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TECHNICAL REPORT

AGRONOMIC CHARACTERIZATION OF THE ARGENTINA INDICATOR REGION

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16. Abstract

This report constitutes part of the Argentina Agronomic Understanding Task of the Supporting Research Project of the AgRISTARS program. Agronomic conditions, crop-livestock land use and agricultural practices within the four-province Argentina Indicator Region are described to provide background information useful to persons working on corn/soybean area estimation tasks. An overview of the Argentina Indicator Region including information on topography, climate, soils and vegetation is presented which is followed by a regionalization of crop-livestock land use especially prepared for this study. Corn/soybean production and exports are subsequently discussed as are agricultural practices. Similarities and differences in the physical agronomic scene, crop-livestock land use and agricultural practices between the U.S. Corn Belt and the Argentine Pampa are discussed in context. The report also contains a section on the Argentine agricultural economy and a sizable appendices section. Included in the appendices are crop calendars for the Argentina Indicator Region and an accompanying description, notes on crop-livestock zones, wheat production, field size, and agricultural problems and practices.

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January 1982

PREFACE

The Agriculture and Resources Inventory Surveys Through Aerospace Remote Sensing Program, AgRISTARS, is a six-year program of research, development, evaluation, and application of aerospace remote sensing for agricultural resources, which began in Fiscal Year 1980. This program is a cooperative effort of the National Aeronautics and Space Administration, the U.S. Departments of Agriculture, Commerce, and the Interior, and the U.S. Agency for International Development. AgRISTARS consists of eight individual projects.

The work reported herein was sponsored by the Supporting Research (SR) Project under the auspices of the National Aeronautics and Space Administration, NASA. Mr. Robert B. MacDonald, NASA Johnson Space Center, is the NASA Manager of the SR Project and Dr. Glen Houston was the Technical Coordinator for the reported effort.

The Environmental Research Institute of Michigan and the Space Sciences Laboratory of the University of California at Berkeley comprised a consortium having responsibility for development of corn/soybeans area estimation procedures applicable to South America within both the Supporting Research and Foreign Commodity Production Forecasting Projects of AgRISTARS. An integral part of this task was to obtain an understanding of agricultural areas and cropping systems in Argentina, particularly corn/soybean production zones.

This reported research, intended to serve as an agronomic characterization of the Argentina Indicator Region, was performed within the Environmental Research Institute of Michigan's Infrared and Optics Division, headed by Richard R. Legault, a Vice-President of ERIM, under the technical direction of Robert Horvath, Program Manager, with assistance from the Space Sciences Laboratory at the University of California at Berkeley, under the direction of Dr. Robert N. Colwell, Principal Investigator, and Claire Hay, Project Manager.

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INTRODUCTION

This report was prepared to provide detailed information on agricultural conditions and practices within the Argentina Indicator Region, a portion of Argentina of interest to AgRISTARS. The effort was conducted by ERIM as part of a task on Argentina-Brazil Agronomic Understanding under the Supporting Research (SR) Project of the AgRISTARS program.

1.1 ARGENTINA-BRAZIL AGRONOMIC UNDERSTANDING TASK

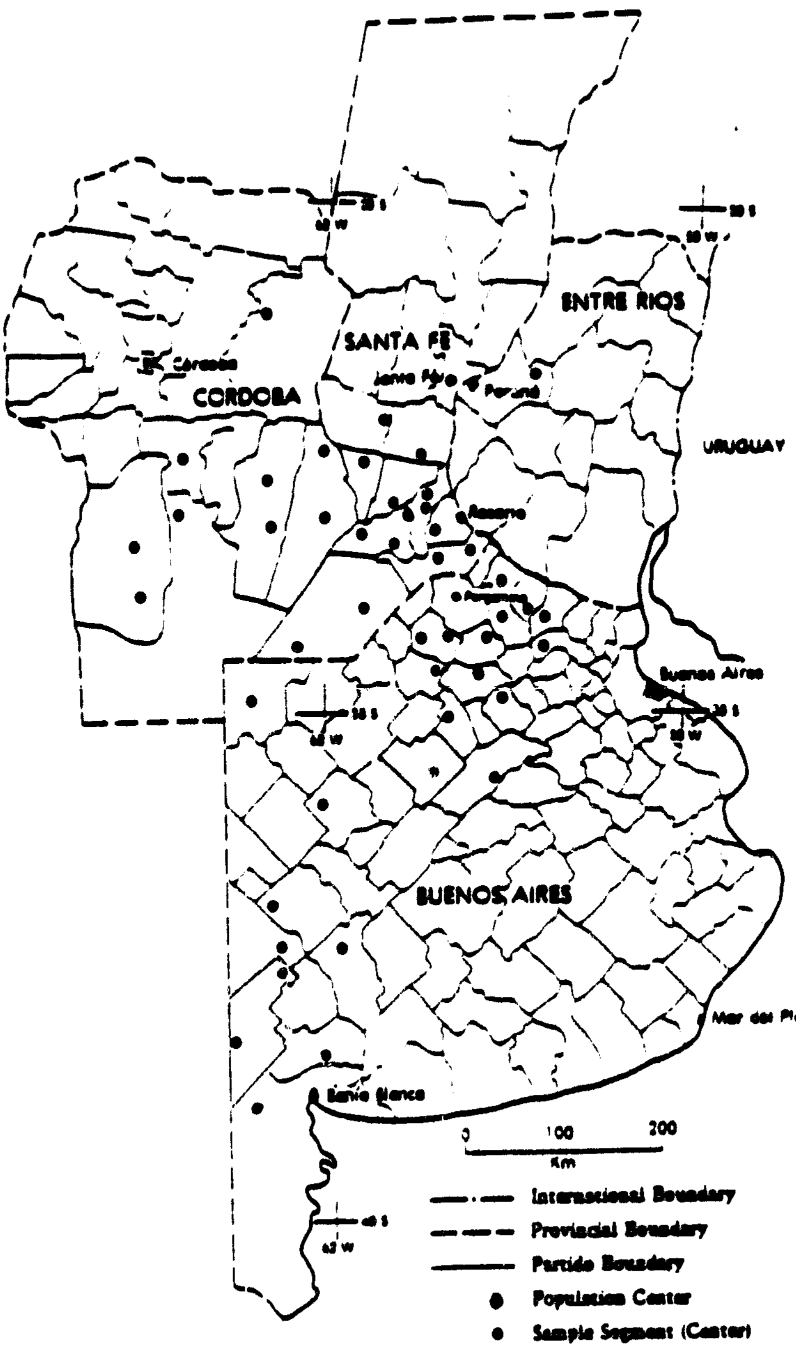
The principal reason for establishing a task on Argentina-Brazil Agronomic Understanding was to help ensure an orderly transition from a U.S.-based technology development (U.S. Corn/Soybean Area Estimation to one adaptable to foreign areas (Argentina and Brazil)). As such, the task was designed to anticipate and/or respond to data and information needs so that techniques designed and developed primarily with U.S. data could be adapted to handle expected agronomic conditions found in Argentina and Brazil. This requires the collection, organization and summarization of a wide variety of information relating to country-specific agricultural crop types, crop-livestock practices, the location and extent of agricultural regions, soils and climatic data and other factors that characterize the agricultural systems operating in Argentina and Brazil. This report was prepared in accordance with the objectives stated and responds to the continuing requirements of this task and supplements and expands upon an earlier report [1] published in October 1981, which describes ground data collection activities undertaken in Argentina during February 1981.

1.2 OVERVIEW OF THIS REPORT

The aim of this report is to provide a background and basis for understanding the different crop-livestock practices within the Argentina Indicator Region and an interpretation of them in the context of AgRISTARS remote sensing applications. Specifically, the report is intended as an agronomic characterization source document for the Argentina Indicator Region that will be useful to AgRISTARS personnel engaged in corn/soybean crop area estimation tasks. In doing so, the report provides: (a) an overview of the Argentina Indicator Region including information on topography and drainage, climate, soils and vegetation, (b) a regionalization of agriculture with a description of crop types, crop mixes and agricultural practices, and (c) an overview of Argentina's agricultural economy and its effect on crop-livestock land use and practices. Maps are also included where needed as are pertinent statistics. The appendices contain crop calendars and an accompanying text for the Argentina Indicator Region. Notes are also included on crop-livestock regions, planting practices in southwestern Buenos Aires province, field sizes and patterns of sample segments visited in Argentina during the Argentina 1981 ground data collection effort, and agricultural problems and practices.

1.3 STUDY AREA DEFINED

The AgRISTARS Argentina Indicator Region established for the Corn/Soybeans classification and area estimation technology experiment includes four provinces located in the east-central part of the country. Three of the provinces, Buenos Aires, Córdoba and Santa Fé, comprise the Pampa heartland, while a fourth province, Entre Ríos, is located immediately to the east (see Map 1). The Argentina Indicator Region, hereafter referred to as the study area, is situated in the lower middle



MAP 1. AgRISTARS STUDY AREA IN ARGENTINA

latitude zone of the southern hemisphere roughly between thirty and forty degrees South latitude and fifty-nine and sixty-five degrees West longitude.

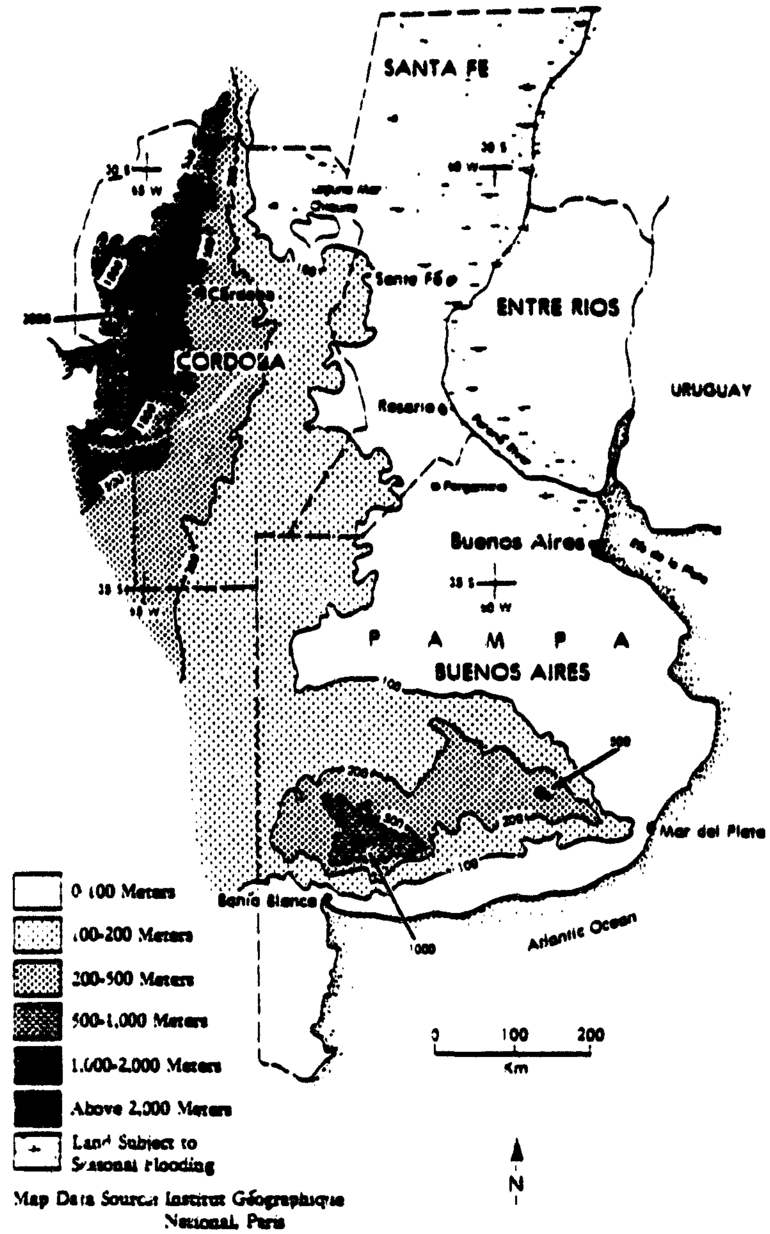
Fifty sample segments had been selected in the four provinces (see Map 1), twenty-five of which are former LACIE segments. Twenty-six of the segments are in Buenos Aires province, fourteen are in Santa Fé province, nine are in Córdoba province and one is located in Entre Ríos province. The greatest concentration of segments is found in northern Buenos Aires and adjacent southern Santa Fé. Southern Buenos Aires and central Córdoba are secondary zones of sample segments. Also, two relatively isolated segments are found; one in extreme northeastern Córdoba, and a second in northwestern Entre Ríos. The selection of these sample segments is discussed in detail in a report recently completed by Lockheed Engineering and Management Services Company (LEMSCO) [2].

2
OVERVIEW OF THE STUDY AREA

A variety of physiographic factors including nearly level terrain, a mild climate, and fertile soil have been conductive to the development of agriculture in the Pampa region. In the core of the study area covering northwest Buenos Aires as well as southern Santa Fé and Córdoba, a long growing season, adequate rainfall, fertile soil and level terrain have favored the cultivation of corn and more recently soybeans. Likewise, conditions in the southern part of the study area (southern Buenos Aires) are near optimum for wheat production. Somewhat less favorable conditions prevail in Entre Ríos, but crop-livestock production is still important.

2.1 TOPOGRAPHY AND DRAINAGE

The AgRISTARS four-province study area mainly lies within the borders of the Argentine Pampa, a very large flat to slightly rolling plain that stretches westward into the Argentine interior from the coast of Buenos Aires province, the Río de la Plata estuary and the lower Paraná River Valley (see Map 2). A long, low ridge-like escarpment extending along the shoreline of southern Buenos Aires province and a similar feature along the western margin of the Paraná River Valley delimit the Pampa on the southeast and east, respectively. The Pampa extends westward and southwestward well beyond the borders of the study area, and ultimately to the desert zone which separates it from the Andean mountain front. It extends northward to the Chaco, a subtropical scrub woodland zone and southwestward to northern Patagonia. The Pampa is the agricultural heartland of Argentina and encompasses most of the AgRISTARS study area including all of Buenos Aires province and most of



MAP 2. PHYSIOGRAPHY OF AgRISTARS STUDY AREA IN ARGENTINA

Santa Fé and Córdoba provinces except for the extreme north. The province of Entre Ríos, located immediately east of the Paraná River and west of the Uruguay River, is strictly speaking not a part of the Pampa but is a flat plain broken by north-south aligned ridges.

Sedimentary materials cover nearly all of the Pampa region. This eastern portion of the Pampa is covered by very fine windblown (loess) material carried from areas farther west along the Andean front, while coarser sandy materials dominate the western Pampa. The flat relief of the region is broken only by the Sierra de Córdoba on the northwest margin in western Córdoba (2,000 meters elevation) and two smaller and lower highland areas in southern Buenos Aires province, the Sierra de la Ventana (1,000 meters elevation) and the Sierra de Tandil (500 meters elevation). In the northeast, the flat plains of Entre Ríos are broken by a series of north-south trending ridges of low relief.

Within the Pampa, two topographic divisions based on slope can be distinguished, although the differences between them are subtle. Some areas of the Pampa exhibit slightly rolling topography (pampa ondulada) such as portions of northern Buenos Aires, southern Córdoba and southern Santa Fé. Slope ranges in these areas generally vary from 1 to 3%. In contrast, the flat low-lying Pampa (pampa deprimida) has a topographic slope of no more than 1%. Such near level topography characterizes central Buenos Aires province. Despite such distinctions nearly all of the AgRISTARS study area, with the exception of a few isolated hill areas, lies no more than 200 meters above sea level.

