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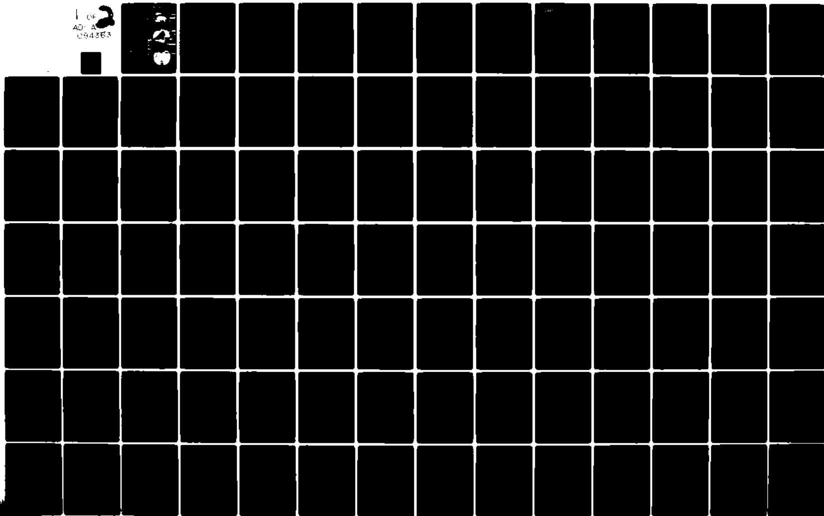

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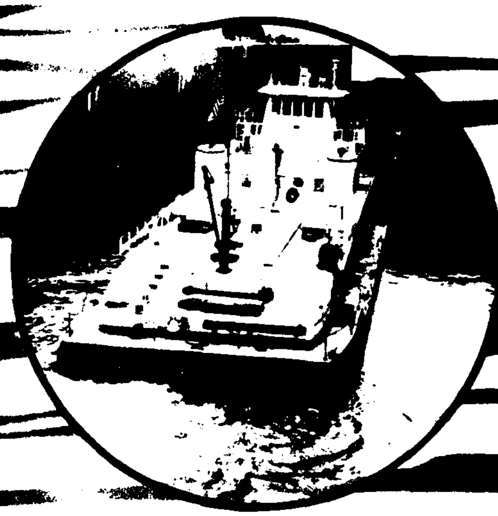
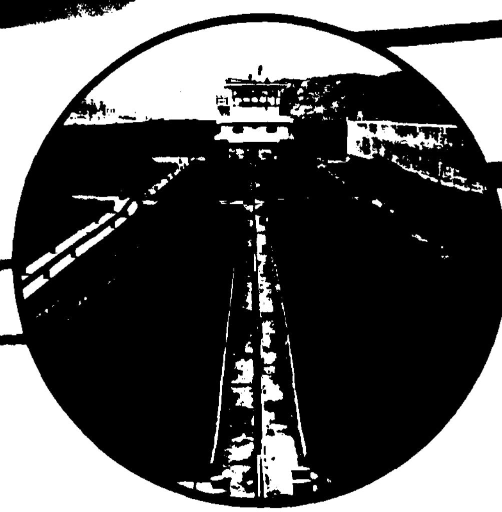
Projections Of Demand For Waterborne Transportation

Ohio River Basin
1980 - 2040

Volume 7

Grains





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REPORT DOCUMENTATION PAGE

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1. REPORT NUMBER	2. GOVT ACCESSION NO. AD-A094 363	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Projections of Demand for Waterborne Transportation, Ohio River Basin 1980, 1990, 2000, 2020, 2040; Vol. 7, Group V: Grains A094362		5. TYPE OF REPORT & PERIOD COVERED Vol. 7 of 17
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s)		8. CONTRACT OR GRANT NUMBER(s) DACW69-78-C-0136
9. PERFORMING ORGANIZATION NAME AND ADDRESS Robert R. Nathan Associates, Inc. Consulting Economists 1301 Pennsylvania Ave., N.W. Washington, DC 20004		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS Ohio River Basin Navigation Studies
11. CONTROLLING OFFICE NAME AND ADDRESS U.S. Army Corps of Engineers, Ohio River Div. ATTN: Navigation Studies Branch, Planning Div. P.O. Box 1159, Cincinnati, OH 45201		12. REPORT DATE December 1980
		13. NUMBER OF PAGES 131
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office) U.S. Army Corps of Engineers, Huntington District P.O. Box 2127 Huntington, WV 25721		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for Public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Bulk cargo
Commodity resource inventory
Economic development
Economic forecasting
Inland waterways
Market demand analysis
Modal split analysis
Ohio River Basin
River basin development
Traffic surveys
Grains

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This Corps of Engineers report describes one of three independent but complementary studies of future freight traffic on the Ohio River Basin Navigation System. Each of the studies considers existing waterborne commerce and develops a consistent set of projects of future traffic demands for all of the navigable waterways of the Basin. Each report contains information on past and present waterborne commerce in the Basin and projections by commodity groups and origin-destination areas from 1976 to at least 1990.

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(Continued from #20)
The three study projections, in conjunction with other analytical tools and system information, will be used to evaluate specific waterway improvements to meet short and long-term navigation needs. The output from these studies will serve as input to Corps' Inland Navigation Simulation Models to help analyze the performance and opportunities for improvement of the Ohio River Basin Navigation System. These data will be used in current studies relating to improvement of Gallipolis Locks, the Monongahela River, the Upper Ohio River, the Kanawha River, the Lower Ohio River, the Cumberland River and the Tennessee River, as well as other improvements.

This document is volume 7 of the 17 volume report shown below.

The study included a Commodity Resource Inventory, a Modal Split Analysis and a Market Demand Analysis. The work included investigation and analyses of the production, transportation and demand characteristics of each of the major commodities transported on the Ohio River and its tributaries. For each of 15 commodity groups, the demand for waterway transportation into, out of and within the Ohio River Basin was projected through the year 2040. A detailed study analysis and discussion for each commodity group is presented in 15 individually bound reports, supplemented by a methodology report. A study summary aggregates the commodity group totals for each of the several projections periods and lists the total waterborne commerce for each of the 72 operational locks and dams in the Ohio River Basin. The study results are presented in the following 17 documents:

Volume	Subject Title	
1	Study summary	
2	Methodology	
3	Group I:	Coal and coke
4	Group II:	Petroleum fuels
5	Group III:	Crude Petrol.
6	Group IV:	Aggregates
7	Group V:	Grains
8	Group VI:	Chemicals and chemical fertilizers
9	Group VII:	Ores and Minerals
10	Group VIII:	Iron ore, steel and iron
11	Group IX:	Feed and food products, nec.
12	Group X:	Wood and paper products
13	Group XI:	Petroleum products, nec.
14	Group XII:	Rubber, plastics, nonmetallic, mineral, products, nec.
15	Group XIII:	Nonferrous, metals and alloys, nec.
16	Group XIV:	Manufactured products, nec.
17	Group XV:	Other, nec.

Additionally, an Executive Summary is available as a separate document.

Final rept.

GROUP V. GRAINS.

PROJECTIONS OF DEMAND FOR WATERBORNE TRANSPORTATION, OHIO RIVER BASIN, 1980, 1990, 2000, 2020, 2040. Volume 7.

Prepared for

U.S. ARMY CORPS OF ENGINEERS
OHIO RIVER DIVISION, HUNTINGTON DISTRICT

Contract No. DACW69-78-C-0136

by

Robert R. Nathan Associates, Inc.
Consulting Economists
Washington, D.C.

DECEMBER 1980

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Robert R. Nathan Associates, Inc.
Projections of demand for waterborne transportation, Ohio River Basin, 1980, 1990, 2000, 2020, 2040 / Prepared for the U.S. Army Corps of Engineers, Huntington District ... by Robert R. Nathan Associates, Inc., December 1980. Cincinnati, Ohio : U.S. Army Corps of Engineers, Ohio River Division, 1980.
17 v. : ill. ; 28 cm.
Contract DACW69-78-0136.
"...one of three independent but complementary studies of future freight traffic on the Ohio River Basin Navigation System."

CONTENTS: v.1. Study summary.--v.2. Methodology.--v.3. Commodity groups .

1. Shipping--Ohio River Basin. 2. Inland water transportation--Ohio River Basin--Statistics. 3. Ohio River Basin. I. United States. Army. Corps of Engineers. Ohio River Division. II. United States. Army. Corps of Engineers. Huntington District. III. Title.

HE597.03N3 OCLC no. 7030444

PREFACE

This Corps of Engineers report describes one of three independent but complementary studies of future freight traffic on the Ohio River basin navigation system. Each of the studies considers existing waterborne commerce and develops a consistent set of projections of future traffic demands for all of the navigable waterways of the basin. Each report contains information on past and present waterborne commerce in the basin with projections by commodity group and origin-destination areas from 1976 to either 1990 or 2040.

The three projections, in conjunction with other analytical tools and waterway system information, will be used to evaluate specific waterway improvements required to meet short and long-term navigation needs. The output from these studies will serve as input to Corps inland navigation simulation models to help analyze the performance and requirements for improvements of the Ohio River basin navigation system. These data will be used in current studies relating to improvements of Gallipolis Locks, the Monongahela River, the Upper Ohio River, the Kanawha River, the Lower Ohio River, and the Tennessee River, as well as for other improvements.

The reports on the three studies are referred to as the "CONSAD," the "BATTELLE," and the "NATHAN" reports. The latter and final report was completed in November 1980. It was prepared for the Corps of Engineers by Robert R. Nathan Associates, Inc., Consulting Economists, Washington D.C. This study encompasses the period 1976-2040, and is by far the most detailed of the three.

The "CONSAD" report, completed in January 1979, was prepared for the Corps by the CONSAD Research Corporation of Pittsburgh, Pennsylvania. The study and the 1976-1990 projected traffic demands discussed in that report were developed by correlating the historic waterborne commodity flows on the Ohio River navigation system, with various indicators of regional and national demands for the commodities. The demand variables which appeared to best describe the historic traffic pattern for each of the commodity groups was selected for projection purposes. The projected values for the demand variables are based upon the 1972 OBERS Series E Projections of National and Regional Economic Activity. The OBERS projections serve as national standards and were developed by the Bureau of Economic Analysis of the U.S. Department of Commerce, in conjunction with the Economic Research Service of the Department of Agriculture.

The "BATTELLE" report was completed in June 1979, and was prepared for the Corps by the Battelle Columbus Laboratories, Columbus, Ohio. The study and the 1976-1990 traffic projections discussed in that report were developed by surveying all waterway users in the Ohio River Basin through a combined mail survey and personal interview approach. The purpose of the survey was to obtain an estimate from each individual shipper of his future commodity movements, by specific origins and destinations, as well as other associated traffic information. All identifiable waterway users were contacted and requested to provide the survey information. In addition, personal interviews were held with the major shippers. The responses were then aggregated to yield projected traffic demands for the Ohio River navigation system.

The "NATHAN" report presents the findings of a commodity resource inventory, a modal split analysis and a market demand analysis. The work included investigation and analyses of the production, transportation, and demand characteristics of each of the major commodities transported on the Ohio River and its tributaries. For each of 15 commodity groups, the demand for waterway transportation into, out of, and within the Ohio River basin was projected through the year 2040. A detailed study analysis and discussion for each commodity group is presented in 15 individually bound reports, supplemented by a methodology report. A Study Summary and an Executive Summary present appropriately abbreviated discussion and findings resulting from these analyses. The Study Summary aggregates the commodity group totals for each of the several projection periods and lists the total waterborne commerce for each of the 72 operational locks and dams in the Ohio River Basin.

The "NATHAN" report, "Projections of Demand for Waterborne Transportation, Ohio River Basin, 1980, 1990, 2000, 2020, 2040" consists of the following volumes:

Subject Title	Number of Pages	Volume Number
Study Summary	220	1
Methodology	118	2
Group I: Coal and Coke	134	3
Group II: Petroleum Fuels	66	4
Group III: Crude Petroleum	42	5
Group IV: Aggregates	64	6
Group V: Grains	131	7
Group VI: Chemicals and Chemical Fertilizers	90	8
Group VII: Ores and Minerals	61	9
Group VIII: Iron Ore, Steel and Iron	104	10
Group IX: Feed and Food Products, Nec.	44	11
Group X: Wood and Paper Products	61	12
Group XI: Petroleum Products, Nec.	38	13
Group XII: Rubber, Plastic, Nonmetallic Mineral Products, Nec.	41	14
Group XIII: Nonferrous Metals and Alloys, Nec.	57	15
Group XIV: Manufactured Products Nec.	35	16
Group XV: Others, Nec.	48	17

Additionally, an Executive Summary is available as a separate document.

RRNA

PROJECTIONS OF DEMAND FOR WATERBORNE TRANSPORTATION OHIO RIVER BASIN 1980, 1990, 2000, 2020, 2040

Group V: Grains

Prepared for
U.S. Army Corps of Engineers
Huntington District
Contract No. DACW69-78-C-0136

by

Robert R. Nathan Associates, Inc.
Consulting Economists
Washington, D.C.

November 1980

TABLE OF CONTENTS

I. INTRODUCTION

Commodity Group V consists of grains. In 1976, the Ohio River System (ORS) accounted for about 11 percent of the corn, 10 percent of the soybeans, and 12 percent of the wheat shipped on domestic waterways.[1] Although grains represented only about 3 percent of total waterborne commerce in the ORS in 1976, they were one of the fastest growing waterborne commodity movements, flowing to and/or from almost every major port equivalent (PE) in the inland waterway system. Grains also provided one of the higher value and longer haul movements in the system.

The areas within the Ohio River Basin (ORB) for which projections of Group V consumption, production, and movements have been made are designated as Primary Study Areas (PSAs). The PSAs for Group V are those U.S. Department of Commerce, Bureau of Economic Analysis Areas (BEAs) and the area segments (aggregation of counties within a BEA) that are origins or destinations of Group V waterborne movements. A map showing Group V PSAs is presented in Appendix A to this report.

In addition to the PSAs, external areas linked to the ORB through waterborne commerce were identified. Areas (BEAs) outside the ORB that are destinations of waterborne grain movements originating in the ORB are designated as Secondary Consumption Areas (SCAs). Areas (BEAs) outside the ORB that are origins of Group V waterborne movements destined for the ORB are designated as Secondary Production Areas (SPAs).

Outbound waterway flows (traffic from a PE within the ORS to a PE outside the ORS) of grains originated principally on the Ohio

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1. U.S. Army Corps of Engineers, Waterborne Commerce of the United States, 1976 ed. (New Orleans: COE, n.d.), Vol. V.

River. Outbound flows increased from 619.0 thousand tons in 1969 to 4.0 million tons in 1976. Inbound waterway flows, from PEs outside the ORS to PEs within the ORS, were destined principally for the Tennessee River. Inbound waterway flows decreased, in relative terms, from 12.1 percent of total waterborne movements in the ORS in 1969 to 4.8 percent in 1976. Local waterway flows (i.e., traffic from one PE to another within the ORS) remained relatively constant at 0.1 percent of total ORS movements.

A. Description of Commodity Group V

The individual products included in Group V are:

Waterborne Commerce Statistics Code (WCSC)	Product
0102	Barley and rye
0103	Corn
0104	Oats
0105	Rice
0106	Sorghum
0107	Wheat
0111	Soybeans.

The most important grains, in terms of total past and future ORS waterborne movements, are corn, wheat, and soybeans. In 1976, these grains accounted for 52.6, 26.1, and 20.0 percent of ORS waterborne grain traffic, respectively (Table 1). These three commodities accounted for between 94 and 99 percent of the waterborne movements of grains in the ORS between 1969-76.

The other four commodities had relatively small waterborne movements in the 1969-76 period -- between 1 and 6 percent of total waterborne grain traffic. Barley and rye movements were all inbound, destined for the Ohio River, and in general accounted for less than 1 percent of Group V waterborne movements. Oats, which accounted for about 3 percent of total ORS waterborne grain movements, were generally inbound and destined for the Tennessee River. Sorghum movements, which accounted for less than 1 percent of ORS grain traffic, were generally outbound from the Ohio River, destined for the lower Mississippi River.

During the base period, 1969-76, only one waterborne movement of rice occurred in the ORS. This was an inbound movement in 1974 that originated on the Arkansas River and was destined for Chattanooga, Tennessee.

Table 1. Ohio River System: Waterborne Shipments of Grains by Commodity, Inbound, Outbound and Local Movements, 1969-76

(Thousands of tons unless otherwise specified)

Commodity and type of movement	1969	1970	1971	1972	1973	1974	1975	1976	Average annual percentage change, 1969-76
Total	3,304.1	3,375.6	3,973.3	3,119.6	3,012.6	3,355.0	4,097.3	5,582.0	7.8
Inbound	2,532.8	2,823.7	2,919.3	1,912.6	1,740.0	1,742.3	1,368.1	1,418.0	(8.0)
Outbound	619.2	422.4	928.9	1,092.2	1,102.0	1,497.3	2,609.0	4,035.0	30.7
Local	152.2	129.5	125.0	114.8	170.5	115.4	120.1	129.0	(2.3)
Barley and rye	46.8	36.7	36.7	41.6	11.3	6.9	11.1	--	a
Inbound	46.8	36.7	36.7	41.6	11.3	6.9	11.1	--	a
Outbound	--	--	--	--	--	--	--	--	--
Local	--	--	--	--	--	--	--	--	--
Corn	1,709.1	1,774.5	1,832.6	1,126.3	1,331.5	1,209.0	1,666.7	2,938.3	8.1
Inbound	1,452.1	1,540.0	1,534.4	832.6	789.6	682.5	376.5	263.7	(21.6)
Outbound	179.6	178.1	262.8	267.8	491.9	505.4	1,263.5	2,639.4	46.8
Local	77.4	56.4	35.4	25.9	50.0	21.1	26.7	35.2	(10.6)
Oats	73.3	78.2	158.6	128.0	81.2	98.1	48.4	59.7	(2.9)
Inbound	65.9	78.2	158.6	128.0	81.2	97.1	45.8	37.7	(7.7)
Outbound	6.1	--	--	--	--	1.0	--	5.0	(2.8)
Local	1.3	--	--	--	--	--	2.6	17.0	44.4
Rice	--	--	--	--	--	0.8	--	--	a
Inbound	--	--	--	--	--	0.8	--	--	a
Outbound	--	--	--	--	--	--	--	--	--
Local	--	--	--	--	--	--	--	--	--
Sorghum	7.2	24.1	28.3	32.8	7.1	--	--	9.2	3.6
Inbound	7.2	22.6	10.7	--	--	--	--	--	a
Outbound	--	1.5	17.6	32.8	4.6	--	--	9.2	a
Local	--	--	--	--	2.5	--	--	--	a

(Continued)

Table 1. (Continued)

Commodity and type of movement	1969	1970	1971	1972	1973	1974	1975	1976	Average annual percentage change, 1969-76
Wheat	787.4	796.7	1,006.6	1,050.4	688.1	1,044.0	1,342.6	1,458.4	9.2
Inbound	705.4	760.0	861.8	786.7	610.2	697.1	750.2	901.2	3.6
Outbound	58.5	12.5	143.5	259.4	60.7	332.5	568.8	538.9	37.3
Local	23.5	24.2	1.3	4.3	17.2	14.4	23.6	18.3	(3.5)
Soybeans	680.2	665.5	910.6	740.5	893.3	996.3	1,028.6	1,117.1	7.3
Inbound	255.3	386.2	317.1	123.7	247.7	257.8	184.6	215.5	(2.4)
Outbound	374.9	230.4	505.1	532.2	544.8	658.5	776.7	843.1	12.3
Local	50.0	48.9	88.4	84.6	100.8	80.0	67.3	58.5	2.3

Note: Individual items may not add to total due to rounding.
a. No tonnages reported in 1969 and/or 1976.
Source: Waterborne Commerce by Port Equivalents, 1969-76, supplied by the U.S. Army Corps of Engineers.

These four commodities (barley and rye, sorghum, oats, and rice) are not expected to move in the Ohio River System in significant quantities in the future. To the extent that they are produced in the PSAs at all, they often are consumed on the farm where grown and therefore are not generally shipped. Because of their insignificance in terms of waterway movements, these commodities have not been analyzed in depth during the course of this study. Group V historical and projected production and consumption do not include these minor grains.

B. Existing Waterway Traffic Flows

The total inbound, outbound, and local grain traffic in the ORS was recorded at 3.3 million tons in 1969, increasing to 5.6 million in 1976. Two distinct trends can be noted in regard to ORS waterborne grain movements. Outbound grain increased at an average annual rate of 30.7 percent, increasing the relative share of grains in total ORS outbound traffic from 3.9 percent in 1969 to 15.0 percent in 1976. The inverse was the case in regard to inbound movements, which decreased from 2.5 million tons in 1969 to 1.4 million in 1976, an average annual decrease of 8.0 percent. Local grain movements within the ORS remained relatively small and unchanged (Table 2).

B-1. BEA-to-BEA Waterway Flows

Between 1969 and 1976, total waterborne grain movements in the ORS increased at an average annual rate of 7.8 percent.

The most significant PSAs, in terms of the volume of outbound waterborne grain movements, were BEAs 55 (Evansville), 62 (Cincinnati), 49 (Nashville), 60 (Indianapolis), 63 (Dayton), and 115 (Paducah), which together accounted for over 90 percent of ORS outbound grain movements in 1976 (Table 3). Over 96 percent of the grain outbound from these six BEAs was destined for BEA 138 (New Orleans) for export via Gulf Coast ports.

In terms of inbound movements, the most significant PSAs were BEAs 48 (Chattanooga), 47 (Huntsville), 55 (Evansville), and 45 (Birmingham), which together accounted for over 97 percent of inbound movements to the PSAs in 1976 (Table 3). Over 83 percent of the inbound grain destined to these PSAs originated in BEAs 91 (Minneapolis), 111 (Kansas City), 77 (Chicago), 119 (Tulsa), and 78 (Peoria), all of which are served by the upper Mississippi River and the Illinois Waterway.

Table 2. Ohio River System: Waterborne Shipments of All Commodities and of Grains, 1969 and 1976

(Thousands of tons unless otherwise specified)

	Total		Inbound		Outbound		Local	
	1969	1976	1969	1976	1969	1976	1969	1976
All commodities	159,835.8	200,770.5	21,001.1	29,439.5	16,071.1	26,854.0	122,763.6	144,477.0
Grains	3,304.1	5,582.0	2,532.8	1,418.0	619.2	4,035.0	152.2	129.0
As a percentage of all commodities	2.1	2.8	12.1	4.8	3.9	15.0	0.1	0.1

Source: Waterborne Commerce by Port Equivalents, 1969 and revised 1976, supplied by the U.S. Army Corps of Engineers.

Table 3. Ohio River Basin: Waterborne Commerce by BEA, 1976
Group 5: Grains

(Thousands of tons)

Origins	Total	ORB BEAs	BEA 44[a]	BEA 45[a]	BEA 47	BEA 48	BEA 50	BEA 55	BEA 62	BEA 115
		Destinations								
Total	5,582.0	1,547.0	26.3	114.2	420.8	807.9	11.1	163.6	1.1	2.0
ORB BEAs	4,164.0	129.0	1.1	17.2	30.9	62.4	2.0	13.4	0	2.0
46[a]	21.4	4.8	--	1.0	1.9	1.9	--	--	--	--
49	269.3	15.2	--	1.1	2.3	4.8	2.0	5.0	--	--
52	1.1	0	--	--	--	--	--	--	--	--
53[a]	34.6	0	--	--	--	--	--	--	--	--
54	113.8	10.0	--	2.4	3.5	2.8	--	1.3	--	--
55	1,907.8	54.1	1.1	8.9	11.2	30.9	--	--	--	2.0
56[a]	76.4	2.4	--	--	1.2	1.2	--	--	--	--
60[a]	243.8	9.1	--	1.1	3.1	3.5	--	1.4	--	--
61[a]	53.3	1.4	--	--	--	1.4	--	--	--	--
62	892.1	18.0	--	2.7	4.2	7.6	--	3.5	--	--
63[a]	183.9	4.0	--	--	1.3	1.7	--	1.0	--	--
64[a]	76.9	2.7	--	--	--	1.5	--	1.2	--	--
114	38.4	2.4	--	--	1.2	1.2	--	--	--	--
115	251.2	4.9	--	--	1.0	3.9	--	--	--	--
Non-ORB BEAs	1,418.0	1,418.0	25.2	97.0	389.9	745.5	9.1	150.2	1.1	0
57	11.8	11.8	--	1.4	5.5	4.9	--	--	--	--
77	147.5	147.5	2.6	33.2	60.3	51.4	--	--	--	--
78	122.3	122.3	1.6	23.2	60.1	36.3	--	--	1.1	--
79	22.0	22.0	--	2.0	6.4	11.6	--	2.0	--	--
81	1.1	1.1	--	--	1.1	--	--	--	--	--
89	6.4	6.4	--	--	3.3	3.1	--	--	--	--
91	445.1	445.1	9.5	14.6	68.7	290.3	5.8	56.2	--	--
103	3.3	3.3	--	--	--	2.2	--	1.1	--	--
107	13.2	13.2	--	1.0	5.7	6.5	--	--	--	--
108	1.1	1.1	--	--	--	1.1	--	--	--	--
111	383.9	383.9	6.7	4.1	63.8	219.3	1.1	88.9	--	--
112	1.1	1.1	--	--	1.1	--	--	--	--	--
113	25.8	25.8	1.2	6.0	9.5	9.1	--	--	--	--
114[b]	134.9	134.9	1.1	11.5	100.2	22.1	--	--	--	--
115[b]	6.4	6.4	--	--	2.0	3.3	1.1	--	--	--
117	1.1	1.1	--	--	--	--	1.1	--	--	--
119	85.7	85.7	2.5	--	1.1	82.1	--	--	--	--
134	2.2	2.2	--	--	--	2.2	--	--	--	--
138	1.1	1.1	--	--	1.1	--	--	--	--	--
141	2.0	2.0	--	--	--	--	--	2.0	--	--

(Continued)

Table 3. (Continued)

Origins	Destinations: Non-ORB BEAs	BEA 38	BEA 46[b]	BEA 111	BEA 114[b]	BEA 117	BEA 133	BEA 137	BEA 138	BEA 140	BEA 141	BEA 143
Total	4,035.0	4.4	19.1	2.2	17.8	1.0	2.2	76.1	3,896.0	3.1	10.1	3.0
ORB BEAs	4,035.0	4.4	19.1	2.2	17.8	1.0	2.2	76.1	3,896.0	3.1	10.1	3.0
46[a]	16.6	--	--	1.0	--	--	--	2.9	12.7	--	--	--
49	254.1	1.1	--	1.2	--	--	--	4.7	247.1	--	--	--
52	1.1	--	--	--	--	--	--	--	--	--	1.1	--
53[a]	34.6	--	1.0	--	--	--	--	1.1	32.5	--	--	--
54	103.8	--	--	--	--	--	--	--	103.8	--	--	--
55	1,853.7	2.0	5.9	--	9.2	--	--	41.6	1,782.6	3.1	6.3	3.0
56[a]	74.0	--	--	--	--	--	--	2.0	72.0	--	--	--
60[a]	234.7	--	1.4	--	1.1	--	--	3.1	229.1	--	--	--
61[a]	51.9	--	--	--	--	--	--	1.0	50.9	--	--	--
62	874.1	1.3	6.9	--	4.2	--	1.2	14.5	846.0	--	--	--
63[a]	179.9	--	1.4	--	1.1	--	--	3.0	174.4	--	--	--
64[a]	74.2	--	--	--	--	--	--	1.2	73.0	--	--	--
114	36.0	--	1.0	--	1.1	--	--	--	33.9	--	--	--
115	246.3	--	1.5	--	1.1	1.0	1.0	1.0	238.0	--	2.7	--
Non-ORB BEAs												
57												
77												
78												
79												
81												
89												
91												
103												
107												
108	** Traffic external to the Ohio River System **											
111												
112												
113												
114[b]												
115[b]												
117												
119												
134												
138												
141												

a. A non-waterside BEA origin or destination for waterborne traffic originating from or destined to port equivalents in the Ohio River System.
b. Waterborne traffic originating from or destined to port equivalents not located in the Ohio River System.
Source: U.S. Army Corps of Engineers, Waterborne Commerce by Port Equivalents, revised 1976.

Within the ORS hinterland, other PSAs shipped and received smaller amounts than the above-mentioned BEAs. It is expected that this pattern will remain relatively unchanged. Those BEAs that ship are, and will continue to be, major production points. Most ORS hinterland receivers are waterside grain processors who are and will be servicing the large southeastern livestock production market.

In 1976, over 16 percent of outbound waterborne grain flows originated in non-waterside BEAs, and about 9 percent of inbound flows were destined to non-waterside BEAs (Table 3).

B-2. Highlights of Important Links

Of the 5.5 million tons of grains transported in the ORS in 1976, 40 million tons (over 70 percent) were outbound shipments. Inbound shipments accounted for 25 percent of ORS Group V traffic. Less than 2 percent of the traffic was local to the ORS.

a. Local movements

Local movements of grain within the ORS have been and are expected to remain insignificant relative to total Group V waterborne movements. Local movements amounted to 129.0 thousand tons in 1976, about 2.3 percent of Group V waterborne traffic. The Ohio River was the origin for about 85 percent of the ORS local traffic. Most local traffic was destined for the Tennessee River (Table 4).

Given that grain is a long-haul, high value-to-weight commodity (with an average waterway haul well over 1,000 miles),[1] it is expected that local shipments will remain relatively insignificant.

b. Inbound movements

Inbound waterborne movements of grain to the ORS decreased dramatically between 1969-76, in terms of both total ORS waterborne grain movements and total ORS inbound movements of all commodities. In 1969, inbound movements accounted for more than 75 percent of ORS waterborne grain movements. By 1976, this percentage had decreased to 25 percent.

The Tennessee River was the principal destination for inbound grain. Between 1969-76, approximately 90 percent of grain inbound

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1. U.S. Army Corps of Engineers, Waterborne Commerce of the United States, 1976 ed. (New Orleans: COE, n.d.), Vol. V.

Table 4. Ohio River System: Waterborne Receipts of Grains, by River of Origin and River of Destination, 1976

(Thousands of tons)

	Destinations		
Origins	Total	Ohio River	Tennesee River
Total	1,547.0	165.9	1,381.1
Ohio River System	129.0	14.6	114.4
Green River	5.0	5.0	--
Ohio River	109.0	9.6	99.4
Tennessee River	15.0	--	15.0
Outside Ohio River System	1,418.0	151.3	1,266.7
Arkansas River	85.7	--	85.7
Gulf Intercoastal Waterway	2.0	2.0	--
Illinois Waterway	298.7	1.1	297.6
Lower Mississippi River	7.5	--	7.5
Missouri River	402.6	90.0	312.6
Upper Mississippi River	620.4	58.2	562.2
White River	1.1	--	1.1

Source: *U.S. Army Corps of Engineers*, Waterborne Commerce by Port Equivalents, revised 1976.

to the ORS was destined for the Tennessee River. Of the 1.4 million tons of grain received on the Tennessee in 1976, 1.3 million, or 92 percent, originated outside the ORS; 99.4 thousand tons originated on the Ohio, and 15.0 thousand tons originated on the Tennessee River (Table 4). This pattern remained relatively constant over time. However, the amount of grain destined for the Tennessee that originated within the ORS (i.e., on the Ohio and the Tennessee Rivers) increased from 3 percent of total Tennessee River receipts in 1969 to over 8 percent in 1976.

Total waterborne movements to the Tennessee decreased almost 50 percent in volume between 1969 and 1976, from 2.5 million to 1.4 million tons. In 1969, inbound grain destined for the Tennessee came principally from the Illinois Waterway and the upper Mississippi River. By 1976, the importance of these two rivers as origins for inbound movements to the Tennessee decreased (Table 4).

Wheat was the predominant inbound grain and consisted of hard wheat from Kansas that originated on the Missouri River, and spring wheat from Minnesota that originated on the upper Mississippi. These wheats are not grown in the PSAs and are necessary in the blending of wheats for the production of flour. Flour mills were the major wheat recipients.

In 1976, corn accounted for about 19 percent of inbound grain traffic and was destined primarily for feed manufacturers on the Tennessee River. Soybeans accounted for over 15 percent of total inbound grain traffic in 1976 and were destined for soyameal and oil processing plants on the Tennessee.

