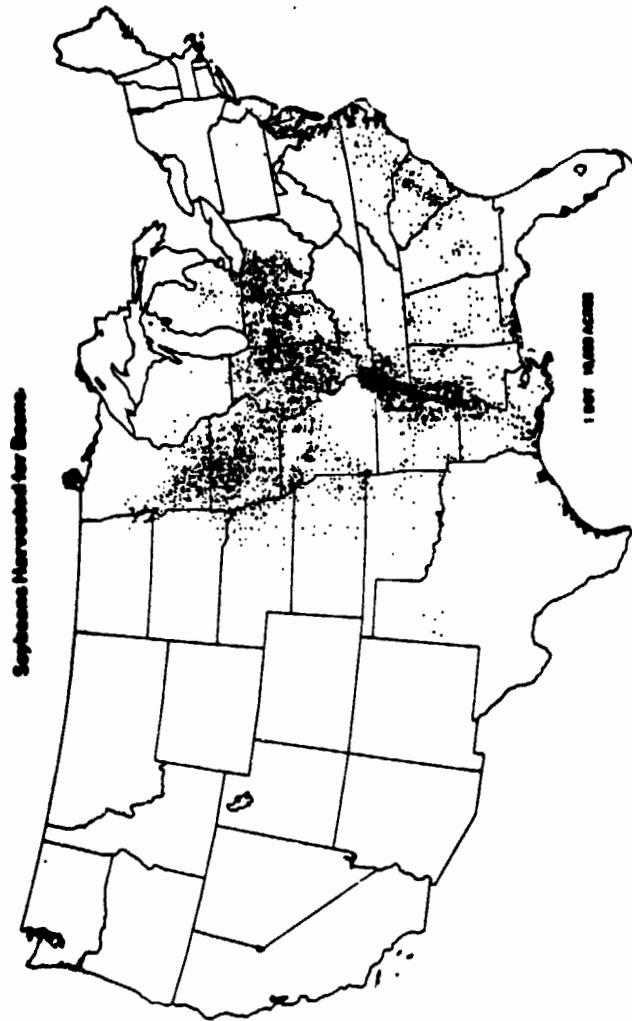
The value of the United States soybean crop in 1976 was \$9.3 billion. The distribution of this value is very similar to the production of the soybean crop. Illinois leads with 20 percent, Iowa follows with 17 percent, Indiana with 8 percent, Ohio with 8 percent, and the Mississippi Valley area with 22 percent.

1976 SEASONAL AVERAGE PRICE OF SOYBEANS RECEIVED BY FARMERS (DOLLARS/BUSHEL)



Source: Annual Price Summary,
June 1977, Crop Reporting
Board, SRS, USDA

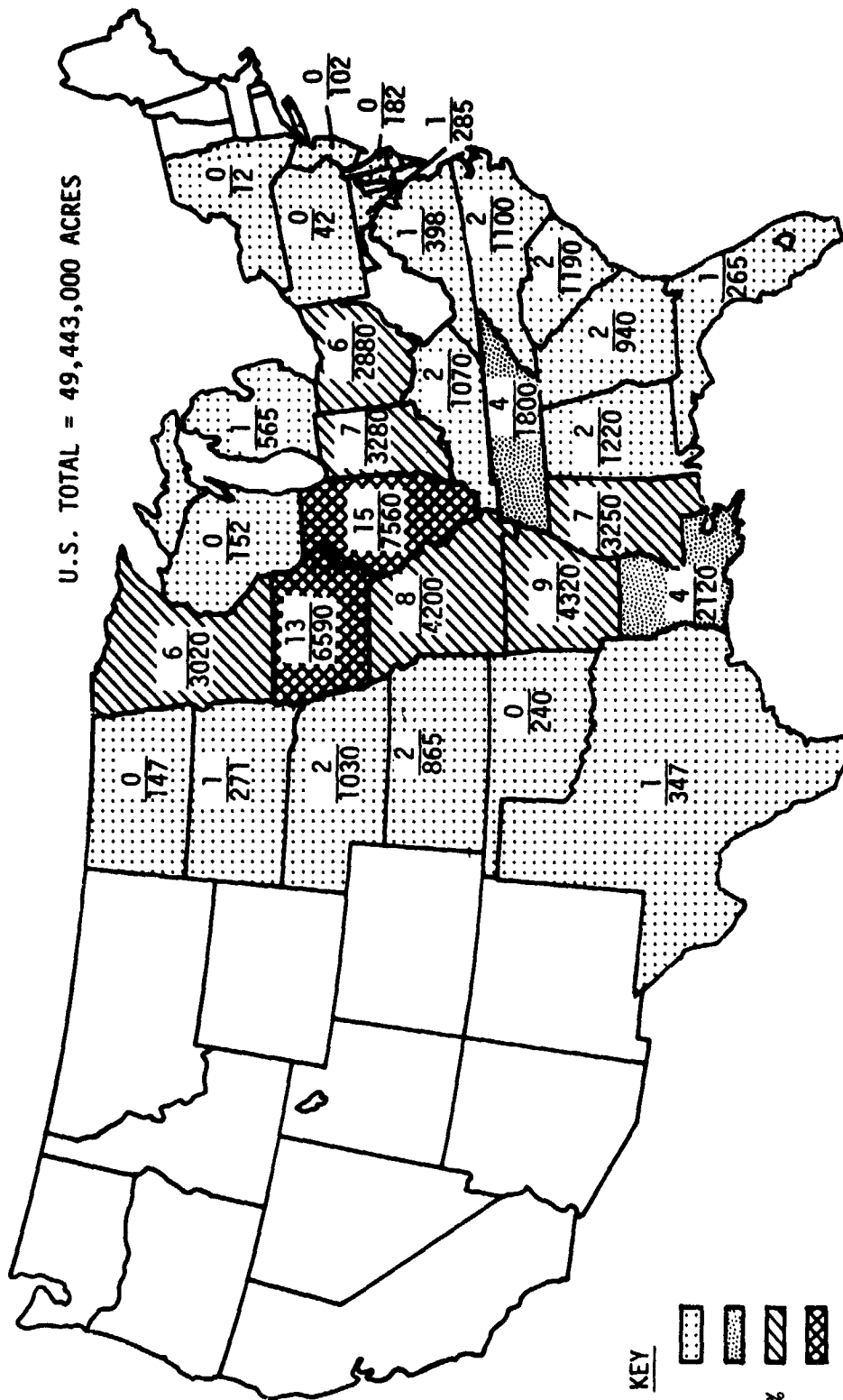
Soybeans are grown primarily for beans, which are processed for oil and meal. Over 40 percent of the 49 million acres of soybeans harvested in 1976 are centered in the Corn Belt states. The Mississippi Valley area is another important growing region and accounts for about 25 percent of the area harvested. The map below shows where the soybean crop is grown in each state. About 10 percent of the acres are treated by air.



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AREA OF SOYBEANS HARVESTED (1,000 ACRES)

U.S. TOTAL = 49,443,000 ACRES



KEY

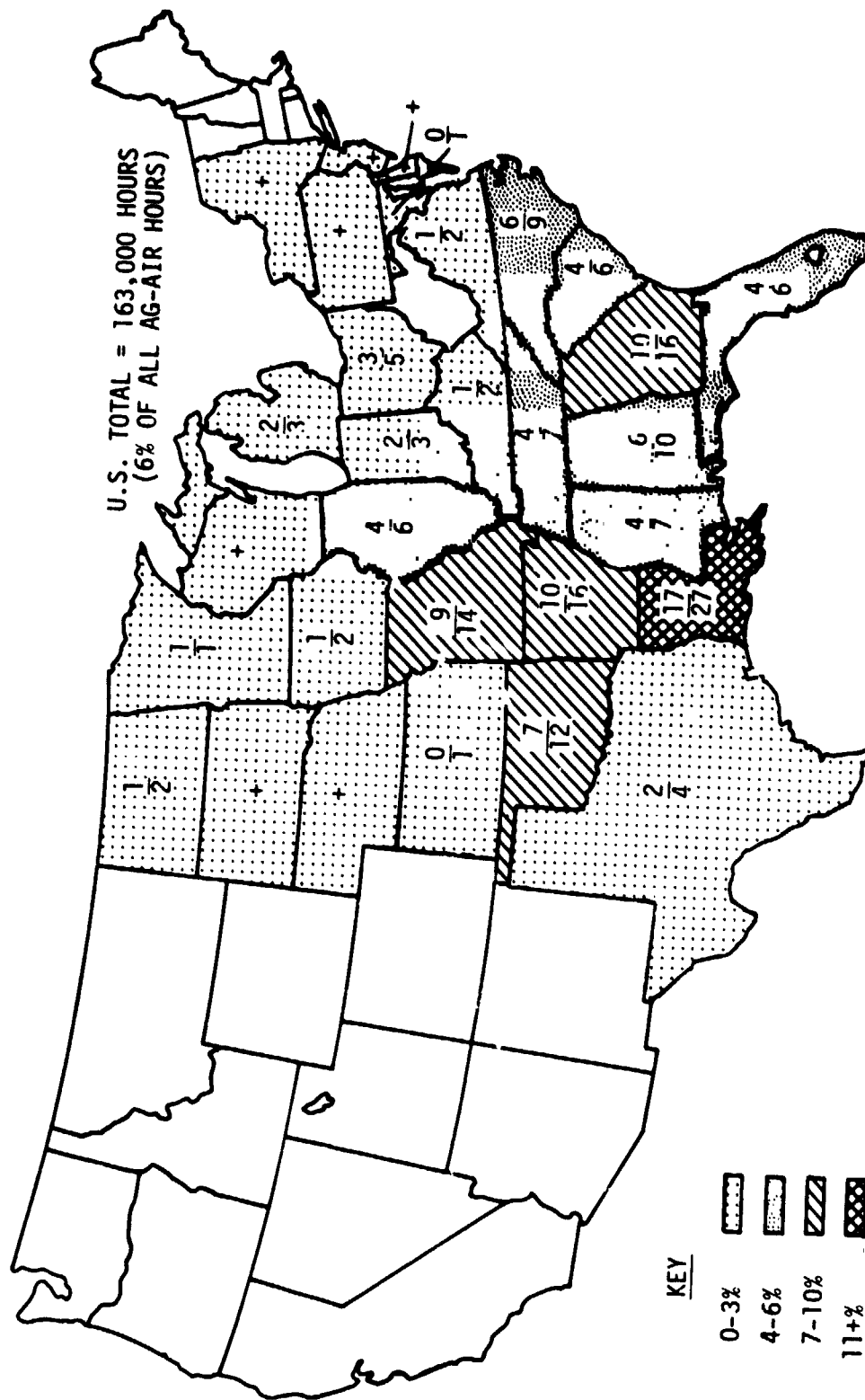
- 0-2%
- 3-4%
- 5-10%
- 11+%

% U.S. (0 INDICATES <1%)
X X
AREA HARVESTED

Source: U.S. Crop Reporting Board,
Crop Production, Annual
Summary, January 1977

Once again, as in wheat and in corn, the hours flown for soybeans are not centered in the area where soybeans are harvested and produced. Louisiana accounts for 17 percent of the nation's hours flown for soybeans, followed by Mississippi and Georgia with 10 percent each, Missouri with 9 percent and Oklahoma with 7 percent. Just over 9 percent of the hours flown for soybeans are located in the Corn Belt states. The total hours flown for soybeans accounts for 6 percent of all ag-air hours.

ESTIMATED HOURS FLOWN FOR SOYBEANS BY STATE (1,000 HOURS)



KEY

- 0-3%
- 4-6%
- 7-10%
- 11+%

% U.S.
HOURS FLOWN

LESS THAN 1,000 HOURS

A wide variety of ag-air activities are found in soybeans. Most of the hours flown are for application of insecticides, herbicides or fungicides. In some areas, wheat is seeded in the soybean fields before harvesting. The crop is then defoliated allowing the leaves to fall and cover the wheat seeds.

NATIONWIDE BREAKDOWN OF AG-AIR HOURS FOR SOYBEANS

<u>APPLICATION</u>	<u>% OF TOTAL HOURS</u>
INSECTICIDE	40.4
HERBICIDE	26.2
FUNGICIDE	10.2
DEFOLIANT/DESSICANT	4.3
FERTILIZER	1.5
SEEDING	1.5
MISCELLANEOUS	5.4
UNATTRIBUTED	10.5
	<u>100.0</u>

SOURCE: NAAA QUESTIONNAIRE DATA

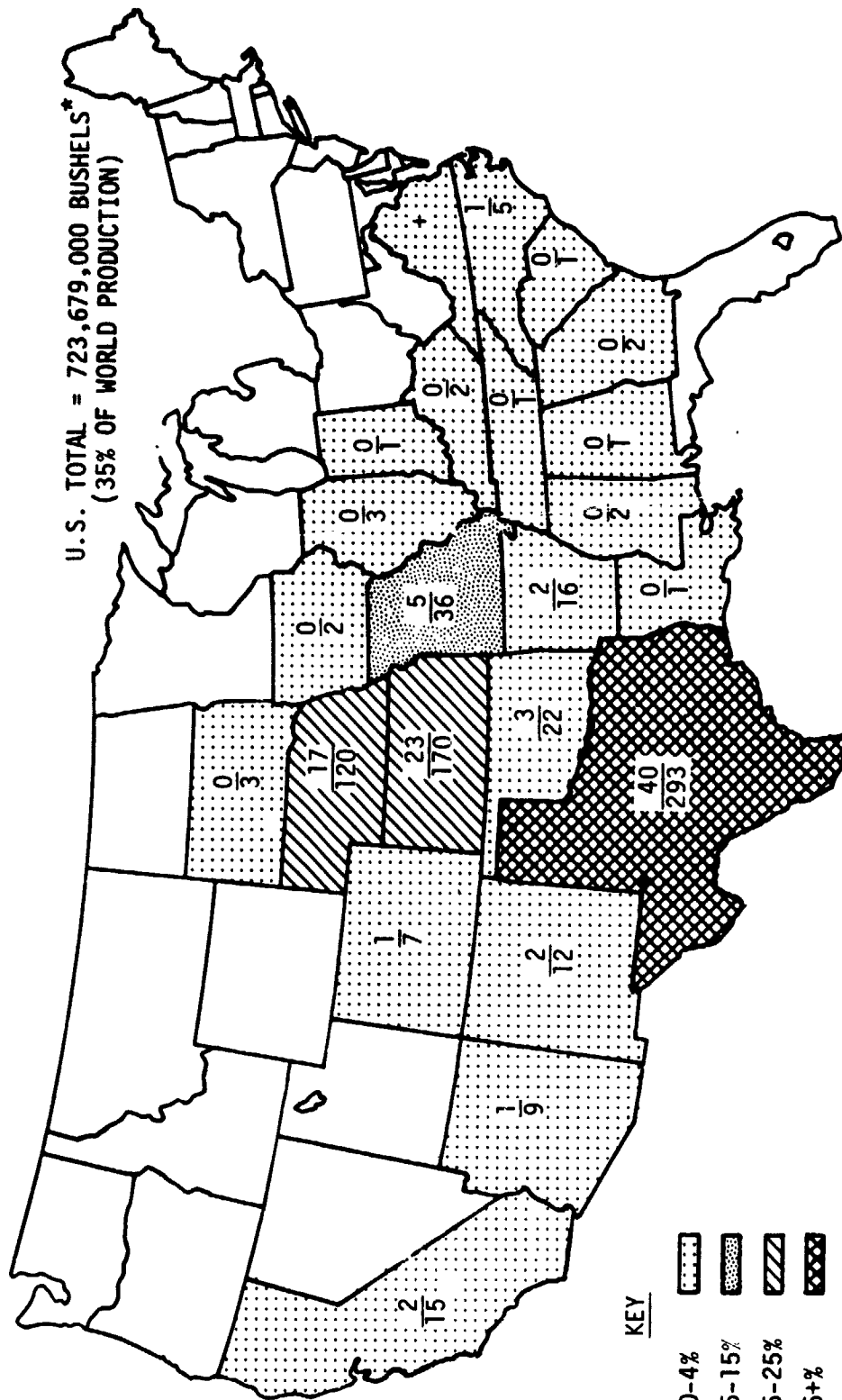
Three states were chosen to show the variety of ag-air activities for soybeans. In Louisiana, about 40 percent of the time is spent applying herbicides and 40 percent applying insecticides. In Arkansas 50 percent of the time is spent applying herbicides and only 20 percent applying insecticides. In Georgia, nearly all work is applying insecticides, about 80 percent. All three states apply Benlate as a fungicide. In both Louisiana and Arkansas, two applications of Benlate are generally needed, but in Georgia, just one.

TYPICAL AG-AIR ACTIVITIES FOR SOYBEANS

STATE	DATE	MATERIAL*	CHEMICAL NAME	AMOUNT OF CHEMICAL/ACRE	APPLICATION RATE OF TOTAL MIX/ACRE	NUMBER OF APPLICATIONS	REMARKS
LOUISIANA	MAY- JUNE	HB	DINAP TRIFLURALIN	1/4 - 1/3 GAL. 1/4 GAL.	5 - 10 GAL.	1	37% OF HOURS
	JUNE- AUGUST	IN	METHYL PARATHION METHOMYL	1/4 GAL. 1/4 GAL.	2 GAL.	2	40% OF HOURS
		FN	BENLATE	1/2 #	5 GAL.	2	
GEORGIA	JULY- AUGUST	IN	TOXAPHENE METHOMYL CARBARYL PARATHION	1/8 - 1/4 GAL. 1/8 - 1/4 GAL. 1/4 GAL. 1/8 GAL.	1 - 2 GAL.	2 - 5	80% OF HOURS
		FN	BENLATE	1/2 #	5 GAL.	1	
ARKANSAS	MAY- JUNE	HB	TRIFLURALIN DINAP	1/4 GAL. 1/4 - 1/3 GAL.	5 - 10 GAL.	1	52% OF HOURS
	JULY- AUGUST	IN	METHYL PARATHION	1/4 GAL.	1 - 5 GAL.	1	
	AUGUST- SEPTEMBER	FN	BENLATE	1/2 #	5 GAL.	2	31% OF HOURS
* HB-HERBICIDE, IN-INSECTICIDE, FN-FUNGICIDE							

Texas accounts for 40 percent of the sorghum production in the United States. Kansas and Nebraska combined produce about as much as Texas. The United States produces about 35 percent of the world's production of sorghum. In 1976 the United States produced slightly over 700 million bushels of sorghum.

SORGHUM CROP PRODUCTION (1,000,000 BUSHELS)



KEY

- 0-4% [Dotted Pattern]
- 5-15% [Horizontal Lines]
- 16-25% [Diagonal Lines]
- 26+% [Cross-hatched Pattern]

% U.S. (0 INDICATES <1%)
PRODUCTION

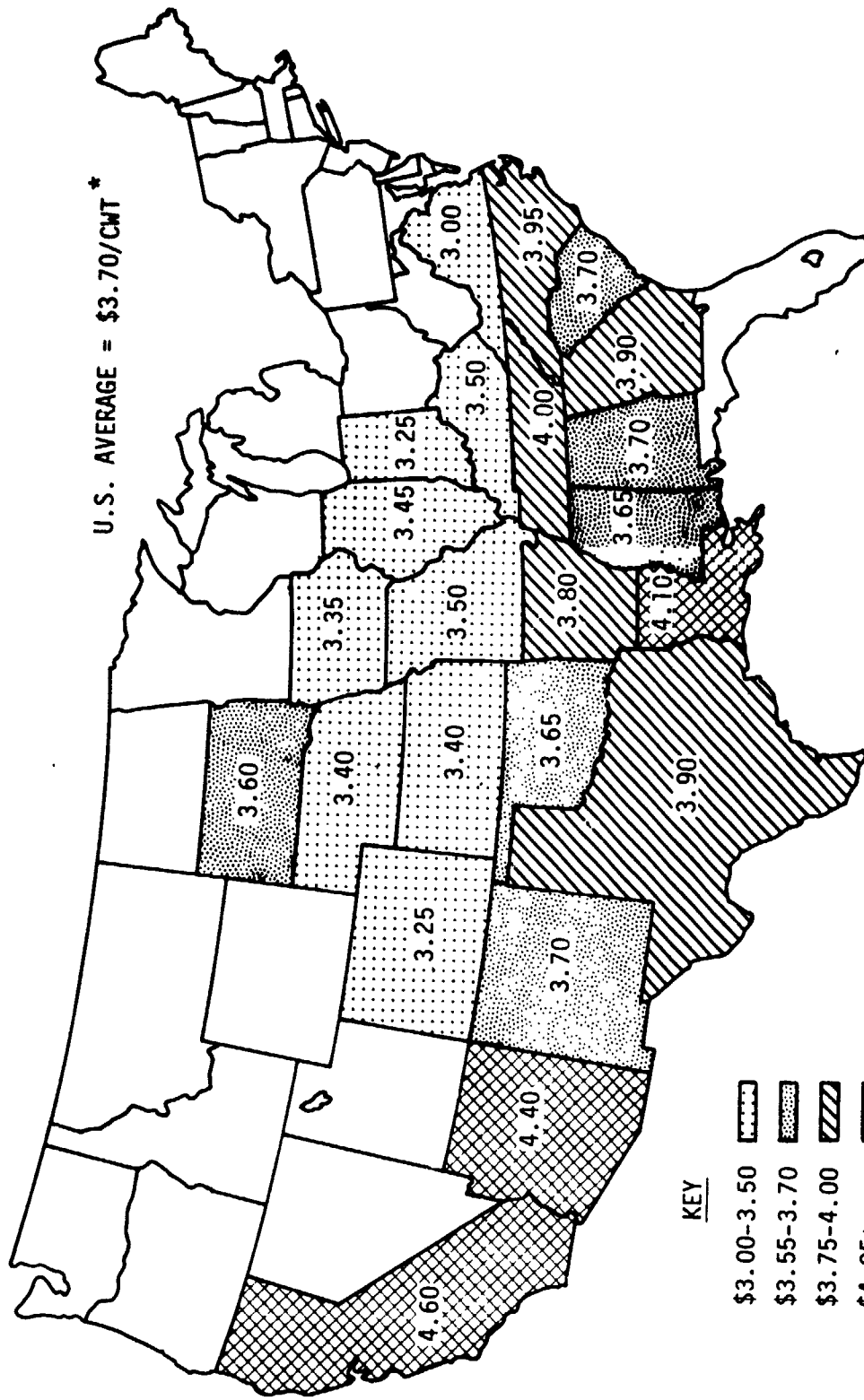
LESS THAN 1,000,000 BUSHELS

* 56 LBS/BUSHEL

Source: U.S. Crop Reporting Board,
Crop Production, Annual
Summary, January 1977

In 1976 the sorghum crop was valued at \$1.5 million. Texas accounts for about 40 percent of this value, and Kansas and Nebraska accounts for another 40 percent.

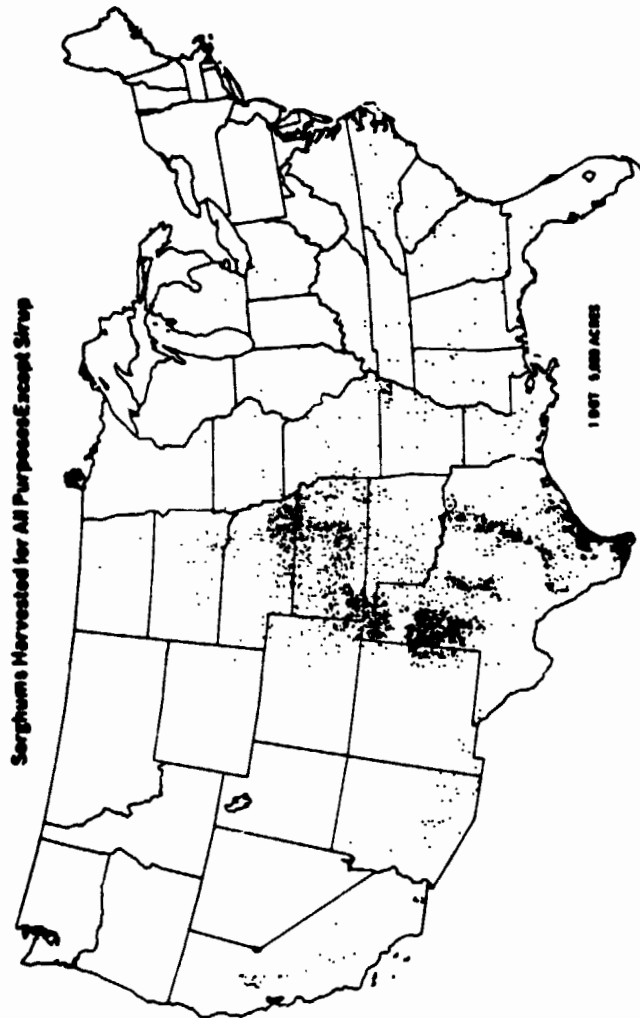
1976 SEASONAL AVERAGE PRICE OF SORGHUM RECEIVED BY FARMERS (DOLLARS/CWT)



Source: Annual Price Summary,
June 1977, Crop Reporting
Board, SRS, USDA

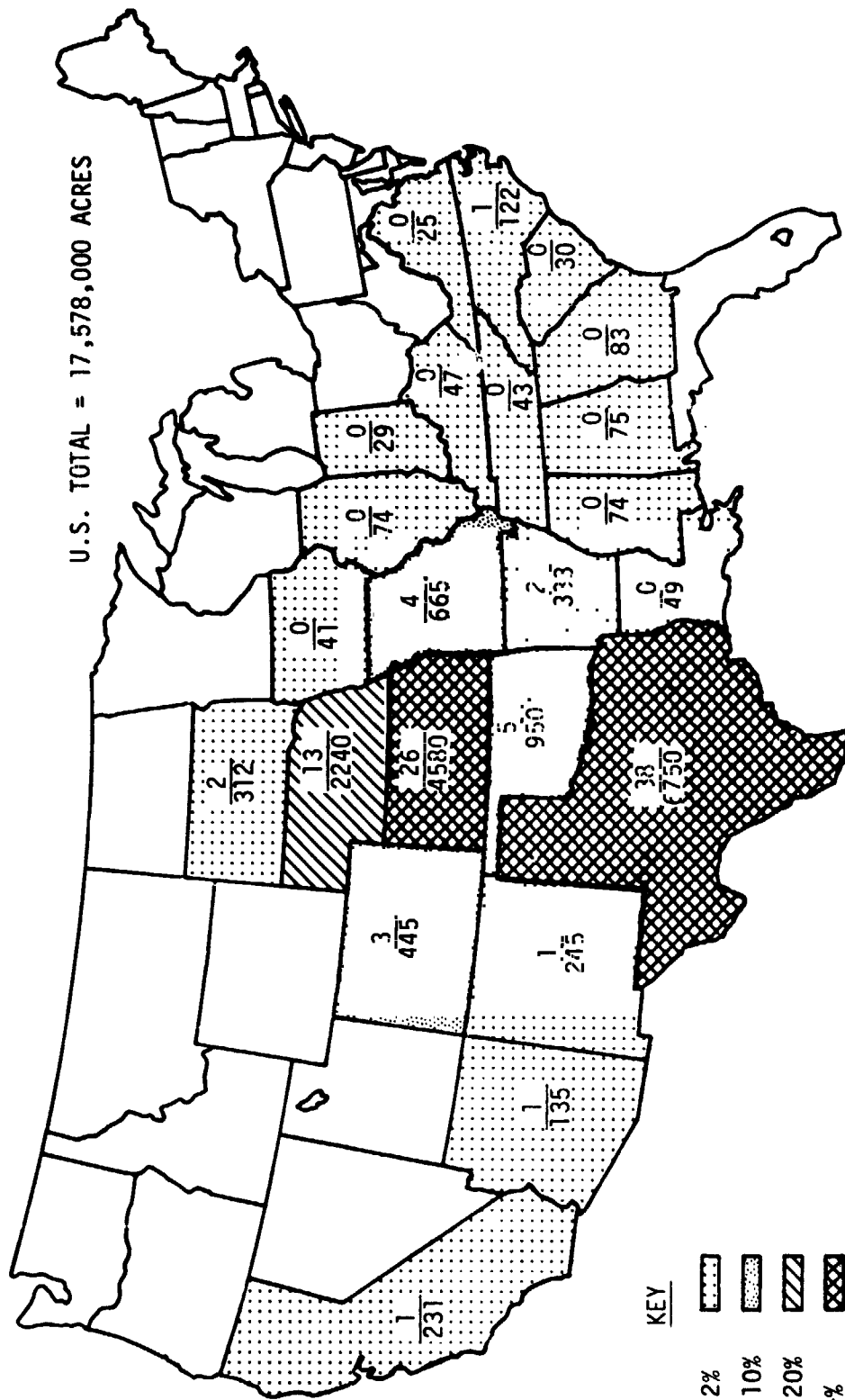
* CWT (HUNDREDWEIGHT) = 100 LBS.

Sorghum is well adapted to heat and tolerates limited moisture conditions. For this reason, most grain sorghums are grown in the Southern Plains States. Sorghum grain is used primarily as a livestock feed. The acreage of sorghum harvested is distributed very similarly to the production of sorghum. Texas accounts for about 40 percent and Kansas and Nebraska for another 40 percent of the 17.5 million acres. The map below shows where the sorghum crop is grown in each state. About 40 percent of the acres are treated by air.



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AREA OF SORGHUM HARVESTED (1,000 ACRES)



Source: U.S. Crop Reporting Board,
Crop Production, Annual
Summary, January 1977

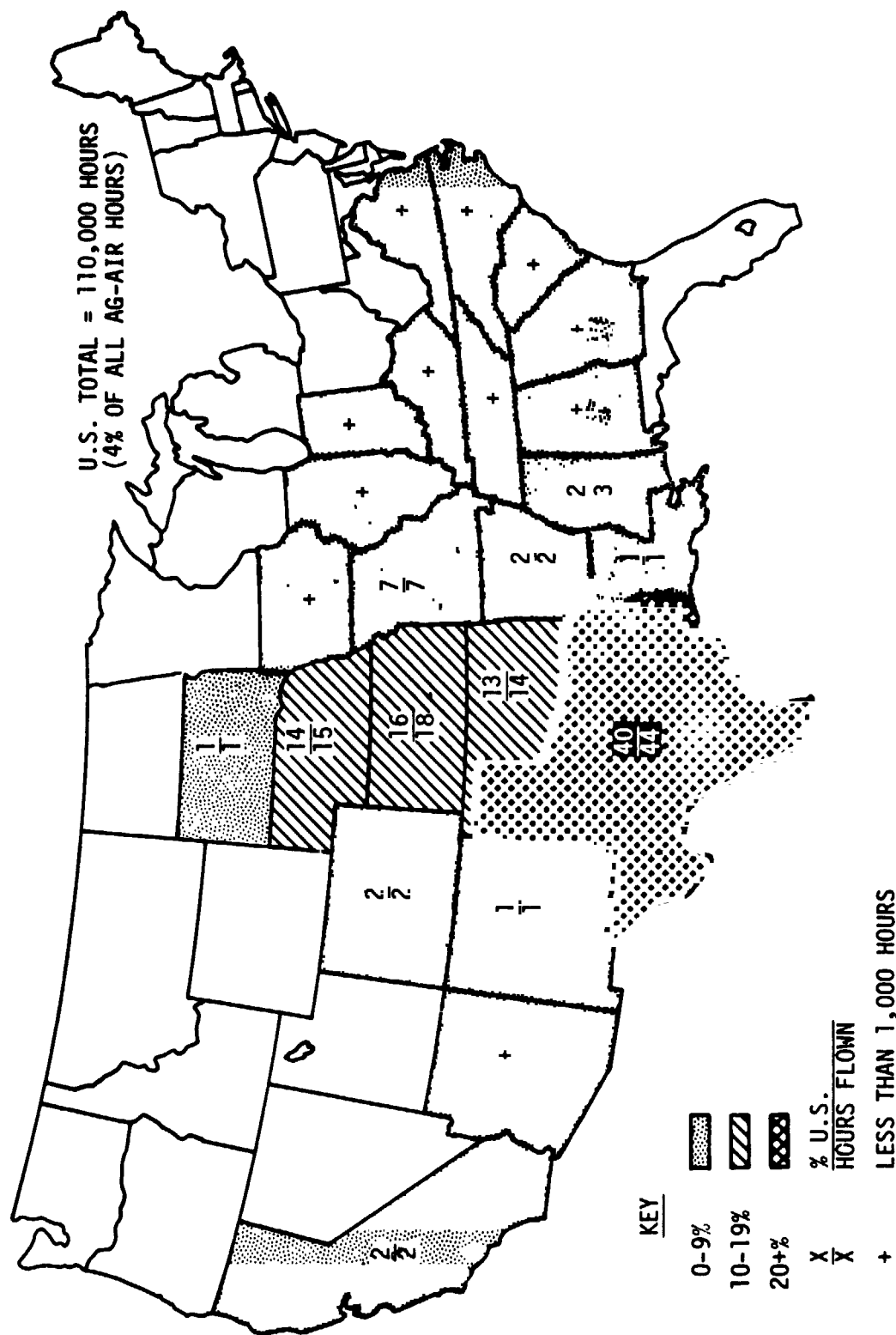
KEY

- 0-2% (dotted pattern)
- 3-10% (horizontal lines)
- 11-20% (vertical lines)
- 20+% (cross-hatch pattern)

% U.S. (0 INDICATES <1%)
AREA HARVESTED

The estimated hours flown for sorghum are shown in the map at the right. Texas accounts for about 40 percent of the hours flown, and Kansas and Nebraska account for about 30 percent of the hours flown. Oklahoma accounts for another 13 percent. The hours flown for sorghum account for 4 percent of all ag-air hours.

ESTIMATED HOURS FLOWN FOR SORGHUM BY STATE (1,000 HOURS)



800

Tabulation of the NAAA Questionnaire data show that two thirds of the time spent flying over sorghum is for the application of insecticides. About 20 percent is for application of herbicides.

NATIONWIDE BREAKDOWN OF AG-AIR HOURS FOR SORGHUM

<u>APPLICATION</u>	<u>% OF TOTAL HOURS</u>
INSECTICIDE	62.4
HERBICIDE	21.0
FERTILIZER	1.5
DEFOLIANT/DESSICANT	0.6
SEEDING	0.3
MISCELLANEOUS	4.0
UNATTRIBUTED	<u>10.2</u>
	100.0

SOURCE: NAAA QUESTIONNAIRE DATA

The ag-air activities for sorghum are very similar in all states. Slightly more herbicide work is done in the North than in the South, and slightly more insecticide work is done in the South than in the North. In Texas, insecticide work accounts for 75 percent of the hours flown and, in Kansas, insecticide work accounts for 67 percent of the hours.

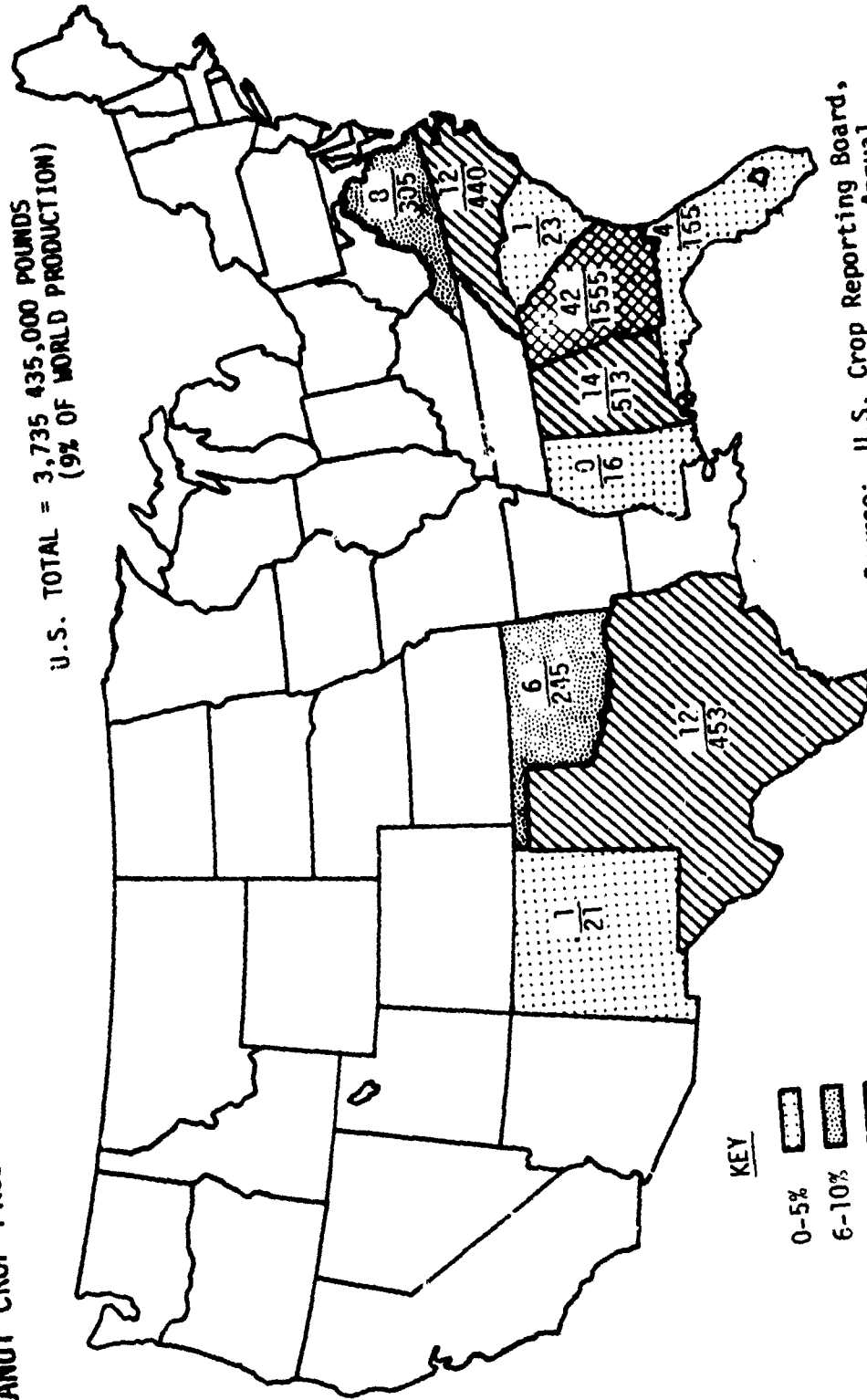
TYPICAL AG-AIR ACTIVITIES FOR SORGHUM

STATE	DATE	MATERIAL *	CHEMICAL NAME	AMOUNT OF CHEMICAL/ACRE	APPLICATION RATE OF TOTAL MIX/ACRE	NUMBER OF APPLICATIONS	REMARKS
TEXAS	MARCH- JULY	HB	PROPACINE ATRAZINE 2,4-D	1 1/2 # 1 1/2 # 1/5 - 1/4 GAL.	2 - 3 GAL.	1	
	JULY- SEPTEMBER	IN	PARATHION DISULFOTOM	1 PT. 1/2 PT.	1 - 2 GAL.	2	75% OF HOURS
KANSAS	MAY- JUNE	HB	PROPACINE 2,4-D	1 1/2 # 1/5 - 1/4 GAL.	2 GAL.	1	
	JULY- SEPTEMBER	IN	PARATHION DISULFOTOM	1 PT. 1/2 PT.	1 GAL.	2	67% OF HOURS
* HB-HERBICIDE, IN-INSECTICIDE							

The three major peanut producing areas in the United States are the Georgia-Alabama area, accounting for more than 50 percent of the nation's peanut production, the Virginia-Carolina area, accounting for about 20 percent of the nation's production, and Texas which accounts for about 12 percent. As a whole, the United States accounts for 9 percent of the world's peanut production.

PEANUT CROP PRODUCTION (1,000,000 POUNDS)

U.S. TOTAL = 3,735 435,000 POUNDS
(9% OF WORLD PRODUCTION)



KEY

- 0-5%
- 6-10%
- 11-15%
- 16+%

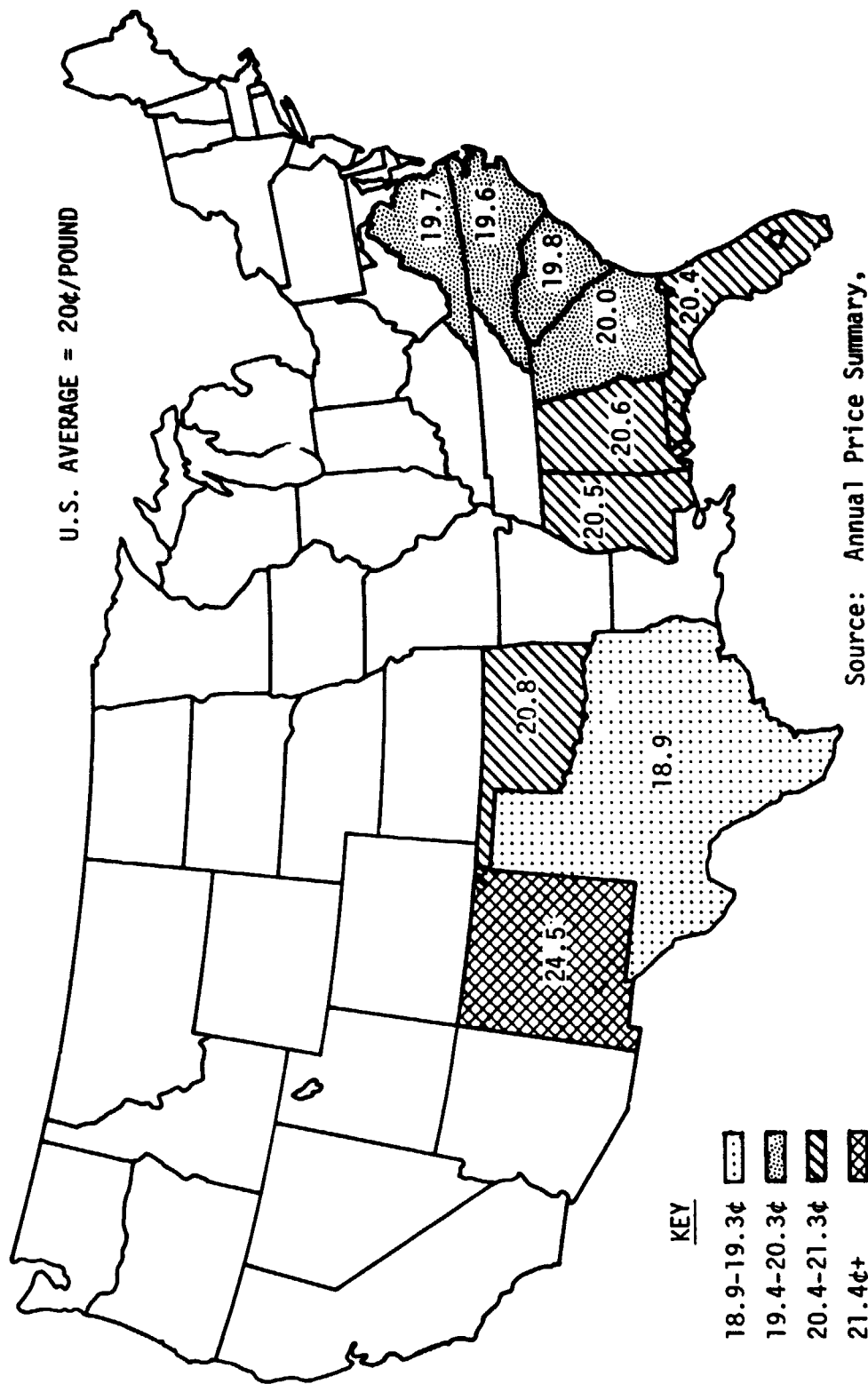
% U.S. (0 INDICATES < 1%)
PRODUCTION

Source: U.S. Crop Reporting Board,
Crop Production, Annual
Summary, January 1977

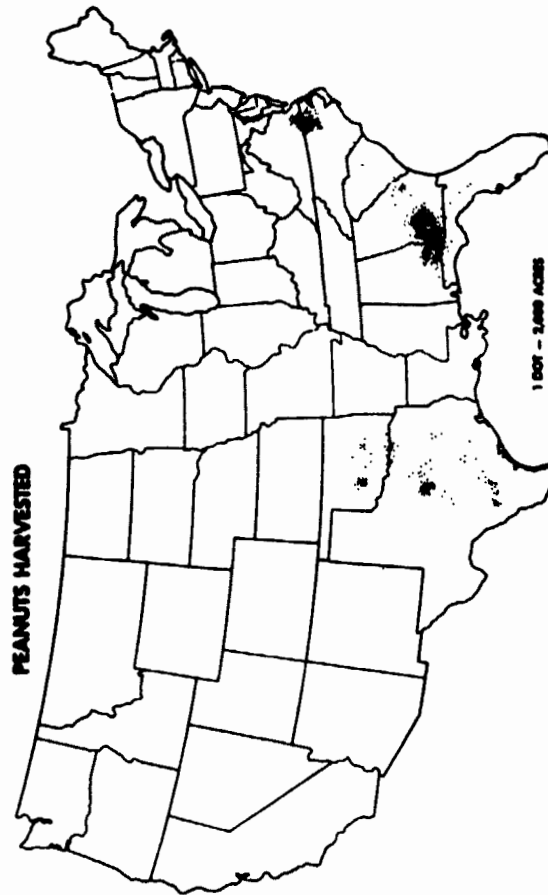
geon

The value of the peanut crop in 1976 was over \$747 million. The Georgia-Alabama area accounted for more than 50 percent of this value. About 20 percent is located in the Virginia-Carolina area and 12 percent in Texas.

1976 SEASONAL AVERAGE PRICE OF PEANUTS RECEIVED BY FARMERS (CENTS/POUND)



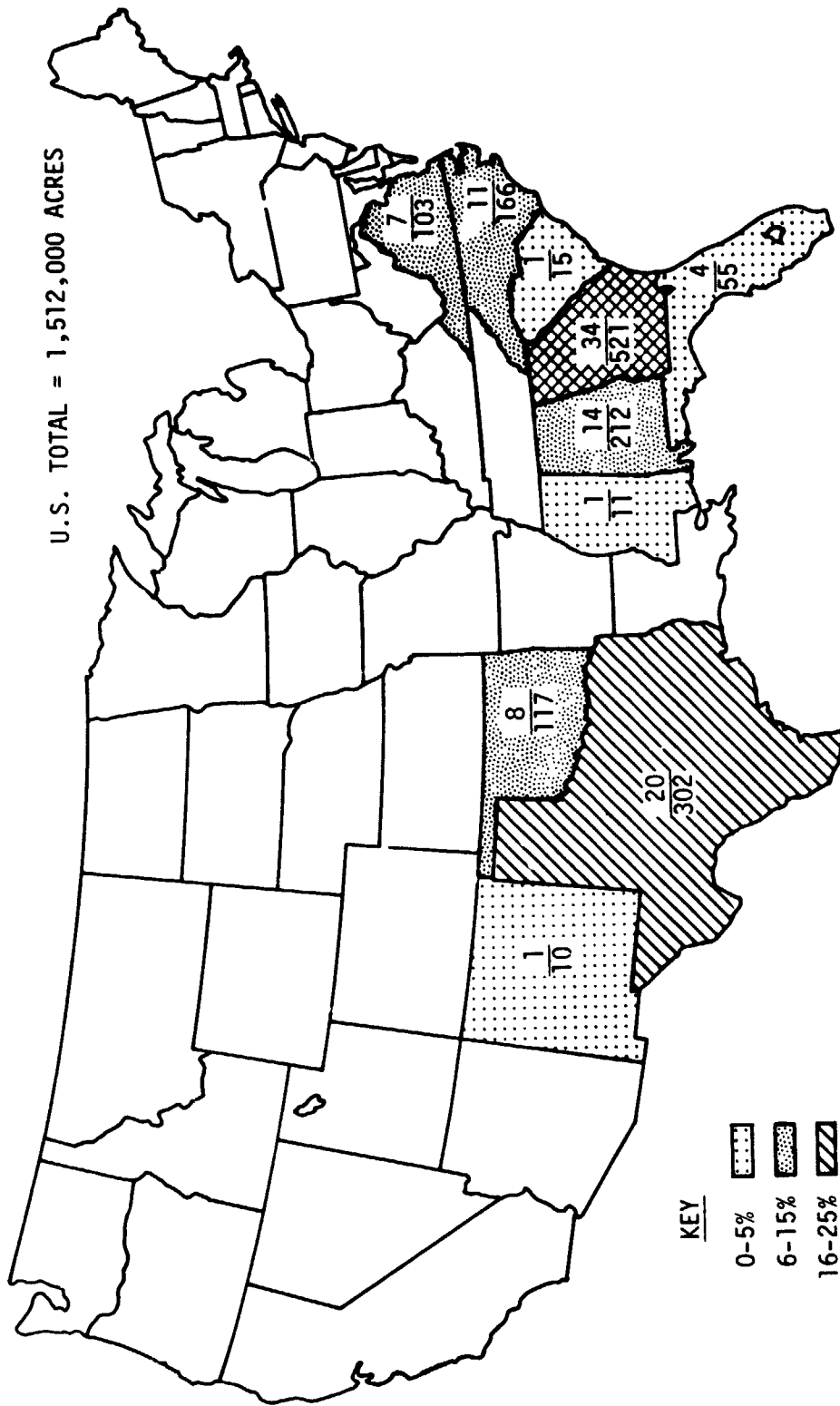
The acreage harvested for peanuts follows the same general distribution as production and value. The Georgia-Alabama area accounts for nearly 50 percent of the nation's acreage, the Virginia-Carolina area about 20 percent and Texas again about 20 percent. The map below shows where the peanut crop is grown in each state. About 30 percent of the peanut crop is treated by air.