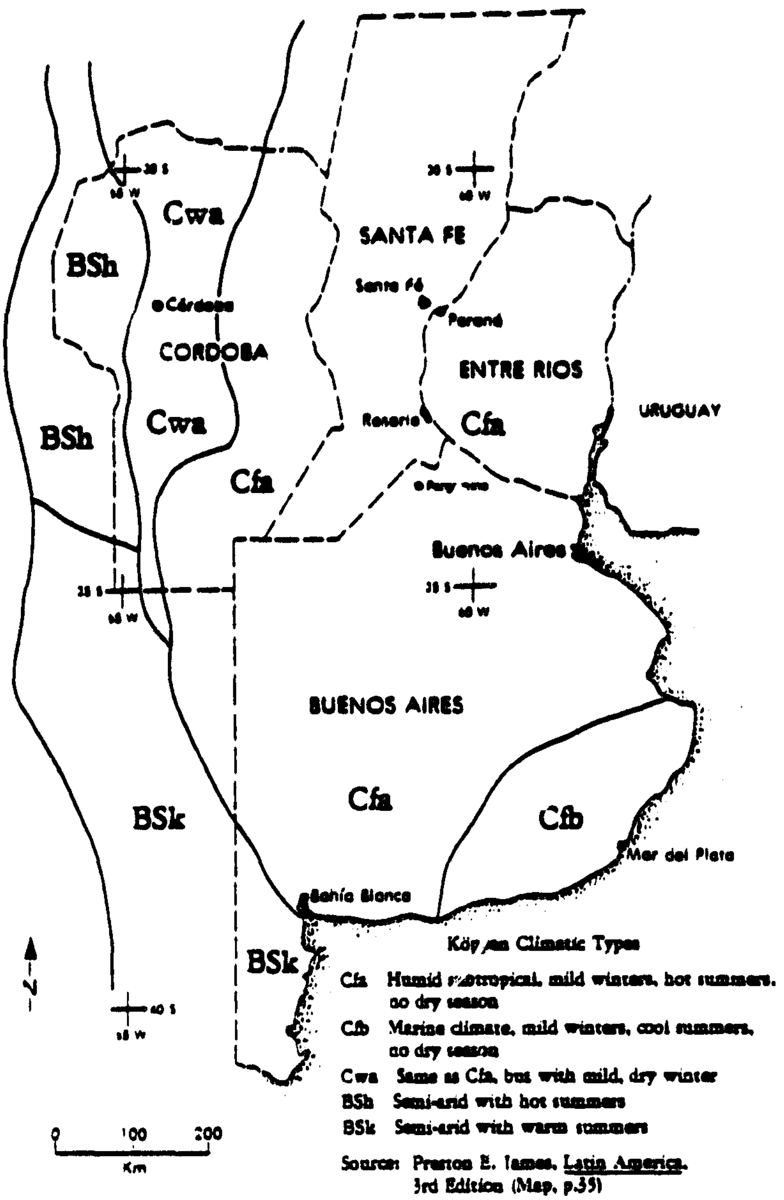
The Pampa region including the AgRISTARS study area, is a zone largely dominated by interior drainage, although a few slow-moving rivers reach the Atlantic coast or the Paraná River. Interior drainage is common throughout due to the existence of topographic depressions throughout the Pampa. Most depressions in the interior are marshlands fed by small rivers. Due to low relief, very large bands of marshland parallel the lower courses of the Paraná and Uruguay Rivers south to the Río de la Plata estuary. Due to low stream velocity, sandbars are numerous along the twisting lower river channel and pose navigation problems for waterborne traffic. Similar conditions are found along the lower course of the Uruguay River which also joins the Río de la Plata. Consequently, the southern portion of Entre Ríos province is nearly all marshland. Northern Santa Fé and northern Entre Ríos also contain marshland near or along rivers tributary to the Paraná. Córdoba province is climatically drier but still contains sizable marsh and wetland zones as well as croplands subject to flooding. This is especially true near Laguna Mar Chiquita, a large isolated saline lagoon located in northeastern Córdoba. Buenos Aires province also contains extensive interior marsh areas, some of which are subject to flooding, along the course of the Salado River southwest of the city of Buenos Aires. In extreme southern Buenos Aires, some small interior salt water lagoons and dry lakes are found. Although many of these areas have been drained for agricultural purposes, many zones within the study area are subject to summer flooding and crop-livestock losses are sometimes substantial during such episodes, especially in northern Córdoba, northern Santa Fé, and Entre Ríos.

2.2 CLIMATE

The four-province AgRISTARS study area exhibits considerable climatic variation with respect to temperature, precipitation totals, and seasonality and variability of precipitation. The latitudinal extent from northern Santa Fé to southern Buenos Aires is approximately 1400 km which is latitudinally equivalent to the distance from central Florida to north central Ohio. Maximum east-west distance of the four provinces is about 850 km. Most sample segments are clustered in southern and northern Buenos Aires, with the remaining ones being more dispersed farther northward. Also, the southernmost and northernmost segments are separated by a distance of nearly 900 km while others are separated from east to west by 475 km. Thus, climatic variation and its influence on agriculture in different segment zones is significant.

The AgRISTARS segments occur in three different climatic zones. Forty-six of the fifty segments are located in a zone of humid subtropical climate that extends southwestward from Paraguay and Brazil into Santa Fé, Entre Ríos, the eastern third of Córdoba, and nearly all of Buenos Aires except the extreme south, and adjacent Uruguay (see Maps 1 and 3).

Farther west in central Córdoba, another type of subtropical climate with wet summers and dry winters is found. Segment 611 (Río Cuarto) and Segment 604 (Juárez Celman) are located in this zone. Much farther southward in extreme southern Buenos Aires, a mid-latitude steppe (semi-arid) climate is found. The southernmost AgRISTARS segments, Segment 578 (Villarino) and Segment 556 (Puán-West) lie within this zone. Two other climatic types also occur within the Argentina Indicator Region. Extreme western Córdoba has a very warm steppe (semi-arid) climate and southeastern Buenos Aires has a cool marine climate because of its proximity to cold currents offshore in the Atlantic Ocean. However, no segments have been allocated to agricultural areas in southeastern Buenos Aires. Although most of the study area has a humid subtropical climate great differences in growing season, temperature and precipitation patterns occur. However, a considerable number of segments are also located in zones that are transitioned between a humid subtropical climate and semi-arid conditions. Segments in the western and southwestern portion of the study area



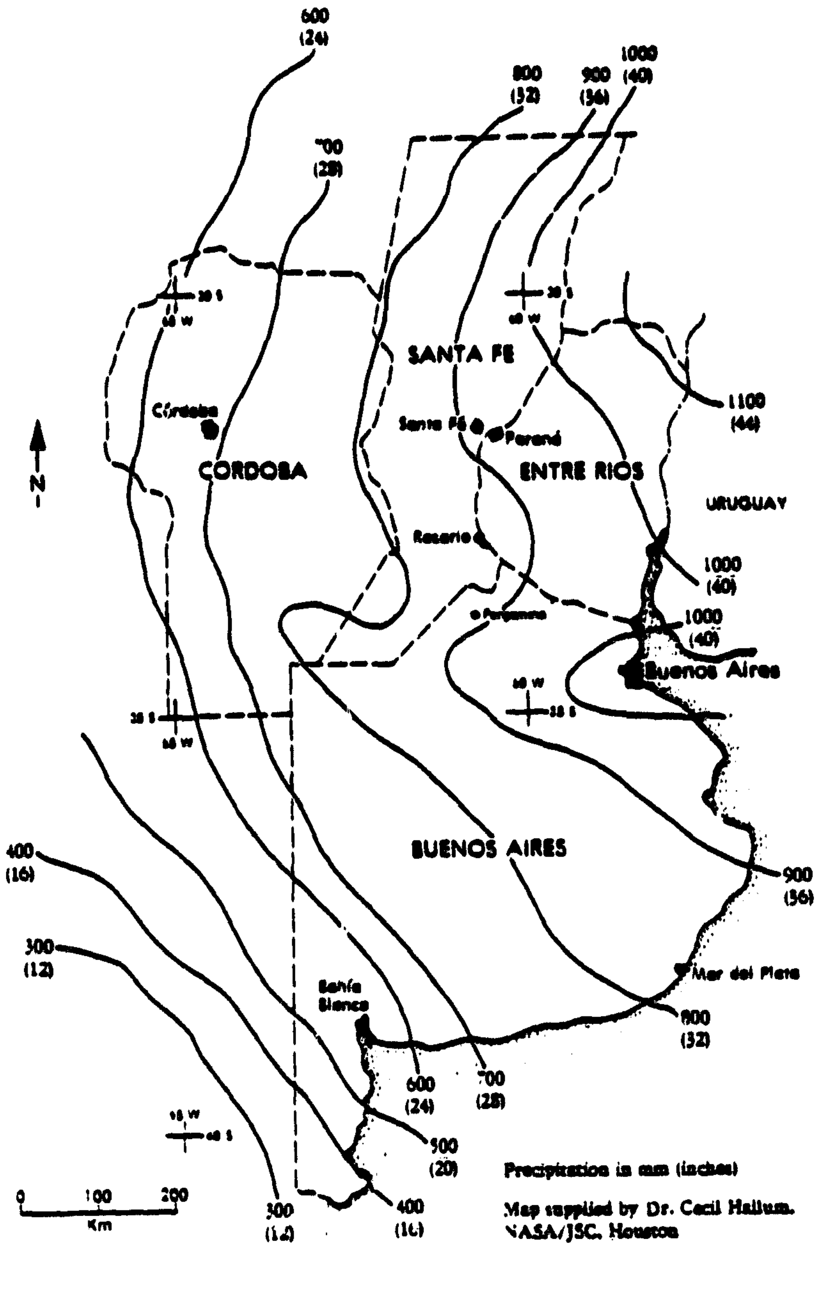
MAP 3. CLIMATE OF AgRISTARS STUDY AREA IN ARGENTINA

typify such conditions. Climatic change is gradual due to flat relief with the exception of some isolated highland areas.

Three basic precipitation conditions exist: (1) total precipitation received decreases from east to west and southwest (see Map 4), (2) precipitation in the east is normally evenly distributed throughout the year while areas in the north and west have summer maximums and winter dry season, and (3) evapotranspiration rates decrease from north to south.

Total precipitation decreases westward from eastern Buenos Aires on the Atlantic and Río de la Plata-Paraná boundaries. Farther northward precipitation likewise decreases from northeast Entre Ríos westward. The immediate area surrounding the city of Buenos Aires receives slightly more than 1000 mm (40 in) of rainfall annually while northeastern Entre Ríos receives slightly more, between 1000 and 1100 mm (40 in to 44 in). Westward from both locations, rainfall decreases along a series of north-south aligned isohyets (lines connecting areas of equal precipitation). Northern Santa Fé and the city of Santa Fé as well as parts of eastern Buenos Aires receive 900 to 1000 mm (36-40 in). Western Santa Fé and northwestern and north central Buenos Aires receive between 800 and 900 mm (32-36 inches). Eastern Córdoba and south central Buenos Aires normally report still lower values 700-800 mm (28-32 in) while western Córdoba and southern Buenos Aires receive only 600-700 mm (24-28 in) (see Map 4).

Precipitation continues to decrease in areas closer to the arid continental interior and Patagonia to the south. In western Córdoba the water deficit is pronounced (less than 600 mm, 24 in) and similar amounts are received at Bahía Blanca. Southwest of Bahía Blanca and west of Córdoba, precipitation continues to decrease toward the arid zones outside the study area. In extreme southern Buenos Aires less rainfall averages less than 400 mm (16 in) annually (see Map 4).



MAP 4. ANNUAL PRECIPITATION IN AgRISTARS STUDY AREA OF ARGENTINA

The seasonality of precipitation is also important. Precipitation in the eastern Pampa of Buenos Aires province is generally well distributed throughout the year, thus precipitation is not only adequate in terms of total amount received but there is no dry season. Farther westward, most rainfall increasingly tends to occur in summer and is less reliable throughout the year.

The climate of the Pampa region is generally characterized by long, hot humid summers, moderate amount of precipitation and mild winters. However, in the north long, hot humid summers are the result of heating of landmass areas at subtropical latitudes while the nearby Atlantic provides a moisture source. Daily high temperatures of 35°C (95°F) are not uncommon in summer throughout most of the area, and humid conditions prevail at this time. One contributing factor is that tropical air masses easily penetrate the region in summer from the northern continental interior partly due to the lack of topographic barriers such as mountains. However, in the extreme west the high temperatures in summer are somewhat ameliorated by lower humidity because of greater distance from ocean moisture sources. Likewise, summer temperatures in the southern portion of the Argentina Indicator Region are cooler because of greater distance from the Equator and also due to proximity to the Atlantic Ocean. However, heat waves can and do occur on occasion even in the far south. Southeastern Buenos Aires contrasts sharply with the rest of the Pampa in that summer temperatures are much cooler, 4 to 5°C (7 to 8°F), due to the cold Falkland Island (Islas Malvinas) current offshore. By the same token, winter temperatures are not as low as in comparable latitudes of interior North America since the southern and southwesterly winter airflow is predominantly of marine origin.

Winter temperatures throughout the study area are mild although frost and short periods of freezing weather can occur at interior locations such as Córdoba province. However, severe winter conditions accompanied by sub-freezing temperatures and snow which occur in the U.S. Corn Belt are not found in the Pampa. Temperatures for the coldest month in Buenos Aires (city) average about 10°C (50°F) at Bahía Blanca in the south 8°C (46°F) and at Córdoba (city) about 10°C (50°F).

Much greater differences exist in precipitation in terms of amount received, seasonality, variability, and evapotranspiration. All of these factors are critical for agriculture and exert a greater effect on crop-livestock land use than does temperature which is more uniform summer months rather than being well distributed throughout the year. The change to a summer maximum rainfall regime in southwestern Buenos Aires and Córdoba is in marked contrast that of the eastern Pampa bordering the Paraná-Rio de la Plata Basin. The city of Córdoba in north-central Córdoba province receives not only less total rainfall than Buenos Aires (city) but 80% of that rainfall occurs from November through April during the southern hemisphere summer. Río Cuarto, about 175 km to the south has a similar regime. Marcos Juárez in east central Córdoba receives slightly more precipitation because of its more easterly location but also has a strong summer rainfall maximum tendency. Bahía Blanca located in extreme southern Buenos Aires receives less yearly precipitation, but still exhibits a summer maximum.

Evapotranspiration rates or the rate at which vegetation transpires water, as well as surface evaporation, are high in the northern part of the study area, particularly in summer due to higher temperatures associated with lower latitudes and increased distance from moisture sources. Total precipitation received in the north is therefore less effective than farther south. Consequently more rainfall is required to maintain adequate moisture levels for agriculture than in areas farther southward. The AgRISTARS segments in western Córdoba and northern Santa Fé are located within areas having high summer evapotranspiration rates.

The Andean mountain system to the west is a barrier to moisture bearing winds and accounts for the dryness of interior Argentina. Also, moisture amounts from the Atlantic rapidly decrease westward which decreases precipitation at interior locations. However, dryness in the extreme southern coastal areas of Buenos Aires is due to the clockwise circulation of low pressure systems preceding cold fronts which results in onshore winds crossing cold ocean currents thus inhibiting precipitation.