The Ohio River, the only ORS river other than the Tennessee to receive grain, received between 7 and 11 percent of total grain inbound to the ORS between 1969-76. Grain inbound to the Ohio River was destined principally for three PEs and was a type not grown locally in the ORS hinterland. These grains were hard red winter and durum spring wheats, destined for flour mills, and barley and rye, destined for Kentucky and Indiana for use by distillers in the production of whiskey.[1] Between 1969-76, no grain movements were destined for the Monongahela, Allegheny, Kanawha, Cumberland, Kentucky, Green, or Clinch/Emory Rivers or to the Barkley Canal.

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1. According to the Annual Statistical Review, 1977 ed., of the Distilled Spirits Council of the United States, Kentucky and Indiana produced over 80 percent of all whiskeys produced in the United States in 1976.

Inbound grain flows to the Tennessee River, and the ORS in general, decreased as grain production in states adjacent to the ORS increased and as Tennessee area consumption decreased. In addition, the strength of the Gulf export market made it relatively unattractive for a barge originating on the upper Mississippi or the Illinois Waterway to divert into the ORS.

c. Outbound movements

Outbound waterborne movements of grains from the ORS increased over 550 percent between 1969-76, at an average annual growth rate of 30.7 percent. This increase, from 619.2 thousand tons in 1969 to 4.0 million tons in 1976, can be attributed to the growth in the PSAs' production to meet growing domestic and export demand.

In general, ORS outbound waterborne grain flows between 1969 and 1976 were concentrated on the Ohio River, which accounted for more than 90 percent of the outbound flows. A major portion of the Ohio River's grain shipments, over 86 percent in 1976, originated on the Mt. Vernon-Cincinnati corridor. During the period, outbound flows also originated on the Cumberland, Green, and Tennessee Rivers (Table 5).

As shown in Tables 5 and 6, the lower Mississippi River was the most important destination for Ohio River outbound traffic in both absolute and relative terms. In 1969, the Baton Rouge-New Orleans export market of the lower Mississippi River received 553.7 thousand tons, or 75 percent, of the Ohio River's outbound movements. By 1976, the lower Mississippi's receipt of Ohio River movements increased more than 550 percent to about 3.6 million tons, or over 97 percent of the Ohio's outbound movements.

The past and future significance of the Ohio River is linked to two factors. First, it is bordered by those PSAs in the ORS hinterland in which growth in grain production has historically been concentrated. Second, the Ohio River has the best developed facilities to handle waterborne grain, with barge-loading facilities with good rail and truck route interchanges.

The lower Mississippi was important to the waterborne movements of grain in the ORS in general. Its export market strength drew outbound movements from the ORS and diverted inbound movements. In addition to flows from the Ohio River, the lower Mississippi attracted grain from the Cumberland, Green, and Tennessee Rivers.

Table 5. Ohio River System: Waterborne Shipments of Grains, by River of Destination and River of Origin, 1976

(Thousands of tons)

	Origins				
Destinations	Total	Cumberland River	Green River	Ohio River	Tennessee River
Total	4,164.0	12.0	176.0	3,840.4	135.6
<u>Ohio River System</u>	129.0	0	5.0	109.0	15.0
Ohio River	14.6	--	5.0	9.6	--
Tennessee River	114.4	--	--	99.4	15.0
<u>Outside Ohio River System</u>	4,035.0	12.0	171.0	3,731.4	120.6
Gulf Intercoastal Waterway	86.2	--	1.0	78.6	6.6
Houston Ship Channel	6.1	--	--	6.1	--
Lower Mississippi River	3,917.3	12.0	170.0	3,624.6	110.7
Missouri River	2.2	--	--	--	2.2
Mobile River	4.4	--	--	3.3	1.1
Upper Mississippi River	17.8	--	--	17.8	--
White River	1.0	--	--	1.0	--

Source: U.S. Army Corps of Engineers, <u>Waterborne Commerce by Port Equivalents</u>, revised 1976.

Table 6. Ohio River System: Waterborne Grain Shipments to the Lower Mississippi River, by Ohio River System Origin, 1969-76

(Thousands of tons unless otherwise specified)

Ohio River System origin	1969	1970	1971	1972	1973	1974	1975	1976	Average annual percentage change, 1969-76
Total	567.8	354.5	844.8	941.7	994.3	1,381.7	2,368.1	3,917.3	31.8
Cumberland	--	--	--	6.1	11.4	15.6	3.8	12.0	18.4[a]
Green	--	1.3	46.0	44.8	48.4	77.6	90.1	170.0	125.3[b]
Ohio	553.7	338.8	775.4	882.1	912.3	1,270.2	2,238.1	3,624.6	30.8
Tennessee	14.1	14.4	23.4	8.8	22.2	18.3	36.1	110.7	34.2

Note: Individual items may not add to total due to rounding.
a. Percentage change computed for 1972-76.
b. Percentage change computed for 1970-76.
Source: Waterborne Commerce by Port Equivalents, 1969-76, supplied by U.S. Army Corps of Engineers.

Table 6, which indicates total shipments from the ORS to the lower Mississippi between 1969 and 1976, shows the tremendous growth in lower Mississippi grain receipts from the ORS, at an average annual rate of 31.8 percent. The Green River's shipments to the lower Mississippi grew the fastest of any ORS river, followed by the growth of the Tennessee. Relatively, however, the Ohio River has been and is expected to remain the most significant ORS outbound shipper of grains to all destinations and particularly to the lower Mississippi.

The importance of corn, wheat, and soybeans in terms of outbound waterborne traffic from the ORS to the lower Mississippi is indicated in Table 7. Corn, wheat, and soybeans accounted for 98.7 percent of the lower Mississippi's receipts from the ORS in 1969, and for 99.7 percent in 1976. The growth in corn and wheat movements was phenomenal, most notably between 1974-76. As of 1976, corn was the predominant grain of the three.

Intermodal transfers of Group V products are common in the ORS hinterland in terms of truck-barge and truck-rail transfers, but rare in terms of rail-barge transfers.

The system by which grain flows from the grain surplus areas of Ohio, Illinois, and Indiana to the grain deficient areas of the South (Tennessee, Kentucky, Georgia, Mississippi, and Alabama) is complex and interactive. Grain moves by truck from one farm to another, or to country elevators that collect and merchandise grain. It then moves to consumption destinations by truck and rail. Riverside elevators receive grain by truck, both directly from the farm and from country elevators. The radius of a riverside elevator's drawing area served by truck ranges from 150 to 200 miles. These elevators have limited storage capacities and high turnover rates and generally have both rail and barge links, as well as rail and barge loading facilities. Multimode capability allows the larger elevators flexibility in responding to various market demands and price situations.

Discussions with industry experts and ORS shippers indicate that rail-to-barge or barge-to-rail links are rare and are generally in response to short-term cyclical market conditions. It may become profitable for a waterborne receiver (grain merchandiser) with a rail link to send grain receipts to a market where prices are more favorable because of higher than usual demand.

Table 7. Ohio River System: Waterborne Grain Shipments to the Lower Mississippi River, by Grain Type, Selected Years, 1969-76

(Thousands of tons unless otherwise specified)

	1969	1971	1973	1974	1976	Average annual percentage change, 1969-76
Corn	166.5	252.3	470.2	482.8	2,607.0	48.1
Soybeans	353.7	472.6	489.9	610.5	789.7	12.2
Wheat	40.2	101.4	28.7	284.3	508.6	43.7
Other[a]	7.4	18.5	5.5	4.1	12.0	7.2
Total	567.8	844.8	994.3	1,381.7	3,917.3	31.8

Note: Individual items may not add to total due to rounding.
a. Other includes barley and rye, oats, rice and sorghum.
Source: Waterborne Commerce by Port Equivalents, 1969-76, supplied by U.S. Army Corps of Engineers.

C. Summary of Study Findings

The consumption of grain in the PSAs decreased at a annual rate of 0.86 percent between 1969-76. Total grain consumption, by each of the three end uses of grain (livestock feed, processing, and seed), decreased from 23.5 million tons in 1969 to 22.1 million tons in 1976. Grain consumed by livestock, representing on the average 75 percent of total consumption during the period, accounted for most of this decrease.

In the future, grain consumption is expected to increase at a gradual and steady rate of 0.54 percent per annum between 1976-2000. Total consumption of grain in the PSAs is expected to reach 22.4 million tons in 1980 and 23.3 million tons in 1990. Beyond 2000, grain consumption is expected to increase at a decreasing rate, reaching a level of 27.1 million tons in 2040. Corn will be the predominant grain consumed, and livestock will remain the major consumer of all grain.

Between 1969-76, the production of grain in the PSAs increased at an average annual rate of 7.0 percent. Although production was concentrated in PSAs in Indiana, Illinois, and Ohio, the greatest growth was experienced in the PSAs in the southern states. The PSAs' grain production growth exceeded U.S. production increases, and during this period the PSAs increased their relative share of U.S. total production of corn, wheat, and soybeans. The PSAs' grain production increased from 15.9 million tons in 1969, 7.7 percent of U.S. production, to 25.6 million tons, approximately 9.2 percent of U.S. production. The production mix remained relatively stable over time, with corn representing approximately 74 percent of ORS hinterland's total production of corn, wheat, and soybeans. Of these three grain types, soybeans represented about 18 percent of grain production in the PSAs, and wheat represented about 8 percent of production.

Grain production in the PSAs is expected to increase at a annual rate of 1.01 percent between 1976 and 2000. A notable decrease is expected to occur between 1976 and 1980, when production will drop more than 20 percent from 25.6 million tons to 19.9 million tons. This projected decrease is based on anticipated decreases in the production of corn. Most of this decrease is projected to occur in the southern section of the ORS hinterland, specifically Tennessee and Kentucky.

Decreases in future grain production in the PSAs can be attributed to reduction in corn acreage. Because of declining prices, farmers are expected to either enter the feed grain program or plant soybeans, a more profitable crop. Each acre of planted corn produced 87.9 bushels in the ORS hinterland in 1976, and each acre of soybeans produced 29.9 bushels. By planting soybeans rather than corn, each acre will produce fewer tons of grain. Thus the total grain production (in terms of tonnage) for the PSAs is expected to decline.

Beyond 1980, grain production in the PSAs is expected to increase, reaching a level of 25.2 million tons in 1990 and rising to 46.4 million tons in 2040. BEAs 49 (Nashville), 54 (Louisville), 55 (Evansville), 60 (Indianapolis), 62 (Cincinnati), 63 (Dayton), 64 (Columbus), and 115 (Paducah) are expected to remain the prime ORS hinterland production areas.

In 1976, waterway movements of grain totalled 5.6 million tons for the ORS. Of this total, 4.0 million tons were outbound movements, 1.4 million tons were inbound, and 129 thousand tons were local. Beginning in 2000, the margin between ORS hinterland grain production and consumption is expected to widen, and more grain will be available for shipment. As of 2000, of the total amount of grain available for shipment, approximately twice as much will be shipped out of the hinterland by rail as by water.

Between 1976 and 1980, waterway flows are expected to decrease, dropping from a 1976 level of 5.6 million tons to 4.2 million tons. After 1980, waterway movements are expected to increase steadily to 6.0 million tons by 2000 and to 8.6 million tons by 2040. Over the entire period 1976-2040, inbound waterborne movements are expected to decrease at an average annual rate of 0.52 percent. However, outbound movements are expected to increase an average 0.95 percent per annum, and local movements are expected to increase at a rate slightly faster than outbound but to remain small relative to total waterborne grain movements in the ORS.

II. MARKET DEMAND ANALYSIS

Projections of future grain consumption in the PSAs generally have been based on assumptions about the future that underlie analyses and projections of the U.S. Department of Agriculture (USDA). As the premier agricultural research entity in the United States, USDA has resources and experience that could not be duplicated by this study.

Consumption of grains in the PSAs decreased slightly between 1969-76, from 23.5 million tons to 22.1 million tons. Consumption decreased most rapidly in those PSAs that were the largest producing areas. Consumption is accounted for by three end uses: livestock feed, processing, and seed. Between 1969-76, livestock consumption accounted for approximately 75 percent of total grain consumption, processing accounted for approximately 23 percent, and seed for about 2 percent. This pattern of consumption is expected to remain relatively constant. Consumption of grains in the PSAs is expected to increase by 14 percent between 1976 and 2000, and by 8 percent between 2000 and 2040.

A. Market Areas

In addition to local demand for Group V commodities produced in the PSAs, demand is generated by Secondary Consumption Areas (SCAs) located outside the ORB. These SCAs are defined as BEAs that are the destinations of waterborne movements originating in the Ohio River Basin.

A-1. Primary Study Areas (PSAs)

This study has identified 19 BEAs and BEA segments in the ORB that either have been or will be the ultimate origins or destinations of waterborne grain movements. Table A-1 presents the BEAs and BEA segments that constitute the PSAs for grains, and for which grain consumption has been analyzed and projected.

The delineation of the Primary Study Areas for grains was the result of an extensive and thorough process. RRNA, in conjunction with a grain commodity expert familiar with the region, considered a series of PSA delineations of likely hinterlands based on surplus production, distance from the river, waterside facilities, and physical barriers. The accuracy of the PSA hinterland chosen was confirmed by conversations with major ORS shippers and receivers.

A-2. Secondary Consumption Areas (SCAs)

BEAs outside the Ohio River Basin that are destinations of waterborne grain shipments from the ORS hinterland have not been segmented. It should be recognized that many of these destination BEAs are not the points of ultimate consumption for grains produced in the PSAs. Rather, they are distribution centers from which grain moves into foreign (export) trade or to other areas where final consumption occurs.

Much of the grain produced and shipped from Illinois, Indiana, and Ohio (the primary producing states in the area served by the ORS) is destined for southern states and for export abroad (Table 8). The northeast market generally is served by Ohio production. The northeastern states that are destinations of production from these three "Corn Belt" states are New York, Pennsylvania, and New Hampshire. This northeastern market is served by truck and rail. The western market accounted for less than 1 percent of interstate shipments from Illinois, Indiana, and Ohio in 1970.

Of the grain produced in and shipped from Ohio, Illinois, and Indiana in 1970, more than 37 percent was destined for the South (Table 8). The state-level distribution pattern of grain shipped to the South from the latter three states is shown in Table 9.

The southern states are the primary domestic market for grain grown in the PSAs. These states, in general, are deficit feed grain areas, with large grain-consuming animal industries, mainly poultry. Although these states may have harvest time surpluses sufficient to handle area demand temporarily, throughout the year they are generally net importers.

Over 80 percent of interstate grain received by the five southern states of Alabama, Georgia, Kentucky, Mississippi, and

Table 8. Illinois, Indiana and Ohio Grain Shipments by Destination, 1970

(Thousands of bushels unless otherwise specified)

Origins	Destinations					
	Other corn belt states	West	Northeast	South	Export	Total interstate shipments
Illinois	85,002	7,710	9,860	282,753	281,712	667,037
Indiana	103,805	20	15,285	103,611	137,745	360,466
Ohio	20,928	--	43,780	78,258	83,580	226,546
Total	209,735	7,730	68,925	464,622	503,037	1,254,049
As a percentage of total interstate shipments	16.6	0.6	5.5	37.1	40.1	100.0

Source: Stallings, T. L., Harris, J. M. and Sappington, C. Grain Movements Between Southern and Corn Belt States, Southern Cooperative Series, Bulletin No. 209, March 1976.

Table 9. Indiana and Ohio Grain Shipments Destined to the South, by State, 1970

(Thousands of bushels unless otherwise specified)

	Destinations					
Origins	PSA state[a]	North and South Carolina	Virginia and West Virginia	Florida	Louisiana	Total South
Illinois	258,314	1,739	--	9,334	13,366	282,753
Indiana	97,071	4,424	362	1,754	--	103,611
Ohio	21,161	26,764	30,298	35	--	78,258
Total	376,546	32,927	30,660	11,123	13,366	464,622
As a percentage of total interstate shipments to the South	81.0	7.1	6.6	2.4	2.9	100.0

a. Alabama, Georgia, Kentucky, Mississippi and Tennessee.

Source: Stallings, J. L., Harris, J. M. and Sappington, C. Grain Movements Between Southern and Corn Belt States, Southern Cooperative Series, Bulletin No. 209, March 1976.

Tennessee originated in Ohio, Illinois, and Indiana. Grain produced and shipped from these states was destined for other southern states, but in relatively small amounts (Table 10).

A-3. The Export Market

Forty percent of the grain (over 500 million bushels) produced and shipped from Indiana, Illinois, and Ohio in 1970 was destined for export points and shipped by rail and/or water (Table 9). The Toledo and Chicago export centers of the Great Lakes drew grain from the three ORS hinterland "Corn Belt" states; Chicago drawing from northern Illinois and northeast Indiana, and Toledo from central and northwest Indiana and north central Ohio.[1]

In addition to Toledo, the Gulf Coast ports and the Port of Baltimore are important export centers for ORS hinterland grain, and for export-bound Corn Belt grain in general. Baltimore receives grain by rail from the Midwest and serves the European market, primarily the Netherlands, West Germany, Italy, the United Kingdom, and Spain. Midwest and ORS hinterland grain also is railed to Norfork, Charleston, and Mobile for export.

In terms of U.S. waterborne grain traffic, the Baton Rouge-New Orleans area received over 90 percent of the corn, 97 percent of the soybeans, and 40 percent of the wheat that originated from identified shipping areas on the inland waterways between 1970-74.[2] The Baton Rouge-New Orleans area is expected to continue to provide a strong market for surplus ORS hinterland grain production. In 1976, the Baton Rouge-New Orleans area exported 43.6 million tons of the approximately 104 million tons of grain exported from the United States.[3] The Ohio River System accounted for about 10

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1. The Great Lakes accounted for approximately 8 percent (8.7 million tons) of U.S. grain exports in 1976. U.S. Army Corps of Engineers, Waterborne Commerce of the United States, 1976 ed. (New Orleans: COE, n.d.), Vol. V.

2. U.S. Department of Agriculture, Economic Research Service, Water Carriers and Inland Waterways in Agricultural Transportation, Agricultural Economic Report No. 379, by Floyd D. Gaibler (Washington, D.C.: USDA, 1977).

3. U.S. Army Corps of Engineers, Waterborne Commerce of the United States, 1976 ed. (New Orleans: COE, n.d.) Vol. V. The ports of New Orleans and Baton Rouge accounted for approximately 40 percent of U.S. grain exports in 1976. The amount of PSA grain destined for export via other ports, coastal or Great Lakes, is unknown.

Table 10. Alabama, Georgia, Kentucky, Mississippi and Tennessee Grain Receipts by Origin, 1970

(Thousands of bushels unless otherwise specified)

	Origins									
	12 southern states	Illinois	Indiana	Ohio	Iowa	Missouri	Minnesota	Kansas	Others[a]	Total interstate receipts
Destinations										
Alabama	4,209	67,479	9,177	1,094	4,263	3,609	10,610	1,501	--	101,942
Georgia	23,121	60,771	24,222	1,708	--	10,771	--	--	1,811	122,404
Kentucky	592	10,671	37,400	9,864	--	250	2,031	--	157	60,965
Mississippi	2,337	53,030	11,770	--	5,787	5,869	859	484	2,028	82,164
Tennessee	7,603	66,363	14,502	5,710	582	2,488	5,873	7,060	7,057	117,238
Total	37,862	258,314	97,071	18,376	10,632	22,987	19,373	9,045	11,053	464,622
As a percentage of total interstate receipts	7.8	53.3	20.0	3.8	2.2	4.7	4.0	1.9	2.3	100.0

a. Michigan, Nebraska, South Dakota and Wisconsin.

Source: Stallings, J. L., Harris, J. M. and Sappington, C. Grain Movements Between Southern and Corn Belt States, Southern Cooperative Series, Bulletin No. 209, March 1976.

percent, or 3.9 million tons, of the area's exports in that year. This was 97 percent of outbound ORS waterborne grain movements, and over 70 percent of total waterborne grain movements.

The export market is anticipated to remain the dominant force in U.S. grain production. The importance of the export market to the United States and the Ohio River System hinterland is illustrated by the fact that the output of one out of every three acres in this country was exported, compared to one out of every five acres a decade ago. The quantity of corn, wheat, and soybeans exported from the United States increased 137 percent between 1969-76. The value of these exports increased between 1969-76 from $2.2 billion to $12.7 billion, expressed in current dollars.

B. Commodity Uses

Corn, wheat, and soybeans are the principal grains produced in the United States and constitute almost all waterborne grain traffic in the ORS. Other grains (such as barley and rye, oats, rice, and sorghum) move in relatively small quantities on the waterway.

B-1. Corn, Wheat and Soybeans

Corn is primarily a feed grain that is converted into pork, beef, poultry, and dairy products. Wheat, primarily a food grain, is converted into cereals or into flour for use by the baking industry in bread and other bakery products. The principal products from soybeans are oil and meal. As a major source of food fats and oils, soybeans are now the largest single source of vegetable fats and oil. Since 1950, soybean oil has exceeded cotton seed oil as the principal oil source in the manufacturing of both margarines and shortenings. The importance of soybean meal as a protein animal feed has increased rapidly, presently accounting for over half the total protein feed supply. Table 11 specifies in bushels and percentages the use of corn, wheat, and soybeans for feed, industrial purposes, seed, and exports in 1975.

Nearly 62 percent of the wheat produced in the United States was exported in 1975. Approximately 29 percent was used in food and for industrial purposes, primarily flour. Only 4 percent moved directly as feed, and 5 percent was used for seed. In the foreseeable future, it is probable that foreign demand will continue to provide the most important markets for U.S. wheat.

Most of the wheat consumed domestically is ground for edible flour. There are seven classes of wheat, as designated in the official grain standards of the U.S. Department of Agriculture: hard red spring wheat, soft red winter wheat, white winter wheat, hard red winter wheat, durum wheat, red durum wheat, and mixed wheat. Mixtures of wheats to obtain specific flour characteristics are common. The soft wheats produce flour used in baked goods, such as pies, pastry, and cakes. The hard wheats are used in making breads and rolls. Durum wheats are used in making pastas. Wheat is also used for making beer and, at times, is used in the production of starch and alcohol.

Approximately 62 percent of all corn consumed in the United States in 1975 was fed to livestock (Table 11). An additional 30 percent moved into the export market, primarily to Japan and to the European Common Market countries. Smaller quantities also moved into Eastern Europe and to the developing countries of the world. More than 90 percent of corn exported is to be used as feed grains.

Corn will continue to be the most important feed grain produced in the United States. Exports will continue to grow as incomes increase in Europe and in Asia. Food and seed use of corn will remain relatively small.

Food uses of corn include starch, corn syrup, corn sugar, alcohols, alcholic beverages, and corn oil. Corn oil is used as an edible oil and also is used in soaps, belt dressings, core oils, paints and varnishes, and in the manufacture of rubber substitutes. Corn-derived confectionary flakes are used as an additive and conditioner in candy, cookies, and pastries. Corn syrup, derived from the germ of the corn, is a fast-growing sugar substitute in soft drinks and also is used in ice cream, candy, citrus imitations, cereal coating, and by the canning industry. Non-food uses of refined corn syrup (dextrose) include use as a base for the manufacture of lactic acid, sorbitol, and mannitol, which are industrial chemicals of growing usefulness. Corn starch is used predominantly by the paper industry and is used in powdered sugar, pie crusts, cake mixes, paint, wallboard, and ceiling tiles. Protein derived from corn is used for producing hard, tough, grease-resistant coatings and for formulating polishes and inks. Corn tassels are used for livestock and poultry feed, and corn stalks are used as cattle feed.

Soybeans are primarily crushed into oil and meal. In 1975, 58 percent of soybean production was crushed, and 37 percent was exported to foreign countries (Table 11). Soybeans are exported

Table 11. United States: Utilization of Corn, Wheat and Soybeans, 1975

Use	Wheat		Corn		Soybeans		All grains[a]	
	Millions of bushels	Percent	Millions of bushels	Percent	Millions of bushels	Percent	Millions of bushels	Percent
Livestock feed	81.0	4.2	3,558.0	61.8	12.0	1.0	3,651.0	39.9
Food and industrial use	559.0	29.3	491.0	8.5	865.1[b]	58.2	1,915.1	20.0
Seed	95.0	5.0	c		53.5	3.6	148.5[d]	1.6
Exports	1,173.0	61.5	1,711.0	29.7	555.0	37.2	3,439.0	37.6
Total utilization	1,908.0	100.0	5,760.0	100.0	1,486.5	100.0	9,154.5[e]	100.0

a. The total of corn, wheat and soybeans.
b. Beans crushed for food and feed purposes.
c. Included with food and industrial use.
d. Understated because corn for seed included with food and feed use.
e. May not add to total due to rounding.
Source: U.S. Department of Agriculture, Agricultural Statistics, 1977.

primarily to Common Market countries, Japan, and China. Less than 4 percent of the beans were used for seed, and less than 1 percent of raw beans were fed to livestock. It is expected that exports will remain strong, reflecting economic growth that is occurring in Europe and Japan.

Soybean oil is used almost exclusively as a food oil in the production of shortening, margarine, and cooking and salad oils. However, non-food uses, including uses as a drying oil for linoleum, as paint and varnish, and as a mix with linseed oil, account for about 7 percent of consumption. Soybean oil is also used in core oils, soaps, lubricants, and rubber compounding. Epoxidized soybean oil is used in vinyl and alkyd resins as a plasticizer and to increase heat resistance. Soybean flour is used in bakery food products, and soy proteins are used in canned soups and as meat extenders.

In total, nearly 40 percent of the use of corn, wheat and soybeans is for feed. Thirty-eight percent is exported, and approximately 20 percent is used for food and industrial purposes. Less than 2 percent is replanted as seed (Table 11).

B-2. Minor Grains

Barley and rye, oats, rice, and sorghum are other grains that moved in the ORS between 1969-76, but in relatively small quantities. Table 12 presents the uses of these grains in the United States in 1975.

Barley has a high protein content but low gluten; therefore, it is adequate as animal feed but makes a poor breadstuff. The chief non-feed use of barley is as malt, which is barley that has been germinated and then dried. Malt is used for making beer and malt extracts. Barley is also consumed directly by humans as pearl barley and in breakfast foods.

Oats, although one of the most nutritious of grains, is used predominantly as an animal feed. Rolled oats and oatmeal are used as cereal food and for some bakery products, but the grain is not suitable as a breadstuff. Oat hulls are used for the production of furfural[1] and other chemicals.

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1. Furfural is a liquid aldehyde used as a solvent and in making phenolic resins and furan. Furan is used in the manufacture of nylon.

Table 12. United States: Utilization of Barley, Oats, Rice, Rye and Sorghum, 1975

Use	Barley		Oats		Rice		Rye		Sorghum	
	Millions of bushels	Percent	Millions of bushels	Percent	Millions of bushels	Percent	Millions of bushels	Percent	Millions of bushels	Percent
Livestock feed	182	51.4	562	85.0	--	--	7.0	36.6	502	68.1
Food and industrial use	148	41.8	85	12.9	36.8	38.0	6.2	32.5	6	0.8
Exports	24	6.8	14	2.1	56.5	58.4	1.1	5.8	229	31.1
Seed	a	--	a	--	3.5	3.6	4.8	25.1	a	--
Total utilization	354	100.0	661	100.0	96.8	100.0	19.1	100.0	737	100.0

a. Included with food and industrial use.
Source: U.S. Department of Agriculture, Agricultural Statistics, 1978.

Rice is a cereal grass, and its predominant use is as direct food. The milling of rice leaves a by-product that is used as animal feed. Other by-product food uses of rice include flour, cereal, and puddings, and for the manufacture of starch and alcoholic beverages. Rice bran oil is used as a salad and cooking oil and in lubricants. Rice wax is used in polishes.

Rye is valued chiefly for the production of whiskey and alcohol and for feeding animals. Between 12 and 15 percent of the rye produced in the United States is used in distilled alcohols. When used for flour, rye is blended with wheat and other flours.

Sorghum is used almost exclusively as an animal feed. A limited amount is used as sorghum, or sorgo, syrup, which is high in mineral salts valuable as foods. The syrup contains sugars other than sucrose and can be used in some confectionery.

All five of these grains are used as seed. Rice, rye, and barley straw (the sunbleached and dry stalks of the plant) are tough and resilient straws, are used for packing, bedding, and in the production of strawboard.

C. Consumption Characteristics

The price of grain is determined by the interaction of derived demand and grain supply functions. As incomes, population, expected prices, and prices of competing and complementary goods change in the United States and in the world, the demand for meat, oil products, flour, and cereals changes. Grain is sold in an international market; therefore, the price and the movement of grain depends, in part, on world demand.

Grain prices also depend upon grain supply. Everything else being equal, increases in the supply of grain decrease price. The United States has had an historical comparative advantage in the production of grain. Although production abroad is increasing (e.g., Brazil is making inroads into world grain markets, especially soybeans), the United States will be in a favorable competitive production position for the remainder of this century.

Grain prices in local markets are based on prices quoted in the formal futures markets. Therefore, if the price for delivery in December is $2.20/bushel for corn in the futures market, an elevator operator may offer 30 cents less, or $1.90/bushel, to the local farmer. The extent to which the offer is less than the futures market price depends on the location of the local market relative to markets in which the local elevator will be selling grain, local transportation costs, the supply of grain, storage capacities, and local demand. It is important to note that the futures market reflects expected prices in some future period, and the price in the local market reflects current supply and demand relationships.

C-1. Corn, Wheat, and Soybeans

As indicated above, corn is primarily consumed as feed, wheat is processed into flour, and soybeans are crushed into meal and oil. The consumption characteristics of these grains are determined by their end-uses and by the market conditions affecting their end-uses.

a. Feed Grain Consumption

Changes in the number of animal units fed from one year to the next are determined mainly by the change in the total supply of feed concentrates and by the relative levels of feed and livestock prices. Effective price levels are those that prevail when farmers are making decisions regarding the number of animal units to be fed during the crop year. Breeding for the fall pig crop takes place in the preceding spring, and breeding for the spring pig crop occurs in the preceding fall and winter. Hens fed during the crop year come mainly from chicks hatched the preceding spring. Thus, the number of animal units fed in the crop year, beginning in October, is determined mainly by the price levels prevailing during the corresponding calendar year.

A second factor influencing the number of animal units fed is the anticipated cost of feed grain. Obviously the higher the anticipated grain price, the higher the expected cost of the feed and the lower the profit expectations.[1] These results are obvious

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1. The feeding industry is very capital intensive, with a large demand for short-term borrowed money. The rise in interest rates that followed the Federal Reserve System's October 1979 credit-tightening actions impacted on the feeding industry markedly. One producer reported that his total dollar interest costs had risen to about $45 dollars for each head of cattle, from about $30 a head in the previous spring (Wall Street Journal, 5 December 1979, p. 38). Higher feed and interest costs significantly impact on the feeder's costs of putting a pound on one of his cattles. When the price for fed cattle is weak and the above conditions prevail, feedlots will be marginally profitable at best.

from the 1973-74 period when livestock numbers were reduced drastically as corn and soybean meal prices rose to record highs.

To some extent, grains can be substituted for one another in feeding. The controlling factors are the protein level and energy content (calories) that any one grain will provide relative to its price.

Corn is the major grain that is converted into feed because it has a relatively high feed value at a relatively low price. Sorghum has a relative feeding value ranging from 90 to 100 percent of the value of corn, depending upon the livestock species (Table 13).

In the foreseeable future, corn will be the major feed ingredient. Although sorghum is a near substitute for most species of livestock, it has a comparative disadvantage in terms of production. Most midwestern states produce corn rather than sorghum. Wheat can be substituted for corn, up to 50 percent in most grain rations. However, price differentials relative to its feed value prevent wheat from being used as feed. Given our existing feed and wheat programs, it is not likely that wheat will become a major feed grain by the year 2000. Oats and barley are poor substitutes, both in terms of the amount that can be included in the ration and in terms of their relative feeding value. In summary, corn is expected to be the major feed grain for the remainder of this century.

Grain fed livestock rations vary by species. For example, hogs and poultry must have large quantities of grain in their diets. On the other hand, the ruminant animals,[1] such as cattle and sheep, may have a high roughage ration or a high concentrate ration. Decisions by the farmer to feed grain to the ruminants are based on grain prices, roughage prices, and the price of beef and sheep. In general, during periods of inflated prices, or during a period of rising livestock prices and relatively cheap grain prices, grain, rather than high roughage diets, will be fed to the ruminants.

In addition to ration variation by species, grain fed to various livestock species varies by state or region, based on the relative prices of grains. The ration fed to the various livestock categories by both type of grain and by selected PSA states is shown in Table 14.

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1. Even-toed hoofed mammals that chew the cud and have a complex 3- or 4-chambered stomach.