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OF POOR QUALITY

AREA OF PEANUTS HARVESTED (1,000 ACRES)

U.S. TOTAL = 1,512,000 ACRES



KEY

- 0-5%
- 6-15%
- 16-25%
- 26+%

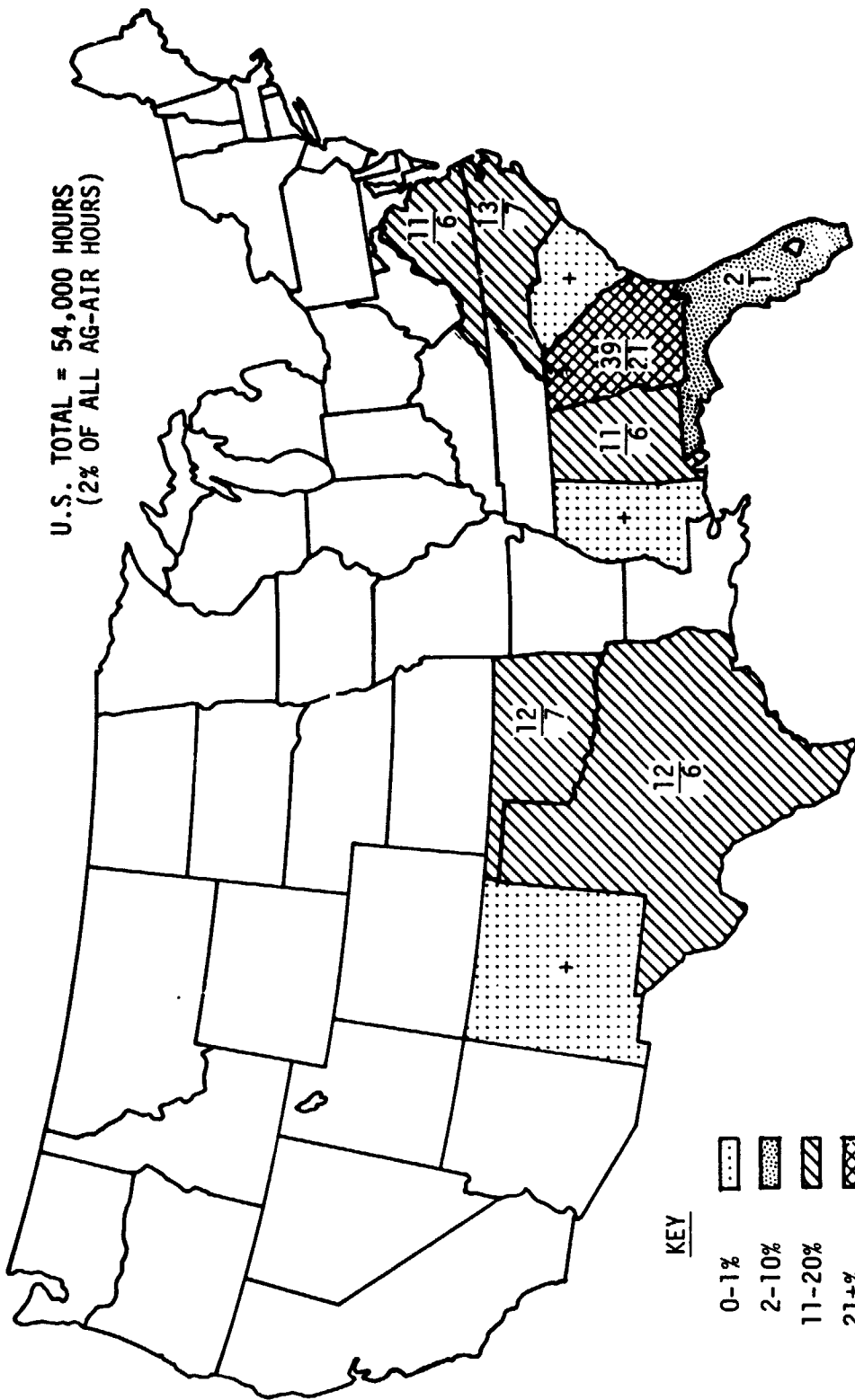
Source: U.S. Crop Reporting Board,
Crop Production, Annual
Summary, January 1977

800

About 54,000 hours were spent treating peanuts by air. The Georgia-Alabama area accounts for half of the hours with the Virginia-Carolina area and Texas and Oklahoma combined equally accounting for the other half.

ESTIMATED HOURS FLOWN FOR PEANUTS BY STATE (1,000 HOURS)

U.S. TOTAL = 54,000 HOURS
(2% OF ALL AG-AIR HOURS)



KEY

- 0-1% [Dotted pattern]
- 2-10% [Diagonal lines]
- 11-20% [Cross-hatch pattern]
- 21+% [Solid black]

% U.S.
HOURS FLOWN

LESS THAN 1,000 HOURS

X
X
+

A breakdown of the ag-air hours for peanuts shows that most of the work is for application of fungicides. Often an insecticide will be added to one of the fungicide applications.

NATIONWIDE BREAKDOWN OF AG-AIR HOURS FOR PEANUTS

<u>APPLICATION</u>	<u>% OF TOTAL HOURS</u>
FUNGICIDE	67.2
INSECTICIDE	17.0
HERBICIDE	7.9
FUNGICIDE/INSECTICIDE	7.5
MISCELLANEOUS	0.4
	<u>100.0</u>

SOURCE: NAAA QUESTIONNAIRE DATA.

Activities for two peanut growing regions are shown. When the peanut vine begins to grow between the planted rows, ground riggs can cause substantial injuries to the crop. Furthermore, after heavy rains, the plant is more susceptible to disease. These factors favor air applications.

TYPICAL AG-AIR ACTIVITIES FOR PEANUTS

STATE	DATE	MATERIAL*	CHEMICAL NAME	AMOUNT OF CHEMICAL/ACRE	APPLICATION RATE OF TOTAL MIX/ACRE	NUMBER OF APPLICATIONS
GEORGIA	AUGUST	FN	BENLATE BRAVO DIFOLATAN	1/2 # 1-1/2 PT. 3 PT.	5 GAL.	6
	SEPTEMBER	IN	PARATHION METHOMYL	1/2 # 1/4-1 #	5 GAL.	1-2
TEXAS	MAY- AUGUST	FN	BENLATE BRAVO DIFOLATAN	1/2 # 1-1/2 PT. 3 PT.	5 GAL.	8-14
	MAY- AUGUST	IN	METHOMYL	1 QT.	5 GAL.	1
* FN-FUNGICIDE, IN-INSECTICIDE						

The summary table shown at the right gives general information for eight major ag-air crops included in the data base. These crops include the three most important crops in United States agriculture: corn, wheat and soybeans. This table indicates that the detailed ag-air data base covers about 72 percent of the ag-air flying time and a similar fraction of total area harvested in the United States.

SUMMARY DATA FOR EIGHT MAJOR AG-AIR CROPS

CROP	FLYING TIME		AREA HARVESTED		PRODUCTION (1,000 UNITS)	PRICE (PER UNIT)	VALUE OF CROP (\$ THOUSANDS)	% WORLD PROD.
	HOURS	%US	1000 ACRES	%US				
COTTON	645,500	24.8	10,899	3.3	10,557 BL	\$310.56	3,278,582	16.4
RICE	316,800	12.2	2,501	0.7	117,019 CWT	6.63	775,836	1.7
WHEAT	265,200	10.2	70,824	21.2	2,147,408 BU	2.85	6,120,113	11.0
VEGETABLES	174,400	6.7	3,380	1.0	25,287 TNS	124.02	3,136,155	7.5
CORN	166,800	6.4	83,185	24.9	6,216,032 BU	2.32	14,421,194	46.8
SOYBEANS	162,700	6.2	49,443	14.8	1,264,890 BU	7.32	9,258,995	55.4
SORGHUM	109,900	4.2	17,578	5.3	723,679 BU	3.70	2,677,612	35.5
PEANUTS	54,400	2.1	1,504	0.4	3,857,122 LBS	0.196	756,530	9.4
TOTAL	1,895,700	72.8	239,314	71.6			40,425,017	

A summary of the materials and the more important chemicals applied by air is given at the right. Although, for example, some 35 chemicals are applied to cotton, only those most often cited by operators are listed. This list is by no means complete but gives a general idea of which materials are used on these important ag-air crops.

50

145

Price information on several pesticides is given to show the range of costs of materials applied by air.

STATISTICS ON PESTICIDE PRICES

- SELECTED CHEMICALS
- METHYL PARATHION
- TOXAPHENE
- 2,4-D

During the period 1974-1975, insecticide prices increased 31 percent on the 6 chemicals surveyed by USDA. The next year however, the average price rose only 4 percent. During 1976, prices for the selected insecticides decreased by 5 percent. Herbicide prices followed the same pattern; a 43 percent increase in 1974, a 1 percent decrease in 1975, and a 9 percent decrease in 1976. Fungicide prices increased 40 percent in 1974, 11 percent in 1975 and remained the same the next year. In general, prices for most pesticides have shown a small decrease in price the past year after a 50 percent rise during the preceding 2-year period.

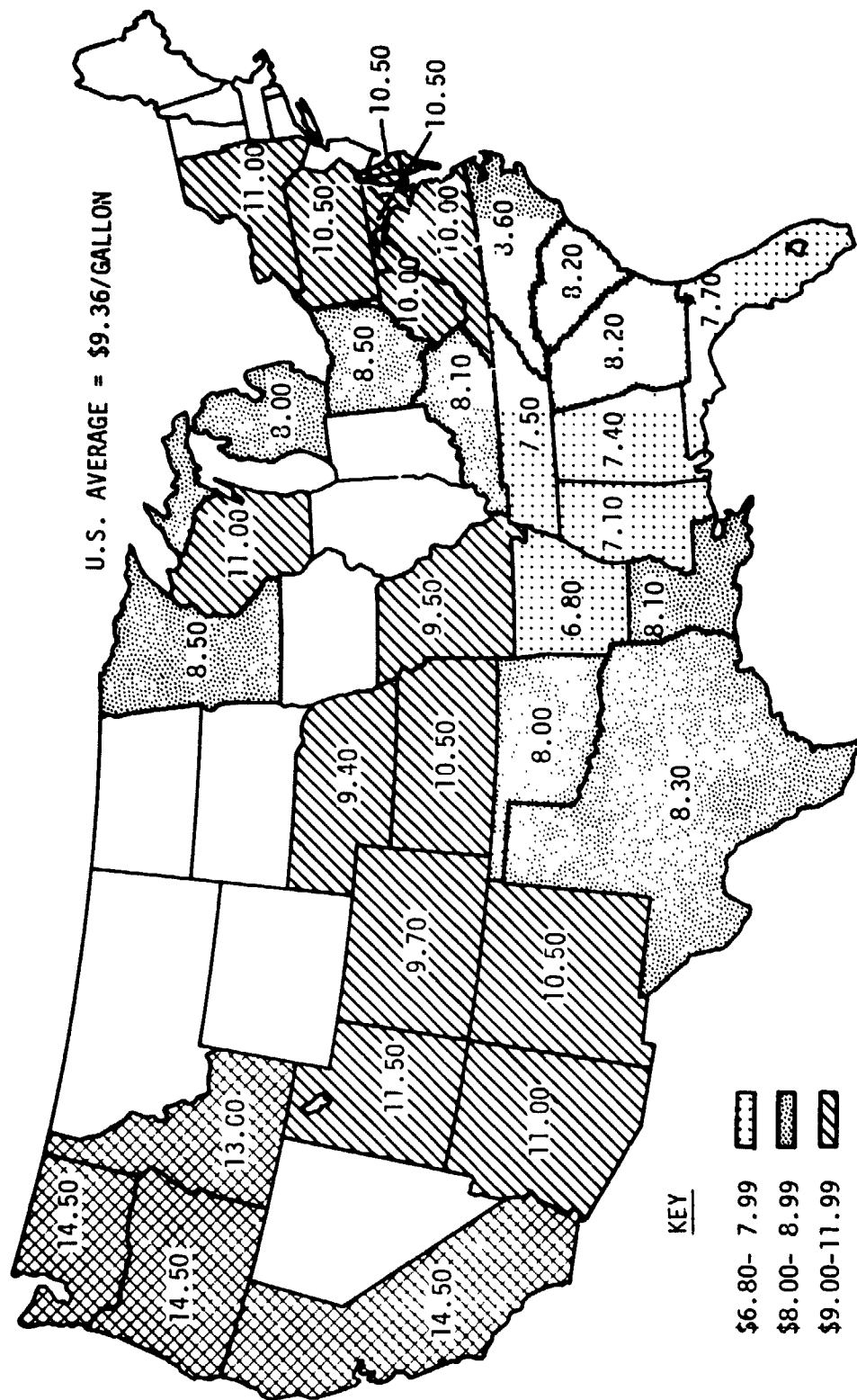
PRICE OF SELECTED MATERIALS (U.S. AVERAGE IN DOLLARS)

CROP	MATERIAL	CHEMICAL	UNIT	PRICE			
				1977	1976	1975	1974
COTTON	HB	TREFLAN (4#/GAL)	GAL	25.80	—	—	—
	IN	TOXAPHENE (6#/GAL)	GAL	5.30	5.87	5.80	4.57
	IN	METHEL PARATHION (4#/GAL)	GAL	8.04	9.36	10.10	6.57
	DF	DEF	GAL	15.20	—	—	—
	DF	PARAQUAT	GAL	39.54	—	—	—
RICE	HB	PROPANIL	GAL	9.50	—	—	—
	HB	ORDRAM (10% GRANULAR)	LB	.44	—	—	—
		CARBOFURAN	LB	.28	—	—	—
WHEAT	HB	2,4-D (4#/GAL)	GAL	8.95	10.10	9.72	5.84
CORN	IN	ATRAZINE (80% WP)	LB	2.16	2.72	2.95	2.34
	IN	ALACHLOR (4#/GAL)	GAL	14.40	—	—	—
SOYBEANS	IN	CARBARYL (80% WP)	LB	1.85	1.73	1.42	1.10
	FN	BENLATE	LB	7.70	—	—	—

— Data not available

Prices for any particular chemical vary greatly by state. For example, methyl parathion, an insecticide used extensively on cotton, shows a \$7.40 difference between California and Mississippi.

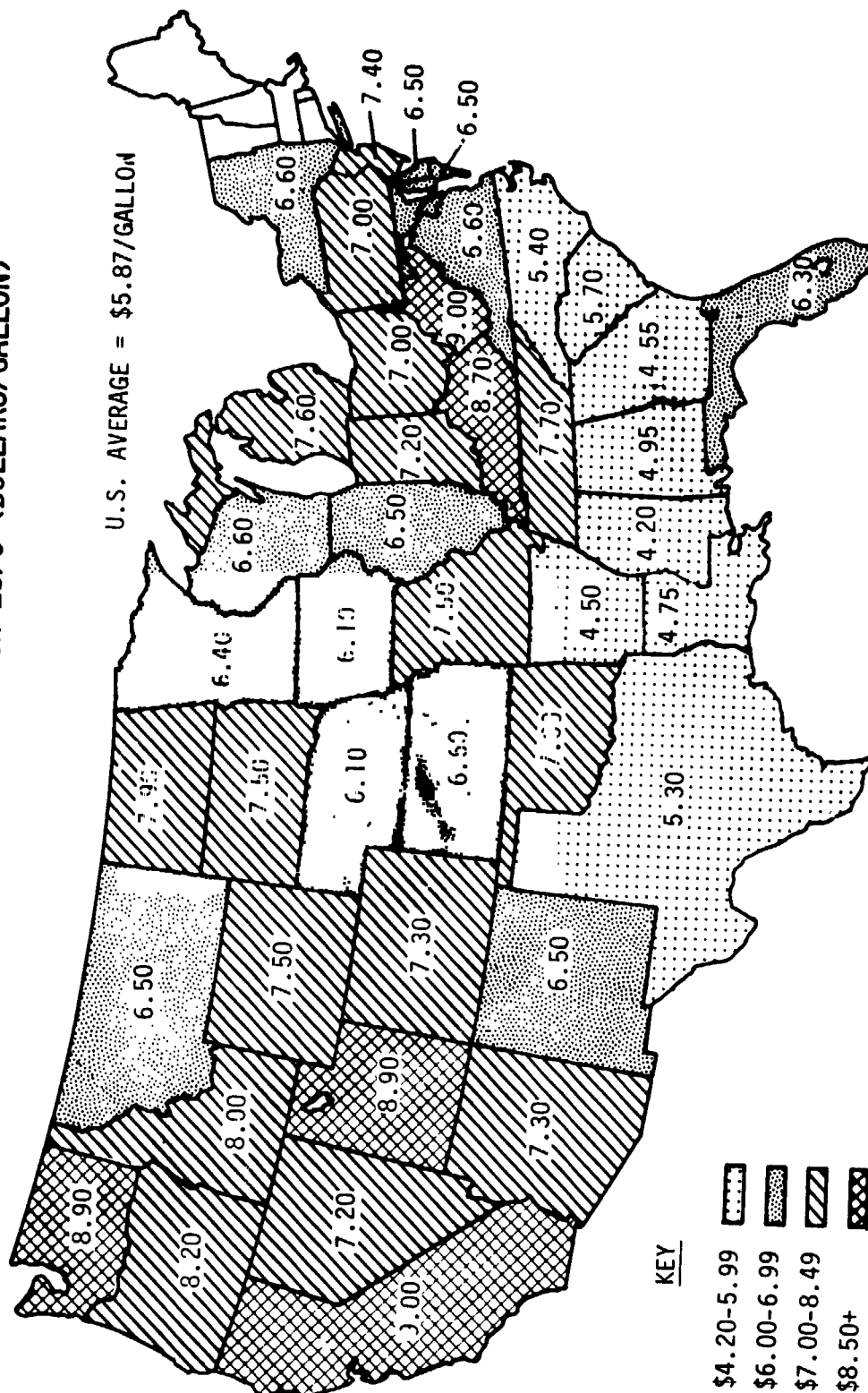
AVERAGE PRICE PAID BY FARMERS FOR METHYL PARATHION* IN 1976 (DOLLARS/GALLON)



Source: Annual Price Summary,
June 1977, Crop Reporting
Board, SRS, USDA

Again, a wide range of prices exist across the country for Toxaphene. This insecticide, also used on cotton, shows a \$4.80 difference between California and Mississippi in 1976. This pesticide has since been restricted in California.

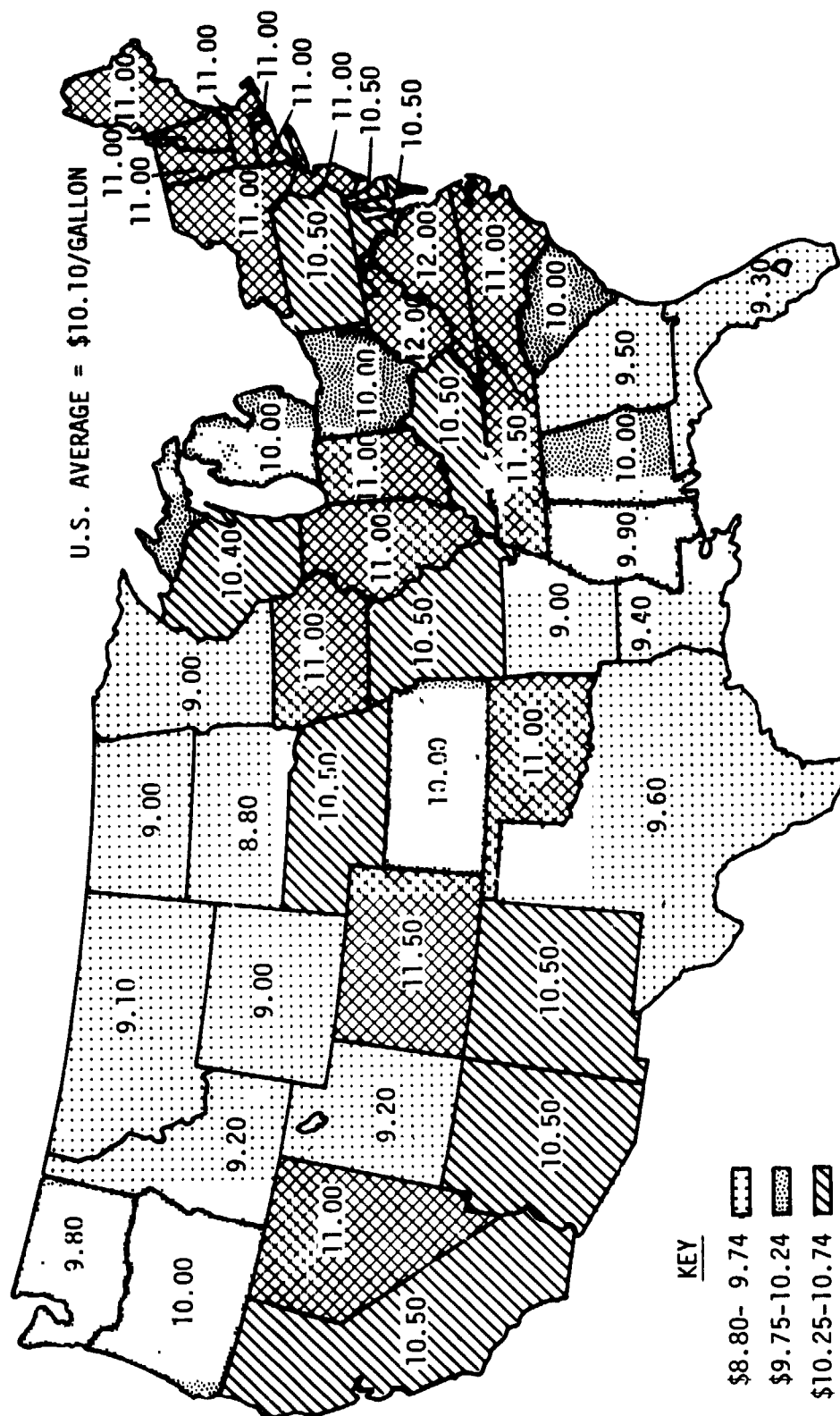
AVERAGE PRICE PAID BY FARMERS FOR TOXAPHENE* IN 1976 (DOLLARS/GALLON)



Source: Annual Price Summary,
June 1977, Crop Reporting
Board, SRS USDA

The herbicide 2,4-D, used widely on wheat, varies somewhat less than the two previous examples. In the northern states, where most ag-air hours are for wheat, the price for 2,4-D is fairly constant. However, the herbicide is also used on rice and there is a \$1.50 difference between the price in California and Arkansas.

AVERAGE PRICE PAID BY FARMERS FOR 2,4-D* IN 1976 (DOLLARS/GALLON)



KEY

- \$8.80- 9.74
- \$9.75-10.24
- \$10.25-10.74
- \$10.75+

* 4 LBS./GAL. EMUL. CONCENTRATE

Source: Annual Price Summary,
June 1977, Crop Reporting
Board, SRS, USDA

Econ

Considerably fewer hours are flown for wheat in Kansas than are flown in many other states. However, Kansas is the leading state in wheat production. The factors that influence aerial applications to wheat in Kansas are discussed here.

APPLICATION RATIONALE FOR WHEAT IN KANSAS

- IMPORTANT WHEAT INSECTS
- IMPORTANT WHEAT WEEDS
- IMPORTANT WHEAT DISEASES
- SUMMARY OF MATERIAL APPLICATION

The more important wheat insects in Kansas are identified here. Most insects can be controlled with the use of insecticides such as parathion, malathion and toxaphene. However, it is not always economical to control wheat insects. Control is economical only if insect infestations are discovered before major damage is done, if a suitable control agent is available and if the price that wheat is commanding in the marketplace is sufficiently high to warrant control. For many of the insects identified here, control is rarely economical.

IMPORTANT WHEAT INSECTS IN KANSAS

INSECT	TIME OF YEAR DAMAGE LIKELY	IMPORTANCE AS WHEAT PEST	METHOD OF CONTROL	CHEMICAL CONTROL PRACTICAL
ARMY CUTWORM	MARCH-MAY	HEAVY OUTBREAKS IN DRY YEARS	INSECTICIDES	FOR LARGE INFESTATIONS (4-5 WORMS PER SQ. FT.)
ARMYWORM	MAY-JUNE	OCCASIONALLY SERIOUS IN COOL, WET SPRINGS	CLIP PLANT	--
BANKS GRASS MITE	FALL OR SPRING	INFESTATIONS UNUSUAL	--	--
BROWN WHEAT MITE	FEB-APRIL	DAMAGE USUALLY BELOW ECONOMIC LEVELS	--	CONTROL RARELY PROFITABLE
CROWN APHID	SEPT-NOV	LITTLE DAMAGE	--	NOT JUSTIFIED
ENGLISH GRAIN APHID	SEPT-NOV AND MAR-JUNE	NO APPARENT INJURY	--	NOT JUSTIFIED
FALL ARMYWORM	SEPT-OCT	INFESTATIONS RARE, POSSIBLY SERIOUS	PARATHION, TOXAPHENE	SOMETIMES
FALSE WIREWORM	FALL-PLANTING TIME	IRREGULAR, MORE COMMON IN DRY YEARS	INSECTICIDES (WITH FUNGICIDES)	SOMETIMES
FLEA BEETLE	SEPT-OCT	LIMITED TO ISOLATED AREAS IN FIELD MARGINS	--	--
GRASSHOPPER	SEPT-OCT AND SPRING	DAMAGE IN FIELD MARGINS, MORE IN DRY YEARS	MALATHION, BEFORE TOXAPHENE, BEFORE PLANTING	SOMETIMES
GREENBUG	SEPT-OCT, SOME- TIMES MAR-APRIL	SEVERE INFESTATIONS ABOUT ONE IN TEN YEARS	DEMETRON, PARATHION, METHYL PARATHION	WHEN MORE THAN 100 BUGS PER FOOT OF ROW
HESSIAN FLY	FALL, ALSO APR-MAY	HISTORICALLY GREAT IMPORTANCE	CULTURAL	NOT PRACTICAL

There are a number of weeds that can cause losses in wheat yield in Kansas. The important ones are identified here. Weeds are controlled mostly by cropping practices and by the use of 2,4-D. The incidence of weeds in wheat is strongly influenced by weather, with greater infestations occurring during wet years. As with insects, it is not always economical to control weeds by chemical means. The decision to control involves factors of weather, expected damage and wheat price. Nonetheless, in any particular year, anywhere from 0 to 20 percent of the total wheat acreage might be subject to chemical weed control.

IMPORTANT WHEAT WEEDS IN KANSAS

WEED	IMPORTANCE OF WHEAT WEED IN KANSAS	METHOD OF CONTROL
WINTER ANNUAL GRASSES: DOWNY BROME JAPANESE BROME CHEAT JOINTED GOATGRASS	GRASSES ARE OF SOME IMPORTANCE; HOWEVER, CONTROL IS GENERALLY MAINTAINED--MAJOR IMPACT IS ON CROPPING PRACTICE	GRASSES ALL CONTROLLED BY PLANTING ROW CROPS FOR 2-3 YEARS--NO EFFECTIVE HERBICIDE CONTROL KNOWN
WINTER ANNUAL BROAD-LEAVED WEEDS: TANSY MUSTARD TREACLE MUSTARD FIELD PENNYCRESS VIRGINIA PEPPERWEED SHEPARDSPURSE	WINTER ANNUAL BROADLEAVED WEEDS ARE THE OBJECT OF THE MAJORITY OF HERBICIDE USE IN KANSAS	BROADLEAVED WEEDS ARE CONTROLLED BY APPLICATION OF 2,4-D--DECISION TO CONTROL DEPENDS ON MOISTURE, PRICE OF WHEAT, ETC.
SUMMER ANNUAL BROAD-LEAVED WEEDS: WILD BUCKWHEAT PRICKLY LETTUCE REDROOT PIGWEED KOCHIA SUNFLOWER	WILD BUCKWHEAT IS A SERIOUS WEED IN EAST-CENTRAL AND SOUTH-CENTRAL KANSAS--IS MOVING WESTWARD--HEAVY WEEDS OCCUR DURING WET YEARS	WILD BUCKWHEAT IS CONTROLLED BY DICAMBA OR BROMOXNYL--OTHERS CONTROLLED BY 2,4-D
PERENNIALS: FIELD BINDWEED	CAUSE ABOUT \$0.5 MILLION LOSS IN YIELD IN SOUTHWEST KANSAS	CONTROLLED BY 2,4-D AND BY TILLAGE

A number of the more important wheat diseases in Kansas are shown here. Most diseases are controlled either by fungicides or by the use of resistant varieties. The use of fungicides, however, is not generally economical except in the event of a severe outbreak. Diseases which are subject to economical control by fungicides in severe years include leaf rust, stem rust, powdery mildew and septoria. Of these, leaf rust is the most important, but its control presents a formidable logistics problem. The window for treatment of leaf rust, that is, the time between the first detectable outbreak of the disease and the time by which it must be treated to prevent major damage, is typically as short as one week. During this time, a major outbreak could require the application of as much as 6 million pounds of fungicide in the state of Kansas alone. It is presently not economical to retain the capability to meet this requirement on a demand basis. Thus, leaf rust often goes untreated. Many other diseases are not of sufficient consequences to warrant chemical control. This is the case with take-all and cephalosporium stripe, for example. The conclusion reached here is that wheat diseases are highly variable from year to year and generally cannot be treated economically by the use of chemicals, either by air or by other means.

IMPORTANT WHEAT DISEASES IN KANSAS

DISEASE	TIME OF YEAR DISEASE TRANSMITTED	IMPORTANCE AS WHEAT DISEASE	METHOD OF CONTROL
SOIL-BORNE MOSAIC	FALL-WINTER	MOSTLY EAST AND CENTRAL KANSAS, OCCASIONAL SEVERE OUTBREAKS--'66, '74, '75 ONE MILLION ACRES AFFECTED	PLANT LATE/RESISTANT VARIETIES CAN BE CONTROLLED BY FUMIGATING SOIL BUT COST IS PROHIBITIVE
WHEAT STREAK MOSAIC	FALL-SPRING	SEV'E IN CENTRAL AND WESTERN KANSAS AT TIMES	PLANT LATE/RESISTANT VARIETIES NOT VERY EFFECTIVE--NO KNOWN CHEMICAL CONTROL
LOOSE SMUT	DURING BLOOM	SEVERE IN EASTERN KANSAS	TREAT SEED/RESISTANT VARIETIES
BUNT	BEFORE EMERGENCE	NOT VERY IMPORTANT	TREAT SEED WITH FUNGICIDE
LEAF RUST	MILD WINTER	SOME EVERY YEAR, OCCASIONALLY SEVERE	RESISTANT VARIETIES/FUNGICIDES (MANZATE 200)
STEM RUST	APRIL-MAY	OFTEN NO LOSS BUT LARGE POTENTIAL	RESISTANT VARIETIES/FUNGICIDES (DIATHANE M-45)
TAKE-ALL	CONTINUOUS	NOT IMPORTANT BUT MOST SERIOUS IN KANSAS AND NEW YORK	ROTATION OUT OF WHEAT
CEPHALOSPORIUM STRIPE	CONTINUOUS	NOT MAJOR--DAMAGE LOCALIZED TO A FEW FIELDS	ROTATE, BURN STUBBLE, DEEP PLOW
SEED ROT/ SEEDLING BLIGHT	CONTINUOUS	LARGELY CONTROLLED, OCCURS IN DAMP SOIL	ROTATE, TREAT SEED WITH FUNGICIDES

In summary, there are three factors which limit the extent of aerial application to wheat in Kansas, or for that matter, any chemical application to wheat in Kansas. First, wheat is a relatively low revenue-per-acre crop and thus is subject mainly to reactive rather than preventive control; second, the decision to control is based on a number of factors relating to the economics of control, and it is simply not always economical to chemically control wheat insects, weeds or diseases; third, treatment of certain problems requires prompt and extensive applications, creating prohibitive logistics problems; and fourth, Kansas is a good place to grow wheat--that is, it is not subject to as many or as significant damaging agents as wheat planted in other locations. The problems with wheat in Kansas are, however, variable from year to year, and, while very little application might be made in one year, there may be a rather substantial amount of application made in the next year. As an example, while 1977 was a rather trouble-free year and one in which little chemical control was exercised, 1976 saw a significant cutworm outbreak. About one million acres were treated during that outbreak, some one-third to one-half of that by air. Proceeding out of Kansas, to the north, weeds become an increasing problem, and, to the south, insects become an increasing problem.

SUMMARY OF MATERIAL APPLICATION TO WHEAT IN KANSAS

- WHEAT IS A RELATIVELY LOW REVENUE-PER-ACRE CROP--PREVENTIVE CONTROL IS NOT GENERALLY EXERCISED
- PROBLEMS IN WHEAT ARE HIGHLY VARIABLE YEAR TO YEAR AND DEPEND, AMONG OTHER THINGS, ON WEATHER--IN ANY PARTICULAR YEAR, FROM 0% TO 20% OF THE WHEAT CROP MIGHT BE TREATED
- THE LOGISTICS OF CHEMICAL CONTROL MAY BE PROHIBITIVE
- THE DECISION TO CONTROL A PROBLEM DEPENDS ON THE ECONOMICS OF CONTROL AND INCLUDES SUCH FACTORS AS:
 - STATE OF DAMAGE WHEN PROBLEM IS IDENTIFIED
 - FUTURE POTENTIAL DAMAGE
 - AVAILABILITY OF AN EFFECTIVE CONTROL MEASURE
 - COST OF CONTROL
 - EXPECTED WHEAT PRICE
- IT IS NOT NECESSARILY ECONOMICAL TO EFFECT CONTROL
- KANSAS IS A GOOD PLACE TO GROW WHEAT--IT IS LESS SUSCEPTIBLE TO DISEASE, WEED AND INSECT DAMAGE IN KANSAS THAN IN OTHER AREAS

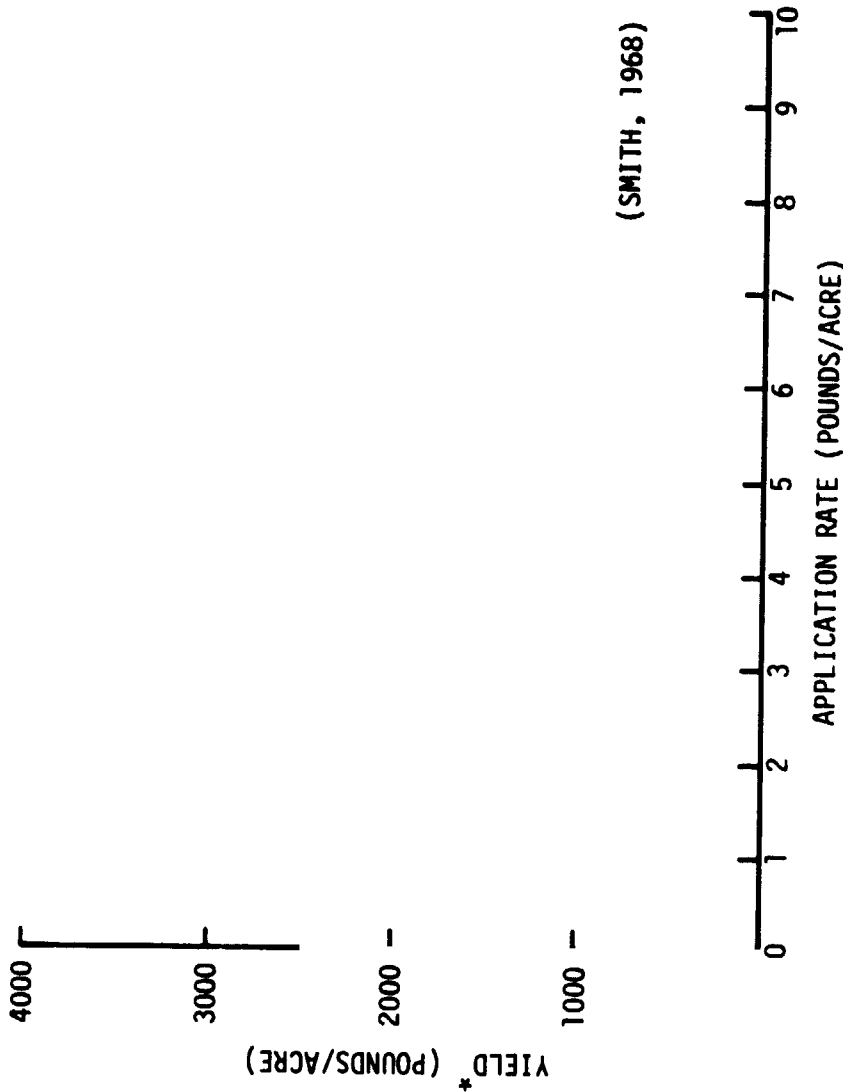
As one of the benefit estimates depends on efficacy of pesticides, an extensive search was performed of published sources in order to uncover experimental data relating crop yield to the quantities of herbicides applied. Relatively few worthwhile data sources were uncovered that pertain to the most important crops and could be regarded as relevant to aerial application. Nonetheless a few curves were uncovered that do appear to have some value, if we are willing to assume them to be typical. The four references cited appear in the bibliography.

EFFICACY OF HERBICIDES

- PROPANIL
- ATRIZINE
- DNBP
- HOE-23408

About 50 field experiments with Propanil were conducted in Arkansas at four plot locations during 1960 and 1965. The work of Roy Smith included a number of variables not relevant to this study and are not discussed here. Commercial varieties of rice were planted on well prepared seed beds. Propanil was applied at 0.5 to 12 pounds per acre pre-emergent or post-emergent by ground and aerial equipment. Usual cropping practices were followed. Propanil was found to be most effective in controlling grass weeds when applied to plants 0.5 to 2 inches tall. It was usually ineffective when applied pre-emergent or post-emergent to grass more than 6 inches tall. Propanil at 3 pounds per acre or more controlled weeds. Rice treated with propanil at 3 to 12 pounds per acre yielded significantly more than untreated rice. Propanil was less effective at 2 pounds per acre than at higher rates. A mix of 10 to 15 gallons of water per acre was sufficient for effective control of grass by aerial equipment. Applications below 10 gallons per acre drifted more than those at higher volumes, especially with wind velocities above 5 miles per hour. Aerial equipment was more satisfactory than ground equipment because levees did not reduce spraying efficiency and fields too wet to support ground equipment could be sprayed rapidly and at the right time. Medium fine droplets of 200 to 300 μ in diameter were considered satisfactory for ground and aerial equipment. Yield data for two years for 2 plots at various application rates are given in the graph at the right.

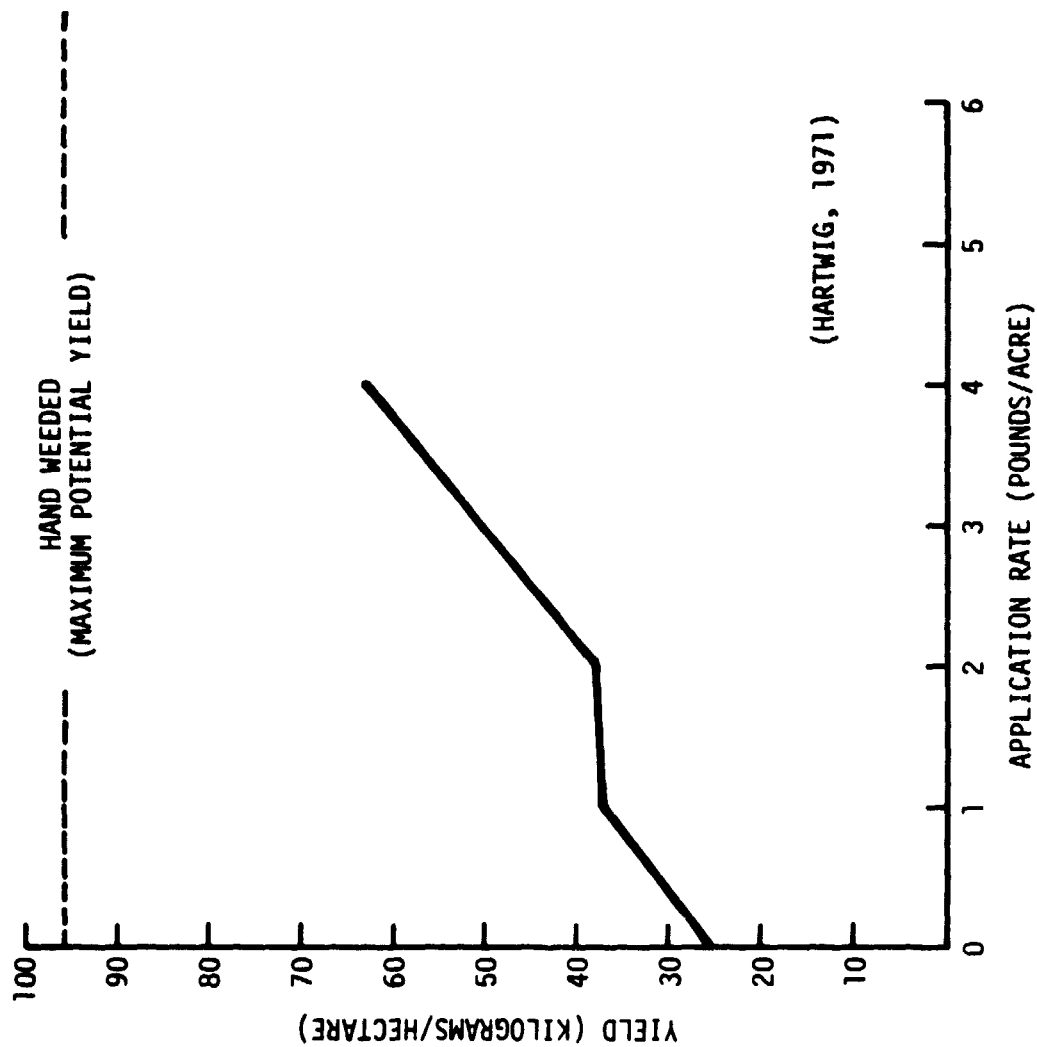
APPLICATION OF PROPANIL TO RICE IN ARKANSAS



* Average yield at Stuttgart and Rohwer plots, 1961 and 1962.

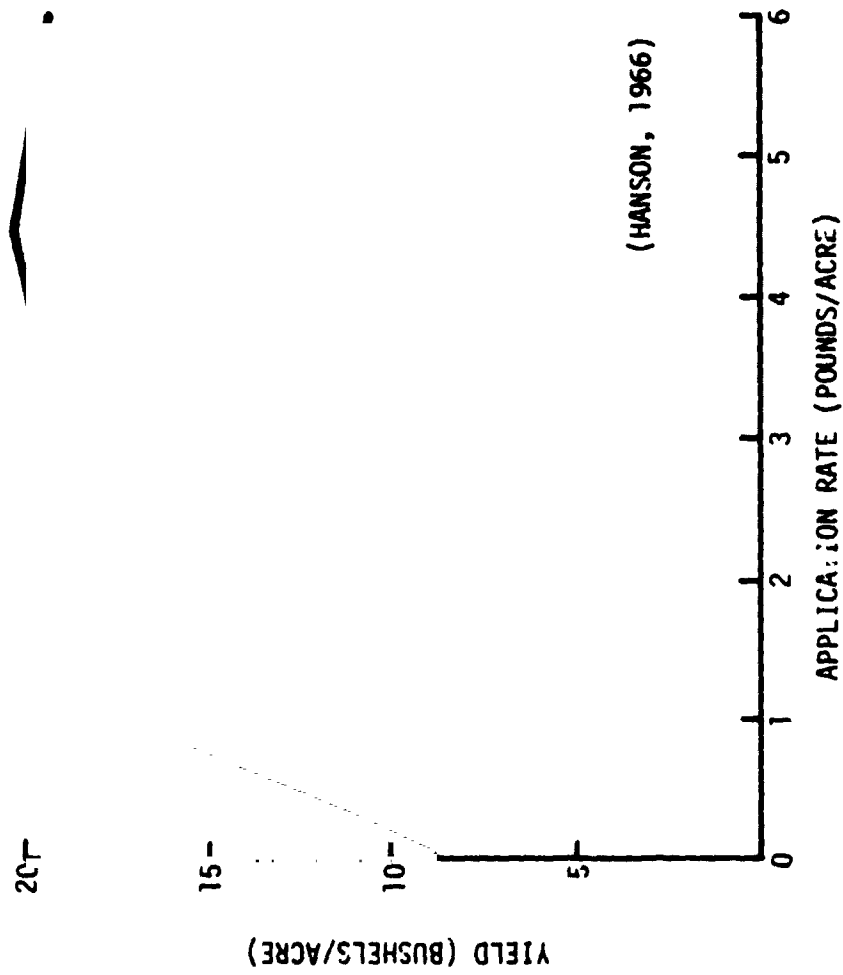
A study of the application of Atrazine to corn in Pennsylvania is shown at the right. Atrazine was applied at the rates of 1, 2 and 4 pounds of active ingredient per acre. A control plot did not receive herbicide applications and one other plot was weeded by hand to show the maximum potential weed control. Yield data indicate that the best crop yield with herbicide application is obtained with the 4 pound rate.

APPLICATION OF ATRIZINE TO CORN IN PENNSYLVANIA



Several experiments were conducted in Mississippi during 1965 to study the safety and effectiveness of DNBP or dinitro for post-emergent weed control in soybeans. Experiments relating to directed sprays and weed free plots are not discussed here. DNBP was applied broadcast over-all using a standard herbicide boom by ground riggs. The spray volume for all experiments was an overall rate of 40 gallons per acre. The application of DNBP at 2.25 to 3 pounds per acre as an over-all spray on soybeans is recommended and used in many areas for control of emerged grasses and broadleaved weeds. The soybean leaves may be burned from this treatment but the plants usually recover and grow normally. Because of increased injury to the bean plant at high temperatures, this treatment is not recommended for use when temperatures following treatment may exceed 85 degrees Fahrenheit. An experiment was conducted to determine if the DNBP at lower dosages could be safely applied over-all at temperatures above 85 degrees and still provide satisfactory weed control. DNBP was applied at rates from 0.25 to 6 pounds per acre. The maximum air temperature for the days following the application was 90 degrees. Yield data for various application rates of DNBP is given in the graph at the right. Weed control and yield of soybeans increased with rates of DNBP up to 3 pounds per acre. Fair to very good control of weeds was obtained with 0.75 and 1.5 pounds of DNBP per acre with insignificant injuries to soybeans. Serious reductions in stand were obtained at rates above 4 pounds per acre. Although best yields were obtained at the higher dosages, the injury to the beans was severe. Under slightly different conditions, Hanson notes, significant reductions in yields might have resulted.

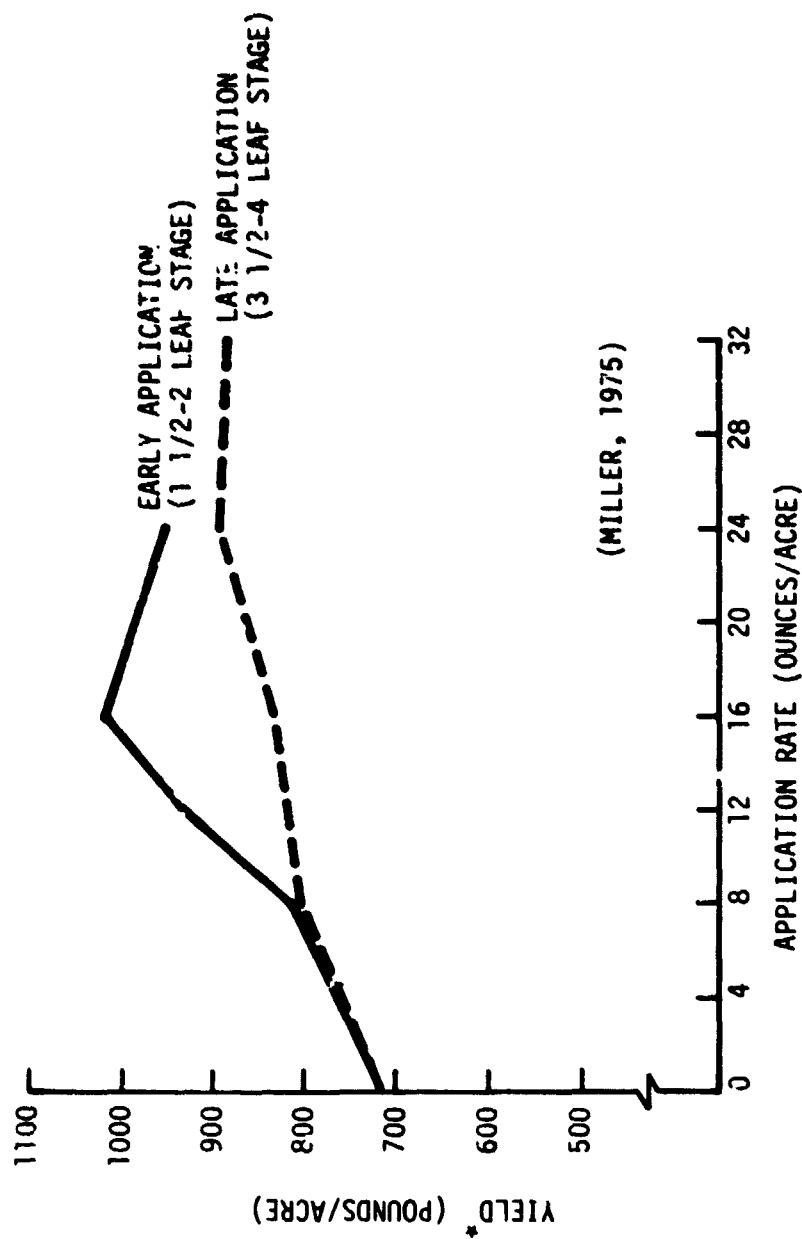
APPLICATION OF DNBP TO SOYBEANS IN MISSISSIPPI



8303

Studies were conducted at several locations in North Dakota during 1974 to evaluate weed control and crop response from HOE-23408 at several stages alone and in combination with broadleaf herbicides. Treatments were applied post-emergent at two different leaf stages with a bicycle wheel sprayer delivering 8.5 gallons per acre. Wildoats and foxtail control with HOE-23408 increased as herbicide rates increased at both stages of application. Wheat showed excellent tolerance to HOE-23408 at all locations. Little or no wheat injury was observed at rates as high as 32 ounces per acre. All treatments increased wheat yields above the nontreated control. Wheat yields were generally higher with the early rather than late post-emergent applications. Highest yields were obtained with 16 ounces per acre of HOE-23408 for the early applications. Weed control with HOE-23408 was reduced when broadleafed herbicides were added.

APPLICATION OF HOE-23408⁺ TO WHEAT IN NORTH DAKOTA



⁺ An experimental post-emergence herbicide for wild oat and foxtail in wheat.

^{*} Average yield of Waluron and Ellar plots, 1974.