Because of the study area's lower middle latitude location, frontal weather is common, and as in North America, temperatures rapidly drop with the passage of a cold front or rise with the arrival of warm air masses of tropical origin. As in interior North America, changeable cyclonic weather is also a feature of the Pampa and the arrival of cold fronts after prolonged periods of warm weather in summer often triggers thunderstorm activity. The formation of convectional storms due to surface heating is also common during this season. In winter much of the western Pampa experiences cool, dry, clear weather due to the precipitation blocking effect of the Andes. However, near Buenos Aires the proximity of ocean moisture makes winter precipitation more common.

2.2.1 CLIMATE AND AGRICULTURE

Because of its size and differing rainfall characteristics, the Pampa region can be divided into three zones: (1) the Humid Pampa which includes those areas which receive more than 800 mm (32 in) of annual precipitation, (2) the Sub-Humid Pampa an area receiving 700-800 mm (28-32 in) of precipitation and the Semi-Arid Pampa which receives less than 700 mm (28 in) of precipitation.

Geographically, the three zones form a series of concentric crescents that radiate westward from the city of Buenos Aires. The Humid Pampa is the innermost zone and is the production center for corn and soybeans which are crops that have high moisture requirements. The zone includes all of Buenos Aires province except the western and southwestern portions, southern Santa Fé and extreme southeastern Córdoba. Surrounding the Humid Pampa on the northwest, west and southwest is the drier Sub-Humid Pampa, an area that is important for sorghum, winter wheat and rye all of which are more drought-resistant than corn or soybeans. This zone includes the western portion of Buenos Aires, most of Córdoba except the southeast and central Santa Fé. Central Santa Fé receives sufficient precipitation to be included as part of the Humid Pampa but rainfall effectiveness is reduced due to high evapotranspiration. The outermost crescent, the Semi-Arid Pampa, lies even farther from the center and includes the southwesternmost part of Buenos Aires and adjacent La Pampa province bordering Buenos Aires on the west. Winter wheat and some sorghum are again the major crops in that zone, where drought is a major risk facing farmers.

The amount, seasonality, and variability of precipitation in the Pampa region has exerted a profound influence on agricultural land use. Moisture requirements for corn, soybeans, and other crops vary and in some parts of the Pampa insufficient total rainfall restricts the types of crops that can be grown because of drought risk. In some areas insufficient rainfall is a problem while other areas receive adequate total moisture but are intermittently affected by drought. Other zones may be handicapped by high evapotranspiration rates which severely reduce the effect of precipitation received. To a lesser extent temperature is also a factor.

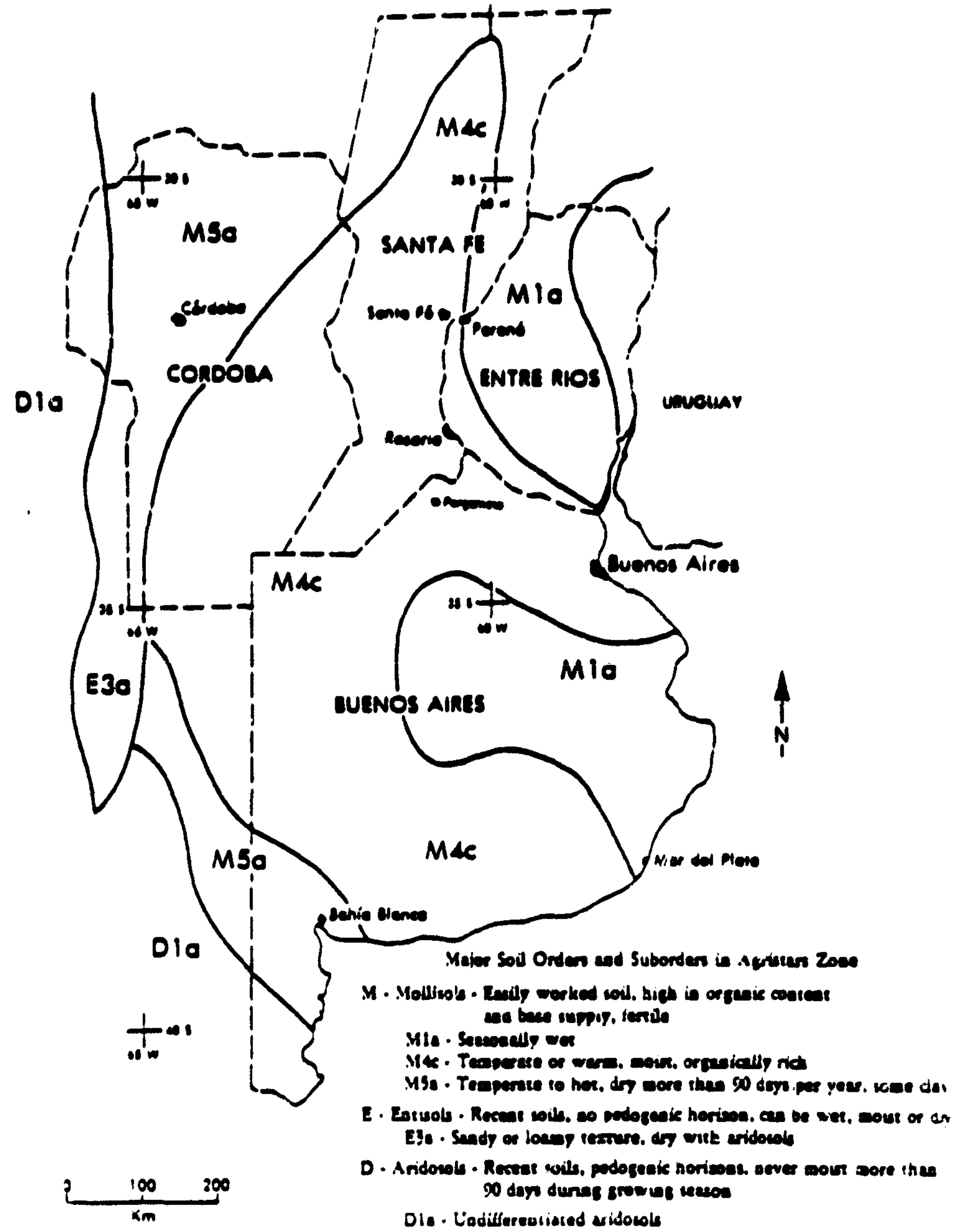
Historically, the uncertainty of rainfall has tended to confine corn production to northern Buenos Aires and southern Santa Fé west to the Paraná River particularly the zone along the Pergamino-Rosario axis. Sufficient total rainfall and humidity is dependable from year to year.

However, to the north and west, corn production becomes a risk. Northern Santa Fé receives about the same precipitation as northern Buenos Aires-southern Santa Fé zone but higher temperatures and greater evapotranspiration make the zone distinctly marginal for corn or soybeans. Sorghum which is more drought-resistant is therefore the chief coarse grain in the north. Rainfall, even in western Buenos Aires and southern Córdoba, is likewise less dependable. Evapotranspiration rates are slightly lower than northern Santa Fé but absolute rainfall is less and the chances for drought are much greater than near Rosario, Pergamino or the city of Buenos Aires. Soybean cultivation is mainly concentrated in northwestern Buenos Aires, southern Santa Fé and southeastern Córdoba. To the west cultivation is limited by increasing risk of drought which becomes a problem only about 100 miles west of the main corn-soybean production core. In the southern portion of the AgRISTARS study region, corn and soybean production are likewise restricted. In the vicinity of Bahía Blanca, total rainfall is about 40% below that of the Humid Pampa corn-soybean zone and corn and soybeans are of little importance, due not so much to temperature, but to insufficient precipitation.

However, the zone is well suited for wheat which is drought resistant. Southeast Buenos Aires, on the other hand, receives sufficient precipitation for corn/soybean cultivation but temperatures are too cool to favor maturation of the crop. As a result, flax rather than soybeans is the dominant oilseed crop, with wheat and oats being the principal grains, the latter being grown as a forage crop.

2.3 SOILS AND VEGETATION

The Argentine Pampa is one of the world's major crop-livestock production zones partly due to the high fertility of its soils, nearly all of which are Mollisols (see Map 5). The surface of the Pampa is



Source: Henry D. Foth, Fundamentals of Soil Science, Chapter 11, (Map. p. 255)

MAP 5. SOILS OF AgRISTARS STUDY AREA IN ARGENTINA underlain by Precambrian crystalline basement rock much of which is granite, but these formations outcrop in only a few locations such as in the Sierra de Tandil and Sierra de la Ventana in southern Buenos Aires. Fine, deep soils cover these crystalline rock formations in the remaining areas of Buenos Aires, and all of Santa Fé as well as most of Córdoba and Entre Ríos. Exposed rock and gravel are rarely found apart from the isolated highland zones and no exposed rock occurs within any of the sample segments. However, some weathered, rocky soils occur in Segment 578 (Villarino).

Soils within the Humid Pampa consist of fine, windblown (aeolian) material transported eastward from the arid west of Argentina. In general, those soil particles of finest texture were transported the farthest as suspended dust particles. Conversely, heavier sand particles were transported for a lesser distance and today form the Semi-Arid sandy Pampa to the west of the Humid Pampa. The fine windblown material which constitutes the soil of most of Buenos Aires, all of southern Santa Fé and southern Córdoba, is powdery, yellowish loess which is an extremely productive soil for agriculture. Subsurface layers of lime deposited through groundwater precolation are common throughout the southern portion of the humid pampa especially near Banía Blanca [3]. Despite the fertility of most of the Pampa zone, especially in southeastern Buenos Aires, some soil nutrient deficiencies exist, especially with respect to phosphorous and nitrogen. To some extent the nitrogen deficiency stimulated alfalfa production not only for use as a cattle feed but as a means whereby soils could be enriched in nitrogen for subsequent planting of cereal crops. Moreover, the practice proved to be popular since the water table in most areas is sufficiently close to the surface to be utilized as a moisture source by the roots of the alfalfa plant. Since about 1970 soybean cultivation, valuable as it is for its own sake, has also provided nitrogen for wheat in double-cropping zones.

Organic content of soils is variable through the AgRISTARS segment zones. In southern Córdoba some zones have soils averaging 3-4% organic content, but soils farther north and west decrease in organic content and are more sandy and less fertile. Soils in the Pampa of central Buenos Aires vary between 1-3% organic content while soils in the rolling Pampa areas farther south contain about 3% organic matter. The most fertile soil area of the entire Pampa is found in southeastern Buenos Aires beginning about fifty km inland from Mar del Plata and extends in a fan-like pattern about 150 km to the southwest, west and northwest.

2.3.1 SOIL TYPES

The soils within the AgRISTARS study area (Mollisols) are easily worked, fertile and are well-suited for agriculture. This same type of soil occurs in the U.S. Corn Belt. The Mollisols of the Argentine Pampa are nearly black in their upper layer or horizon and are rich in organic matter. The soils can be moist or dry depending on location, precipitation received and time of year. Within the Argentine Pampa several different sub-types of Mollisols have developed mainly due to parent material and climate. The most extensive sub-type are the Udolls which occur in the Humid Pampa. These soils have developed under relatively mild climatic conditions (compared with the U.S. Corn Belt). They are usually reasonably moist since about 625 mm (25 in) to 1000 mm (40 in) of precipitation occur within the zone with drier conditions being more prevalent in the west. These soils are high in organic matter and have great potential for high agricultural productivity. The Udoll sub-type of Mollisols form a large crescent beginning at Bahía Blanca in the south, then extends northwestward to southwestern

Córdoba; then northeastward in a finger-like projection to extreme northern Santa Fé and then southeastward to the city of Buenos Aires. To the west of this crescent are Ustolls, a drier soil variant of the former type. Ustolls are found in extreme western and all of northern Córdoba and have developed under temperate to hot conditions in areas that are dry at least ninety days annually. Nearly all of the fifty segments are located within the humid Udoll Mollisol soil zone of the Humid Pampa. However, four segments in southern Córdoba are located in a transitional zone separating the Humid Pampa soils (Udolls) from those of the semi-arid pampa (Ustolls). In addition, one segment in northern Córdoba lies barely within the Ustoll soils zone. Ustoll soils (dry Mollisols) are also found in extreme southern Buenos Aires in two of the five segments located in that area.

The soils of Entre Ríos are also Mollisols but are of the Alboll subtype. These soils contain light gray subsurface horizons and are less permeable because of higher clay content. Because of greater annual precipitation and poor drainage, these soils are seasonally wet throughout the year. The same subtype of soils occurs in the pampa deprimida (Depressed Pampa) of east central Buenos Aires where drainage is also a problem and annual precipitation is relatively high (1000 mm - 40 in) [4].

Soil fertility levels are generally high since only light to moderate leaching occurs. As a result, most soil nutrients are retained. This factor combined with the practice of recycling grasslands through rotation has maintained soil fertility through the years and soil impoverishment and depletion is not an acute problem. Yet, crop yields are much lower than natural conditions would seem to indicate due to poor management practices in most areas. This problem will be dealt with in a subsequent section of this report [5].

2.3.2 VEGETATION TYPES

Significant differences in vegetation are found in the four-province study area. The Pampa zone which covers nearly all of Buenos Aires as well as southern Santa Fé and Córdoba was a prairie grassland when the first Spanish explorers arrived. Tall plumed grasses covered most of the zone and marsh vegetation was also quite extensive given the numerous topographic depressions and poor drainage in the area. For the most part, grass rather than trees dominated the landscape except along water courses. As the Pampa was settled this native vegetation type was greatly modified through the planting of trees as windrows, woodlots as well as in towns. Even greater changes resulted as the Pampa grasses were plowed under for agriculture.

Vegetation throughout the study area correspond closely with precipitation amounts received. Precipitation decreases rapidly southwestward from the Humid Pampa and the grassland-windrow vegetation type gives way to the short grass steppe vegetation type of the southern panhandle of Buenos Aires province. Along the Paraná valley north and northeast of the Humid Pampa, extensive marsh and tropical scrub forest extend far upriver and continue northward out of the study area. In certain areas, the marshland extends westward to include low-lying areas of southern and central Santa Fé province. Similar vegetation tropical scrub forest and marsh interspersed with grassland occur in western and northern Entre Ríos while the center and southeast is "parkland", i.e., grassland with scattered trees. Southern Santa Fé is mainly a grassland area modified by man to include windrows and woodlots, while the north represents a southern extension of the tripical scrub woodland or Chaco zone. Central Santa Fé is transitional between the grassland and Chaco vegetative types. In the far northeast of Santa Fé conditions are sufficiently humid to support broadleaf-evergreen forests. Córdoba is similar to Santa Fé in terms of vegetation, i.e., grassland and scattered trees in the south and tropical scrub vegetation in the northern Chaco zone. However, drier conditions reduce the amount of vegetation cover and limit tree size.

Vegetation within the study zone is closely correlated with precipitation amount and effectiveness. As noted earlier, precipitation decreases westward from eastern Buenos Aires and the Paraná River. Where rainfall and precipitation effectiveness are higher, luxuriant grass cover and trees are the predominant vegetation association. In the extreme northeast, broadleaf evergreen forest occurs due to this factor. However, as rainfall decreases westward, the Pampa grasslands give way to short-grass steppe vegetation such as in extreme western Buenos Aires and Córdoba. Farther northward, rainfall likewise diminishes westward with east central Santa Fé receiving more moisture than central Córdoba. However, drought-resistant scrub forest is common throughout the far north because of higher evapotranspiration rates due to lower latitude. As a result, drought-resistant scrub forest and grasses predominate even though considerable rainfall occurs.