Table 13. Nutrient Value of Selected Feeds Compared to Corn for Livestock and Poultry

(Percent)

Species	Wheat[a]	Sorghum[b]	Oats[c]	Barley[d]
Hogs	90-100	90-95	65-75	85
Cattle	100-105	90-95	85-90	95
Sheep	100-105	90-95	85-90	95
Poultry	100	20 or 100[e]	50-60	80[f]

a. Substitutability for corn up to 50 percent of grain ration.
b. Substitutability for corn up to 100 percent of grain ration.
c. Substitutability for corn up to 35 percent of grain ration.
d. Substitutability for corn up to 50-75 percent of grain ration.
e. Maximum 20 percent of bird resistant sorghum; 100 percent on yellow sorghum.
f. Standard weight barley.
Source: Ohio State University, Department of Animal Science Nutrition Specialists.

Table 14. Ohio River Basin: Livestock Feed Rations by Grain Type and Selected Livestock Category, for Selected Primary Study Area States

(Tons)

State and ration	Livestock category					
	Milk cows	Cattle on feed	Hens and pullets	Turkeys raised	Pigs raised	Sheep and lambs
Illinois						
Corn	1.7000	1.2300	0.0375	0.0360	0.4615	0.0650
Soybeans[a]	0.4250	0.0950	0.0070	0.0075	0.0550	0.0200
Wheat	b	0.0600	0.0025	0.0020	0.0225	b
Indiana						
Corn	1.3050	1.1625	0.0330	0.0175	0.3890	0.0955
Soybeans[a]	0.4000	0.0948	0.0080	0.0068	0.0650	0.0053
Wheat	b	0.0025	b	b	0.0075	b
Kentucky						
Corn	1.7640	1.5120	0.0330	0.0252	1.5120	0.0504
Soybeans[a]	0.3300	0.0660	0.0126	0.0055	0.0990	0.0044
Wheat	0.2100	0.1800	0.0050	0.0030	0.1800	0.0060
Tennessee						
Corn	1.5000	1.7565	0.0320	b	0.4455	b
Soybeans[a]	0.1425	0.0355	0.0070	b	0.0495	b
Wheat	0.0100	b	b	b	0.0010	b

a. Ration stated in soybean meal terms.
b. No ration fed.
Source: Compiled by RRNA from interviews with academic sources.

In determining the amount of grain that will be consumed by animals, waste or loss must also be included. It is normally assumed that an additional 5 percent of the total ration will be lost in the manufacturing and feeding process.

The amount of grain consumed by livestock will depend on the growth in the livestock industry, livestock cycles, technological changes, and institutional characteristics. The annual production of pork and poultry has steadily increased since 1950 (Table 15). Hog production varies from year to year because of the hog cycle, and poultry production increases rather consistently from one year to the next.

The hog cycle is approximately four years in length; therefore, the hog farmer will increase hog production in response to expected price increases and subsequently decrease production for four years in anticipation of falling prices. Variations occur in the four-year cycle due to fluctuations in the size of the corn crop (corn prices) and the impact of the cattle cycle.

Cattle production has been increasing very rapidly and cyclically (Table 15). Beef is the predominant source of meat, accounting for 45 percent of the total meat production in 1977. The cycle in beef cattle numbers is more than twice as long as is the cycle in hogs. Again, farmers increase beef production whenever prices are expected to increase and decrease production whenever prices are expected to decline. These livestock production decisions, with reference to anticipated prices, are based more on psychological than economic reasoning.

There is presently a down-trend in the cycle. The cycle should bottom out in late 1979 or early 1980. This suggests that by 1990 and the year 2000, the cattle industry could exhibit two full cycles.

Veal and lamb are not important contributors to meat production in the United States. In 1977, the veal and lamb industries contributed only 2 percent to total meat production (Table 15). These downward trends will not change in the foreseeable future.

Major technological changes and institutional changes have occurred in the poultry industry with modest changes in the cattle and hog industries. Research has substantially increased the rate of gain in the poultry industry. This means that less grain is required to produce a pound of poultry, and birds currently move to

Table 15. United States: Meat Production by Species, Selected Years, 1950-77

(Millions of pounds)

Year	Beef	Veal	Lamb and mutton	Pork	Poultry[a]	Total
1950	9,534	1,230	597	10,714	N.A.[b]	
1960	14,728	1,109	768	11,598	6,928	35,131
1965	18,699	1,020	651	11,142	9,556	41,068
1970	21,685	588	551	14,699	12,953	50,476
1975	23,976	873	410	11,779	13,975	51,011
1977	25,279	834	351	13,247	16,054	55,765

a. Live weight, poultry slaughtered under Federal inspection.
b. N.A. - not available.
Source: U.S. Department of Agriculture, Economic Research Service: Livestock and Meat Statistics. U.S. Department of Agriculture, Agricultural Statistics.

market in shorter periods of time than in the past. Poultry production has also moved into southern states because of the climatic advantages. This means that grain produced in the Midwest must be shipped into the South.

Some changes have also occurred in the beef and hog industries. Hogs and cattle, predominantly produced in the Midwest and West, are produced by independently owned farm firms. Large feedlots for cattle are growing in numbers, and large finishing operations are appearing in the hog industry. Vertical integration does not appear to be an important or growing institution in either of these industries.

Hogs and cattle are fattened in midwestern feedlots characterized by economies of scale, cheaper feed grains, adequate handling facilities, intensive management, and a ready market.

b. Grain Processing

Soybeans and wheat are processed into food and feed products. As previously indicated, soybeans have become the major source of protein feed for beef, hogs, and poultry. For example, in 1960, 8.8 million tons of soybean meal were fed to livestock. In 1977-78, the U.S. Department of Agriculture estimated that the domestic use of soybean meal had reached an all time high of 21.4 million tons. Substitutes for soybean meal protein include fish, palm, sunflower, peanut, and cottonseed meal. Soybeans will continue to be a very important source of protein for feed. As a result, the price of livestock and their products will have a direct bearing on the price of soybeans and their movements.

Soybean oil is also a very important product of processing. Ninety-three percent of the soybean oil produced in 1977 was consumed by the food industry; the non-food industry consumed the remaining 7 percent. This product is used in shortening, margarine, cooking and salad oils, paints and varnishes, resins and plastics, and other drying oil processes.

Since consumption of oil is increasing, changes in the demand factors, income, population, prices of competing goods and expected prices will have a direct impact on the price of soybeans. For the remainder of this century, soybean oil will be an important product. If economic growth continues, prices of soybeans can be expected to increase, resulting in increased production of soybeans relative to other grains.

Wheat, a food grain, is primarily processed into flour and cereal products. The per capita consumption of flour and cereal is relatively stable, averaging 107 pounds for flour and 2.9 pounds for cereal in 1977. Increases in demand for these products are influenced by population growth and changes in prices of competing products. Flour will continue to be an important ingredient in our diets, but wheat prices will be equally influenced by foreign demand for wheat. It must be kept in mind that more than 60 percent of the U.S. wheat has been exported in recent years.

c. Grains for Seed

The volume of grain used for seed is unimportant relative to other uses (Table 11). Many scientific breakthroughs relating to seed occurred in the first half of this century. Because of research and extension education efforts, most farmers are planting hybrid seeds. An important change in the last 15 years appears to be the increase in seeding rates for corn in the southern states. Since the utilization of grain for seed is a minor use of grain, changes in seeding rates will have only a minor impact on the price or movement of grain.

C-2. Minor Grains

The use of barley and rye, oats, rice, and sorghum as feed grains is limited relative to the use of corn, wheat, and soybeans. As stated earlier, sorghum is a near substitute for corn in terms of its relative feeding value. However, it has a comparative disadvantage because of the more abundant supply of corn. Oats and barley have considerably lower relative feeding value and can be substituted for corn up to 35 percent, between 50-75 percent of grain rations.

Price and demand for barley and rye are related to the brewing industry as well as to the livestock and food industries. Demand for rice is heavily influenced by the export market.

D. Existing Aggregate Demands

Between 1969-76 grain consumption in the PSAs averaged about 23 million tons annually. Much of the grain produced in the PSAs was consumed by the export market, but the majority was consumed domestically in the Northeast and in areas in the Southeast exterior to the ORS hinterland. The export market has been and is expected to remain a significant force in ORS hinterland grain production and the dominant force in the waterborne movement of grain. The export market at the Gulf Coast ports of New Orleans and Baton Rouge consumed about 90 percent of outbound waterborne shipments of grain from the PSAs. In 1976, the New Orleans-Baton Rouge export market for ORS waterborne grain accounted for over 15 percent of PSA production.[1] Grain produced in the PSAs and destined for export is also moved by truck and rail.

Between 1969-76, waterborne grain flows from the ORS to the Baton Rouge and New Orleans ports accounted for somewhat more than 5 percent of all grain exported from the United States. The volume and value of U.S. agricultural exports increased dramatically. Historical data show that the U.S. share of world grain trade increased from about 36 percent in the 1960-62 period to about 50 percent in the 1975-77 period. The developed countries consumed the largest share of U.S. grain exports, but in the present decade, the developing countries have increased their U.S. grain imports more rapidly than the developed countries.

D-1. Corn, Wheat, and Soybeans

Consumption of corn, wheat, and soybeans in the PSAs during 1969-76 fluctuated between 22.0 million tons and 24.7 million tons. However, in general consumption decreased during the period. In the ORS hinterland, as a whole, consumption was concentrated in 12 of the 19 PSAs, mostly in the southeastern area of the hinterland. BEAs 54 (Louisville), 44 (Atlanta), 60 (Indianapolis), 62 (Cincinnati), and 63 (Dayton), major producing PSAs, accounted for a large percentage of ORS hinterland grain consumption (Table 16). These BEAs were and are expected to be significant producers of meat, poultry, and food and dairy products for northeastern and southeastern U.S. markets. Corn was the predominant feed grain, followed by soybeans and wheat.

a. Livestock Consumption

Livestock is the major consumer of grain in the United States and in the area served by the ORS. Between 1969-76, on the average, livestock accounted for 75 percent of the corn, wheat, and soybeans consumed in the PSAs (Table 17). Livestock consumption was the largest single end-use of grain in most PSAs. As shown in

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1. The amount of ORS hinterland grain destined for export through other coastal ports and the Great Lakes is unknown.

Table 16. Ohio River Basin: Consumption of Grains,[a] by BEAs or BEA Segments,[b] 1969-76

(Thousands of tons unless otherwise specified)

BEA and BEA segment	1969	1970	1971	1972	1973	1974	1975	1976	Average annual percentage change, 1969-76
Primary Study Areas	23,459.3	24,706.7	23,906.1	23,215.7	23,315.5	22,287.7	21,950.6	22,081.5	(0.86)
BEA 44: Atlanta, GA	1,667.8	1,673.4	1,621.7	1,625.3	1,544.0	1,559.9	1,532.4	1,577.8	(0.79)
BEA 45: Birmingham, AL	1,295.8	1,311.7	1,319.6	1,323.8	1,258.5	1,214.8	1,218.8	1,272.9	(0.25)
BEA 46: Memphis, TN	385.4	385.1	433.8	368.7	370.0	386.4	373.3	310.9	(3.02)
BEA 47: Huntsville, AL	1,911.4	1,992.1	2,038.1	2,054.8	2,003.9	2,000.8	2,050.2	2,059.8	1.07
BEA 48: Chattanooga, TN	1,840.1	1,861.6	1,915.5	1,909.5	1,849.3	1,813.5	1,797.7	1,823.0	(0.13)
BEA 49: Nashville, TN	2,601.3	2,781.2	2,632.8	2,502.7	2,519.5	2,353.2	2,404.6	2,270.6	(1.92)
BEA 50: Knoxville, TN	342.0	338.6	357.2	371.6	334.6	329.5	343.0	326.7	(0.65)
BEA 52: Huntington, WV	320.3	326.2	309.6	285.1	308.0	266.0	271.6	256.2	(3.14)
BEA 53: Lexington, KY	1,230.4	1,437.6	1,278.0	1,188.1	1,196.8	1,168.4	1,198.3	1,177.8	(0.62)
BEA 54: Louisville, KY	1,910.6	2,071.7	1,892.4	1,837.2	1,865.4	1,783.8	1,752.9	1,778.6	(1.02)
BEA 55: Evansville, IN	2,782.1	3,054.8	2,828.4	2,744.5	2,740.2	2,617.1	2,472.8	2,550.5	(1.23)
BEA 56: Terre Haute, IN	100.8	112.6	103.7	88.3	92.4	88.6	73.6	83.4	(2.67)
BEA 60: Indianapolis, IN	1,804.2	1,893.0	1,845.3	1,784.3	1,791.2	1,763.4	1,639.3	1,760.8	(0.35)
BEA 61: Anderson, IN	189.3	188.3	193.1	161.8	178.0	167.9	164.7	164.8	(1.96)
BEA 62: Cincinnati, OH	1,298.2	1,374.4	1,325.4	1,276.3	1,399.6	1,187.9	1,168.7	1,202.3	(1.09)
BEA 63: Dayton, OH	1,645.8	1,678.1	1,683.2	1,669.3	1,758.0	1,692.5	1,615.0	1,602.7	(0.38)
BEA 64: Columbus, OH	638.9	650.4	644.5	609.8	695.7	559.8	561.1	539.1	(2.40)
BEA 114: St. Louis, MO	204.1	214.2	225.9	217.4	218.0	208.4	205.2	205.2	0.08
BEA 115: Paducah, KY	1,290.9	1,361.7	1,258.0	1,197.2	1,192.6	1,125.8	1,107.4	1,118.3	(2.03)

Note: Individual items may not add to total due to rounding. Data assembled on a county level and aggregated into BEAs and BEA segments.

a. Total consumption of corn, wheat and soybeans. Corn is corn for grain. Wheat is all wheat. Soybeans are soybeans for beans. Consumption of grains represents the addition of the consumption of corn, wheat and soybeans by livestock, seed and processing.

b. BEA segments defined as counties which are ultimate origins or destinations of waterborne movements.

Source: Livestock consumption was estimated by taking the number of livestock by county for 11 categories of livestock (milk cows, cattle on feed, other cattle, hogs and pigs, sheep and lambs, hens and pullets, other chickens, broilers, turkeys, and horses and mules) and multiplying by an annual ration provided by the U.S. Department of Agriculture Crop Reporting Services for each grain (corn, wheat and soya) for each of the eight states (Alabama, Georgia, Illinois, Indiana, Kentucky, Mississippi, Ohio and Tennessee). The rations were assumed to remain constant

(Continued)

Table 16. (Continued)

over the eight-year period. The livestock numbers were taken, to the extent possible, from data provided annually by the U.S. Department of Agriculture Crop Reporting Services for each of the eight states. Where only state totals were available, these were distributed on a county level based on the county distribution of the 11 livestock categories as provided by the U.S. Department of Agriculture, Census of Agriculture, 1974. Consumption of grains by processors was estimated by utilizing lists of grain processors by type of grain, capacity, and city and state location. These lists were provided by commodity experts. Processors were assigned to their appropriate county and BEA and BEA segment and assumed to be operating at capacity. Consumption of grains for seed was estimated by multiplying the BEA and BEA segment acres harvested for each grain by the crop seeding rate as provided for state and year in the U.S. Department of Agriculture, Agricultural Statistics (various years). A factor was included in the multiplication to reflect the difference between acres harvested and acres planted. Seeding rates were weighted for BEAs and BEA segments in two or more states, e.g., BEA 55.

[illegible] BEA Segment, [illegible] Estimated 1969-76

(Thousands of tons)

BEA and BEA segment	1969	1970	1971	1972	1973	1974	1975	1976
Primary Study Area	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	22,2[illegible].6	[illegible]	[illegible],281.5
Livestock	[illegible]	[illegible]	[illegible],44.4	[illegible]	[illegible]	16,534.1	[illegible]	16,319.5
Processing	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	5,42[illegible].4	[illegible]	5,42[illegible].4
Seed	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	341.6
BEA 44: Atlanta, GA	[illegible]	[illegible]	[illegible]	[illegible]	1,544.[illegible]	1,559.9	[illegible]	1,577.8
Livestock	[illegible]	[illegible]	[illegible]	1,247.2	1,165.5	1,180.7	1,152.6	1,198.2
Processing	[illegible]	[illegible]	377.0	377.0	377.0	377.0	377.0	377.0
Seed	1.3	1.0	1.1	1.1	1.5	2.2	2.9	2.6
BEA 45: Birmingham, AL	[illegible]	1,311.7	[illegible]	1,323.8	1,258.4	1,214.7	1,218.9	1,272.9
Livestock	1,263.1	[illegible]	[illegible]	1,295.6	1,228.0	1,183.8	1,185.2	1,239.4
Processing	19.6	19.6	19.6	19.6	19.6	19.6	19.6	19.6
Seed	[illegible]	[illegible]	[illegible]	8.6	10.8	11.3	14.1	13.9
BEA 46: Memphis, TN	[illegible].4	385.[illegible]	433.7	368.7	370.1	386.5	373.3	310.8
Livestock	[illegible]	361.5	409.5	344.1	344.8	360.4	345.1	282.7
Processing	16.5	16.5	16.5	16.5	16.5	16.5	16.5	16.5
Seed	6.9	7.0	7.7	8.1	8.8	9.6	11.7	11.6
BEA 47: Huntsville, AL	1,911.3	1,992.0	2,038.1	2,054.8	2,003.9	2,000.9	2,050.1	2,059.8
Livestock	809.8	890.4	934.5	949.9	897.1	892.3	937.5	948.6
Processing	1,091.3	1,091.3	1,091.3	1,091.3	1,091.3	1,091.3	1,091.3	1,091.3
Seed	10.2	10.3	12.3	13.6	15.5	17.3	21.3	19.9
BEA 48: Chattanooga, TN	1,840.1	1,861.7	1,915.5	1,909.6	1,849.2	1,813.6	1,797.7	1,823.1
Livestock	890.7	912.2	965.4	958.8	898.0	861.4	844.7	870.7
Processing	946.9	946.9	946.9	946.9	946.9	946.9	946.9	946.9
Seed	2.5	2.6	3.2	3.9	4.3	5.3	6.1	5.5

(Continued)

Table 17. (Continued)

BEA and BEA segment	1969	1970	1971	1972	1973	1974	1975	1976
BEA 49: Nashville, TN	2,601.2	2,781.3	2,632.8	2,502.6	2,519.5	2,353.2	2,404.6	2,270.6
Livestock	2,427.9	2,608.0	2,456.2	2,321.9	2,339.2	2,164.5	2,214.5	2,078.4
Processing	161.4	161.4	161.4	161.4	161.4	161.4	161.4	161.4
Seed	11.9	11.9	15.2	19.3	18.9	27.3	28.7	30.8
BEA 50: Knoxville, TN	342.0	338.6	357.2	371.5	334.6	329.5	343.0	326.7
Livestock	268.9	285.5	303.9	318.2	281.2	275.8	289.3	272.9
Processing	52.4	52.4	52.4	52.4	52.4	52.4	52.4	52.4
Seed	0.7	0.7	0.9	0.9	1.0	1.3	1.3	1.4
BEA 52: Huntington, WV	319.3	326.1	309.6	285.2	308.0	266.0	271.6	256.3
Livestock	318.8	325.6	308.9	284.5	307.2	265.1	270.7	255.4
Processing	--	--	--	--	--	--	--	--
Seed	0.5	0.5	0.7	0.7	0.8	0.9	0.9	0.9
BEA 53: Lexington, KY	1,230.5	1,437.7	1,278.0	1,188.2	1,196.8	1,168.3	1,198.3	1,177.8
Livestock	1,223.5	1,430.8	1,270.6	1,180.9	1,189.6	1,160.6	1,190.5	1,170.0
Processing	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6
Seed	1.4	1.3	1.8	1.7	1.6	2.1	2.2	2.2
BEA 54: Louisville, KY	1,910.5	2,071.7	1,892.3	1,837.3	1,865.4	1,783.8	1,752.9	1,778.7
Livestock	1,597.6	1,759.1	1,578.5	1,522.4	1,550.2	1,465.3	1,435.3	1,461.7
Processing	306.0	306.0	306.0	306.0	306.0	306.0	306.0	306.0
Seed	6.9	6.6	7.8	8.9	9.2	12.5	11.6	11.0
BEA 55: Evarsville, IN	2,782.0	3,054.8	2,828.3	2,744.5	2,740.1	2,617.0	2,472.8	2,550.5
Livestock	2,303.0	2,576.1	2,343.7	2,254.7	2,242.8	2,112.5	1,971.5	2,049.3
Processing	436.5	436.5	436.5	436.5	436.5	436.5	436.5	436.5
Seed	42.5	42.2	48.1	53.3	60.8	68.0	64.8	64.7
BEA 56: Terre Haute, IN	100.7	112.5	103.6	88.3	92.3	88.7	73.7	83.4
Livestock	96.3	108.5	99.3	84.0	87.8	83.2	68.4	78.0
Processing	--	--	--	--	--	--	--	--
Seed	4.4	4.0	4.3	4.3	4.5	5.5	5.3	5.4

(Continued)

Table 17. (Continued)

BEA and BEA segment	1969	1970	1971	1972	1973	1974	1975	1976
BEA 60: Indianapolis, IN	1,804.1	1,893.1	1,845.2	1,784.2	1,791.2	1,763.3	1,639.2	1,760.7
Livestock	1,142.5	1,233.3	1,183.9	1,120.4	1,124.9	1,093.5	970.8	1,092.1
Processing	632.4	632.4	632.4	632.4	632.4	632.4	632.4	632.4
Seed	29.2	27.4	28.9	31.4	33.9	37.4	36.0	36.2
BEA 61: Anderson, IN	189.3	188.3	193.1	161.8	178.0	167.9	164.6	164.8
Livestock	185.1	184.5	189.0	157.3	173.2	162.2	159.2	159.5
Processing	--	--	--	--	--	--	--	--
Seed	4.2	3.8	4.1	4.5	4.8	5.7	5.4	5.3
BEA 62: Cincinnati, OH	1,298.3	1,374.4	1,325.4	1,276.3	1,399.5	1,188.1	1,168.7	1,202.4
Livestock	1,273.6	1,350.5	1,299.3	1,248.6	1,370.0	1,156.5	1,136.9	1,171.2
Processing	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7
Seed	17.0	16.2	18.4	20.0	21.8	23.9	24.1	23.5
BEA 63: Dayton, OH	1,645.7	1,678.1	1,683.2	1,669.3	1,758.1	1,692.4	1,614.9	1,602.6
Livestock	777.7	810.4	812.7	795.9	882.3	813.0	732.8	721.8
Processing	841.2	841.2	841.2	841.2	841.2	841.2	841.2	841.2
Seed	26.8	26.5	29.3	32.2	34.6	38.2	40.9	39.6
BEA 64: Columbus, OH	638.9	650.4	644.5	609.8	695.6	559.8	561.1	539.0
Livestock	568.3	579.4	571.6	534.7	619.3	479.7	478.9	457.6
Processing	45.9	45.9	45.9	45.9	45.9	45.9	45.9	45.9
Seed	24.7	25.1	27.0	29.2	30.4	34.2	36.3	35.5
BEA 114: St. Louis, MO	204.1	214.3	225.9	217.5	218.0	208.5	205.2	205.2
Livestock	194.2	206.7	216.7	206.7	206.5	196.8	193.8	192.8
Processing	--	--	--	--	--	--	--	--
Seed	9.9	7.6	9.2	10.8	11.5	11.7	11.4	12.4
BEA 115: Paducah, KY	1,290.9	1,361.7	1,258.1	1,197.2	1,192.6	1,125.7	1,107.4	1,118.3
Livestock	800.7	870.7	764.5	700.9	696.0	627.0	601.1	619.0
Processing	480.0	480.0	480.0	480.0	480.0	480.0	480.0	480.0
Seed	10.2	11.0	13.6	16.3	16.6	18.7	26.3	19.3

(Continued)

Table 17. (Continued)

Note: Individual items may not add to total due to rounding. Data assembled on a county level and aggregated into BEAs and BEA segments.

a. Total consumption of corn, wheat and soybeans only. Corn is corn for grain. Wheat is all wheat. Soybeans are soybeans for beans.

b. BEA segments defined as counties which are ultimate origins or destinations of waterborne movements.

Source: Livestock consumption was estimated by taking the number of livestock by county for 11 categories of livestock (milk cows, beef cows, cattle on feed, other cattle, hogs and pigs, sheep and lambs, hens and pullets, other chickens, broilers, turkeys, and horses and mules). Each category was multiplied by an annual ration provided by the U.S. Department of Agriculture Crop Reporting Services for each grain (corn, wheat and soya) for each of the states (Alabama, Georgia, Illinois, Indiana, Kentucky, Mississippi, Ohio and Tennessee). The rations were assumed to remain constant over the eight-year period. The livestock numbers were taken, to the extent possible, from data provided annually by the U.S. Department of Agriculture Crop Reporting Services for each of the eight states. Where only state totals were available, these were distributed on a county level based on the county distribution of the 11 categories as provided by the U.S. Department of Agriculture, Census of Agriculture, 1974. Consumption of grains by processors was estimated by utilizing lists of grain processors by type of grain, capacity, and city and state location. These lists were provided by commodity experts. Processors were assigned to their appropriate county and BEA and BEA segment and assumed to be operating at capacity. Consumption of grains for seed was estimated by multiplying the BEA and BEA segment acres harvested for each grain by the crop seeding rate as provided for state and year in the U.S. Department of Agriculture, Agricultural Statistics (various years). A factor was included in the multiplication to reflect the difference between acres harvested and acres planted. Seeding rates were weighted for BEAs and BEA segments in two or more states, e.g., BEA 55.

Table 18, in only a few BEAs [47 (Huntsville), 48 (Chattanooga) and 63 (Dayton)] did grain consumption by other end uses equal or exceed livestock consumption.

However, livestock consumption of corn, wheat, and soybeans in the PSAs decreased by more than 9 percent between 1969-76, declining from 17.8 million tons in 1969 to 16.3 million tons in 1976.

Of the 11 categories of livestock, the four poultry classes are predominant in the southeastern PSAs. Hogs and cattle raised in these PSAs generally are sent to the Midwest (Illinois and Indiana) to feedlots to be "fed-out" and marketed. This pattern exists because of the in-place administrative, management, and distribution structure for livestock production in the Midwest, as well as the distribution of grain surpluses.

b. Processing Consumption

As presented in Table 17, commercial processing accounted for between 22 and 25 percent of grain consumption in the ORS hinterland during 1969-76. Some PSAs had no processing capacity: namely, BEAs 52 (Huntington), 56 (Terre Haute), 61 (Anderson), and 114 (St. Louis). Eight of the 19 PSAs accounted for more than 90 percent of hinterland grain consumption by processors. In each of the eight BEAs [44 (Atlanta), 47 (Huntsville), 48 (Chattanooga), 54 (Louisville), 55 (Evansville), 60 (Indianapolis), 63 (Dayton), 115 (Paducah)] there was and is a soybean processor.

For the ORS hinterland, in general, soybean processors represented about 64 percent of total processing capacity between 1969-76. Corn processing capacity, both wet and dry-milling, accounted for 24 percent of ORS hinterland grain processing capacity, and wheat processing capacity accounted for approximately 12 percent.

Processing capacity is concentrated largely in the southeastern PSAs. In these areas, processors are frequently part of integrated poultry farms (i.e., the processor prepares the feed and owns and markets the birds).

c. Seed Consumption

Consumption of grain for seed is a minor end-use and accounted for less than 1 percent of total grain consumption in 1970 to more than 1.5 percent in 1976. Between 1969-76, ORS hinterland seed consumption increased 56 percent from 218,400 tons to 341,600 tons. This increase is directly related to the increases in grain production in the PSAs. By PSA, there is some variation in the percentage share that seed consumption represents of total grain consumption, depending upon the presence and capacity of processors and the concentration of livestock production.

In general, grain consumption for seed was greater and grew at a faster rate in those PSAs in which ORS hinterland grain production was significant and growing. Examples include BEAs 49 (Nashville), 55 (Evansville), and 60 (Indianapolis).

D-2. Minor Grains

U.S. aggregate demand for barley and rye, oats, rice, and sorghum was presented earlier in this report under commodity uses. As discussed, the major end-use for all of these minor grains, except rice, is animal feed. Barley and rye are also used in the production of distilled spirits and beer. Most rice is consumed as food.

Export demand between 1969-75 for these five grains, as a percent of total U.S. supply (beginning stocks + production + imports), averaged as follows:

Barley	8.6 percent
Oats	1.8
Rice	51.0
Rye	12.4
Sorghum	20.2[1]

In general, these minor grains are consumed on the farms where they are produced. For the eight states in the ORS hinterland that have counties which comprise PSAs, minor grain use on farms where produced, as a percent of production, in 1976 was as follows:

Barley	61.9 percent
Oats	54.8
Rice	0.5
Rye	38.0
Sorghum	61.6[2]

1. U.S. Department of Agriculture, Agricultural Statistics, 1977 ed. (Washington, D.C.: USDA, 1978).
2. Ibid.

In 1970, all rye that was produced in Illinois, Ohio, and Indiana, and that was not consumed on the farm where produced or within the state, was destined for Kentucky. Almost all barley went to Corn Belt states other than Illinois, Ohio, and Indiana. Sorghum was destined for Alabama, Georgia, and Louisiana. About 45 percent of oat shipments was destined for other Corn Belt states, with the Northwest and the South each receiving an additional 20 percent.[1]

E. Forecasting Procedures and Assumptions

Regional-level projections of livestock production (grain consumption) that correspond to the Ohio River System hinterland do not exist. Livestock production projections for the states that contain PSAs of the ORS hinterland exist but were found to be inadequate in that the time frames, assumptions, and base data did not correspond.

National agriculture projections of the USDA were selected as the state-level base for projections of grain consumption in the PSAs. These projections were developed by a computer model that simulates the farm production sector with linkages to the natural resource base, the food consumption sector, the general economy, farm inputs, and world trade.

E-1. U.S. Department of Agriculture: National Interregional Agricultural Projections Systems

The USDA National Interregional Agricultural Projections Systems (NIRAP) provides nationally and interregionally consistent projections under a wide range of assumptions. The model starts from the national level and disaggregates national projections to regional and state levels by individual commodities.[2] The presence and interaction of several factors (such as historical commodity production and utilization, cropland availability, and anticipated future food prices) are considered in the model.

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1. J.L. Stalling, et al., Grain Movements Between Southern and Corn Belt States, Southern Cooperative Series, No. 209 (Auburn, AL: Alabama Agricultural Experiment Station, 1976).

2. National projections are disaggregated to state levels based on a varying distribution of state shares of national production over time.

NIRAP system scenarios are precise statements of assumptions and/or projections required to describe the "environment" of the agricultural economy. The baseline scenario was chosen with variables that constitute boundaries of assumed growth ranges for major attributes, such as income, that cause non-price related shifts in the quantity of major commodities and aggregate output demanded and supplied. The model allows for adjustments in response coefficients and elasticities, where logic and consistency require, to allow for changes in producers' and consumers' responses to price.

The attributes quantified in the scenario bounds are divided into demand and supply shift attributes:

Demand Attributes	Supply Attributes
Domestic population growth	Public expenditures for research and extension
Domestic income growth	Environmental controls
Taste and preferences (meat substitutability)	Inflation
Agricultural trade	Climate

The baseline can be interpreted as the midpoint of possible combinations of attribute values falling in a range considered manageable.

The projected demand and supply attributes for the baseline food and agricultural scenario for 1985, 1990, and 2000 for the United States are presented in Table 18.

State and commodity level projections are generated by USDA for the years 1985, 1990, and 2000, providing a consistent and comparative set of projections. These are generally regarded as the best set of state and commodity level projections available.

USDA's state level livestock production projections for the years 1985, 1990, and 2000 are in millions of pounds for cattle, hogs, sheep, chickens, broilers, and turkeys; in millions of eggs for hens and pullets; and in pounds of milk for dairy cows. Pounds of livestock, number of eggs and pounds of milk were converted into livestock numbers for the period 1985, 1990, and 2000. State level

Table 18. Grains: Projected Demand and Supply Attributes, Baseline Scenario, 1985, 1990 and 2000, United States

Attribute and level	Actual 1975-77	1985	1990	2000
Demand				
Population growth (millions)				
Series II	215.2	232.9	242.3	260.4
Economic growth (GNP) (billions 1972 dollars)				
Moderate (3.0 percent/year)	1,271.4	1,594.4	1,848.4	2,484.0
Economic growth (per capita disposable income) (1972 dollars)				
Series II population - moderate GNP	4,148.0	4,876.0	5,497.0	7,005.0
Tastes and preferences (percent meat substitutes)	2-5	2-5	2-5	2-5
Agricultural trade	High	Moderate	Moderate	Moderate
Supply				
Public expenditures for agricultural research and extension program (millions 1972 dollars)				
3.0 percent growth	795.0[a]	1,155.8	1,339.0	1,800.7
Inflation index (1972 = 100)				
Moderate (5.0 percent year)	116.0	171.0	218.3	355.6
Climate (Index)[b]				
Neutral	97.0	101.6	101.6	101.6

a. 1973-75 average.

b. The Stallings' weather index. This index is designed to measure the direct influence of weather and the indirect influence of insects and disease on agricultural output. Variables such as crop variety, soil and certain cultural practices are held constant. The index is computed as the ratio of the actual to the computed yields of a linear regression. An index value of 100 is normal weather. Adverse weather would yield values less than 100 and better than normal weather would yield values greater than 100.