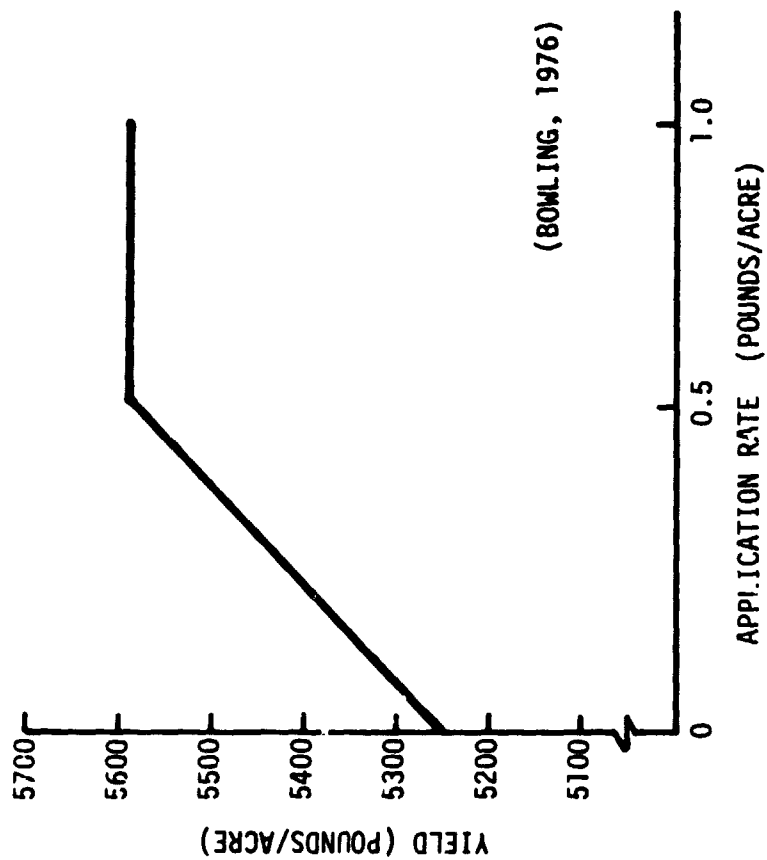
Published sources were also searched to reveal experimental data relating crop yield to the quantities of insecticide employed. As with the herbicide data, the usable insecticide results are sparse. The reasons are similar -- multiplicity of variables, unusable form of reporting, and data anomalies suggesting errors or unexplained influences. Only a small number of usable reports were found that dealt with the most important crops and that can be regarded as relevant to aerial application. The three references cited appear in the bibliography.

EFFICACY OF INSECTICIDES

- CARBOFURAN
- CARBARYL
- DISULFOTON

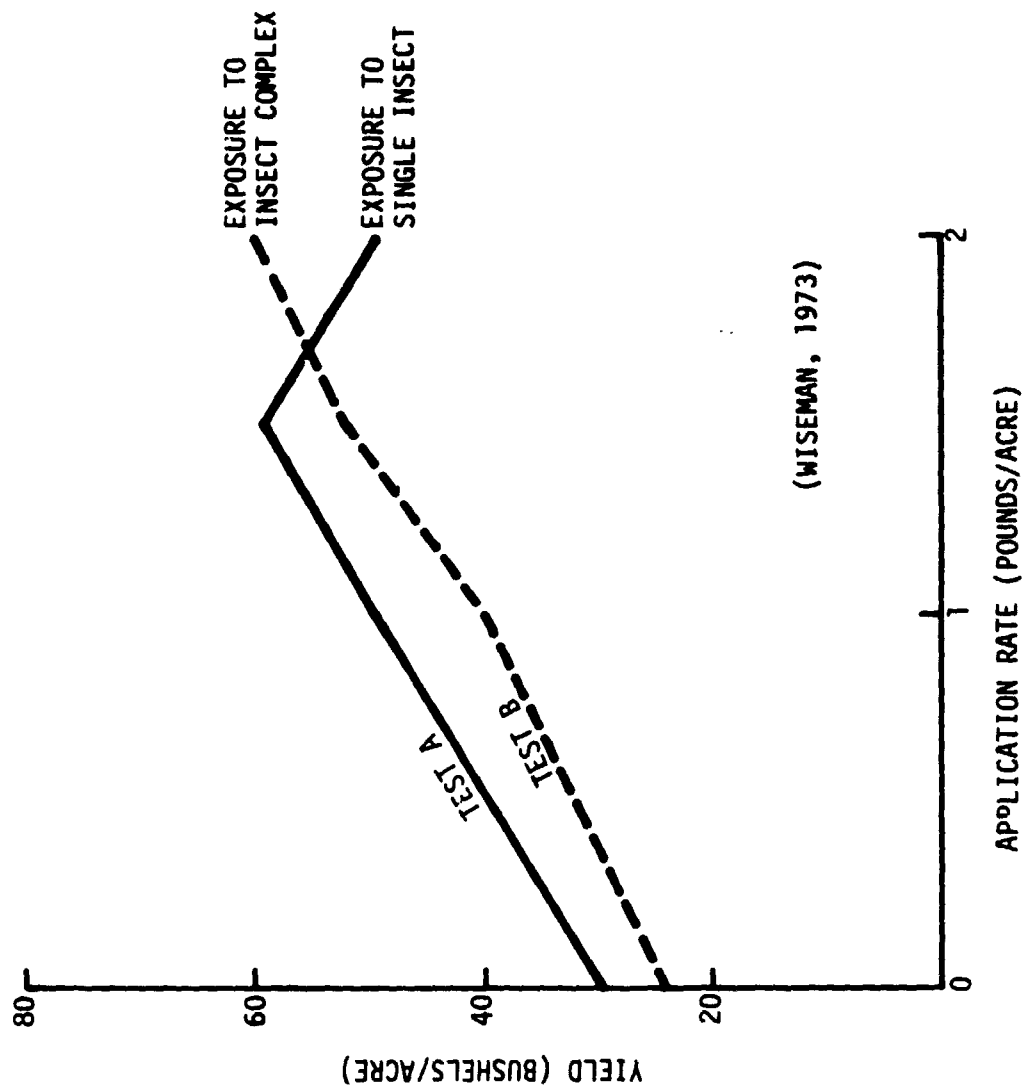
Five studies to evaluate granular carbofuran for control of rice weevil were conducted in Texas from 1967 to 1975. Studies with other chemicals are not discussed here. Circular plots were established by inserting aluminum lawn edging into the ground around drill planted rice plants flooded with water. Granular insecticides were distributed by hand within the enclosed plots. Normal cropping practices were followed. Carbofuran effectively controlled a moderate infestation when application was made at 4 to 14 days post-flood at either 0.5 or 1 pound per acre. Carbofuran controlled larval populations when applied at rates of 0.33, 0.5 and 1 pound per acre one week post-flood. When applied at the same rate two weeks post-flood carbofuran was partially effective in controlling a heavy infestation. Carbofuran at 0.5 and 1 pound per acre reduced larval populations to low levels when applied one or two weeks post-flood. Mean yields were increased with carbofuran at both rates at both application dates. Yield increases were statistically significant when carbofuran was applied at either rate one week post-flood.

APPLICATION OF CARBOFURAN TO RICE IN TEXAS



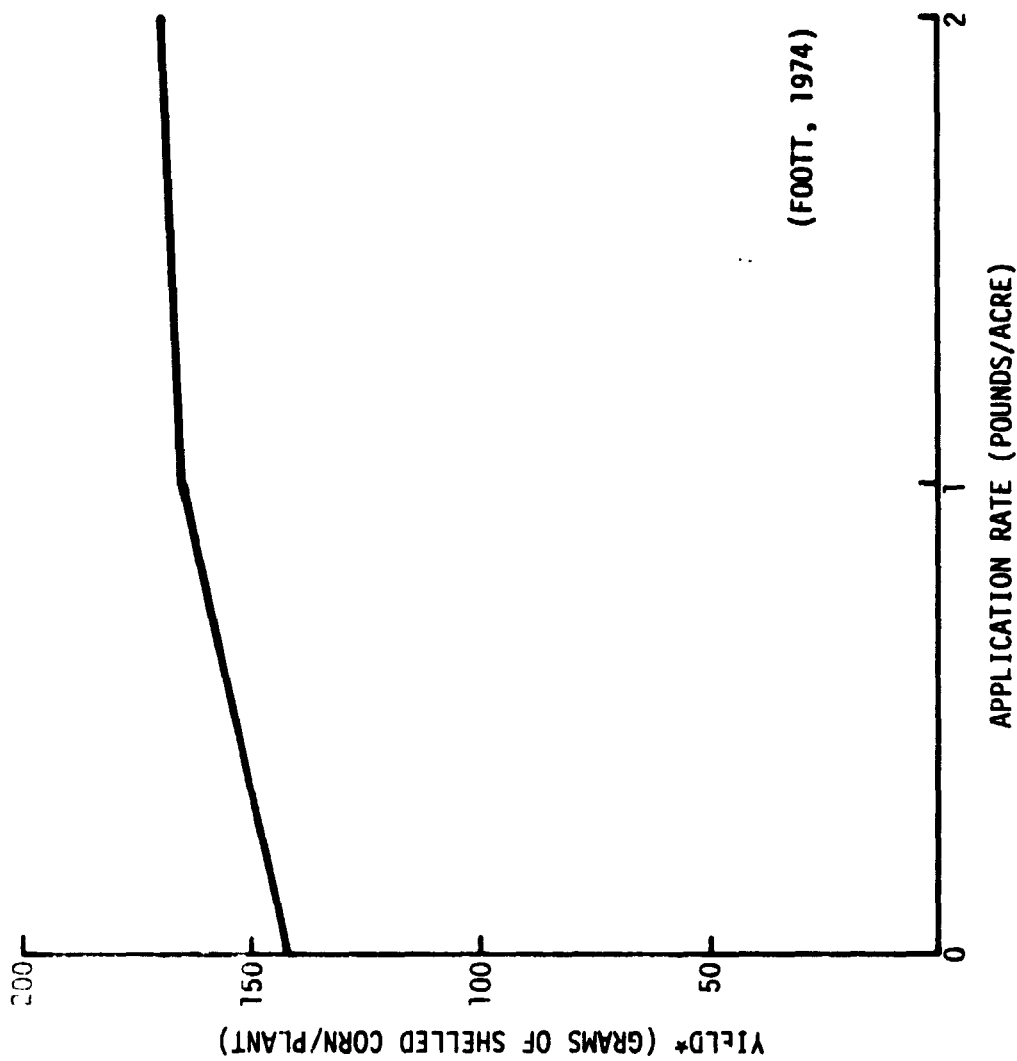
Studies were made in 1971 to determine the effectiveness of several systemic insecticides and carbaryl applied at various rates and times in reducing losses in yield in Georgia from the sorghum midge only, or from the complex of insects that attack sorghum (sorghum midge, corn earworm, the sorghum webworm, and several others). Fourteen insecticide treatments were used; however, only one is discussed here. Carbaryl, 80 percent SP was applied with a Solo knapsack sprayer at 1, 1.5 and 2 pounds per acre in 18 gallons of water at 10 percent flowering. Studies were also done with multiple applications. Sorghum midges were most effectively controlled by three applications of carbaryl at 1.5 pounds per acre, next most effectively by 2 applications, and next by 1 application. However, the clearest indication of the effectiveness of carbaryl is seen in the differences in control obtained with a single application of 1, 1.5 or 2 pounds per acre. This is shown in the graph at the right.

APPLICATION OF CARBARYL TO SORGHUM IN GEORGIA



Several granular systemic insecticides which were effective against root worm were examined for their effects on levels of infestation and injury by the corn leaf aphids in field corn. The investigation was conducted in Ontario from 1969 to 1972. Granular systemic insecticides were applied as a side dressing on each side of the rows of corn in furrows 2 inches deep and 2 inches from the plants. Disulfoton was applied at 1 and 2 pounds per acre each year. Average yields for the four years are shown in the graph at the right. Precipitation probably was an important factor in the 3 pollination apparently increased the uptake of disulfoton and caused a surge of aphid mortality during pollination. The greater effectiveness of disulfoton could result from this relatively low water solubility. Whereas materials with a high water solubility could be absorbed by plants or leached from the root area early in the season, disulfoton might be retained in larger amounts near the root for uptake during midseason rains. Foott concludes that in some years growers who use disulfoton would prevent significant yield losses due to aphids. This material would be most effective when moderate rainfall occurs in the 7 to 10 days preceding pollination, the period during which there is often a very rapid increase in aphid population.

APPLICATION OF DISULFOTON TO FIELD CORN IN ONTARIO



* Average yields for four years.

Published sources were searched for experimental data relating droplet size of spray to yield of crop. As with herbicide and insecticide studies, the usable droplet size results are sparse. The reasons are that most studies deal only with measurement of droplets, contacts with insects, drift problems, distribution and importance of controlling droplet size. The usable data report insect kill or plant damage rather than yield for insecticides. No usable data were found reporting on herbicides. The two references cited appear in the bibliography.

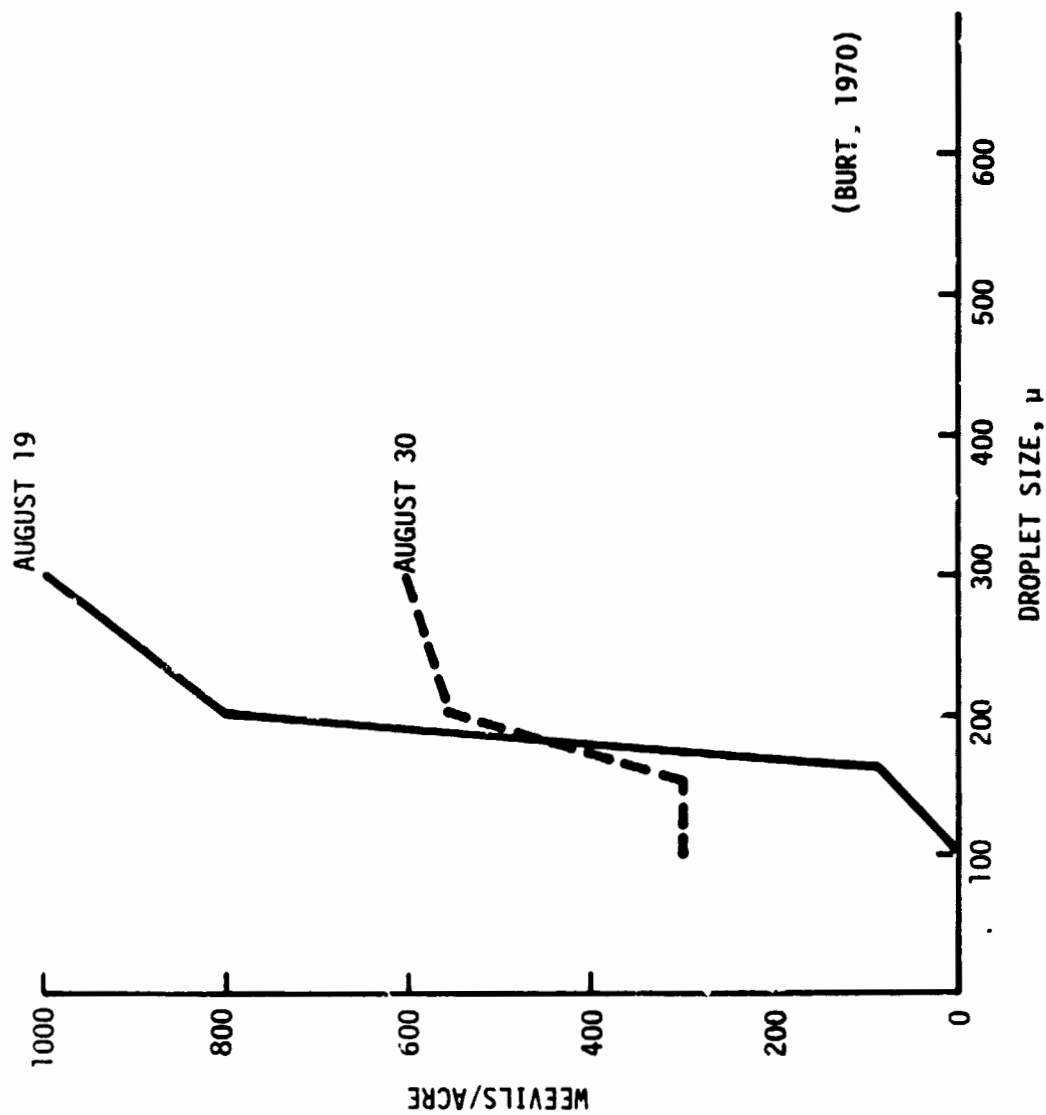
EFFECT OF DROPLET SIZE

- AZINPHOSMETHYL
- MONOCROTOPHOS

Considerable controversy exists over the effects of droplet size on application efficacy for insect control. The leading work in this area is presently being done by Dr. Chester Himel of the University of Georgia.* To begin with, Himel points out that a droplet of 15 to 20 μ diameter contains a lethal dose of insecticide for most insects. If the insect comes into contact with a droplet of insecticide of that size or larger, the insect is killed. The problem is thus reduced to one of bringing droplets of this size or larger into contact with the insects. Two phenomena are involved in this process. First, the higher the number of droplets per unit volume the more likely an insect is to come into contact with one. This fact favors smaller droplet size since this leads to more drops per unit volume for a given amount of material. The second phenomena has to do with the transport mechanism by which the droplet is conveyed from the spray device to the insect. It has been shown that droplets larger than about 200 μ tend to fall to the ground with the primary transport mechanism being the force of gravity. Droplets smaller than about 200 μ tend to remain suspended in the air and rely on air turbulence as the primary transport mode. Since most insects live on the underside of leaves, falling drops seldom come in contact with them. The smaller droplets transported by turbulent motions of the atmosphere do tend to reach the underside of leaves and thus are more effective against insects. Investigators who adhere to Himel's theory believe that the use of smaller droplet sizes result in a more effective use of chemical, thus not only better controlling insects but also allowing reductions in the quantity of chemical applied. The work of Beal et al. (1970) shown here bare out Himel's theory.

*Several studies by Himel appear in the bibliography.

DROPLET SIZE OF AZINPHOSMETHYL FOR TWO APPLICATION TIMES SPRAYED FOR BOLL WEEVIL CONTROL IN MISSISSIPPI



The total amount of spray volume applied and the resulting coverage are important aspects of pesticide application, and their influence on control has not been well established. It is important to note that many drop-size studies have involved the use of conventional nozzle equipment that create sprays composed of a wide range of drop sizes with the mass-median diameter or some other statistically calculated diameter being used as a single parameter to characterize the spray. It is therefore understandable that the results of these studies are frequently inconsistent and inconclusive relative to the biological response attributed to a particular drop size. The research of Jimenez et al. in 1976 was made with ground riggs equipped with jet stream atomizers that produced sprays having a very narrow range of drop sizes. The purpose of this study was to see if there were any differences in insect mortality, crop yield, and the quality of the crop that could be attributed to the different drop size classes or to different amounts of spray volume applied per acre. Cotton crops in Oklahoma were treated five times at about weekly intervals with varying amounts of monocrotophos. At weekly intervals in each plot, 100 squares from the upper third of the plant was pulled at random and the percent of damaged squares was determined for each application and is shown in the graph at the right. There was no significant difference in square damage between any of the treatments although the larger gallonages are generally associated with lower square damage, regardless of drop size. Yield data showed significantly poorer yields for the small drop size classes for all spray volumes. No differences in fiber quality could be attributed to the treatment.

DROPLET SIZE OF MONOCROTOPHOS FOR THREE APPLICATION RATES SPRAYED FOR BOLLWORM CONTROL ON COTTON IN OKLAHOMA

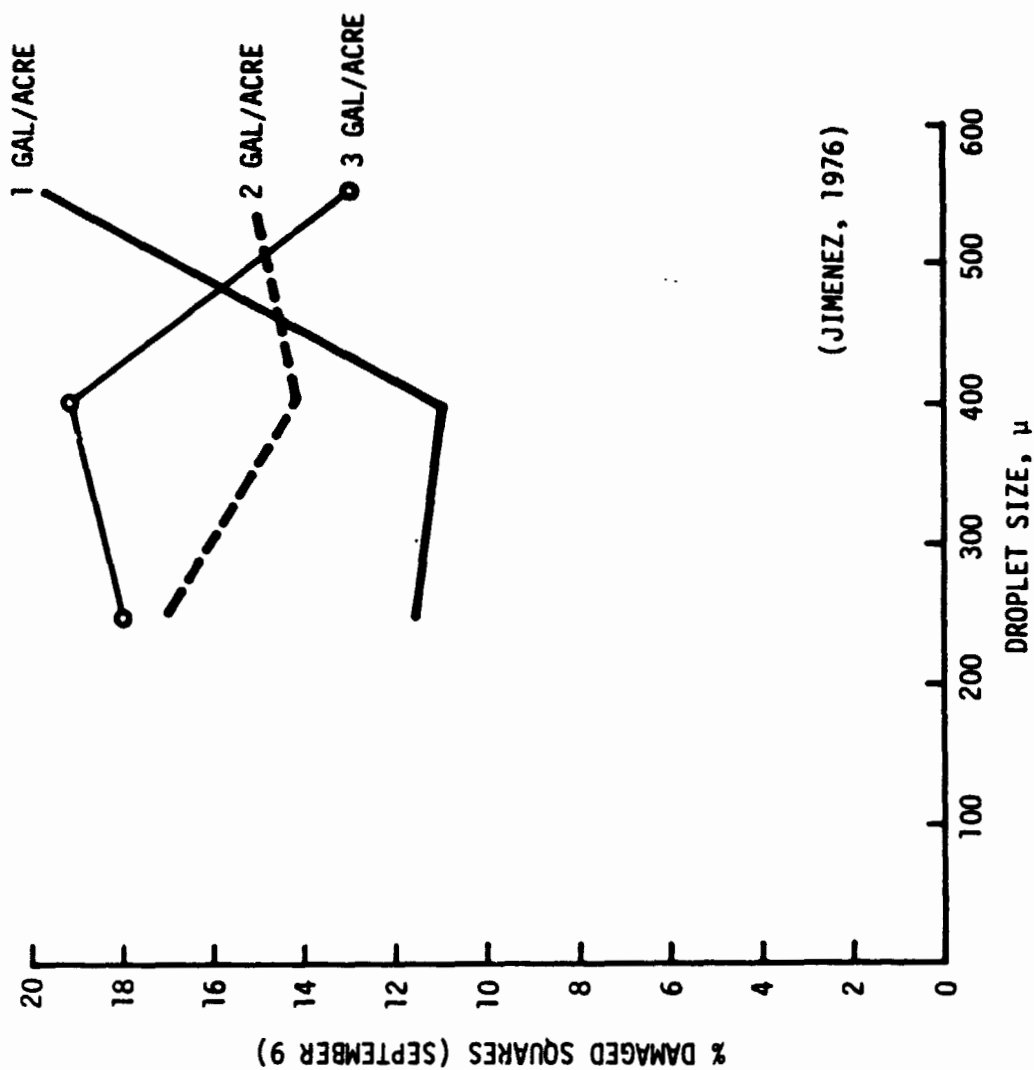


PHOTO: A PIPER CUB SPRAYING AN INFESTED AREA FOR
FOR LOCUST IN MOROCCO IN 1954. PHOTO
COURTESY OF FAO, ROME, ITALY.

PART III
THE WORLD AG-AIR INDUSTRY



503

ORIGINAL PAGE IS
OF POOR QUALITY

There are approximately 24,000 aircraft in the world agricultural aircraft fleet today, treating over 500 million acres. Between 50 and 60 countries engage in ag-air activities. The United States and the U.S.S.R. account for more than 75 percent of the world ag-air fleet and area treated by ag-air. Mexico, Argentina, New Zealand, Canada, Australia, Brazil, Columbia and China have ag-air fleets that number over 200 planes and engage in significant ag-air activities. The remaining 50 countries utilize agricultural aircraft to a lesser extent.

Data on ag-air operations in individual countries is difficult to come by. However, in this section a general outline is given of agricultural activity worldwide. Eight major crops were selected to give an overview of the variations in productivity, yield, and area planted in countries around the world. In addition, fertilizer usage is outlined. Finally, data on ag-air operations for several individual countries is presented, as an example of the variety of ag-air operations around the world.

THE WORLD AG-AIR INDUSTRY

- NUMBER OF AIRCRAFT
24,553 TOTAL
- AREA TREATED BY AG-AIR
233 MILLION HECTARES
(575 MILLION ACRES)
- FLEET SIZE OF MAJOR AG-AIR COUNTRIES

USSR	10,000	CANADA	400
US	8,649	AUSTRALIA	247
MEXICO	800	BRAZIL	219
ARGENTINA	539	COLUMBIA	208
NEW ZEALAND	451	CHINA	200
- MAJOR WORLD CROPS -- MILLION HECTARES (ACRES) HARVESTED

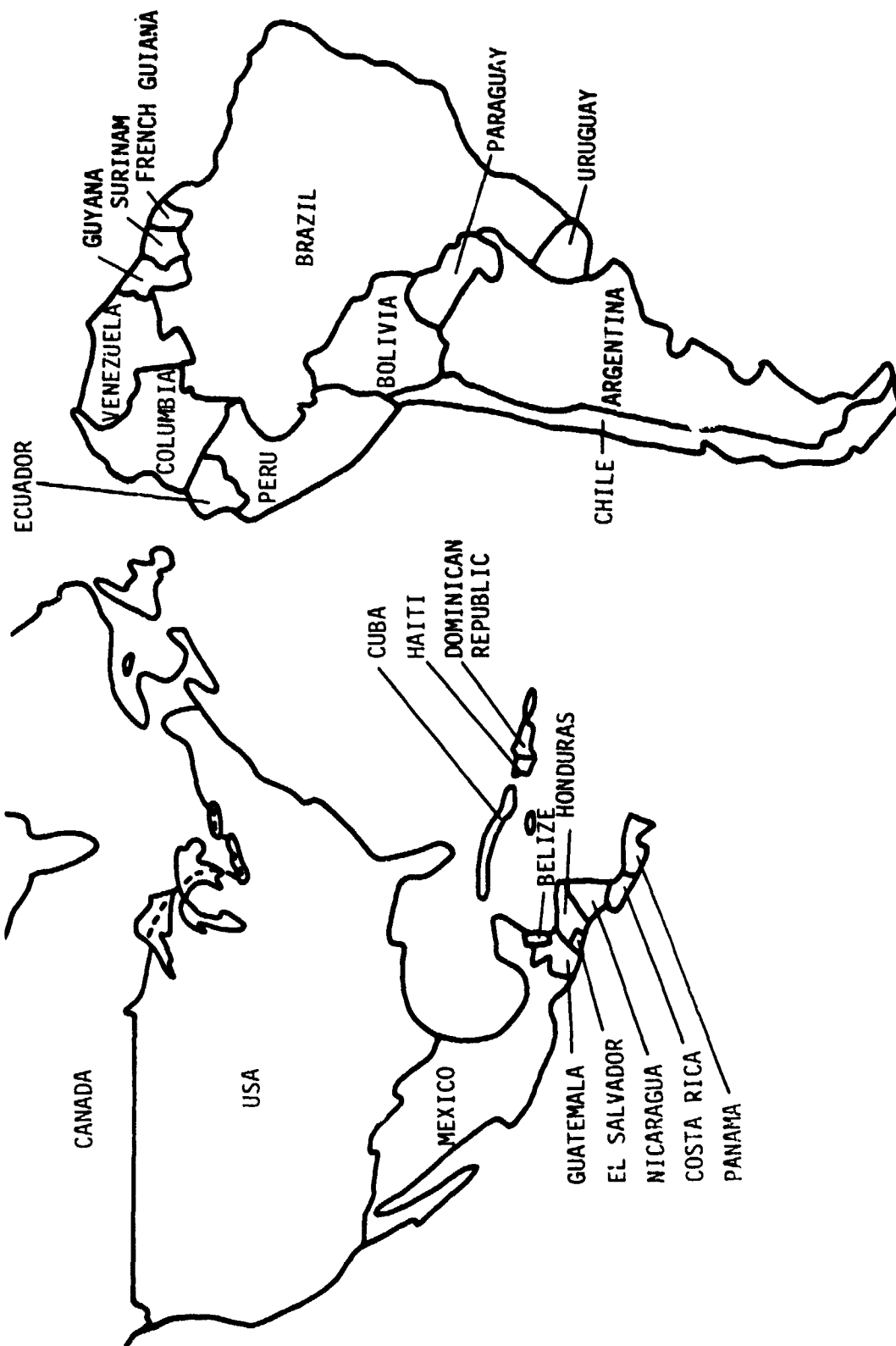
BARLEY	93 (231)	SORGHUM	44 (109)
CORN	118 (292)	SOYBEAN	45 (111)
COTTON	31 (77)	WHEAT	235 (581)
RICE	142 (351)	VEGETABLES AND MELLONS	(NOT AVAILABLE)
- WORLD FERTILIZER USAGE
89 MILLION METRIC TONS (98 MILLION SHORT TONS)
- TYPES OF AGRICULTURAL AIRCRAFT USED SUMMARIZED FOR:

NEW ZEALAND	UNITED KINGDOM
AUSTRIALIA	FRANCE
BRAZIL	ISRAEL
JAPAN	YUGOSLAVIA
SOUTH AFRICA	CHILE
- AG-AIR OPERATIONS SUMMARIZED FOR:

USSR	AUSTRALIA
NEW ZEALAND	MEXICO

The map at the right shows country names for the Western Hemisphere. It should be referred to when examining the world maps which follow on which country names do not appear.

COUNTRIES OF THE WESTERN HEMISPHERE



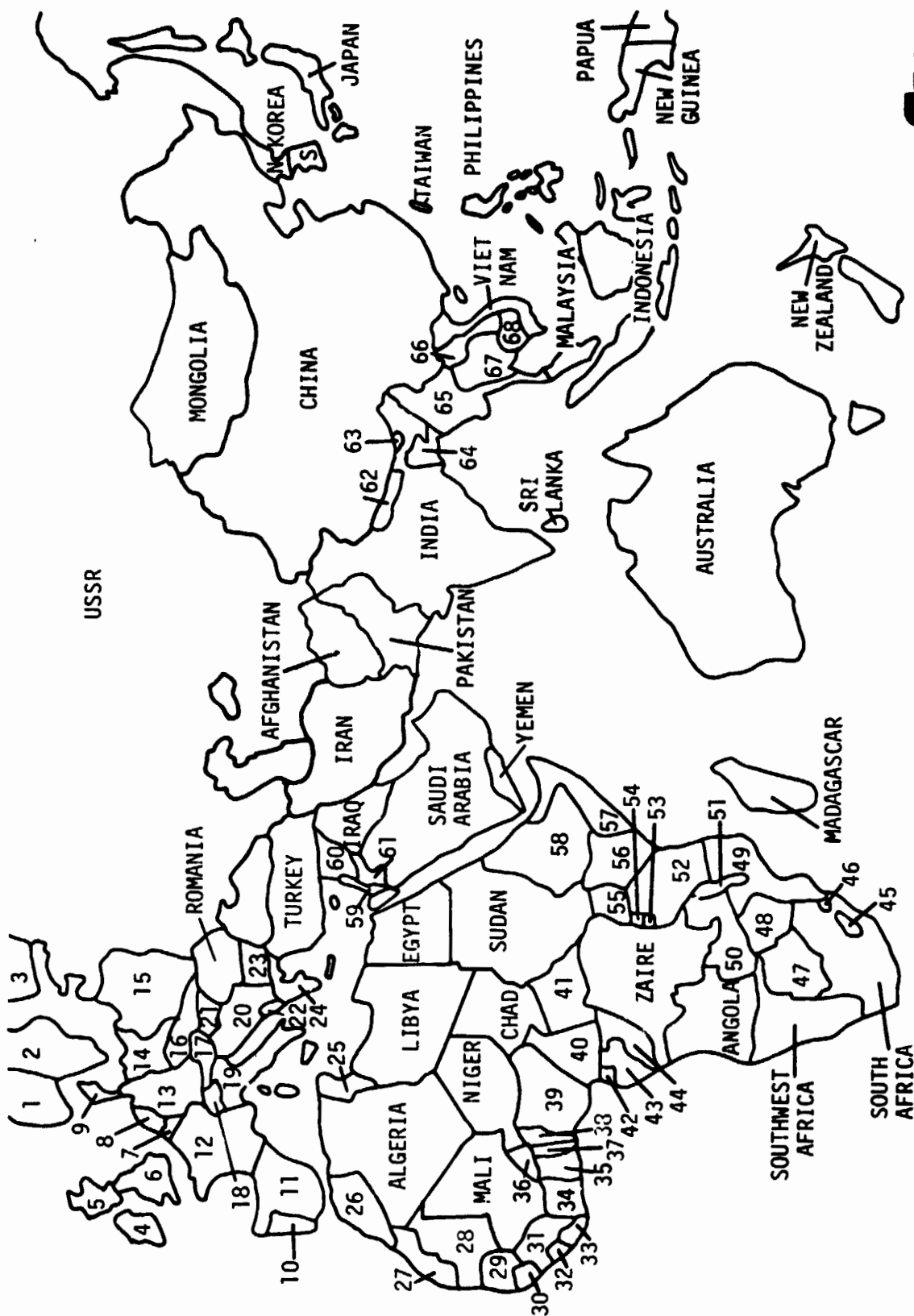
The map at the right shows country names for the Eastern Hemisphere. It should be referred to examining the world maps which follow on which country names do not appear.

EUROPE

1. Norway	21. Hungary
2. Sweden	22. Albania
3. Finland	23. Bulgaria
4. Ireland	24. Greece
5. Scotland	<u>AFRICA</u>
6. Great Britain	25. Tunisia
7. Belgium	26. Morocco
8. Netherlands	27. Spanish Sahara
9. Denmark	28. Mauritania
10. Portugal	29. Senegal
11. Spain	30. Gambia
12. France	31. Guinea
13. West Germany	32. Sierra Leone
14. East Germany	33. Liberia
15. Poland	34. Ivory Coast
16. Czechoslovakia	35. Ghana
17. Austria	36. Upper Volta
18. Switzerland	37. Togo
19. Italy	38. Benin
20. Yugoslavia	39. Nigeria
	40. Cameroon

41. Central Africa	61. Jordan
42. Equatorial Guinea	<u>ASIA</u>
43. Gabon	62. Nepal
44. Congo	63. Bhutan
45. Lesotho	64. Bangladesh
46. Swaziland	65. Burma
47. Botswana	66. Laos
48. Rhodesia	67. Thailand
49. Mozambique	68. Kampuchea
50. Zambia	
51. Malawi	
52. Tanzania	
53. Burundi	
54. Rwanda	
55. Uganda	
56. Kenya	
57. Somalia	
58. Ethiopia	
<u>MIDDLE EAST</u>	
59. Israel	
60. Syria	

COUNTRIES OF THE EASTERN HEMISPHERE



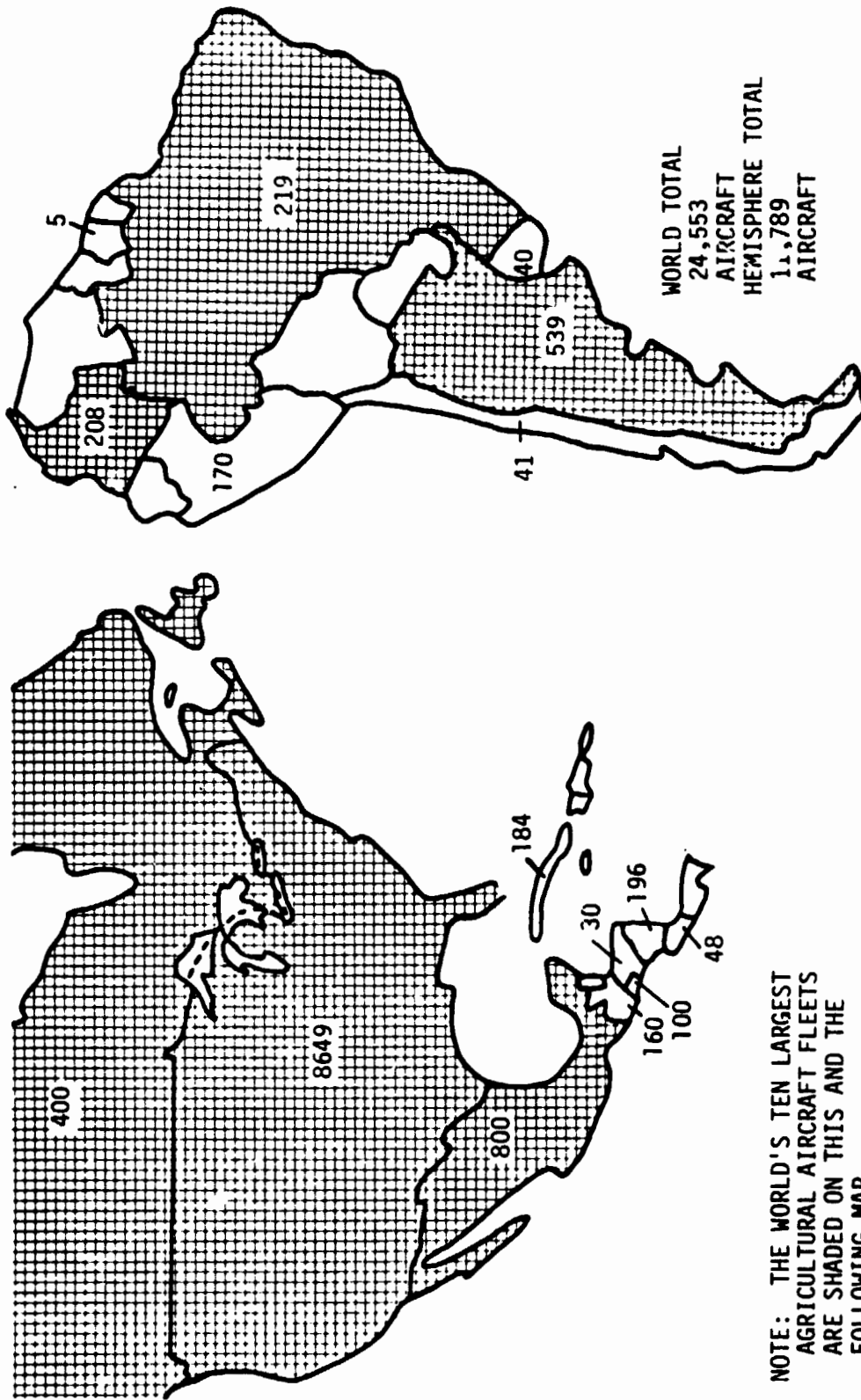
Econ

The following two maps show the best available estimates of the current world agricultural aviation fleet. There are approximately 24,553 agricultural aircraft currently in use around the world. The fleet is fairly evenly divided between the Western and Eastern Hemispheres. Of the 11,789 aircraft in the Western Hemisphere approximately 90 percent are found in North and Central America with the remainder in South America.

The United States has the largest fleet in this hemisphere. It contains 35 percent of the world's total agricultural aviation fleet and 73 percent of the hemisphere's fleet. Mexico (7 percent of the hemisphere's fleet), Argentina (5 percent), Brazil (2 percent), and Cuba (2 percent) follow in order of decreasing importance.

In many countries outside the United States, aircraft that are included in the agricultural aircraft fleet are often poorly utilized and/or used for activities other than crop treatment. This may unavoidably result in overestimating the intensity of aircraft use in agriculture.

THE WORLD AGRICULTURAL AIRCRAFT FLEET--WESTERN HEMISPHERE



NOTE: THE WORLD'S TEN LARGEST AGRICULTURAL AIRCRAFT FLEETS ARE SHADED ON THIS AND THE FOLLOWING MAP.

Source: Akesson and Yates, The Use of Aircraft in Agriculture, 1974 and contacts with U.S. Embassies and foreign governments

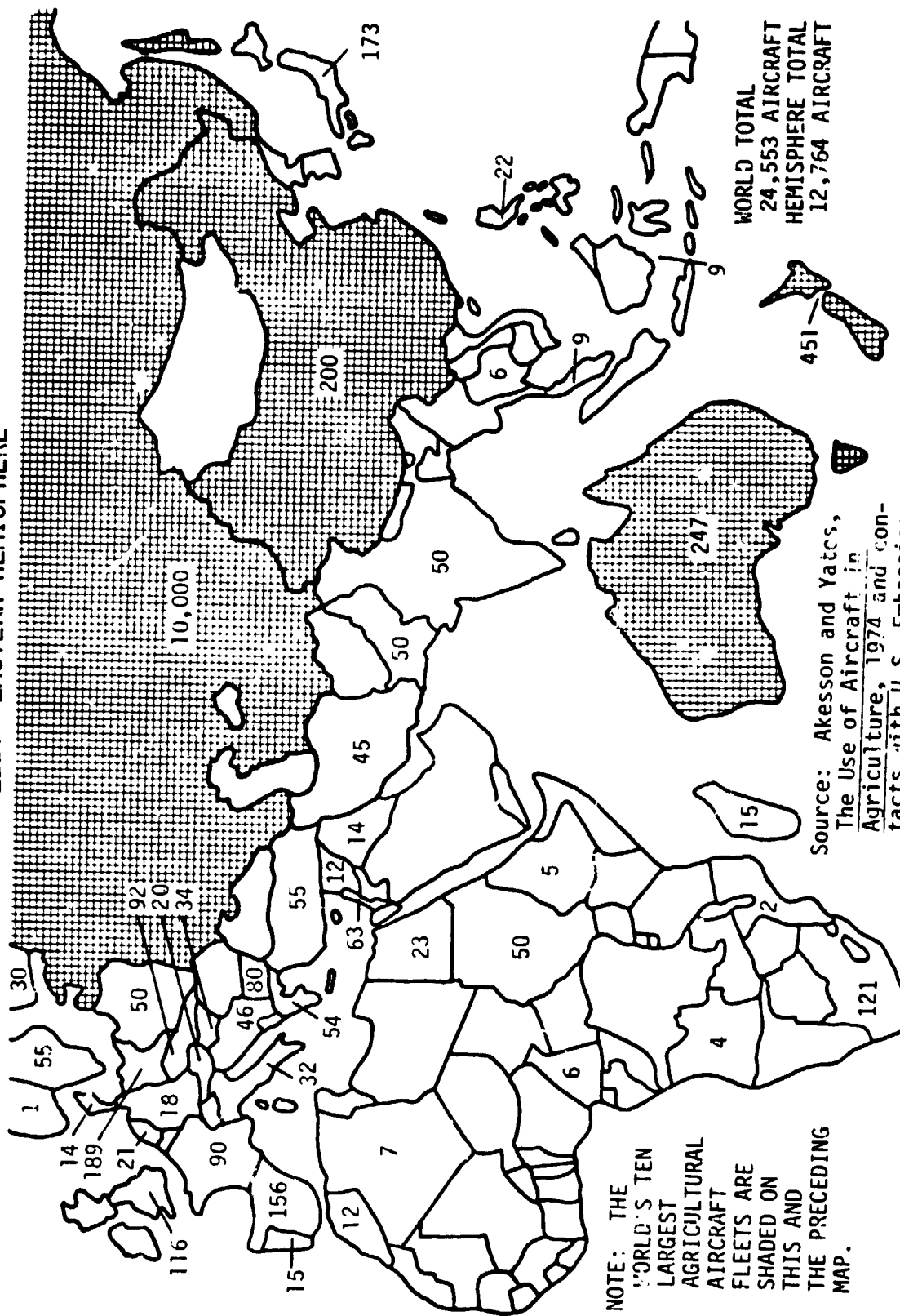
ESON

There are about 12,764 agricultural aircraft in the Eastern Hemisphere. Asia (including the U.S.S.R.) contains 84 percent of the hemisphere's fleet followed by Europe (9 percent), Oceania (5 percent) and Africa (2 percent).

The U.S.S.R. has the largest agricultural aircraft fleet in this hemisphere and the world. With approximately 11,000 fixed and rotary wing agricultural aircraft it contains 41 percent of the world fleet and 78 percent of the hemisphere's fleet. New Zealand (4 percent of hemisphere's total), Australia (2 percent) and China (2 percent) follow in order of decreasing importance.

In many countries, particularly in the Middle East, foreign agricultural spraying companies are engaged during the spraying season to treat the countries' crops. These planes are not counted in the fleet of the countries they operate in, but rather, are counted in the fleet size of their countries of origin.

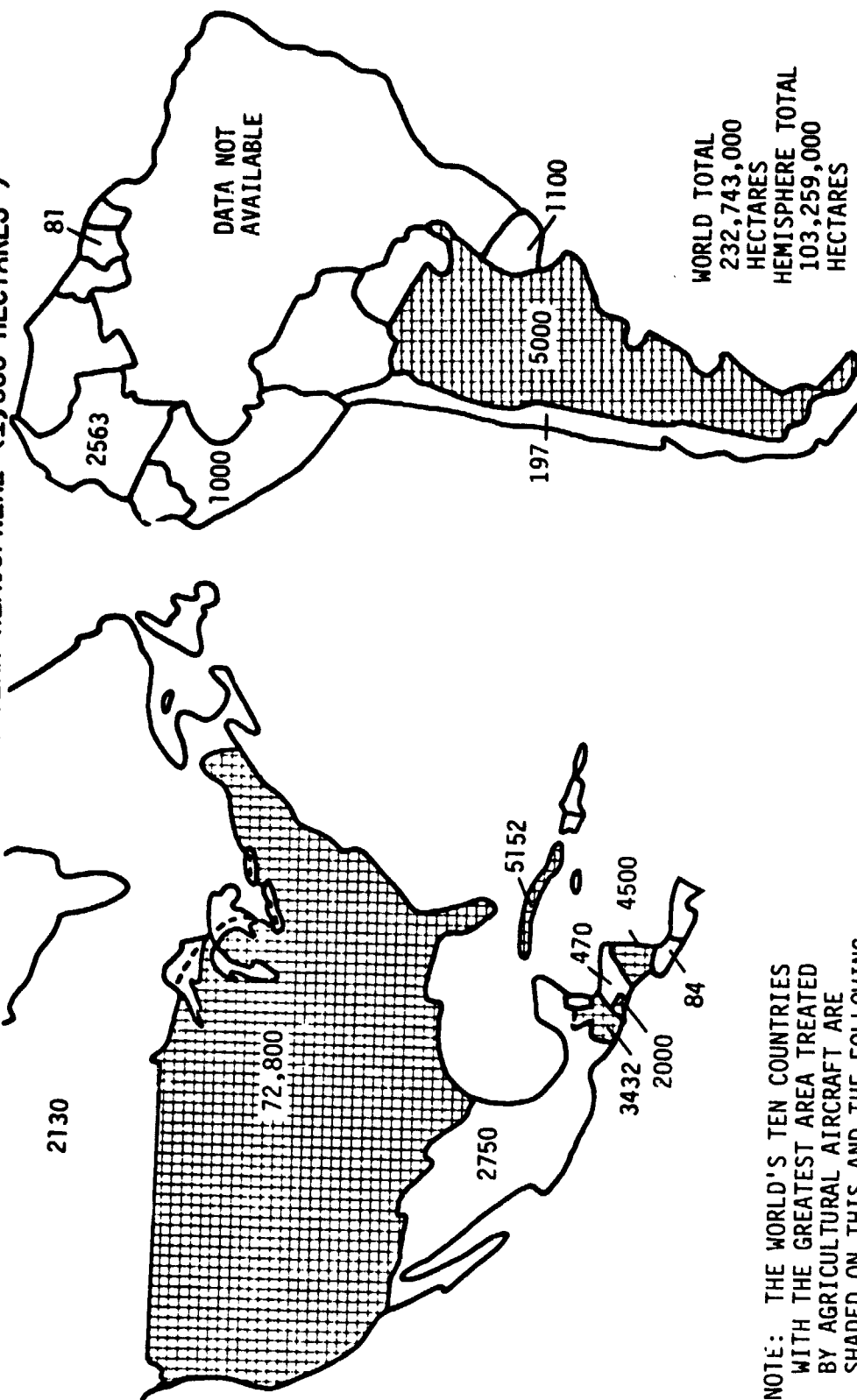
THE WORLD AGRICULTURAL AIRCRAFT FLEET--EASTERN HEMISPHERE



Approximately 231 million hectares are treated worldwide by agricultural aviation. Forty-four percent of the treated hectares are found in the Western Hemisphere. Approximately 90 percent of the treated hectares in this hemisphere are found in North and Central America with the remainder in South America.

The United States treats 31 percent of the world total and 7 percent of the hemisphere's total hectares treated by air. Cuba (5 percent of the hemisphere's total), Argentina (5 percent), Nicaragua (4 percent), Guatemala (3 percent) and Mexico (3 percent), follow in order of decreasing importance.

AREA TREATED BY AGRICULTURAL AIRCRAFT--WESTERN HEMISPHERE (1,000 HECTARES*)



NOTE: THE WORLD'S TEN COUNTRIES WITH THE GREATEST AREA TREATED BY AGRICULTURAL AIRCRAFT ARE SHADED ON THIS AND THE FOLLOWING MAP.

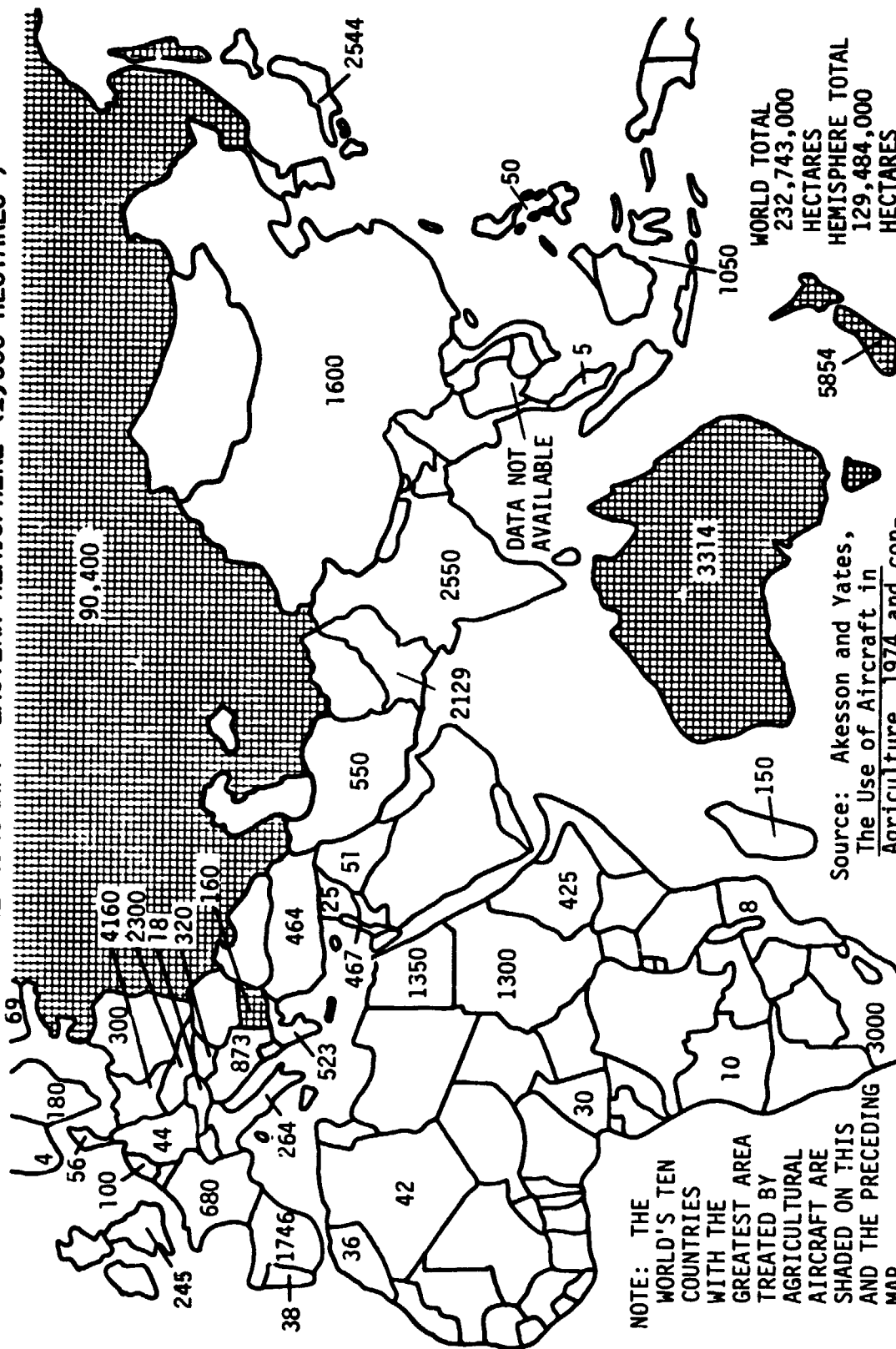
* 1 HECTARE = 2.471 ACRES

Source: Akesson and Yates, The Use of Aircraft in Agriculture, 1974 and contacts with U.S. Embassies and foreign governments

Fifty-six percent of the world's agricultural area treated by air is found in the Eastern Hemisphere. Asia (including the U.S.S.R.) treats 80 percent of the hemisphere's total hectares treated followed by Europe (8 percent), Oceania (7 percent) and Africa (5 percent).