3

CROP-LIVESTOCK ZONES IN THE AgRISTARS STUDY AREA

A variety of important crops are raised in the AgRISTARS study zone. Coarse grains, fine grains and oilseed crops dominate the agricultural sector but beef cattle raising is also an integral part of the rural scene. The production of these crops tend to be concentrated in the Humid Pampa and the adjacent Sub-Humid Pampa. Except for wheat and cattle raising and some sheep ranching, the Semi-Arid Pampa is much less important. The production core for most crops is northwest Buenos Aires, southeastern Córdoba, and southern Santa Fé. A second zone in southern Buenos Aires is important for winter forage crops and is also the center of winter wheat production. Other crops such as flax are important in Entre Ríos. Climatic conditions, soil, and rainfall favor the production of corn and soybeans in the Humid Pampa agricultural "core zone". Sorghum is also suited to this area, but because of lower prices and competitive land use, is relegated to drier areas unsuited for corn and soybeans since it is drought-tolerant. The "core zone" itself is a crop-livestock production complex. Coarse grains such as corn are grown for hogs while cattle are pastured on alfalfa, sorghum or natural pasture unlike the feedlot zones in the U.S. which are west of the corn belt. Also, unlike Brazil, the main soybean production zone does not correspond to the major wheat zone. Soybean-wheat double cropping is important but much of Argentina's wheat is also produced in the cooler, drier south. These systems are discussed in a subsequent section of the report.

Despite the relative physiographic homogeneity of the Pampa region which characterizes most of the AgRISTARS study area in Argentina, very substantial differences in agricultural land use, crop mix and practices exist, due mainly to differences in rainfall amount and distribution (see Map 6). These differences as well as similarities are discussed in the following sections.

3.1 ZONE 1 - COTTON

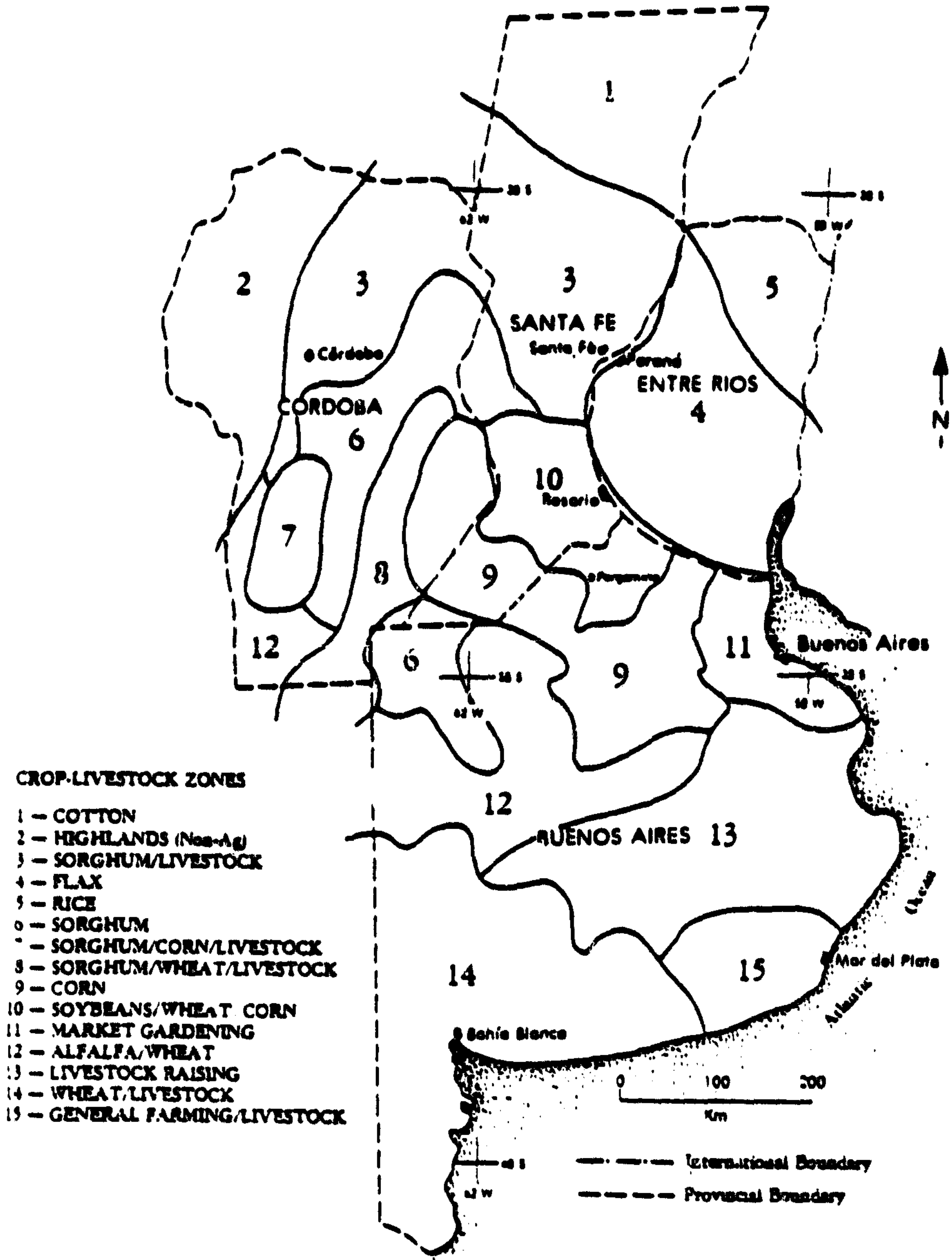
The cotton area shown in northern Santa Fé is a southward extension of Argentina's major cotton production zone which also covers parts of the provinces of Formosa, Chaco and Santiago del Estero [6]. Moderate rainfall, high evapotranspiration, poor drainage and sporadic flooding of cotton plantings characterize the zone. The zone is geographically remote from all fifty segments in the study area and is therefore not directly relevant to the corn/soybean agronomic understanding efforts of this subtask.

3.2 ZONE 2 - HIGHLANDS

This highland zone in extreme northwestern Córdoba (Sierra de Córdoba) is a non-agricultural zone and is likewise not of direct concern to the Argentina agronomic understanding subtask.

3.3 ZONE 3 - SORGHUM/LIVESTOCK; ZONE 6 - SORGHUM; ZONE 7 - SORGHUM/CORN/LIVESTOCK; ZONE 8 - SORGHUM/WHEAT/LIVESTOCK

These four zones represent various crop mixes, but in all cases, sorghum cultivation is significant. The zones are all located in the Sub-Humid Pampa, west and northwest of the Humid Pampa centered on northern Buenos Aires. In all four zones, sorghum along with beef livestock raising is the chief rural activity. Zone 3 covers northern Córdoba and central Santa Fé. Livestock pasture is the chief land use in this zone with most sorghum grown being forage sorghum. The sorghum plant's resistance to drought makes it the chief crop as very little corn or soybeans being grown in the far north due to moisture limitations



MAP 6. CROP-LIVESTOCK ZONES IN ARGENTINA INDICATOR REGION

and drought prevalence. Still, the amount of sorghum grown in Zone 3 is much less than in Zone 6 due to high evapotranspiration which reduces precipitation effectiveness except for northeast Córdoba where more sorghum is grown. Zone 6 is a slightly more humid area than Zone 3 and is Argentina's major sorghum production zone. The largest portion is located in central Córdoba, while the remainder is located in extreme western Buenos Aires. Livestock raising remains important, but the percentage of land devoted to sorghum is much greater in Zone 6 than in Zone 3. In addition, some soybeans are grown in the zone. Zone 7 is similar to Zone 6, but corn is also a major crop. Zone 7 is the largest producer of corn in Argentina outside of the Humid Pampa for reasons not clearly understood, given the low average annual precipitation for the zone 700 mm (28 in). However, livestock activities and forage sorghum production remain important. Zone 8 is similar to Zone 7 except that wheat production is also important. Precipitation is also slightly higher 750 mm (30 in). Wheat production is greatest in the northern portion of Zone 8 and gradually decreases southward. Also, the zone accounts for less of the Argentine wheat total than in the past as newer production zones in southwestern Buenos Aires have become more important. The northern part of Zone 8 is relatively densely populated by Argentine rural standards, and has been an important agricultural zone since about 1900.

Agricultural practices within the four zones are fairly uniform. Irrigation is virtually non-existent and many sorghum fields are weed-infested due in part to the high organic content of the soil and the lack of herbicide application which encourage weed proliferation. Furthermore, fertilizer use remains low due to high prices and high natural soil fertility. Crop rotation is practiced but no consistent, organized system exists. Land left in pasture for several years is generally planted in forage sorghum with the decision to plant being made in a real-time context because of weather and changing market prices. Most pastures are unimproved in the north but alfalfa becomes more important in Zone 6. Also, the flooding of forage crops in low-lying areas may necessitate sudden new plantings of sorghum or oats planted for livestock ground forage.

3.4 ZONE 4 - FLAX

Zone 4 covers most of Entre Ríos province except the extreme northeast. Flax is the chief crop grown in the zone with the heaviest concentration being in central and southern Entre Ríos. Livestock raising is of some importance, as are corn and soybeans in the extreme west-central portion. Although one segment is allocated to Entre Ríos, Zone 4 is somewhat peripheral to corn/soybean technology development for Argentina, as flax and linseed oil production dominate the zone's economy.

3.5 ZONE 5 - RICE

Zone 5 is a southern continuation of Argentina's major wet rice production zone, most of which is located in Corrientes province to the north outside the study area [7].

3.6 ZONE 9 - CORN; ZONE 10 - SOYBEANS/WHEAT/CORN

Zones 9 and 10 located in the Humid Pampa of northern Buenos Aires, southeastern Córdoba and southern Santa Fé are the chief areas of interest relative to the Argentina agronomic understanding subtask. Zones 9 and 10 account for approximately 80% of Argentina's corn while Zone 10 accounts for over 90% of the nation's soybeans. Climatic conditions within the zones are very favorable for the cultivation of both crops, but soybean production is highest in the northeastern portion of the larger corn production zone. Corn and alfalfa production along with livestock raising, is important in Zone 9, as is sunflower cultivation. Zone 10 is also important for corn cultivation but soybean/wheat double cropping surpasses corn in area planted and is the chief agricultural activity. About 75% of the soybeans grown are double cropped with wheat but this percentage may vary about 10% above or below this figure for different years.

Mechanized agricultural production is widespread in Zones 9 and 10. Although mechanization levels are lower than in the U.S. Corn Belt, they are nevertheless high by Latin American standards. Three- to five-bottom (moldboard) plows are commonly employed on smaller farms, while ten- to fifteen-bottom implements are the rule for large properties. No-till planting is not widely practiced since plowing is considered a weed control measure.

Planting times are governed by temperature, drainage conditions ard moisture availability. Corn is normally planted from mid-September to mid-October in both zones and harvested in March. However, planting and crop growth dates, as well as harvest dates, vary with weather and location. Soybean planting in the two zones normally begins about November 1 to 15 but dates vary widely. However, the planting date for single-crop soybeans is usually several weeks earlier than for soybeans which are double-cropped with wheat. Harvesting begins in April and can continue into June. Row width for corn, soybeans, and grain sorghum is 70 cm, and that of forage sorghum and winter wheat is 15 cm.

Several other agricultural practices deserve mention. In some areas, wheat and alfalfa re intercropped in the same field; the wheat being harvested first with the alfalfa being left for pasture. In addition, variable crop rotation schemes are found in Zones 9 and 10. Single-crop soybeans as well as soybeans double-cropped with wheat are often followed by pasture, while corn may be followed by rye or alfalfa. These rotation patterns are discussed in more detail in Section 5.9.

3.7 ZONE 11 - MARKET GARDENING

Zone 11 is a zone of intensive vegetable and fruit production serving the city of Buenos Aires. The zone, which forms a crescent around metropolitan Buenos Aires on its northern, western and southwestern margins, is located outside the major corn/soybean production zone and is not directly relevant to the AgRISTARS agronomic understanding subtask.

3.8 ZONE 12 - ALFALFA/WHEAT

This, the major alfalfa/wheat production zone in the Argentina study area, is located to the southwest of the principal corn/soybean growing areas [8]. Despite its proximity to the corn/soybean zone, corn production is much less and soybean production is negligible due to decreased annaul precipitation and erratic and unreliable rainfall patterns. Drought is a major risk in the zone and farmers therefore plant alfalfa or wheat. Sunflowers are also of some importance. Alfalfa is planted in March as winter forage throughout the zone, and is cut in May, July and September. In October, alfalfa is usually planted for a second time and the process is repeated. Unlike the U.S. Corn Belt, feedlot fattening of livestock is not commonly practiced in Argentina. Rather, alfalfa is the principal livestock feed, along with forage sorghum. Winter wheat is also grown, but production is generally less than in eastern Córdoba to the north, or areas farther south in Buenos Aires. In some areas of the zone, wheat and alfalfa are intercropped in the same field. Also, alfalfa is sometimes rotated with rye to restore soil moisture. Despite drought risk, irrigation is not practiced in the zone.

3.9 ZONE 13 - LIVESTOCK RAISING

Zone 13 located in central Buenos Aires is a low-lying, poorly drained area devoted mainly to beef livestock raising. Corn and soybean production are not important within the zone, due principally to poor drainage and flood risk. However, annual precipitation is sufficiently high 800-900 mm (32 to 36 in) to support their cultivation. Oats, barley and rye are grown within the zone as cattle feed but many cattle are sent to alfalfa producing areas in Zone 12 for fattening prior to marketing. Some wheat is also grown, but as in the case of Zone 12, the amount grown is much less than in southern Buenos Aires.

3.10 ZONE 14 - WHEAT/LIVESTOCK

Argentina's largest and most important wheat growing region is located in southwestern Buenos Aires, south of a diagonal line separating it from Zones 12, 13 and 15. Pasture, wheat cultivation and some forage sorghum dominate rural land use but wheat is by far the most important crop produced. Precipitation decreases steadily from northeast to southwest to the extent that corn and soybean production is precluded in the southwest. Wheat is normally planted in June and harvested in late December. Following harvest, oats are normally planted in wheat stubble as forage for cattle. Also, several varieties of pasture grass are planted, but alfalfa plantings are of little importance, unlike areas farther north. Irrigation is rarely practiced and many pastures are unimproved and weedy.

3.11 ZONE 15 - LIVESTOCK/GENERAL FARMING

In southeastern Buenos Aires, the crop mix is considerably different from other areas of the Pampa. Total annual precipitation is nearly double that of southwestern Buenos Aires and relative humidity is much higher. In addition, the soils of southeastern Buenos Aires are very high in organic matter (16%) and are among the most productive in Argentina. However, poor drainage and salinity are problems in some locales. Durum wheat, potatoes, and pasture (alfalfa) used for livestock raising rather than fattening, dominate land use in Zone 15. Although potato production is favored by the cool, moist climate as is rye and barley cultivation, the cooler temperatures discourage the production of corn and soybeans within the zone despite rich soils. Potatoes, which are the chief crop, are normally planted for two years followed by the planting of wheat, and then oats.

4

CORN/SOYBEAN PRODUCTION AND RELATED STATISTICS

Argentina's corn production has continued to be important in the nation's agricultural economy through the 1970's. In contrast, soybeans were of little importance at the beginning of that decade, but emerged as a major export crop by the late 1970's. Production trends are discussed and additional information on the distribution and location of corn/soybean production is given to supplement that presented in Section 3.6.