Source: Leroy Quance, et. al., Adjustment Potential in U.S. Agriculture, Volume I: Scenario, Production, Price and Income Projections to 1985, 1990 and 2000, U.S. Department of Agriculture, Economics, Statistics, and Cooperatives Service, Economic Projections and Analytical Systems, National Economic Analysis Division, Washington, D.C.: n.d.

livestock numbers for 1980 were estimated by interpolating backwards an annual growth trend line of the 1974-76 base to 1985.

E-2. Disaggregation of State Level Data to BEA Level

For the period 1969-76, the number of each of the 11 different categories of livestock produced by PSA was identified and divided by the state total to derive a percentage share produced in each PSA. Linear regression analysis in conjunction with expert judgment was used to allocate percentage shares for each PSA for the projection period to the year 2000. These projected percentage shares were multiplied by the USDA projected state livestock numbers, by category. Thus, USDA projections of livestock production were allocated to each PSA.

Projections of livestock production to 2040 were estimated by determining, for each PSA, the difference between a livestock production average of 1974-76 and 2000 and dividing this difference by two and allocating this to 2040. Thus, the rate of increase in livestock numbers between 2000 and 2040 is one-half the increase expected between 1974-76 and 2000.

Consumption of corn, wheat, and soybeans by livestock category was estimated by multiplying feed rations, as specified by USDA, times livestock numbers for each PSA for each projection year. Corn, wheat, and soybean consumption for each species and for each PSA was multiplied by 1.05 to reflect the 5 percent grain loss in the handling process.

Grain processing capacity, as estimated for 1969-76, was assumed constant for the period 1980 to 2040 except for known expansion [BEA 47 (Huntsville)]. Plans for expansion and new entries are basically unknown, and companies are unwilling to supply additional information.

For the period 1980 to 2040, grain production for each PSA was divided by yield per acre, as estimated by USDA, to estimate acres harvested. The seeding rates per crop and per state, as specified by USDA, were multiplied by the estimated acres harvested for each PSA. In this way, seed use for planting for each PSA was estimated for the years 1980 to 2040.

For each of the three principal crops, the projected consumption by each of the three end-uses was summed to estimate total consumption by crop by PSA. The total consumption of each of the three crops was summed to estimate total grain consumption for the years 1980 to 2040 for each PSA.

F. Probable Future Demands

The projections for grain consumption in the PSAs suggest gradual but steady increases in total grain consumption between 1976 and 2000, 0.54 percent annually, and between 2000 and 2040, 0.19 percent annually (Table 19). With the exception of BEAs 61 (Anderson), grain consumption by livestock, processing, and seed is to increase in all PSAs between 1976 and 2000. BEA 56 (Terre Haute) is expected to experience a notable increase. BEA 56's increase will be from increased consumption by livestock.

Corn will remain the predominant grain consumed in the ORS hinterland, representing, on the average, 60 percent of total grain consumption. Soybeans will account for about 35 percent of total grain consumed, and wheat for about 5 percent. Livestock feed will remain the major end-use of grain in the PSAs, followed by processing and seed.

In the ORS hinterland, as a whole, consumption is expected to remain concentrated in 12 of the 19 PSAs. The ORS hinterland is expected to remain a significant producer of meat, poultry, and food and dairy products for the northeastern and southeastern markets of the United States.

The aggregate demand for ORS hinterland grain represented by the export market in the future is expected to remain significant. However, the domestic market is expected to remain the major consumer of ORS hinterland grain. Given income and population increases, the demand for food in the developing countries is expected to almost quadruple as these countries' share of world agricultural imports increases from 15.3 percent in 1970 to 39.4 percent in the year 2000.[1] U.S. agricultural exports to the developing countries are expected to increase substantially under assumed income and population increase. However, consumption by developed countries of U.S. grain, and ORS hinterland grain, is expected to dominate the export market.

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1. U.S. Department of Agriculture, Economic Research Service, World Economic Conditions in Relation to Agricultural Trade, WEC-13 (Washington, D.C.: USDA, p. 49).

Table 19. Ohio River Basin: Consumption of Grain[a], by BEAs or BEA Segments[b], Estimated 1976 and Projected 1980-2040, Selected Years

(Thousands of tons unless otherwise specified)

BEA and BEA segment		Estimated 1976	Projected 1980	1990	2000	2020	2040	Average annual percentage change 1974-76—2000	2000-2040
Primary Study Areas		22,081.5	22,352.2	23,323.4	25,139.0	26,104.0	27,102.8	0.54	0.19
BEA 44:	Atlanta, GA	1,577.8	1,558.6	1,666.5	1,789.8	1,876.0	1,968.2	0.53	0.24
BEA 45:	Birmingham, AL	1,272.9	1,234.0	1,305.0	1,521.1	1,600.9	1,686.8	0.74	0.26
BEA 46:	Memphis, TN	310.9	353.1	389.0	427.8	445.9	463.8	1.34	0.20
BEA 47:	Huntsville, AL	2,059.8	2,062.9	2,201.7	2,351.2	2,425.0	2,500.3	0.55	0.15
BEA 48:	Chattanooga, TN	1,823.0	1,812.4	1,917.2	1,985.1	2,027.7	2,070.9	0.36	0.11
BEA 49:	Nashville, TN	2,270.6	2,453.3	2,623.3	2,940.0	3,075.0	3,215.1	1.08	0.22
BEA 50:	Knoxville, TN	326.7	339.5	354.7	372.1	393.3	414.2	0.54	0.27
BEA 52:	Huntington, WV	256.2	276.7	268.7	297.7	284.2	284.5	0.63	(0.11)
BEA 53:	Lexington, KY	1,177.8	1,233.0	1,291.6	1,415.6	1,512.1	1,609.0	0.77	0.32
BEA 54:	Louisville, KY	1,778.6	1,747.3	1,818.1	1,955.7	2,063.8	2,173.4	0.40	0.26
BEA 55:	Evansville, IN	2,550.5	2,428.6	2,576.3	2,873.2	3,037.2	3,206.4	0.50	0.27
BEA 56:	Terre Haute, IN	83.4	144.5	148.7	159.3	164.6	169.9	2.73	0.16
BEA 60:	Indianapolis, IN	1,760.8	1,776.9	1,829.1	1,926.2	1,977.9	2,032.9	0.37	0.13
BEA 61:	Anderson, IN	164.8	156.3	153.5	156.1	153.8	150.1	(0.23)	(0.10)
BEA 62:	Cincinnati, OH	1,202.3	1,234.4	1,239.7	1,356.9	1,401.1	1,447.2	0.13	0.16
BEA 63:	Dayton, OH	1,602.7	1,719.6	1,674.5	1,671.3	1,670.4	1,672.0	0.17	0.00
BEA 64:	Columbus, OH	539.1	595.7	569.6	569.6	570.3	572.5	0.23	0.01
BEA 114:	St. Louis, MO	205.3	194.4	206.1	228.9	237.0	245.4	0.45	0.17
BEA 115:	Paducah, KY	1,118.3	1,031.0	1,090.1	1,159.4	1,187.8	1,220.2	0.15	0.13

Note: Individual items may not add to total due to rounding. Data assembled on a county level and assembled into BEAs or BEA segments.

a. Total consumption of corn, wheat and soybeans only. Corn is corn for grain. Wheat is all wheat. Soybeans are soybeans for beans. Consumption of grain represents the addition of the consumption of corn, wheat and soybeans by livestock, processing and seed.

b. BEA segments defined as counties which are ultimate origins or destinations of waterborne movements.

Source: U.S. Department of Agriculture, Economic Research Service, USDA National-Interregional Agricultural Projections (NIRAP) System, July 1978.

This source provides state level projections of livestock production, by livestock category, to 2000. Livestock numbers raised by each of the states of Alabama, Georgia, Illinois, Indiana, Kentucky, Mississippi, Ohio and Tennessee were averaged for 1974, 1975 and 1976 and represent base year livestock production. The base year level was subtracted from the 2000 projections. This difference was divided by two and reported as 2040. The difference between 2000 and 2040 was equally divided among the remaining years in ten year intervals. For each BEA and BEA segment, the percentage of the respective states' total livestock production (1969-1976) was estimated and was projected into the future using trend analysis, in conjunction with expert judgement. The percent of the state's total livestock production allocated to each BEA and BEA segment by period (1980 to 2040) was multiplied by the state totals to estimate livestock production by BEA and BEA segment. Livestock numbers were multiplied by the corn, wheat and soybean ration fed by category by state. Acres harvested were multiplied by seeding rates by state to estimate grain consumption by seed. Processing capacity was assumed to remain constant from 1976 with the exception of known expansions and new construction.

Although the export market will remain a dominant force in ORS hinterland aggregate grain demand, the ORS hinterland will satisfy only between 5 and 10 percent of total export demand for U.S. grains.

III. COMMODITY RESOURCES INVENTORY

Projections of future grain production in the PSAs generally have been based on assumptions about the future that underlie analyses and projections of the U.S. Department of Agriculture. As the premier agricultural research entity in the United States, USDA has resources and experience that could not be duplicated by this study.

Production of grains in the PSAs increased markedly between 1969-76, from 16.0 million tons to 25.6 million tons. Production increased most rapidly in those PSAs in the southeastern portion of the ORS hinterland. However, the largest producing PSAs were those in the States of Indiana, Illinois, and Ohio. Production of grains in the PSAs is expected to increase by 27 percent between 1976 and 2000, and by 44 percent between 2000 and 2040.

A. Production Areas

The production of Group V commodities in the PSAs is supplemented by production in Secondary Production Areas (SPAs) located outside the Ohio River Basin. These SPAs are defined as BEAs that are the origins of Group V waterborne movements destined to the Ohio River Basin.

Major SPA origins of grain shipped into the ORS hinterland include Iowa, Missouri, Minnesota, and Kansas, as well as other midwestern Corn Belt states. These Corn Belt states accounted for more than 15 percent of the interstate grain receipts of Alabama, Georgia, Kentucky, Mississippi, and Tennessee in 1970 (Table 10). Grain originating in the Corn Belt states was also destined for Ohio, Illinois, and Indiana, and included grains not grown locally in the quantities or qualities necessary to satisfy end-use demands. These included such grains as barley and rye for brewing and various wheats for flour.

The Tennessee River, the principal destination for grain inbound to the ORS hinterland, received most of its grain from the Illinois Waterway and the Missouri and Upper Mississippi Rivers. This grain included wheat produced in Kansas and Minnesota and shipped from BEA 91 (Minneapolis). BEA 91 shipments accounted for 34 percent of the Tennessee's grain receipts in 1976.

B. Production Characteristics

The factors that will determine future production of grains in the PSAs are economic, institutional, and technological in nature.

B-1. Corn, Wheat, and Soybeans

Total U.S. grain production increased rapidly during the third quarter of the twentieth century (Table 20). The major production increases occurred in soybeans, corn, and wheat, and production of the minor crops (oats, barley and rye) decreased. Soybean production increased 497 percent between 1950 and 1977, corn production increased by 108 percent, and wheat production increased 99 percent. These changes are a result of economic conditions, policies, educational and research programs, and the development of new technologies and innovations.

a. Economic Characteristics of Production

World economic conditions have fostered the growth in U.S. output of soybeans, corn, and wheat. Because of economic development, the world is demanding more meat and protein products. Soybeans have a comparative advantage as a source of protein. In addition, southern farmers have found soybeans to be an alternative crop to cotton. Meat production is primarily based on the consumption of corn and soybean meal, as well as roughages. Thus, the increased demand for meat in the United States and throughout the world has stimulated the demand and price of soybeans and corn.

In many countries of the developing world, cereals and flour are an important part of the diet. Again, wheat and rice have a comparative advantage in this important international food market. Increasing incomes and population growth have stimulated demand and, as a result, the price of wheat. Oats, barley, and rye have not been competitive products in supplying protein for either animals or people.

Table 20. United States: Grain Production and Yields for Wheat, Corn, and Soybeans, Selected Years, 1950-77

(Thousands of bushels, bushels per harvested acre)

Year	Wheat		Corn		Soybeans	
	Production	Yield	Production	Yield	Production	Yield
1950	1,019	16.0	3,057	37.0	287	21.0
1960	1,354	26.0	3,906	54.0	555	23.0
1965	1,315	26.5	4,102	74.1	845	24.0
1970	1,351	31.0	4,152	72.4	1,127	27.0
1975	2,122	30.6	5,828	86.3	1,547	29.0
1977	2,025	30.6	6,357	90.8	1,716	30.0

Source: U.S. Department of Agriculture, Agricultural Statistics, selected years.

b. Institutional Characteristics of Production

United States agricultural programs have been an important stimulant for the production of feed grains and wheat. The programs began in earnest in the 1930s when farmers were caught in a serious price squeeze between income and expenses. The first Agricultural Adjustment Act was passed in 1933. Its purposes were to:

- secure the voluntary reduction in acreage in basic crops;
- eliminate unfair pricing practices of dealers and processors;
- acquire tax funds to pay farmers not to produce;
- follow improved conservation practices; and
- provide an adequate supply of food with relative stable prices to consumers.

These programs primarily supported the price of corn and wheat. The minor crops were included, but most discussion and applications were in terms of wheat and corn. The government stockpiled large quantities of these products to ensure that the program would function.

These programs continued through the 1960s. New acts were passed by Congress, but the goals and purposes remained the same. In the late 1[illegible]0s, the first world food shortage was recognized. This encouraged farmers to produce a maximum output of grain and livestock products. For most of the 1970s, grain was sold in a free market, and prices were free to fluctuate. Because of the spiraling prices, farmers produced record levels of corn, wheat, and soybeans.

By the end of the 1970s, consumers and livestock farmers were dissatisfied with fluctuating grain prices, and wheat farmers were sustaining losses. Thus, the political environment was again ripe for the institution of new programs. The names changed, but the ideas and goals remained the same as those in the earlier programs.

Under the Food and Agriculture Act of 1977, income support is provided to the participating producer through the target price concept, which guarantees eligible producers a direct payment if farm prices received fall below established target prices. Deficiency, or target price, payments vary inversely with market prices. No payments are made if the national weighted average market price is at or above the target price.

The Food and Agriculture Act also provides price support loans. A producer complying with farm programs can commit any quantity of his crop as collateral for a loan from the Commodity Credit Corporation (CCC). The total amount that can be borrowed is equal to the quantity of the crop placed under loan times the loan rate. Compliance with average set-aside provisions is a condition for loan eligibility.

A normal crop acreage set-aside program[1] is implemented if the Secretary of Agriculture determines that supplies of a designated commodity are likely to be excessive. The purpose of such a program is to bring supplies into better balance with anticipated demand over a period of time, by curbing production through acreage cutbacks. Consideration is given to the need for adequate carryover to maintain reasonable and stable supplies and prices and to meet any national emergency.

Under the Food and Agricultural Act of 1977, there was a 20 percent set-aside for the 1978 wheat crop. The basic program requirement was that farmers set aside an acreage equal to 20 percent of their 1978 wheat plantings. The set-aside acreage must be protected by an approved cover crop or other approved conservation practices, such as stubble or stubble mulch. The program includes target prices, loan rates, payment limitations, and grain reserves.

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1. Acreage set-aside is that which is removed from production, and in any year is based on a farmer's acreage planted for harvest in that year. Acreage set-aside must be cropland that was tilled within the previous three years for a crop other than hay or pasture. And, when set-aside requirements for a crop planted on the farm are in effect, a farm's acreage planted to designated crops plus any set-aside cannot exceed the established normal crop acreage in order for the farm to be eligible for program benefits. Compliance with acreage set-aside provisions for each of the programs for wheat, feed grains, cotton, or rice is a condition of eligibility for loans, purchases, or payments, on any designated commodity produced. (For further discussion see Commodity Research Bureau, Inc., Commodity Yearbook, published in New York, 1978.)

Corn is subject to provisions of the Food and Agricultural Act of 1977 and the 1978 Feed Grain Production Program. The terminology and purposes are similar to those specified in the Wheat Program. The national average loan rate for 1978 was $2.00/bushel, and the target price was $2.10/bushel. Loans on the 1978 crop were expected to be available to farmers through May 31, 1979, with a loan maturity date nine months from loan application date. Again, the requirements and payments may vary as specified by the Secretary of Agriculture.

The Food and Agricultural Act of 1977 covers the 1978 through 1981 crops and is designed to bring supply and demand into balance by making it attractive for farmers to reduce production and to make use of a three-year grain reserve. Its success in supporting prices will depend upon the extent to which producers participate in these programs and upon weather and climatic conditions and technological changes.

It is anticipated that the program will re-establish stable grain and food prices for consumers and profit levels that are acceptable to farmers. In addition, there should be a stable, adequate supply of food for U.S. consumers and a reserve of food for emergency purposes. If accepted by farmers, the rate of growth in grain production may be retarded. However, it is doubtful that U.S. grain production will be declining because of the world economic conditions.

Agricultural extension programs and research efforts continue to increase yields and agricultural output. The extension programs began in earnest in the 19th century. All land grant universities have strong agricultural schools that are committed to improving the economic well-being of farmers. This is a strong force which has increased the productivity of U.S. agriculture.

Extension programs are geared toward the education of the farmer through demonstration. Through extension, the farmer is provided information on seeding, fertilization, harvesting, and marketing. Valuable information is provided on the economic impact of the implementation of certain government policies on the individual operation.

c. Technological Characteristics of Production

Until World War I, U.S. farm output was a function of the amount of cropland under cultivation and available animal power.

Starting in the 1920s, animal power was replaced by the internal-combustion engine, but output did not increase significantly because cropland did not expand. The decrease in output of the early 1930s, caused by the Depression, was followed by rapid growth after 1935 in response to a drive toward more intense use of land resources. Between 1940 and 1965, agricultural production in the U.S. grew by two-thirds. Even more remarkable was the rapid growth in grain output from the period of 1950 to 1977 (Table 20). Wheat yields, for example, increased from 16 bushels per acre to 30.6 bushels; soybean yields increased from 21 bushels to 30 bushels; and corn yields increased from 37 bushels per acre to 90.8 bushels.

As can be seen in Tables 21, 22, and 23, for corn, wheat, and soybeans, respectively, during 1969-76 the PSAs frequently had yields per harvested acre that were greater than those of the United States as a whole. In the ORS hinterland, yields were the greatest in the midwestern PSAs (i.e., in Ohio, Illinois, and Indiana). However, large increases in acres harvested of all three principal crops, particularly in soybeans, occurred in the southeastern PSAs. In many cases, soybean acres harvested doubled between 1969 and 1976 (Table 23).

It is important to note that of the three principal crops, corn yields almost three times as many bushels per harvested acre as wheat or soybeans. Therefore, the decision to grow corn affects the amount of grain (in weight terms) that is available to be transported at any one time or by any one mode.

Based on the changes in yields, it is obvious that changes in technologies such as the introduction of hybrid seeds, fertilizers, herbicides, insecticides, and new machinery have more than offset restrictive agricultural production policies. In one sense, there appears to be a paradox: reduction in production on the one hand versus increased production on the other. Instead, observe that the underlying goals are consistent in both programs: to provide a stable adequate supply of food for people at a price that will ensure an adequate income for U.S. farmers.

Weather can have an adverse, although generally short-term, effect on grain production. Bad weather can delay planting, fertilization, and second cropping; force abandonment of planted acres; and substantially lower yields.

..., Average Harvested, and Yield per Acre, by BEAs or BEA Segments[a], 1969-76

(... of bushels, thousands of acres, bushels per acre harvested)

BEA and BEA segment	1969	1970	1971	1972	1973	1974	1975	1976
United States								
Production	4,687,057.0	4,151,938.0	5,641,112.0	5,573,320.0	5,646,806.0	4,663,631.0	5,828,961.0	6,266,359.0
Acres harvested	54,574.0	57,358.0	64,047.0	57,421.0	61,894.0	65,357.0	67,505.0	71,300.0
Yield per acre	85.9	72.4	88.1	97.1	91.2	71.4	86.3	87.9
Primary Study Areas								
Production	412,209.1	308,627.8	484,434.0	446,112.6	444,462.7	426,097.3	486,693.5	671,252.8
Acres harvested	5,074.8	5,176.7	5,809.0	4,959.2	5,211.2	5,552.8	5,751.5	6,601.1
Yield per acre	81.2	59.6	83.4	90.0	85.3	76.7	84.6	101.7
BEA 44: Atlanta, GA								
Production	993.2	634.0	1,194.0	1,248.9	1,069.3	1,273.0	1,260.3	1,467.7
Acres harvested	23.6	21.0	24.2	25.3	20.2	22.8	21.1	25.7
Yield per acre	42.2	30.2	49.4	49.5	53.0	55.9	59.6	57.0
BEA 45: Birmingham, AL								
Production	4,234.0	2,787.0	4,250.2	3,646.1	4,120.9	4,271.1	5,386.2	5,455.2
Acres harvested	122.2	105.2	100.1	76.0	85.8	90.0	99.6	100.0
Yield per acre	34.7	26.5	42.5	48.0	48.1	47.5	54.1	54.6
BEA 46: Memphis, TN								
Production	4,854.2	3,865.4	7,146.0	6,881.0	6,194.7	6,113.2	7,145.3	10,043.3
Acres harvested	99.0	98.0	123.1	88.9	95.6	100.3	114.6	135.7
Yield per acre	49.0	39.4	58.1	77.4	64.8	60.9	62.3	74.0
BEA 47: Huntsville, AL								
Production	4,981.5	4,027.0	6,733.3	4,906.0	5,230.1	5,658.6	7,437.1	9,733.3
Acres harvested	143.1	123.3	144.0	90.8	97.8	104.7	122.3	137.9
Yield per acre	34.9	32.7	46.9	54.0	53.5	54.0	60.8	70.6
BEA 48: Chattanooga, TN								
Production	4,211.8	2,969.0	5,394.0	5,475.3	6,270.6	5,487.5	6,852.1	10,728.7
Acres harvested	88.0	79.7	95.8	85.1	96.3	94.9	102.3	143.0
Yield per acre	47.9	37.3	56.3	64.4	65.1	57.8	67.0	75.1

(Continued)

Table 21.(Continued)

BEA and BEA segment	1969	1970	1971	1972	1973	1974	1975	1976
BEA 49: Nashville, TN								
Production	22,908.9	17,583.7	30,769.0	28,159.9	30,084.7	29,376.6	27,940.4	49,017.2
Acres harvested	373.3	362.0	464.5	369.7	403.8	413.9	457.9	536.3
Yield per acre	61.4	48.6	66.2	76.2	74.5	71.0	61.0	91.4
BEA 50: Knoxville, TN								
Production	1,622.1	1,402.0	2,030.0	2,346.0	2,161.0	2,161.0	2,410.0	3,451.0
Acres harvested	27.1	28.2	33.9	34.2	39.5	34.5	38.4	44.7
Yield per acre	59.9	49.7	59.9	68.6	72.7	62.6	62.8	77.2
BEA 52: Huntington, WV								
Production	2,366.1	1,516.6	2,590.7	2,479.6	2,535.1	2,677.7	2,906.3	3,266.7
Acres harvested	31.4	29.4	36.6	32.3	33.8	37.2	36.1	36.8
Yield per acre	75.4	51.6	70.8	76.8	75.0	72.0	80.5	88.8
BEA 53: Lexington, KY								
Production	8,224.0	6,379.5	11,429.8	11,228.4	11,637.1	11,969.8	10,304.6	14,318.1
Acres harvested	106.8	107.9	150.7	133.1	136.0	144.1	142.1	144.2
Yield per acre	77.0	59.1	75.8	84.4	85.6	83.1	72.5	99.3
BEA 54: Louisville, KY								
Production	19,829.9	12,722.6	23,924.2	23,368.6	25,736.8	26,065.7	22,898.9	36,033.5
Acres harvested	240.1	245.3	307.2	268.0	297.0	329.3	340.8	366.4
Yield per acre	82.6	51.9	77.9	87.2	86.7	79.2	67.2	98.3
BEA 55: Evansville, IN								
Production	100,218.6	58,637.1	194,990.7	105,999.8	99,166.7	95,234.8	117,139.7	153,324.6
Acres harvested	1,180.9	1,199.1	1,216.6	1,085.9	1,114.7	1,171.1	1,254.2	1,451.8
Yield per acre	84.9	48.9	86.3	97.6	89.0	81.3	93.4	105.6
BEA 56: Terre Haute, IN								
Production	8,336.6	7,381.7	11,076.2	7,395.9	11,263.6	7,171.1	11,365.4	13,866.9
Acres harvested	94.9	102.7	108.2	89.0	108.7	102.0	109.8	133.1
Yield per acre	87.8	71.9	102.4	105.6	103.6	70.3	103.5	104.2

(Continued)

Table 21. (Continued)

BEA and BEA segment	1969	1970	1971	1972	1973	1974	1975	1976
BEA 60: Indianapolis, IN								
Production	78,476.1	61,649.2	89,642.7	83,694.6	89,224.1	67,712.7	80,398.2	113,898.3
Acres harvested	793.8	842.0	898.9	803.9	861.0	885.0	871.0	983.5
Yield per acre	98.9	73.2	99.7	104.1	103.6	76.5	92.3	115.8
BEA 61: Anderson, IN								
Production	10,180.9	8,651.2	11,764.8	10,082.3	11,036.3	10,333.3	11,680.3	17,338.4
Acres harvested	105.3	107.9	130.1	106.9	110.8	129.6	141.1	161.5
Yield per acre	96.7	80.2	90.4	94.3	99.6	79.7	82.8	107.4
BEA 62: Cincinnati, OH								
Production	38,012.1	28,381.2	42,576.4	37,045.3	37,286.1	38,856.7	40,626.1	55,818.7
Acres harvested	422.7	420.9	494.8	432.7	436.6	491.1	476.7	535.6
Yield per acre	89.9	67.4	86.0	85.6	85.4	79.1	85.2	104.2
BEA 63: Dayton, OH								
Production	46,771.0	45,596.0	62,451.0	52,826.0	48,418.0	53,327.5	61,492.0	74,077.0
Acres harvested	507.5	559.0	662.9	568.7	580.7	640.2	628.5	687.1
Yield per acre	92.2	81.6	94.2	92.9	83.4	83.3	97.8	107.8
BEA 64: Columbus, OH								
Production	37,839.0	33,584.0	45,214.0	38,756.0	35,910.7	42,366.6	44,779.0	61,554.0
Acres harvested	422.2	45[illegible].5	507.8	434.7	465.2	525.6	501.0	561.9
Yield per acre	89.6	73.7	89.2	89.2	77.2	80.6	89.4	109.5
BEA 114: St. Louis, MO								
Production	8,104.0	5,470.3	8,777.6	8,977.6	6,939.8	5,530.7	10,595.6	11,987.6
Acres harvested	154.6	158.4	140.6	117.1	103.6	96.1	130.6	154.0
Yield per acre	52.4	34.5	62.4	76.7	67.0	57.6	81.1	77.8
BEA 115: Paducah, KY								
Production	10,045.1	5,390.3	12,479.4	9,595.3	9,467.1	10,511.7	14,076.0	25,872.6
Acres harvested	138.4	131.3	169.1	117.0	124.1	140.4	163.5	261.9
Yield per acre	72.6	41.1	73.8	82.0	76.3	74.9	86.1	98.8

Note: Individual items may not equal total due to rounding. Corn is corn for grain.

a. BEA segments defined as counties which are ultimate origins for destinations of waterborne movements.

Source: U.S. production, acreage harvested, and yield data for 1969 to 1974 from U.S. Department of Agriculture, Agricultural Statistics, 1977; data for 1975 and 1976 from U.S. Department of Agriculture, Crop Production; 1977 Annual Summary; Acreage, Yield and Production, January 1978. BEA and BEA segment level data estimated from production data provided annually for 1969-76 by the U.S. Department of Agriculture, Crop Reporting Services of the states of Alabama, Georgia, Illinois, Indiana, Kentucky, Mississippi, Ohio, and Tennessee.

Table 22. United States and Ohio River Basin: Wheat Production, Acreage Harvested, and Yield Per Acre, by BEAs or BEA Segments[a], 1969-76

(Thousands of bushels, thousands of acres, bushels per acre harvested)

BEA and BEA segment	1969	1970	1971	1972	1973	1974	1975	1976
United States								
Production	1,442,679.0	1,351,558.0	1,617,789.0	1,544,936.0	1,705,167.0	1,796,187.0	2,134,833.0	2,147,408.0
Acres harvested	47,146.0	43,564.0	47,674.0	47,284.0	53,869.0	65,613.0	69,641.0	70,824.0
Yield per acre	30.6	31.0	33.9	32.7	31.6	27.3	30.6	30.3
Primary Study Areas								
Production	42,403.7	39,016.4	48,567.5	52,023.8	35,739.3	63,303.2	70,523.6	69,135.9
Acres harvested	1,164.6	1,059.2	1,117.1	1,293.8	1,174.0	1,925.0	1,872.5	1,923.4
Yield per acre	36.4	36.8	43.5	40.2	30.4	32.9	37.7	35.9
BEA 44: Atlanta, GA								
Production	106.6	108.0	183.3	108.9	84.7	254.0	247.7	324.8
Acres harvested	3.4	3.1	5.0	4.1	2.7	7.9	8.9	9.7
Yield per acre	31.5	35.3	36.6	26.4	31.1	32.3	27.9	33.4
BEA 45: Birmingham, AL								
Production	107.1	119.1	198.4	163.8	125.8	191.7	231.6	242.1
Acres harvested	3.4	3.8	6.4	5.8	5.6	7.0	8.4	7.7
Yield per acre	31.6	31.4	31.0	28.4	22.7	27.4	27.6	31.6
BEA 46: Memphis, TN								
Production	432.0	662.8	774.8	741.5	508.5	873.1	866.3	1,098.8
Acres harvested	12.8	17.9	21.6	23.6	17.7	30.0	29.4	30.8
Yield per acre	33.9	37.0	35.9	31.4	28.7	29.1	29.5	35.7
BEA 47: Huntsville, AL								
Production	960.6	1,091.2	1,396.1	1,321.8	833.4	1,617.9	1,702.5	1,589.2
Acres harvested	28.4	31.7	39.5	41.6	27.7	50.9	56.1	45.4
Yield per acre	33.8	34.4	35.4	31.8	30.1	31.8	30.4	35.0
BEA 48: Chattanooga, TN								
Production	250.4	250.9	372.2	339.1	248.2	420.3	470.2	416.7
Acres harvested	4.1	7.0	10.5	10.9	8.3	13.7	14.7	12.7
Yield per acre	60.8	35.8	35.6	31.3	29.9	30.8	32.0	32.7

(Continued)

Table 22. (Continued)

BEA and BEA segment	1969	1970	1971	1972	1973	1974	1975	1976
BEA 49: Nashville, TN								
Production	4,236.4	4,282.4	4,903.9	4,733.1	2,916.4	6,712.6	6,812.8	6,915.0
Acres harvested	121.7	115.6	126.0	142.0	84.6	217.3	207.5	217.4
Yield per acre	34.8	37.1	38.9	33.3	34.5	30.9	32.8	31.8
BEA 50: Knoxville, TN								
Production	224.4	255.8	263.6	273.2	227.3	349.0	357.3	443.7
Acres harvested	6.3	7.1	7.0	8.4	7.1	11.0	10.8	11.8
Yield per acre	35.9	36.0	37.9	32.7	32.0	31.7	33.1	37.6
BEA 52: Huntington, WV								
Production	106.8	81.7	99.1	100.8	89.1	118.4	122.7	108.8
Acres harvested	3.1	2.7	2.9	3.0	3.2	4.1	4.1	3.7
Yield per acre	34.8	30.0	34.7	34.1	27.5	28.9	30.3	29.8
BEA 53: Lexington, KY								
Production	444.4	424.1	582.2	503.3	427.2	594.1	562.3	527.6
Acres harvested	14.4	12.9	15.5	15.9	13.8	19.6	17.9	17.3
Yield per acre	30.9	32.8	37.5	31.8	31.0	30.3	31.4	30.5
BEA 54: Louisville, KY								
Production	1,567.9	1,376.1	1,721.9	1,937.5	1,803.9	3,412.9	3,051.0	2,184.5
Acres harvested	46.4	39.9	42.8	55.6	54.1	107.4	88.0	81.6
Yield per acre	33.8	34.5	40.2	34.8	33.3	31.8	34.7	26.8
BEA 55: Evansville, IN								
Production	8,853.2	7,320.2	10,112.6	11,543.6	9,502.8	14,121.3	14,284.8	14,207.1
Acres harvested	247.3	211.0	220.2	286.3	309.5	460.5	393.9	417.0
Yield per acre	35.8	34.7	45.9	40.3	30.7	30.7	36.3	34.1
BEA 56: Terre Haute, IN								
Production	802.3	654.4	825.8	1,098.1	732.6	1,297.7	1,536.1	1,418.1
Acres harvested	23.4	17.3	18.9	23.7	21.2	42.2	40.8	42.9
Yield per acre	34.3	37.3	43.7	46.3	34.6	30.8	37.7	33.1

(Continued)

Table 22.(Continued)

BEA and BEA segment	1969	1970	1971	1972	1973	1974	1975	1976
BEA 60: Indianapolis, IN								
Production	5,327.2	4,658.2	5,101.8	6,367.2	4,186.1	7,554.7	9,125.1	8,030.9
Acres harvested	131.8	112.8	104.8	129.4	117.8	206.3	201.8	219.4
Yield per acre	40.4	41.3	48.7	49.2	35.5	36.6	45.2	36.6
BEA 61: Anderson, IN								
Production	689.2	689.6	678.6	751.5	486.0	1,170.7	1,304.3	1,310.6
Acres harvested	18.4	16.1	14.4	15.2	14.8	30.1	28.9	30.6
Yield per acre	37.5	42.8	47.1	49.4	32.8	38.9	45.1	42.8
BEA 62: Cincinnati, OH								
Production	4,001.9	3,708.1	4,190.1	3,896.1	2,582.3	4,490.6	4,892.1	5,018.7
Acres harvested	114.7	104.0	99.8	101.4	103.3	139.7	134.8	140.8
Yield per acre	34.9	35.7	42.0	38.4	25.0	32.1	36.3	35.6
BEA 63: Dayton, OH								
Production	6,002.0	5,371.0	6,842.0	6,969.0	4,297.0	8,266.1	10,930.8	10,285.6
Acres harvested	149.6	131.7	142.9	147.0	131.6	203.7	244.7	239.5
Yield per acre	40.1	40.8	47.9	47.4	32.7	40.6	44.7	42.9
BEA 64: Columbus, OH								
Production	5,336.3	4,944.8	5,754.6	5,856.2	3,426.0	6,947.4	8,132.0	8,184.4
Acres harvested	137.4	133.8	130.6	135.9	116.0	182.6	209.3	205.6
Yield per acre	38.8	37.0	44.1	43.1	29.5	38.0	38.9	39.8
BEA 114: St. Louis, MO								
Production	1,811.4	1,684.4	2,826.4	3,635.3	2,234.2	2,568.8	3,406.5	4,045.5
Acres harvested	62.9	51.0	61.4	86.3	95.2	104.4	96.0	106.6
Yield per acre	28.8	33.0	46.0	42.1	23.5	24.6	35.5	38.0
BEA 115: Paducah, KY								
Production	1,143.6	1,342.6	1,740.2	1,683.8	1,027.8	2,342.0	2,487.5	2,783.8
Acres harvested	35.3	39.9	47.1	58.0	39.9	86.7	76.5	82.9
Yield per acre	32.4	33.6	36.9	29.0	25.8	27.0	32.5	33.6

Note: Individual items may not equal total due to rounding. Wheat is all wheat.

a. BEA segments defined as counties which are ultimate origins or destinations of waterborne movements.