The U.S.S.R. contains 39 percent of the total world hectares treated by agricultural aviation and 71 percent of the Eastern Hemisphere's total. New Zealand (5 percent of the hemisphere's total), East Germany (3 percent) and Australia (3 percent) follow in order of decreasing importance.

AREA TREATED BY AGRICULTURAL AIRCRAFT--EASTERN HEMISPHERE (1,000 HECTARES*)



NOTE: THE WORLD'S TEN COUNTRIES WITH THE GREATEST AREA TREATED BY AGRICULTURAL AIRCRAFT ARE SHOWN ON THIS MAP.

* 1 HECTARE = 2.471 ACRES

Source: Akesson and Yates, The Use of Aircraft in Agriculture, 1974 and contacts with U.S. Embassies and foreign governments

WORLD TOTAL
232,743,000
HECTARES
HEMISPHERE TOTAL
129,484,000
HECTARES

205

The table at the right shows production figures for selected crops and countries in 1976. The United States is the world's leading producer of corn (47 percent of the world production), sorghum (35 percent), and soybeans (55 percent). The U.S.S.R. produces the most barley (37 percent of the world total) followed by China (21 percent), Canada (5 percent), France (4 percent), and the United States (4 percent). Again, the U.S.S.R. is the largest single producer of cotton (23 percent of the world total), followed by China (20 percent), and the United States (16 percent). The U.S.S.R. also produces the largest amount of wheat (23 percent of the world total) followed by the United States (14 percent). Finally, China is the leading producer of rice, harvesting 34 percent of the world total. Japan follows with 4 percent. The United States produces approximately 2 percent of the total rice tonnage.

1976 PRODUCTION FOR SELECTED CROPS AND COUNTRIES (1,000 METRIC TONS*)

COUNTRY	BARLEY	CORN	COTTON	RICE	SORGHUM	SOYBEAN	WHEAT
ARGENTINA	760	5855	430	309	5200	695	11200
AUSTRALIA	2840	129	65	417	1120	41	12000
BRAZIL	50	17929	1261	9560	490	11227	3200
BULGARIA	1800	2900	33	70	-	80	3100
CANADA	10303	3675	-	-	-	252	23523
CHINA	21000	34114	7200	116570	22	12143	43003
COLUMBIA	71	884	1	1560	428	75	60
CUBA	-	125	3	420	1	-	-
CZECHOSLOVAKIA	3100	500	-	-	1	-	4640
EL SALVADOR	-	463	166	51	164	1	-
EAST GERMANY	3300	2	-	-	-	-	2600
FRANCE	8280	5477	-	37	251	-	16089
GUATAMALA	-	686	271	24	96	-	48
JAPAN	210	11	-	15292	1	110	222
MEXICO	460	8945	583	450	3350	260	3354
NEW ZEALAND	344	232	-	-	-	1	427
NICARAGUA	-	201	330	80	55	-	-
PERU	165	670	208	570	45	1	148
SPAIN	5163	1543	129	392	158	7	4176
UNITED KINGDOM	7793	2	-	-	-	-	4773
URUGUAY	47	210	1	215	118	23	505
U.S.A.	8215	157893	5959	5308	18382	34425	58444
U.S.S.R.	69500	10300	8300	2100	300	510	96900
YUGOSLAVIA	653	9112	6	28	11	45	5980
WORLD	189654	334014	36426	345386	51812	62117	417478

Source: FAO, The Production Yearbook, 1976.

* 1 METRIC TON = 2,204.6 LBS.

The yield of a crop is the connecting link between area harvested and production. While the area planted in a particular crop may not vary substantially from year to year, yield can vary greatly due to changing weather, pests, etc. This will produce wide fluctuations in tonnage of a crop harvested. Further, some countries may plant very large areas with a crop and thus appear to be large producers, yet because of chronically low yields may actually contribute only a relatively minor portion of total world production.

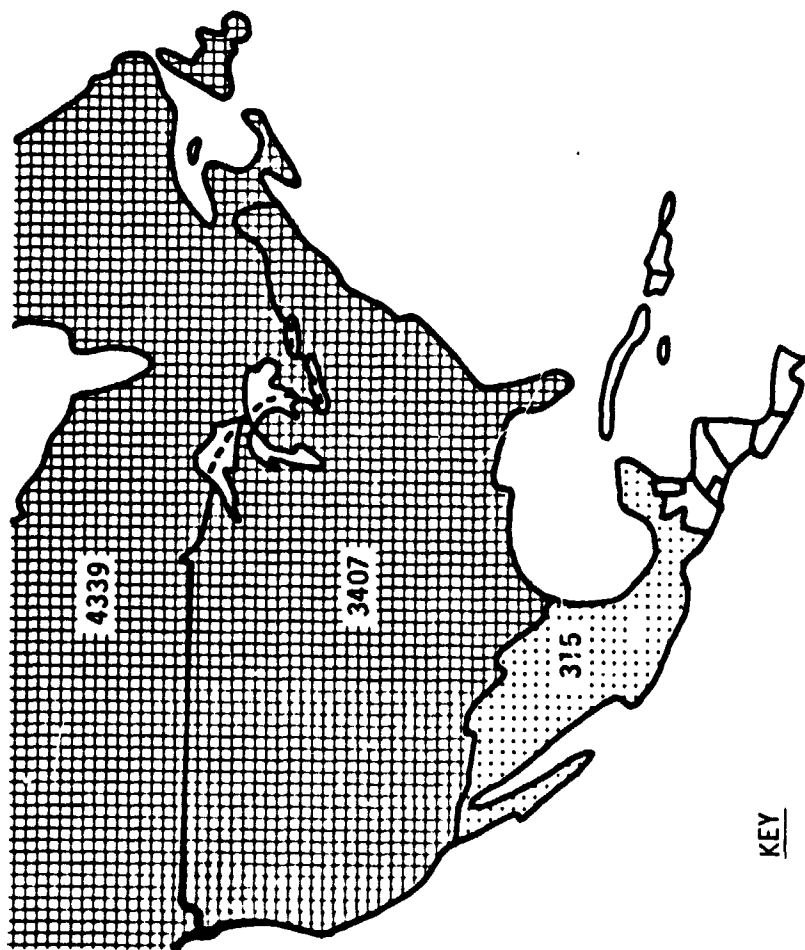
1976 YIELD FOR SELECTED CROPS AND COUNTRIES (KG/HECTARE)

COUNTRY	BARLEY	CORN	COTTON	RICE	SORGHUM	SOYBEAN	WHEAT
ARGENTINA	1520	2117	310	3541	2835	1603	1561
AUSTRALIA	1235	2515	926	5645	2222	1478	1348
BRAZIL	1160	1612	244	1451	2539	1750	906
BULGARIA	3396	4793	427	3933	-	2206	3909
CANADA	2375	5442	-	-	-	1681	2112
CHINA	1556	2954	480	3294	3042	855	1387
COLUMBIA	1552	1365	436	4262	2464	2000	1200
CUBA	-	962	269	2100	1100	-	-
CZECHOSLOVAKIA	3647	2632	-	-	3347	-	3654
EL SALVADOR	-	2017	783	3636	314	2400	-
EAST GERMANY	3882	2000	-	2000	-	-	3467
FRANCE	3029	3844	-	4089	3210	-	3760
GUATAMALA	1500	1335	1158	1287	1680	-	1309
JAPAN	2619	2750	-	5503	1000	1321	2496
MEXICO	1460	1278	872	2903	2839	1733	4207
NEW ZEALAND	3932	7117	-	-	-	3000	4283
NICARAGUA	-	883	592	2963	826	-	-
PERU	892	1675	530	4419	3000	1183	1060
SPAIN	1594	3489	538	6071	4377	1388	1507
UNITED KINGDOM	3571	2000	-	-	-	-	3877
URUGUAY	1068	1189	538	4135	2185	1150	939
U.S.A.	2411	5489	520	5244	3053	1721	2039
U.S.S.R.	2029	3118	892	4008	1531	669	1630
YUGOSLAVIA	2229	3841	322	3500	2200	1957	3469
WORLD	2030	2829	399	2428	1179	1384	1774

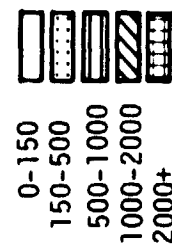
Source: FAO, The Production Yearbook, 1976.

The map at the right shows the Western Hemisphere barley harvest. In 1976 approximately 93 million hectares of barley were harvested worldwide. Ten percent of the harvested area is found in the Western Hemisphere and of that area nearly 90 percent is found in North America. Canada, with 47.6 percent of the hemisphere's and 4.6 percent of the world's harvested area, and the United States with 37.4 percent of the hemisphere's and 3.6 percent of the world's harvested area, are the major barley producers in this hemisphere.

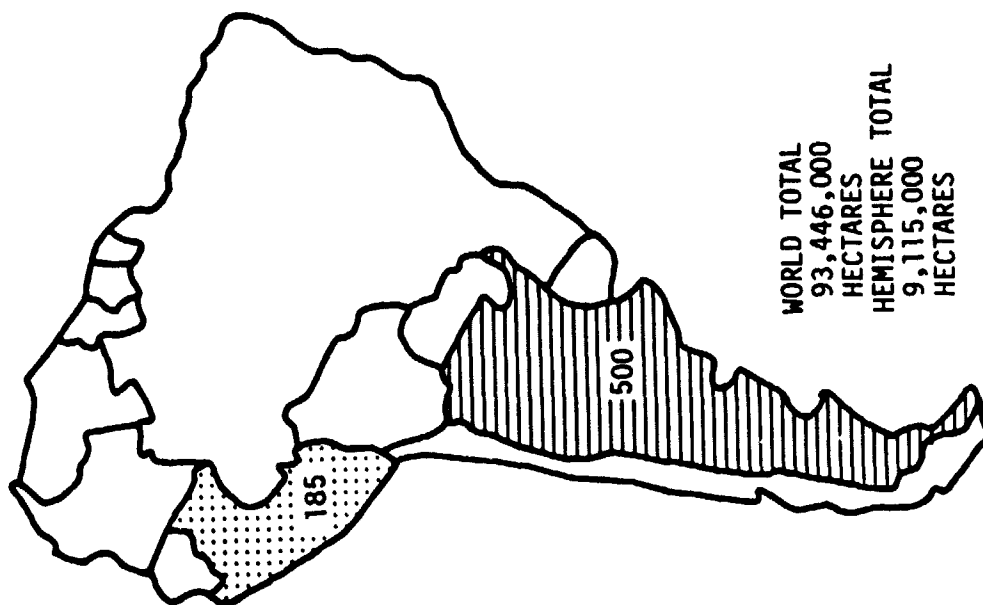
1976 BARLEY HARVEST--WESTERN HEMISPHERE (1,000 HECTARES*)



KEY



* 1 HECTARE = 2.471 ACRES



WORLD TOTAL
93,446,000
HECTARES
HEMISPHERE TOTAL
9,115,000
HECTARES

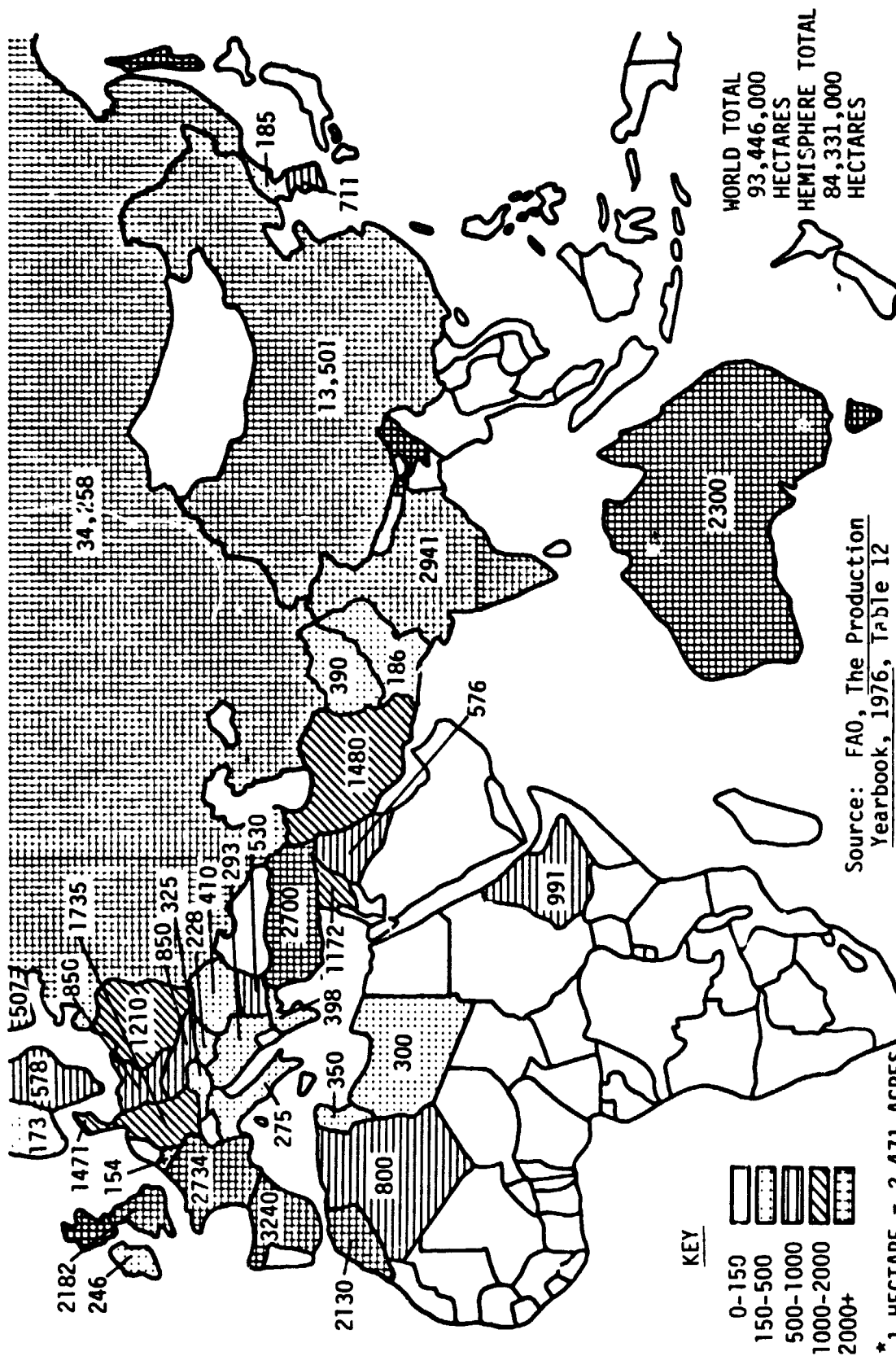
Source: FAO, The Production Yearbook,
1976, Table 12

geon

Ninety percent of the world barley harvest is concentrated in the Eastern Hemisphere. Asia (including the USSR) harvests 69.5 percent of the hemisphere's total barley area followed by Europe (22.1 percent), Africa (5.6 percent), and Oceania (2.8 percent).

The USSR is the major producer in this hemisphere, harvesting 40 percent of the barley area here and 36.7 percent of the area worldwide. China, Spain, India, France, Turkey and Australia follow in order of decreasing importance for area harvested.

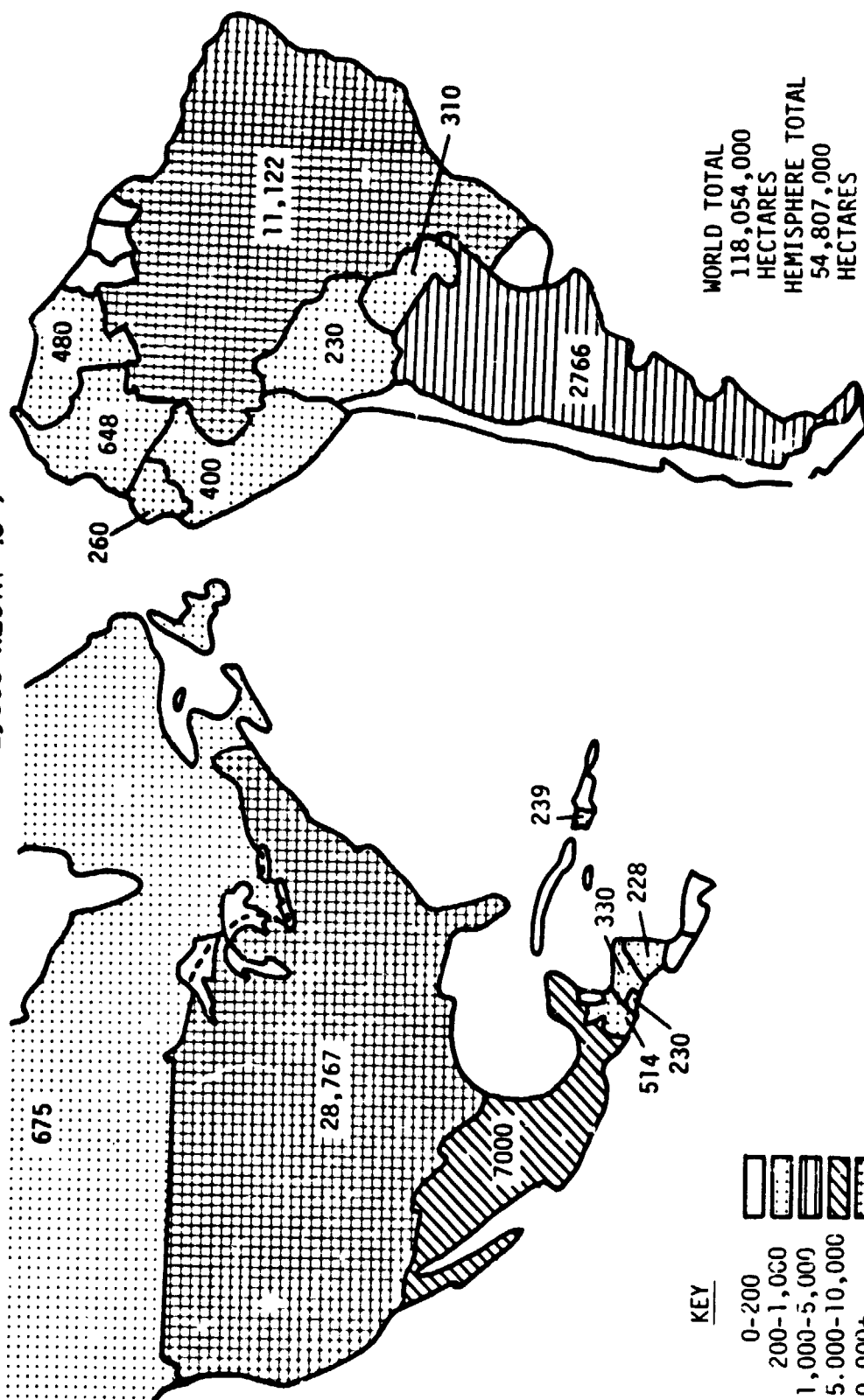
1976 BARLEY HARVEST--EASTERN HEMISPHERE (1,000 HECTARES*)



Econ

The map at the right shows the Western Hemisphere corn harvest. In 1976 approximately 118 million hectares of corn were harvested worldwide. Forty-six percent of the harvested area is located in the Western Hemisphere. Approximately 70 percent of this hemisphere's corn harvest is found in North and Central America with the remainder in South America. The United States is the leading corn producer in the Americas, harvesting 52 percent of the corn area in this hemisphere and 24 percent of the corn area worldwide. Brazil, Mexico and Argentina follow in order of decreasing importance for area harvested.

1976 CORN HARVEST--WESTERN HEMISPHERE (1,000 HECTARES*)



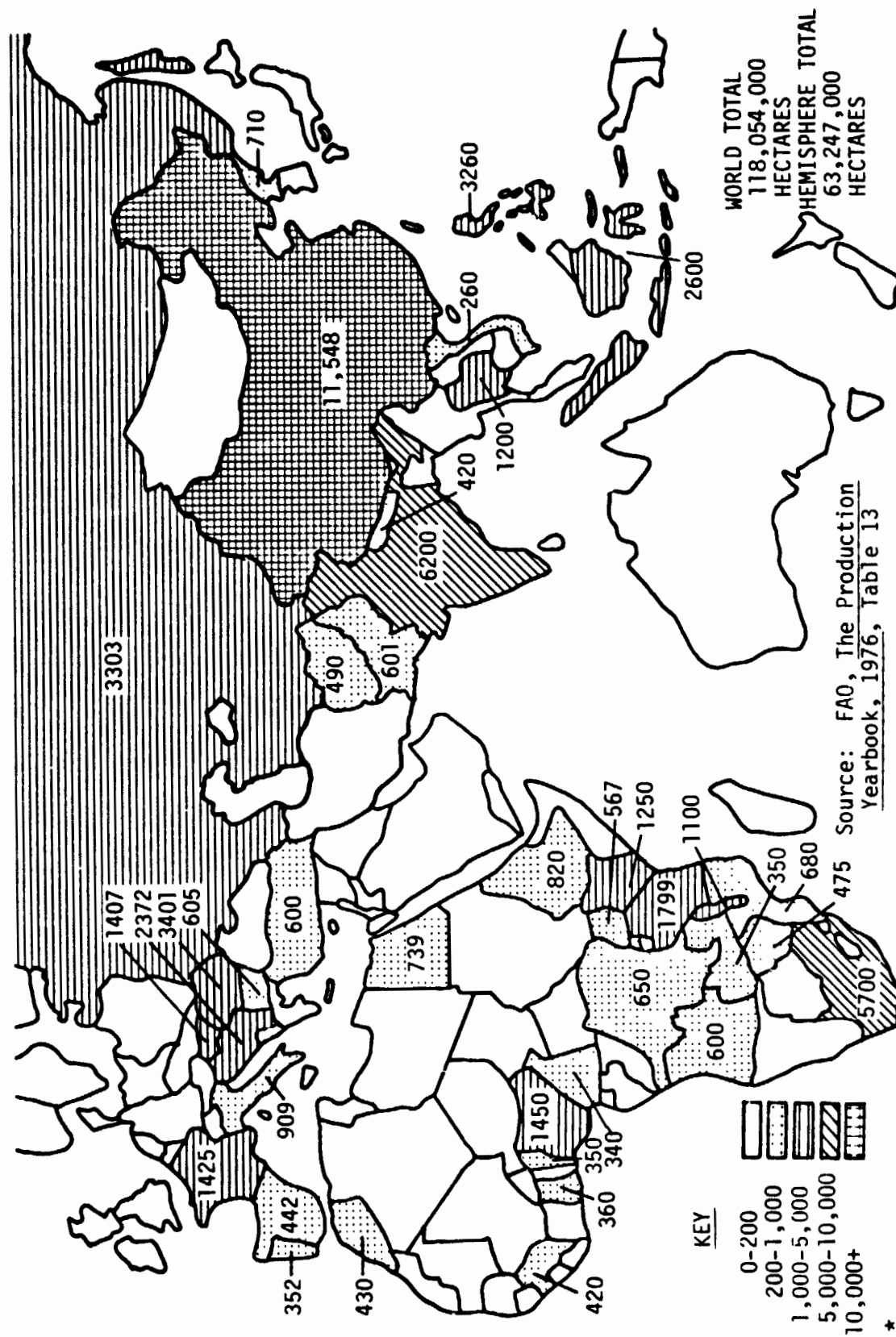
* 1 HECTARE = 2.471 ACRES

Source: FAO, The Production Yearbook, 1976, Table 13

Fifty-four percent of the world corn harvest is located in the Eastern Hemisphere. Asia (including the USSR) harvests 50.3 percent of the corn area planted in this hemisphere followed by Africa (31.1 percent), Europe (18.5 percent), and Oceania (0.1 percent).

China leads the countries in this hemisphere in corn area planted, harvesting 18.3 percent of the hemisphere's corn area and 9.8 percent of the total world area. India, South Africa and Romania follow in order of decreasing importance.

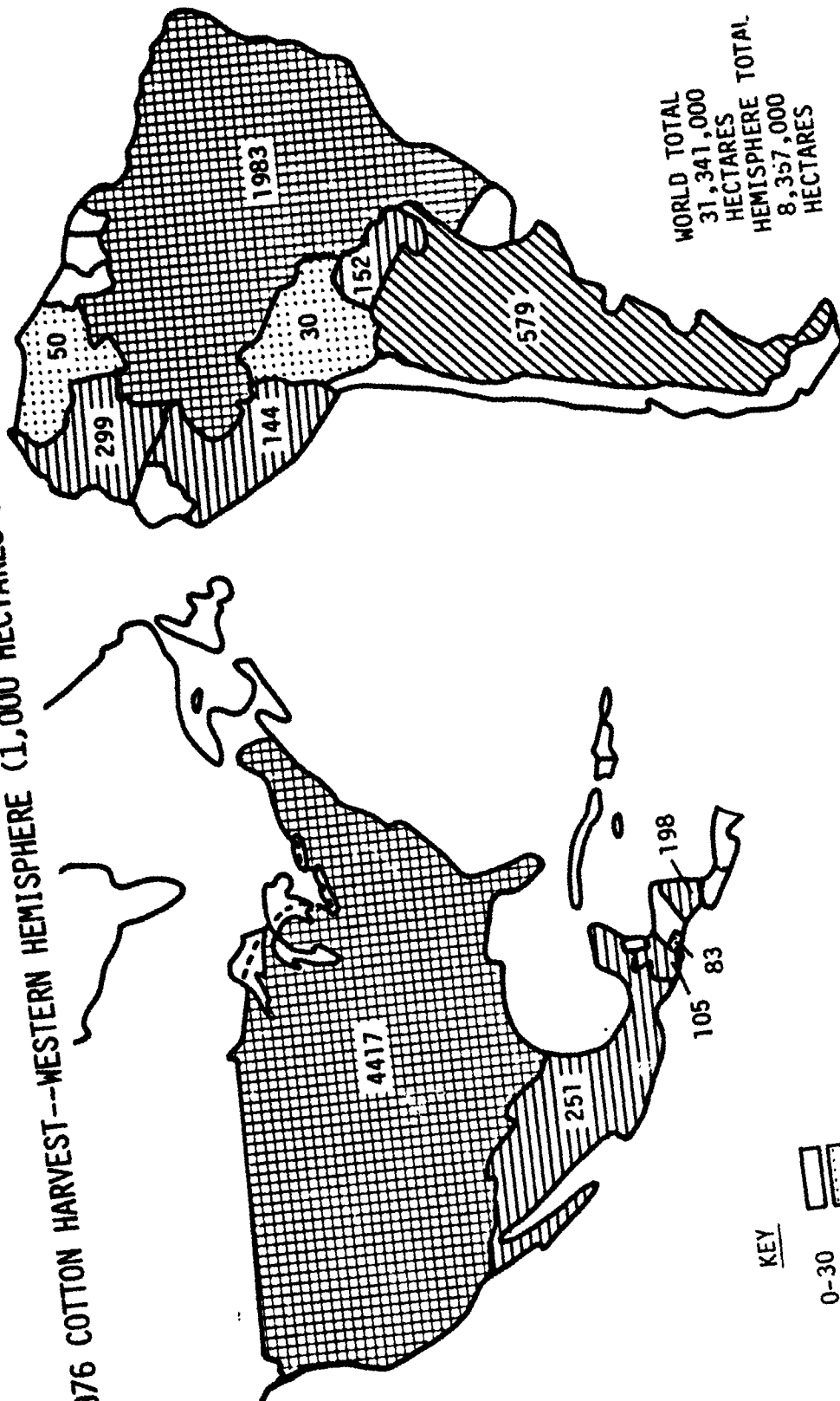
1976 CORN HARVEST--EASTERN HEMISPHERE (1,000 HECTARES*)



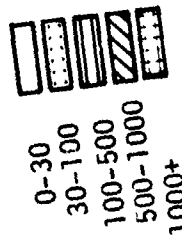
Econ

The map at the right shows the Western Hemisphere cotton harvest. In 1976 over 31 million hectares of cotton were harvested. Twenty-seven percent of the cotton harvested is concentrated in the Western Hemisphere. Approximately 60 percent of the area harvested is located in North and Central America with the remaining 40 percent in South America. The United States is the leading cotton producer in the Americas, harvesting slightly more than 50 percent of the cotton area in this hemisphere and 14 percent worldwide. In the Western Hemisphere, Brazil, Argentina, Colombia, and Mexico follow in order of decreasing importance for area harvested.

1976 COTTON HARVEST--WESTERN HEMISPHERE (1,000 HECTARES*)



KEY



*1 HECTARE = 2.471 ACRES

WORLD TOTAL
31,341,000
HECTARES
HEMISPHERE TOTAL
8,357,000
HECTARES

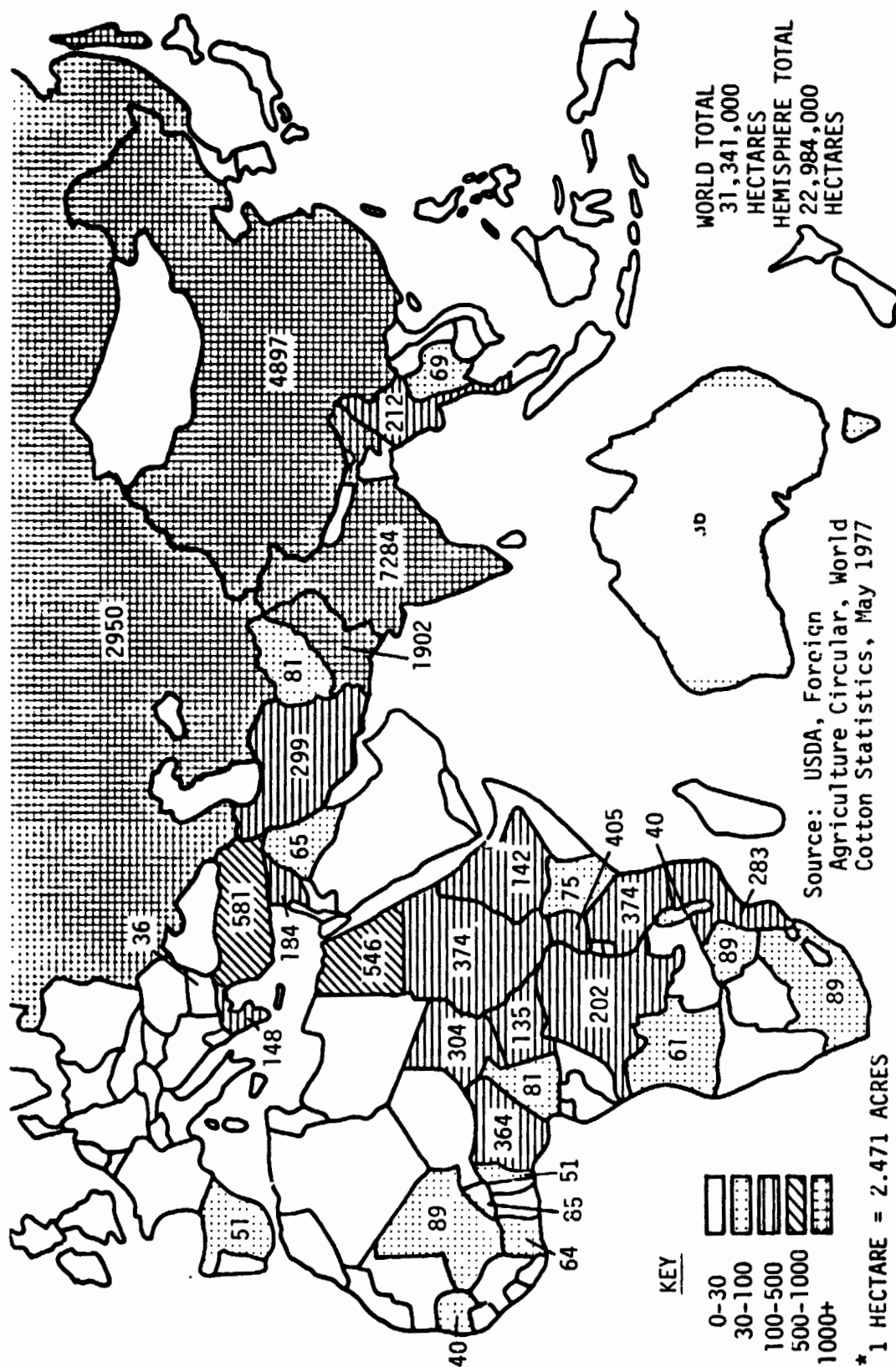
Source: USDA, Foreign Agriculture Circular,
World Cotton Statistics, May 1977

USDA

Seventy-three percent of the world cotton harvest is concentrated in the Eastern Hemisphere. Asia (including the USSR) harvests 81.1 percent of the cotton area planted in this hemisphere followed by Africa (17.5 percent), Europe (1.2 percent), and Oceania (0.2 percent).

India leads the countries in this hemisphere in area of cotton harvested, harvesting 31.7 percent of the cotton area and 23.2 percent worldwide. China and the USSR follow in order of decreasing importance.

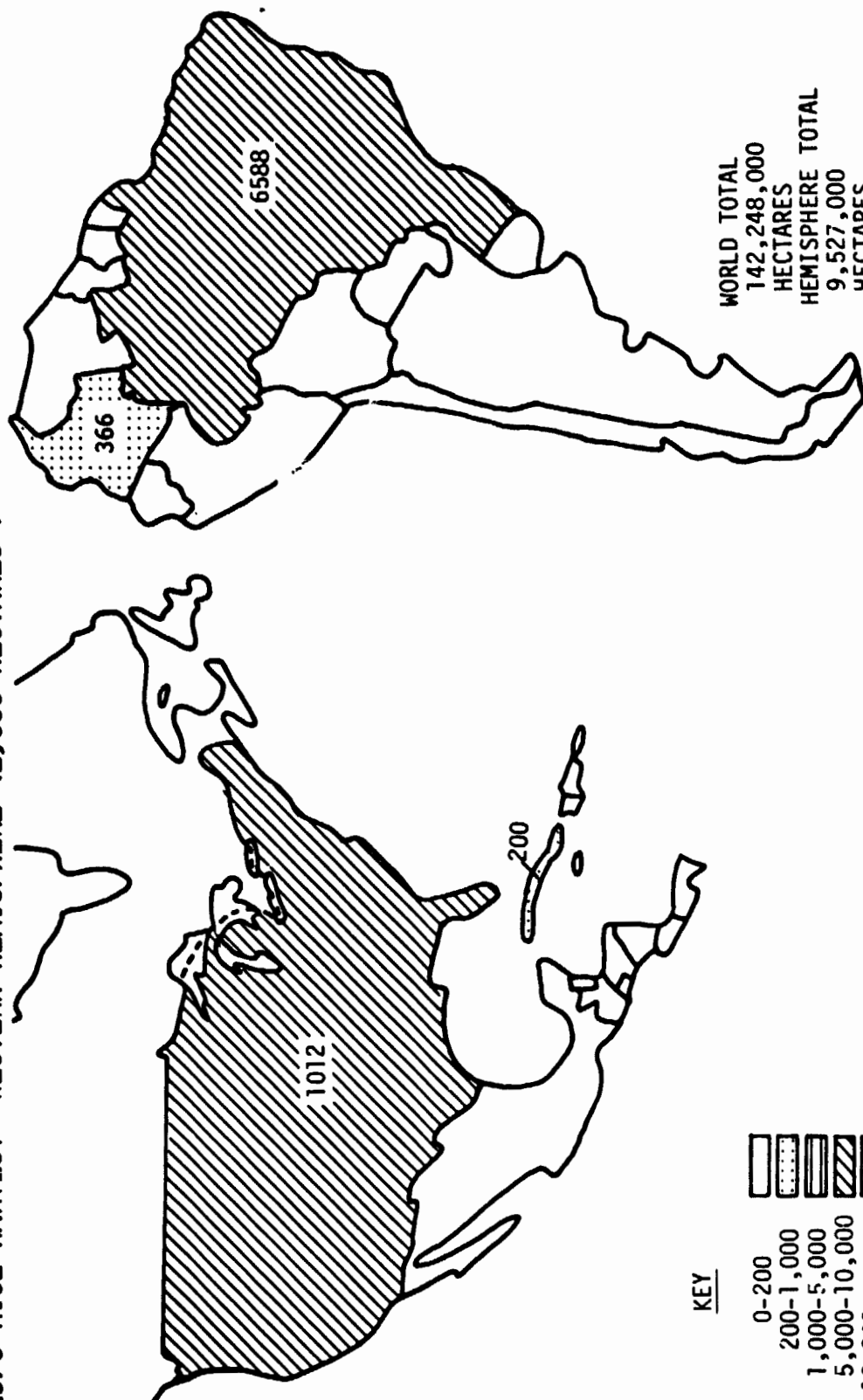
1976 COTTON HARVEST--EASTERN HEMISPHERE (1,000 HECTARES)*



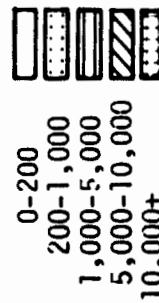
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The map at the right shows the Western Hemisphere rice harvest. In 1976 approximately 142 million hectares of rice were harvested. Only 6.7 percent of the harvest is concentrated in the Western Hemisphere. Eighty-one percent of the harvest in this hemisphere is located in South America. Brazil, harvesting 69 percent of the hemisphere's total rice area and 5 percent of the world total, is the largest producer here followed by the United States.

1976 RICE HARVEST--WESTERN HEMISPHERE (1,000 HECTARES*)



KEY



* 1 HECTARE = 2.471 ACRES

Source: FAO, The Production Yearbook, 1976, Table 11

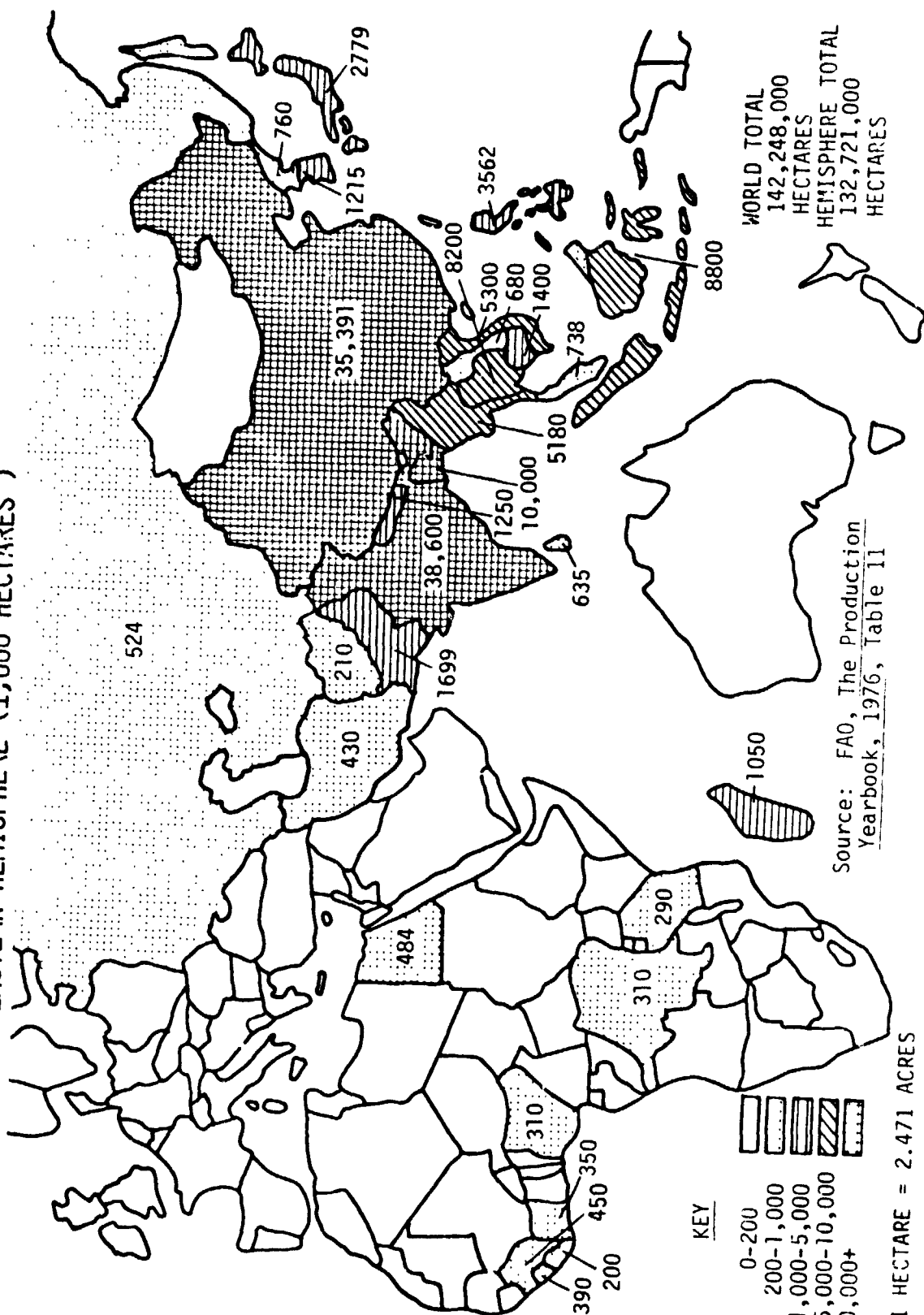
223

Ninety-three percent of the world rice harvest is concentrated in the Eastern Hemisphere.

Asia (including the USSR) harvests 96.2 percent of the rice area in this hemisphere followed by Africa (3.5 percent) and Europe (0.3 percent).

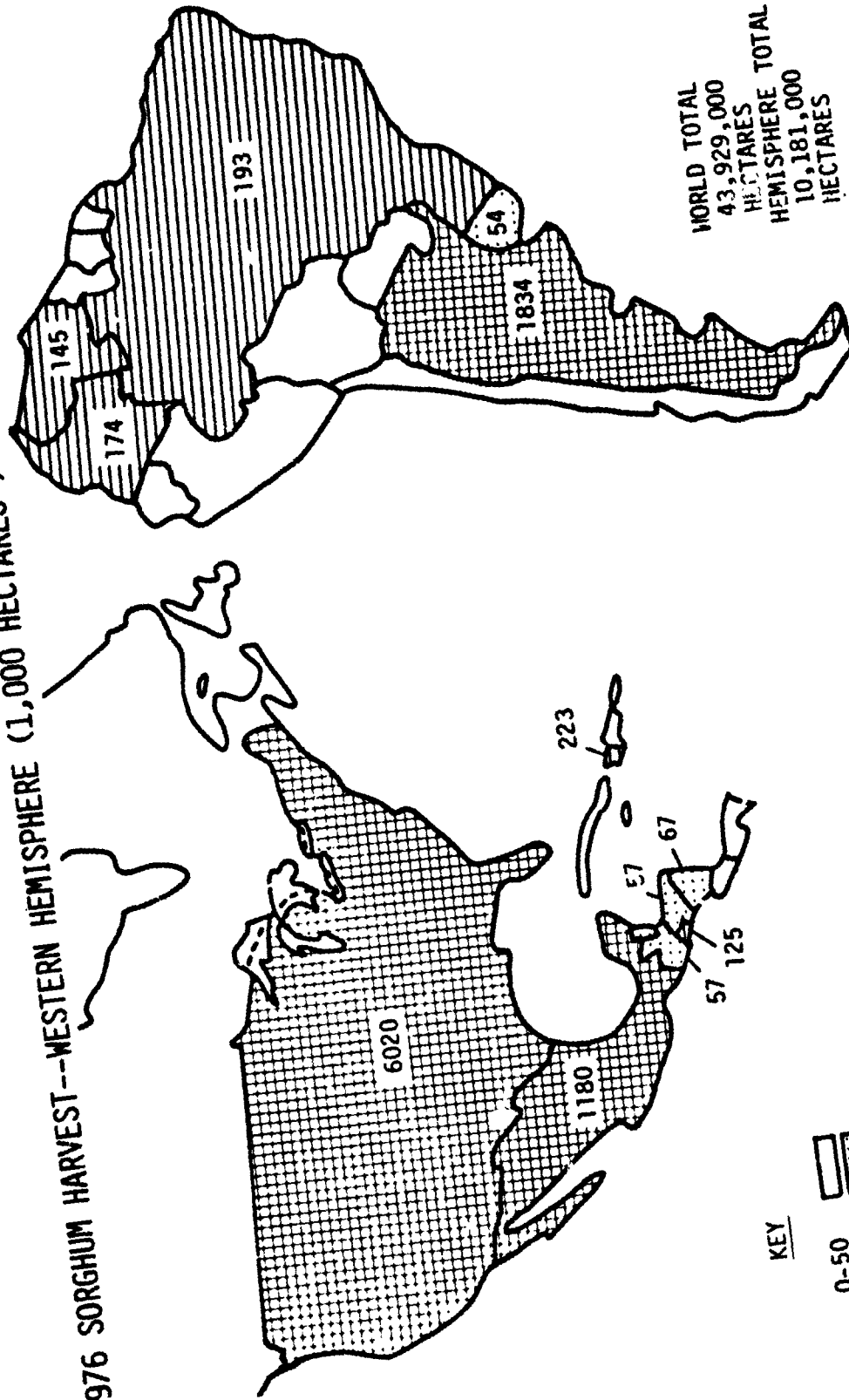
India harvests the greatest area here, 29 percent of the hemisphere's total and 27 percent of the world total rice area. China, Bangladesh, Indonesia, Thailand, Vietnam, Burma, the Philippines and Japan follow in order of decreasing importance.

1976 RICE HARVEST--EASTERN HEMISPHERE (1,000 HECTARES*)



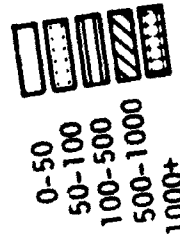
The map at the right shows the Western Hemisphere sorghum harvest. In 1976 nearly 44 million hectares of sorghum were harvested worldwide. Twenty-three percent of the harvested area is located in the Western Hemisphere. Approximately three-quarters of the hemisphere's sorghum harvest is found in North and Central America with the remainder in South America. The United States is the leading sorghum producer in the Americas, harvesting 59 percent of the sorghum area in this hemisphere and 13.7 percent worldwide. Argentina and Mexico follow in order of importance for area harvested.

1976 SORGHUM HARVEST--WESTERN HEMISPHERE (1,000 HECTARES*)



WORLD TOTAL
43,929,000
HECTARES
HEMISPHERE TOTAL
10,181,000
HECTARES

KEY



* 1 HECTARE = 2.471 ACRES

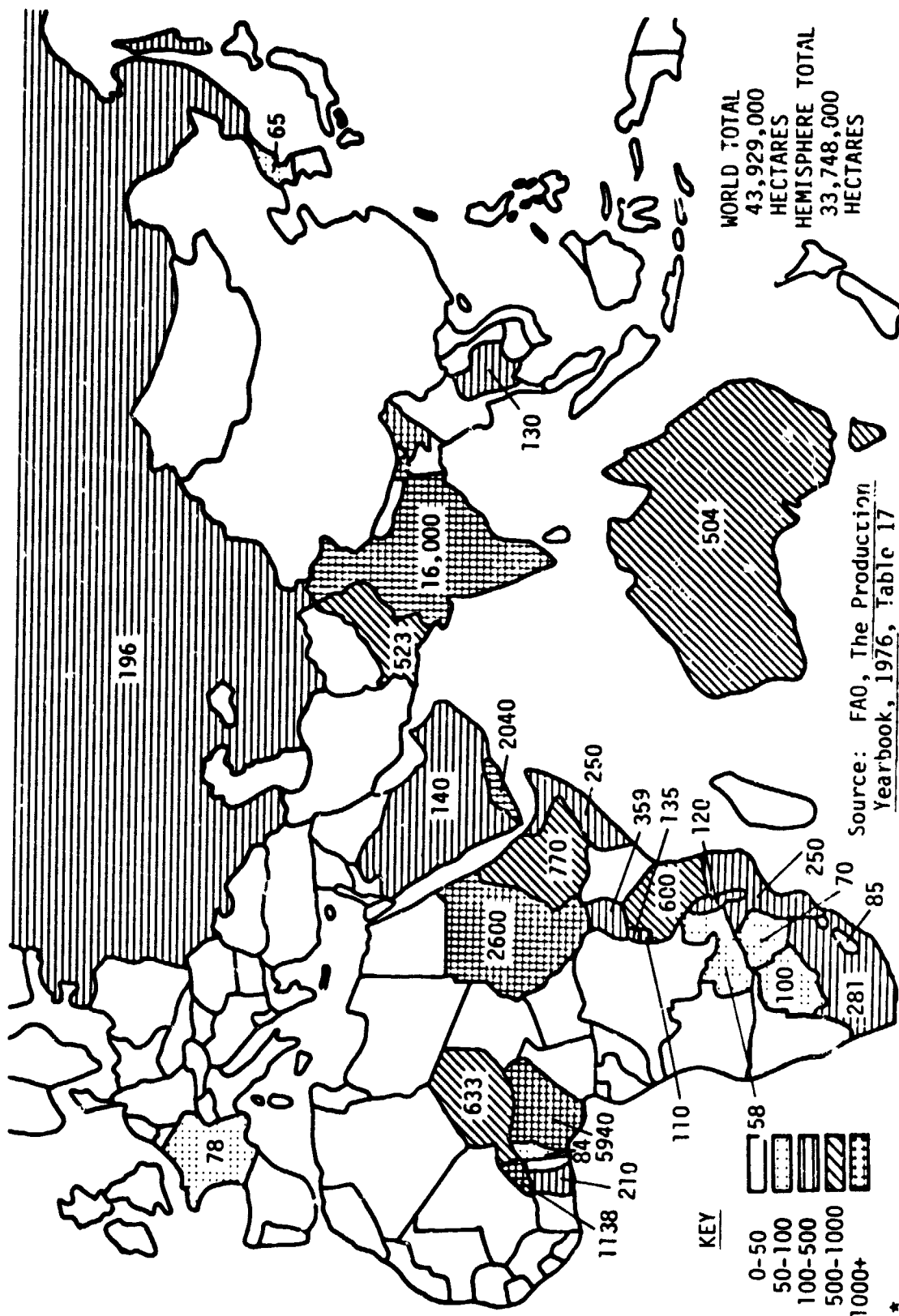
Source: FAO, The Production Yearbook,
1976, Table 17

egon

Seventy-seven percent of the world sorghum harvest is concentrated in the Eastern Hemisphere. Asia (including the USSR) harvests 56.8 percent of the sorghum area followed by Africa (41.3 percent), Oceania (1.5 percent) and Europe (0.4 percent).