4.1 CORN PRODUCTION AND EXPORT STATISTICS

Argentina's leading crop in terms of tonnage produced is corn; however, yield, area harvested and production exhibit considerable variation (see Table 1). Between crop years 1969/70 and 1980/81 corn production fluctuated considerably from slightly less than six million metric tons in crop years 1971/72 and 1975/76 to about ten million tons in crop year 1970/71. However, production throughout the period averaged about 8.7 million tons, with production during crop years 1971/72, 1974/75, 1975/76 and 1979/80 being below normal, probably due to unfavorable weather [9] (see Table 1).

The Argentine corn crop for crop year 1980/81 is estimated at about 13.0 million metric tons, an excellent harvest despite rains during the harvest period. The corn yield for this most recent crop year was 3.77 metric tons/hectare [10]. However, this is in marked contrast to corn production in crop year 1979/80 when production totaled only 6,400,000 metric tons as a result of very low yields and decreased area harvested due to severe drought (see Table 1).

NOTE: All weights are in metric tons.

TABLE 1. CORN YIELD, AREA HARVESTED AND PRODUCTION IN ARGENTINA

Crop Year	Yield Metric Tons/ Hectare	Area Harvested (in thousands of hectares)	Production (in metric tons rounded to nearest thousand)
1969/70	2.333	4,017	9,360,000
1970/71	2.442	4,066	9,930,000
1971/72	1.862	3,147	5,860,000
1972/73	2.721	3,565	9,700,000
1973/74	2.840	3,486	9,900,000
1974/75	2.508	3,070	7,700,000
1975/76	2.117	2,766	5,855,000
1976/77	3.278	2,532	8,300,000
1977/78	3.647	2,660	9,700,000*
1978/79	3.103	2,900	9,000,000*
1979/80	2.570	2,490	6,400,000
1980/81	3.768	3,450	13,000,000

Source: Economic Information on Argentina and Attaché Report USDA/FAS
See References Cited, No. 9.

*Provisional figures

Yield per unit area, and area harvested, the chief production determinates have both fluctuated in the case of corn. However, from crop year 1976/77 to present, yields have tended to be higher than in previous years with the exception of crop year 1979/80. Area harvested in hectares from crop year 1975/76 has fluctuated considerably but production has remained reasonably high due to increased yields during most of this period (see Table 1).

Argentina has traditionally been an important exporter of corn. Following the 1978 harvest most corn exported went to Italy, Spain, Portugal and the USSR in that order of importance. During the market year following the 1979 harvest, the destination of corn exports changed significantly. The Soviet Union was the most important purchaser followed by the Netherlands, Italy and Spain.

An early 1981 corn production in Argentina was forecast at about 10.0 million metric tons with 3.6 million hectares planted [11]. This estimate was subsequently dropped due to heavy rains which extended the harvest period into April and May. However, production proved to be higher than anticipated - an estimated 13.0 million metric tons. Of this total, 9.6 million metric tons are destined for export, of which 78% will be purchased by the Soviet Union which has firmly established itself as the chief consumer of Argentine corn [12].

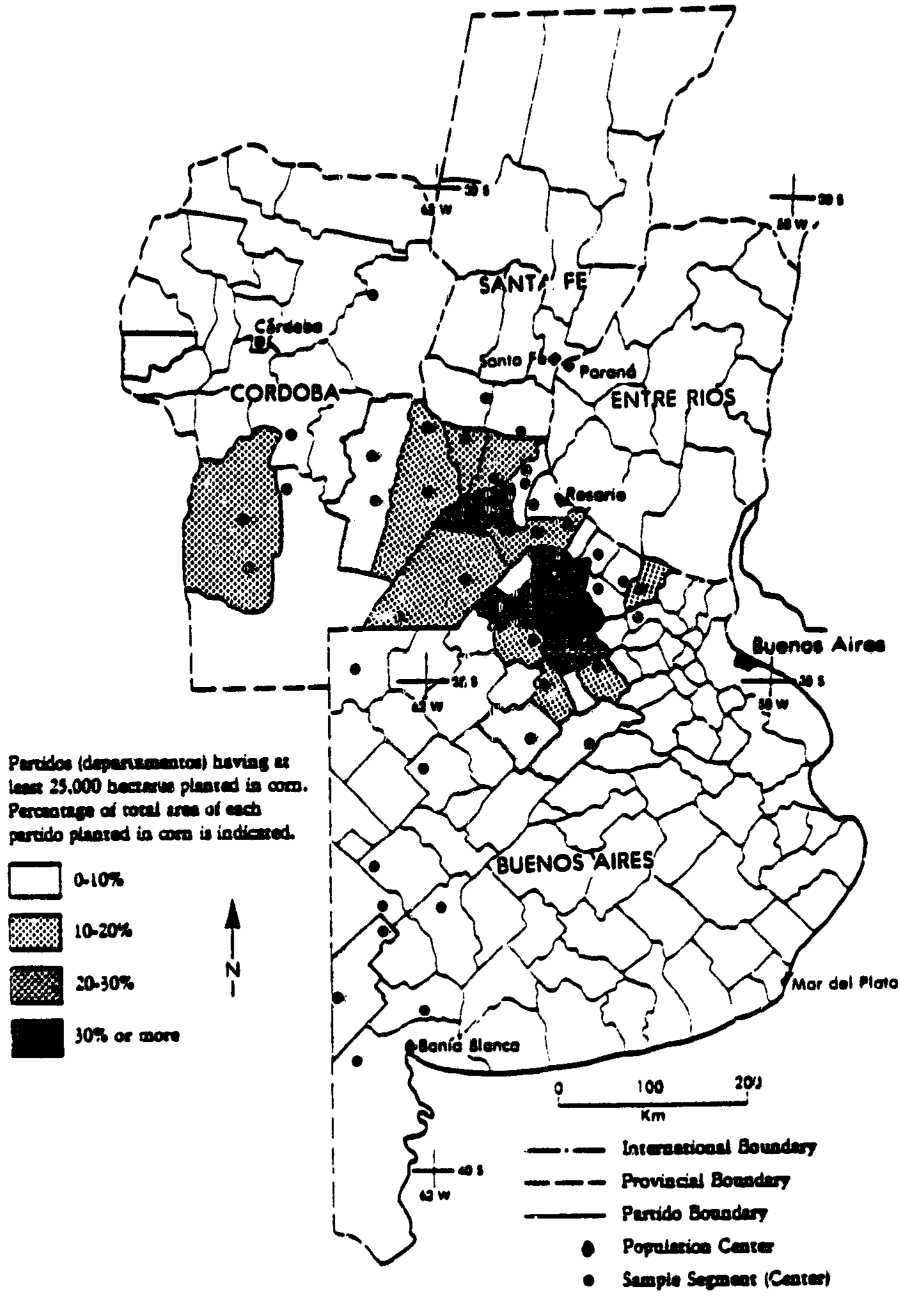
4.2 DISTRIBUTION OF CORN PRODUCTION

Corn is one of Argentina's principal crops both in terms of tonnage produced and in terms of exports. However, due to drought risk and poor drainage, production is not widely distributed throughout the Pampa but rather is concentrated within a portion of the Humid Pampa covering extreme northern Buenos Aires, southern Córdoba and southern

Santa Fé (see Map 7). Rainfall is sufficiently ample and reliable in most of these zones for successful corn cultivation although southern Córdoba is more drought-prone than the remaining areas mentioned. The highest production density is found in northern Buenos Aires. Southern Córdoba is likewise very important for corn but sorghum is also significant. In adjacent southern Santa Fé, soybeans comprise much of the crop mix along with corn.

Over 90% of Argentina's corn is grown within the AgRISTARS four-province study area, but Buenos Aires is by far the most important producer. In crop year 1976/77 that province produced 48.2% of Argentine's crop (four million metric tons), more than double that of the second-ranking producer, Santa Fé province. Santa Fé that same crop year produced 1.85 million metric tons and accounted for 22.3% of the national total. Córdoba, nearly as important as Santa Fé, ranked third in corn production with 1.56 million metric tons being harvested for 18.8% of the total. Entre Ríos, the fourth province in the AgRISTARS study area is not a major corn producer and accounted for only 240,000 metric tons of the crop (2.9%) in the 1976/77 crop year [13].

In crop year 1976/77 Córdoba and Santa Fé were rapidly increasing in importance as corn producers. Production in Córdoba increased 145% over 1975/76 while that of Santa Fé increased 34%, indicating that corn in Córdoba is of recent importance. Because of these increases, as well as a 42% increase in Buenos Aires production, corn production was projected to increase to 8,300,000 tons for Argentina [14]. However, this dramatic production increase is somewhat offset by the fact that crop year 1975/76 was the lowest corn production year within the crop year 1969/70 to 1980/81 reporting period (see Table 1). In Córdoba production increases resulted from both additional land being planted in corn as well as higher yields. In the case of Santa Fé and Buenos Aires, the



MAP 7. DENSITY OF PLANTED AREA IN CORN 1977/78 CROP YEAR

increase was probably due to a greater extent to increased yields. In crop year 1977/78 corn production in Argentina reached 9.7 million metric tons, the highest since crop year 1970/71 (see Table 1).

4.3 SOYBEAN PRODUCTION AND EXPORT STATISTICS

Compared to other crops such as corn, soybeans are a recent crop in Argentina to having assumed importance only after 1970. Production until crop year 1972/73 was less than 100,000 tons and production increases throughout this period were very modest. However, in crop year 1972-73 production jumped markedly and approached the 300,000 ton mark given the growing world demand for protein. Subsequent years saw greater production increases about 500,000 tons in 1973-74 and 1974-75, and about 700,000 tons by 1975-76. Production greatly increased in crop year 1976-77 to about 1.4 million tons and soybeans as a major oilseed crop in the Humid Pampa of Argentina was firmly established [15] (see Table 2). By crop year 1977/78 production had increased to 2.5 million tons, and by crop year 1978/79 3.7 million tons were harvested [16]. However, weather conditions in crop year 1980/81 were very dry and unfavorable for soybeans and this was reflected in a 1980/81 crop year production total of 3.5 million metric tons, a slight decline from the previous year. Crop year 1981/82 projections are higher since planted area is expected to increase 8% which should result in 3.8 million metric tons of soybeans being produced, assuming crop year 1980/81 yields [17]. Historically, increasing soybean production in Argentina was accompanied by a commensurate increase in area planted. In crop year 1969/70 about 30,000 hectares were devoted to soybeans. However, planted area more than doubled by crop year 1971/72 to 80,000 hectares and doubled again in crop year 1972/73 to 170,000 hectares. In crop year 1973/74 the trend continued with about 375,000

TABLE 2. SOYBEAN YIELD, AREA PLANTED AND PRODUCTION IN ARGENTINA

Year	Yield (metric tons/ hectare)	Area Planted (area planted in hectares)	Production (metric tons)
1969/70	.985	30,470	30,000
1970/71	2.122	37,700	80,000
1971/72	1.128	79,800	90,000
1972/73	1.593	169,440	270,000
1973/74	1.327	376,700	500,000
1974/75	1.286	369,500	475,000
1975/76	1.582	442,500	700,000
1976/77	1.972	710,000	1,400,000
1977/78	2.083	1,200,000	2,500,000
1978/79	2.256	1,640,000	3,700,000
1979/80	2.206	2,040,000**	4,500,000**
1980/81	1.989	1,760,000**	3,500,000
1981/82	1.989 (Projected)	1,900,000** (Projected)	3,780,000 (Projected)

Source: Economic Information on Argentina and Attaché Report
USDA/FAS See References Cited, No. 15.

**Provisional Figure

hectares being planted and the same for the following year. The planted area for crop year 1975/76 was 443,000 hectares followed by a 60% increase in crop year 1976/77. In crop year 1976/77 area planted nearly doubled and continued to increase through crop year 1979/80, after which planted area decreased slightly. Increases in yield have accompanied production and planted area increases yields have been quite high since crop year 1976/77 although there was a slight decline in crop year 1980/81 due to drought. The yield for crop year 1981/82 is projected at about 2.0 metric tons/ha which compares very favorably with U.S. soybean yields (see Table 2 and Section 5.12, Reference 37).

There are indications that soybean production is stabilizing as more farmers are planting corn rather than single-crop soybeans due to better corn prices in early 1981. It is worthy to note that Brazil has followed the same production trends, i.e., production of soybeans is stabilizing although total production is much higher than in Argentina.

In early 1981 some significant land use shifts were underway in the Argentina corn/soybean zone. Corn was replacing some single-crop soybeans because of higher prices being paid for the former crop. In addition, peanuts replaced some single-crop soybeans in Córdoba, and dry beans was given greater emphasis over single-crop soybeans in Tucumán province in extreme northwestern Argentina. These decreases in planted soybean area were being offset to some extent by increased wheat plantings, but increased wheat production does not always result in more soybeans being grown since much of the wheat in Argentina is grown outside the soybean/wheat double-cropping zone. Soybeans and other oilseed crops such as flax, sunflower, peanuts and tung are also somewhat affected by the shift to corn. Oilseed production for crop year 1981/82 (6.1 million metric tons) was, in fact, estimated to be down about 10% from the previous crop year due to depressed prices although export of soybeans were expected to remain high [18].

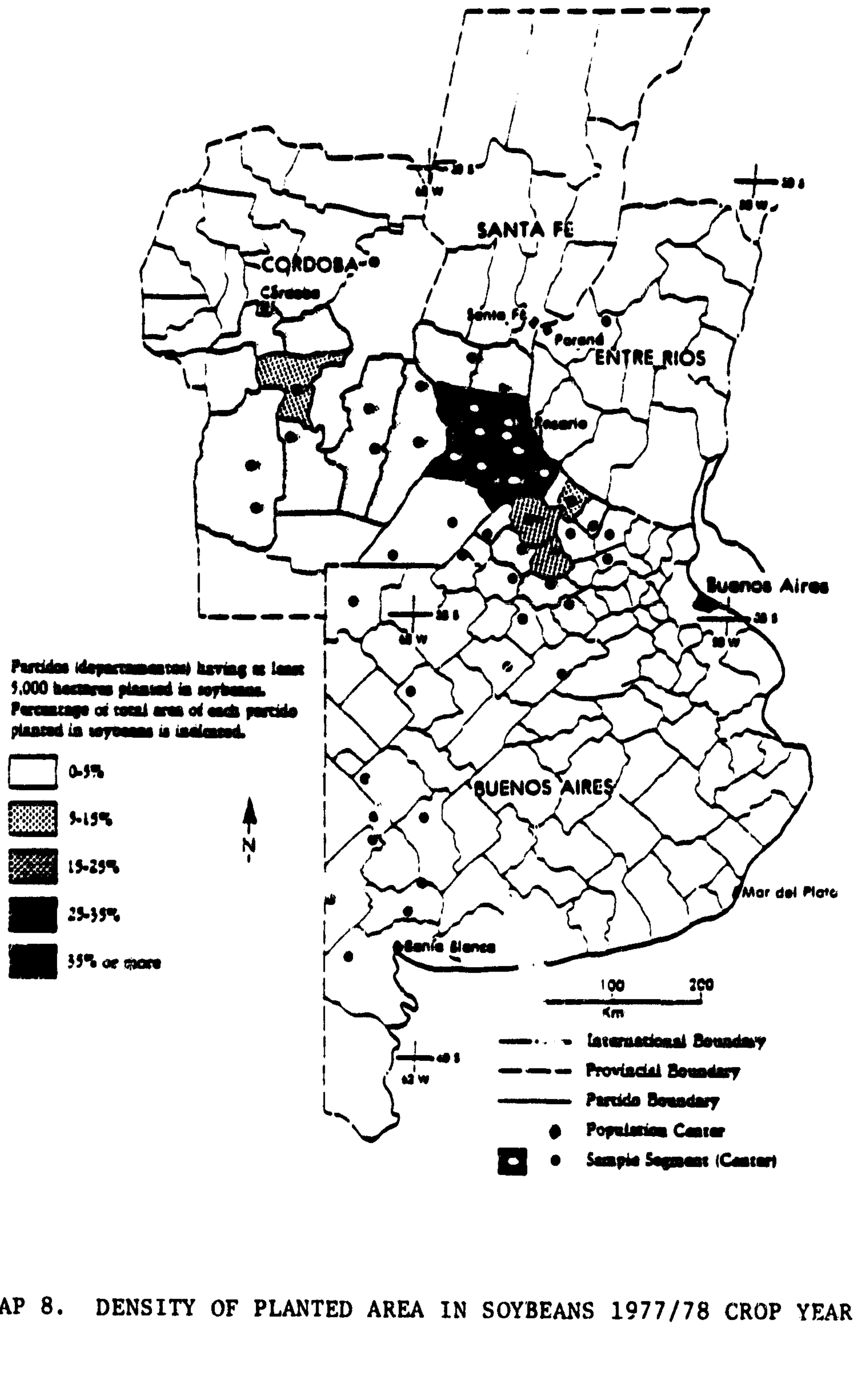
More than one-half of Argentina's soybean crop is exported, which in 1980 resulted in the sale of 2.7 million metric tons of the product abroad. In 1981 soybean exports were expected to increase to about 2.9 million metric tons although the final figure was not available at the time of writing. Of the 2.7 million metric tons exported in 1980, 740,000 million metric tons of more than 25% of the total, were purchased by the Soviet Union. The second-ranking consumer of Argentine soybeans in 1980 was the Netherlands [19].