Source: U.S. production, acreage harvested, and yield data for 1969 to 1974 from U.S. Department of Agriculture, Agricultural Statistics, 1977; data for 1975 and 1976 from U.S. Department of Agriculture, Crop Production; 1977 Annual Summary; Acreage, Yield and Production, January 1978. BEA and BEA segment level data estimated from production data provided annually for 1969-76 by the U.S. Department of Agriculture, Crop Reporting Services of the states of Alabama, Georgia, Illinois, Indiana, Kentucky, Mississippi, Ohio, and Tennessee.

Table 23. [illegible] Soybean Production, Acres Harvested and Yield Per Acre, by [illegible] or BEA Segments[a], 1969-76

([illegible] of bushels, thousands of acres, bushels per acre harvested)

BEA and [illegible] segment	1969	1970	1971	1972	1973	1974	1975	1976
United States								
Production	1,113,[illegible].0	1,127,100.0	1,175,989.0	1,270,630.0	1,547,165.0	1,214,802.0	1,547,383.0	1,287,560.0
Acres harvested	41,337.0	42,249.0	42,701.0	45,698.0	55,796.0	52,368.0	53,579.0	49,358.0
Yield per acre	27.4	26.7	27.5	27.8	27.7	23.2	28.9	26.1
Primary Study Areas								
Production	104,71[illegible].7	98,862.4	120,739.4	125,176.3	146,641.9	134,051.6	164.796.6	156,446.4
Acres harvested	3,51[illegible].8	3,521.9	4,007.5	4,672.2	5,524.4	5,315.1	5,791.7	5,238.0
Yield per acre	29.8	28.1	30.1	26.8	26.5	25.2	28.5	29.9
BEA 44: Atlanta, GA								
Production	575.6	416.0	436.5	385.4	709.6	986.2	1,589.5	1,226.8
Acres harvested	24.1	18.9	15.3	18.7	32.5	43.2	58.7	50.6
Yield per acre	23.9	22.0	28.5	20.6	21.8	22.9	27.1	24.3
BEA 45: Birmingham, AL								
Production	4,084.5	4,151.9	4,655.1	4,340.9	5,314.0	5,364.7	7,586.6	8,588.4
Acres harvested	178.5	185.3	190.5	221.9	283.5	294.3	367.0	363.4
Yield per acre	22.9	22.4	24.4	19.6	18.7	18.2	20.7	23.6
BEA 46: Memphis, TN								
Production	4,021.0	3,747.0	4,442.0	4,189.0	4,693.0	4,657.0	6,662.9	5,621.6
Acres harvested	168.8	164.5	171.6	184.8	214.1	215.9	277.9	269.8
Yield per acre	23.8	22.8	25.9	22.7	21.9	21.6	24.0	20.8
BEA 47: Huntsville, AL								
Production	5,063.7	4,823.5	6,649.0	6,380.0	7,786.0	8,077.0	11,885.5	10,747.0
Acres harvested	219.9	219.9	255.7	296.8	376.1	382.6	484.9	461.8
Yield per acre	23.0	21.9	26.0	21.5	20.7	21.1	24.5	23.3
BEA 48: Chattanooga, TN								
Production	1,125.0	1,064.3	1,374.7	1,641.2	1,802.8	2,256.2	2,651.5	2,175.5
Acres harvested	48.1	48.5	55.9	76.2	88.7	105.9	118.3	101.1
Yield per acre	23.4	21.9	24.6	21.5	20.5	21.3	22.4	21.5

Table 23. (Continued)

BEA and BEA segment	1969	1970	1971	1972	1973	1974	1975	1976
BEA 49: Nashville, TN								
Production	2,420.0	2,734.0	4,638.7	7,153.9	9,101.7	9,392.4	10,966.0	12,290.5
Acres harvested	94.4	105.8	157.7	270.9	351.2	378.3	423.8	456.1
Yield per acre	25.6	25.8	29.4	26.4	25.9	24.8	25.9	26.9
BEA 50: Knoxville, TN								
Production	158.6	136.5	187.6	145.0	209.0	295.5	291.1	267.9
Acres harvested	5.7	5.5	7.1	6.6	9.4	12.0	12.9	11.6
Yield per acre	27.8	25.0	26.4	22.0	22.2	24.6	22.6	23.1
BEA 52: Huntington, WV								
Production	130.3	139.5	201.8	175.1	262.9	273.9	395.5	354.4
Acres harvested	4.3	5.0	7.3	7.4	10.4	11.3	11.9	11.2
Yield per acre	30.6	28.0	27.6	23.6	25.2	24.2	33.1	31.6
BEA 53: Lexington, KY								
Production	40.5	46.0	116.2	86.6	99.3	153.9	264.1	348.0
Acres harvested	1.5	1.8	4.3	3.4	4.0	7.1	11.7	12.6
Yield per acre	27.0	26.0	26.9	25.7	24.9	21.6	22.5	27.5
BEA 54: Louisville, KY								
Production	2,746.2	2,604.1	3,049.0	3,239.3	3,137.6	3,237.1	3,116.5	3,288.7
Acres havested	90.1	91.3	106.6	122.9	128.7	132.3	130.7	116.2
Yield per acre	30.5	28.5	28.6	26.4	24.4	24.5	23.8	28.3
BEA 55: Evansville, IN								
Production	20,066.4	19,843.3	24,207.2	27,020.6	29,116.6	26,300.4	31,265.6	29,076.5
Acres harvested	680.1	732.3	866.3	937.3	1,126.7	1,064.0	1,050.7	960.9
Yield per acre	29.5	27.1	27.9	28.8	25.8	24.7	29.8	30.3
BEA 56: Terre Haute, IN								
Production	2,375.9	2,405.6	2,453.3	2,165.9	2,237.3	1,604.9	2,084.9	2,232.6
Acres harvested	79.4	76.0	77.7	75.0	81.7	71.4	65.2	59.7
Yield per acre	29.9	31.7	31.6	28.9	27.4	22.5	32.0	37.4
BEA 60: Indianapolis, IN								
Production	19,107.3	16,336.5	18,1[illegible]5.9	17,145.3	21,926.3	16,167.1	19,021.6	18,860.2
Acres harvested	539.9	[illegible]	539.9	592.3	682.8	615.2	568.3	511.9
Yield per acre	35.4	32.2	33.6	28.9	32.1	26.3	33.5	36.8

(Continued)

Table 23. (Continued)

BEA and BEA segment	1969	1970	1971	1972	1973	1974	1975	1976
BEA 61: Anderson, IN								
Production	2,774.3	2,147.8	2,463.5	2,676.9	3,558.3	2,823.7	2,867.1	2,518.9
Acres harvested	[illegible]	[illegible]	78.3	92.4	104.6	96.1	87.2	75.5
Yield per acre	[illegible]	[illegible]	31.5	29.0	34.0	29.4	32.9	33.4
BEA 62: Cincinnati, OH								
Production	[illegible]	6,474.6	8,261.4	7,819.5	9,796.8	9,663.4	11,50[illegible].4	10,735.4
Acres harvested	[illegible]	216.1	266.3	320.6	370.1	353.8	36[illegible].7	323.4
Yield per acre	[illegible]	[illegible]	[illegible]	24.4	26.5	27.3	31.4	33.2
BEA [illegible]: Dayton, OH								
Production	[illegible]	11,156.0	[illegible]	12,406.0	17,156.4	15,069.5	17,667.1	15,355.3
Acres harvested	341.6	360.7	378.3	467.2	561.5	502.2	485.3	447.5
Yield per acre	35.0	30.9	34.0	26.6	30.6	30.0	36.4	34.3
BEA 64: Columbus, OH								
Production	10,734.5	[illegible]	[illegible]	11,119.8	13,219.6	13,283.1	16,020.8	15,875.4
Acres harvested	[illegible]	338.4	373.8	436.5	505.9	460.2	460.8	433.7
Yield per acre	[illegible]	29.7	[illegible]	25.5	26.1	28.9	34.8	36.6
BEA 114: St. Louis, MO								
Production	[illegible]	[illegible]	[illegible]	7,264.5	6,425.1	5,500.8	7,386.8	7,152.6
Acres harvested	[illegible]	[illegible]	[illegible]	163.4	175.5	169.4	167.0	175.5
Yield per acre	21.4	34.4	36.1	44.5	36.6	32.5	44.2	40.8
BEA 115: Paducah, KY								
Production	[illegible]	[illegible]	9,126.1	9,821.4	10,089.6	8,944.7	11,571.1	9,731.1
Acres harvested	[illegible]	247.8	303.3	377.9	417.0	399.9	642.7	395.5
Yield per acre	27.1	25.4	30.1	26.0	24.2	22.4	18.0	24.6

Note: Individual items may not add to total due to rounding. Soybeans are soybeans for beans.
a. BEA segments defined as counties which are ultimate origins or destinations of waterborne movements.
[illegible] production, acreage harvested, and yield data for 1969 to 1974 from U.S. Department of Agriculture, Agricultural Statistics, 1977; data for 1975 and 1976 from U.S. Department of Agriculture, Crop Production; 1977 Annual Summary; Acreage, Yield and Production, January 1978. BEA and BEA segment level data estimated from production data provided annually for 1969-76 by U.S. Department of Agriculture Crop Reporting Services of the states of Alabama, Georgia, Illinois, Indiana, Kentucky, Mississippi, Ohio, and Tennessee.

A notable decline in production occurred in 1974 because of poor weather conditions. Despite greater acreage devoted to most crops, weather demonstrated its influence by holding many major crop yields at the lowest levels in a decade and resulted in larger than normal abandonment. Very late planting and replanting occurred because of extremely wet conditions in the spring, followed by hot and dry summer weather, an earlier than normal frost, and poor drying conditions at harvest.

Insect infestation and blight can dramatically affect production. In the corn blight year 1970, the U.S. average yield per acre dropped about 14 bushels below the trend line. Limitations put on the use of pesticides and herbicides have also affected yields. In this eight-year time frame, 1975 was a record production year in the United States and in the PSAs for most crops, major and minor.

B-2. Minor Grains

The U.S. production of oats, barley, and rye has generally decreased over time, while sorghum and rice production has increased (Table 24). As with corn, wheat, and soybeans, the minor crops are also included in U.S. set-aside programs and price-support programs. The 1978 feed grain acreage set-aside program requirement is 10 percent of the 1978 acreage planted to sorghum and barley. To qualify for target price payments on normal production, 1978 acreage must be reduced from 1977 plantings by 5 percent for sorghum and 20 percent for barley. Barley, sorghum, and rice are eligible for the loan rate system only.

The minor grains exhibited significant growth in output per acre from 1960 to 1977, specifically between 1960 and 1965 (Table 24). Barley yields, for example, increased from 31.0 bushels per acre to 42.9 between 1960 and 1965, and rice yields from 3,423 pounds per acre to 4,255, a 25 percent increase.

These crops, as are all crops, are affected by weather conditions. Dry weather, frost, drought, and low subsoil moisture can decrease production.

C. Feedstocks (Available Cropland)

Increasing national and world needs for agricultural products should result in more intense utilization of existing, and the conversion of land from other uses, to cropland. A recently completed study of non-federal land by the Soil Conservation Service (SCS) provides national and regional level data on (1) the potential for converting land in other use to cropland, (2) the extent of land that can be readily converted, (3) the problems related to developing this land for crop production, and (4) land use changes and trends. These data, and those provided by the various state Soil

Table 24. United States: Grain Production and Yields for Barley, Oats, Rice, Rye and Grain Sorghum, Selected Years, 1960-77

(Thousands of bushels, bushels per harvested acre)

	Barley		Oats		Rice		Rye		Grain Sorghum	
	Production	Yield	Production	Yield	Production[a]	Yield[b]	Production	Yield	Production	Yield
1960	429,005	31.0	1,153,332	43.4	54,591	3,423	33,108	19.6	619,594	39.7
1965	393,055	42.9	929,554	50.2	76,281	4,255	33,307	22.6	672,698	51.6
1970	416,139	42.8	917,159	49.2	83,805	4,618	36,840	25.8	683,571	50.4
1975	383,920	43.9	657,640	48.3	127,972	4,567	17,875	22.0	760,069	49.0
1977	415,803	43.8	747,914	55.6	99,223	4,412	16,998	24.5	790,647	56.2

a. Production in 1,000 cwt.
b. Yield in pounds per harvested acre.
Source: Data for 1960-75 from U.S. Department of Agriculture, *Agricultural Statistics*, 1977 ed. Data for 1977 from U.S. Department of Agriculture, Crop Reporting Board, *Crop Production, 1977 Annual Summary: Acreage, Yield, and Production*, 1978.

and Conservation Needs Inventory Committees, serve as an analytical base for evaluating historical and future ORS hinterland land use. Land, more specifically land that is potential cropland, provides the basis for future increases in grain production. The inventory of land "suitable" as cropland acts as a constraint to increases in future grain production.

Within this century, scientific and technological developments, and resulting increases in crop and livestock production, have greatly altered the farm sector's land use pattern. Developments leading to low cost nitrogenous fertilizer production, herbicides, and pesticides have facilitated major shifts in cropping systems by limiting crop rotations and greatly increasing areas of intertilled crops with little or no meadow crops. Improvements in farm mechanization have greatly affected agricultural land requirements as the combustion engine displaced draft animals and so released for the production of crop and livestock for market approximately 50 million acres of cropland devoted to feeding these animals.

Increases in the production, size, and performance of crop and livestock machinery, especially equipment associated with crop production and harvesting, contributed significantly to changes in land use. Mechanization favored those parts of the hinterland and the United States having large expanses of level to mildly rolling land, and penalized predominantly rolling to hilly land. Technological developments in automotive transportation and highway systems resulted in high density and vertical urban growth patterns and increased access and speed in serving more distant markets.

In many important agricultural sections of the United States, and in the ORS hinterland, the area of land in farms has been decreasing rapidly during recent decades, while large increases have occurred in non-farm uses of land. Dramatic changes occurred in national level land use between 1967 and 1975, with a net loss to cropland of 30.5 million acres. About 60 percent of the 17 million acres converted to urban and built-up areas was land in capability classes I-III. (This is land classified as potential cropland, with some soils having moderate to severe limitations that reduce plant choice or require conservation practices.) Nearly 7 million acres were converted to water during the same period.

As new cropland is needed, most will be gained from pasture and range and most will require the implementation of conservation practices. The opportunities to gain new cropland without commitments to conservation are already limited in nearly all the crop production regions. The Corn Belt, Delta, Appalachian, and Southeast regions (which include the PSAs in the ORS hinterland) have more options than the Nation as a whole for converting land to cropland. Of land presently in other uses in these four regions, 37.8 million acres are estimated to have a high potential for conversion to cropland. Erosion and wetness are the most serious problems facing these regions. These and other problems (such as soil, climate, ownership, commodity prices, and production and development costs) affect the likelihood that conversion to cropland from present land uses will occur in the foreseeable future.

As land suitable as cropland is used or is adapted to non-farm uses, the margin of suitable land available to be brought into grain production narrows. Any methodology that projects grain production must, therefore, include a cropland availability constraint. Such a constraint was incorporated at two levels in the projections of grain production in the PSAs. The state level projections of the USDA include a cropland availability constraint, as did the disaggregate PSA production projections.

As shown in Table 25, a relatively large percentage of the total land area in the ORS hinterland was farmland in 1974, approximately 44.1 million acres, or 53 percent, of a total land area of 83.4 million acres. Of this total farmland, 28.0 million acres, or 64 percent, was cropland. Of the 28.0 million area of total cropland, 16.3 million acres, over 58 percent, were harvested as grain; 10 million acres were pasture, and 1.8 million acres were either idle, in summer fallow, were cropland on which all crops failed, or were cropland used for soil improvement crops.

Land was most intensively farmed in those PSAs located in the major grain producing states of Ohio, Illinois, and Indiana [i.e., BEAs 53 (Lexington), 55 (Evansville), 56 (Terre Haute), 60 (Indianapolis), 61 (Anderson), 62 (Cincinnati), 63 (Dayton), and

Table 25. Ohio River Basin: Land Area and Farm and Nonfarm Utilization, by BEAs or BEA Segments,[a] 1974

(Thousands of acres unless otherwise specified)

BEA and BEA segment	Total land area	Farmland: Total farmland: Amount	Farmland: Total farmland: As a percent of total land	Farmland: Cropland: Total cropland	Farmland: Cropland: Cropland harvested	Farmland: Cropland: Pasture	Farmland: Cropland: Other cropland[b]	Farmland: Woodland	Farmland: Other farmland[c]	Nonfarmland[d]
Primary Study Areas	83,415.4	44,064.3	52.8	27,988.6	16,270.5	9,962.8	1,755.3	9,296.0	6,779.7	39,411.0
BEA 44: Atlanta, GA	5,177.0	1,213.8	23.5	502.9	168.5	295.8	38.6	471.5	239.4	3,963.1
BEA 45: Birmingham, AL	8,116.6	2,493.9	30.7	1,193.7	603.2	496.5	94.0	809.7	490.5	5,622.7
BEA 46: Memphis, TN	2,134.5	1,245.4	58.4	721.2	424.6	225.7	70.9	339.3	184.9	889.1
BEA 47: Huntsville, AL	5,767.1	2,842.2	49.3	1,629.0	908.3	614.5	106.3	730.7	482.5	2,924.8
BEA 48: Chattanooga, TN	4,972.0	1,653.5	33.3	839.1	385.6	406.5	47.0	566.6	247.8	3,318.4
BEA 49: Nashville, TN	12,400.1	7,233.4	57.8	4,165.5	1,635.8	2,251.3	278.4	1,989.1	1,078.8	5,226.8
BEA 50: Knoxville, TN	4,314.3	1,230.6	28.5	671.9	230.3	403.8	37.8	381.7	176.9	3,083.7
BEA 52: Huntington, WV	2,455.7	852.2	34.7	343.6	127.3	181.4	34.9	317.9	190.7	1,603.5
BEA 53: Lexington, KY	3,843.8	3,109.8	80.9	2,023.8	588.9	1,324.0	110.8	483.9	602.1	734.0
BEA 54: Louisville, KY	5,403.0	3,546.2	65.6	2,203.6	974.2	1,063.0	166.4	760.3	582.4	1,856.8
BEA 55: Evansville, IN	6,942.7	4,668.4	67.2	3,518.6	2,677.7	622.9	218.0	608.9	540.9	2,274.3
BEA 56: Terre Haute, IN	643.8	409.4	63.6	301.4	232.9	44.6	23.9	54.6	53.4	234.4
BEA 60: Indianapolis, IN	4,047.3	2,629.9	65.0	2,044.4	1,730.5	242.9	71.0	295.8	289.7	1,417.4
BEA 61: Anderson, IN	514.9	408.0	79.2	331.3	280.5	40.1	10.7	35.2	41.5	106.9
BEA 62: Cincinnati, OH	5,553.1	3,670.6	66.1	2,351.5	1,277.7	879.4	194.4	651.3	667.7	1,882.6
BEA 63: Dayton, OH	2,575.6	2,023.2	78.6	1,669.8	1,473.1	147.4	49.3	149.8	203.6	552.4
BEA 64: Columbus, OH	4,891.2	2,574.2	52.6	1,778.3	1,360.7	330.1	87.5	373.3	442.6	2,317.0
BEA 114: St. Louis, MO	1,102.7	769.5	69.8	631.5	499.3	86.1	46.1	59.2	78.9	333.2
BEA 115: Paducah, KY	2,560.0	1,490.1	58.2	1,067.5	691.4	306.8	69.3	217.2	205.4	1,070.0

Note: Individual items may not add to total due to rounding. Data assembled on a county level and aggregated into BEAs and BEA segments. Nonfarmland derived by subtracting total farmland from total land area.

a. BEA semgents defined as counties which are ultimate origins or destinations of waterborne movements.

b. Includes cropland used for soil improvement crops, cropland on which all crops failed, land in cultivated summer fallow, and idle cropland.

c. Includes pastureland and rangeland other than cropland and woodland pasture; and land in house lots, barn lots, ponds, roads, wastelands, etc.

d. Includes pasture, range, wood and forestlands not in farms; urban, industrial and nonfarm residential areas; parks and wildlife refuges, military lands; and roads, railroads and miscellaneous other areas.

Source: Data for total land area from Table 26. All other information from U.S. Department of Commerce, Bureau of the Census, Census of Agriculture, 1974, for the states of Alabama, Georgia, Illinois, Indiana, Kentucky, Mississippi, Ohio and Tennessee.

114 (St. Louis)]. In these PSAs, farmland, as a percentage of total land, represented between 64 to 81 percent. Furthermore, a large percentage of the farmland was cropland, and a significant area of that cropland was harvested.

The margin of land available and suitable for cropland in an area already so intensively farmed is of concern. A constraint was estimated to ensure that the area required to be harvested, to meet projections of production, would not exceed the area suitable for harvesting.

The land suitable as cropland was estimated by aggregating county level data, on the classes and subclasses of land considered suitable as cropland, into PSAs. For purposes of this study, land capability classes and subclasses I, IIe, IIw, IIIe, and IIIw were selected and summed to define land suitable as cropland in any one county. Soils in class I have few limitations that restrict their use. Soils in class II have some limitations that reduce the choice of plants or require moderate conservation practices or both. Soils in class III have severe limitations that reduce the choice of plants or require special conservation practices or both. Subclass "e" is made up of soils where the susceptibility to erosion is the dominant problem or hazard in their use. Subclass "w" is made up of soils where excess water is the dominant hazard or limitation in their use (see Appendix for detailed definition).

Following the above procedure, an estimated 44 percent, or 36.9 million acres, of the total land area of the ORS hinterland was determined suitable as cropland (Table 26). This 36.9 million acres of land suitable as cropland, relative to 16.3 million acres that were harvested in the hinterland in 1974, indicate that in spite of the existing high level of cropland utilization in the PSAs, there still remains a great deal of unused suitable cropland. An estimated 56 percent, or 20.7 million acres, of the total land area of the hinterland was suitable as cropland but was not used as cropland in 1974. The greatest margin of unused land suitable as cropland was in the southeastern PSAs where between approximately 55 and 90 percent of the land suitable as cropland was not harvested as of 1974 [i.e., BEAs 44 (Atlanta), 45 (Birmingham), 46 (Memphis), 47 (Huntsville), 48 (Chattanooga), 49 (Nashville), 50 (Knoxville), 52 (Huntington), 53 (Lexington), 54 (Louisville) and 115 (Paducah).

With one exception, projected acres by PSA segment met the land suitability constraint within safe margins. Projected acres harvested in BEA 60 (Indianapolis), an already intensively farmed

Table 26. Ohio River Basin: Total Land Area, Land Suitable as Cropland, Cropland Harvested and Remaining Land Suitable for Crops, by BEAs or BEA Segments,[a] 1974

(Thousands of acres unless otherwise specified)

BEA and BEA segment		Total land area	Land suitable as cropland[b]		Cropland harvested		Remaining land suitable	
			Amount	As a percent of total land area	Amount	As a percent of total land suitable	Amount	As a percent of total land suitable
Primary Study Areas		83,415.4	36,921.6	44.3	16,270.5	44.1	20,651.3	55.9
BEA 44:	Atlanta, GA	5,177.0	1,493.4	28.8	168.5	11.3	1,324.9	88.7
BEA 45:	Birmingham, AL	8,116.6	2,548.4	31.4	603.2	23.7	1,945.2	76.3
BEA 46:	Memphis, TN	2,134.5	951.7	44.6	424.6	44.6	527.1	55.4
BEA 47:	Huntsville, AL	5,767.1	2,653.7	46.0	908.3	34.2	1,745.4	65.8
BEA 48:	Chattanooga, TN	4,972.0	1,725.9	34.7	385.6	22.3	1,340.3	77.7
BEA 49:	Nashville, TN	12,400.1	4,991.0	40.2	1,635.8	32.8	3,355.2	67.2
BEA 50:	Knoxville, TN	4,314.3	999.2	23.2	230.3	23.0	768.9	77.0
BEA 52:	Huntington, WV	2,455.7	383.8	15.6	127.3	33.2	256.5	66.8
BEA 53:	Lexington, KY	3,843.8	1,778.5	46.3	588.9	33.1	1,189.6	66.9
BEA 54:	Louisville, KY	5,403.0	2,393.3	44.3	974.2	40.7	1,419.1	59.3
BEA 55:	Evansville, IN	6,942.7	4,329.6	62.4	2,677.7	61.8	1,651.9	38.2
BEA 56:	Terre Haute, IN	643.8	384.8	59.8	232.9	60.5	152.0	39.5
BEA 60:	Indianapolis, IN	4,047.3	2,705.2	66.8	1,730.5	64.0	974.7	36.0
BEA 61:	Anderson, IN	514.9	378.9	73.6	280.5	74.0	98.4	26.0
BEA 62:	Cincinnati, OH	5,553.1	2,453.6	44.2	1,277.7	52.1	1,175.9	47.9
BEA 63:	Dayton, OH	2,575.6	2,084.5	80.9	1,473.1	70.7	611.4	29.3
BEA 64:	Columbus, OH	4,891.2	2,380.1	48.7	1,360.7	57.2	1,019.5	42.8
BEA 114:	St. Louis, MO	1,102.7	830.6	75.3	499.3	60.1	331.3	39.9
BEA 115:	Paducah, KY	2,560.0	1,455.5	56.9	691.4	47.5	764.1	52.5

Note: Individual items may not add to total due to rounding. Data assembled on a county level and aggregated into BEAs and BEA segments.

a. BEA segments defined as counties which are ultimate origins or destinations of waterborne movements.

b. Includes land capability classes and subclasses I, IIe, IIw, IIIe and IIIw as measured in 1967.

Source: Total land area and land suitable as cropland tabulated from the soil and water conservation needs inventories conducted for the year 1967 by the State Soil and Conservation Needs Inventory Committees of the states of Alabama, Georgia, Illinois, Indiana, Kentucky, Mississippi, Ohio and Tennessee. Cropland harvested tabulated from the U.S. Department of Commerce, Bureau of the Census, Census of Agriculture, 1974 ed.

area, equalled the land area judged suitable as cropland. However, no adjustment to BEA 60's projected production was deemed necessary. One might find that as an area approached full utilization of suitable cropland that growth in production would be slower than projected or that land previously judged unsuitable would be brought into production.

D. Existing Production Levels

Grain production in the Ohio River System hinterland is characterized by intensive utilization of cropland, increasing acres harvested of all acres planted, and higher yields per acre. National and ORS hinterland crop production, in general, experienced strong growth between 1969 and 1976.

D-1. Corn, Wheat, and Soybeans

Ohio River System hinterland production of corn, wheat, and soybeans, the most important waterborne grains, increased steadily between 1969-76. Almost 16 million tons of grain were produced in the ORS hinterland in 1969, increasing to 25.6 million tons in 1976. The increase represents an annual growth of 7 percent (Table 27). In the ORS hinterland as a whole, production was concentrated in five PSAs, all of which include areas in the highly agricultural states of Ohio, Illinois, Indiana, and Kentucky. BEAs 55 (Evansville), 60 (Indianapolis), 62 (Cincinnati), 63 (Dayton), and 64 (Columbus) represented between 65 to 70 percent of total hinterland grain production during 1969-76. Although these PSAs exhibited strong growth in production between 1969-76, the greatest increase occurred in the southeastern PSAs: BEAs 47 (Huntsville), 48 (Chattanooga), 49 (Nashville), 50 (Knoxville), and 115 (Paducah). Between 1969-76, grain production increased in each of the 19 PSAs in the ORS hinterland without exception.

Production of three major crops in the ORS hinterland increased at a faster rate than U.S. production during the 1969-76 period (Table 27). Hinterland production, as a percentage of total U.S. grain production of corn, wheat, and soybeans, increased from 7.7 percent, or 16 million of 208.6 million tons in 1969, to 9.2 percent, or 25.6 million of 278.5 million tons in 1976.