India leads the countries in this hemisphere in area of sorghum harvested, harvesting 47.4 percent of the area and 36.4 percent of the worldwide sorghum area. Nigeria, Sudan, Yemen, Upper Volta, Ethiopia, Niger and Tanzania follow in order of decreasing importance.

1976 SORGHUM HARVEST--EASTERN HEMISPHERE (1,000 HECTARES*)

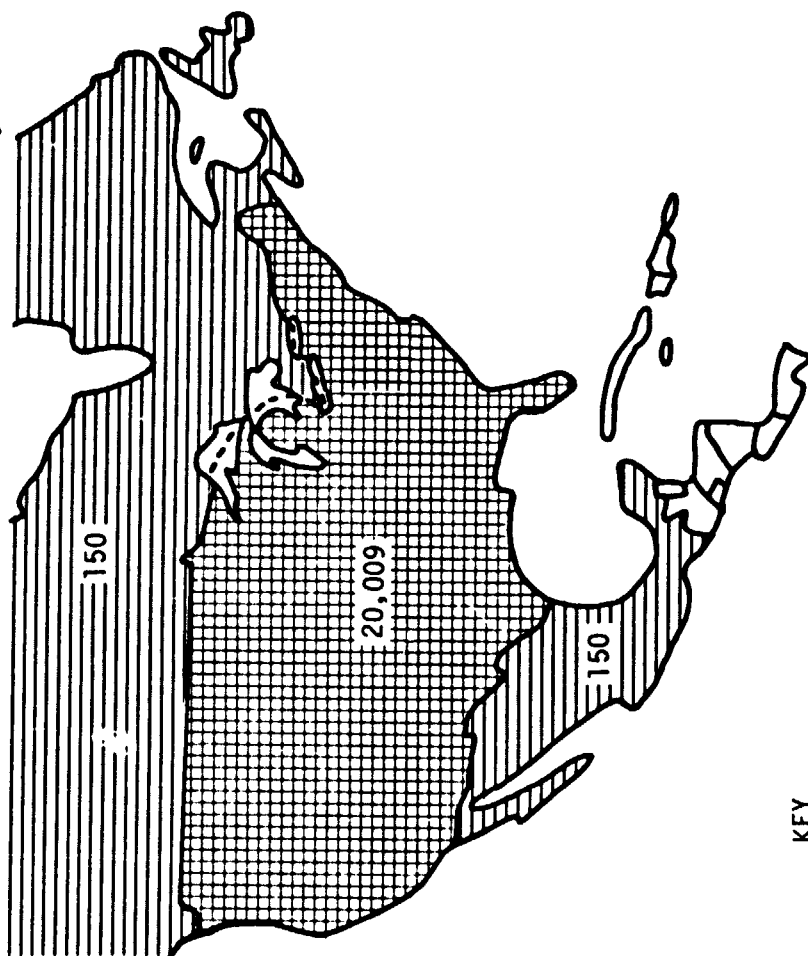


Source: FAO, The Production Yearbook, 1976, Table 17

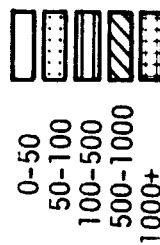
* 1 HECTARE = 2.471 ACRES

The map at the right shows the Western Hemisphere soybean harvest. In 1976 nearly 45 million hectares of soybeans were harvested worldwide. Sixty-one percent of the harvest is concentrated in the Western Hemisphere. Approximately three-quarters of the hemisphere's soybean harvest is found in North and Central America with the remainder in South America. The United States is the leading soybean country in the Americas, harvesting 73 percent of the soybean area planted in this hemisphere and 44.6 percent worldwide.

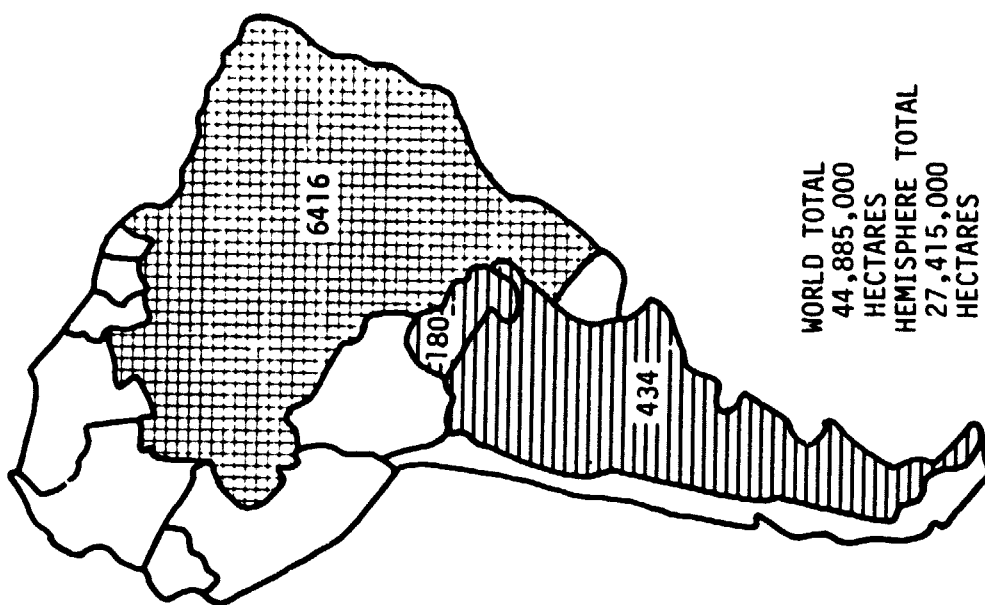
1976 SOYBEAN HARVEST--WESTERN HEMISPHERE (1,000 HECTARES*)



KEY



* 1 HECTARE = 2,471 ACRES



WORLD TOTAL
44,885,000
HECTARES
HEMISPHERE TOTAL
27,415,000
HECTARES

Source: FAO, The Production Yearbook,
1976, Table 28

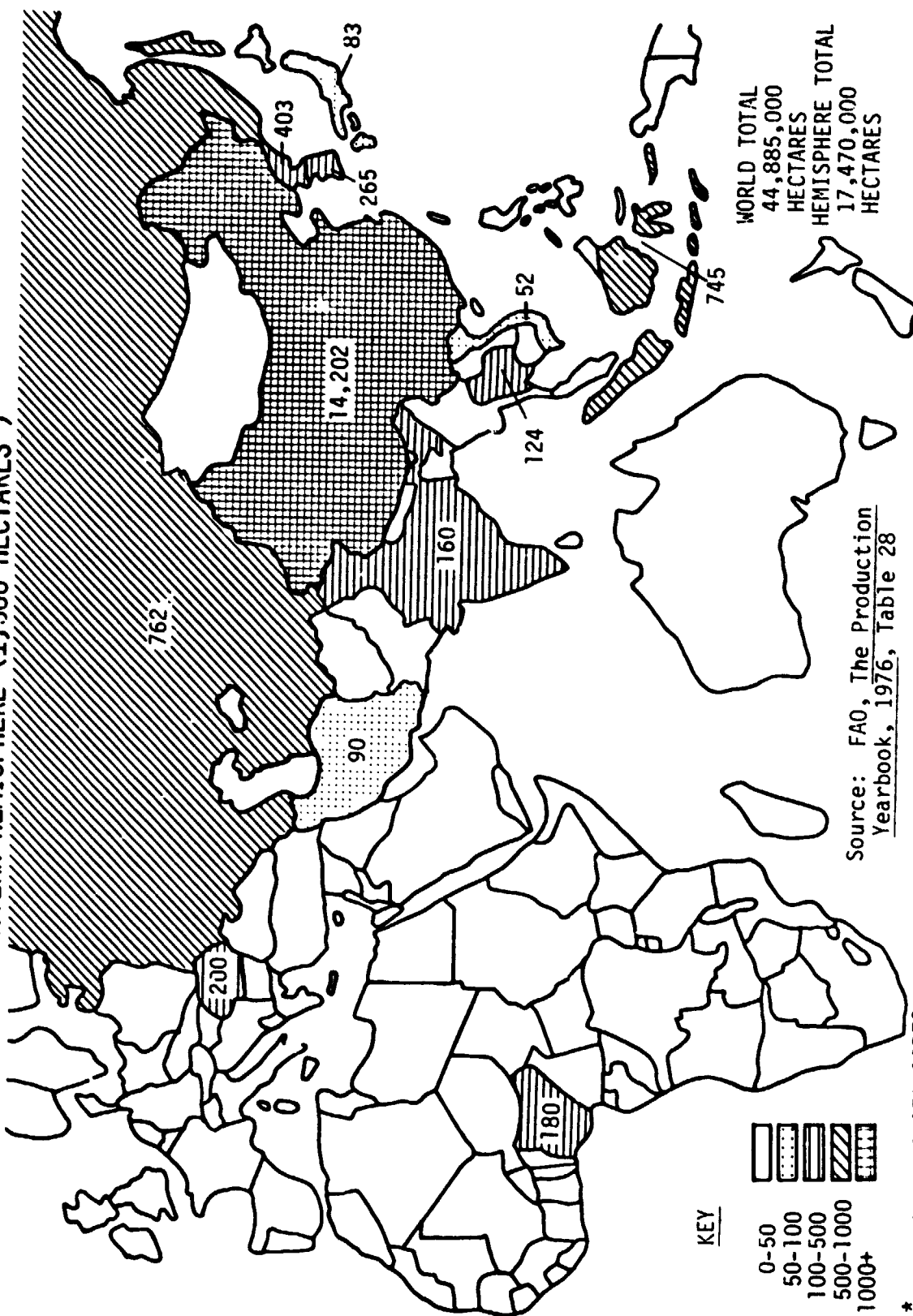
econ

Thirty-nine percent of the world soybean harvest is concentrated in the Eastern Hemisphere.

Asia (including the USSR) harvests 96.9 percent of the soybean area planted in this hemisphere followed by Europe (1.7 percent), Africa (1.2 percent), and Oceania (0.2 percent).

China leads the countries in this hemisphere in terms of soybean area, harvesting 81.3 percent of the area and 31.6 percent worldwide.

1976 SOYBEAN HARVEST--EASTERN HEMISPHERE (1,000 HECTARES*)



KEY

- 0-50
- 50-100
- 100-500
- 500-1000
- 1000+

WORLD TOTAL
44,885,000
HECTARES
HEMISPHERE TOTAL
17,470,000
HECTARES

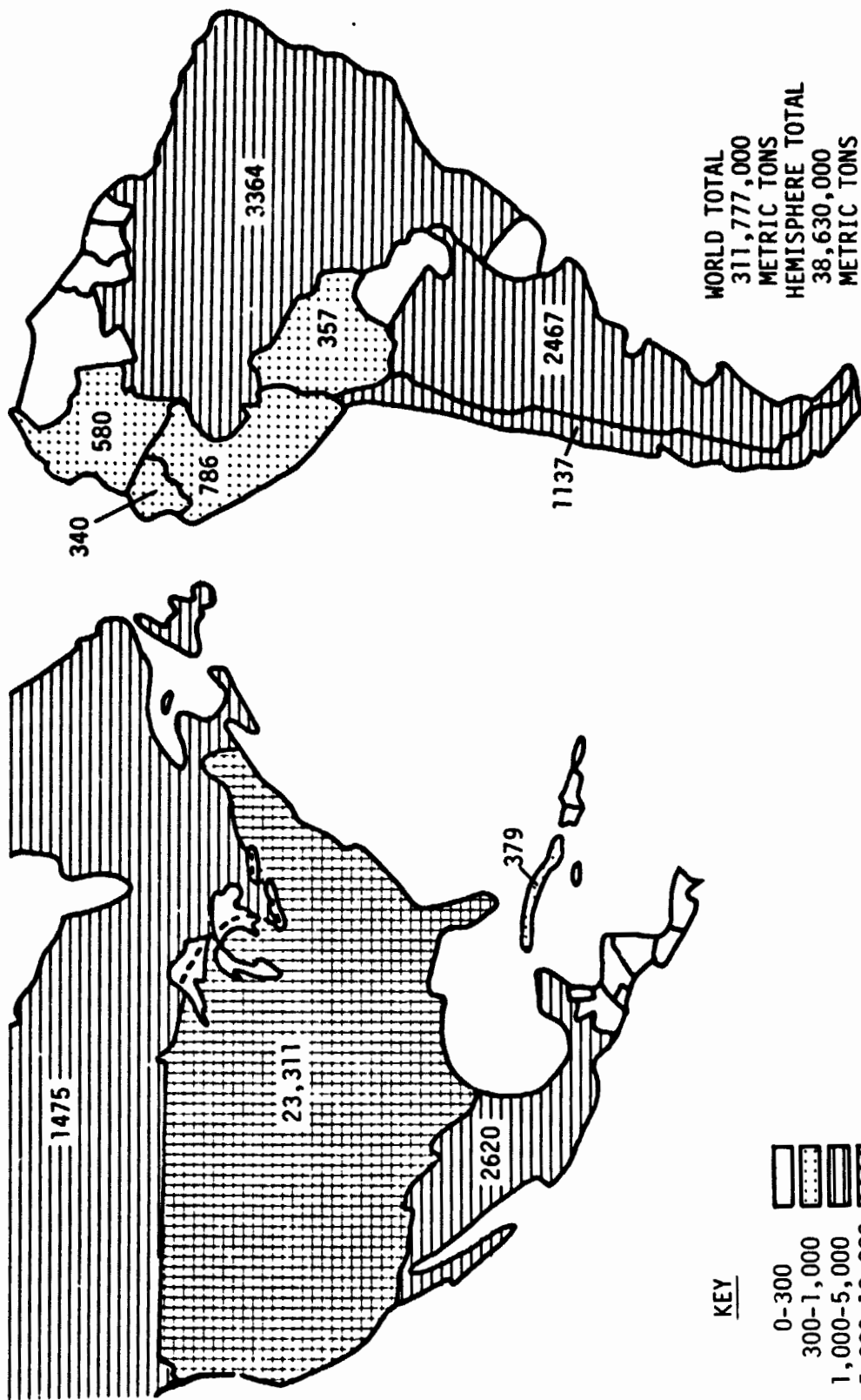
Source: FAO, The Production
Yearbook, 1976, Table 28

* 1 HECTARE = 2.471 ACRES

UN

The map at the right shows the Western Hemisphere vegetable and melon harvest. In 1976 nearly 312 million metric tons of vegetables and melons were harvested worldwide. Twelve percent of the harvest is located in the Western Hemisphere. Approximately three-quarters of the production is located in North and Central America with the remainder in South America. The United States is the leading producer of vegetables and melons, harvesting 60 percent of the hemisphere's total production and 7.5 percent of the world total production. Brazil, Mexico, Argentina, Canada and Chile follow in order of decreasing importance.

1976 VEGETABLE AND MELON HARVEST--WESTERN HEMISPHERE (1,000 METRIC TONS)



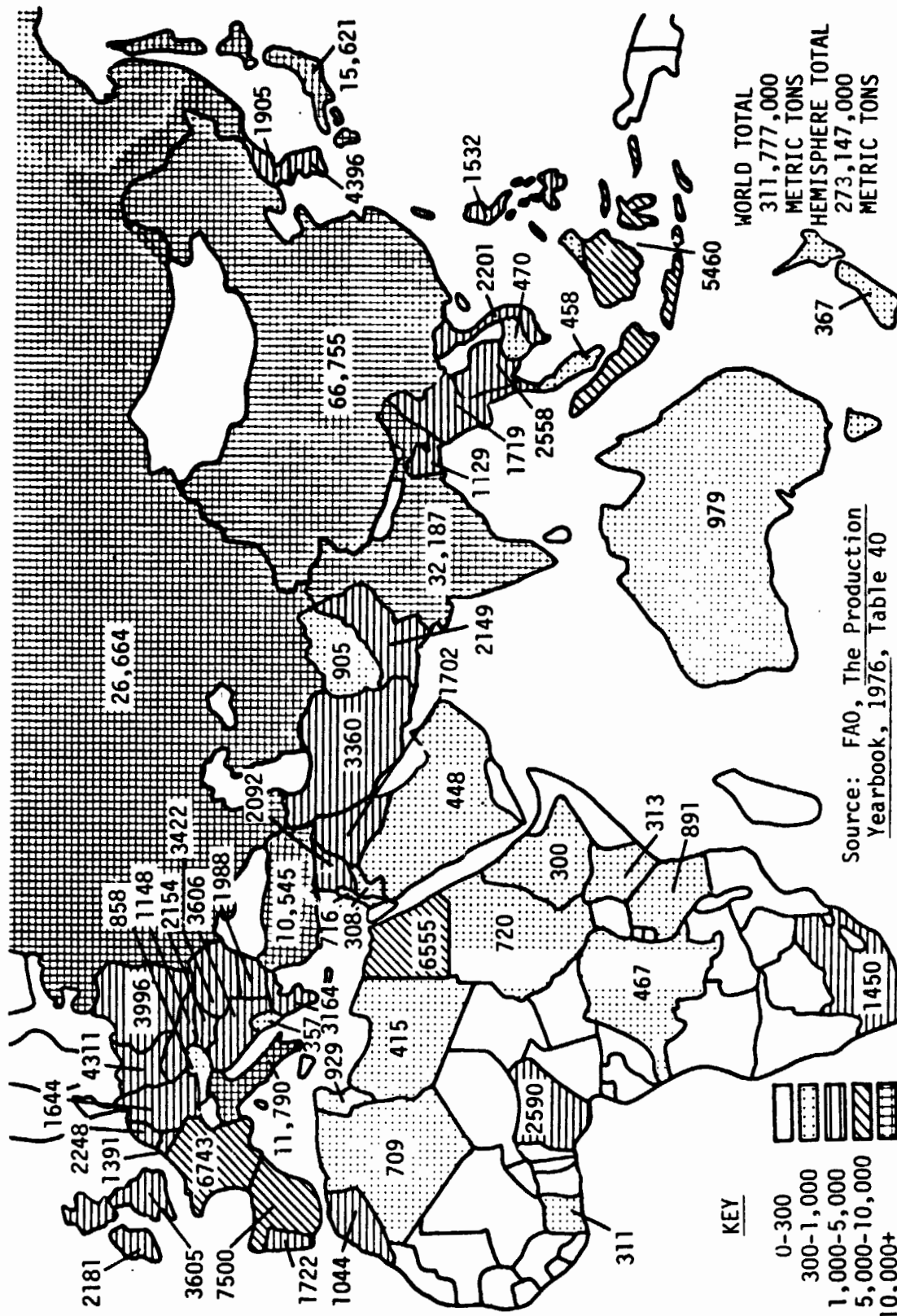
Source: FAO, The Production Yearbook, 1976, Table 40

235

Eighty-eight percent of the world vegetable and melon harvest is concentrated in the Eastern Hemisphere. Asia harvests 68.4 percent of the production here followed by Europe (23.7 percent), Africa (7.3 percent), and Oceania (0.6 percent).

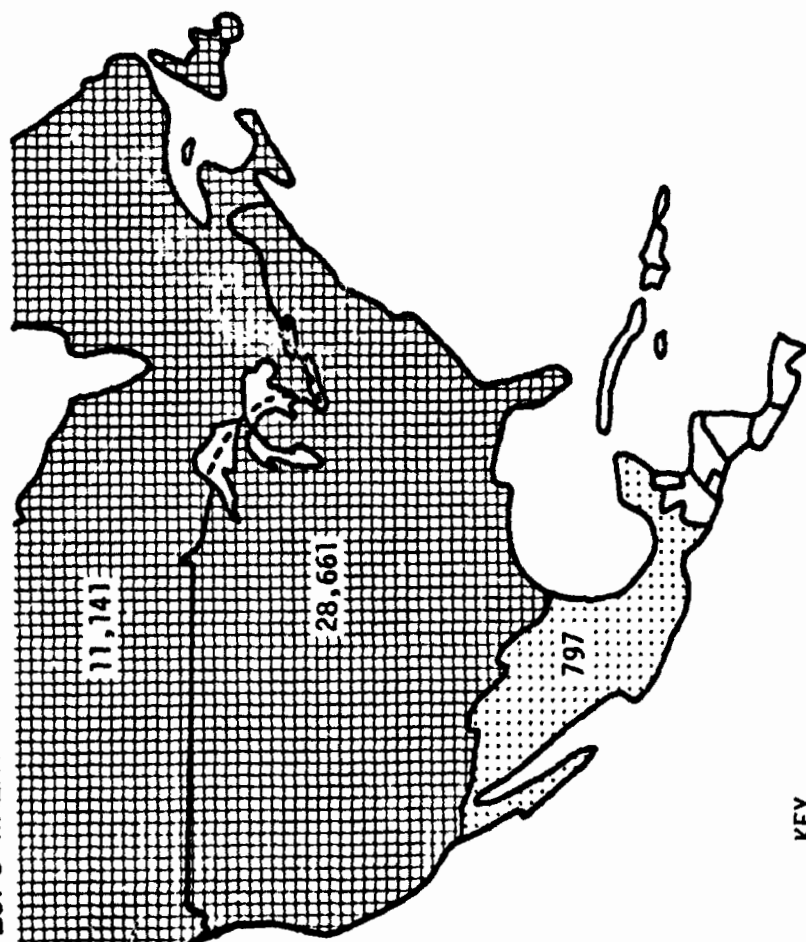
China is the leading producer of vegetables and melons, harvesting 24 percent of the hemisphere's total and 21 percent of the world total. India, the USSR, Japan, Turkey, Spain and France follow in order of decreasing importance.

1976 VEGETABLE AND MELON HARVEST--EASTERN HEMISPHERE (1,000 METRIC TONS)



The map at the right shows the Western Hemisphere wheat harvest. In 1976, 235 million hectares of wheat were harvested worldwide. Twenty-three percent of the harvest is concentrated in the Western Hemisphere. Approximately three-quarters of the hemisphere's wheat area is found in North and Central America with one-quarter in South America. The United States is the leading wheat producer in this hemisphere with 54 percent of the total wheat area here and 12.2 percent of the world wheat area. Canada, Argentina, and Brazil follow in order of decreasing importance for area harvested.

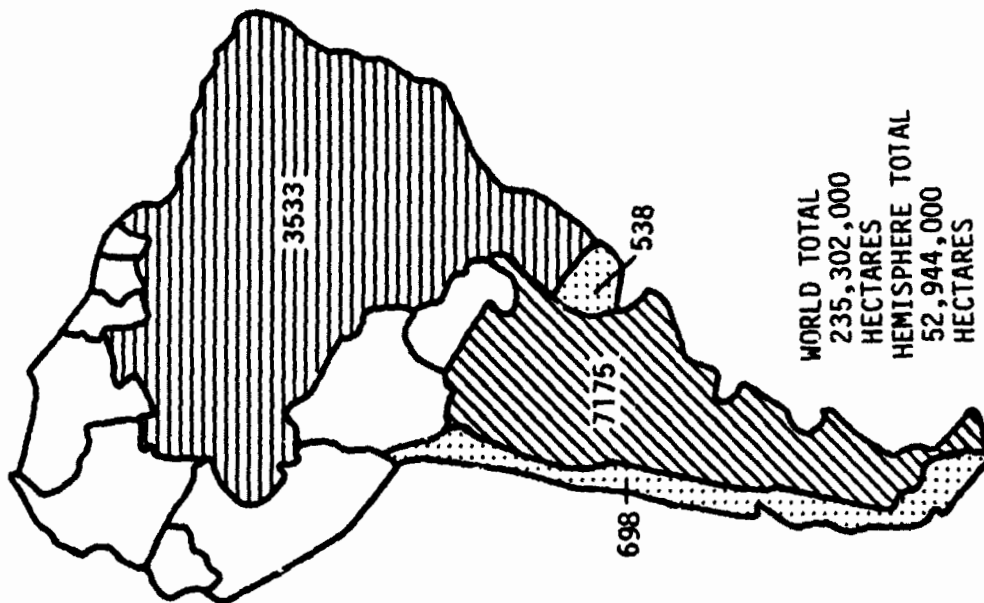
1976 WHEAT HARVEST--WESTERN HEMISPHERE (1,000 HECTARES*)



KEY



* 1 HECTARE = 2.471 ACRES



WORLD TOTAL
235,302,000
HECTARES
HEMISPHERE TOTAL
52,944,000
HECTARES

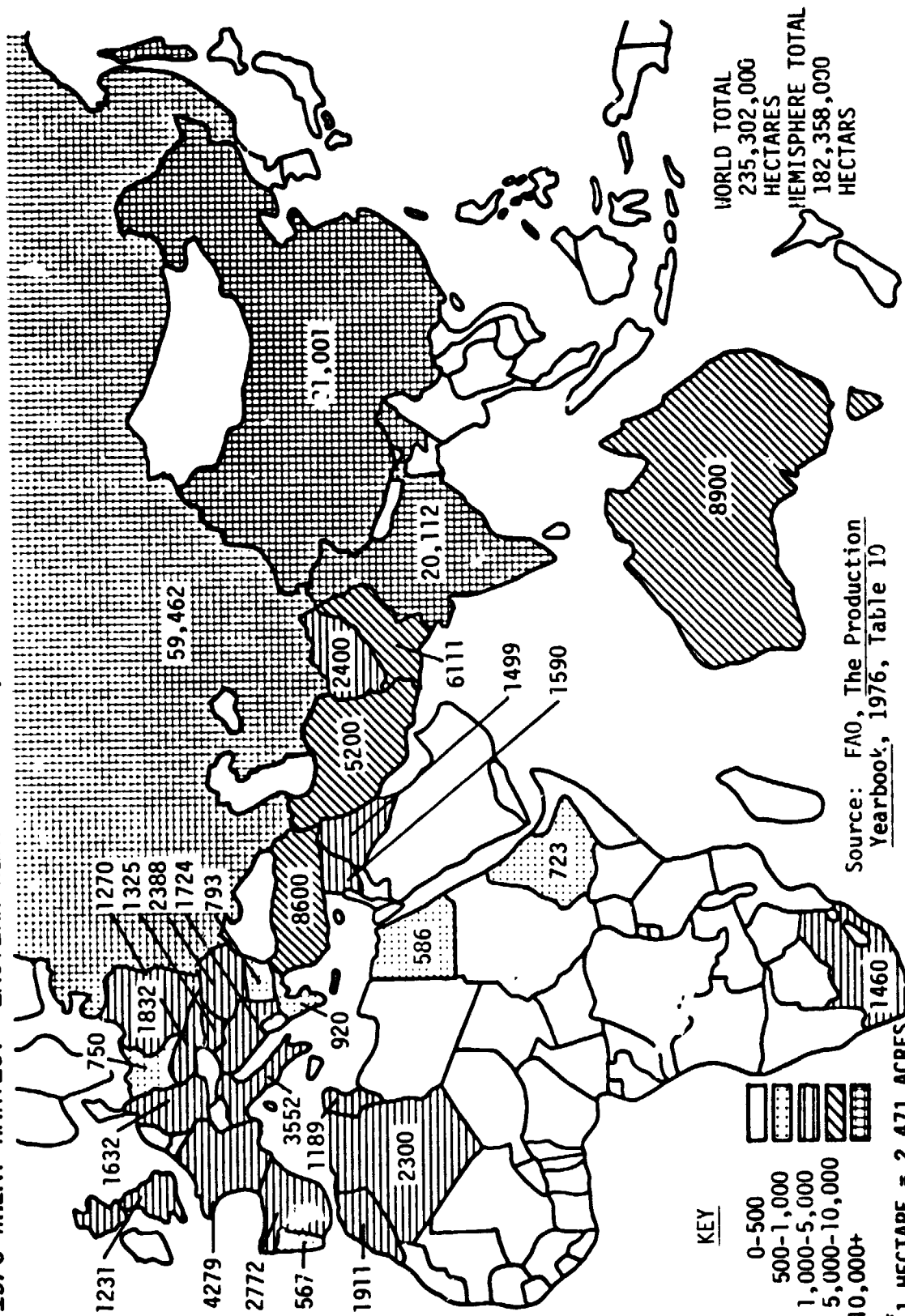
Source: FAO, The Production Yearbook,
1976, Table 10

ESON

Seventy-seven percent of the world wheat area is found in the Eastern Hemisphere. Asia (including the USSR) harvests 75.5 percent of the wheat area planted here followed by Europe (14.7 percent), Africa (4.9 percent), and Oceania (4.9 percent).

The USSR is the major wheat producer in this hemisphere, harvesting 33 percent of the hemisphere's and 25 percent of the total world wheat area planted. China, India, Australia, Turkey, Pakistan, Iran, and France follow in order of decreasing importance for area harvested.

1976 WHEAT HARVEST--EASTERN HEMISPHERE (1,000 HECTARES*)

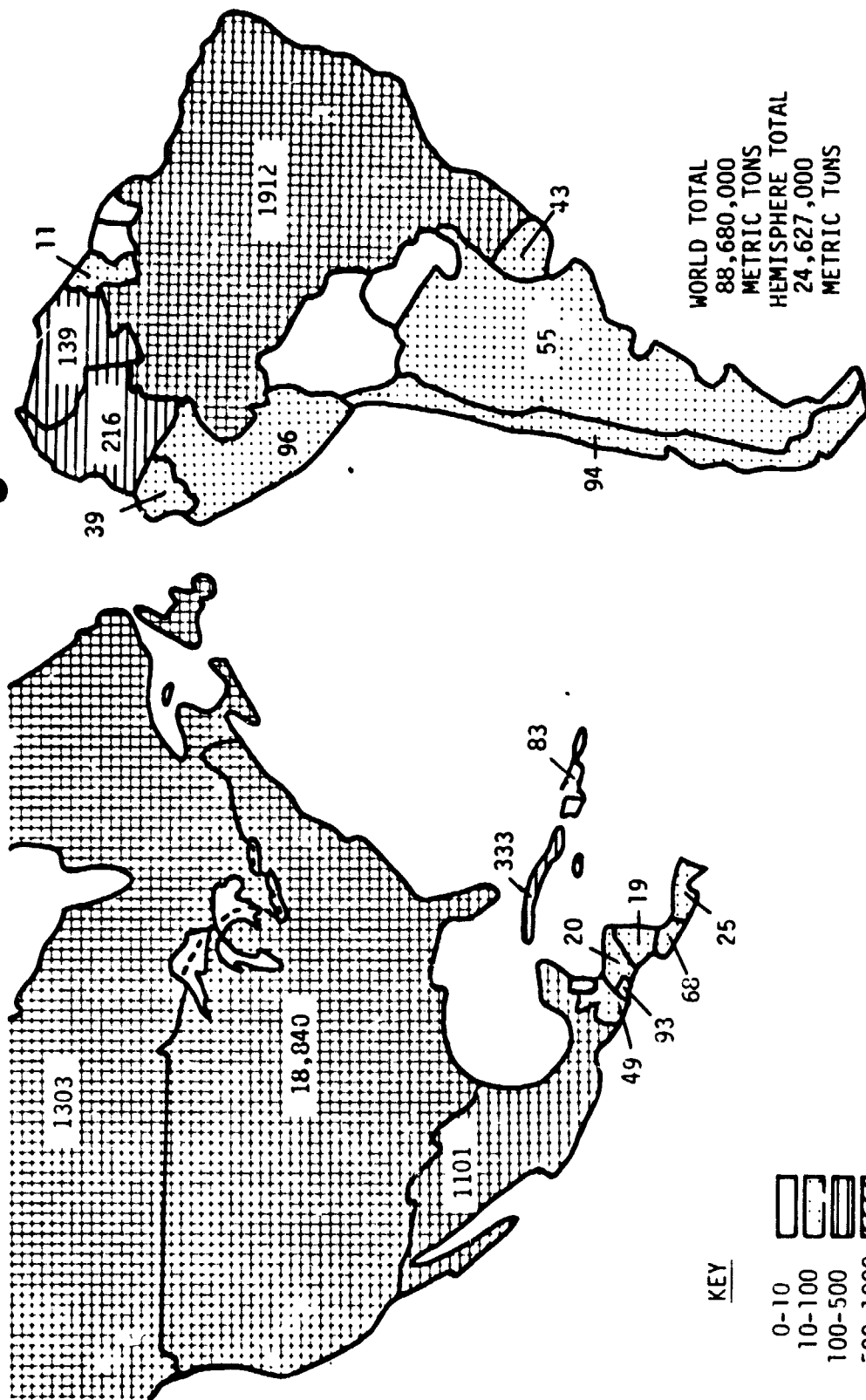


241

The map at the right shows Western Hemisphere fertilizer consumption. The figures presented here are combined totals for nitrogenous, phosphate, and potash fertilizers for each country. In 1976 the worldwide consumption of these three categories of fertilizer was 88.7 million metric tons.

Twenty-eight percent of this total consumption is concentrated in the Western Hemisphere. Approximately 90 percent of the hemisphere's fertilizer is consumed in North and Central America with 10 percent consumed in South America. The United States is the leading user of fertilizer in this hemisphere, comprising 77 percent of the hemisphere's total and 21 percent of the world's total fertilizer consumption. Brazil, Canada, and Mexico follow in order of decreasing importance.

1976 FERTILIZER CONSUMPTION--WESTERN HEMISPHERE (1,000 METRIC TONS)

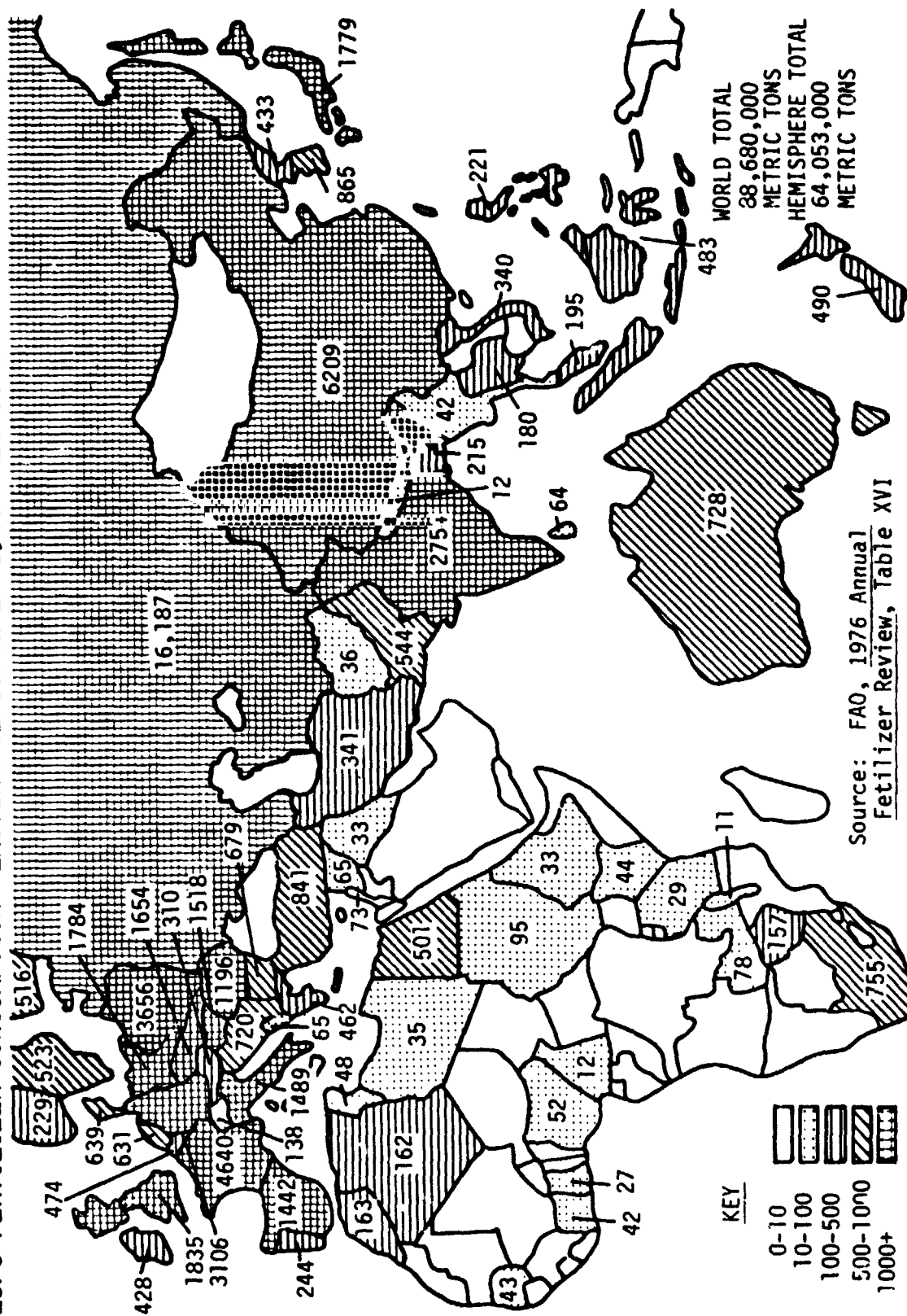


Source: FAO, 1976 Annual Fertilizer Review, Table XVI

Seventy-two percent of total fertilizer consumption occurs in the Eastern Hemisphere. Asia (including the USSR) consumes approximately 50 percent of the hemisphere's fertilizer followed by Europe (44.4 percent), Africa (3.8 percent), and Oceania (1.9 percent).

The USSR is the largest consumer of fertilizer here, comprising 25 percent of the hemisphere's total and 18.2 percent of the world's total fertilizer consumption. China, France, Poland, West Germany, India, Great Britain, East Germany, Japan, Czechoslovakia, Hungary, Italy and Spain follow in order of decreasing importance.

1976 FERTILIZER CONSUMPTION--EASTERN HEMISPHERE (1,000 METRIC TONS)



A breakdown of the ag-air fleets for ten countries is given at the right. As can be seen, a substantial number of U.S. aircraft are used in other countries. Japan, South Africa, the United Kingdom, Israel and Chile employ almost entirely U.S. aircraft. The major portion of the fleets in New Zealand, Australia and France are U.S. aircraft. Almost 60 percent of the Yugoslavian fleet is made up of U.S. aircraft. Most of the Brazilian fleet is the Embraer Ipanema.

TYPES OF AGRICULTURAL AIRCRAFT USED IN SELECTED COUNTRIES

AIRCRAFT	NEW ZEALAND	AUSTRALIA	BRAZIL	JAPAN	SOUTH AFRICA	UNITED KINGDOM	FRANCE	ISRAEL	YUGOSLAVIA	CHILE
FIXED WING										
CESSNA 180	40	7			17	1				12
CESSNA 188	44	69	36			9	9			
DHC 2 BEAVER	18	23								
FLETCHER FU24	114	19	3		22	4	1		27	
GRUMMAN AGCAT		7							7	
ANTONOV AN-2	40		24		14		7	9		9
PIPER PA-18	36	82			43	50	8			15
PIPER PA-25										
ROCKWELL			6		21	4	1	40		
THRUSH COMMANDER		1								
TRANSAVIA		16	150		1	2				2
PL-12 AIRTRUCK	22	21			3			3	12	
OTHER										
ROTARY WING										
AEROSPATIALE LAMA										
ALOUETTE II						1	2			
BELL 47	26	1		139		1	1	9		
BELL JETRANGER				4		23	46	2		
HILLER UH-12	27			4		3				
HUGHES 300C						17	2			3
HUGHES 269B,C	84			21						
S.A. DJIN				5		1	13			
OTHER										
TOTAL	451	247	219	173	121	116	90	63	46	41

Source: Contacts with U.S. embassies and foreign governments.

There are an estimated 10,000 agricultural aircraft in the U.S.S.R. of which 75 percent are fixed wing. All agplanes used in the U.S.S.R. are supplied by the Polish Pezetel aircraft company. Since the agplane in the U.S.S.R. is a multipurpose aircraft, they are usually converted to passenger and cargo transport use during slack periods. More than 90 million hectares (223 million acres) are treated by agricultural aircraft with more than a third of the area treated being for the application of fertilizers. About 25 percent of the area is treated for insects or plant diseases and another 25 percent for herbicide applications.

AGRICULTURAL AIRCRAFT OPERATIONS IN THE USSR

- APPROXIMATELY 10,000 AIRCRAFT TOTAL
 - 7500 FIXED WING
 - 2500 ROTARY WING
- POLAND'S PEZETEL AIRCRAFT COMPANY SUPPLIES ALL OF THE USSR'S AIRCRAFT
- ALMOST ALL AG AIRCRAFT ARE CONVERTED TO PASSENGER AND/OR CARGO TRANSPORT USE DURING SLACK PERIODS
- 90,400,000 HECTARES TREATED (223,400,000 ACRES)
 - 24,500,000 HECTARES - COMBATTING CROP AND TREE PESTS AND DISEASES
 - 23,600,000 HECTARES - WEED KILLING
 - 37,700,000 HECTARES - FERTILIZER APPLICATION
 - 4,400,000 HECTARES - DEFOLIATION AND DESSICATION OF CROPS

There are 451 agricultural aircraft and 83 ag-air companies in New Zealand that treat over 5 million hectares (12.7 million acres) of crop and rangeland. Of the 192,000 hours flown in 1976, about 15 percent were nonrevenue producing. About 80 percent of all ag-air work is for the application of fertilizers which has been a major factor in improving the fertility of the hilly pasture lands used for grazing sheep and cattle.

AGRICULTURAL AIRCRAFT OPERATIONS IN NEW ZEALAND

- 451 AIRCRAFT
- 83 OPERATING COMPANIES
- 5,854,000 HECTARES TREATED (14,465,000 ACRES)
- APPROXIMATELY 198,000 TOTAL FLYING HOURS IN 1976
- 15% OF TOTAL FLYING HOURS ARE NON-REVENUE HOURS
- 1,063,000 METRIC TONS OF SOLID MATERIAL ARE APPLIED BY AIR (1,172,000 TONS)
147,000 HOURS ARE FLOWN WITH SOLID MATERIAL
- 46,400,000 LITERS OF LIQUID ARE APPLIED BY AIR (12,258,000 GALLONS)
26,000 HOURS ARE FLOWN WITH LIQUID MATERIAL
- 41% OF ALL FERTILIZER USED IS SPREAD BY AIR
- GOVERNMENT ENCOURAGES USE OF AG-AIR BY A SYSTEM OF FERTILIZER SUBSIDIES
 - \$2.50/TON SUBSIDY IF FERTILIZER IS SPREAD BY THE FARMER
 - \$4.00/TON SUBSIDY IF FERTILIZER IS SPREAD BY A WHEELED CONTRACTOR
 - \$8.00/TON SUBSIDY IF FERTILIZER IS SPREAD BY AG-AIR
- AG-AIR HAS BEEN MOST BENEFICIAL IN IMPROVING THE FERTILITY OF NEW ZEALAND'S
HILLY PASTURE LANDS FOR SHEEP AND CATTLE GRAZING

There are 247 agricultural aircraft in Australia flying about 67,000 hours in 1976. Of these hours about 20 percent are nonrevenue producing. More than 3 million hectares (8.2 million acres) are treated annually, of which a third is for the application of fertilizers, a third for applications to crops and a third for applications to pastures or other vegetation.

AGRICULTURAL AIRCRAFT OPERATIONS IN AUSTRALIA

- 247 AIRCRAFT
- 67,000 TOTAL FLYING HOURS IN 1976
- 20% OF TOTAL FLYING HOURS ARE NON-REVENUE PRODUCING
- 3,314,000 HECTARES TREATED (8,188,894 ACRES)
 - 1,164,000 HECTARES TOP DRESSED AND SEEDED
 - 2,059,000 HECTARES SPRAYED -- CONSISTING OF:
 - 234,000 HECTARES OF PASTURE
 - 1,253,000 HECTARES OF CROPS
 - 572,000 HECTARES OF OTHER VEGETATION
 - 91,000 HECTARES RECEIVE OTHER FORMS OF TREATMENT

Mexico has a rather large ag-air fleet of 800 aircraft. However, most aircraft only fly 150 to 200 hours a year. About 90 percent of the cotton crop is treated annually about 8 times for insect control. In all, under 3 million hectares (6.8 million acres) are treated in Mexico.

AGRICULTURAL AIRCRAFT OPERATIONS IN MEXICO

- 800 AIRCRAFT
- 2,750,000 HECTARES TREATED (6,795,000)
- 150-200 HOURS PER AIRCRAFT PER YEAR
- 90% OF THE COTTON CROP (300-400,000 HECTARES) IS TREATED APPROXIMATELY EIGHT TIMES PER SEASON
- MOST OTHER CROPS RECEIVE SOME TREATMENT BY AIR. CORN RECEIVES THE LEAST TREATMENT SINCE IT IS USUALLY GROWN ON VERY SMALL, FAMILY-TENDED PLOTS.

PHOTO: A RUSSIAN VETERINARY LABORATORY EXPERT
FLYING AN AN-2 APPLIES AN INSECTICIDE
TO A WHEAT FIELD IN OUTER MONGOLIA IN
1966. PHOTO COURTESY OF FAO, ROME, ITALY.

PART IV
AGRICULTURAL AIRCRAFT OF THE WORLD



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The major agricultural aircrafts manufactured worldwide are listed on the next five pages. Comparative data are given where obtainable for each aircraft. Following the list, 28 of the aircraft are discussed individually and a three-view drawing given. Finally, seven manufacturers' sales and distribution networks are discussed.

INTERNATIONAL ROTARY WING AGRICULTURAL AIRCRAFT

Aircraft	Empty Wt. Lbs	Gross Wt. Lbs	Rotor Diameter Ft	Engine	Year of Intro	Construction Location	Production Rate Per Year	Cumulative Production	Price, \$	Remarks
Aérospatiale Alouette II LAMA	2251	4300	36.1	Artouste III B 858 HP Turbine	1969	Maignane, France	n.a.	40	325,000	Uses Turbine Engine of Alouette-III Helicopter
Bell Model 47	1699	2850	37.1	260 HP Lycoming	1946	Fort Worth, Texas		5000	50,000*	Series 47 Discontinued Weights and Engine From Model 47G-5
Continental Copter Mk VIB	1667	2850	35.1	260 HP Lycoming	1959	Fort Worth, Texas	10-12	100	58,000	Converted From Bell Model 47
Hiller UH-12	1759	3300	35.4	305 HP Lycoming	1963	Porterville, California	60	2115	78,200	Previously Produced by Fairchild Hiller
Hughes 300C	1046	2150	26.8	225 HP Lycoming	1956	Culver City, California	n.a.	n.a.	59,500	Similar to Earlier Model 259A
Kamov KA-26	4885	5570	42.7	Twin 325 HP M-14V-26	1964	USSR	n.a.	600	n.a.	NATO Designated Hoodlum
Silvercraft SH-4A	1142	1900	29.6	205 HP Lycoming	1965	Varese, Italy	n.a.	n.a.	**	Cooperative Effort with SIAI-Marchetti SpA
WSK-PZL Swidnik MI-2	5213	8157	47.5	Twin 400 or 450 SHP ISOTOV	1961	Swidnik, Poland	n.a.	n.a.	**	NATO Designated Hodlite
* Price depends on age, equipment, airframe, and hours on engine.							 Production discontinued.			
** Not imported to the United States.							n.a. Data not available.			

U.S. FIXED WING AGRICULTURAL AIRCRAFT

Aircraft	Empty Wt., Lbs	Gross Wt., Lbs	Wing Span, Ft	Engine	Year of Intro	Construction Location	Production Rate Per Year	Cumulative Production	Price, \$	Remarks
Air Tractor AT-301	3600	6600	45.1	600 HP P&W	1972	Olney, Texas	50	122	58,500	Produced at Snow Facility Olney, Texas
Boeing Stearman	1936	2810	32.2	220 HP Lycoming	1935	Wichita, Kansas		10,346	10,500*	Army Training Aircraft Discontinued in 1945
Cessna A185F Agcarryall	1905	3350	35.8	300 HP Continental	1971	Wichita, Kansas	12	92	45,750	Similar to Model 185 Skywagon
Cessna A188B Agpickup	1965	3200	40.7	230 HP Continental	1971	Wichita, Kansas		53	25,000*	Discontinued in 1976
Cessna A188B Agtruck	2038	4200	41.7	300 HP Continental	1971	Wichita, Kansas	269	1539	45,950	Similar to A188B Agwagon
Cessna A188B Agwagon	2012	4000	40.7	300 HP Continental	1965	Wichita, Kansas	36	1498	40,700	Oldest of Cessna Current Production Agplanes
Emair MA-1B	6250	8400	41.7	1200 HP Wright	1969	Harlingen, Texas	16	47	67,100	Largest Agplane Produced in United States
Grumman G-164A Agcat	2870	4500	35.9	450 HP P&W	1957	Elmira, New York	207**	2066**	56,465	Also Produced in 600 HP Version
Grumman G-164B Agcat	3025	4500	42.3	450 HP P&W	1976	Elmira, New York	207**	2066**	58,800	Also Produced with 525 HP Continental Engine
*Price depends on age, equipment, airframe, and hours on engine. **Cumulative production and production rates include all Agcat aircraft.							 Production discontinued. n.a. Data not available.			