At present Argentina is attempting to secure more overseas markets for soybeans, corn, wheat, sorghum and other crops grown for export through bilateral trade agreements with other countries, especially the USSR. Argentina will annually supply the Soviet Union with 500,000 tons of soybeans through 1985 as a result of a 1980 Argentine/Soviet trade agreement. This agreement is discussed in more detail in Section 6.3 [20].

In conclusion, the following should be noted. Both planted area and production increased after 1970 and peaked in 1978 and 1979. In the early 1980's production a slight decline is evident. Total production may stabilize around 4.0 million metric tons produced annually for the near future since land use shifts are underway to other crops such as corn and peanuts in single soybean crop areas yet, the continuing demand for soybeans resulting from Argentina's recent bilateral trade agreements with the USSR and the People's Republic of China may once again stimulate production and expansion of sown area.

4.4 DISTRIBUTION OF SOYBEAN PRODUCTION

In 1978/79, 59% of Argentina's soybeans were grown in Santa Fé province, almost all of the production being in the southern part of the state west and south of the city of Rosario (see Map 8). The state



MAP 8. DENSITY OF PLANTED AREA IN SOYBEANS 1977/78 CROP YEAR

produced about 2,180,000 metric tons of soybeans. However, yields in the state appeared to be lower than in other areas, averaging 1150 kg/ha or 1.15 metric tons/ha. The national yield average for 1977-1979 was about 2.2 metric tons/ha. The province is the nation's foremost producer, with most plantings concentrated in the southern portion of the state. Land use farther north in Santa Fé is mainly devoted to pasture or sorghum since the area is too dry for soybeans.

Córdoba province in 1978/79 ranked second as a producer but accounted for a much smaller percentage of the total harvest (18%) for a total of 656,000 metric tons. However, the province is significant in the rapid growth of soybean production which jumped 119% from crop year 1977/78 to crop year 1978/79. Again, as in the case of Santa Fé, much of Córdoba (the north) is unsuited for soybeans because of dryness. The southern part of the state is the leading soybean growing area, but central Córdoba has the highest production density. This latter area is within Argentina's major peanut production zone.

Buenos Aires ranks third as a soybean producer and in 1978/79 accounted for about 14% of the national production (520,000 tons). Most production is concentrated in the extreme northern part of the province adjacent to Córdoba and Santa Fé which is Argentina's leading corn growing area. The principal production zone covering the three provinces accounted for 91% of Argentina's soybeans [21]. However, Entre Ríos is a much less important producer.

5
AGRICULTURAL PRACTICES

A variety of agricultural practices are utilized by farmers within the AgRISTARS study zone and probably the most important factors governing the use or adoption of a particular practice is the cost/benefit which accrues to the farmer. This is particularly true in Argentina given the extremely high rate of inflation. Costs of farm inputs such as fertilizer, insecticides, herbicides and farm equipment are extraordinarily high compared to most nations; and some practices, although advised, are simply not undertaken due to their high cost or the possibility of non-return on money invested. The problem of non-implementation of certain agricultural practices is thus largely economic in nature. In the case of Argentina, the failure to adopt some beneficial practices is not the result of ignorance on the part of the farmer due to illiteracy, nor the lack of agricultural information. The country, in fact, has one of the highest literacy rates in the western hemisphere and a rather well-developed agricultural research and assistance infrastructure compared to other Latin American nations. Instead, inflation, changing governmental agricultural policies, oscillating crop prices, weather and until very recently the uncertainty of agricultural markets have been influencing factors. Planting and crop rotation decisions, in particular, are often driven by market prices and may vary widely from year to year. In northern Buenos Aires province, farmers planted more sorghum and corn than usual in 1980 at the expense of single-crop soybean production since higher sorghum prices favored that shift. However, double-cropped soybeans continued to be important due to favorable wheat prices [22]. In 1981 oilseeds, especially soybeans, were favorably priced and a 13% increase in production was forecast [23]. Fertilizer use fluctuates widely depending on price and its use may be curtailed when prices increase. During such times farmers mainly depend on the high natural fertility of the Pampa soils for crop success. The presence of weed-infested fields in many areas is also indicative of the high costs associated with weeding. In such cases, many farmers elect to reduce production costs even though it may result in reduced yields per unit area.

Other agricultural practices are somewhat traditional in nature and probably stem from the historical development of the Pampa. One such example would be the use of alfalfa plantings for beef cattle fattening rather than the feedlot method so common in the United States. Likewise, the presence of significant livestock raising operations and extensive pasture lands even within the major agricultural zones is testament that the Pampa zone is a former ranching zone that has given way partly but not totally to agriculture, and then only toward the close of the Nineteenth Century.

Crop types and rural land use have also changed due in part to soil and climatic factors as well as economic competition for crops best suited for different agro-ecological zones. Ideal conditions for sorghum cultivation exist in the northern Humid Pampa but much of the production has shifted to drier areas due to the drought-resistant nature of the crop. In addition, much of Argentina's wheat production has shifted far to the south and west of southern Santa Fé province where the crop was originally cultivated by Italian immigrants. Corn and more recently soybeans, now characterize the Humid Pampa since suitable conditions do not exist elsewhere in Argentina for their cultivation. Thus the principal of comparative advantage has done much to influence crop-livestock land use, farmer practices and decision-making.

Some agricultural practices in the AgRISTARS study zone differ considerably from those of the United States while others are similar, but all merit discussion. These include tillage methods, planting methods, harvesting mode, crop mixes and crop rotation patterns.

5.1 TILLAGE

Plowing operations in the study area are largely mechanized with tractors being commonly used to prepare fields for planting. However, the type of tractor and plow combination utilized is governed by the size of field and the financial resources of the farmer. Three- to five-bottom (moldboard) plows are often used on smaller farms while much larger ten- to fifteen-bottom plows are used on larger fields, particularly those on large farms, whose operators have sufficient capital to purchase larger tractors and implements. In northern Santa Fé and Córdoba, both of which are subject to seasonal flooding, chisel plowing is practiced by some farmers as an erosion control measure. However, minimum-till or no-till planting methods have not been widely adopted to date by farmers in the Argentine Pampa because of weed proliferation. To some extent, plowing is therefore considered a weed control measure [24].

5.2 PLANTING PRACTICES

Planting practices vary both by crop and location. Within the study area, corn, sorghum, and soybeans are the major summer crops as is sunflower while wheat is the major winter crop. Spring grains such as barley and rye tend to be more important in southeastern Buenos Aires as do potatoes since their cultivation is favored by ample moisture and lower summer temperatures. Planting times are governed to a great extent by temperatures, drainage needs of the crops and water availability.

The planting of summer crops begins first in the north and then gradually moves south to the extent that in the case of corn planting dates are about one month earlier in western Córdoba or southern Santa Fé than in southern Buenos Aires. Water availability is especially important for grain sorghum planting in the northwest due to drought risk and high evapotranspiration. The crop variety planted, long-cycle or short-cycle, is dependent on when rainfall occurs in relation to normal planting time. If rains arrive late, a short-cycle variety is planted, so as to avoid the danger of occasional frost at harvest time. In southern Buenos Aires planting time is both precipitation driven (because of dryness) and temperature driven because of higher latitude. Soybean planting times are not only strongly influenced by weather but are also dependent on double cropping practices since normally about 75% of all soybeans grown are double-cropped with wheat in southern Santa Fé, eastern Córdoba and northern Buenos Aires. Single-crop soybeans grown are usually planted several weeks earlier.

5.3 ROW WIDTH

Information on row width and plant density in the AgRISTARS study area was obtained for seven crops, all of which are important to the agronomic understanding task. These crops include corn, forage sorghum, grain sorghum, peanuts, soybeans, sunflower and wheat. Of these, sorghum (both types) and corn are potential confusion crops in Córdoba and Santa Fé and to a lesser extent in Buenos Aires. Also peanuts and soybeans could be potential confusion crops in central Córdoba. The row width, plant spacing and plant density of the seven crops is shown in Table 3.

TABLE 3. AVAILABLE INFORMATION ON ROW WIDTH, SPACING AND DENSITY OF CROPS IN AgRISTARS STUDY ZONE

Crop	Row Width	Spacing Between Plants in Row	Density
Corn	70 cm	4 seeds per linear meter	---
Forage Sorghum	15-20 cm, 30 cm in drier areas	Irregular	14-15 kg of seed per hectare, 1,000 seeds = 25-30 grams
Grain Sorghum	70 cm	8-15 seeds per linear meter less for long-cycle sorghum	60,000 plants/ hectare
Peanuts	1 meter		100 kg per hectare
Soybeans	70 cm	35 seeds per linear meter	
Sunflower	70 cm	2 seeds per linear meter	
Wheat	15 cm		100-120 kg per hectare, 250-300 plants per m^2

Source: Information provided by Engineer Agronomist Claudio A. Fonda, Agricultural Estimates Section, Ministry of Agriculture and Livestock Raising, Buenos Aires.

5.4 CORN VARIETIES PLANTED

Most of the corn planted in the AgRISTARS study zone (northern Buenos Aires, southern Córdoba and southern Santa Fé) is flint corn rather than dent corn which is common in the United States. Argentine exports of flint corn to western Europe for the 1980 market year were primarily for poultry feed in the Netherlands, Italy, and Spain. In 1981 Argentine dent corn was also sold to Brazil to supply that country's burgeoning poultry industry. Flint corn now being exported to the USSR is ostensibly for both poultry and livestock feed.

Most corn varieties used in Argentina are variants of corns that are adapted to local conditions. However, improved varieties and hybrids have been developed in recent years in Argentina, some of them by multinational grain companies. Both flint and dent corn hybrids have been developed by commercial companies and are now being marketed. Table 4 shows the common varieties or hybrids planted in Argentina.

5.5 SOYBEAN VARIETIES PLANTED

Both single crop and double crop soybeans are grown in Argentina, the latter being double cropped with wheat. Planting dates are different for single crop and double crop soybeans. Normally first crop (single crop) soybeans are in the pre-harvesting stage in March while second crop (double cropped) soybeans are in the podding or grain-forming stage. In the 1979/80 crop year about 65%-75% of the soybeans grown in Argentina were double-cropped, while 85%-90% of the nation's soybeans were double cropped in the 1980/81 crop year [25].

Climatically, agro-ecological conditions in the Argentina soybean zone are roughly analogous to the lower Mississippi Valley in the United States except annual precipitation tends to be somewhat less.

TABLE 4. COMMON CORN VARIETIES OR HYBRIDS PLANTED IN ARGENTINA

FLINT CORN (A-2-1)

Cargill:	Record 110, Record 111, Record 120, Record 140, Record 150; T80, T81, T82; Prêcoz 8, Prêcoz 10; Trópico 220
Dekalb:	4F31, 4F32, 4F33, 4F34, 4F35
Morgan:	300, 400, Triunfador, Puntero, Morgan 52
Northrup King:	Norkin Fierro, Norkin Troja, Norkin Zea
INTA:	Abati, Irupe
Continental:	Contiplata, Contioro, Contiplus, Contimax, Contigran

DENT CORN (A-2-2)

Cargill:	360

SEMI-DENT CORN (A-2-3)

Cargill:	Semident

Source: Information provided by Mr. Hosea F. Harkness, Vice-President, Sparks Commodities, Inc., Memphis, Tennessee.

As a result, the first soybean varieties in Argentina were varieties used in northern Mississippi and Tennessee that were subsequently modified and adapted for local conditions. The chief varieties of soybeans planted in Argentina are shown in Table 5.

A key issue on soybean varieties planted is the total amount of daylight required for the plant to mature in a manner that will guarantee maximum yields since the plant is extremely photosensitive. If the daily photo period is too short for the variety the plant will flower early thereby reducing yields. By the same token, if the photo period is too long the crop will begin to flower late, likewise reducing yields. When the variety planted is adapted for local latitudinal conditions, the plant reaches maturity and flowers at the optimum time which assures higher yields [26].

The location of the main Argentina corn-soybean zone (33°S to 35°S) is latitudinally equivalent to that of production areas in North Carolina, Tennessee and Mississippi (33°N to 36°N). Argentine hybrids of such U.S. soybean varieties as Bragg and Davis have consequently been widely accepted by farmers in the Humid Pampa. In contrast, higher latitude soybean varieties such as those planted in the U.S. Midwest, would flower too rapidly in Argentina because of the shorter day length. Conversely, low-latitude varieties of soybeans such as those which have now been developed for use in central and even northern Brazil, have extremely short photoperiods and would flower too late in Argentina.

5.6 SORGHUM VARIETIES PLANTED

Grain sorghum varieties planted depend on precipitation patterns for any given year, e.g., early rains, late rains, etc. As a result, short-cycle, medium-cycle and long-cycle hybrids varieties have been developed. Short-cycle grain sorghum is usually planted if rains for

TABLE 5. COMMON SOYBEAN VARIETIES OR HYBRIDS PLANTED IN ARGENTINA

Group III:	Williams Calland
Group IV:	SRF 450
Group V:	Forrest
Group VI:	Halesoy 71; Hood, Hood 75; Bragg; Hale 3; Davis

Source: Information provided by Mr. Hosea F. Harkness, Sparks Commodities, Inc.

plantings are later than usual and when the possibility of occasional frost exists should the harvest be unduly delayed for any reason. This is particularly applicable to the drier, more southerly areas of the Pampa where winters can be more rigorous.

Forage sorghum is also widely planted not only in good soils in Santa Fé province but also in marginal areas with poorer soils. Hybrid forage sorghums also are quite tolerant of the higher temperatures and evapotranspiration found in northern Santa Fé and Córdoba. Table 6 shows the major sorghum hybrids planted.