Corn accounted for almost three-fourths of the hinterland's 1976 total production of all three crops. The predominance of corn, relative to wheat and soybeans, was also displayed in the PSAs' grain consumption and waterborne shipments. As indicated

Table 27. United States and Ohio River Basin: Production of Grains,[a] by BEAs or BEA Segments,[b] Estimated 1969-76

(Thousands of tons unless otherwise specified)

BEA and BEA segment	1969	1970	1971	1972	1973	1974	1975	1976	Average annual percentage change, 1969-76
United States	208,641.1	190,734.9	241,911.6	240,667.0	255,841.4	221,053.9	273,481.7	278,529.0	4.2
Primary Study Areas	15,964.3	12,785.6	18,653.7	17,817.5	17,927.0	17,862.1	20,699.6	25,576.9	7.0
BEA 44: Atlanta, GA	48.3	33.5	52.1	49.8	53.8	72.9	90.5	87.7	8.9
BEA 45: Birmingham, AL	244.5	206.3	264.8	237.4	278.8	286.5	385.7	418.0	8.0
BEA 46: Memphis, TN	269.7	240.7	356.8	340.8	329.7	337.3	426.3	483.1	8.7
BEA 47: Huntsville, AL	320.4	290.4	430.2	368.7	405.3	449.6	616.4	643.1	10.5
BEA 48: Chattanooga, TN	159.3	122.7	203.6	212.8	237.2	234.1	285.7	378.4	13.2
BEA 49: Nashville, TN	841.6	703.2	1,148.4	1,145.8	1,203.6	1,306.5	1,316.5	1,949.8	12.8
BEA 50: Knoxville, TN	56.9	51.1	70.4	78.3	93.5	79.9	87.0	118.0	11.0
BEA 52: Huntington, WV	73.4	49.1	81.6	77.7	81.6	86.8	97.0	105.4	5.3
BEA 53: Lexington, KY	244.9	192.8	341.1	332.2	341.8	357.8	313.5	427.4	8.3
BEA 54: Louisville, KY	685.0	475.9	813.4	810.0	869.3	929.8	826.6	1,173.7	8.0
BEA 55: Evansville, IN	3,675.7	2,458.2	3,971.5	4,127.3	3,937.5	3,881.5	4,649.1	5,594.6	6.2
BEA 56: Terre Haute, IN	329.0	298.4	408.7	361.2	404.7	288.0	427.1	498.1	6.1
BEA 60: Indianapolis, IN	2,932.0	2,357.3	3,209.7	3,050.5	3,283.4	2,609.1	3,097.3	3,998.0	4.5
BEA 61: Anderson, IN	389.2	327.5	423.9	385.4	430.6	409.4	452.4	600.7	6.4
BEA 62: Cincinnati, OH	1,402.4	1,100.8	1,566.5	1,389.5	1,416.2	1,513.5	1,630.3	2,036.6	5.5
BEA 63: Dayton, OH	1,849.3	1,773.5	2,341.2	2,061.5	2,000.5	2,194.5	2,581.3	2,845.0	6.4
BEA 64: Columbus, OH	1,542.5	1,390.9	1,798.8	1,595.4	1,505.8	1,794.3	1,979.6	2,446.7	6.8
BEA 114: St. Louis, MO	397.8	332.6	495.2	578.8	454.4	397.3	620.9	672.1	7.8
BEA 115: Paducah, KY	502.4	380.6	675.9	614.3	599.0	633.4	816.5	1,100.5	11.9

Note: Individual items may not add to total due to rounding. Data assembled on a county level and aggregated into BEAs and BEA segments.

a. Total production of corn, wheat, and soybeans only. Corn is corn for grain. Wheat is all wheat. Soybeans are soybeans for beans.

b. BEA segments defined as counties which are ultimate origins or destinations of waterborne movements.

Source: Total U.S. production for 1969 to 1974 from U.S. Department of Agriculture, Agricultural Statistics, 1977 and 1978 eds.; data for 1975 and 1976 from U.S. Department of Agriculture, Crop Production: 1977 Annual Summary; Acreage, Yield and Production, January 1978. BEA and BEA segment level data, estimated from production data provided annually for 1969-76 by the U.S. Department of Agriculture Crop Reporting Services of the states of Alabama, Georgia, Illinois, Indiana, Kentucky, Mississippi, Ohio and Tennessee.

earlier, corn yields almost three times as many bushels per harvested acre as wheat or soybeans. Corn production, as a percentage of the production of all three, varied from 36.6 to 93.9 percent of any one PSA's total production in 1976. Corn production as a percentage of the total was lowest in the southeastern PSAs in Georgia and Alabama, where soybeans were the preferred crop. Of the three principal crops, corn represented a greater percentage share of total grain production in the ORS hinterland in 1976 (73.5 percent) than did corn in terms of U.S. production (63.0 percent) (Table 28). In 1976, the PSAs produced 10.7 percent of the corn grown for grain in the United States.

Wheat is not as important a crop in the PSAs as it is in the United States in general. Wheat represented only 8 percent of total grain production in the hinterland in 1976; however, it represented 23 percent of U.S. production. In the ORS hinterland as a whole, wheat is grown in the largest quantities in Ohio, Illinois, and Indiana. However, in the southeastern PSAs, wheat, in many cases, represented a larger percentage share of total production. The hinterland produced only 3.2 percent of all wheat grown in the United States in 1976.

Soybeans represented a larger percentage share of total production in the PSAs (18.4 percent) in 1976 than they did for the Nation as a whole (13.9 percent). The percent that soybean production represented of total production of grain in the PSAs in 1976 varied widely, ranging from 2.5 percent in BEA 52 (Huntington) to 61.7 percent in BEA 45 (Birmingham). In 1976, soybean production in the PSAs represented 12.2 percent of U.S. production of soybeans for beans (Table 28).

D-2. Minor Grains

The production of barley, oats, rice, rye, and sorghum in the PSAs and in the United States is secondary to the production of corn, wheat, and soybeans. Production of these minor grains in 1976 is shown in Table 29. Production of barley, sorghum, and rice in the hinterland was and is a relatively small share of total U.S. production.

The production of oats and rye in those states that include areas of the Ohio River System hinterland represented 12.3 percent and 19.8 percent of total U.S. production of these grains in 1976, respectively. Most of the oats and rye produced in these states was either consumed on the farm where produced or was trucked for

Table 28. United States and Ohio River Basin: Production of Grains, by Types of Grains, and by BEAs or BEA Segments,[a] Estimated 1976

(Thousands of tons unless otherwise specified)

BEA and BEA Segment		Total[b] Amount	Total[b] Percent	Corn Amount	Corn As a percent of total	Wheat Amount	Wheat As a percent of total	Soybeans Amount	Soybeans As a percent of total
United States		278,529.0	100	175,528.3	63.0	64,335.2	23.1	38,665.5	13.9
Primary Study Areas		25,576.9	100	18,802.6	73.5	2,076.1	8.1	4,698.1	18.4
BEA 44:	*Atlanta, GA*	87.7	100	41.1	46.9	9.8	11.1	36.8	42.0
BEA 45:	Birmingham, AL	418.0	100	152.8	36.6	7.3	1.7	257.9	61.7
BEA 46:	Memphis, TN	483.1	100	281.3	58.2	33.0	6.8	168.8	34.9
BEA 47:	Huntsville, AL	643.1	100	272.6	42.4	47.7	7.4	322.7	50.2
BEA 48:	Chattanooga, TN	378.4	100	300.5	79.4	12.5	3.3	65.3	17.3
BEA 49:	Nashville, TN	1,949.8	100	1,373.0	70.4	207.7	10.7	369.1	18.9
BEA 50:	Knoxville, TN	118.0	100	96.7	81.9	13.3	11.3	8.0	6.8
BEA 52:	Huntington, WV	105.4	100	91.5	86.8	3.3	3.1	10.6	10.1
BEA 53:	Lexington, KY	427.4	100	401.1	93.9	15.8	3.7	10.5	2.5
BEA 54:	Louisville, KY	1,173.7	100	1,009.3	86.0	65.6	5.6	98.8	8.4
BEA 55:	Evansville, IN	5,594.6	100	4,294.8	76.8	426.6	7.6	873.2	15.6
BEA 56:	Terre Haute, In	498.1	100	388.4	78.0	42.6	8.6	67.0	13.5
BEA 60:	Indianapolis, IN	3,998.0	100	3,190.4	79.8	241.2	6.0	566.4	14.2
BEA 61:	Anderson, IN	600.7	100	485.7	80.9	39.4	6.6	75.6	12.6
BEA 62:	Cincinnati, OH	2,036.6	100	1,563.5	76.8	150.7	7.4	322.4	15.8
BEA 63:	Dayton, OH	2,845.0	100	2,075.0	72.9	308.9	10.9	461.1	16.2
BEA 64:	Columbus, OH	2,446.7	100	1,724.2	70.5	245.8	10.0	476.7	19.5
BEA 114:	St. Louis, MO	672.1	100	335.8	50.0	121.5	18.1	214.8	31.9
BEA 115:	Paducah, KY	1,100.5	100	724.7	65.8	83.6	7.6	292.2	26.5

Note: Individual items may not add to total due to rounding. Data assembled on a county level and aggregated into BEAs and BEA segments.

a. BEA segments defined as counties which are ultimate origins or destinations of waterborne movements.

b. Total production of corn, wheat and soybeans only. Corn is corn for grain. Wheat is all wheat. Soybeans are soybeans for beans.

Source: Total U.S. production data from U.S. Department of Agriculture, Crop Production: 1977 Annual Summary; Acreage, Yield and Production, January 1978. BEA and BEA segment data estimated from production data provided annually for 1969-76 by the U.S. Department of Agriculture Crop Reporting Services of the states of Alabama, Georgia, Illinois, Indiana, Kentucky, Mississippi, Ohio and Tennessee.

Table 29. United States and Ohio River System Hinterland[a]: Production of Minor Grains,[b] 1976

(Thousands of tons unless otherwise specified)

	Barley	Oats	Rice	Rye[c]	Grain Sorghum
United States	8,931.9	8,741.0	115,648.0	418.8	20,162.9
Ohio River System hinterland	70.8	1,075.9	6,048.0[d]	82.9	359.2
As a percentage of U.S. production	0.8	12.3	5.2	19.8	1.8

a. The states of Alabama, Georgia, Illinois, Indiana, Kentucky, Mississippi, Ohio and Tennessee.
b. Barley, oats, rice, rye and sorghum for grain.
c. Production in thousands of cwt.
d. Mississippi only.
Source: U.S. Department of Agriculture, Crop Production: 1977 Annual Summary; Acreage, Yield and Production, January 1978.

consumption in contiguous states. These grains have not and are not expected to move in great quantities by either rail or water.

United States production of barley has been and will remain concentrated in North Dakota, California, Montana, Minnesota, Idaho, and South Dakota; oat production in Minnesota, Iowa, Wisconsin, and North and South Dakota; rice production in Arkansas, Texas, California, and Louisiana; rye production in Minnesota, North and South Dakota, Georgia, and Nebraska; and grain sorghum production in Texas, Kansas, and Nebraska.

E. Forecasting Procedures and Assumptions

Regional level projections of grain production that correspond to the Ohio River System hinterland do not exist. Grain production projections for the states that contain PSAs of the ORS hinterland exist but were found to be inadequate in that the time frames, assumptions, and base data did not correspond.

In general, projections of grain production have been based on disaggregations of USDA national projections. The methods used in disaggregating the USDA projections are presented below.

E-1. U.S. Department of Agriculture: National - Interregional Agricultural Projections System (NIRAP)

The state level projections generated by the USDA NIRAP system for 1985, 1990, and 2000 were used as the base for grain production projections for the PSAs. The baseline scenario was chosen. The assumptions and constraints that underlie this model are the same for the grain production projections as they were for projecting livestock production (grain consumption). The system takes account of the presence and interaction of such variables as commodity production, land use, soil erosion, crop yield, and energy and irrigation water requirements. Elasticities of price and demand by commodity are included. The model's demand and supply attributes and macro-economic assumptions are as outlined in Table 18.

The state and commodity level production projections generated by the NIRAP system provide a consistent and comparative set of projections for the years 1985, 1990, and 2000. State production of corn, wheat, and soybeans for 1980 was estimated by interpolating backwards the annual growth trend line of the 1974-76 base to 1985.

E-2. Disaggregation of State Level Data to BEA Level

For the period 1969-76, the amount of corn, wheat, and soybeans produced in each PSA was identified and divided by the respective state total to derive a percentage share produced of each of the three crops in each of the 19 PSAs. A linear regression analysis, in conjunction with expert judgment, was used to project these percentage shares for each PSA to the year 1980, 1990, and 2000. These projected percentage shares were multiplied by the USDA projected state totals of grain production by commodity for 1980, 1990, and 2000. Thus, USDA projections of corn, wheat, and soybean production were allocated to each PSA.

For corn and wheat, for each PSA, the difference between grain production for the 1974-76 average and grain production in 2000 was allocated to 2040. Thus, the rate of increase between 2000 and 2040 is the same as the rate of increase between the 1974-76 average and 2000. This assumption was based on the conclusion by many economists that USDA has conservatively estimated corn and wheat production for 2000.

For soybeans, for each PSA the difference between the 1974-76 average grain production level and that in the year 2000 was divided by three. This amount was allocated to 2040. This rate of increase between 2000 and 2040 is one-third of the rate of increase that is expected to occur in any one PSA between the base year average and 2000. This assumption is based on the conclusion by many economists that USDA has liberally estimated soybean production to the year 2000.

For each of the three crops, the projected production of each, by PSA, was summed to estimate total grain production by PSA for each of the five projection years.

Acres harvested by crop were estimated for the period 1980 to 2040 by dividing production for each of the PSAs by the yield per harvested acre as estimated by USDA.[1] For all PSAs, the total acres

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1. A basic assumption underlying the crop yield projections is that the rapid increase in agricultural productivity that occurred during 1950-74 will continue in 1975-85 but at a slower rate of increase. National average crop yield projections for the major crops in 1985 show the following increases over the 1972-74 averages: wheat - 24 percent, corn - 34 percent, soybeans - 15 percent. In total, yield projections are generally consistent

in grain were less than or equal to the estimated number of acres available for grain production. Projected grain production levels, yields, and acres planted are necessarily based on well-defined sets of assumptions.[1] Included in these assumptions are propositions underlying weather conditions, world economic and political realities, and changes in technologies. Changes in any one assumption such as weather will alter grain production levels for a specific year from projected levels. Changes in political or economic world conditions could alter production levels from expected outcomes for a period of years. All grain production data are estimated on a tenuous base, and grain production levels in 2000 or 2040 could vary from these levels projected by USDA and other agricultural economists.

F. Probable Future Production Levels

The application of the above methodology yields an estimated average increase of total grain production for the PSAs of 1.01 percent between 1976 and 2000. By 1980, grain production in the hinterland is expected to decrease over 20 percent, dropping from the 1976 level of 25.6 million tons to 19.9 million tons (Table 30). This decline in production is a function of expected decreases in the production of corn, which yields almost three times as much grain by weight per harvested acre as soybeans and wheat. Corn production is expected to decrease in each of the eight states which encompass the PSAs, most notably in Kentucky and Tennessee. Those PSAs in which corn represented the largest percentage share of the total aggregate production of all three principal crops in

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with a 1.0 to 1.5 percent annual increase in agricultural productivity and moderate increases in yield -- increasing inputs such as chemical fertilizers. Crop yield projections used in the NIRAP system are the same as those used in the 1972 OBERS projections of regional economic activity in the U.S. See U.S. Department of Agriculture, Economic Research Service, USDA National - Interregional Agricultural Projections (NIRAP) System, July 1978.

1. Some of these assumptions include: no major wars; no major disruption in the world economy; historical trends in environmental relationships and controls; and historical patterns and trends in consumer tastes and preferences. See U.S. Department of Agriculture, Economic Research Service, USDA National - Interregional Agricultural Projections (NIRAP) System, July 1978.

[illegible],[a] [illegible] BEA Segment,[b]
[illegible] 2040, Selected Years

(Thousands of tons [illegible] otherwise specified)

BEA and BEA segment	Estimated 1976	Projected 1980	Projected 1990	Projected 2000	Projected 2020	Projected 2040	Average annual percentage change 1976-78--2000	Average annual percentage change 2000-2040
Primary Study Areas	25,576.9	19,859.7	25,199.4	32,549.6	39,361.2	46,719.5	1.01	0.91
BEA 44: Atlanta, GA	47.7	113.3	154.5	270.5	328.8	392.6	4.80	0.94
BEA 45: Birmingham, AL	418.9	439.4	637.0	905.5	1,049.8	1,201.4	3.27	0.71
BEA 46: Memphis, TN	483.1	477.8	582.6	762.5	839.1	916.9	1.92	0.46
BEA 47: Huntsville, AL	633.1	663.0	949.9	1,359.6	1,541.3	1,727.2	3.17	0.60
BEA 48: Chattanooga, TN	378.4	311.9	436.3	618.3	698.8	782.0	2.07	0.59
BEA 49: Nashville, TN	1,949.8	1,765.8	2,210.2	3,040.0	3,432.8	3,836.6	1.87	0.58
BEA 50: Knoxville, TN	118.0	65.5	99.3	126.4	150.3	176.5	0.29	0.84
BEA 52: Huntington, WV	1[illegible]5.4	79.8	1[illegible].4	118.7	133.4	148.6	0.50	0.56
BEA 53: Lexington, KY	427.4	302.4	377.2	499.3	574.4	655.7	0.65	0.68
BEA 54: Louisville, KY	1,173.7	1,663.3	1,300.8	1,731.5	2,237.5	2,808.4	1.63	1.22
BEA 55: Evansville, IN	5,594.6	2,450.0	3,453.1	4,873.2	6,831.0	9,082.0	(0.57)	1.57
BEA 56: Terre Haute, IN	498.1	393.6	497.0	643.0	878.5	1,141.8	1.07	1.45
BEA 60: Indianapolis, IN	2,998.0	3,582.5	4,015.8	4,612.4	5,872.1	7,128.9	0.60	1.09
BEA 61: Anderson, IN	600.7	247.9	323.4	426.9	613.4	817.3	(1.41)	1.64
BEA 62: Cincinnati, OH	2,036.6	1,771.5	2,209.1	2,647.1	3,088.6	3,537.0	1.10	0.73
BEA 63: Dayton, OH	2,845.0	2,636.3	3,380.0	4,037.6	4,465.3	4,892.8	1.47	0.48
BEA 64: Columbus, OH	2,446.7	1,934.0	2,479.4	2,961.2	3,275.6	3,589.7	0.80	0.48
BEA 113: St. Louis, MO	672.1	723.1	839.1	1,165.5	1,349.2	1,545.8	2.32	0.71
BEA 114: Paducah, KY	1,190.5	841.6	1,192.3	1,750.4	2,001.3	2,338.3	1.95	0.73

Note: Individual items may not add to total due to rounding. Data assembled on a county level and aggregated into BEAs and BEA segments.

a. [illegible] production of corn, wheat, and soybeans only. Corn is corn for grain. Wheat is all wheat. Soybeans are soybeans for beans.

b. [illegible] defined as counties which are ultimate origins or destinations of waterborne movements.

[illegible] U.S. Department of Agriculture, Economic Research Service, [illegible] National-Interregional Agricultural Projections [illegible], July 1978.

[illegible] level [illegible] project [illegible] 2000. Bushels of grain produced by each of the [illegible] Alabama, Illinois, Indiana, Kentucky, Mississippi, Ohio and Tennessee were averaged for 1974, [illegible] level was subtracted from the 2000 [illegible] [illegible] base year production for soybeans [illegible] allocated to 2040. [illegible] BEA [illegible] was estimated and was [illegible] The percent of the states' total [illegible] was multiplied times the state totals [illegible] The yield per acre [illegible] was divided into the [illegible] 2040 to be equal to or less than [illegible] for 1976 from Table 27.

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1976 are also those which are expected to experience the greatest decreases in total production in 1980. To some extent, increases in soybean production are expected to offset decreases in corn production.

The 1976-80 production decrease is amplified, to some extent, by the fact that 1976 and earlier years were anomalous in terms of grain production. Because of favorable weather conditions, yields were abnormally high. In addition, relatively high prices induced the planting and harvesting of a disproportionately large number of acres of corn.

Because the 1980 projections were derived by interpolating backwards from 1985 (the first projection year in the USDA NIRAP System), it was felt that caution demanded that these estimates be checked against estimates derived by projecting 1980 state level production from 1976-78 actual production and 1979 intended plantings. This supportive analysis confirmed the accuracy of the initial estimates.

By 1990, the PSAs' production is expected to increase to 25.2 million tons, almost reaching the high level of 1976. By 1990, production in a majority of the PSAs is expected to exceed 1976 production levels (Table 30). Growth in production is expected to be the greatest in the southeastern PSAs.

Between 2000 and 2040, grain production in the PSAs is expected to increase but at a decreasing rate. Total grain production in 2000 is estimated to be 32.5 million tons and increase to 46.7 million tons in 2040, an average annual growth of 0.91 percent. Growth in production is expected to be the greatest in those PSAs which are contained in the States of Alabama, Georgia, and Tennessee. However, production is expected to remain concentrated in those PSAs which encompass areas in the States of Illinois, Indiana, Kentucky, and Ohio.

In the future, grain production in the PSAs will be a decreasing percentage share of projected national grain production. Specifically, corn production in the PSAs in 1990 is expected to represent approximately 7 percent of U.S. production, wheat production will be 2.8 percent, and soybean production will be 11.4 percent. By 2000, total grain production in the PSAs is expected to represent 7.7, 2.8, and 12.5 percent of projected national production of corn, wheat, and soybeans, respectively.

IV. TRANSPORTATION CHARACTERISTICS

Two forces work to move grain within the ORS hinterland. These are the ability of the western areas of the hinterland to produce grain surpluses for shipment both within and outside the hinterland and the demand of deficit areas within the hinterland for both PSA and outside production. In 1976, a net total of 3.5 million tons of grain was shipped out of the hinterland. Of this net total, 2.6 million tons were shipped out via water. The gross amount of waterborne grain flows has been and is expected to continue to increase over time. Outbound waterway flows in 1980 are expected to decline from the high levels of 1976 but to recover by 1990. Inbound waterway flows are expected to remain relatively stable between 1976 and 1980 and then to decrease in subsequent years. Local waterway movements, from one point to another within the ORS, will continue to be insignificant in the future (Table 31).

A. Existing Modal Split

Because of inadequate data, total shipments and receipts of grain cannot be determined for the PSAs. While both rail and water data are available, there is no source of adequate data to determine inbound and outbound truck movements. The determination of total shipments requires summation of the movements by all modes.

It is not possible to establish the existing modal split of total PSA grain movements. It is possible, however, to develop judgments about the modal split on the basis of available rail and water data, and on the basis of net shipments and receipts implied by the consumption and production estimates made for each PSA. These data provided estimates of net truck movements, and information from shippers and receivers of grain permitted analysis of truck transportation.

Table 31. Ohio River Basin: Production, Consumption and Shipments by Mode of Transportation of Grains,[a] Estimated 1976 and Projected 1980-2040, Selected Years

(Thousands of tons unless otherwise specified)

	Estimated 1976	Projected 1980	1990	2000	2020	2040	Average annual percentage change 1976-2000	2000-2040
Production	25,576.9	19,859.7	25,199.4	32,549.6	39,361.2	46,719.5	1.01	0.91
Consumption	22,081.5	22,352.2	23,323.4	25,139.0	26,104.0	27,102.8	0.54	0.19
Net shipments (receipts)	3,495.4	(2,492.5)	1,876.0	7,410.6	13,257.2	19,616.7	3.18	2.46
Net waterborne	2,617.0	1,119.6	2,103.5	3,462.9	4,839.2	6,353.8	1.18	1.53
Net rail	5,048.8	2,316.8	3,847.2	6,562.3	9,747.8	13,082.4	1.10	1.74
Net truck	(4,170.4)	5,928.9	(4,074.7)	(2,616.7)	(1,329.8)	180.5	(1.92)	b
Gross waterborne shipments:								
Outbound	4,035.0	2,593.5	3,492.6	4,674.6	5,957.5	7,372.6	0.62	1.15
Inbound	1,418.0	1,473.9	1,389.1	1,211.7	1,118.3	1,018.8	(0.65)	(0.43)
Local	129.0	86.1	114.9	156.7	199.2	246.0	0.76	1.15
Total	5,582.0	4,153.5	4,996.6	6,043.0	7,275.0	8,637.4	0.33	0.90

Note: Projected net shipments (receipts) determined by subtracting projected consumption from projected production. Projected modal split for the PSAs was estimated from projections of modal split for each BEA and BEA segment. For most BEAs, projected modal split remains constant in the future except when data, analyses and conversations with industrial authorities indicated otherwise. Gross waterborne shipments (inbound, outbound, local) were projected by assuming that the relationship between gross and net waterborne shipments in 1976 would remain constant in the future except when data, analyses and conversations with industrial authorities indicated otherwise.

a. Total production of corn, wheat and soybeans only. Corn is corn for grain. Wheat is all wheat. Soybeans are soybeans for beans. Consumption of grains represents the addition of the consumption of corn, wheat and soybeans by livestock, processing and seed.

b. Not defined.

Source: Tables 19, 30 and 35; Waterborne Commerce by Port Equivalents, revised 1976, and ICC Railroad Waybill Sample, 1976, supplied by the U.S. Army Corps of Engineers.

The Ohio River System hinterland has been and is expected to remain (with the exception of 1980) a net exporter of grain. BEAs 55 (Evansville), 60 (Indianapolis), 62 (Cincinnati), 63 (Dayton), and 64 (Columbus) are expected to generate the greatest volume of outbound shipments by both water and rail, with rail continuing to be the most important mode of transport. Historically, most of rail bound movements of grain either originated from BEAs 55, 60, 63, or 64, or were destined for BEAs 44 (Atlanta), 45 (Birmingham), 47 (Huntsville), or 48 (Chattanooga) (Table 32).

Waterborne movements of grain were relatively important in those PSAs where production and/or consumption took place near the waterway. However, the drawing or distribution area of grain movements is more distant from the river than it is for other commodities. For example, aggregates has a 20-mile drawing area, on the average, and grain hauls range from 75 to 100 miles.

The movements of grain by truck in the hinterland were inbound. In general, truck movements were inbound to PSAs that are net consumers of grain. Truck movements predominate in the intrastate movement of grain and in grain movements to contiguous states.

B. Intermodal Characteristics

Intermodal transfers of grain commonly have been truck-to-barge-to-truck and truck-to-rail-to-truck movements. They rarely have been barge-rail transfers. When grain is off-loaded to rail or barge, it is generally sent to its final destination (to the processor, to export, to the grain merchandiser). It may, however, also be moved again by truck. Industry authorities and ORS shippers indicated that rail-to-barge or barge-to-rail links are rare and are generally in response to short-term anomalous market situations.

Shippers and receivers along the river were surveyed to ascertain the 1976 percentage distribution of grain shipped which was transshipped from/to landlocked PSAs. Grain traffic flows were determined with identification of the producing BEA as the origin BEA, the point of transfer to water as the shipping BEA, the waterway destination as the receiving BEA, and the ultimate consumption point designated as the destination BEA.

C. Factors Affecting Modal Choice

The production, marketing, and utilization of ORS hinterland grain relies on an integrated and complex grain-marketing system.

Table 32. Ohio River Basin: Production, Consumption and Shipments by Mode of Transportation of Grains,[a] by BEAs or BEA Segments,[b] Estimated 1976

(Thousands of tons)

BEA and BEA segment	Production	Consumption	Shipments (receipts)						
				Water					
			Total net	Net	Inbound	Outbound	Local	Net rail	Net truck
Primary Study Areas	25,576.9	22,081.5	3,495.4	2,617.0	1,547.0[c]	4,164.0[c]	129.0[c]	5,048.8	(4,170.4)
BEA 44: Atlanta, GA	87.7	1,577.8	(1,490.1)	(26.3)	26.3	0	0	(726.3)	(737.5)
BEA 45: Birmingham, AL	418.0	1,272.9	(854.9)	(114.2)	114.2	0	0	(393.8)	(346.9)
BEA 46: Memphis, TN	483.1	310.9	172.2	21.4	0	21.4	0	30.1	120.7
BEA 47: Huntsville, AL	643.1	2,059.8	(1,416.7)	(420.8)	420.8	0	0	(318.0)	(677.9)
BEA 48: Chattanooga, TN	378.4	1,823.0	(1,444.6)	(807.9)	807.9	0	0	(493.4)	(143.3)
BEA 49: Nashville, TN	1,949.8	2,270.6	(320.8)	269.3	0	269.3	0	224.2	(814.3)
BEA 50: Knoxville, TN	118.0	326.7	(208.7)	(11.1)	11.1	0	0	(171.9)	(25.7)
BEA 52: Huntington, WV	105.4	256.2	(150.8)	1.1	0	1.1	0	10.4	(162.3)
BEA 53: Lexington, KY	427.4	1,177.8	(750.4)	34.6	0	34.6	0	(49.7)	(735.3)
BEA 54: Louisville, KY	1,173.7	1,778.6	(604.9)	113.8	0	113.8	0	(22.7)	(696.0)
BEA 55: Evansville, IN	5,594.6	2,550.5	3,044.1	1,744.2	163.6	1,907.8	0	1,576.5	(276.6)
BEA 56: Terre Haute, IN	498.1	83.4	414.7	76.4	0	76.4	0	152.1	186.2
BEA 60: Indianapolis, IN	3,998.0	1,760.8	2,237.2	243.8	0	243.8	0	1,721.7	271.7
BEA 61: Anderson, IN	600.7	164.8	435.9	53.3	0	53.3	0	0	382.6
BEA 62: Cincinnati, OH	2,036.6	1,202.3	834.3	891.0	1.1	892.1	0	968.0	(1,024.7)
BEA 63: Dayton, OH	2,845.0	1,602.7	1,242.3	183.9	0	183.9	0	843.3	215.1
BEA 64: Columbus, OH	2,446.7	539.1	1,907.6	76.9	0	76.9	0	1,173.1	657.6
BEA 114: St. Louis, MO	672.1	205.3	466.8	38.4	0	38.4	0	281.5	146.9
BEA 115: Paducah, KY	1,100.5	1,118.3	(17.8)	249.2	2.0	251.2	0	243.7	(510.7)

Note: Gross and net waterborne rail shipments (receipts) were determined for 1976 from U.S. Army Corps of Engineers waterborne commerce data and Interstate Commerce Commission railroad waybill data. Total net shipments (receipts) were determined by subtracting consumption from production. Net truck shipments (receipts) were determined by subtracting net waterborne and rail shipments (receipts) from total net shipments (receipts).

a. Total production and consumption of corn, wheat and soybeans only. Corn is corn for grain. Wheat is all wheat. Soybeans are soybeans for beans. Consumption of grains represents the addition of the consumption of corn, wheat and soybeans by livestock, processing and seed.

b. BEA segments defined as counties which are ultimate origins or destinations of waterborne movements.

c. Total Primary Study Area shipments equal inbound, outbound and local shipments for the PSAs as a unit and do equal the sum of shipments reported for each of the BEAs and BEA segments.

Source: Estimated production and consumption from Tables 19 and 30. Water and rail shipments (receipts) from Waterborne Commerce by Port Equivalents, revised 1976, and ICC Railroad Waybill Sample, 1976, supplied by the U.S. Army Corps of Engineers.

The surplus of grain production over grain consumption in any one area indicates the magnitude of grain movements from farm and country elevators to terminal elevators for subsequent shipment to processors, feed manufacturers, and export points.

Grain from farms moves primarily to four types of firms: (1) country elevators; (2) terminal, subterminal, and export elevators; (3) feed mills and manufacturers; and (4) grain processors. By far the largest portion of grain moves to country elevators and terminal elevators and is shipped directly or indirectly to processors, export terminals, and feed and processing firms.

The country elevator operators sell grain through the most profitable channels available. The operators' modal choice to various destinations depends on the demand, the relative cost and availability of transportation facilities, and the distance to be covered.

C-1. Transport Costs and Distance

The importance of truck transport is greatest in short hauls within a state and to adjacent states. The market areas served by truck vary during harvest time when shortages of barge and rail facilities combine with storage capacity limitations at terminal facilities to extend market distances.

Water and rail are the modes that have the economic advantage in moving grain to distant points. The elevator operator's marketing and modal choice decision in regard to barge and rail depends upon the price he will receive after subtracting his freight costs to each facility from the bid offered at each of the delivery points. Water and rail compete with and between one another for both grain supplies from inland elevators and for alternative domestic and export markets.

The decision to transport grain by barge is made when the bid at the barge terminal, less transportation costs to that terminal, exceeds the margin available from sales to a local processor, sale to a nearby rail terminal, or direct shipment to a distant export or domestic market. Therefore, the market share of grain moving by barge at any one time is a function not only of relative barge and rail rates to export points (the dominant outlet for barge grain), but also of accessional costs to the river and the relative strength of alternative markets, especially domestic processors and feeders.[1]

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1. U.S. Department of Transportation, Distribution Systems Analysis, Vol. II of Modal Traffic Impacts of Waterway User Charges (Washington, D.C.: GPO, 1977).