U.S. FIXED WING AGRICULTURAL AIRCRAFT (CONTINUED)

Aircraft	Empty Wt., Lbs	Gross Wt., Lbs	Wing Span, Ft	Engine	Year of Intro	Construction Location	Production Rate Per Year	Cumulative Production	Price, \$	Remarks
Piper PA-18A	946	1750	35.3	150 HP Lycoming	1949	Lock Haven, Pennsylvania		2650	12,500*	Discontinued Model of PA-18 Super Cub
Piper PA-25 Pawnee D	1561	2900	36.2	235 HP Lycoming	1959	Lock Haven, Pennsylvania	94	5045	35,190	Also Produced With 265 HP Lycoming Engine
Piper PA-36 Whee Brave	2175	4400	38.8	285 HP Continental	1972	Lock Haven, Pennsylvania	164	745	49,690	Also Produced In 300 HP and New 365 HP Versions
Rockwell A-9 AG Commander	1600	3300	35	235 HP Lycoming	1963	Afton, Wyoming		595	5,000*	Discontinued, Formerly Callair A-9 Series
Rockwell B-1 AG Commander	2500	4950	43	400 HP Lycoming	196	Afton, Wyoming		35	15,000*	Discontinued, Formerly Callair B-1 Series
Rockwell S-2D AG Commander	3400	6000	44.4	600 HP P&W	1965	Olney, Texas		412	9,500*	Discontinued, Formerly Snow S-2D
Rockwell Thrush Commander 600	3700	6900	44.5	600 HP P&W	1968	Albany, Georgia	121**	1337**	78,500	S-2R Series Developed From S-2D
Rockwell Thrush Commander 800	4100	7800	44.5	800 HP Wright	1974	Albany, Georgia	121**	1337**	78,500	Second Only to Emair MA-1B in Size
Weatherly 201C	2505	4800	39	IP	1967	Hollister, California	n.a.	220	46,500	Dispersal System is Design Integrated
* Price depends on age, equipment, airframe, and hours on engine.								Production discontinued.		
** Cumulative production and production rates include all Thrush aircraft.							n.a.	Data not available.		

FOREIGN FIXED WING AGRICULTURAL AIRCRAFT

Aircraft	Empty Wt., Lbs	Gross Wt., Lbs	Wing Span, Ft	Engine	Year of Intro	Construction Location	Production Rate Per Year	Cumulative Production	Price, \$	Remarks
AAHSA Quail Commander	1600	3600	34.8	290 HP Lycoming	1971	Pasteje, Mexico	75	250	46,000	Formerly Produced By Rockwell in the United States
Aero Boero 180 AG	1212	1860	35.2	180 HP Lycoming	1969	Cordoba, Argentina	n.a.	n.a.	n.a.	Agricultural Version of Model 180 RV
Aero Boero 260 AG	1587	2976	35.8	260 HP Lycoming	1971	Cordoba, Argentina	n.a.	n.a.	n.a.	Similar to Model 180 AG Except for Larger Engine
AN-2R	7605	12125	58.7	1000 HP Shvetsov	1947	Mielec Poland	n.a.	3800*	110,000	Production Moved From USSR in 1960
EMB-201 Ipanema	2205	3968	36.8	300 HP Lycoming	1969	Sao Paulo State Brazil	144	369	n.a.	Over 80% of Brazilian Agricultural Fleet
Fletcher FU 24-950	2620	5430	42	400 HP Lycoming	1964	Hamilton, New Zealand	n.a.	230	n.a.	Developed by Sargent-Fletcher of El Monte, California
Hal-31 MK. 2 Basant	2645	4300	39.4	400 HP Lycoming	1972	Kanpur, India	n.a.	100	n.a.	Originally Produced for Indian Ministry of Food and Agriculture
ICA-Brasov IAR-826	2469	4188	42	290 HP Lycoming	1970	Brasov, Romania	n.a.	n.a.	n.a.	All Metal Version of IAR-822
ICA-Brasov IAR-827	2667	5160	45.9	400 HP Lycoming	1970	Brasov, Romania	n.a.	n.a.	n.a.	Developed Version of IAR-826
Pilatus PC-6 Turbo Porter	2678	6100	49.7	550 SHP P&W Turbo Prop	1959	Stans, Switzerland	n.a.	n.a.	n.a.	Built By Fairchild Industries in United States

*More than 5,000 AN-2s were built before 1960 in the USSR.

n.a. Data not available.

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FOREIGN FIXED WING AGRICULTURAL AIRCRAFT (CONTINUED)

Aircraft	Empty Wt., Lbs	Gross Wt., Lbs	Wing Span, Ft	Engine	Year of Intro	Construction Location	Production Rate Per Year	Cumulative Production	Price, \$	Remarks
PZL-101 Gawron (Rook)	2213	3660	41.6	260 HP AJ-14R	1958	Warsaw-Okecie, Poland		300	**	Discontinued, Designated Standard Agplane of USSR in 1960s
PZL-106 KRUK (Raven)	3527	6614	48.5	600 HP PZL-35	1973	Warsaw-Okecie, Poland	n.a.	600	**	Designated to Replace PZL 101 Rook
Socata MS-893 RALLYE Commodore 180	1212	2315	31.5	180 HP Lycoming	1964	Aeronort de Tarbes-Ossun, France	n.a.	n.a.	n.a.	AG Version Designated Agricolallye
Transavia PL-12 Airtruk	1710	4090	39.3	300 HP Rolls Royce Continental	1965	Seven Hills NSM, Australia	n.a.	90*	n.a.	Unique Tail Design Facilitates Loading and Dispersal
Transavia T-320 Airtruk	1800	4090	39.3	325 HP Continental	1976	Seven Hills NSM, Australia	n.a.	n.a.	n.a.	Same Airframe Design as PL-12 Airtruk
Utva 60AG	2271	3814	37.4	270 HP Lycoming	1960	Pancevco, Yugoslavia	n.a.	n.a.	n.a.	Superceded by UTVA-66 Series
UTVA-65 Super Privrednik	2505	4431	42.3	350 HP Lycoming	1973	Pancevco, Yugoslavia	n.a.	n.a.	n.a.	Replaced UTVA-65 Privrednik Series
MSK-MIELEC M-15	6812	12456	73.3	Ivchenko AI-25 Turbopan	1971	Mielec, Poland	n.a.	100	**	Primarily Used For Large Fields in USSR
ZLIN-37A CHELAK	2295	4080	40.1	315 HP M 462 RF	1963	Kunovice, Czechoslovakia	n.a.	600	n.a.	Designated Bumble Bee
* Includes PL-12 and T-320 Airtruk. ** Not imported to the United States.							 Production discontinued. n.a. Data not available.			

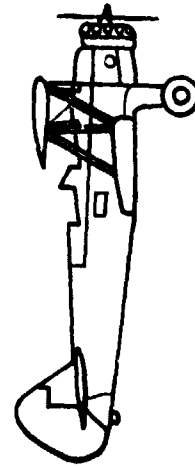
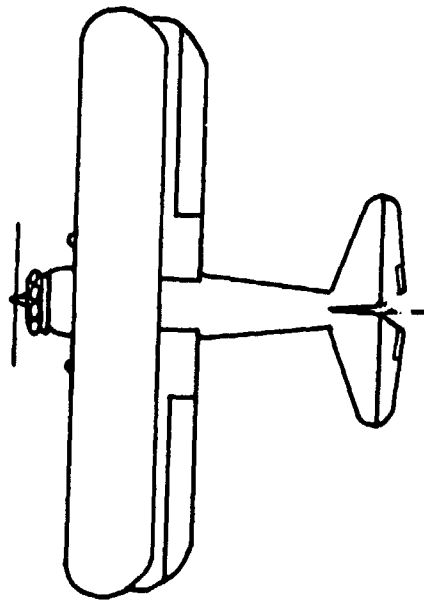
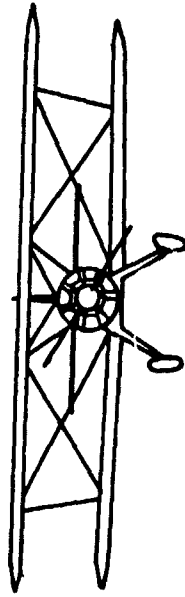
BOEING STEARMAN

Although not built for agricultural purposes, the Stearman is widely used today in agricultural aviation. The first training version of the Stearman was the P-13 which was ordered by the army in 1935. Between 1935 and the completion of its production in February 1945, 10,346 Stearman aircraft had been built. The plane has a wingspan of 32.2 ft, is 25 ft in length, is 9.2 ft high and has a gross weight of about 2,810 lbs. The Stearman was produced in several versions using a 220 hp Lycoming engine, a 220 hp Continental engine or a 225 hp Jacobs engine.

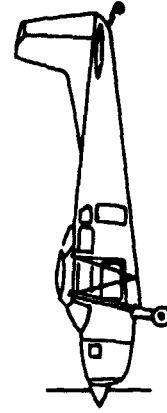
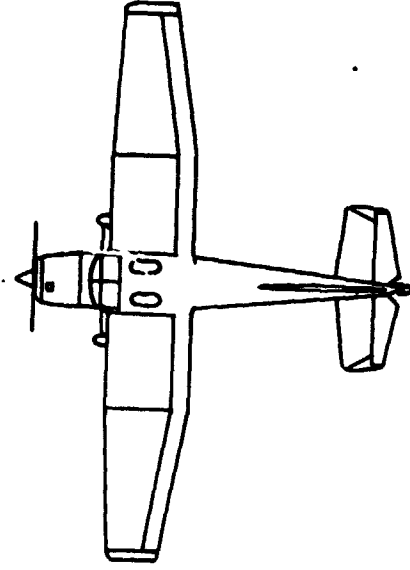
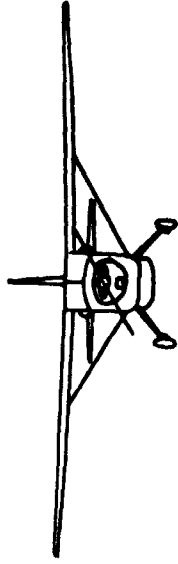
CESSNA AGCARRYALL

Introduced on December 8, 1971 along with the AgWagon, AgTruck and AgPickup by Cessna, a total of 62 AgCarryalls had been delivered by January 1976. Generally similar to the Model 185 Sky-Wagon, the 185F has a wingspan of 35.8 ft, is 7.7 ft in height, 25.9 ft in length, has a gross weight with dispersal equipment of 3,350 lbs and a hopper capacity of 151 gals. The average swath for the AgCarryall is 55-65 ft. The AgCarryall is powered by a 300 hp Continental engine and is the fastest of the Cessna agricultural fleet with a maximum speed of 149 mph.

BOEING STEARMAN



CESSNA AGCARRYALL



CESSNA AGWAGON, AGTRUCK AND AGPICKUP

The AgWagon, AgTruck and AgPickup are all part of Cessna's A188B series of agricultural aircraft. The AgWagon, introduced in 1965, is the basic aircraft in the series with Cessna making slight modifications and introducing the AgTruck and AgPickup in 1971.

The AgWagon features a 300 hp Continental 10-520-D flat six engine and has a maximum speed of 121 mph. The AgWagon has a 40.7 ft. wingspan, is 7.8 ft in height, 25.5 ft in length and has a gross weight of 4 000 lbs. Its hopper capacity is 200 gals and the average swath is 60-70 ft.

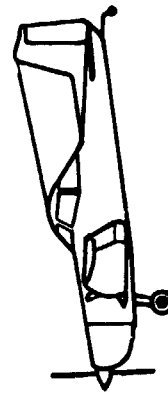
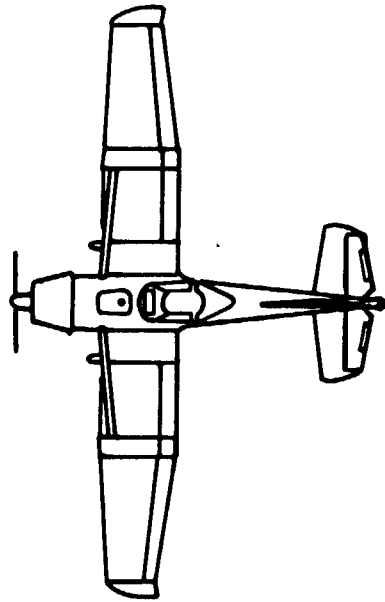
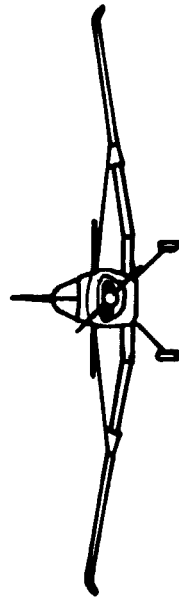
Discontinued in 1976, the AgPickup is only significantly different from the AgWagon in two respects. The AgPickup is 200 lbs lighter than the AgWagon and has a smaller 230 hp powerplant. The A188B AgTruck is a slightly larger version of the AgWagon. The AgTruck is 200 lbs heavier than the AgWagon and has a larger 280 gal hopper.

EMAIR MA-1

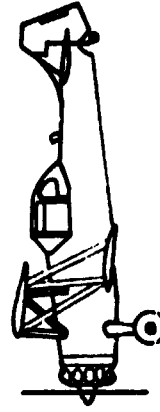
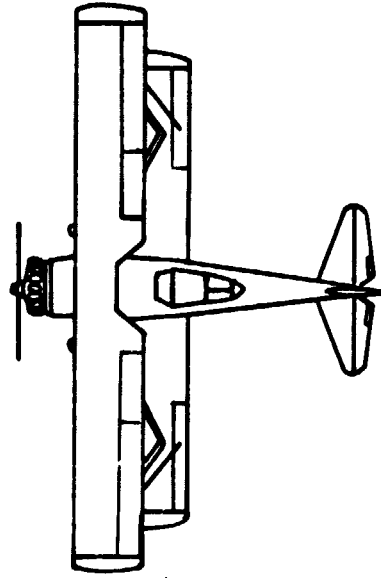
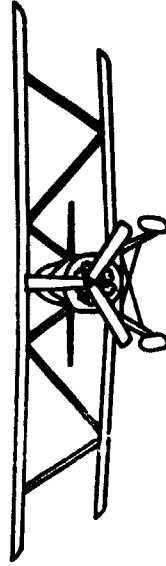
Under contract to Murrayair Ltd. of Hawaii, the MA-1 first flew on July 27, 1969. The MA-1 biplane has a wingspan of 41.7 ft, is 28.7 ft long and 11.8 ft high with a gross weight of about 7,000 lbs. It has a hopper capacity of 450 gals and is powered by a 600 hp Pratt and Whitney engine. A new version designated MA-1B is similar in size but is powered by a 1,200 hp Wright engine and has a normal operating weight of 8,400 lbs making it the largest agricultural aircraft manufactured in the U.S.

800

CESSNA AGWAGON



EMAIR MA-1



EMBRAER EMB-200 AND EMB-201 IPANEMA

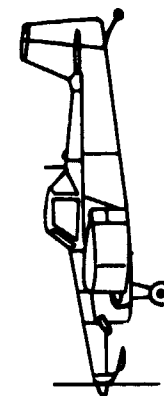
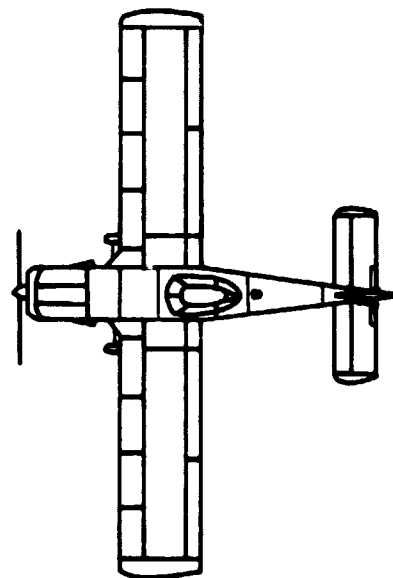
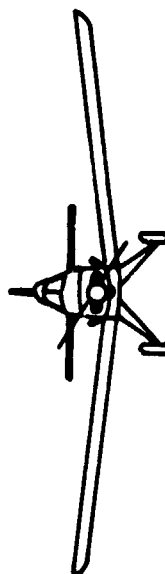
Design started for the original EMB-200 in May 1969 under specifications furnished by the Brazilian Ministry of Agriculture. The prototype PP-ZIP made its first flight on July 30, 1970. Production of the EMB-200 ended in 1974 with the completion of 73 aircraft. The EMB-201 is currently being produced at a rate of about 12 per month.

The basic difference between the EMB-200 and EMB-201 models is the engine. The EMB-200 was built with a 260 hp Lycoming as compared with the larger 300 hp Lycoming in the EMB-201. Each aircraft has a 36.8 ft wingspan, is 24.4 ft in length, 7.2 ft in height and has a maximum takeoff weight of about 4,000 lbs. Hopper capacity of the aircraft is 180 gals.

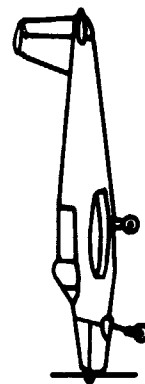
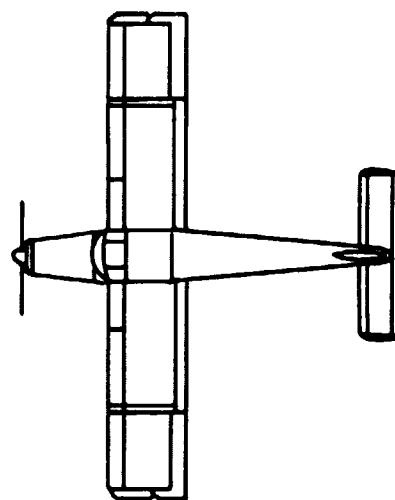
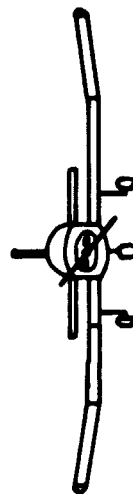
AEROSPACE FLETCHER FU-24-950

First flown in 1954, the FU-24 agricultural aircraft was developed by Sargent-Fletcher Company of El Monte, California for use in New Zealand. Since 1964 the FU-24 has been produced at the Aerospace factory in Hamilton Airport, New Zealand. A total of 218 Fletcher aircraft had been produced by the beginning of 1976 for use in New Zealand, as well as Iraq, Australia, Bangladesh, Pakistan, Thailand, Uruguay and several Pacific Island countries. The current FU-24-950 has a wingspan of 42 ft, is 31.8 ft long, 10.2 ft high and has a maximum takeoff weight of 5,430 lbs. The FU-24-950 is powered by a 400 hp Lycoming engine.

EMBRAER EMP 201 IPANEMA



FLETCHER FU-24-950



GRUMMAN AG-CAT

The Ag-Cat agricultural biplane first flew on May 22, 1957 and first deliveries were made in 1959. By March 1976, 1,642 Ag-Cats were built and in service in 34 countries. Currently the Ag-Cat is built in four versions, the G-164A/450, the G-164A/600, the G-164B/450 and the G-164B/525. The G-164A/450 is the basic Ag-Cat with a wingspan of 35.9 ft, a height of 11 ft, a length of 24.3 ft and a gross weight of 4,500 lbs. The G-164A/450 has a hopper capacity of 300 gals. and an average swath of 60-100 ft. The G-164A/450 is powered by a 450 hp Pratt and Whitney engine. The G-164A/600 is identical to the G-164A/450 except for the larger 600 hp engine. In 1976 Grumman introduced the Super Ag-Cat B versions of the Ag-Cat series. Of these the G-164B/450 is similar to the basic G-164A/450 except that the wingspan of the Ag-Cat B is about 6.4 ft longer to permit the use of increased span spraybooms for greater swath width. The average swath of the G-164B is 70-120 ft. Again the G-164B/450 and G-164B/525 are similar with 450 hp Pratt and Whitney and 525 hp Continental engines respectively.

270

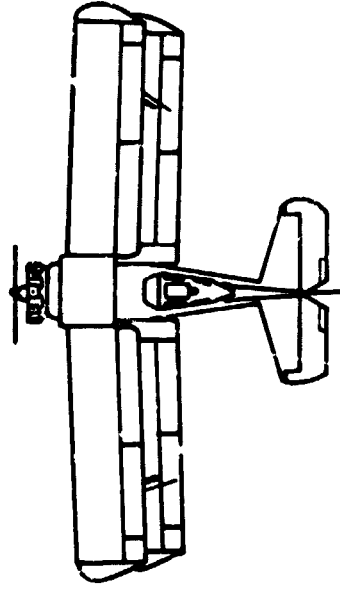
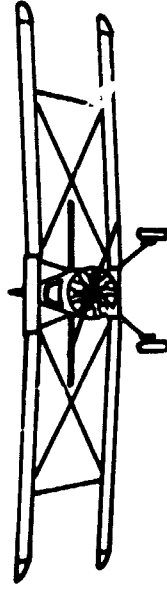
PIPER PA-18A

Although the PA-18 Super Cub was not produced exclusively for agricultural application, it was found that this small monoplane could easily be adapted for ag-air application. Piper consequently developed the PA-18A agricultural version of the original PA-18 Super Cub.

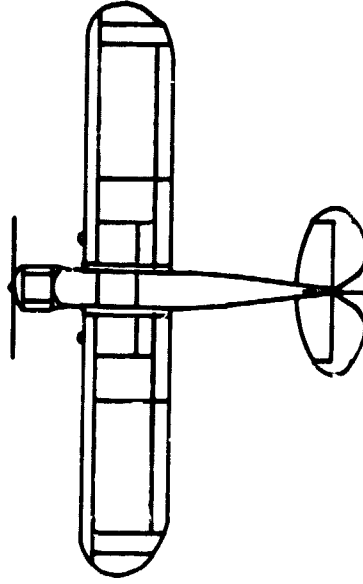
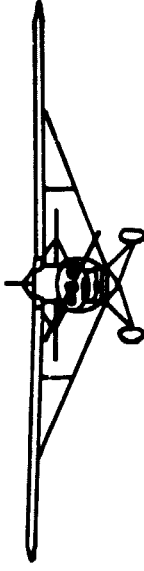
The PA-18A has a wingspan of 35.3 ft, is 22.5 ft in length, 6.7 ft in height and has a gross weight of 1,750 lbs. The aircraft is powered by a 150 hp Lycoming engine and has a useful load of 804 lbs.

Econ

GRUMMAN AG-CAT



PIPER PA-13A



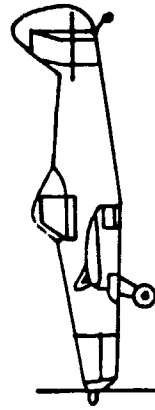
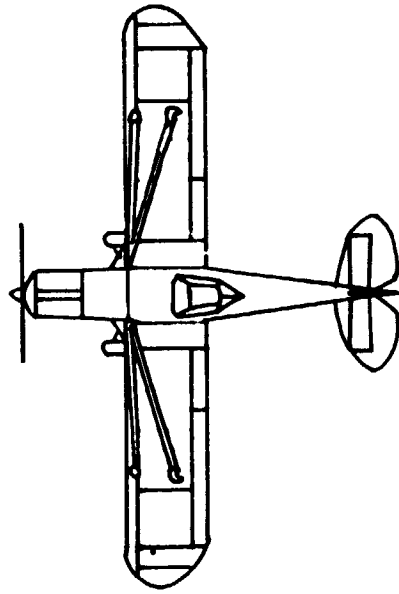
PIPER PA-25 PAWNEE D

Developed at Piper's Vero Beach Development Center, the first five production Pawnees were delivered in August 1959. The original Pawnee, from which the current Pawnee D evolved in 1973, was designed specifically as an agricultural aircraft for dispersal of chemical dusts and sprays. Although the original version was produced with a 150 hp Lycoming engine, current models are powered by 230 and 265 hp Lycoming powerplants. The PA-25 has a wingspan of 36.2 ft, is 7.2 ft in height, 24.7 ft in length, has a gross weight with dispersal equipment of 2,900 lbs and a hopper capacity of 150 gals. The average swath of the PA-25 is 50 ft.

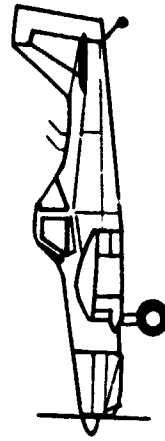
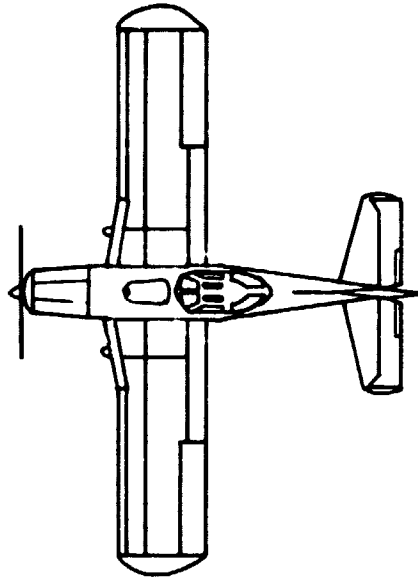
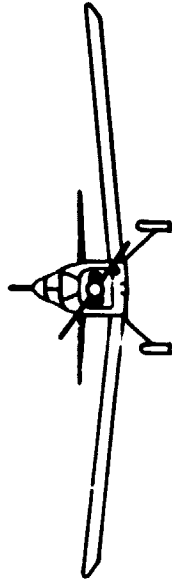
PIPER PA-36 PAWNEE BRAVE

The Piper PA-36 Pawnee Brave was first introduced on October 9, 1972. A larger and more powerful plane than its predecessor, the PA-25 Pawnee D, the PA-36 has increased capacity for either liquid or dry chemicals. Piper currently produces this aircraft in a 285 hp version using a Teledyne Continental Tiara engine and a 300 hp version which uses a Lycoming engine. At 80 ft, the average swath is 30 ft wider than that of the PA-25. The PA-36 Pawnee Brave has a wingspan of 38.8 ft, is 7.5 ft in height, 27.3 ft in length and has a gross weight of 4,400 lbs. Spray equipment for the PA-36 has the capability of spraying up to 17 gals per acre at 135 mph with a 50 ft swath width. The PA-36 has a 275 gal hopper capacity.

PIPER PA-25 PAWNEE D



PIPER PA-36 PAWNEE BRAVE



PILATUS PC-6 TURBO-PORTER

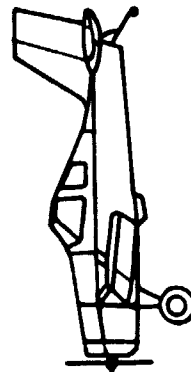
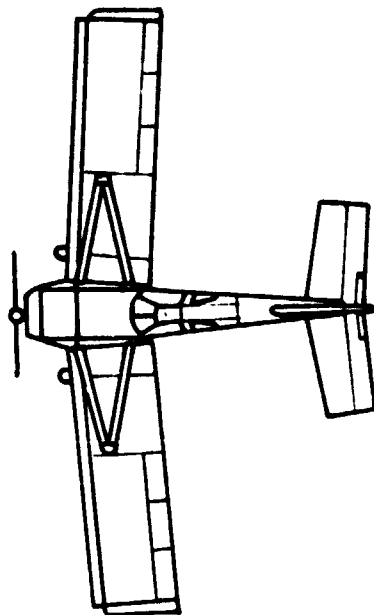
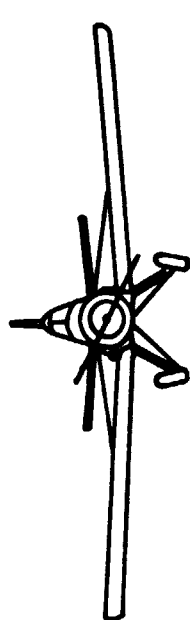
Built in Switzerland by Pilatus and under license in the U.S. by Fairchild, the PC-6 Turbo-Porter is the turboprop engine version of the basic PC-6 single-engine utility aircraft. The current production model is the PC-6/B2-H2 and can be acquired in an agricultural version. The Turbo-Porter has a wingspan of 49.7 ft, is 35.8 ft in length, and has a tail down height of 10.5 ft. Powered by a 550 shp Pratt and Whitney turboprop engine it has a maximum takeoff weight of 6,100 lbs. The agricultural version has a hopper capacity of 351.4 gal and effective swath widths ranging from 43 to 1,310 ft depending upon application configuration purchased and chemical being applied.

PZL-106 KRUK (RAVEN)

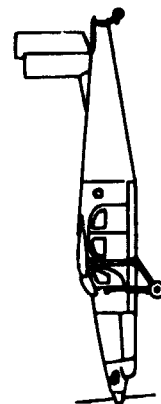
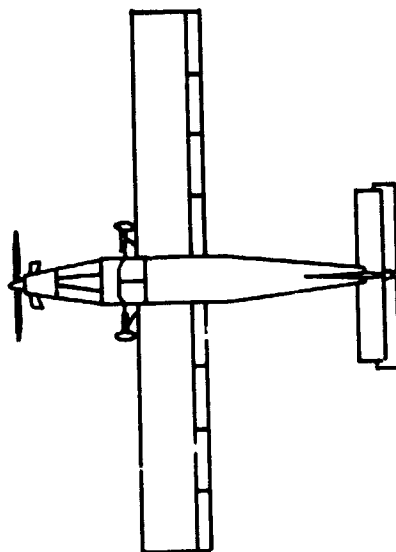
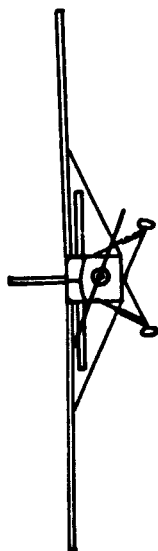
Initially a redesigning effort of the PZL-101, the PZL-106 was designed in 1972 by a team led by Andrzej Frydrychewicz. The plane's prototype first flew on April 17, 1973 powered by a 400 hp Lycoming engine. The current model, of which about 600 will be produced, is powered by a 600 hp PZL-35 engine.

The production version has a 48.5 ft span, is 29.2 ft in length, 11.8 ft in height, with a normal operating weight of about 6,173 lbs. The PZL-106 has a hopper capacity of 370 gals and gives effective swath widths of 33-115 ft.

PZL-105 Kruk (RAVEN)



PILATUS PC-6 TURBO-PORTER



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HAL HA-31 MK II BASANT

Intended primarily for aerial application of pesticides and fertilizers, design for the Basant began in 1968. Certification was secured and 8 pre-production versions were delivered to the Indian Ministry of Food and Agriculture in 1974. Kanpur Division of HAL is contracted to produce 100 Basant aircraft, the first two of which were completed in February 1976.

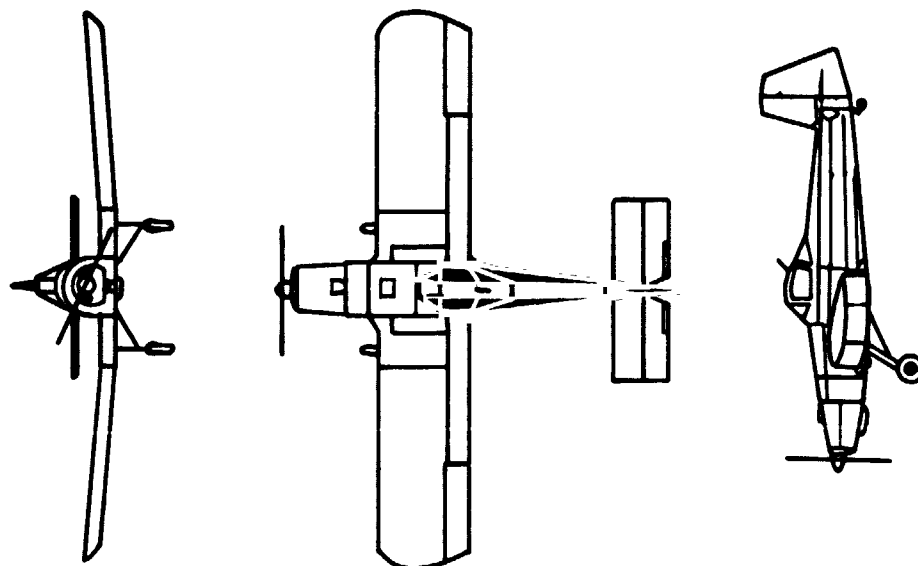
The Basant has a wingspan of 39.4 ft, is 29.5 ft in length, 8.4 ft high and has a basic operating weight of 4,300 lbs. The Basant has a hopper capacity of 247 gals and is powered by a 400 hp Lycoming engine.

ICA-BRASOV IAR-822, 826, 827

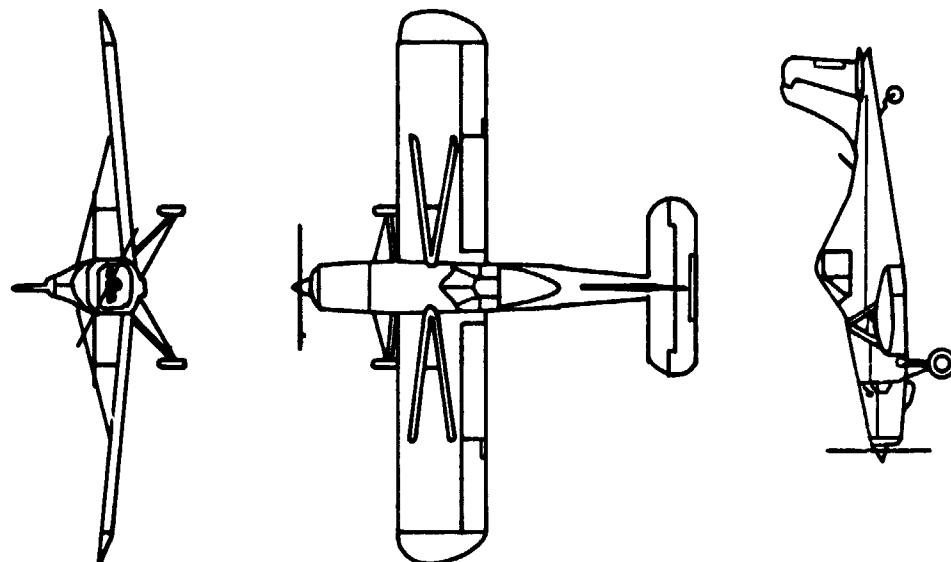
Design of the basic IAR-822 agricultural monoplane began in Romania in October 1968. Built by IRMA the prototype flew for the first time in March 1970. The aircraft is being built in several versions by ICA-Brasov for Romanian use as well as export. The IAR-826 is an all metal version of the basic IAR-822 mixed construction aircraft, the IAR-822B is a special version built for simulation of agricultural runs, and the IAR-827 is a more powerful developmental version of the IAR-826.

The IAR-822 has a wingspan of 42 ft, is 30.8 ft in length, 8.5 ft in height and has a maximum takeoff weight of 4,138 lbs. It has a hopper capacity of 28.25 cu ft and can accommodate 158 gals of liquid chemical. The IAR-822 is powered by a 290 hp Lycoming engine. Specifications for the IAR-822B and IAR-826 are similar except for the reduced hopper capacity of the IAR-822. The IAR-827 has a wingspan of 45.9 ft is 31.6 ft in length, 8.7 ft in height and has a maximum takeoff weight of 5,130 lbs. It uses a 400 hp Lycoming engine.

ICA-BRASOV IAR-822



HAL HA-31 MK II BASANT



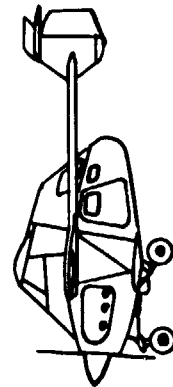
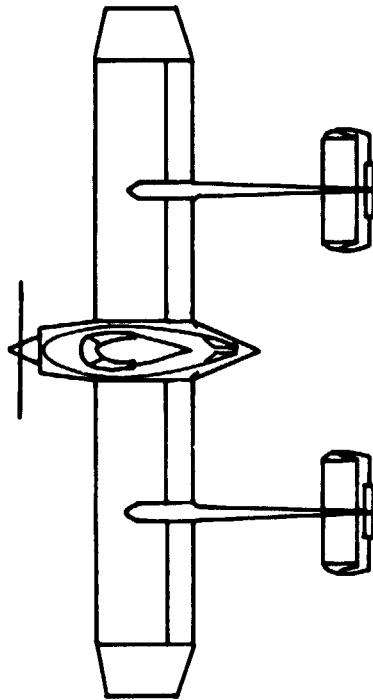
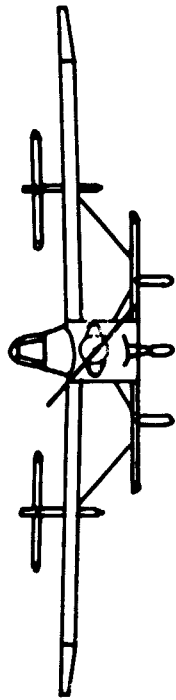
TRANSAVIA PL-12 AIRTRUK

The Airtruk, which was designed initially for spreading fertilizer and seed, received certification in February 1966. Its unique design offers rapid loading and great uniformity of application. Within the period 1966-1974, a total of 72 PL-12 aircraft were built and are in use in Australia, Denmark, India, New Zealand, Thailand and East and South Africa. The PL-12 has a 39.3 ft wingspan, is 21 ft in length, 9 ft in height and has a maximum takeoff weight of 4,090 lbs. Maximum swath width for the PL-12 is about 105 ft. The PL-12 is powered by a 300 hp Rolls Royce engine.

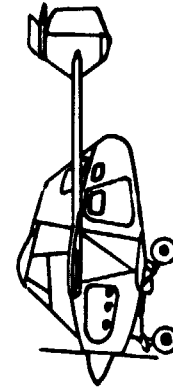
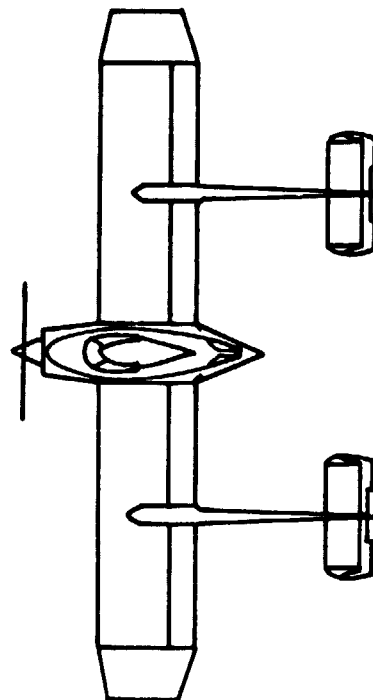
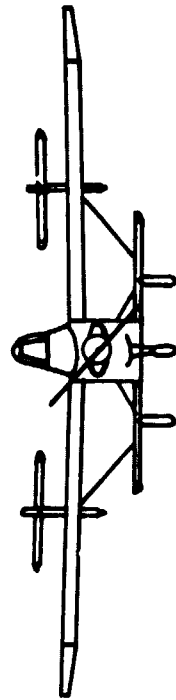
TRANSAVIA T-320 AIRTRUK

The T-320 Airtruk received certification in January 1976 and is a direct consequence of developmental studies of the PL-12. The T-320, like the PL-12, is designed for spraying efficiency and ease of rapid loading. The T-320 has a wingspan of 39.3 ft, is 20.8 ft in length, 9.2 ft in height and has a maximum takeoff weight of 4,090 lbs. The hopper capacity of the T-320 is 216 gals. The most striking differences between the PL-12 and the T-320 are the T-320's larger 325 hp Continental engine and larger diameter propeller.

TRANSANIA PL-12 AIRTRUK



TRANSANIA T-320 AIRTRUK



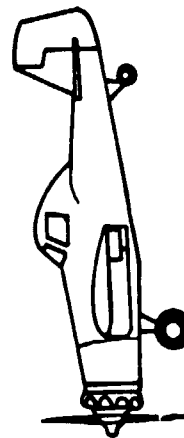
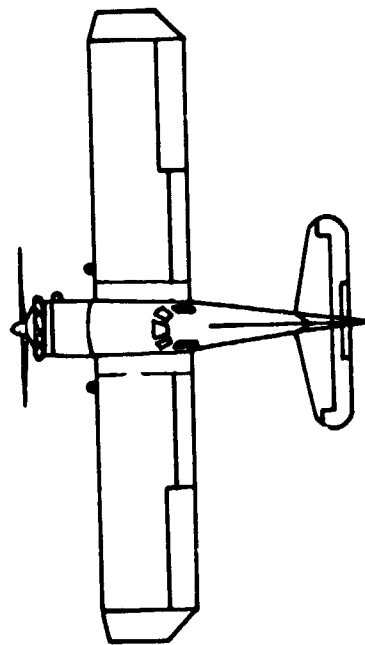
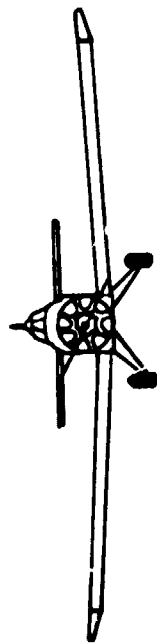
THRUSH COMMANDER

Until the introduction of Emair's MA-1B, the Thrush Commander was the largest aircraft specifically designed for agriculture built in the U.S. Built by Rockwell International, the plane is produced in two versions, the 600 and the 800. The Thrush Commander 600 is the basic version with a wingspan of 44.3 ft, a length of 29.4 ft, a height of 9.2 ft and a gross weight of 6,900 lbs. It has a hopper capacity of 400 gals and an average swath of 80 ft. The Thrush Commander 600 is powered by a 600 hp Pratt and Whitney engine. The Thrush Commander 800 is similar to the 600 version except for its larger 800 hp Wright Cyclone engine and its greater gross weight of 7,800 lbs. The 800 version is also slightly shorter with a length of 29.2 ft.

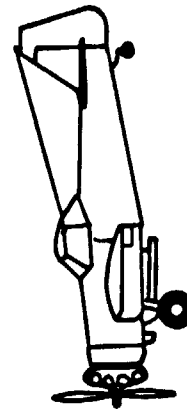
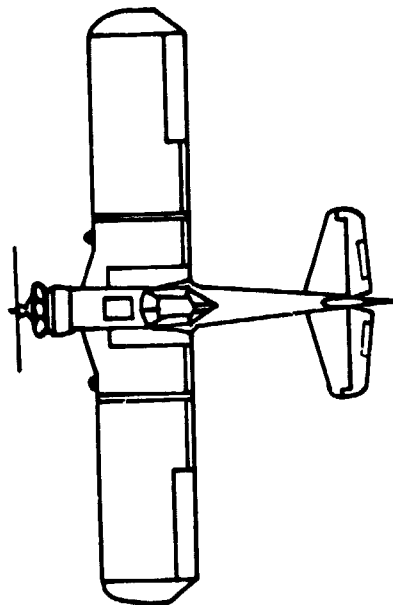
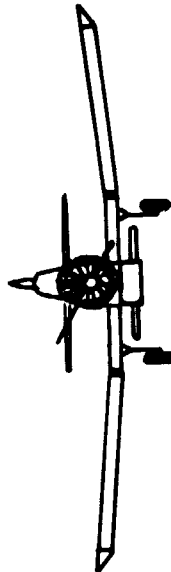
WEATHERLY MODEL 201C

Since its beginning, the Weatherly Aviation Company has delivered approximately 100 agricultural aircraft in the U.S. Weatherly's current model, the 201C, has a wingspan of 39 ft, is 8.1 ft in height, 27.2 ft in length, has a gross weight of 4,800 lbs and a hopper capacity of 270 gals. The engine is a 450 hp Pratt and Whitney.

THRUSH COMMANDER



WEATHERLY MODEL 201C



UTVA-65 PRIVREDNIK AND SUPER PRIVREDNIK-350

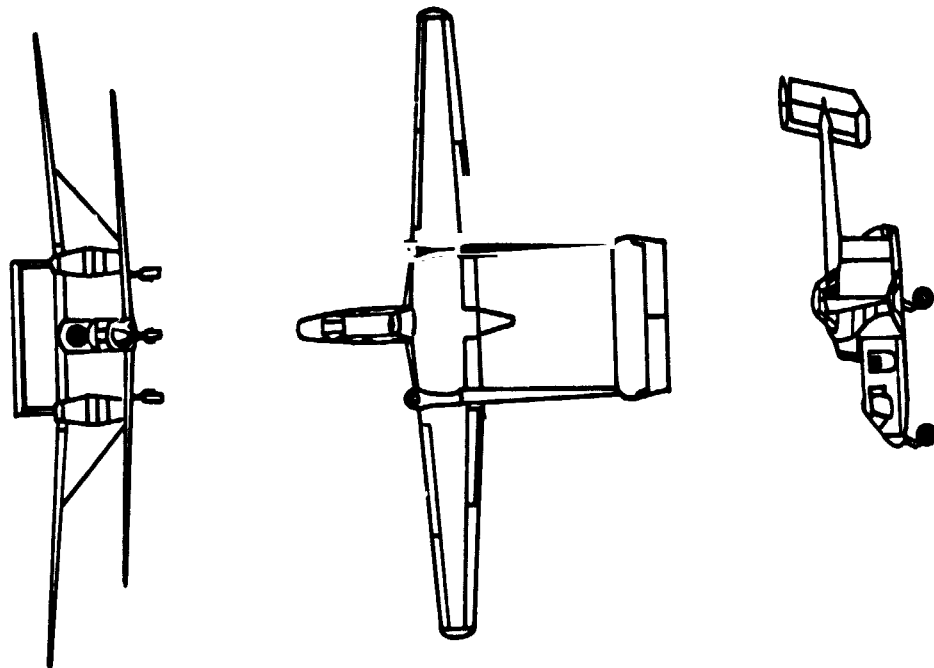
Designed in 1964 by Dipl Ing Branislav Nikolic and Dipl Ing Mirko Dabinovic, the UTV-65 used a number of components from the UTV-60. The prototype Privrednik first flew in 1965 and utilized a 270 hp Lycoming engine. Manufacture of the production version 295 hp Privrednik ended in 1973 with the production of the UTV-65 Super Privrednik-350. Although the Super Privrednik has slightly larger dimensions, the principle difference between the planes is the 350 hp Lycoming which powers the Super Privrednik 350.

The Privrednik has a wingspan of 40.1 ft is 27.8 ft in length, 8.5 ft in height and has a maximum takeoff weight of 4,123 lbs. The Super Privrednik has a wingspan of 42.3 ft, is 28 ft in length, 11.1 ft in height and has a maximum takeoff weight of 4,431 lbs.

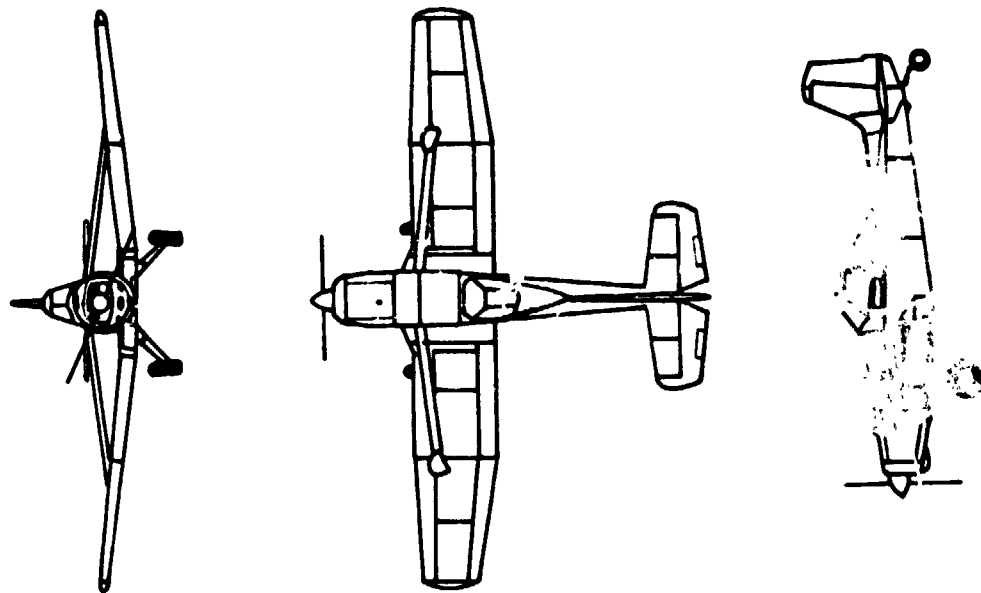
WSK-MIELEC M-15

Under contract between the Polish and Soviet governments, production was started in 1975 on the M-15, a three seat agricultural biplane. Upon signing an agreement with the Polish government in 1971, the Soviets expressed a need for about 3,000 of the aircraft. Due to the availability of fuels, the M-15 is powered by a 3,306 lb thrust turbofan jet engine. The M-15 has an upper wingspan of 72.2 ft, a lower wingspan of 49.2 ft, is 41.1 ft in length, 17 ft in height and has a maximum takeoff weight of 11,684 lbs. The M-15 has two hoppers with a combined capacity of 766 gals.

WSK-MIELEC M-15



UTVA-65 PRIVREDNIK



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WSK-MIELEC (ANTONOV) AN-2R

Designed by Oleg Konstantinovich Antonov, the AN-2 made its first flight in 1947. It is designed specifically for agricultural use and more than 5,000 were built between 1950 and 1960. Licence rights were granted to China and first locally-produced in 1957. Poland took over the manufacture of the AN-2 for Russia in 1960 and by 1976 more than 6,900 AN-2s were built, including 3,670 of the AN-2R agricultural version.

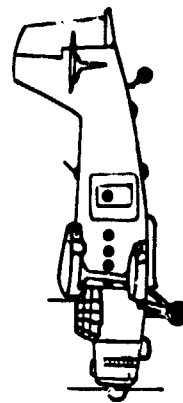
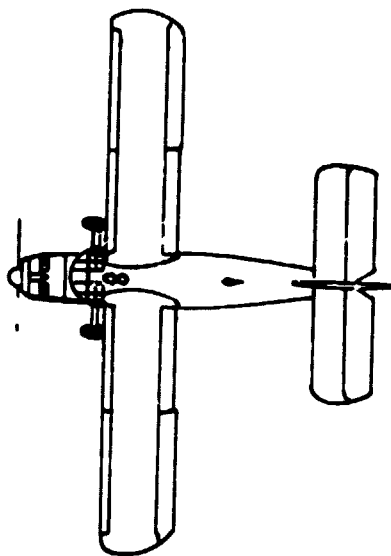
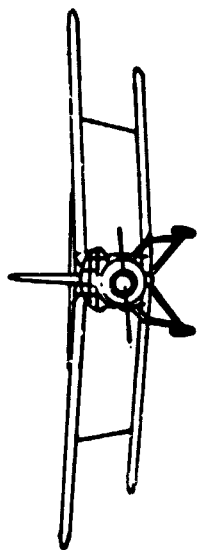
The AN-2 is powered by a 1,000 hp Shvetsov ASH-621R nine-cylinder radial aircooled engine, has an upper wing span of 59.7 ft and a lower wing span of 46.7 ft. It is 20 ft high, 41.7 ft long, has a maximum take-off weight of 12,125 lbs and a hopper capacity of 370 gals.