5.7 WHEAT TYPES PLANTED

Wheat production is rather widely distributed throughout the AgRISTARS study area, but major zones of production can be identified. The most important zone is the southern portion of Buenos Aires province where the crop is often double-cropped with oats. However, wheat is also an important crop in northern Buenos Aires, southern Santa Fé, and eastern Córdoba where it is double-cropped with soybeans. Winter wheat is the main type of wheat planted, while spring wheat production is negligible in most areas since severe winters such as those that occur in the U.S.-Canadian spring wheat belt are not found in Argentina. In general, wheat produced in southwestern Buenos Aires as well as farther northward (northern Buenos Aires, southern Santa Fé and Córdoba) is hard winter wheat used for bread or macaroni, while some semi-hard varieties are used for pastry. However, durum wheat is also grown in southeastern Buenos Aires, an area which is quite humid and relatively cool in summer. Durum wheat, along with cattle-raising and potato cultivation form the crop-livestock base of southeastern Buenos Aires. Durum is used for pasta and has a ready market given the percentage of persons of Italian ancestry in the city of Buenos Aires, Argentina's leading urban center [27].

TABLE 6. COMMON SORGHUM VARIETIES OR HYBRIDS PLANTED IN ARGENTINA

Cargill:	Dupla, Litoral, Traful
Continental:	Baqueano, Cimarron, Espantapájaro, GR111, Overo
Dekalb:	BR64, DA42, DA46, 2DA60, E57A
Funk's:	GA405, GA430 RP, GA431 RD, GA480
Morgan-Pioneer:	B-815, Pioneer 845, Pioneer 989, Pioneer 8311, Pioneer 8440
Northrup-King:	NK180, NK233, NK300, NK308, NK367, Savanna 2, Savanna 3

Source: Information provided by Mr. Hosea F. Harkness, Sparks Commodities, Inc.

At the time of writing the specific varieties of wheat grown are not known. However, this information will be made available at a later date.

5.5 HARVESTING PRACTICES

Large-scale commercial farming operations in Argentina are very advanced by Latin American standards, although mechanization levels are below those of the United States. The harvesting of corn, soybeans, sorghum and wheat, the main commercial crops of Argentina, is highly mechanized in most areas, although manual harvesting is still found in some locales. Mechanized combining is practiced in the major wheat production zones, and tractors and mechanized harvesting equipment is also used in harvesting corn and soybeans. However, harvesting on smaller farms particularly those less than 250 hectares in area was still undertaken using horse-powered equipment in the early 1970's. A major reason for this is the high investment cost necessary to purchase tractors and other farm implements because of high inflation rates. In 1970 there were an estimated 200,000 tractors in the country with an additional 10,000 to 15,000 units being purchased annually [28]. (This number has since increased but the exact number was not known at the time of writing.) Because of the high cost of farm equipment, contract harvesting is particularly important. Producers pay contractors a specified price for harvesting their crop. Although contract harvesting is undertaken for corn, soybeans, and sunflower, it is perhaps most important to wheat producers. Contract harvesting commonly begins in the north where harvesting dates are earliest and then shifts southward as itinerant equipment operators and owners follow the harvest southward. Owners of such contract harvesting firms commonly operate ten to fifteen harvesters. In other cases, farmers rent equipment and harvest the crop themselves [29].

Cotton, which is grown largely in northern Santa Fé and Entre Ríos is a crop whose harvesting remains less mechanized. Likewise, mechanized harvesting of potatoes in southeastern Buenos Aires did not become widely practiced until the late 1970's. Mechanized potato harvesting is undertaken using mainly Argentine-made equipment as imported harvesting equipment does not perform well in potato fields having high weed populations [30].

Contract harvesting to some extent, has roots in the first political era of Juan Perón (1943-55). During that time tenant farmers, often against the wishes of wealthy land owners, were given many new rights including freedom from eviction from their rented properties. Following Perón's downfall large landowners once again gained the right to evict tenant farmers, and some owners rather than having tenants cultivating their fields, chose to job out production to private contractors [31].

5.9 CROP MIXES AND CROP ROTATION

The diversity of crop mixes and crop rotation patterns vary significantly within the study area and are driven by both agro-ecological and market conditions. Five crop mixes and three major rotation patterns comprise the major agricultural scene.

In southwestern Buenos Aires the land is mainly devoted to winter wheat with much of the remaining land left in natural pasture for beef cattle since insufficient rainfall inhibits corn production and excludes soybean cultivation. However, the growing of forage sorghum is of considerable importance and oats, barley and some sunflower are also planted. Areas of pasture also cover much of the area, some of which are weed-infested and some of which are well-tended. In addition, the botanical composition of pasture lands is quite diverse and includes small field plantings of moha (Setaria italica) a hay-like plant, flor amarilla (Diplotaxis tenuifolia) a yellowed-flowered weed which infests numerous pasture lands and that is not eaten by cattle, and pasto llorón (Iragrostis curvula) which is sometimes planted as an erosion control measure. Crop rotation patterns vary to some degree in the zone depending on farmer preference, however, unimproved natural pasture/winter-wheat/unimproved natural pasture/winter-wheat rotation is common. A second common practice is the planting of oats (for pasture) over wheat stubble, and then subsequent planting of wheat. Fields left in pasture one year are thus planted in wheat in the following year with the planting being alternated between fields each year. Also, sunflower and barley rather than oats are occasionally planted following the harvest of winter wheat.

In southeastern Buenos Aires the crop mix is considerably different. Total annual precipitation is nearly double that of southwestern Buenos Aires and relative humidity is much higher. In addition, the soils of southeastern Buenos Aires are very high in organic matter and are among the most productive in Argentina, but poor drainage and salinity are problems in some locales. Durum wheat, potatoes and pasture (alfalfa) used for livestock-raising, rather than fattening, dominate the scene. Also, potato production is favored by the cool, moist climate, but such conditions discourage the production of corn and soybeans despite rich soils. The growing of rye and barley is also of some importance. In southeastern Buenos Aires, potatoes are normally planted for two years followed by the planting of wheat, and then oats. Following these plantings, the field is normally left in natural pasture for three years.

The corn/soybean zone of the Humid Pampa is considerably different from the U.S. Corn Belt in terms of crop mix and agricultural practices. Although corn and soybean production dominates in both areas, some notable differences exist. Winter wheat production is of greater importance in the Argentine corn/soybean zone. Also, unlike the Corn Belt, the growing of grain sorghum, sunflower and flax is collectively important. Furthermore, the Argentine corn/soybean zone is a crop-beef livestock production complex rather than agricultural complex in which livestock production, although important, is secondary. In Argentina a much greater percentage of the land is devoted to beef livestock production within the corn/soybean zone (±40%) and average property size is larger, often exceeding 500 hectares. Beef cattle productivity varies widely in the zone depending on pasture improvements made by landowners. Animal carrying capacity on pastures can vary from 0.5 animals on poor pastures to three to four animals per hectare on improved grazing lands [32].

The Humid Pampa zone is the traditional breadbasket of Argentina and today retains its importance because of location, rich soil, adequate and dependable rainfall, and infrastructure development. Likewise, crop mix is influenced to a greater extent by market considerations, and less by environmental conditions than elsewhere in the AgRISTARS study area. Crop mix tends to change considerably from year to year depending on the market price of crops, nearly all of which can be produced in the zone. Land use competition between crops triggered by the farmer's desire to maximize profits and reduce costs, sharply contrast with such areas as southwestern Buenos Aires or the extreme north where the type of crop that can be grown is limited by insufficient rainfall or high evapotranspiration rates, respectively.

Several agricultural practices including crop rotation patterns, deserve mention. In some areas of the Humid Pampa, including the main corn/soybean zone (Zones 9 and 10), wheat and alfalfa are intercropped in the same field. Planted wheat is mature after about 125 days following the harvest, the alfalfa is left for beef cattle pasture. Two major rotation patterns are also practiced. In many cases, fields may remain in pasture for five or six years after which time a row crop is planted such as corn, grain sorghum, or soybeans. Should single-crop soybeans be planted, the land would revert to a fallow condition following harvest. In cases where second-crop soybeans are planted, winter wheat is sown in the field following the soybean harvest. After one or two years of row crops the land would be left to pasture once again and an adjacent field planted in row crops. A second rotation pattern is the planting of corn, followed by rye, and then corn once again, after which time alfalfa is planted for three years. This practice is a continuation of time-honored rotation schemes whereby alfalfa replaces the nitrogen in the soil. However, alfalfa also lowers soil moisture and rye is planted to compensate for this loss; perhaps prior to planting corn once again. No fixed or rigid rotation pattern is in effect in the Humid Pampa since rotation patterns and the decision of farmers to rotate crops depends on weather and market considerations. Given Argentina's current inflationary problems and the rapidly changing export crop situation from year to year, substantial fluctuation in planted area and production of corn, soybeans, wheat, and sorghum can be expected [33].

The crop mix in the northern part of the AgRISTARS study area, like southwestern Buenos Aires, is largely governed by moisture shortages. In northern Córdoba and Santa Fé the crop mix is much less complex than in the Humid Pampa. Rural land use is dominated mainly by forage sorghum plantings and pasture since insufficient moisture precludes profitable production of corn or soybeans. In this area, land is often left in unimproved pasture for several years after which time forage sorghum may be planted.

Much of the Subhumid Pampa immediately northwest of the Humid Pampa, as well as zones situated between the Humid Pampa and the dry north of Santa Fé and Córdoba, is transitional in terms of crop mix. Corn, forage sorghum, and pasture are main crop-livestock land uses but soybeans are increasingly being planted in this zone. Reliable information on rotation patterns is not available but the planting of row crops on fields that were left in pasture for several years would seem to be a likely practice.

5.10 IRRIGATION

Little in the way of irrigation is practiced in the AgRISTARS study area; even where pronounced moisture deficiencies exist such as in southwestern Buenos Aires, or where evapotranspiration rates are high such as in northern Santa Fé and Córdoba. About 6% of Argentina's crop production is irrigated but this is confined to sugarcane production in the northwestern part of the country (Salta, Tucumán, Jujuy provinces); grape, fruit and vegetable production in the far west (Mendoza province), and apple and pear production in northern Patagonia (Neugués and Río Negro provinces) [34]. A major reason for the lack of irrigated agriculture in the drier parts of the AgRISTARS study zone is that the cost of such systems exceeds benefits given the extremely high costs of farm inputs in the country. As an alternative, farmers continue to plant corn, soybeans (most of which are double-cropped with wheat), and grain sorghum in areas of sufficient rainfall that is well distributed throughout the year. Where drought risk exists, wheat, forage sorghum, and oats, as well as the presence of unimproved natural pasture constitutes the crop-livestock land use scene.

5.11 FERTILIZER USE

Fertilizer use in the AgRISTARS study area has traditionally not been an important input considering the importance of agriculture in Argentina's economy. Argentine farmers historically have used crop rotation schemes to replenish nitrogen and phosphorous in the soil (many areas are naturally deficient in these nutrients) rather than using fertilizer to increase soil nutrients and increase yields. To a great extent this was possible given the high organic content and fertility of soils in the Pampa, especially those of the Humid Pampa in northern and southeastern Buenos Aires. However, the application of fertilizer for wheat production elsewhere in the Pampa is of some importance, particularly in those areas where soils are marginally productive.

Secondly, fertilizer prices as well as those of herbicides and pesticides have increased much more rapidly than farm income due to inflation. Small-scale farmers are most adversely affected by these high input costs and often find it economically unfeasible to apply the necessary amount of fertilizer, even though it may be needed. Agrarian tradition, rich, fertile soils and the high cost of fertilizer have thus kept fertilizer use to a minimum. As a result, Argentina in 1971 was the third lowest consumer of fertilizer in Latin America although usage is now increasing due to government efforts to reduce fertilizer prices [35]. In contrast, fertilizer consumption in Brazil, the other leading agricultural country of South America, is much greater due partly to poorer soils, lower inflation and more government support to the fertilizer industry.

5.12 WEED CONTROL

Weed control in much of the Pampa is not practiced to a great degree. During the ERIM/UCB Consortium ground truthing inventory in

February 1981, numerous weed-infested forage sorghum and pasture fields were noted in many of the sample segments visited, including those in central Santa Fé and northern Córdoba. Farther south in northern Buenos Aires, high weed populations were also observed in some corn and soybean fields. In southwestern Buenos Aires weed-filled pastures and sorghum fields were also noted, although oat plantings over winter wheat stubble were generally free of weeds. Johnson grass, in particular, is a nuisance plant that was often noted growing in northern Córdoba and Santa Fé. Observed populations of Johnson grass in these areas were commonly six feet or more in height and plant density was sufficiently high as to make distinction with forage sorghum difficult upon first notice. In addition, Johnson grass was observed in northern Buenos Aires and also occurs elsewhere throughout the study area. In southern Buenos Aires unimproved pasture with thistle was commonly seen as was flor amarilla, the latter of which reduces the carrying capacity of beef cattle pastures since it is disliked by cattle [36]. As previously noted, the high organic content of Pampa soils also encourages weed proliferation. Moreover, during periods of heavy rain prior to harvest, clay soils in the north can become plastic and weeding of fields can become an extremely difficult task. A third reason for the high weed population which is perhaps the most important factor is that many Argentine farmers do not believe that weeding is worth the time, effort and money expended, although crop yields in the case of coarse grains and soybeans are lowered. In crop year 1979/80 coarse grain yields in Argentina were 2.2 metric tons/ha compared with 5.71 metric tons/ha for the United States. In that same year soybean yields in Argentina were 1.8 metric tons/ha compared with 2.16 metric tons/ha in the U.S. [37].

5.13 LIVESTOCK GRAZING

One livestock management practice is worthy of note. Beef cattle, in addition to being pastured on unimproved pasture and alfalfa, are also often permitted to graze in forage sorghum fields. This reduces the amount of sorghum that is cut for silage and partially alleviates the need for silage storage facilities which are in short supply in Argentina. Although "grass-fed beef" is the rule in Argentina, cattle are sometimes also turned loose in corn fields not slated for harvest. Fields of barley, oats and rye are also sometimes used for cattle feed and are either harvested or more often left as grazing forage.

During periods of severe drought or seasonal flooding 20%-30% percent of cattle forage crops such as sorghum are sometimes lost. As an emergency measure, oats may be planted in fields originally destined for other types of crops (in some cases, corn), so as to provide ground forage for livestock. Such unforeseen shifts in land use due to episodal events are quite common in the poorly drained areas of the Pampa, and along the western margin where drought risk is greatest.

6
THE ARGENTINE AGRICULTURAL ECONOMY

The Argentine agricultural economy in 1980 and 1981 was and continues to be dominated by three major factors: unfavorable weather in some producing areas, the national economy including severe inflation and associated government measures to remedy it, and the partial grains embargo imposed on the Soviet Union in January 1980 by the United States which prompted a new Argentina-USSR bilateral trade agreement. Although the "embargo" was lifted in early 1981 the effects still remain to a great extent.

6.1 WEATHER

Much of the four-province AgRISTARS study zone was affected by drought in the early part of 1980. Conditions were particularly adverse in the nation's major corn, sorghum, and soybean production zones. Specific zones affected including the major corn cultivation zone in northern Buenos Aires province, as well as adjacent production zones in adjacent sections of the provinces of Santa Fé and Córdoba. The main soybean production zone centered in southern Santa Fé was likewise affected as were producing areas in southeastern Córdoba and northern Buenos Aires. This period of drought was followed by excessive rain in these same areas in May 1980. Widespread flooding resulted and damage to crops and fields as well as livestock, had a detrimental effect on production. Also, Argentina's major wheat production areas, particularly the important zone in southern Buenos Aires, was hit by drought in August 1980 resulting in substantial reductions in the wheat crop [38].