Rail and barge rates to export points, in the absence of institutional factors and anomalous explanatory variables, define a hinterland along the waterway from which barge terminals have an economic advantage in attracting grain. Consider an example in which the bid for export corn at the Gulf is $3.60 per bushel, the barge rate from an upriver barge terminal is 17 cents per bushel (plus transfer costs of 3 cents per bushel at the terminal including handling and shrinkage), and the rail rate to the Gulf from inland terminals is 34 cents per bushel. An inland elevator operator's modal choice will be for barge only if the cost of transporting grain to the river terminal is less than 14 cents. Since 14 cents is sufficient to truck a bushel of grain about 90 to 100 (highway) miles, the export grain would, hypothetically, move by barge only from elevators within this distance of the river. The extent to which this differential widens or narrows determines, to some extent, the area from which the barge terminal operator can compete in drawing grain for the market.[1]

Over the course of the year, barge rates will fluctuate in response to the demand for transportation. Barge rates are highest during harvest time, when the demand for transportation is the highest. Barge rate fluctuations are reflected in the differential between the bid at the river elevator and the bid for export at the Gulf. From season to season, the competitive areas for rail and barge shipments for export will vary. This is a function of the ability of barge rates to respond to demands in the short run and the inability of rail rates to respond because of Interstate Commerce Commission (ICC) regulations. As barge rates increase, the distances from the river that barge terminal operators can competitively draw grain decreases. On the other hand, the drawing area of a river terminal is extended an additional 20 or 30 miles from the river during the slack season when barge rates are depressed.

C-2. Other Modal Choice Factors

Among these are physical restrictions, institutional limitations, the inability to alter transportation supply in the short run, the location and facilities of consumers and suppliers, and the requirement for timely shipments.

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1. The above discussion is meant to be purely illustrative of how different modal rate structures affect modal choice, at any one point of time, and to the exclusion of other factors. Of course, other variables discussed in this section (e.g., time and institutional relationships such as those between a grain merchandising operation and its subsidiary processing facility) interplay with rates to affect modal choice.

a. Physical Restrictions

Physical restrictions result from natural limitations such as topography and climatic patterns. Restrictions that affect the economic flow of grain from surplus areas to deficit and export markets are the directional flow of rivers, the location of mountain ranges, and weather. The strength of various markets and modal choices during the year vary as a function of the weather. During the winter months, the use of the northern seaway may be restricted, and under severe weather conditions more southern river routes may be blocked. When rivers are used to transport grain from surplus to deficit areas, the production origin and consumption destination must be on or near the river.

Such physical restrictions as mountain ranges, which are obstructions to the free movement of grain, create additional marketing costs. The effect of physical restrictions often have a more dynamic influence on market structure than transportation, as minimizing model solutions indicate.[1]

b. Institutional Limitations

Institutional limitations established by governmental policies and industry practices may restrict the flow of grain, but also may be subject to rapid change. Such limitations include railroad rate zones and territories, changes in rail and other modal rates, and contractual arrangements of shippers.

Each rail rate territory operates independently in the development of rail rates. This factor creates difficulty in the negotiation of joint, proportional, or combinations of rates among rate territories. The problem associated with the routing and exchange of rail cars among railroad companies from different territories, and even among railroads in the same territory, can sometimes substantially restrict a free flow of grain.

Rail rates are controlled by the ICC, and the action of this agency can significantly affect the grain marketing structure and the modal choice of both the shippers and receivers. Railroads can, within their limited rate flexibility, affect the demand for

1. B.F. Jones, J.W. Sharp, and E. Dean Baldwin, Structure of the Grain Market in Surplus Feed Grain Areas, Southern Cooperative Series No. 207, Research Bulletin No. 927 (West Lafayette, IN: Purdue University, 1975).

rail transport in regard to both volume and seasonality. Through the provision of special rate or mileage allowances for grain moving in shipper-owned/leased cars, the railroads hope to affect modal choice. Some railroads publish tariffs under which the rate per ton varies in accordance with the volume of traffic shipped in some interval (nine months or one year). This rate structure encourages continuous rail shipment throughout the year because a shipment each week is required to meet the volume minimum. Once the requirement is met, the rate is extremely attractive, even when barge rates are at or below annual contract rates.

Various rail rate categories are available in areas of the ORS hinterland, but are not uniformly available to all firms due to firm size or location, or because of particular tariff regulations. It has been found that access to most rate categories tends to increase with the size of the firm, although the pattern is not uniform. Firms with the largest grain storage capacities, and with the equipment and facilities to load a train within a designated time period before demurrage charges are incurred, are able to use almost every rail rate available. Such large-scale elevators often can utilize unit trains that provide faster turnaround time, higher car-utilization rates, and greater efficiency in grain movement.[1] The ability of any firm to use unit trains is a function of rates, the existence of compatible origins and destinations, and the ability of the elevator to loadout grain at an adequate per hour rate (10,000 bushels an hour). The access and use by smaller firms of multiple car rates is limited by their grain storage capacity and loadout rates, i.e., by the volume of grain they have available and are able to move at any one time.

Contractual arrangements for transportation exist in the grain marketing system. A significant fraction of barge grain is shipped under annual contract that guarantees a certain number of barges per month to a shipper at a fixed cost. Although the barge rate does not fluctuate for this portion of barge shipments, the price paid for the grain at the barge terminal is the same as for grain loaded on barges purchased at the spot rate. Also, since the

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1. As of 1978, there were at least 18 unit train facility sites in the Ohio River System hinterland: two in BEA 54 (Louisville), three in BEA 60 (Indianapolis), three in BEA 62 (Cincinnati), four in BEA 63 (Dayton), and six in BEA 64 (Columbus). Ohio Agricultural Research and Development Center, Grain Facilities in the U.S. Specializing in Originating Grain for Export and Soybean Processing Plants, Research Circular 241, by John Sharp (Wooster, OH: OARDC, 1978).

shipper has the option of selling his barge contracts, the opportunity cost of the transportation is equal to the spot rate.[1]

c. Transportation Supply

In the short run, the supply of transportation available to move grain from surplus to deficit areas is relatively fixed. However, in the long run, changes and developments in the total transportation network are possible. Changes such as the construction of a riverside terminal facility, the abandonment of rail trackage, and changes in transportation technology (hopper cars, containerized shipments, etc.) can have a profound effect on the grain marketing system.

The flow of grain at harvest time is restricted by the economic and technical inability of the various modes to substantially increase their transportation facilities in the short run, or to substantially reduce the delay in car and barge turnaround times. However, the fixed capital investment of any shipper in any one mode is made on the basis of the length of the peak harvest period relative to the slack period, when capital will remain idle.

d. Consumer and Supplier Location Facilities and Access

The choice of mode for the transportation of grain is influenced by transportation rates and time implicit in the location of consumption and production areas. Consumption areas can change over time, while production areas remain relatively fixed. In the grain marketing structure, the free flow of grain is possible when origin and destination pairs are established. As the volume of grain moved on such links stabilizes and increases, modal rates may alter.

The movement of grain requires certain minimum loading and unloading facilities, storage capacity, and grain elevators. A riverside grain loading facility requires an appropriate site and some means of conveying grain from the elevator to the barge. Rail spurs must exist for an elevator to move grain by rail. The ability of an elevator to move grain in volume (and to take advantage of certain rate structures) is limited by storage capacity and loadout time.

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1. U.S. Department of Transportation, Distribution System Analysis, Vol. II of Modal Traffic Impacts of Waterway Users Charges (Washington, D.C.: GPO, 1977).

Not all elevators have equal access to all transportation modes, and modal choice can be limited. The largest grain exporters are committed to a multi-mode transport strategy. They own trucks, barges, rail cars, rail and barge terminals in the producing areas, and port facilities which are constructed to throughput both barge and rail grain. This allows the multi-mode owner flexibility in responding to various markets, rate structures, and market time constraints.

e. Time

Time is an important factor in modal choice by itself and as it is embodied in the seasonality of grain movements.[1] The ability of various modes to move grain a certain distance and within a certain time is variable. Time becomes a decision factor in modal choice in situations where the even flow of grain is necessary to operate a processing facility economically, or to allow an export bound vessel to sail with a full load. The pressure of such time frames will result in modal choices that are atypical of the general flow between any one origin or destination.

D. Forecasting Procedures and Assumptions

Generally, the projections of ORS grain movements assume that future origin and destination links and future modal split will conform to the links and modal split in 1976. The general assumption underlying this procedure was that 1976 flows were representative of future flows to a certain degree. This assumption was modified in certain cases when, as a result of discussions with industry sources, specific future changes in links and modal split could be identified. For both water and rail movements, the relationship between inbound, outbound, and net shipments was held constant. Deviations from the 1976 pattern were projected only when specific changes were anticipated. Based on the assumption that there is no change in relative prices of transport modes, and

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1. In 1970, for example, February, March, October, and November were the peak months of outbound grain flows from Illinois, Indiana, and Ohio. Fluctuations during February and March were caused by significant increases in corn and soybean outflows, probably to processing or export. The fluctuations in October and November resulted from increased out-of-state shipments as a result of grain (corn and soybean) harvest. James L. Stallings, et al., Grain Movements Between Southern and Corn Belt States. Southern Cooperative Series, Bulletin No. 209 (Auburn, AL: Alabama Agricultural Experiment Station, 1976).

based on the assumption that relative transport time will not change significantly, it is expected that the future modal split will not vary significantly from the 1976 split.

D-1. Forecasting Procedures for BEA Waterway Flows, 1980-2040

The calculation of waterway flows for each PSA in the ORS hinterland was completed in a two-step process. Gross inbound waterborne receipts for each PSA were estimated as both a proportion of consumption and as a proportion of total net shipments. Gross outbound waterborne shipments for each PSA were estimated as both a proportion of production and as a proportion of total net shipments. In most cases, the relationship of net shipments to gross inbound and outbound waterborne movements was chosen. However, the relationship between gross inbound receipts and consumption was chosen when a PSA was a net producer but had waterborne receipts. The gross outbound shipment relationship to production was chosen when the PSA was a net consumer but had waterborne shipments. The choice of this alternative relationship was made in the specific cases of BEAs 55 (Evansville) and 62 (Cincinnati), where it was felt that the relationship of gross inbound and outbound waterborne movement to net shipments underestimated the volume of waterborne movements in these BEAs, which historically have been responsible for the generation of the greatest proportion of ORS hinterland waterborne grain movements.

The choice of relating either net shipments or production or consumption to gross outbound or gross inbound waterborne movements, respectively, remained consistent across all projection years.

Net waterborne movements for each PSA for each projection year were defined as gross outbound minus gross inbound.

D-2. Forecasting Procedures for Rail Movements, 1980-2040

The calculation of net rail movements for each PSA in the hinterland was obtained by the same process outlined above. Gross inbound rail receipts were estimated as a proportion of consumption and of net shipments; and, gross outbound rail shipments were estimated as a proportion of production and of net shipments. The choice of the production and consumption relationship was made in the case of BEAs 55 (Evansville) and 62 (Cincinnati), where the net shipment relationship was believed to underestimate expected rail movements. This alternative relationship was also chosen where a PSA was a net receiver but had outbound rail shipments or was a net producer and had inbound rail receipts. The choice remains consistent across all projection years and the same as that made in regards to waterway movements.

Net rail movements for each PSA for each projection year were defined as gross outbound minus gross inbound.

D-3. Forecasting Procedures for Estimating Truck Movements and PSAs Receipts and Shipments of Waterborne Movements for BEAs Exterior to the ORB

Truck movements were projected by assuming that net truck was equal to total net shipments less net water and net rail shipments.

Waterway flows from BEAs exterior to the ORS to PSAs were related to the future consumption of each PSA within the hinterland. Flows to BEAs exterior to the ORS from PSAs were related to the future production of each PSA. These relationships were based on historical relationships. Through this procedure, the change in waterborne movements for the hinterland as a whole is captured by the different growth rates of production and consumption of each PSA in the hinterland.

E. Probable Future Modal Split

The probable future modal split of grain shipments within the PSAs is presented in Tables 33 and 34 for 1980 and 1990, respectively. A summary of the modal split of hinterland grain movements for all projection years and for the 1976 base year was presented in Table 31.

The modal split of each PSA is not expected to shift dramatically. In general, those PSAs that have historically been either large outbound or inbound waterway shippers or receivers are expected to remain large shippers. The same is true of rail shippers and/or receivers. The proportional relationship of net rail to net water shipments is expected to remain relatively stable, with net rail shipments being about twice the volume of net water shipments.

Table 33. Ohio River Basin: Production, Consumption and Shipments by Mode of Transportation of Grains,[a] by BEAs or BEA Segments,[b] Projected 1980

(Thousands of tons)

BEA and BEA segment	Production	Consumption	Shipments (receipts)						
				Water					
			Total net	Net	Inbound	Outbound	Local	Net rail	Net truck
Primary Study Areas	19,859.7	22,352.2	(2,492.5)	1,119.6	1,560.0[c]	2,679.6[c]	86.1[c]	2,316.8	(5,928.9)
BEA 44: Atlanta, GA	113.3	1,558.6	(1,445.3)	(25.4)	25.4	--	--	(704.4)	(715.5)
BEA 45: Birmingham, AL	439.4	1,234.0	(794.6)	(106.2)	106.2	--	--	(366.0)	(322.4)
BEA 46: Memphis, TN	477.8	353.1	124.7	15.5	--	15.5	--	21.8	87.4
BEA 47: Huntsville, AL	663.0	2,062.9	(1,399.9)	(415.8)	415.8	--	--	(310.6)	(673.5)
BEA 48: Chattanooga, TN	311.9	1,812.4	(1,500.5)	(839.3)	839.3	--	--	(614.2)	(47.0)
BEA 49: Nashville, TN	1,765.8	2,453.3	(687.5)	244.0	--	244.0	--	128.6	(1,060.1)
BEA 50: Knoxville, TN	65.5	339.5	(274.0)	(14.6)	14.6	--	--	(238.8)	(20.6)
BEA 52: Huntington, WV	79.8	276.7	(196.9)	0.8	--	0.8	--	7.9	(205.6)
BEA 53: Lexington, KY	302.4	1,233.0	(930.6)	24.5	--	24.5	--	(61.6)	(893.5)
BEA 54: Louisville, KY	1,060.3	1,747.3	(687.0)	102.8	--	102.8	--	(65.3)	(724.5)
BEA 55: Evansville, IN	2,450.0	2,428.6	21.4	680.5	155.7	836.2	--	583.2	(1,242.3)
BEA 56: Terre Haute, IN	393.6	144.5	249.1	45.9	--	45.9	--	91.4	111.8
BEA 60: Indianapolis, IN	3,582.5	1,776.9	1,805.6	196.8	--	196.8	--	1,365.3	243.5
BEA 61: Anderson, IN	247.9	156.3	91.6	11.2	--	11.2	--	(14.8)	95.2
BEA 62: Cincinnati, OH	1,771.5	1,234.4	537.1	774.5	1.1	775.6	--	588.3	(825.7)
BEA 63: Dayton, OH	2,636.3	1,719.6	916.7	135.7	--	135.7	--	622.3	158.7
BEA 64: Columbus, OH	1,934.0	595.7	1,338.3	53.8	--	53.8	--	778.6	505.9
BEA 114: St. Louis, MO	723.1	194.4	528.7	44.7	--	44.7	--	318.8	165.2
BEA 115: Paducah, KY	841.6	1,031.0	(189.4)	190.2	1.9	192.1	--	186.3	(565.9)

Note: Projected net shipments (receipts) determined by subtracting projected consumption from projected production. Projected modal split for the PSAs was estimated from projections of modal split for each BEA and BEA segment. For most BEAs, projected modal split remains constant in the future except when data, analyses and conversations with industrial authorities indicated otherwise. Gross waterborne shipments (inbound, outbound, local) were projected by assuming that the relationship between gross and net waterborne shipments in 1976 would remain constant in the future except when data, analyses and conversations with industrial authorities indicated otherwise.

a. Total production and consumption of corn, wheat and soybeans only. Corn is corn for grain. Wheat is all wheat. Soybeans are soybeans for beans. Consumption of grains represents the addition of the consumption of corn, wheat, and soybeans by livestock, processing and seed.

b. BEA segments defined as counties which are ultimate origins or destinations of waterborne movements.

c. Total Primary Study Area shipments equal inbound, outbound and local shipments for the PSAs as a unit and do not equal the sum of shipments reported for each of the BEAs and BEA segments.

Source: Tables 19, 30 and 32; Waterborne Commerce by Port Equivalents, revised 1976, and ICC Railroad Waybill Sample, 1976, supplied by the U.S. Army Corps of Engineers.

Table 34. Ohio River Basin: Production, Consumption and Shipments by Mode of Transportation of Grains,[a] by BEAs or BEA Segments,[a] Projected 1990

(Thousands of tons)

BEA and BEA segment	Production	Consumption	Shipments (receipts)						
				Water					
			Total net	Net	Inbound	Outbound	Local	Net rail	Net truck
Primary Study Areas	25,199.4	23,323.4	1,876.0	2,103.5	1,504.0[c]	3,607.5[c]	114.9[c]	3,847.2	(4,074.7)
BEA 44: Atlanta, GA	154.5	1,666.5	(1,512.0)	(26.6)	26.6	--	--	(737.0)	(748.4)
BEA 45: Birmingham, AL	637.0	1,305.0	(668.0)	(89.2)	89.2	--	--	(307.7)	(271.1)
BEA 46: Memphis, TN	582.6	389.0	193.6	24.1	--	24.1	--	33.8	135.7
BEA 47: Huntsville, AL	930.9	2,201.7	(1,270.8)	(377.4)	377.4	--	--	(238.9)	(654.5)
BEA 48: Chattanooga, TN	436.3	1,917.2	(1,480.9)	(828.5)	828.5	--	--	(445.1)	(207.3)
BEA 49: Nashville, TN	2,210.2	2,623.3	(413.1)	305.1	--	305.1	--	245.0	(963.2)
BEA 50: Knoxville, TN	89.3	354.7	(265.4)	(14.1)	14.1	--	--	(227.5)	(23.8)
BEA 52: Huntington, WV	100.4	268.7	(168.3)	1.0	--	1.0	--	9.9	(179.2)
BEA 53: Lexington, KY	377.2	1,291.6	(914.4)	30.6	--	30.6	--	(60.5)	(884.5)
BEA 54: Louisville, KY	1,300.8	1,818.1	(517.3)	126.3	--	126.3	--	24.2	(667.8)
BEA 55: Evansville, IN	3,453.1	2,576.3	876.8	1,013.2	165.1	1,178.3	--	891.0	(1,027.4)
BEA 56: Terre Haute, IN	497.0	148.7	348.3	64.2	--	64.2	--	127.8	156.3
BEA 60: Indianapolis, IN	4,015.8	1,829.1	2,186.7	238.4	--	238.4	--	1,655.5	292.8
BEA 61: Anderson, IN	323.4	153.5	169.9	20.8	--	20.8	--	(10.8)	159.9
BEA 62: Cincinnati, OH	2,200.1	1,239.7	960.4	962.3	1.1	963.4	--	(85.2)	83.3
BEA 63: Dayton, OH	3,380.0	1,674.5	1,705.5	252.4	--	252.4	--	1,157.7	295.4
BEA 64: Columbus, OH	2,479.4	569.6	1,909.8	77.0	--	77.0	--	1,169.3	663.5
BEA 114: St. Louis, MO	839.1	206.1	633.0	53.6	--	53.6	--	381.7	197.7
BEA 115: Paducah, KY	1,192.3	1,090.1	102.2	270.3	2.0	272.3	--	264.0	(432.1)

Note: Projected net shipments (receipts) determined by subtracting projected consumption from projected production. Projected modal split for the PSAs was estimated from projections of modal split for each BEA and BEA segment. For most BEAs, projected modal split remains constant in the future except when data, analyses and conversations with industrial authorities indicated otherwise. Gross waterborne shipments (inbound, outbound, local) were projected by assuming that the relationship between gross and net waterborne shipments in 1976 would remain constant in the future except when data, analyses and conversations with industrial authorities indicated otherwise.

a. Total production and consumption of corn, wheat and soybeans only. Corn is corn for grain. Wheat is all wheat. Soybeans are soybeans for beans. Consumption of grains represents the addition of the consumption of corn, wheat and soybeans by livestock, processing and seed.

b. BEA segments defined as counties which are ultimate origins or destinations of waterborne movements.

c. Total Primary Study Area shipments equal inbound, outbound and local shipments for the PSAs as a unit and do not equal the sum of shipments reported for each of the BEAs and BEA segments.

Source: Tables 19, 30 and 32; Waterborne Commerce by Port Equivalents, revised 1976, and ICC Railroad Waybill Sample, 1976, supplied by the U.S. Army Corps of Engineers.

The substantial decreases in production of corn in the hinterland in 1980, and the related decrease in the volume of grain available for shipment from the PSAs as a whole, are expected to impact both rail and water shipments almost equally. Net rail and net water shipments are expected to decrease over 50 percent in 1980 from the 1976 high. The most dramatic decreases in both net rail and net water shipments are expected to occur in BEA 55 (Evansville), which historically has been the hinterland's predominant rail and water shipper.

F. Probable Future Waterway Flows

Projected BEA-to-BEA waterway flows for the years 1980, 1990, 2000, 2020, and 2040 are presented in Table 35. Growth indices derived from the traffic projections are presented in Table 36. Projected waterborne grain flows for each projection year are based on the previous projection year's flows, adjusted to reflect expected changes.

Gross waterborne grain movements, as projected, are expected to increase at an annual rate of 0.33 percent between 1976 and 2000, and to exceed the 1976 level of 5.6 million tons. Between 2000, and 2040, gross waterborne grain movements are expected to increase at an average annual rate of 0.90 percent (Table 31).

Between 1976 and 2040, outbound shipments are expected to increase following an initial decline in 1980 due to decreased area production, specifically in PSAs with high surplus production and high outbound waterborne movements. Inbound waterborne grain movements are expected to decrease gradually in the long run; this has been the historical trend. Between 1976 and 2000, inbound flows are expected to decrease at an annual rate of 0.65 percent. Local waterborne grain movements in the ORS are expected to increase steadily between 1990 and 2040, following initial decreases from the 1976 level in 1980 and 1990. However, local movements are expected to remain proportionally small relative to gross ORS waterborne grain movements.

Table 35. Ohio River System: Waterborne Traffic of Grains, by Origin BEA, Shipping BEA, Receiving BEA and Destination BEA, Estimated 1976 and Projected 1980-2040, Selected Years

ORIGIN BEA	SHIPPING BEA	RECEIVING BEA	DESTINATION BEA	FOR COMMODITY GROUP 05 IN HUNDREDS OF TONS 1976	1980	1990	2000	2020	2040
046	047	047	045	10	7	9	16	17	21
046	047	047	047	19	14	6	10	13	14
046	047	047	048	19	14	22	38	41	47
046	047	111	111	10	7	11	19	21	24
046	047	137	137	29	21	33	56	66	76
046	047	138	138	127	92	160	277	331	381
049	115	038	038	11	12	13	17	22	28
049	047	047	045	11	9	11	16	17	21
049	47	047	047	23	20	8	10	13	15
049	047	047	048	26	24	29	41	43	49
049	047	048	048	22	21	25	34	37	41
049	048	050	050	20	22	26	30	33	37
049	055	055	055	50	41	56	79	118	145
049	047	111	111	12	11	14	19	23	26
049	047	137	137	37	32	41	57	64	71
049	055	137	137	10	9	11	16	17	19
049	047	138	138	350	317	399	550	617	686
049	048	138	138	62	56	71	97	109	122
049	049	138	136	64	58	73	100	113	126
049	055	138	138	1695	1536	1932	2661	2987	3324
049	115	138	138	300	272	342	471	529	588
052	052	141	141	11	8	10	12	14	15
053	062	137	137	11	8	10	13	15	17
053	062	138	138	325	230	287	379	436	498
053	062	946	946	10	7	9	12	14	16
054	054	047	045	24	20	21	30	36	38
054	054	047	047	35	31	11	11	13	16
054	054	047	048	28	28	34	44	53	65
054	054	055	055	13	10	14	22	43	82
054	054	138	138	11	10	13	17	21	27
054	062	138	138	1027	929	1170	1556	2004	2497
055	055	038	038	20	9	12	17	23	32
055	055	047	044	11	8	13	19	36	62
055	055	047	045	89	39	52	66	92	124
055	055	047	047	112	47	23	32	53	59
055	055	047	048	134	46	78	109	145	183
055	055	048	048	200	85	142	200	267	336
055	055	115	115	20	19	20	21	21	22
055	055	137	137	416	184	259	364	514	683
055	055	138	138	17651	7731	10908	15392	21605	28753
055	062	138	138	100	44	62	87	122	163
055	115	138	138	75	33	46	65	92	122
055	055	140	140	31	13	19	27	38	50
055	055	141	141	63	26	37	55	75	98
055	055	143	143	30	13	19	26	37	49
055	055	914	914	92	41	57	80	113	151
055	055	946	946	59	24	36	49	69	91
056	055	047	047	12	8	3	5	8	10
056	055	048	048	12	7	10	14	21	29
056	055	137	137	20	12	17	23	34	47
055	055	138	138	720	432	612	849	1252	1704
057	057	047	045	14	13	11	10	8	8

(Continued)

Table 35. (Continued)

ORIGIN BEA	SHIPPING BEA	RECEIVING BEA	DESTINATION BEA	FOR COMMODITY GROUP 05 IN HUNDREDS OF TONS 1976	1980	1990	2000	2020	2040
057	057	047	047	55	56	51	37	32	27
057	057	047	048	19	21	19	17	16	14
057	057	048	048	30	32	30	28	26	23
060	054	047	045	11	8	9	11	15	16
060	054	047	047	16	13	5	5	6	8
060	062	047	047	15	12	4	4	5	8
060	054	047	048	15	12	15	18	26	33
060	062	048	048	20	17	21	25	34	45
060	062	055	055	14	11	15	21	43	69
060	062	137	137	31	26	31	37	55	72
060	054	138	138	506	408	499	613	887	1158
060	062	138	138	1785	1440	1760	2162	3129	4086
060	062	914	914	11	9	11	14	21	27
060	062	946	946	14	12	14	18	25	32
061	062	048	048	14	3	5	8	14	20
061	062	137	137	10	2	4	6	10	15
061	062	138	138	509	107	199	317	538	781
062	062	038	038	13	9	14	17	19	17
062	062	047	045	27	21	26	35	37	39
062	062	047	047	42	37	15	17	18	19
062	062	047	048	35	32	44	52	58	64
062	062	048	048	41	38	52	61	68	75
062	062	055	055	35	28	42	51	76	120
062	062	133	133	12	9	13	16	19	21
062	062	137	137	145	124	154	188	217	248
062	062	138	138	8460	7360	9154	11006	12842	14695
062	062	914	914	42	38	45	56	66	75
062	062	946	946	69	60	75	91	106	123
063	062	047	047	13	8	4	5	0	0
063	062	048	048	17	13	25	34	41	48
063	062	055	055	10	6	11	16	28	32
063	062	137	137	30	22	40	57	66	76
063	062	138	138	1744	1289	2410	3342	3943	4547
063	062	914	914	11	8	15	21	25	28
063	062	946	946	14	11	19	27	32	37
064	062	048	048	15	10	14	18	21	24
064	062	055	055	12	8	13	16	26	29
064	062	137	137	12	9	13	15	17	19
064	062	138	138	708	496	708	887	995	1109
064	064	138	138	22	15	22	28	31	34
077	077	047	044	26	26	26	25	23	20
077	077	047	045	332	325	261	229	182	145
077	077	047	047	603	611	551	430	403	325
077	077	047	048	381	405	389	333	296	290
077	077	048	048	133	141	136	116	103	101
078	078	047	044	16	15	16	15	14	12
078	078	047	045	232	228	182	154	122	96
078	078	047	047	601	607	549	428	392	313
078	078	047	048	263	282	267	230	204	203
078	078	048	048	100	107	102	87	77	77
078	078	062	062	11	11	11	12	13	13
079	079	047	045	20	20	16	14	12	5
079	079	047	047	64	65	59	43	39	34
079	079	047	048	26	28	27	24	22	20
079	079	048	048	90	95	92	82	77	70
079	079	055	055	20	20	20	22	20	25
081	081	047	047	11	11	10	8	7	6
089	089	047	047	31	34	30	22	19	17
089	089	048	048	31	33	32	24	26	23
091	091	047	044	10	10	10	10	10	4
091	091	048	044	85	83	86	86	82	76
091	091	047	045	146	147	117	96	81	46

Table 35. (Continued)

ORIGIN BEA	SHIPPING BEA	RECEIVING BEA	DESTINATION BEA	FOR COMMODITY GROUP 05 IN HUNDREDS OF TONS 1976	1980	1990	2000	2020	2040
091	091	047	047	687	702	671	490	390	344
091	091	047	048	138	148	141	125	119	110
091	091	048	048	2734	2925	2786	2474	2357	2171
091	091	050	048	31	33	32	28	27	25
091	091	050	050	58	79	73	63	60	55
091	091	055	055	562	545	561	613	597	601
103	103	048	048	22	24	23	20	19	18
103	103	055	055	11	10	11	12	12	11
107	107	047	045	10	11	8	6	5	5
107	107	047	047	57	58	51	39	35	30
107	107	047	048	10	10	10	9	8	7
107	107	048	048	55	58	57	51	46	41
108	108	048	048	11	12	11	10	10	10
111	111	046	044	67	65	68	66	64	58
111	111	047	045	41	42	32	24	21	8
111	111	047	047	638	648	618	455	368	330
111	111	048	048	2193	2362	2239	1985	1890	1772
111	111	050	050	11	15	14	13	12	12
111	111	055	055	889	859	888	967	960	916
112	112	047	047	11	11	10	8	7	6
113	113	047	044	12	11	12	12	10	9
113	113	047	045	60	60	47	42	34	32
113	113	047	047	95	96	87	64	62	52
113	113	047	048	91	97	93	83	74	65
114	055	047	047	12	14	50	74	84	97
114	055	048	048	12	14	115	170	187	205
114	055	138	138	301	351	304	448	550	656
114	115	138	138	38	44	38	57	69	83
114	055	914	914	11	12	15	22	26	29
114	055	946	945	10	12	14	21	25	30
115	055	047	047	10	6	2	4	4	6
115	115	048	048	39	30	49	75	81	87
115	115	117	117	10	8	11	16	18	21
115	115	133	133	10	9	11	16	18	21
115	115	137	137	10	8	11	16	18	21
115	049	138	138	52	40	56	83	95	111
115	055	138	138	250	191	271	398	456	532
115	115	138	138	2078	1568	2253	3306	3786	4424
115	115	141	141	27	22	31	43	51	67
115	055	914	914	11	7	12	16	16	21
115	115	946	946	15	12	16	23	27	31
117	117	050	050	11	15	14	13	13	12
119	119	048	044	25	25	26	25	23	22
119	119	047	047	11	12	20	8	6	3
119	119	048	048	821	878	837	749	700	647
134	134	048	048	22	23	23	21	20	20
138	138	047	047	11	11	10	8	7	6
141	141	055	055	20	19	20	23	24	25
914	914	048	044	11	11	11	11	10	9
914	914	047	045	115	112	90	73	57	44
914	914	047	047	1002	1006	908	714	629	540
914	914	047	048	65	73	66	51	44	36
914	914	048	048	156	176	159	121	106	90
915	915	047	047	20	20	18	14	12	11
915	915	048	048	33	36	34	30	28	25
915	915	050	050	11	15	14	12	11	10
			TOTAL	55820	41535	44966	60430	72750	86374

Note: BEAs 915, 914 and 946 refer to counties of BEAs 115, 114 and 46 which are origins and destinations of waterborne movements which are shipped from and to points on the Mississippi River. For PSA, the origin and destination BEAs are defined as points of production and consumption. Shipping and receiving BEAs refer only to that portion of the traffic flow which is waterborne (i.e., points of modal transfer).