LET Z-37Z CMELAK (BUMBLE BEE)

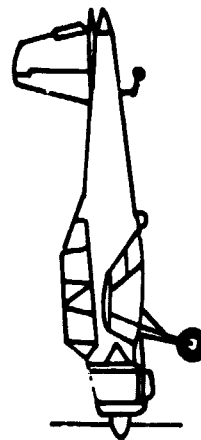
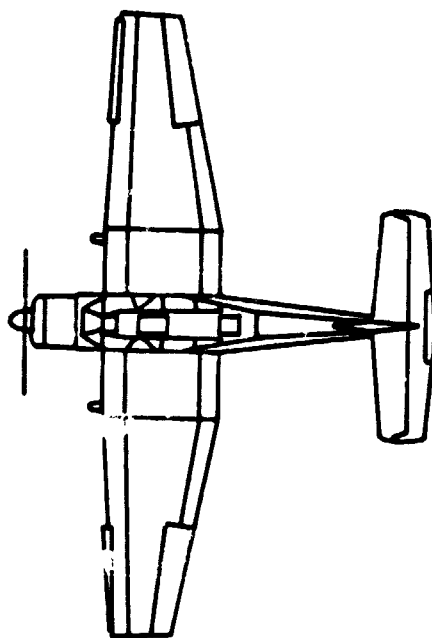
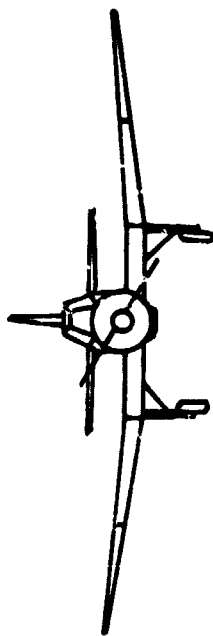
The prototype XZ-37 first flew on March 29, 1963, and by the beginning of 1975 a total of 600 Cmelak aircraft had been delivered in Bulgaria, Czechoslovakia, Finland, Germany, Hungary, India, Iraq, Poland, the United Kingdom and Yugoslavia.

The Cmelak has a wingspan of 40.1 ft, is 28.4 ft in length, 9.5 ft in height and has a maximum takeoff weight of 4,080 lbs. It has a hopper capacity of 172 gals and effective swath ranging from 50-130 ft depending upon substance applied. The Cmelak is powered by a 315 hp nine-cylinder engine.

uSK-MIELEC (ANTONOV) AN-2R



LET Z-37Z CMELAK (BUMBLE BEE)



ALOUETTE II-LAMA

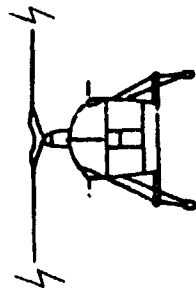
Produced by Aerospatiale of La Courneuve, France, approximately 40 Alouette II-Lama helicopters are used for agricultural applications in France, Italy, Great Britain, Japan, Venezuela, New Zealand and the U.S. The Lama has a main rotor diameter of 36.1 ft, is 42.4 ft in length, 10.1 ft in height and has a maximum takeoff weight of 4,300 lbs. The Lama is powered by an ARTOUSTE III B 858 hp turbine engine and can carry a maximum chemical load of 1,320 lbs.

BELL 47AG-5 AND 47G-5A

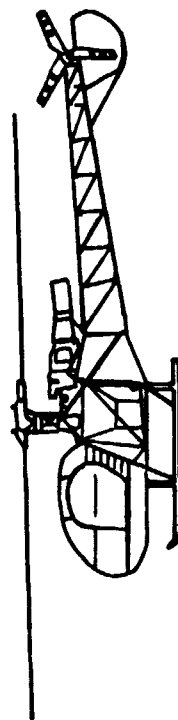
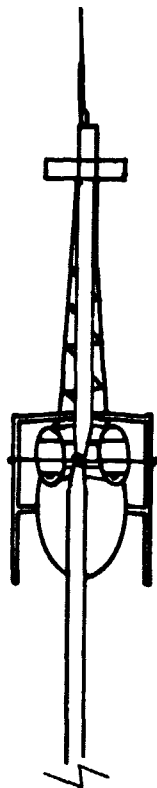
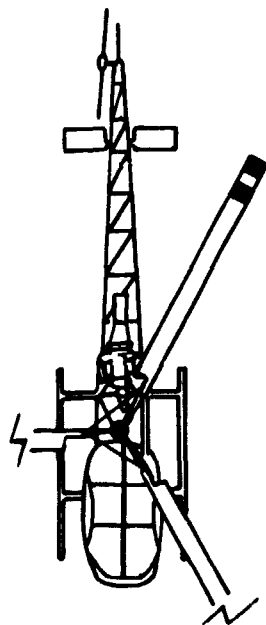
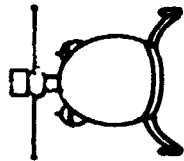
Deliveries of the 47AG-5, an agricultural version of the 47G-5 helicopter, began in January 1966. The Ag-5 utilizes Bell's AgMaster chemical application system manufactured by Transland Aircraft and includes two 60 gal hoppers. It can produce effective swath widths of 20-200 ft. The 47G-5A helicopter is a slightly larger two passenger version of the original Ag-5 helicopter. Both models are powered by a 265 hp Lycoming engine and have a normal gross weight of 2,850 lbs. Each aircraft has a main rotor diameter of 37.1 ft, an overall length of 43.2 ft and a height of 9.3 ft.

C-4

ALOUETTE IT-LAMA



BELL 47 G-5A



CONTINENTAL COPTERS EL TOMCAT

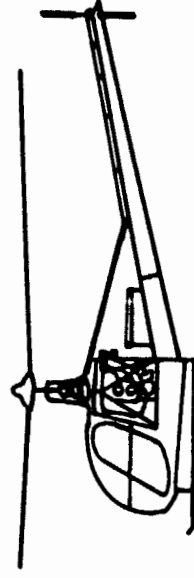
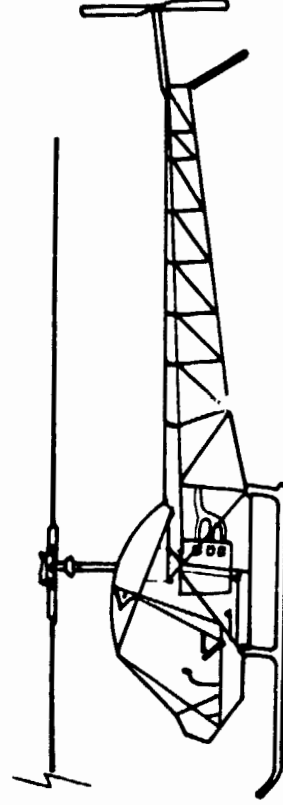
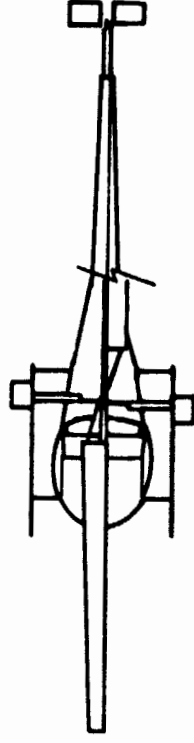
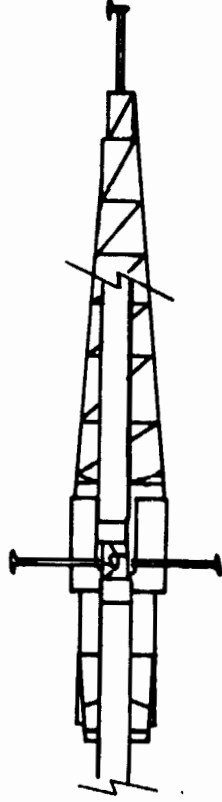
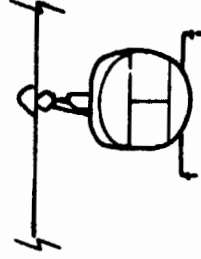
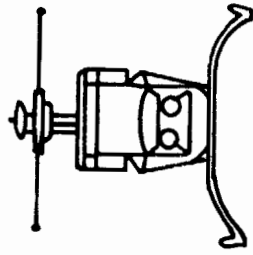
In 1959 Continental Copters of Fort Worth began development and production of single seat agricultural conversions of various Bell 47 helicopters. In April 1959 the prototype made its first flight under the designation El Tomcat MK II. Currently in production are the El Tomcat MK V and El Tomcat MK VI and are derived from the Bell Model 47G-2 and the Bell Model 47G-3B respectively. The current El Tomcat MK VI-B has a main rotor diameter of 37.1 ft, is 43.2 ft in length and 9.3 ft in height. Powered by a turbocharged Lycoming TVO-435 engine, the MK VI-B develops 270 horsepower and has a maximum takeoff weight of 2,850 lbs.

HILLER UH-12

Built primarily as an army training helicopter under the designation OH-23 Raven, many of the UH-12 series have been transformed into agricultural aircraft. Originally built by Fairchild and now produced by Hiller, nearly 2,000 of these helicopters have been built in various versions. The UH-12 has a main rotor diameter of 35.4 ft, is 40.8 ft in length, 9.3 ft in height and has a maximum takeoff weight of 3,100 lbs. The UH-12 is powered by a 305 hp Lycoming engine.

CONTINENTAL COPTER EL TOMCAT

HILLER UH-12



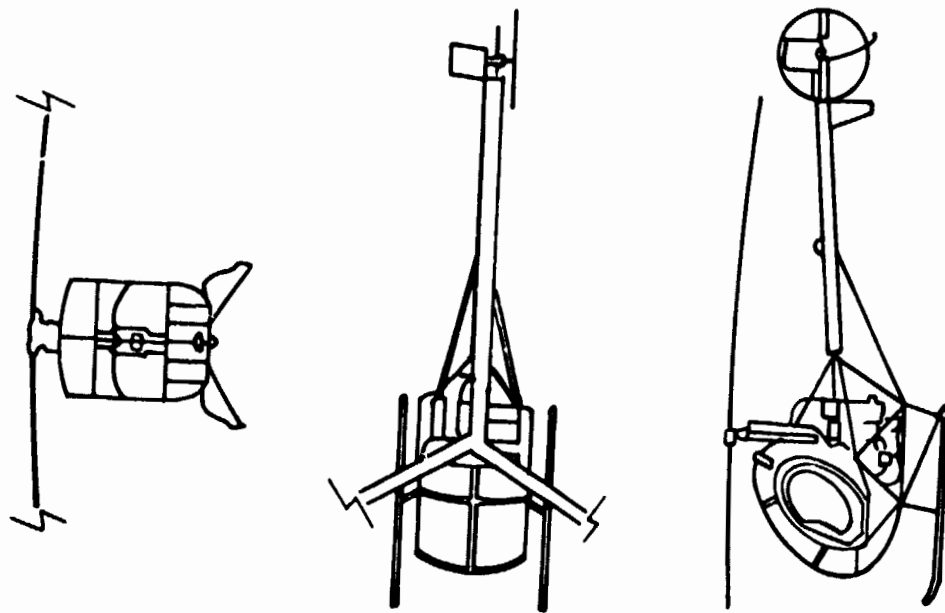
HUGHES MODEL 300C

As is the case with most rotary wing aircraft used in agriculture, the Model 269 was not developed specifically for agricultural use, rather it was produced as a utility and training helicopter and transformed into an agricultural version by a kit produced by Hughes. The aircraft, also produced in a three-seat version as Model 300, has a main rotor diameter of 25.3 ft, a length of 22.3 ft, a height of 7.9 ft and a maximum takeoff weight of 1,670 lbs. The Model 269 is powered by a 180 hp Lycoming engine. The Hughes Model 300C is also produced in Italy under the designation NH-300C by BredaNardi.

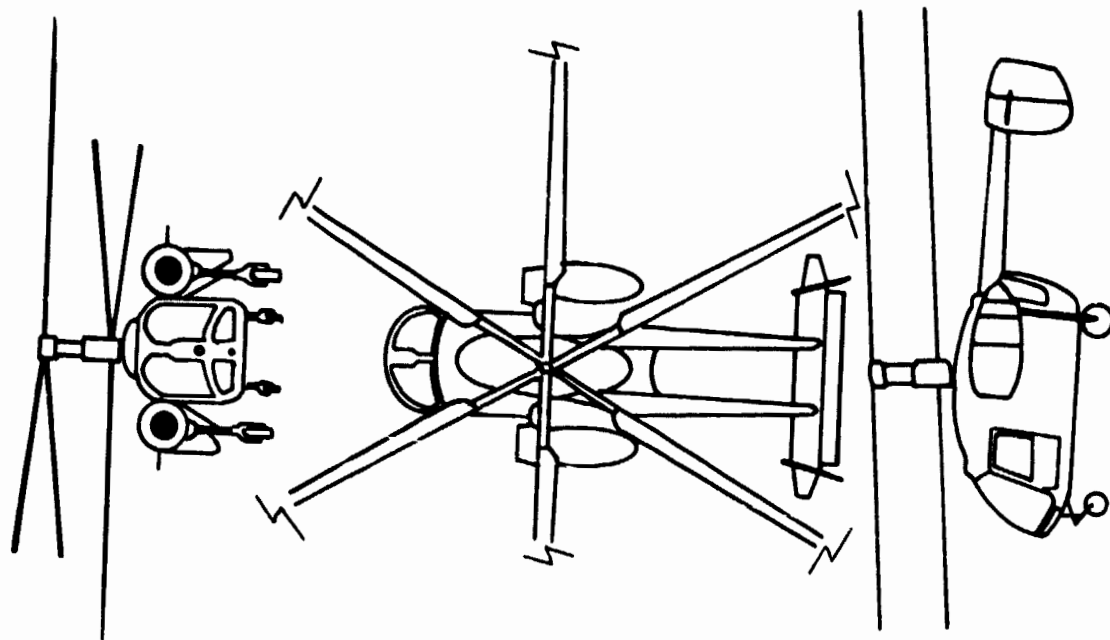
KAMOV KA-26

After announcing details of the aircraft in January 1964, the Soviet Union began intense use of the Ka-26 as an agricultural aircraft in 1970. The aircraft is powered by twin 325 hp engines and in its agricultural version has a normal operating weight of 6,570 lbs. The diameter of each rotor is 42.7 ft. The Ka-26 has an overall length of 42.7 ft, a height of 13.3 ft and a width over spray bars of 36.8 ft. The Ka-26 is capable of carrying 1,985 lbs of chemical for agricultural application.

HUGHES MODEL 300C



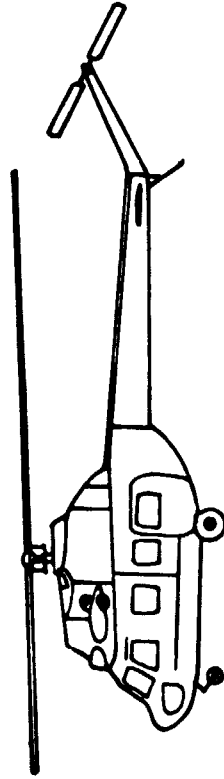
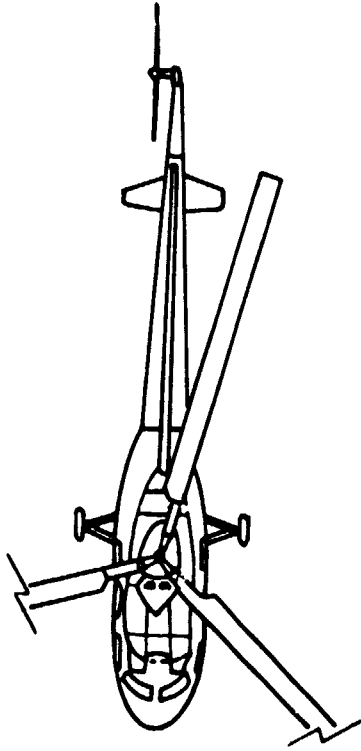
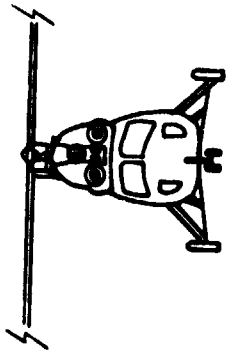
KAMOV KA 26



WSK-SWIDNIK (MIL) Mi-2

Designed in the USSR and constructed in Poland, many hundreds of Mi-2 civil and military aircraft have been built since its announcement in 1961. The Mi-2 is powered by two 400 or 450 shp Polish built turboshaft engines and has a maximum takeoff weight of 8,157 lbs. The aircraft has a main rotor diameter of 47.6 ft, is 57.2 ft in length and 12.3 ft in height. In its agricultural version, the Mi-2 has a hopper on each side of the aircraft with a total capacity of 264 gals. Swath width covered by the spraying version is 130-150 ft.

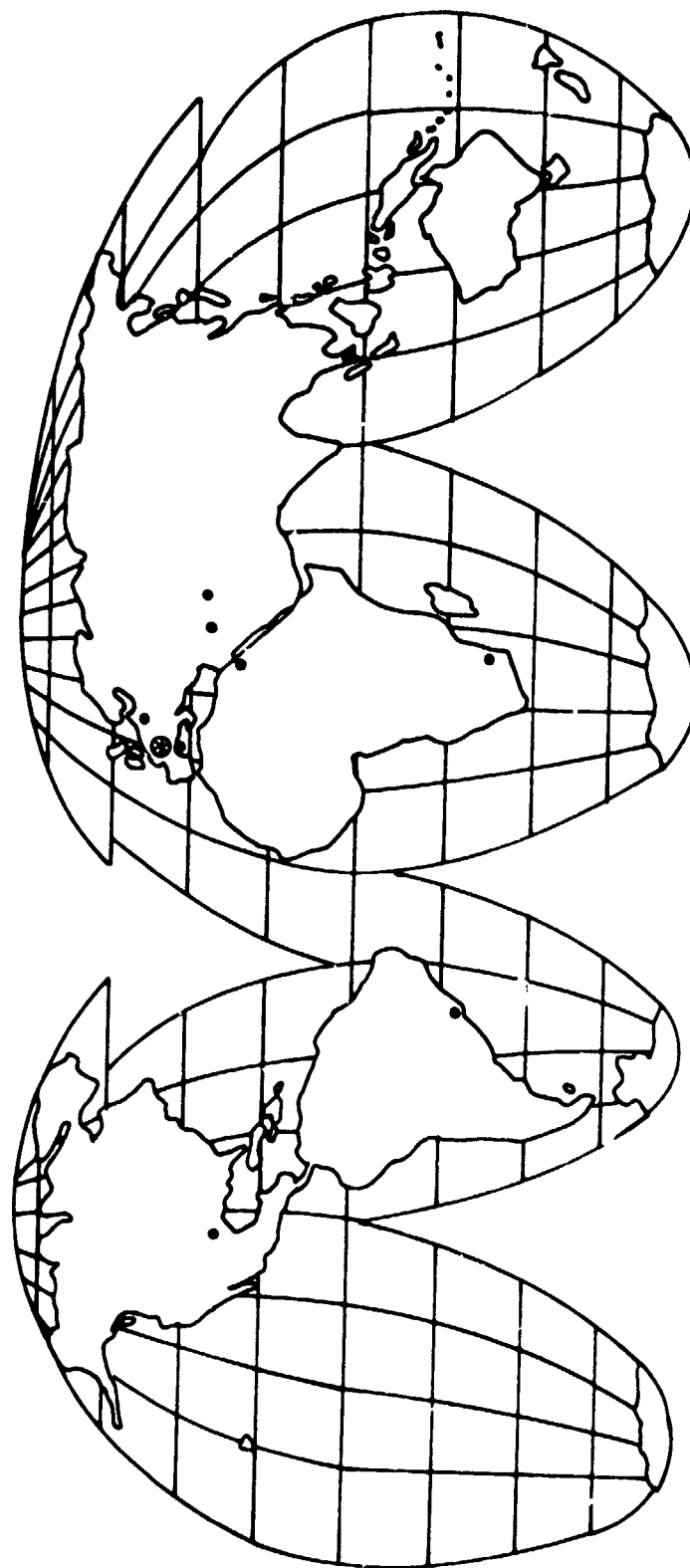
WSK-SWIDNK M1-2



AEROSPATIALE

Sponsored by the French government, the HELICOPTER DIVISION OF SOCIETE NATIONALE INDUSTRIELLE AEROSPATIALE has complete responsibility for the production of helicopters in France. Although the headquarters of Aerospatiale is located in La Courneuve near Paris, only fiberglass components for the Alouette II-Lama are produced there. The main engineering and construction facilities are located in Marignane. For marketing and service, Aerospatiale has set up a network of resident representatives worldwide. Aerospatiale's total overseas network is comprised of 21 service centres, military facilities, licensed agents and subsidiary companies. There are approximately 3,000 Aerospatiale aircraft currently being used in 87 countries.

AEROSPATIALE RESIDENT REPRESENTATIVES AND BASE FACILITIES



- RESIDENT REPRESENTATIVES
- ⊙ MAIN OFFICE

BELL HELICOPTER

BELL HELICOPTER has all of its primary manufacturing and engineering facilities located in the metropolitan Fort Worth, Texas area. Sales in the U.S. and Canada are handled by a factory sales force and all deliveries are made directly from the factory. Service is provided by a network of factory authorized customer service facilities. International sales and service are handled through a network of independent dealers.

BELL INTERNATIONAL MARKETING REPRESENTATIVES

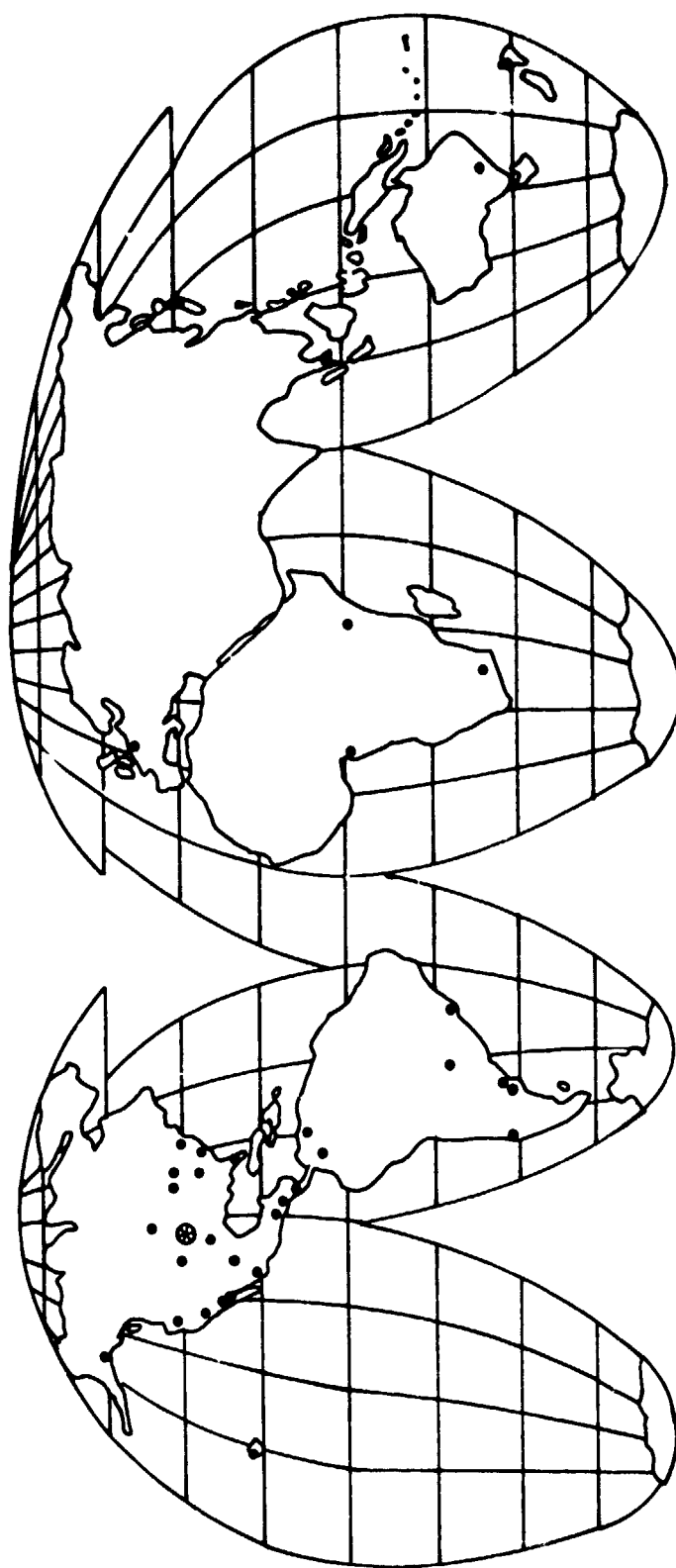


- MARKETING REPRESENTATIVES
- MAIN OFFICE

CESSNA AIRCRAFT COMPANY

Cessna is supported by the worlds largest aircraft dealer organization. More than 1,000 Cessna Dealers exist worldwide for sales and service. Although sales and service for agricultural aircraft are handled by all Cessna dealers, thirty-three facilities exist throughout the U.S. and Canada exclusively for sales and service of agricultural aircraft. All Cessna dealers stock Cessna service parts and equipment and are staffed by factory trained mechanics.

CESSNA ZONE OFFICES

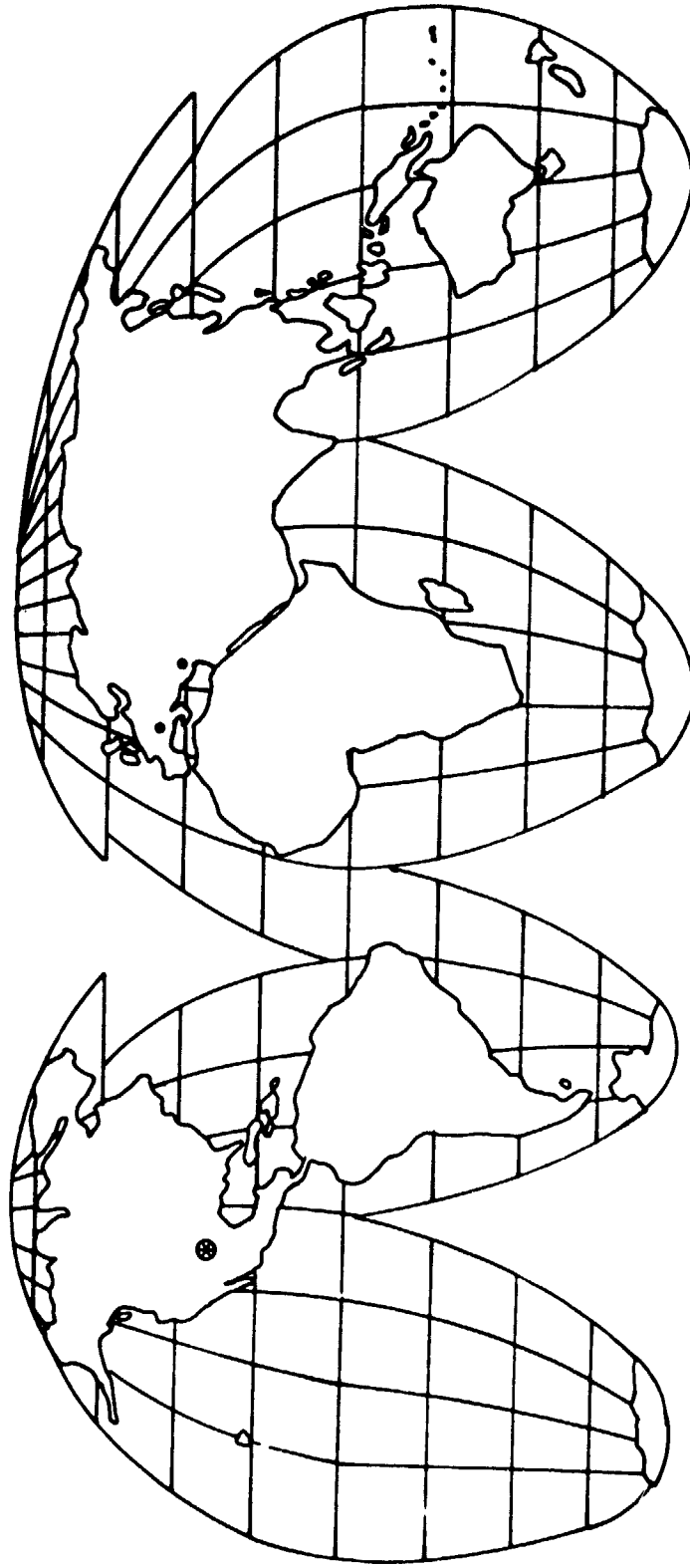


- ZONE OFFICES
- ⊗ MAIN OFFICE

CONTINENTAL COPTERS

Located in Fort Worth, Texas, Continental Copters specializes in converting various Bell aircraft to meet specific agricultural needs. Continental Copters has two foreign distributorships, one in Zurich, Switzerland and the other in Ankara, Turkey. Since the El Tomcat produced by Continental Copters is a variation of a Bell Helicopter, most repairs and service may be handled by Bell maintenance facilities. Damage to the airframe itself, however, requires repair at the Fort Worth facility.

CONTINENTAL COPTERS DISTRIBUTORSHIPS

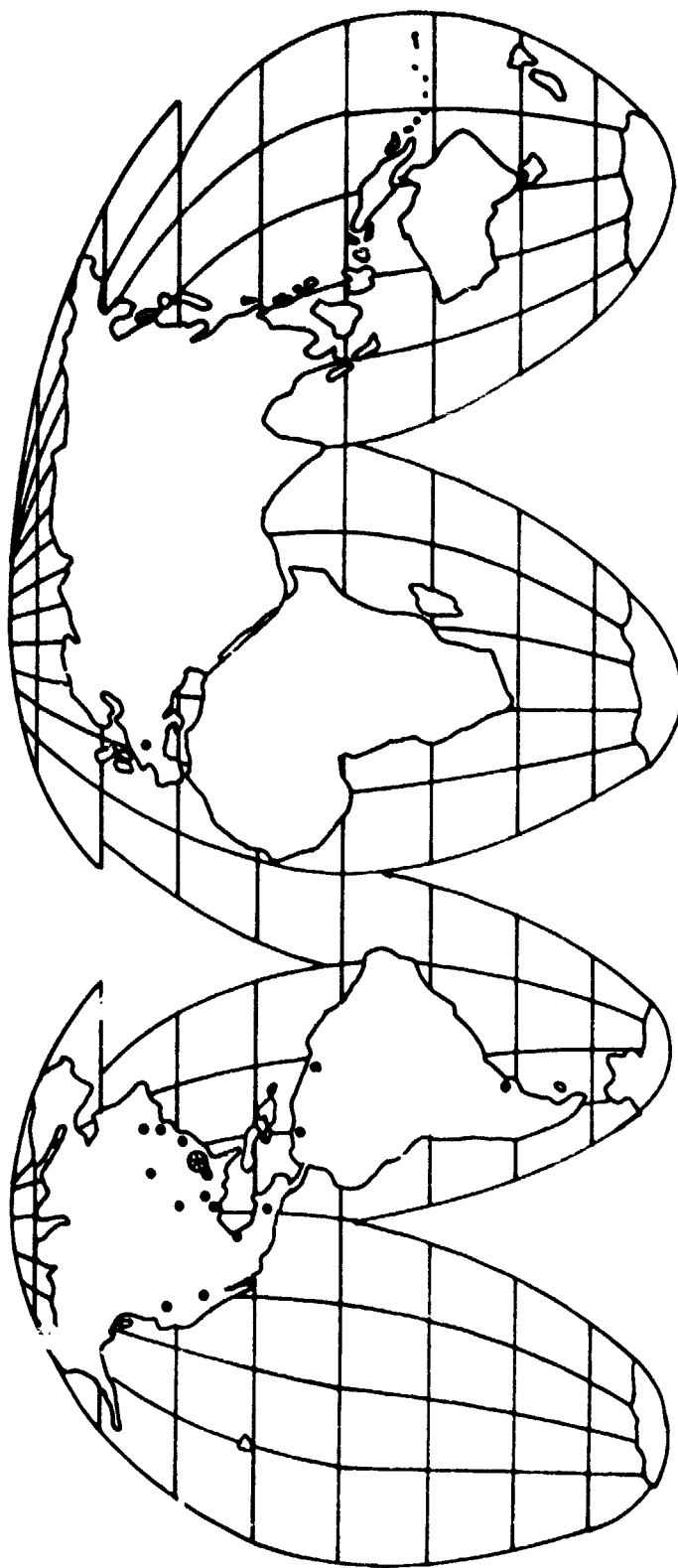


- DISTRIBUTORSHIPS
- ⊗ MAIN OFFICE

GRUMMAN AMERICAN AVIATION CORPORATION

The AgCat series of agricultural biplanes is manufactured by Schweizer Aircraft Corporation of Elmira, New York under subcontract to Grumman. Grumman, which is based in Savannah, Georgia, then distributes the aircraft through seventeen independent dealer organizations. Nine of these organizations are in the U.S. Grumman distributorships also provide maintenance service to AgCat owners.

GRUMMAN DISTRIBUTORSHIPS



- DISTRIBUTORSHIPS
- MAIN OFFICE

HUGHES HELICOPTERS

Based in Culver City, California, Hughes Helicopters is a division of Summa Corporation. Sales and service for Hughes aircraft are handled by a worldwide network of factory-authorized service centers and franchised Hughes distributorships. Each of these facilities carries a complete stock of spare parts and are staffed by factory-trained and government-certified mechanics.

The models 300C and 500C are also produced in Italy by BredaNardi under license from Hughes Helicopters. BredaNardi has six full service repair facilities, two in Italy, two in France and two in Switzerland.

HUGHES SALES & SERVICE CENTERS

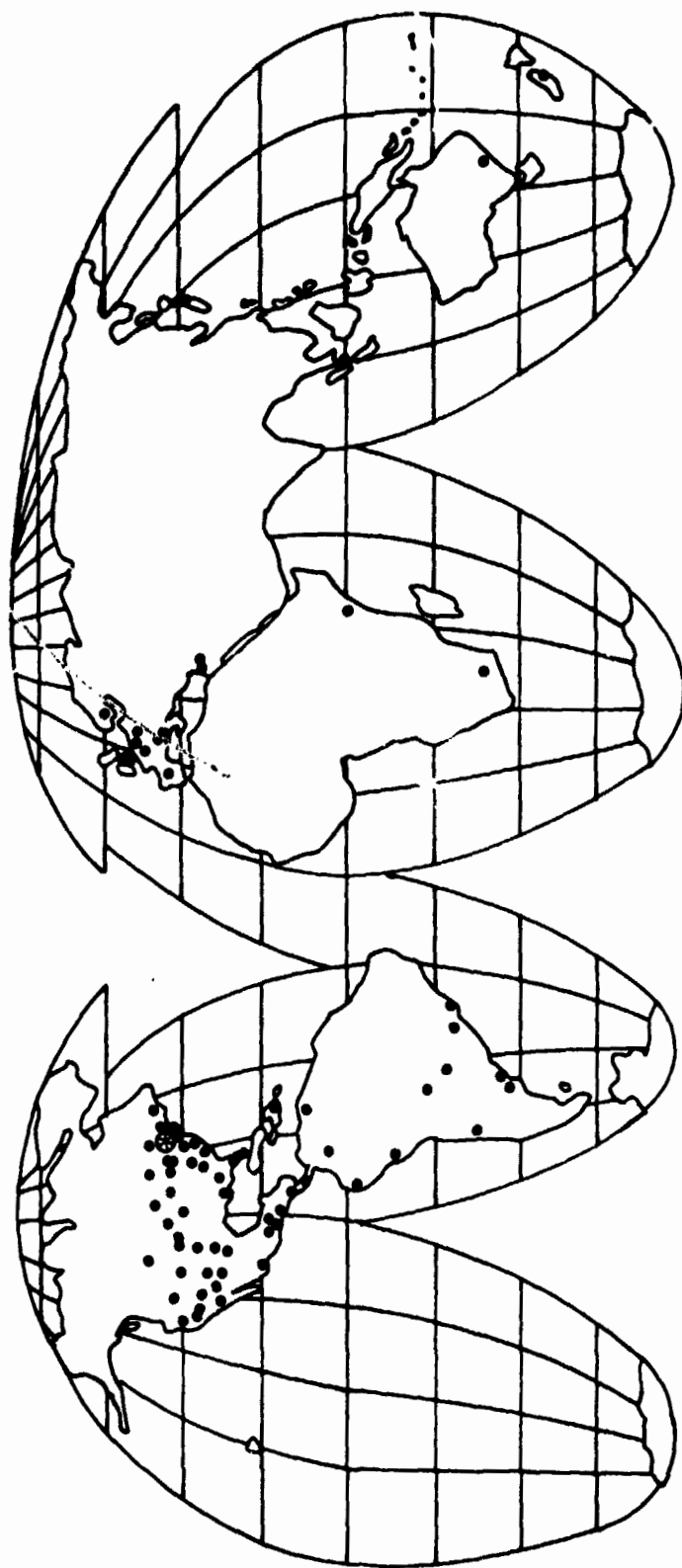


- SALES AND SERVICE CENTERS
- MAIN OFFICE

PIPER AIRCRAFT CORPORATION

Piper Aircraft Corporation, the leading producer of agricultural aircraft in the U.S. is based in Lock Haven, Pennsylvania maintaining a research and development center in Vero Beach, Florida and a European office in Geneva, Switzerland. Piper is supported by approximately seventy distribution organizations with about thirty in the U.S. and Canada. These distribution organizations are independent and also provide maintenance service for Piper aircraft. A full line of Piper parts and equipment are carried by each of these organizations.

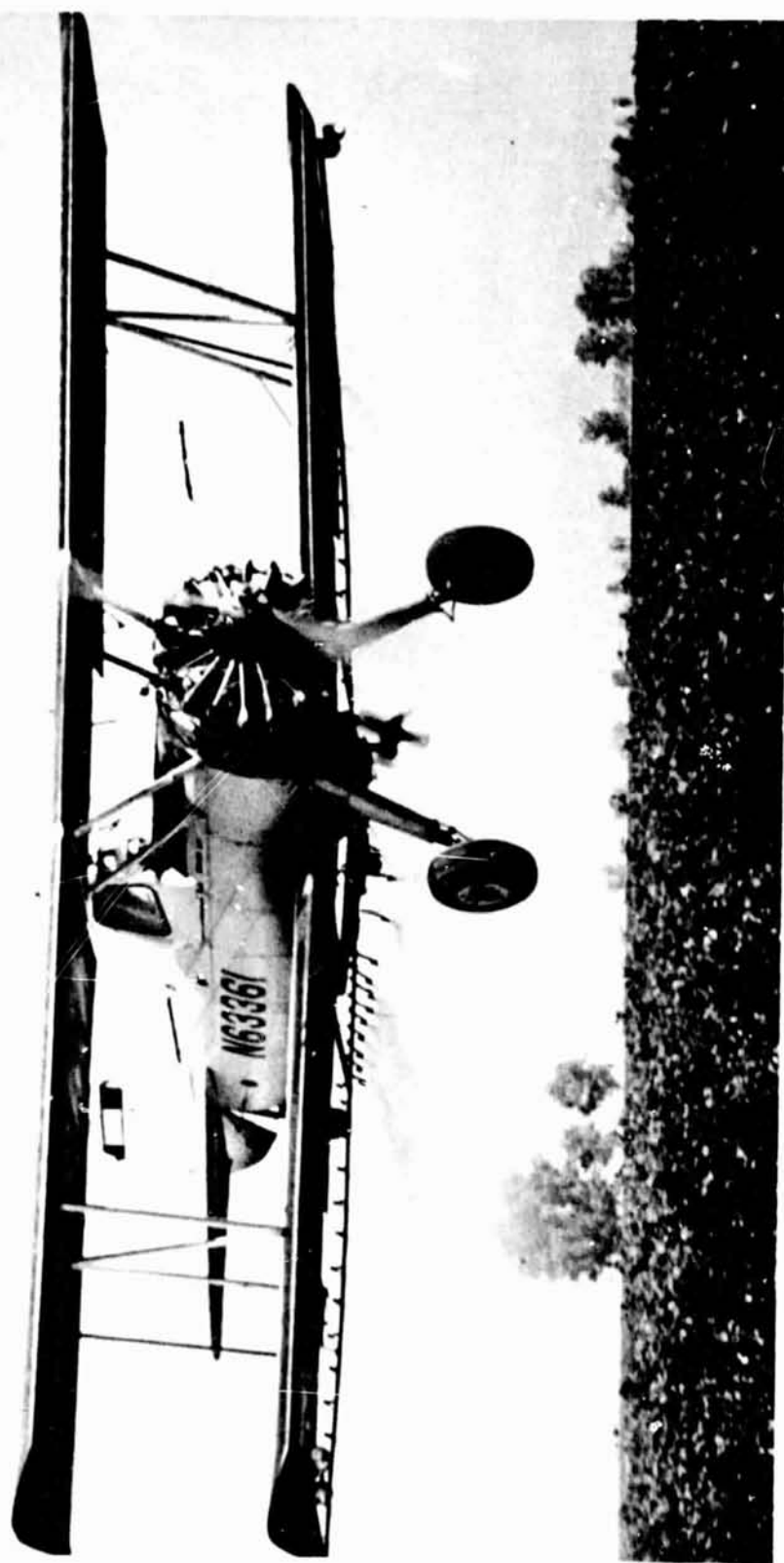
PIPER INTERNATIONAL DISTRIBUTORS



- DISTRIBUTORSHIPS
- MAIN OFFICE

PHOTO: A STEARMAN OPERATED BY THE STOKER COMPANY
OF EL CENTRO, CALIFORNIA, APPLIES A DEFOLIANT
TO COTTON.

PART V -- POTENTIAL BENEFITS
OF IMPROVED AG-AIR TECHNOLOGIES



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The fifth part of this report presents the benefit estimates for the potential technological improvements listed here. The benefits are given parametrically in terms of the potential improvements, for example, reducing the turn time by 5 percent, 10 percent, 15 percent, etc. Annual benefits are shown and an estimate of the present value of the benefit over an infinite horizon at a 10 percent discount rate can be obtained by multiplying the annual benefit by ten.

SUMMARY OF BENEFITS

- INCREASED FERRY SPEED
- REDUCED TURN TIME
- DROPLET SIZE CONTROL FOR INSECTICIDES
- IMPROVED UNIFORMITY OF APPLICATION
- REDUCED FLAGMEN COSTS
- INCREASED PAYLOAD

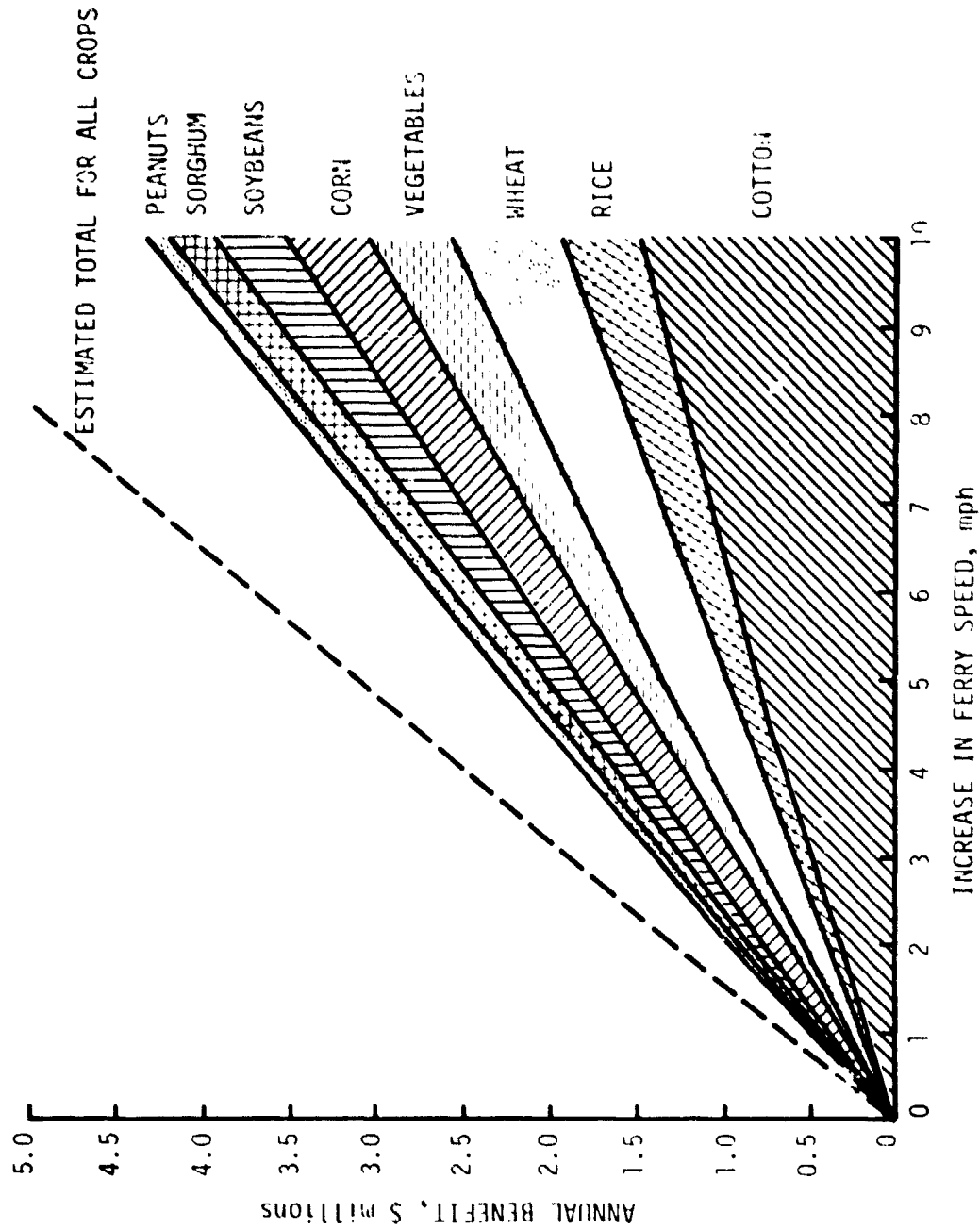
The benefit estimates must be used with caution. Except in the case for uniformity of application, only cost savings benefits have been estimated. Benefits due to the increased use of ag-air from improvement in technologies have not been estimated. Further, the estimates computed for each technology improvement are not strictly additive. For example, an improvement in uniformity of application would result in a smaller quantity of pesticide needed as would also a more uniform droplet size. In general, adding together benefits from independent technology improvements overestimates the total benefit. However, the benefits stated are conservative in that they account only for potential cost savings. Benefits associated with an increase in ag-air use due to the cost reductions obtained are not estimated.

CAUTION!

- ONLY COST SAVINGS BENEFITS HAVE BEEN ESTIMATED (EXCEPT FOR UNIFORMITY OF APPLICATION)--BENEFITS FROM INCREASED USE OF AG-AIR DUE TO IMPROVED TECHNOLOGIES HAVE NOT BEEN ESTIMATED
- THE BENEFITS COMPUTED FOR EACH TECHNOLOGY IMPROVEMENT ARE NOT STRICTLY ADDITIVE
- ADDING TOGETHER BENEFITS FROM INDEPENDENT TECHNOLOGY IMPROVEMENTS, IN GENERAL, OVERESTIMATES THE TOTAL BENEFIT

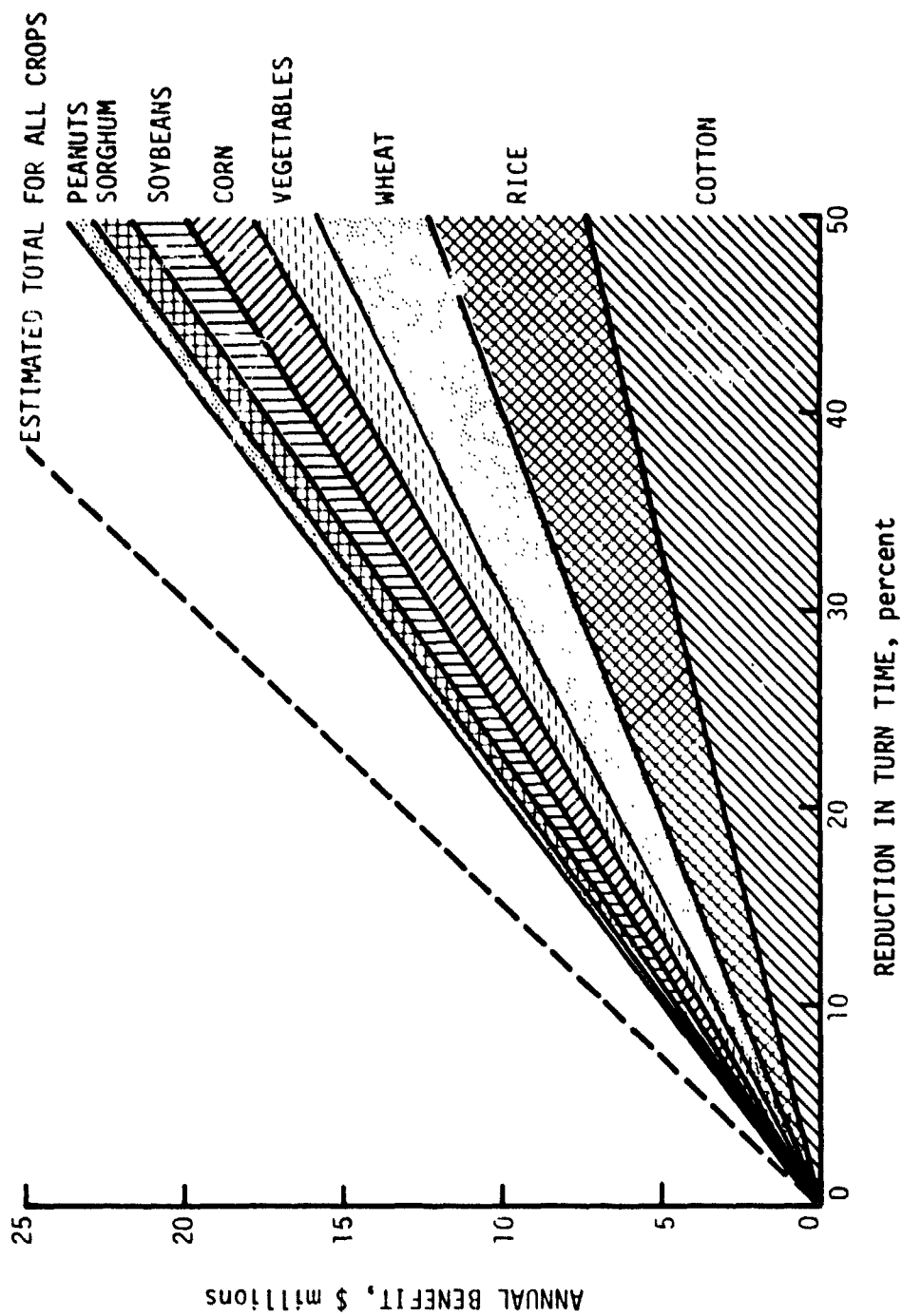
The curves at the right show the potential cost savings from increased ferry speed broken down by crop. Most operators that make applications to rice use satellite landing strips because of frequent loadings associated with fertilizer applications. Therefore, the ferry distances are quite short. However, with cotton and wheat, most applications are made from home base creating lengthy ferry distances. An increase of 10 miles per hour (some 8 percent) could result in an annual savings to the industry of nearly \$6 million.