Table 36. Ohio River System: Growth Rates of Grains Waterborne Commerce, BEA to BEA Projected 1976-2040, Selected Years

BEA Pair[a]	Group No.	Index Value[b]	Year[c] 1976	1980	1990	2000	2020	2040
046045	05	10	1000	700	900	1600	1700	2100
046047	05	19	1000	737	316	526	684	737
046048	05	19	1000	737	1158	2000	2158	2474
046111	05	10	1000	700	1100	1900	2100	2400
046137	05	29	1000	724	1138	1931	2276	2621
046138	05	127	1000	724	1260	2181	2606	3000
049038	05	11	1000	1091	1182	1545	2000	2545
049045	05	11	1000	818	1000	1455	1545	1909
049047	05	23	1000	870	348	435	565	652
049048	05	48	1000	938	1125	1563	1667	1875
049050	05	20	1000	1100	1300	1500	1650	1850
049055	05	50	1000	820	1120	1580	2360	2900
049111	05	12	1000	917	1167	1583	1917	2167
049137	05	47	1000	872	1106	1553	1723	1915
049138	05	2471	1000	906	1140	1570	1762	1961
052141	05	11	1000	727	909	1091	1273	1364
053137	05	11	1000	727	909	1182	1364	1545
053138	05	325	1000	708	883	1166	1342	1532
053946	05	10	1000	700	900	1200	1400	1600
054045	05	24	1000	833	875	1250	1500	1583
054047	05	35	1000	886	314	314	371	457
054048	05	28	1000	1000	1214	1571	1893	2321
054055	05	13	1000	769	1077	1692	3308	6308
054138	05	1038	1000	905	1139	1515	1951	2431
055038	05	20	1000	450	600	850	1150	1600
055044	05	11	1000	727	1182	1727	3273	5636
055045	05	89	1000	438	584	742	1034	1393
055047	05	112	1000	420	205	286	473	527
055048	05	309	1000	424	712	1000	1333	1690
055115	05	20	1000	950	1000	1050	1050	1100
055137	05	416	1000	442	623	875	1236	1642
055138	05	17826	1000	438	618	872	1224	1629
055140	05	31	1000	419	613	871	1226	1613
055141	05	63	1000	413	587	873	1190	1556
055143	05	30	1000	433	633	867	1233	1633
055914	05	92	1000	446	620	870	1228	1641
055946	05	59	1000	407	610	831	1169	1542
056047	05	12	1000	667	250	417	667	833
056048	05	12	1000	583	833	1167	1750	2417
056137	05	20	1000	600	850	1150	1700	2350
056138	05	720	1000	600	850	1179	1739	2367
057045	05	14	1000	929	786	714	571	571
057047	05	55	1000	1018	927	673	532	491

(Continued)

Table 36. (Continued)

BEA Pair[a]	Group No.	Index Value[b]	Year[c] 1976	1980	1990	2000	2020	2040
057048	05	49	1000	1082	1000	918	857	755
060045	05	11	1000	727	818	1000	1364	1455
060047	05	31	1000	806	290	290	355	516
060048	05	35	1000	829	1029	1229	1714	2229
060055	05	14	1000	786	1071	1500	3071	4929
060137	05	31	1000	839	1000	1194	1774	2323
060138	05	2291	1000	807	986	1211	1753	2289
060914	05	11	1000	818	1000	1273	1909	2455
060946	05	14	1000	857	1000	1286	1786	2286
061048	05	14	1000	214	357	571	1000	1429
061137	05	10	1000	200	400	600	1000	1500
061138	05	509	1000	210	391	623	1057	1534
062038	05	13	1000	692	1077	1308	1462	1308
062045	05	27	1000	778	963	1296	1370	1444
062047	05	42	1000	881	357	405	429	452
062048	05	76	1000	921	1263	1487	1658	1829
062055	05	35	1000	800	1200	1457	2171	3429
062133	05	12	1000	750	1083	1333	1583	1750
062137	05	145	1000	855	1062	1297	1497	1710
062138	05	8460	1000	870	1082	1301	1516	1737
062914	05	42	1000	905	1071	1333	1571	1786
062946	05	69	1000	870	1087	1319	1536	1783
063047	05	13	1000	615	308	385	0	0
063048	05	17	1000	765	1471	2000	2412	2824
063055	05	10	1000	600	1100	1600	2800	3200
063137	05	30	1000	733	1333	1900	2200	2533
063138	05	1744	1000	739	1382	1916	2261	2607
063914	05	11	1000	727	1364	1909	2273	2545
063946	05	14	1000	786	1357	1929	2286	2643
064048	05	15	1000	667	933	1200	1400	1600
064055	05	12	1000	667	1083	1333	2167	2417
064137	05	12	1000	750	1083	1250	1417	1583
064138	05	730	1000	701	1000	1253	1405	1567
077044	05	26	1000	1000	1000	962	885	769
077045	05	332	1000	979	786	690	548	437
077047	05	603	1000	1013	914	713	668	539
077048	05	514	1000	1062	1021	875	778	761
078044	05	16	1000	938	1000	938	875	750
078045	05	232	1000	983	784	664	526	414
078047	05	601	1000	1010	913	712	652	521
078048	05	363	1000	1072	1017	873	774	771
078062	05	11	1000	1000	1000	1091	1182	1182
079045	05	20	1000	1000	800	700	600	250
079047	05	64	1000	1016	922	672	609	531
079048	05	116	1000	1060	1026	914	853	776
079055	05	20	1000	1000	1000	1100	1000	1250
081047	05	11	1000	1000	909	727	636	545
089047	05	33	1000	1030	909	667	576	515

(Continued)

Table 36. (Continued)

BEA Pair[a]	Group No.	Index Value[b]	Year[c] 1976	1980	1990	2000	2020	2040
089048	05	31	1000	1065	1032	935	839	742
091044	05	95	1000	979	989	989	968	895
091045	05	146	1000	1007	801	658	555	315
091047	05	687	1000	1022	977	713	568	501
091048	05	2903	1000	1070	1019	905	862	794
091050	05	58	1000	1362	1259	1086	1034	948
091055	05	562	1000	970	998	1091	1062	1069
103048	05	22	1000	1091	1045	909	864	818
103055	05	11	1000	909	1000	1091	1091	1000
107045	05	10	1000	1100	800	600	500	500
107047	05	57	1000	1018	895	684	614	526
107048	05	65	1000	1046	1031	923	831	738
108048	05	11	1000	1091	1000	909	909	909
111044	05	67	1000	970	1015	985	955	866
111045	05	41	1000	1024	780	585	512	195
111047	05	638	1000	1016	969	713	577	517
111048	05	2193	1000	1077	1021	905	862	808
111050	05	11	1000	1364	1273	1182	1091	1091
111055	05	889	1000	966	999	1088	1080	1030
112047	05	11	1000	1000	909	727	636	545
113044	05	12	1000	917	1000	1000	833	750
113045	05	60	1000	1000	783	700	567	533
113047	05	95	1000	1011	916	674	653	547
113048	05	91	1000	1066	1022	912	813	714
114047	05	12	1000	1167	4167	6167	7000	8083
114048	05	12	1000	1167	9583	14167	15583	17083
114138	05	339	1000	1165	1009	1490	1826	2180
114914	05	11	1000	1091	1364	2000	2364	2636
114946	05	10	1000	1200	1400	2100	2500	3000
115047	05	10	1000	600	200	400	400	600
115048	05	39	1000	769	1256	1923	2077	2231
115117	05	10	1000	800	1100	1600	1800	2100
115133	05	10	1000	900	1100	1600	1800	2100
115137	05	10	1000	800	1100	1600	1800	2100
115138	05	2380	1000	764	1084	1591	1822	2129
115141	05	27	1000	815	1148	1593	1889	2296
115914	05	11	1000	636	1091	1455	1455	1909
115946	05	15	1000	800	1067	1533	1800	2067
117050	05	11	1000	1364	1273	1182	1182	1091
119044	05	25	1000	1000	1040	1000	920	880
119047	05	11	1000	1091	1818	727	545	273
119048	05	821	1000	1069	1019	912	853	788
134048	05	22	1000	1045	1045	955	909	909
138047	05	11	1000	1000	909	727	636	545
141055	05	20	1000	950	1000	1150	1200	1250
914044	05	11	1000	1000	1000	1000	909	818
914045	05	115	1000	974	783	635	496	383
914047	05	1002	1000	1004	906	713	626	539

(Continued)

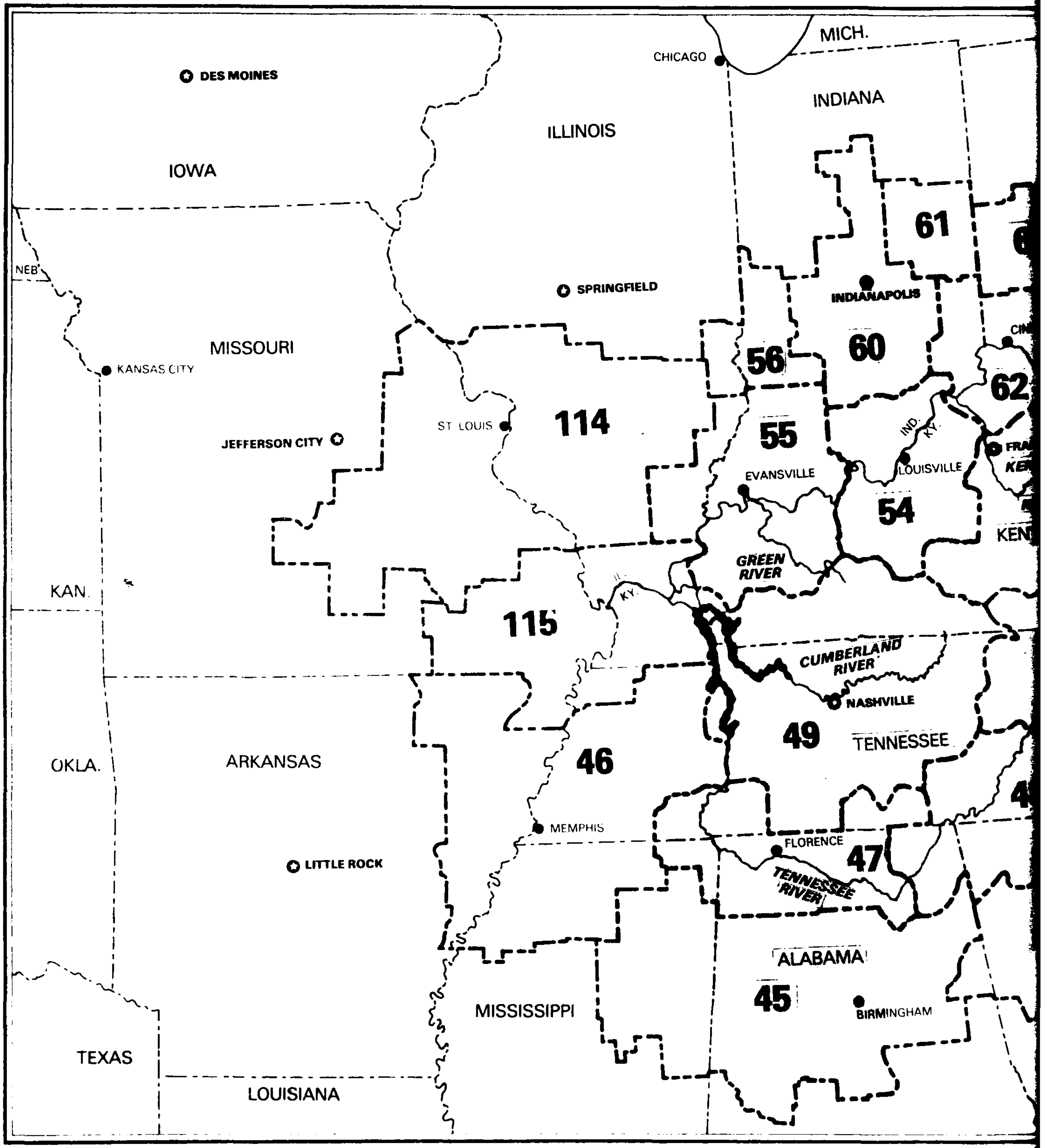
Table 36. (Continued)

BEA Pair[a]	Group No.	Index Value[b]	Year[c] 1976	1980	1990	2000	2020	2040
914048	05	221	1000	1127	1018	778	679	579
915047	05	20	1000	1000	900	700	600	550
915048	05	33	1000	1091	1030	909	848	758
915050	05	11	1000	1364	1273	1091	1000	909

a. The first three digits indicate the BEA of origin; the last three digits indicate the BEA of destination.
b. Hundreds of tons.
c. Growth rates are reported such that 1,000 equals the index value reported in the third column.
d. BEAs 915, 914, and 946 refer to counties of BEAs 15, 14, and 46 which are origins and destinations of waterborne movements which are shipped from and to points on the Mississippi River.
Source: Robert R. Nathan Associates, Inc.

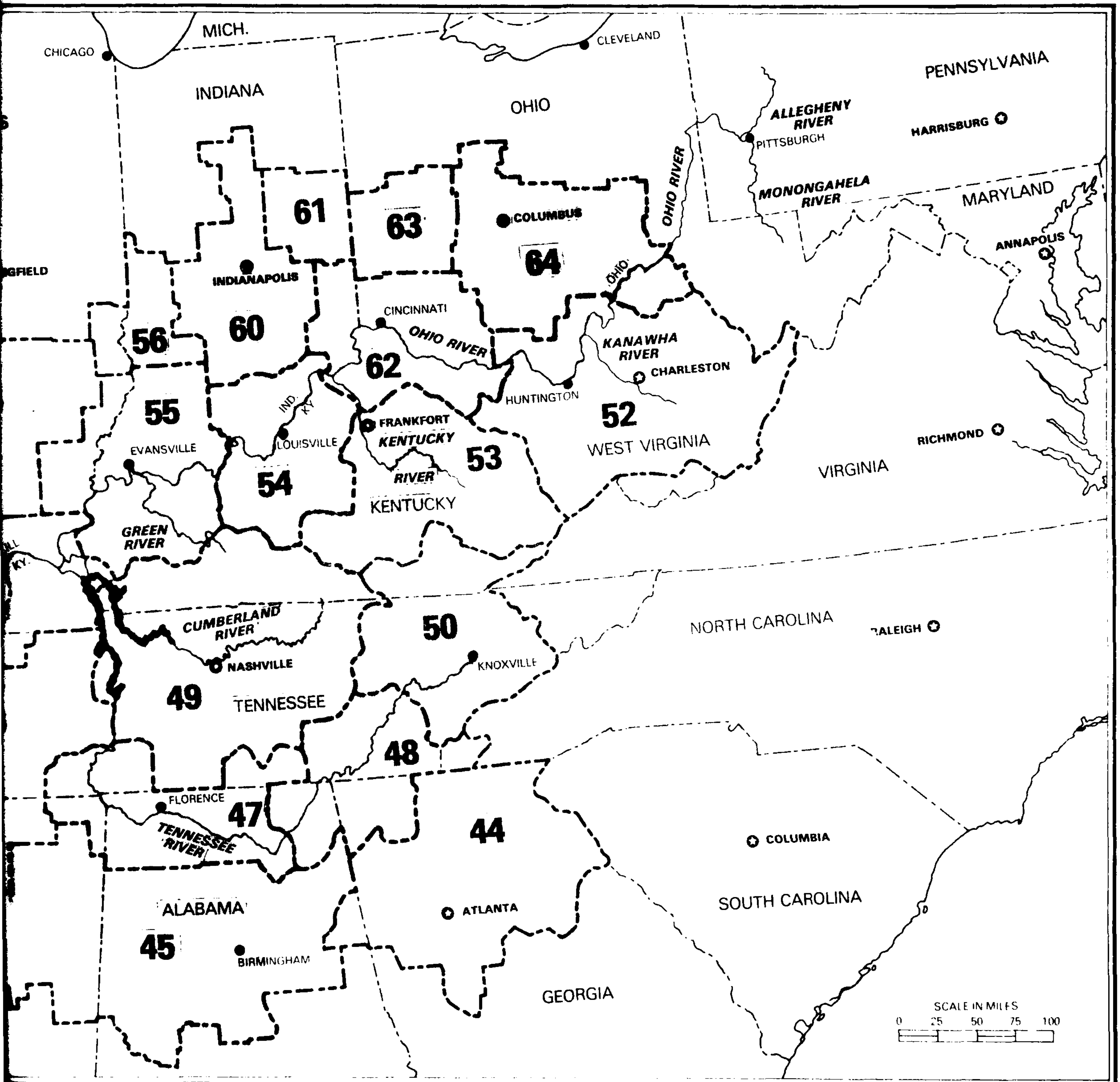
V. APPENDIX A

MAP. A-1. OHIO RIVER BASIN: PRIMARY STUDY AREAS
(BEAs AND BEA SEGMENTS)



SOURCE: ROBERT R. NATHAN ASSOCIATES

MAP A-1. OHIO RIVER BASIN: PRIMARY STUDY AREAS FOR GRAINS
(PEAs AND BEA SEGMENTS)



Primary Study Area

2

Table A-1. Ohio River Basin: Primary Study Areas for Grains (BEA and BEA segment)

BEA 44 (segment): Atlanta, GA
- Cleburne, AL
- Barrow, GA
- Bartow, GA
- Cherokee, GA
- Clarke, GA
- Cobb, GA
- Dawson, GA
- DeKalb, GA
- Fannin, GA
- Floyd, GA
- Forsyth, GA
- Fulton, GA
- Gilmer, GA
- Gwinnett, GA
- Hall, GA
- Jackson, GA
- Lumpkin, GA
- Oconee, GA
- Pickens, GA
- Polk, GA
- Paulding, GA
- Towns, GA
- Union, GA
- Walton, GA
- White, GA

BEA 45 (segment): Birmingham, AL
- Bibb, AL
- Blount, AL
- Calhoun, AL
- Cherokee, AL
- Chilton, AL
- Cullman, AL
- Etowah, AL
- Fayette, AL
- Jefferson, AL
- Lamar, AL
- Marion, AL
- Shelby, AL
- St. Clair, AL
- Walker, Al
- Winston, AL
- Itawamba, MS
- Lee, MS
- Pontotoc, MS
- Prentiss, MS
- Union, MS

BEA 46 (segment): Memphis, TN
- Tippah, MS
- Carroll, TN
- Chester, TN
- Decatur, TN
- Henderson, TN
- Henry, TN
- Weakley, TN

BEA 47: Huntsville, AL
- Colbert, AL
- Franklin, AL
- Lauderdale, AL
- Lawrence, AL
- Limestone, AL
- Madison, AL
- Marshall, AL
- Morgan, AL
- Alcorn, MS
- Tishomingo, MS
- Franklin, TN
- Hardin, TN
- Lincoln, TN
- McNairy, TN
- Wayne, TN

BEA 48 (segment): Chattanooga, TN
- DeKalb, AL
- Jackson, AL
- Catoosa, GA
- Chattooga, GA
- Dade, GA
- Gordon, GA
- Murray, GA
- Walker, GA
- Whitfield, GA
- Bledsoe, TN
- Bradley, TN
- Grundy, TN
- Hamilton, TN
- McMinn, TN
- Marion, TN
- Meigs, TN
- Polk, TN
- Rhea, TN
- Sequatchie, TN

(Continued)

Table A-1 (continued).

BEA 49 (segment): Nashville, TN
- Allen, KY
- Barren, KY
- Butler, KY
- Christian, KY
- Clinton, KY
- Cumberland, KY
- Edmonson, KY
- Logan, KY
- Metcalfe, KY
- Monroe, KY
- Simpson, KY
- Todd, KY
- Trigg, KY
- Warren, KY
- Benton, TN
- Cannon, TN
- Cheatham, TN
- Clay, TN
- Coffee, TN
- Davidson, TN
- DeKalb, TN
- Dickson, TN
- Giles, TN
- Hickman, TN
- Houston, TN
- Humphreys, TN
- Jackson, TN
- Lawrence, TN
- Lewis, TN
- Macon, TN
- Maury, TN
- Montgomery, TN
- Overton, TN
- Perry, TN
- Pickett, TN
- Putnam, TN
- Robertson, TN
- Rutherford, TN
- Smith, TN
- Stewart, TN
- Sumner, TN
- Trousdale, TN
- Warren, TN
- White, TN
- Williamson, TN
- Wilson, TN
- Van Buren, TN

BEA 50 (segment): Knoxville, TN
- Anderson, TN
- Blount, TN
- Campbell, TN
- Cumberland, TN
- Fentress, TN
- Grainger, TN
- Jefferson, TN
- Knox, TN
- Loudon, TN
- Monroe, TN
- Morgan, TN
- Roane, TN
- Scott, TN
- Sevier, TN
- Union, TN

BEA 52 (segment): Huntington, WV
- Boyd, KY
- Carter, KY
- Elliott, KY
- Greenup, KY
- Lawrence, KY
- Rowan, KY
- Gallia, OH
- Lawrence, OH
- Meigs, OH
- Scioto, OH

BEA 53 (segment): Lexington, KY
- Adair, KY
- Anderson, KY
- Bath, KY
- Bourbon, KY
- Boyle, KY
- Casey, KY
- Clark, KY
- Fayette, KY
- Franklin, KY
- Garrard, KY
- Green, KY
- Harrison, KY
- Jessamine, KY
- Lincoln, KY
- Mercer, KY
- Montgomery, KY
- Nicholas, KY
- Russell, KY
- Scott, KY
- Taylor, KY
- Woodford, KY

(Continued)

Table A-1 (continued).

BEA 54 (segment): Louisville, KY
- Clark, IN
- Crawford, IN
- Floyd, IN
- Harrison, IN
- Jefferson, IN
- Orange, IN
- Scott, IN
- Washington, IN
- Breckinridge, KY
- Bullitt, KY
- Grayson, KY
- Hardin, KY
- Hart, KY
- Henry, KY
- Jefferson, KY
- Larue, KY
- Marion, KY
- Meade, KY
- Nelson, KY
- Oldham, KY
- Shelby, KY
- Spencer, KY
- Trimble, KY
- Washington, KY

BEA 55 (segment): Evansville, IN
- Edwards, IL
- Gallatin, IL
- Hamilton, IL
- Saline, IL
- Wabash, IL
- White, IL
- Daviess, IN
- Dubois, IN
- Gibson, IN
- Knox, IN
- Martin, IN
- Perry, IN
- Pike, IN
- Posey, IN
- Spencer, IN
- Vanderburgh, IN
- Warrick, IN
- Caldwell, KY
- Crittenden, KY
- Daviess, KY
- Hancock, KY
- Henderson, KY
- Hopkins, KY
- McLean, KY
- Muhlenberg, KY
- Ohio, KY
- Union, KY
- Webster, KY

BEA 56 (segment): Terre Haute, IN
- Green, IN
- Sullivan, IN

BEA 60 (segment): Indianapolis, IN
- Bartholomew, IN
- Boone, IN
- Brown, IN
- Decatur, IN
- Hamilton, IN
- Hancock, IN
- Hendricks, IN
- Jackson, IN
- Jennings, IN
- Johnson, IN
- Lawrence, IN
- Marion, IN
- Monroe, IN
- Morgan, IN
- Rush, IN
- Shelby, IN

BEA 61 (segment): Anderson, IN
- Henry, IN
- Wayne, IN

BEA 62: Cincinnati, OH
- Dearborn, IN
- Fayette, IN
- Franklin, IN
- Ohio, IN
- Ripley, IN
- Switzerland, IN
- Union, IN
- Boone, KY
- Bracken, KY
- Campbell, KY
- Carroll, KY
- Fleming, KY
- Gallatin, KY
- Grant, KY
- Kenton, KY
- Lewis, KY
- Mason, KY
- Owen, KY
- Pendleton, KY
- Robertson, KY
- Adams, OH
- Brown, OH
- Butler, OH
- Clermont, OH
- Clinton, OH
- Hamilton, OH
- Highland, OH
- Warren, OH

(Continued)

Table A-1 (continued).

BEA 63: Dayton, OH
  Champaign, OH
  Clark, OH
  Darke, OH
  Greene, OH
  Logan, OH
  Miami, OH
  Montgomery, OH
  Preble, OH
  Shelby, OH

BEA 64 (segment): Columbus, OH
  Athens, OH
  Delaware, OH
  Fayette, OH
  Franklin, OH
  Guernsey, OH
  Hocking, OH
  Jackson, OH
  Madison, OH
  Morgan, OH
  Noble, OH
  Pickaway, OH
  Pike, OH
  Ross, OH
  Union, OH
  Vinton, OH
  Washington, OH

BEA 114 (segment): St. Louis, MO
  Franklin, IL
  Jefferson, IL
  Wayne, IL

BEA 115 (segment): Paducah, KY
  Alexander, IL
  Hardin, IL
  Massac, IL
  Pope, IL
  Pulaski, IL
  Ballard, KY
  Calloway, KY
  Carlisle, KY
  Graves, KY
  Hickman, KY
  Livingston, KY
  Lyon, KY
  McCracken, KY
  Marshall, KY

Source: Robert R. Nathan Associates, Inc.

VI. APPENDIX B

LAND CAPABILITY CLASSIFICATION

The following land capability classification system, as developed by the U.S. Department of Agriculture (USDA), Soil Conservation Service, was used as the basis for estimating the potential cropland resource base for future grain production in the PSAs.

The capability classification provides three major categories: (1) unit (the smallest subdivision), (2) subclass, and (3) class (broadest).

The land capability unit is a grouping of soils that are adapted to the same kinds of cultivated crops and pasture plants and that require similar systems of management for these crops.

The land capability subclass is a grouping of land capability units having similar kinds of limitations or hazards. Four kinds of limitations or hazards are recognized: (1) erosion, (2) wetness, (3) soil limitations in the root zone, and (4) adverse climate.

The third and broadest category in the capability classification places all the soils in eight land capability classes. The risks of soil damage or the limitations in use are progressively greater from class I to class VIII. Soils in the first four classes are capable, with good management, of producing adapted cultivated field crops, pasture plants, forest trees, or other adapted plants. Soils in classes V, VI, and VII are suited to the use of adapted native plants. Some soils in classes V and VI are also capable of producing specialized crops, such as certain fruit and ornamentals, and field and vegetable crops under highly intensive management involving elaborate practices for soil and water conservation. Soils in class VIII do not return on-site benefits for inputs of management for crops, grasses, or trees.

This classification system was adopted by each of the eight ORS hinterland states in their inventories of land in 1967 and provides a comparative and consistent set of data upon which to estimate potential cropland. Generalized definitions follow of the land capability classes as used in the Inventory of Soil and Water Conservation Needs for the States of Alabama, Georgia, Illinois, Indiana, Kentucky, Mississippi, Ohio, and Tennessee.

The following five classes and subclasses of land were considered by the USDA Soil Conservation Service to be a conservative estimate of that land in any one county that was suitable as cropland: I, IIe, IIw, IIIe, and IIIw.

Land Suited for Cultivation and Other Uses

Class I. Soils in class I have few limitations that restrict their use.

Soils in this class are suited to a wide range of plants and may be used safely for cultivated crops, pasture, woodland, and wildlife. The soils are nearly level, and erosion hazard is low. They are deep, generally well drained, and easily worked. They hold water well and are either fairly well supplied with plant nutrients or highly responsive to inputs of fertilizer.

The soils in class I are not subjected to damaging overflow. They are productive and suited for intensive cropping. The local climate must be favorable for growing many of the common field crops.

Soils that are wet and have slow or very slow permeable subsoils are not placed in class I. Some kinds of soil in class I may be drained as an improvement measure for increased production and ease of operation.

Soils in class I that are used for crops need ordinary management practices to maintain productivity--both soil fertility and soil structure. Such practices may include the use of one or more of the following: fertilizers and lime, cover and green manure crops, conservation of crop residues and animal manures, and sequences of adapted crops.

Class II. Soils in class II have some limitations that reduce the choice of plants or require moderate conservation practices.

Soils in this class require careful soil management, including conservation practices, to prevent deterioration or to improve air and water relations when the soils are cultivated. The limitations are few, and the practices are easy to apply. The soils may be used for cultivated crops, pasture, and woodland or for wildlife food and cover.

Limitations of soils in class II may include singly or in combination the effects of (1) gentle slopes, (2) moderate susceptibility to water erosion or moderate adverse effects of past erosion, (3) less than ideal soil depth, (4) somewhat unfavorable soil structure and workability, (5) occasional damaging overflow, and (6) wetness correctable by drainage but existing permanently as a moderate limitation.

The soils in this class provide the farm operator less latitude in the choice of either crops or management practices than soils in class I. They may also require special soil-conserving cropping systems, soil conservation practices, water control devices, or tillage methods when used for cultivated crops. For example, deep soils of this class with gentle slopes that are subject to moderate erosion when cultivated may need one of the following practices or some combination of two or more: terracing, stripcropping, contour tillage, crop rotations that include grasses and legumes, vegetated water disposal areas, cover and green manure crops, stubble mulching, fertilizers, manure, and lime. The exact combinations of practices vary from place to place, depending on the characteristics of the soil, the local climate, and the farming system.

Class III. Soils in class III have severe limitations that reduce the choice of plants or require special conservation practices or both.

Soils in class III have more restrictions than those in class II, and when used for cultivated crops, the conservation practices are usually more difficult to apply and maintain. These soils may be used for cultivated crops, pasture, and woodland or for wildlife food and cover.

Limitations of soils in class III restrict the amount of clean cultivation, timing of planting, tillage and harvesting, choice of crops, or a combination of these items. Limitations may result from the effects of one or more of the following: (1) moderately steep slopes; (2) high susceptibility to water erosion or severe adverse effects of past erosion; (3) frequent overflow accompanied by some crop damage; (4) very slow permeability of the subsoil; (5) wetness of some continuing waterlogging after drainage; (6) shallow depths to bedrock hardpan, fragipan, or claypan that limits the rooting zone and the water storage; (7) low moisture-holding capacity; and (8) low fertility not easily corrected.

When cultivated, many of the wet, slowly permeable but nearly level soils in class III require a drainage system and a cropping system that maintains or improves the structure and tilth of the soil. To prevent puddling and to improve permeability, it is commonly necessary to supply organic material to such soils and to avoid working them when they are wet. Each distinctive kind of soil in class III has one or more alternative combinations of use and practices required for safe use, but the number of practical alternatives for average farmers is less than for soils in class II.

Capability Subclass

Subclass is a group of capability units within classes that have the same kind of dominant limitations for agricultural use. Some soils are subject to erosion if they are not protected, while others are naturally wet and must be drained if crops are to be grown. Some soils are shallow or droughty or have other deficiencies. Still other soils occur in areas where climate limits their use. The three kinds of recognized limitations at the subclass level are: risks of erosion, designated by the symbol "e"; wetness, drainage or overflow, designated by the symbol "w"; and rootzone limitations, designated by the symbol "s". Subclasses are not recognized in capability class I.

Subclass "e" is made up of soils where the susceptibility to erosion is the dominant problem or hazard in their use. Erosion susceptibility and past erosion damage are the major soil factors for placing soils in this subclass.

Subclass "w" is made up of soils where excess water is the dominant hazard or limitation to their use. Poor soil drainage, wetness, high water table, and overflow are the criteria for determining which soils belong in this subclass.

For the purposes of this study, classes IV-VIII and subclass "s" soils were considered to be limited in use and generally not suited for cultivation.

VII. SOURCES AND REFERENCES

A. Reports and Publications

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B. Associations, Government Agencies Educational Institutions

Alabama Crop Reporting Service

Cincinnati Board of Trade

Georgia Crop Reporting Service

Illinois Crop Reporting Service

Indiana Crop Reporting Service

Kentucky Crop Reporting Service

Kentucky Department of Commerce

Kentucky River Development Authority

Louisville Board of Trade Grain

Mississippi Crop Reporting Service

Ohio Crop Reporting Service

Ohio River Basin Commission

Ohio State University, Department of Agricultural Economics

Purdue University, Department of Agricultural Economics

Tennessee Crop Reporting Service

U.S. Department of Agriculture, Crop Reporting Service

U.S. Department of Agriculture, Economic Research Service

University of Kentucky, College of Agricultural

University of Tennessee, Department of Agricultural Economics

C. Industrial Shippers and Receivers

ADM Milling, Mt. Vernon, Indiana

Alabama Farmers Co-op, Decatur, Alabama

Allied Mills, Guntersville, Alabama

American Commercial Barge Line
Company, Jeffersonville, Indiana

American Maize Products, Decatur, Alabama

Aurora Terminal, Aurora, Indiana

Bunge, Cairo, Illinois

Cargill, Chattanooga, Tennessee

Central Soya Company, Chattanooga, Tennessee

Central Soya Company, Cincinnati, Ohio

Central Soya Company, Henderson, Kentucky

Clifton Mills, Clifton, Ohio

Con Agra

Continential Grain, Guntersville, Alabama

Continential Grain, Mt. Vernon, Indiana

Davis Grain and Milling, Owensboro, Kentucky

Dixie Portland Flour Mill, Chattanooga, Tennessee

Early and Daniel, Cincinnati, Ohio

Early and Daniel, Louisville, Kentucky

Gold Kist, Atlanta, Georgia

Gold Kist, Decatur, Alabama

Indiana Grain Goldproff, Louisville, Kentucky

Indiana Grain/Queen City Elevators, Cincinnati, Ohio

Owensboro Grain Terminal, Owensboro, Kentucky

Paducah-McCracken Port Authority, Paducah, Kentucky

Piqua Milling, Piqua, Ohio

Pillsbury Company, Cincinnati, Ohio

Ralston Purina, Louisville, Kentucky

Rigsby and Barnard McClansboro, Illinois

Seaboard Allied Milling Company, Chattanooga, Tennessee

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- 8