COST SAVINGS FROM INCREASED FERRY SPEED



Most flyers estimate that the spray valve is open less than one-third of the time actually spent flying. At a speed of 100 miles per hour, a pilot covers a field length of half a mile in under 20 seconds. The average turn time today is over 30 seconds. Cotton and rice are usually grown in fields with shorter run lengths so that the fraction of time spent spraying is even less for these important crops. A 20 percent decrease in turn time would result in an annual savings to the industry of over \$13 million or a present value of over \$130 million at a 10 percent discount rate. The portion of the potential benefit attributable to each crop is presented cumulatively at the right.

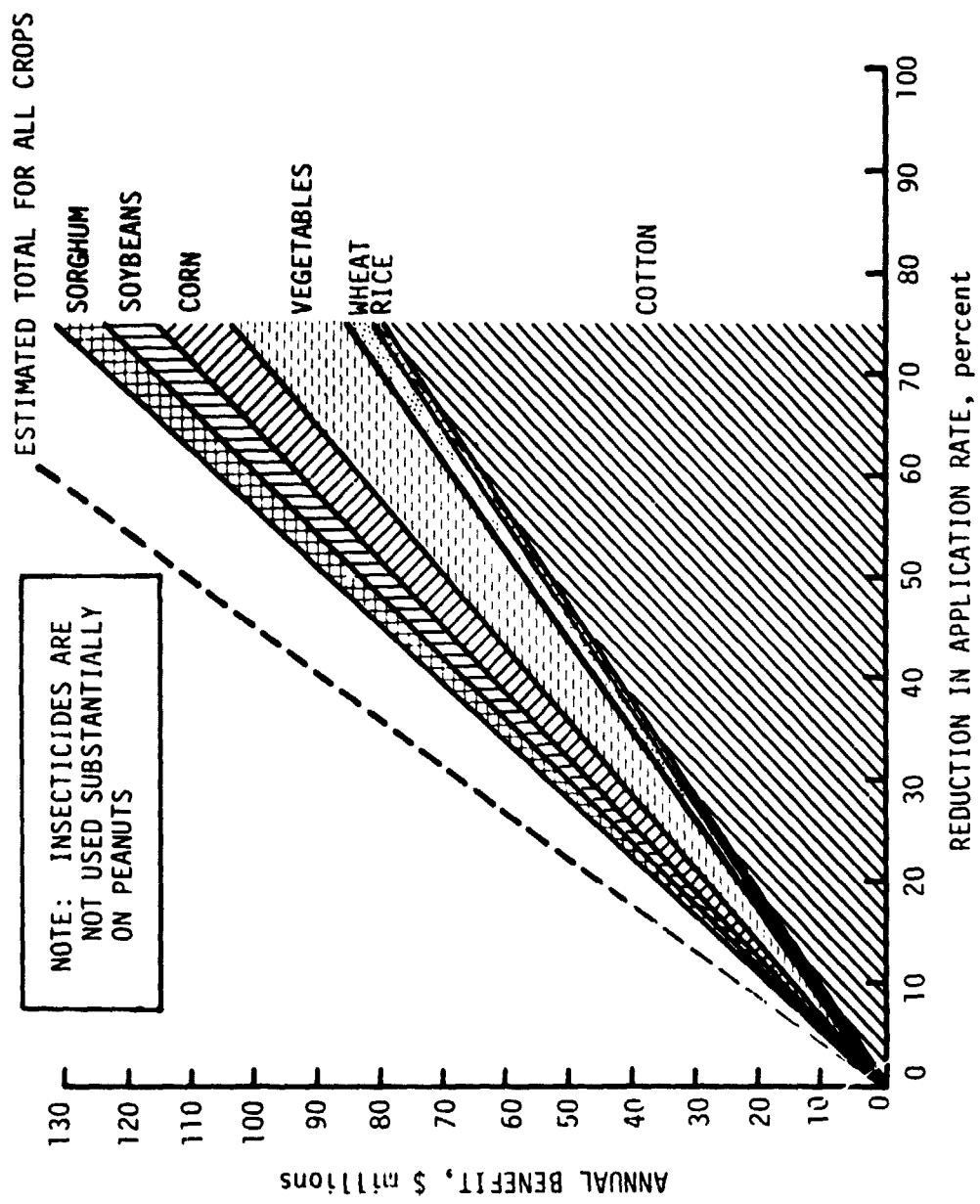
COST SAVINGS FROM REDUCED TURN TIME



Egon

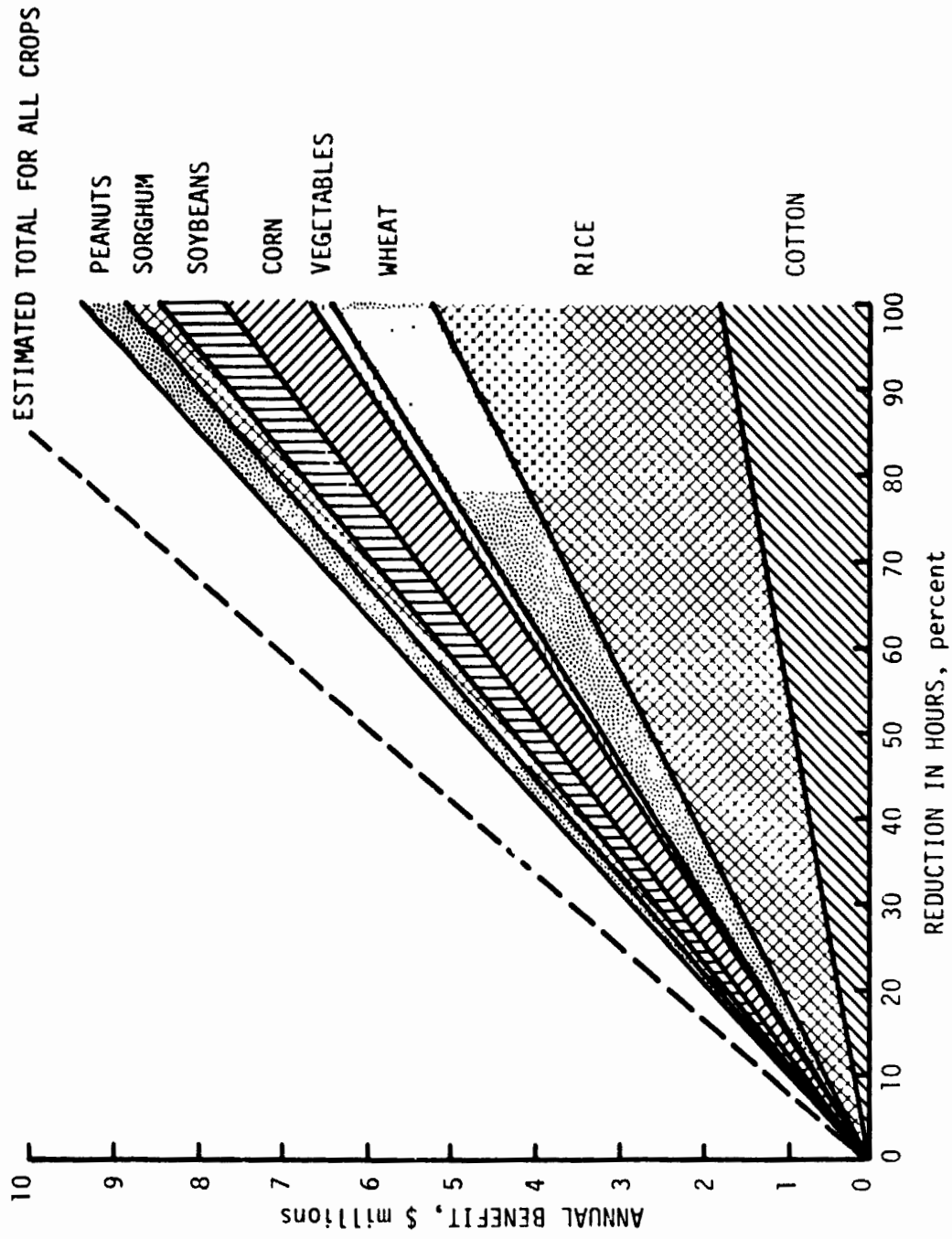
Potential cost savings for droplet size control are shown here cumulatively by crop for insecticide applications. The benefits shown derive from two effects, cost savings from a reduction in the amount of chemical applied and increased productivity in the aircraft resulting from a decrease in the application rate. If, as many investigators feel, a 25 to 75 percent reduction in the application rate can be achieved, the benefits are clearly very large. The majority of these benefits are associated with cotton which is not only the main ag-air crop but also derives this status from the extensive use of insecticides on cotton. The present value of benefits shown would be counted in hundreds of millions of dollars. In addition, however, further unquantified benefits would be achieved due to the reduced environmental impact resulting from reduced use of insecticide and from increased productivity in the treated crops. While not investigated in this study, it may also be possible to achieve benefits from droplet size control in the application of herbicides. The problem with herbicides is mainly one of damage to other crops caused by drifting of the chemical. In this case, eliminating small droplets that might drift is the desirable goal.

COST SAVINGS FROM DROPLET SIZE CONTROL FOR INSECTICIDES



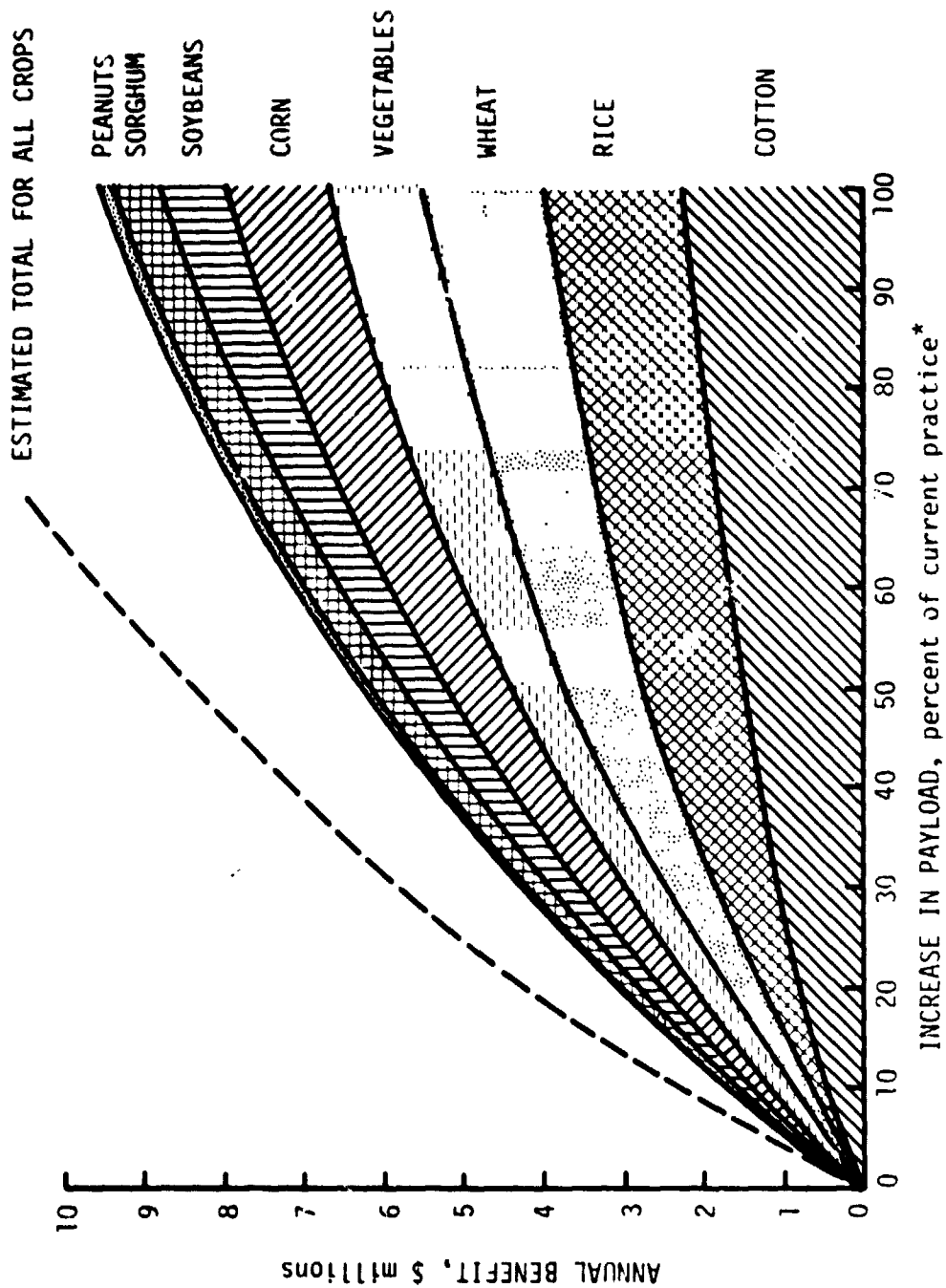
The use of flagmen varies across the country and also by crop. If the use of flagmen could be reduced through improved technologies, a substantial benefit would result. The benefits are difficult to estimate in that most of the labor is supplied by the farmer. Furthermore, flaggers employed by ag-air operators quite often receive fringe benefits such as housing and meals that are difficult to quantify. The annual savings projected at the right are probably on the low side. However, if a 50 percent reduction were possible, an annual savings of about \$6 million would result. Most all applications to rice are flagged by human flaggers. Most insecticide work is not flagged due to the toxicity of the chemicals. The potential cost savings are presented cumulatively by crop.

COST SAVINGS FROM REDUCTION IN USE OF FLAGMEN



A key parameter in the cost-effectiveness of agricultural aircraft is their weight-carrying capacity or payload. This is particularly important for applications of fertilizer or seed where the application rates exceed 100 pounds per acre. The benefits achievable from increased payload are shown at the right. Annual benefits of several million dollars are possible. It is interesting to note that cotton provides a relatively small portion of this benefit since most applications on cotton are at low application rates.

COST SAVINGS FROM INCREASED PAYLOAD



*NOTE: CURRENT PRACTICE IS TO FLY WITH PAYLOADS GENERALLY EXCEEDING CERTIFIED AMOUNTS

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Benefits due to improved uniformity of application of various materials derive from two major factors, reduced crop losses resulting in higher revenues for the farmer and higher productivity in the application process resulting from a reduced application rate. The farmer is basically interested in his net revenue, that is, his gross revenue from the sale of his crop less the costs of producing the crop. For computation of the benefits of improved uniformity of application, the costs of producing the crop can be divided into two parts, one part, called fixed costs, which is independent of the application rate, and the other part, called the marginal cost of application (variable costs), which is directly dependent on the application rate. The farmer would like to maximize his net revenue by adjusting the rate of application to its optimum value. But in general, the technology of the application process is such that it is not possible to control the application rate precisely over the entire field, $\sigma > 0$, thus, the farmer hedges by applying more material than is ideally necessary. The added cost of this "over application" and losses which still result because not all of the field meets or exceeds the ideal application rate comprise a loss to the farmer that could be avoided if the material could be more uniformly applied.

BENEFITS OF IMPROVED UNIFORMITY OF APPLICATION

- BENEFITS DERIVE FROM COST SAVINGS DUE TO REDUCED APPLICATION RATE AND FROM INCREASED REVENUES DUE TO INCREASED CROP PRODUCTION
- NET REVENUE = PRICE X YIELD - FIXED COSTS - VARIABLE COSTS
- DETERMINE AVERAGE NET REVENUE AS A FUNCTION OF AVERAGE APPLICATION RATE--OPTIMIZE AVERAGE APPLICATION RATE
- STANDARD DEVIATION, σ , OF APPLICATION RATE DESCRIBES THE TECHNOLOGY
- LOSS FUNCTION IS DEFINED AS LOST NET REVENUES DUE TO $\sigma > 0$

LOSS = NET REVENUE ($\sigma=0$) - NET REVENUE (σ)

A model that describes the economics of the application process from the farmer's point of view is shown here. As shown, the model is normalized to the ideal application rate and the ideal yield. A very simple efficacy curve is assumed in which crop yield is linearly dependent on application rate up to a saturation point after which it is unaffected by added application. The application rate at the saturation point is referred to as the ideal application rate. The farmer's gross revenues are directly proportional to the crop yield (yield times crop price) and his net revenues are his gross revenues minus his fixed costs and the marginal cost of application. Clearly, the farmer would like to apply the ideal application rate to his entire crop in order to maximize his net revenue but, due to technology limitation, this is not possible. Recognizing that the material will be applied with some nonuniformity, the farmer minimizes his loss by increasing the application rate above the ideal application rate. The loss incurred by the farmer is described by the equation:

$$L = P \left[y_i - \int_0^{\infty} f_q(q) y(q) dq \right] + C_A (\bar{q} - q_i)$$

where

P is the price of the crop which the farmer receives

y_i is the ideal crop yield

$f_q(q)$ is the probability density function describing the uniformity of application

It is a function of $\bar{q}$ and σ .

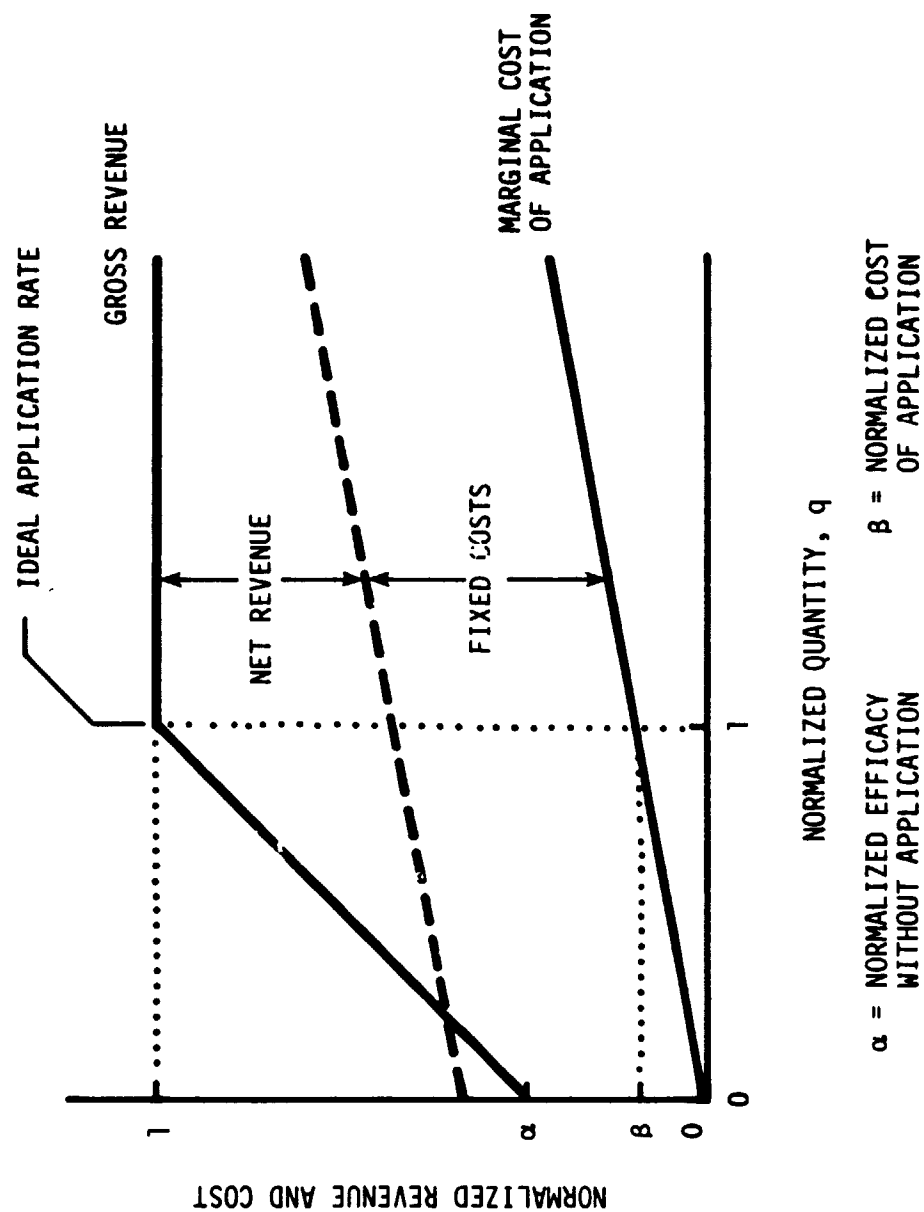
$y(q)$ is the crop yield as a function of the application rate

C_A is the marginal cost of application

$\bar{q}$ is the average application rate

q_i is the ideal application rate

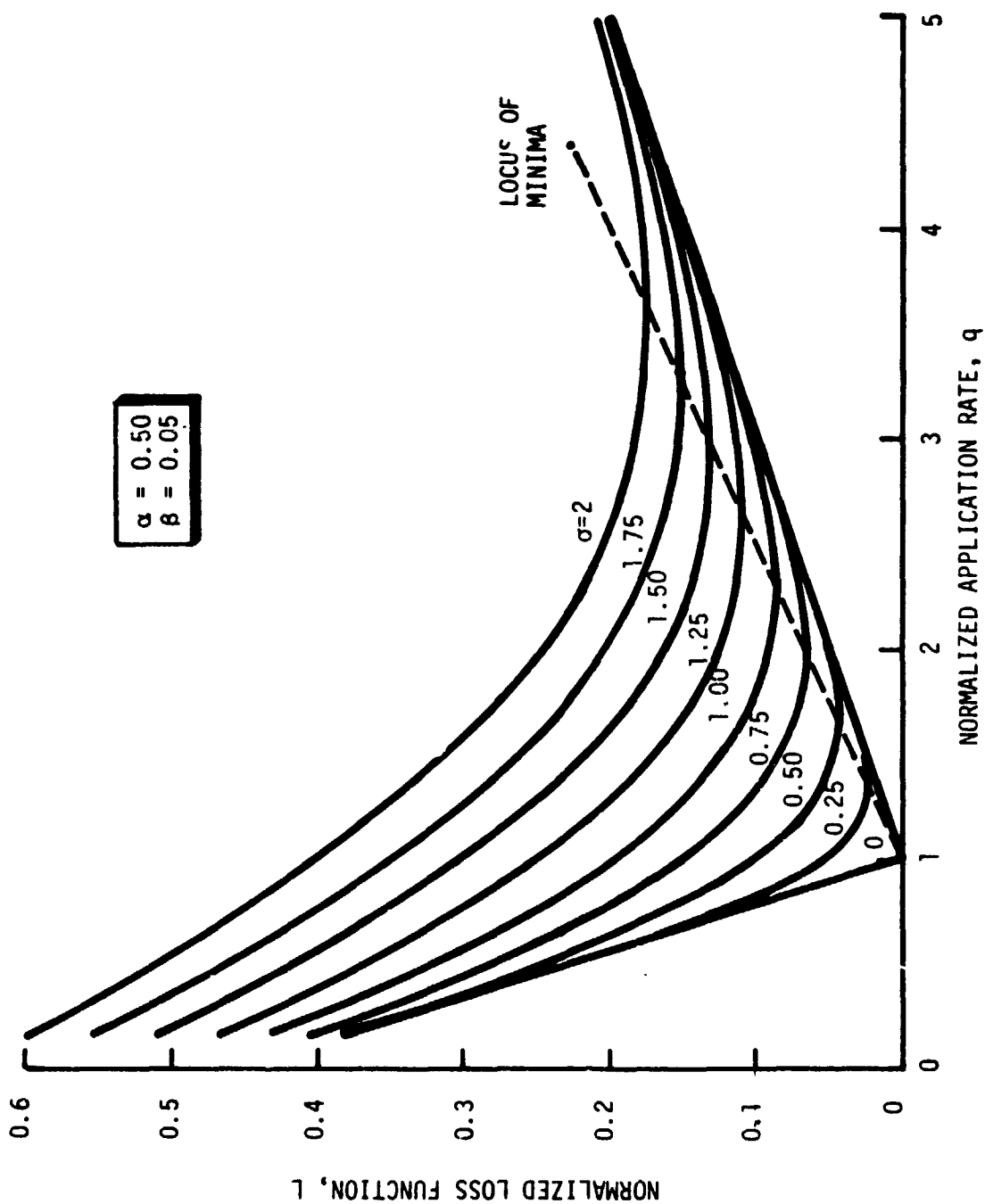
APPLICATION EFFICACY MODEL



The curves at the right show how the loss function is dependent on application rate and the technology, σ , for the case where α (the normalized efficacy or yield without application) is 0.5 and where β (the normalized marginal cost of application) is 0.05.

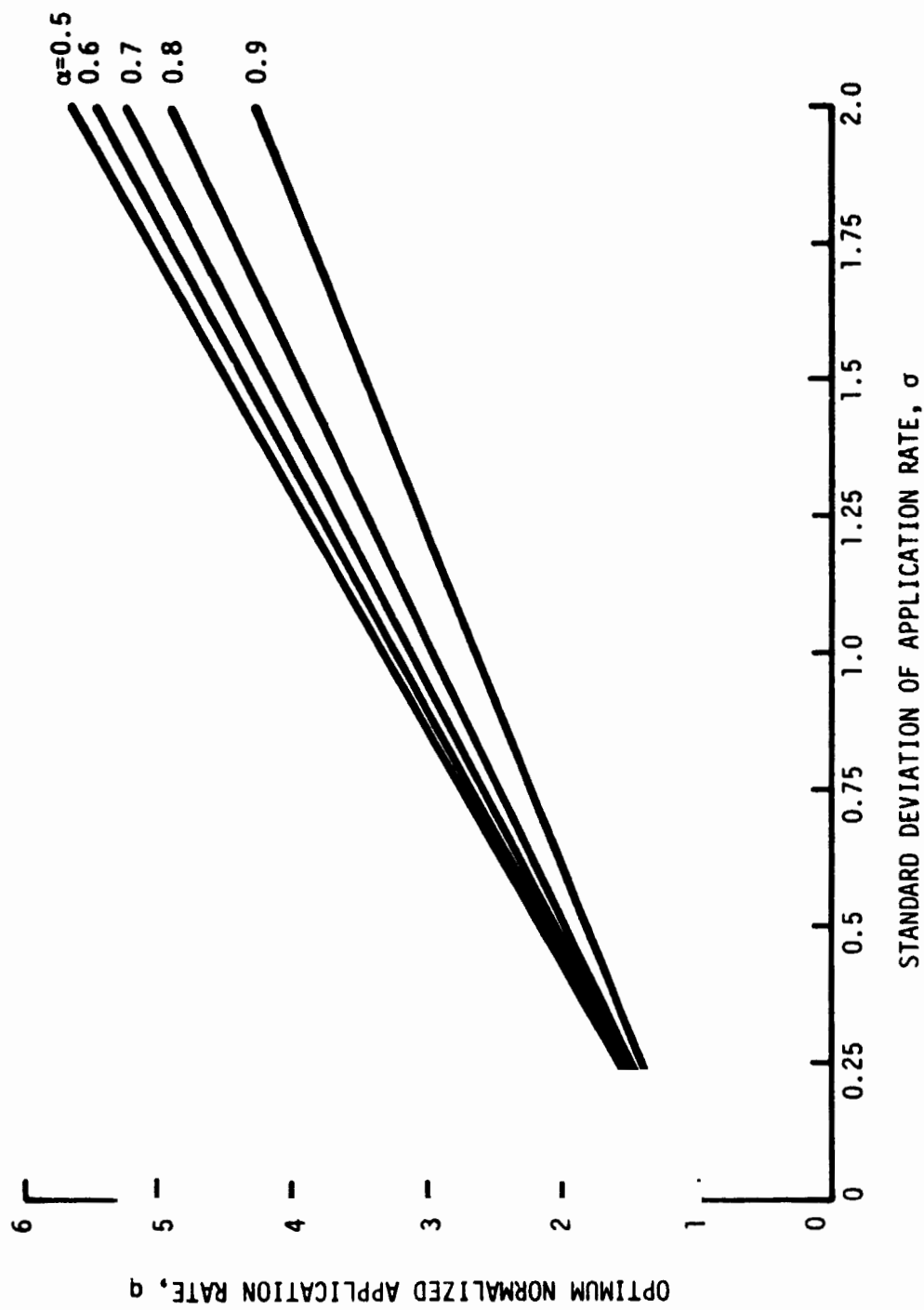


DEPENDENCE OF THE LOSS FUNCTION ON APPLICATION RATE



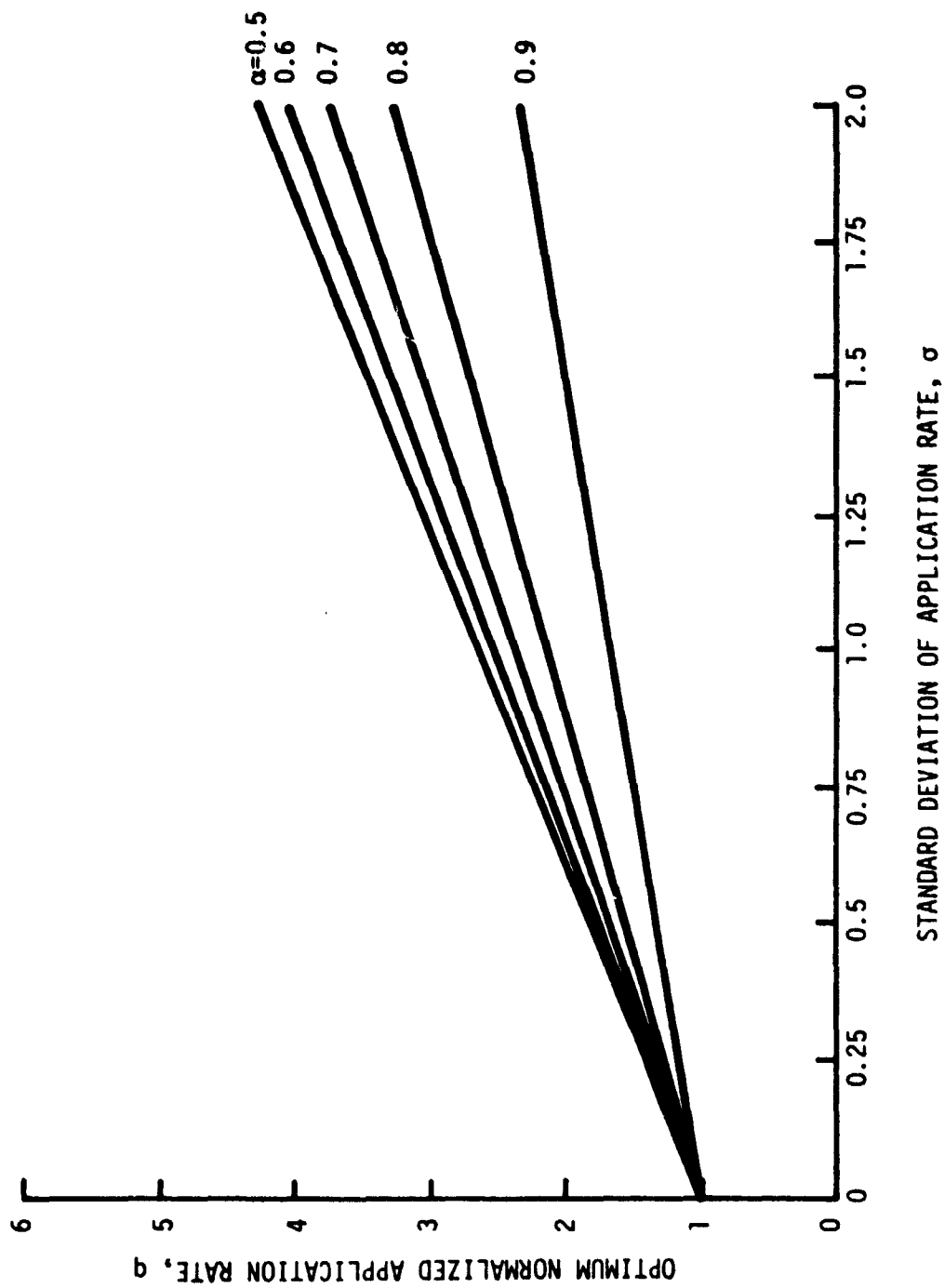
The effect of uniformity of application on optimum application rate is shown at the right for the case where β (the normalized marginal cost of application) is 0.005.

EFFECT OF UNIFORMITY OF APPLICATION ON OPTIMUM APPLICATION RATE, $\beta=0.005$



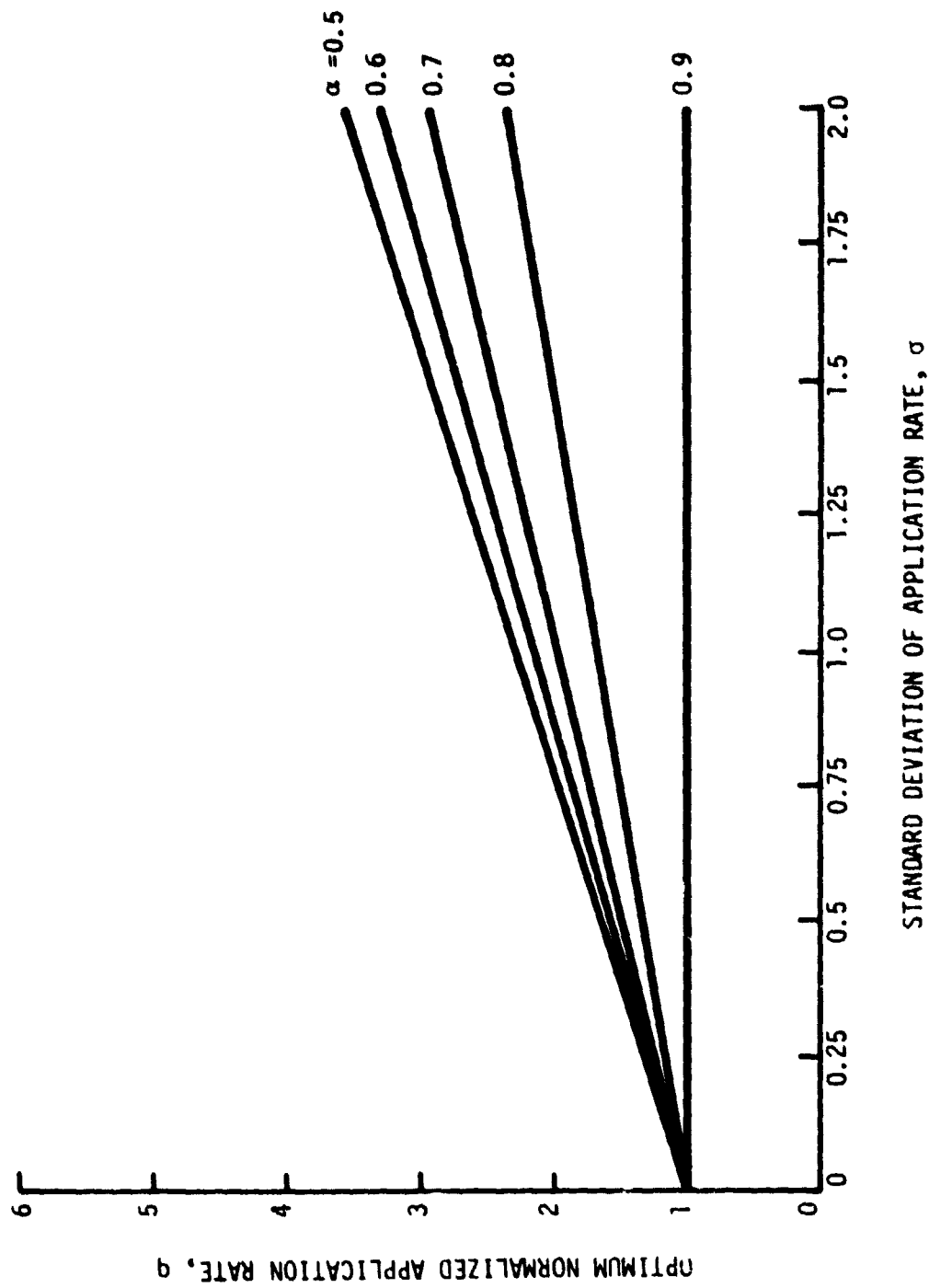
Another example of uniformity of application on optimum application rate is shown at the right,
this one for β (the normalized marginal cost of application) equal to 0.025.

EFFECT OF UNIFORMITY OF APPLICATION ON OPTIMUM APPLICATION RATE, $\beta=0.025$



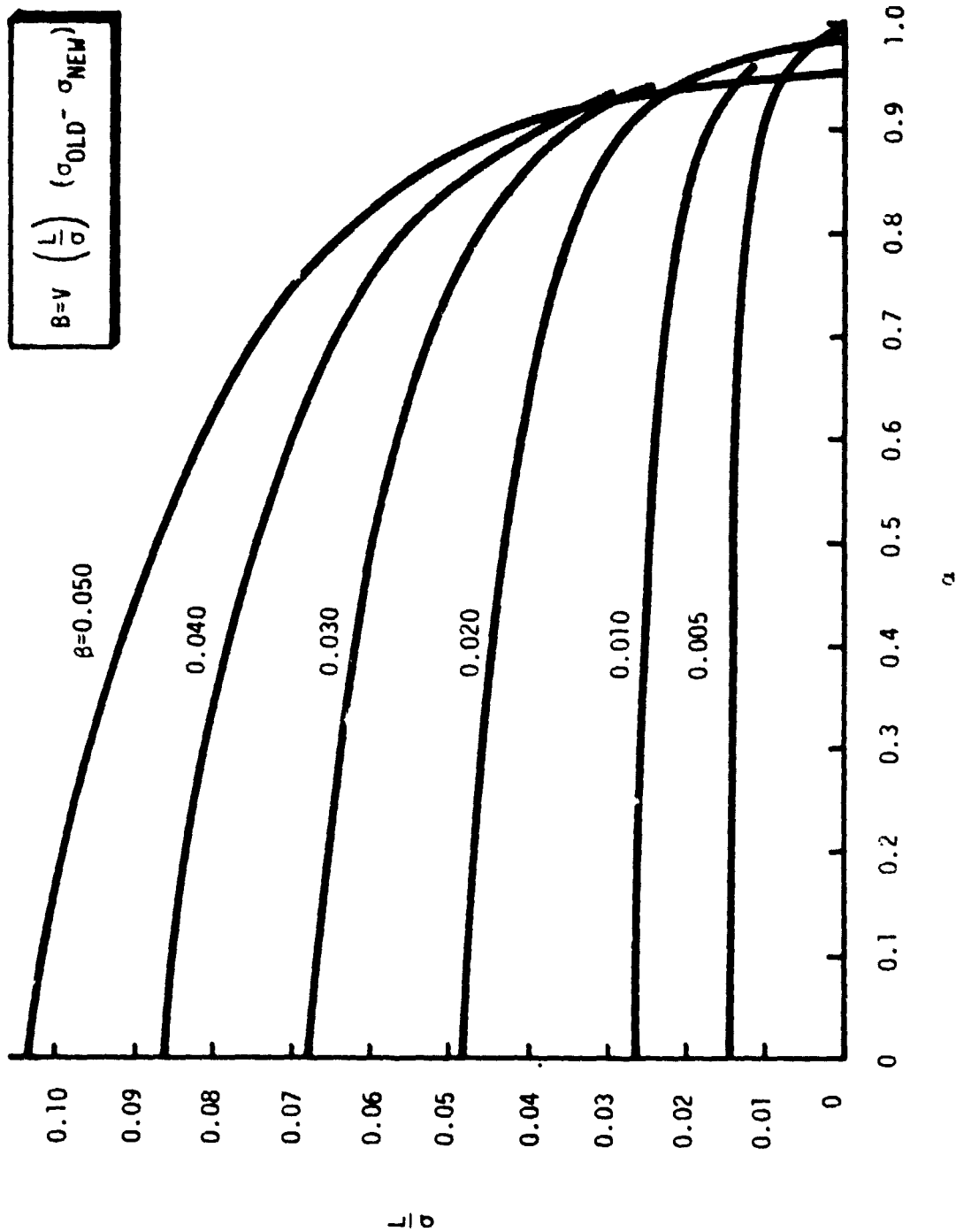
A further example of uniformity of application on optimum application rate is shown at the right. Here β is equal to 0.05.

EFFECT OF UNIFORMITY OF APPLICATION ON OPTIMUM APPLICATION RATE, $\beta=0.05$



An index of benefits due to improved uniformity of application is shown at the right. It combines the data of the previous curves for representative values of β . Once an efficacy function is determined, the cost savings from an improved uniformity of application can be determined. The benefit is then equal to the value of the crop on which the material is applied multiplied by the index value, L/σ , multiplied by the difference between the standard deviation of the application rate for the old technology and the new technology. An example case is worked out on the next page.

INDEX OF BENEFITS DUE TO IMPROVED UNIFORMITY OF APPLICATION



Suppose we wish to compute the cost savings due to improved uniformity of application of Propa. 1 to rice in Texas. Several data need to be known. For 1976, the revenue from rice is computed to be \$381.43/acre in Texas. The cost of application (material) is determined to be \$10.71/gallon. From the work of Smith (1968), discussed earlier and assuming that the above application efficacy model applies, a reasonable value of α was assumed. The cost of application is normalized for this pesticide in Texas; and the value ϵ or L/σ is found on the Index of Benefits. Finally, a value for the current standard deviation of application rate is assumed (applicators currently apply about twice the ideal amount) and an estimate of the improved technologies is assumed. The computed benefit for this example case shows a \$1.9 million savings annually.

EXAMPLE CASE

- EXAMPLE PROBLEM

DETERMINE THE BENEFIT DUE TO IMPROVED UNIFORMITY OF APPLICATION OF PROPANIL TO RICE IN TEXAS

ACREAGE OF CROP - 508,000 ACRES

PRODUCTION OF CROP - 48.1 CWT/ACRE

PRICE OF CROP - \$7.93/CWT

REVENUE FROM CROP - \$381.43/ACRE (\$193,768,000 FOR TOTAL ACREAGE)

COST OF MATERIAL - \$10.71/GAL

MARGINAL COST OF APPLICATION - \$10.71/GAL

- ASSUME α , NORMALIZED EFFICACY WITHOUT APPLICATION

FROM STUDIES OF SMITH (1968), REASONABLE VALUE OF $\alpha=0.6$ IDEAL APPLICATION RATE ABOUT 0.65 GAL/ACRE

- DETERMINE β , NORMALIZED COST OF APPLICATION

$$\beta = \frac{\text{MARGINAL COST OF APPLICATION} \times \text{IDEAL APPLICATION RATE}}{\text{REVENUE FROM CROP PER ACRE}} = \frac{10.71 \times 0.65}{381.43} = 0.0183$$

- FIND L/σ

FROM INDEX OF BENEFITS $L/\sigma = 0.039$

- ASSUME σ , STANDARD DEVIATION OF APPLICATION RATE

PRESENTLY = 0.50 AND THROUGH IMPROVED TECHNOLOGY REDUCES TO 0.25

- COMPUTE BENEFIT

$$B = V \left(\frac{L}{\sigma} \right) (\sigma_{\text{OLD}} - \sigma_{\text{NEW}}) = \$193,768,000 (0.039) (0.5 - 0.25) = \$1,889,000$$

Benefits from research projects such as those that would be performed on ag-air technologies are always captured first by early innovators in the form of increased profits. In the case of the ag-air technologies dealt with in this study, the ag-air manufacturers would be the first to benefit. However, due to the limited size of the markets for their products, the magnitude of this benefit would be substantially limited and disappear altogether as competition eroded the profit margin of the early innovators. The next group to obtain benefits would be the ag-air operators themselves. By using more advanced equipment than their competition, they would be able to supply an improved service at a reduced cost. However, again as neighboring ag-air operators also innovate, the prices charged for ag-air services would be reduced and the benefit would ultimately be passed along to the farmers and finally to the general public. It is in fact the general public that will capture the sustaining benefits of improved ag-air technologies in a steady state economic environment.

WHERE DO AG-AIR BENEFITS GO

- EARLY INNOVATORS ALWAYS CAPTURE EARLY BENEFITS AS INCREASED PROFITS
 - AG-AIR MANUFACTURERS FIRST
 - AG-AIR OPERATORS NEXT
 - THEN FARMERS
- ULTIMATELY--STEADY STATE--BENEFITS GO TO CONSUMERS, I.E., TO THE GENERAL PUBLIC

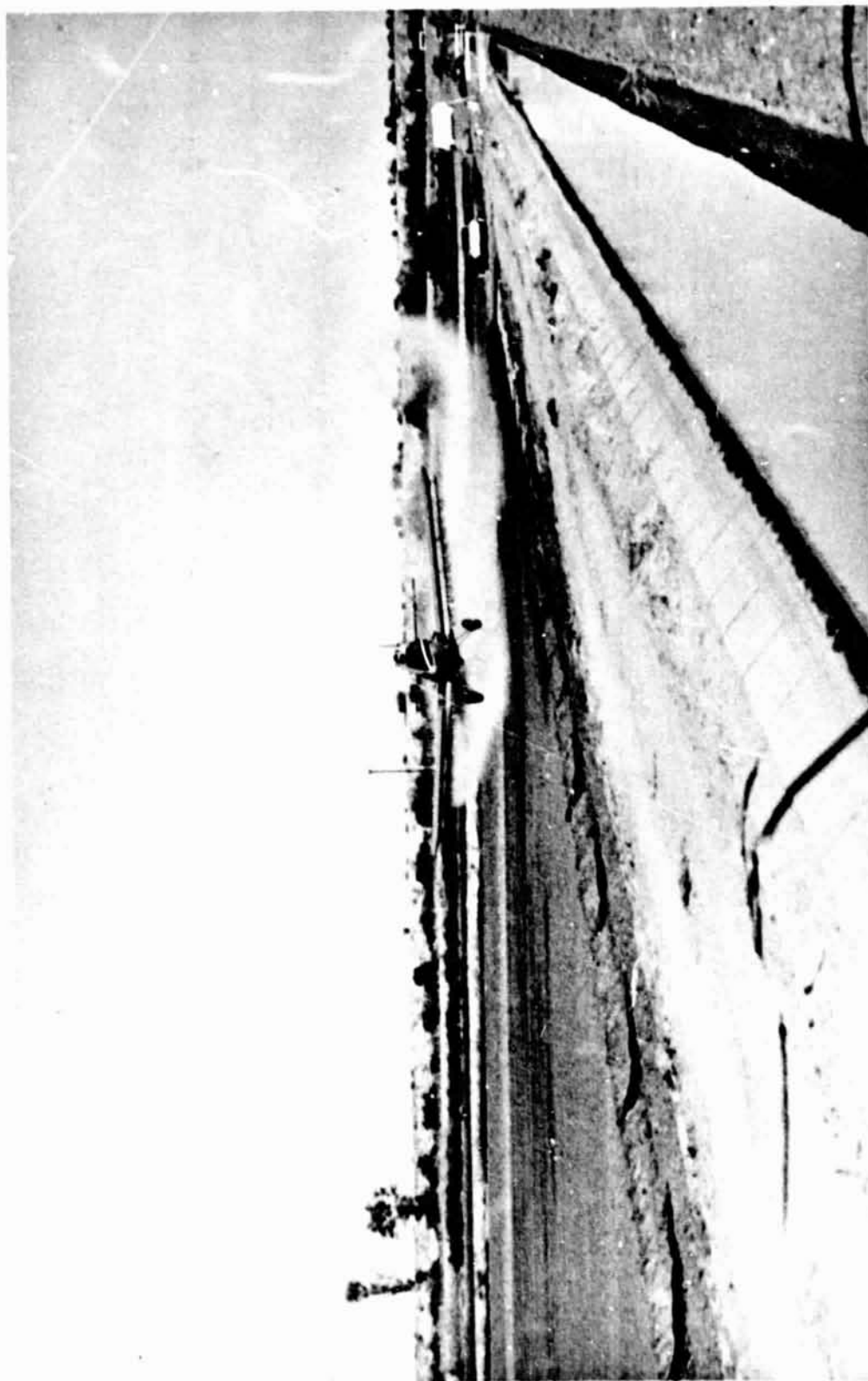
It is seen above that the benefits of improved technologies in agricultural aviation are quite substantial; but this alone, although a necessary condition, is not sufficient to justify a program of federally sponsored research. In addition to the fact that the benefits of the program should be larger than its costs, two additional conditions should be met. First, the private sector, left to its own devices, would not perform the research for any of a number of reasons including, for example, high risk in the research program, a long time horizon for payback, the scale of the program is too large, or the benefits cannot be captured as profits by the private sector entity sponsoring the research. Second, the research objectives must be in keeping with national goals. With respect to the ag-air industry, very little vertical integration is present. The benefits presented above are, in fact, benefits that will ultimately be captured by farmers and consumers and not by ag-air equipment manufacturers. Thus, it is reasonably clear that, by and large, the manufacturers of ag-air equipment cannot expect a significant return on investment for research and technology projects. Clearly, however, increased efficiency of agricultural production has been a sustaining nation goal into which research to improve the efficiency of agricultural aviation comfortably fits.

RATIONALE FOR FEDERAL GOVERNMENT SPONSORED RESEARCH

- RESEARCH HAS TO PAY--BENEFITS LARGER THAN COSTS
- THE PRIVATE SECTOR WOULD NOT DO IT
 - RISK
 - TIME HORIZON
 - SCALE
 - BENEFITS CANNOT BE CAPTURED AS PROFITS
- RESEARCH OBJECTIVES MUST BE IN KEEPING WITH NATIONAL GOALS

PHOTO: A ROCKWELL TURBO THRUSH OPERATED BY THE
STOKER COMPANY OF EL CENTRO, CALIFORNIA
APPLIES AN INSECTICIDE TO A NEW CARROT FIELD.

PART VI
BIBLIOGRAPHY



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