In early 1981 adverse weather again had a negative impact on some crops, particularly cotton. The northern part of Córdoba and Santa Fé provinces, a major cotton zone, suffered serious flooding as a result of heavy rains in January and February. However, lesser amounts of rain proved beneficial to single-crop soybeans then in the pre-harvest stage and double-crop soybeans (planted in conjunction with wheat), then in the grain formation stage. March weather was favorable but heavy rains in the same area in April and May delayed the harvest of corn, soybeans, and sorghum and some quality problems with soybeans developed. Nevertheless, the corn/soybean harvest was expected to be reasonably good, and this same rainfall proved beneficial for fields being prepared for wheat planting in June [39].

6.2 ECONOMIC CONDITIONS

The most severe problem that continues to face farmers and the nation as a whole is the severe rate of inflation which, while lower than previous years, nevertheless reached 125% in late 1981 [40]. Despite government attempts to control inflation through frequent devaluations of the Argentine peso, the peso remains overvalued at the time of writing. Argentine currency was devalued by 10% in early February followed by 30% devaluations in early April and June, respectively, a subsequent 6% devaluation in June, and additional devaluations during the second half of 1981. In addition, small devaluations were made at interim dates during the first half of 1981 [41]. The result is that Argentine agricultural exports which comprise about 75% of the nation's exports are less competitive in world markets [42]. Included among these export crops are sorghum, soybeans, corn, and wheat, Argentina's chief commercial crops. A second effect of the overvalued peso has been the creation of an import market since goods from abroad are often cheaper than domestically produced products. Some foodstuffs are also now being imported for the same reason, even though Argentina has the capability to be essentially self-sufficient in food production. Coupled with the overvalued peso are the high production costs farmers must bear because of inflation. The price of farm equipment, fertilizer, and insecticides along with other inputs which are normally required to increase crop yields, total production and farm efficiency, continues to greatly increase to the extent that many farmers opt for lower productivity using more traditional farming methods in order to reduce production costs.

The government of Argentina is acutely aware of this problem and its adverse effects, especially as they apply to the agricultural sector of the economy. In 1979 and 1980 the Argentine government established export rebates for specific crops (including soybeans) whose export was deemed critical to the country's economy. Farmers growing these crops were reimbursed a certain percentage of their production costs in the form of a rebate so as to guarantee sufficient production to meet export demand [43]. However valuable the measure was for farmers, it was nevertheless inflationary. In an attempt to counter the inflationary effect of the export rebate the government on April 1, 1981 reluctantly instituted (1) an export tax for all oilseeds except peanuts that was to be gradually eliminated by May 1982, (2) the 10% export rebate on peanuts for human consumption was eliminated and replaced by a 2% export tax, (3) a 10% export tax on all oilseed meals except soybeans was instituted and the 10% export rebate eliminated. However, on April 15, the government was able to eliminate the new 2% tax on peanuts and replaced it with a 7% rebate. Also, the export tax on peanuts for crush was eliminated [44].

Such changes in agricultural policy reflect the economic dilemma which now faces both economic planners and farmers in Argentina. Devaluation of the peso was understood to make Argentine exports more competitive and to guarantee better markets abroad for Argentine corn, sorghum, wheat, and soybean producers. Yet devaluation necessitated export rebates to cover higher production costs which were in turn replaced by export taxes. Thus, economic measures and countermeasures have both been instituted by the Argentine government in an effort to help farmers, but only with partial success.

The Argentine government has also attempted to stimulate agricultural production with credits paid to farmers for growing specific crops and is making money available in the form of farm loans. In May 1981 the government announced that loans would be made available to grain and oilseed producers to stimulate increased plantings. The loans can defray up to 100% of production costs provided the farmers maintain their planted areas of grain or oilseeds. Five-year loans with a two-year grace period would also be available to ranchers in order to guarantee the viability of the livestock sector of the economy [45] addition; about that same time, the Argentine government through the Ministry of Economy announced that some farm loans would be refinanced to assist crop-livestock producers.

6.3 CROP MARKETING/EXPORTS

Argentina has traditionally been an exporter of beef, corn, and wheat and more recently soybeans and sorghum. To a great extent, these products have been competitive with those of the United States on the world market. The partial grains embargo imposed on the Soviet Union by the United States in January 1980 had and continues to have a decided effect stimulated on Argentina's agricultural export trade even though the embargo was repealed in early 1981 by the new Reagan administration. Argentina chose not to participate in the embargo and the Soviet Union now is the major customer for Argentine grains. In addition, Argentina has been expanding its agricultural exports to other countries including the People's Republic of China and Mexico, in addition to its traditional customers such as Spain, Italy, the Netherlands and Japan.

Of greatest importance is the bilateral export agreement between Argentina and the Soviet Union that was signed in July 1980 covering the period from 1980 to 1985. In that agreement Argentina indicated its intent of annually selling the Soviets three million metric tons of corn, 2.4 million metric tons of wheat, one million metric tons of sorghum and 500,000 metric tons of soybeans [46]. Moreover beef exports to the USSR will increase following a 1981 agreement which should boost the livestock sector. A second agreement with the People's Republic of China was concluded in August 1980. This bilateral agreement is in effect from January 1981 through December 1984 and actually represents an extension of an existing three-year agreement which will expire December 31, 1981. The new agreement calls for the annual sale of one million to 1.5 million metric tons of corn, soybeans, and wheat to the PRC. The previous agreement called for annual purchases of wheat and corn from 800,000 to 1,000,000 tons. Thus, the agreement represents a significant increase [47].

An agreement with Mexico was also signed in August 1980 for the 1981-82 calendar year which will involve annual sales of one million tons of corn, soybeans, sorghum and sunflowe seed [48]. In addition, trade has expanded with Iraq (grain), Iran (beef), and Brazil (wheat). In total, Argentina intends to export over six million tons of grain in 1981.

The new trade agreements should bolster Argentina's markets abroad and be beneficial to the agricultural sector. Given recent USSR wheat production shortfalls, Argentine grain shipments to the Soviet Union are particularly significant. Also, corn exports to Spain, Italy and Japan, and soybean shipments to the Netherlands have now been augmented by even larger exports to the USSR. The latter nation also purchases much of Argentina's sorghum which was originally destined for Japan prior to the 1980 Argentine/Soviet bilateral trade agreement.

7
CONCLUSIONS

Significant differences exist between the Argentina Indicator Region and the U.S. Corn Belt and these differences are especially notable in the corn/soybean zone of the Humid Pampa. A milder climate, a more varied crop mix, a somewhat more complex agricultural land use pattern and distinct agronomic practices differentiate the Argentina Indicator Region from its U.S. Corn Belt counterpart. Also, the Argentina corn/soybean zone is geographically smaller than the Corn Belt and in fact comprises only about one-sixth of the Argentina Indicator Region in terms of area. Moreover, the percentage of land devoted to beef cattle pasture even in the most intensively cultivated areas is much higher than in the Corn Belt. The Argentina Indicator Region likewise differs from the Corn Belt in terms of planting and harvesting dates, farmer agricultural land use decisions, crop mix and confusion crops. High weed populations are also characteristic of many fields in the AgRISTARS Argentina study area. Significant differences between Argentina and the United States exist in agricultural practices. In the case of Argentina this includes very low levels of fertilizer consumption and a lower level of agricultural mechanization.

Persons working on corn/soybean area estimation tasks should be aware of such differences if crop area estimation technology is to be successfully applied to Argentina. Of particular importance are those differences that relate to crop mix and agricultural practices. The following factors have important implications for crop area estimation techniques as they relate to Argentina:

(a) Planting and harvesting dates can vary considerably due to episodal events such as heavy rains or drought. This is particularly true in southern Santa Fé and central Buenos Aires. In addition, the longer growing season of the Argentine Pampa, in itself, results in more variable planting and harvesting dates than in the Corn Belt since temperature is less of a constraint.

(b) The area planted to corn in marginally dry areas can be radically affected from year to year as well as through the season due to drought. Conversely, soybeans in more humid areas are subject to water stress during and immediately following periods of heavy rains. In the case of both crops the area harvested can therefore be substantially lower than the area planted as a result of these events.

(c) Agricultural land use shifts may be made on a real time basis by farmers due to sudden changes in market prices. Thus land planted in a specific crop for several years may be abruptly planted in another crop, underscoring the notion that changing land use reflects changing economic conditions. Examples are shifts from oilseeds to grains such as sunflower to corn or sorghum, or single-crop soybeans to corn or vice versa, as a function of market prices.

(d) Sorghum can conceivably be a confusion crop in the transition zone between the Humid and Sub-Humid Pampa where both crops are important. This is most likely to occur along the western and southwestern margin of Zone 9 and the northern margin of Zone 10 (see Map 6). To a lesser extent peanuts and soybeans could be confusion crops in parts of central Córdoba (Zone 6), although most of that area is dominated by sorghum production (see Map 6).

(e) Weed-infested corn and sorghum fields are common throughout much of the Argentina Indicator Region, especially in central Santa Fé, most of Córdoba and parts of southern Buenos Aires. To a lesser degree this is also true of soybeans.

Such factors are of great significance to the AgRISTARS Corn/Soybean Area Estimation Task in that they strongly influence the area devoted to corn and soybean cultivation and must necessarily be included in any area estimation model.

Corn/soybean production is expected to remain a key factor in the Argentine agricultural economy along with wheat and sorghum production. Corn and soybeans continue to be in demand in the world marketplace and Argentina's recently concluded bilateral trade agreements with the Soviet Union, the People's Republic of China and Mexico along with export committments to other countries, would seem to guarantee foreign sales of Argentine crops in the foreseeable future. However, inflation, high production costs and changing market prices must also be faced by Argentine farmers. These factors will ultimately influence the area planted in corn and soybeans as will environmental conditions.

APPENDIX A
CROP CALENDAR INFORMATION FOR CORN AND SOYBEANS

The crop calendars discussed and included in this section were prepared by Mr. Nestor A. Darwich (National Institute for Crop-Livestock Technology - INTA, Balcarce, Argentina) for the Foreign Agricultural Service (FAS) of the U.S. Department of Agriculture (USDA). Minor modification and redrafting of the crop calendars was subsequently undertaken and completed by Mr. Byron L. Wood, Space Sciences Laboratory, University of California at Berkeley.

Corn

Planting time for corn in northwest Buenos Aires, the major corn-growing area in Argentina, is from September 20 to October 20, about one month earlier than for soybeans. Corn normally reaches the tasseling stage from November 20 to January 1. This is followed by the yellowing stage one month later. Harvest generally begins about February 10 and continues to March 10. It is worthy to note that the "yellowing" of winter wheat planed in this same area occurs about mid-October about four weeks prior to tasseling and that the wheat harvest occurs during the "early" yellowing stage of corn.

Planting time for corn in southern Buenos Aires is from September 20 to November 10 later than in the north, due to higher latitude. Tasseling occurs from November 20 to January 20 and the latter part of this period coincides with the winter wheat harvesting period in the south (December 20 to January 10). Yellowing of corn in southern Buenos Aires is from January 1 to February 25. Harvesting begins March 1 and continues to April 10.

Crop calendar dates for southern Santa Fé tend to approximate those of northwestern Buenos Aires but are somewhat earlier due to slightly lower latitude. Planting time is from September 10 to October 10. Tasseling normally occurs from November 1 to December 20, yellowing from December 15 to February 1. Harvest is carried out from February 10 to March 10. Generally the tasseling stage is somewhat more protracted southern Santa Fé than in northwest Buenos Aires. Planting is also slightly earlier, in southern Santa Fé, but the yellowing and harvesting stages coincide. Winter wheat harvest in Santa Fé occurs during tasseling stage of corn.

In northern Santa Fé corn is planted over one month earlier than in southern Santa Fé and about six weeks earlier than in northwestern Buenos Aires. From available information it appears that there are two planting times in northern Santa Fé, that to some extent, are concurrent. One planting time extends from August 1 to September 20, while a second planting period is from August 10 to August 20. It is not known if these two planting regimes are for different types of corn or if they are simply alternative planting dates for the same type of corn.

Tasseling of corn in northern Santa Fé is from October 10 to November 1 followed by yellowing from November 10 to January 1. Harvest follows from January 1 to January 20. As in the case of planting, harvesting is at least one month earlier than in southern Santa Fé or northwestern Buenos Aires.

Córdoba province, Argentina's third-ranking corn producer, has later planting dates than either Santa Fé or Buenos Aires, perhaps due to moisture deficiency. Available data are on the province - wide level thus dates given are averages for the total area rather than north and south. Corn planting in Córdoba is from September 20 to November 5 a somewhat longer planting period (by fifteen days) than in

Buenos Aires or southern Santa Fé and about five days longer than in northern Santa Fé. Tasseling occurs from November 20 to January 1 and yellowing from January 5 to February 20 which is several weeks later than elsewhere in the Argentine "Corn Belt". Harvesting is from February 20 to April 1, three weeks later than elsewhere in the Argentine "Corn Belt". However, harvest of corn in Córdoba occurs about two months later than in northern Santa Fé. One reason is the slightly higher latitude of Córdoba, but this is an incomplete explanation.

Entre Ríos is not a major corn producer and only one AgRISTARS sample segment is located in that province. Available province-level crop calendar data indicate that what corn is produced in Entre Ríos province is planted from September 1 to October 10 about the same as southern Santa Fé. Tasseling occurs from November 1 to December 10, yellowing from December 1 to January 10. Finally, harvesting is from January 1 to February 10. Generally speaking, corn is planted earlier and harvested earlier in the more northerly areas of the Argentine corn zone. This is a function of latitude. However, Córdoba is an exception since planting and harvesting dates average about three to six weeks later than in Santa Fé or Entre Ríos depending on location.

Soybeans

Planting time for soybeans in southern Santa Fé begins about October 1 and continues until December 15. Harvest begins about March 25 and continues until June 10. The region leads Argentina in this summer crop, thus planting dates are especially significant. Moreover, because of mild climate and relatively low latitude as compared to such U.S. sites as Illinois or Iowa, planting is earlier. For analog purposes southern Santa Fé would more closely approximate U.S. production zones in northern Mississippi or Arkansas. Soybeans are planted about thirty to forty days later than corn and are harvested much later (seventy days) later than corn. Both are summer crops but soybeans are much later in terms of crop calendar dates.

Soybeans are not an important crop in northern Santa Fé because of dryness. However, those beans that are planted are put in between September 20 and November 10 about two weeks earlier than in the major production zone farther southward. Likewise, harvest time is about one month earlier, March 5 through May 10. Both planting and harvesting dates are much earlier due to the zone's lower latitude (30°S). Higher evapotranspiration rates exist in the north and moisture deficiency during critical stages of crop growth is more of a problem. Consequently, grain or forage sorghum rather than soybeans, is the major crop in the area.

Soybean crop calendars in Córdoba approximate those of Santa Fé. On a province-wide level planting dates are from October 20 to December 20, about three weeks later than southern Santa Fé and about 35 days later than northern Santa Fé. This may be due to moisture deficiency, but the reason is unclear. However, the harvest dates are comparable to southern Santa Fé (April 1 - June 5). Thus the growth cycle in Córdoba is considerably shorter (for the whole province) than in southern or northern Santa Fé.

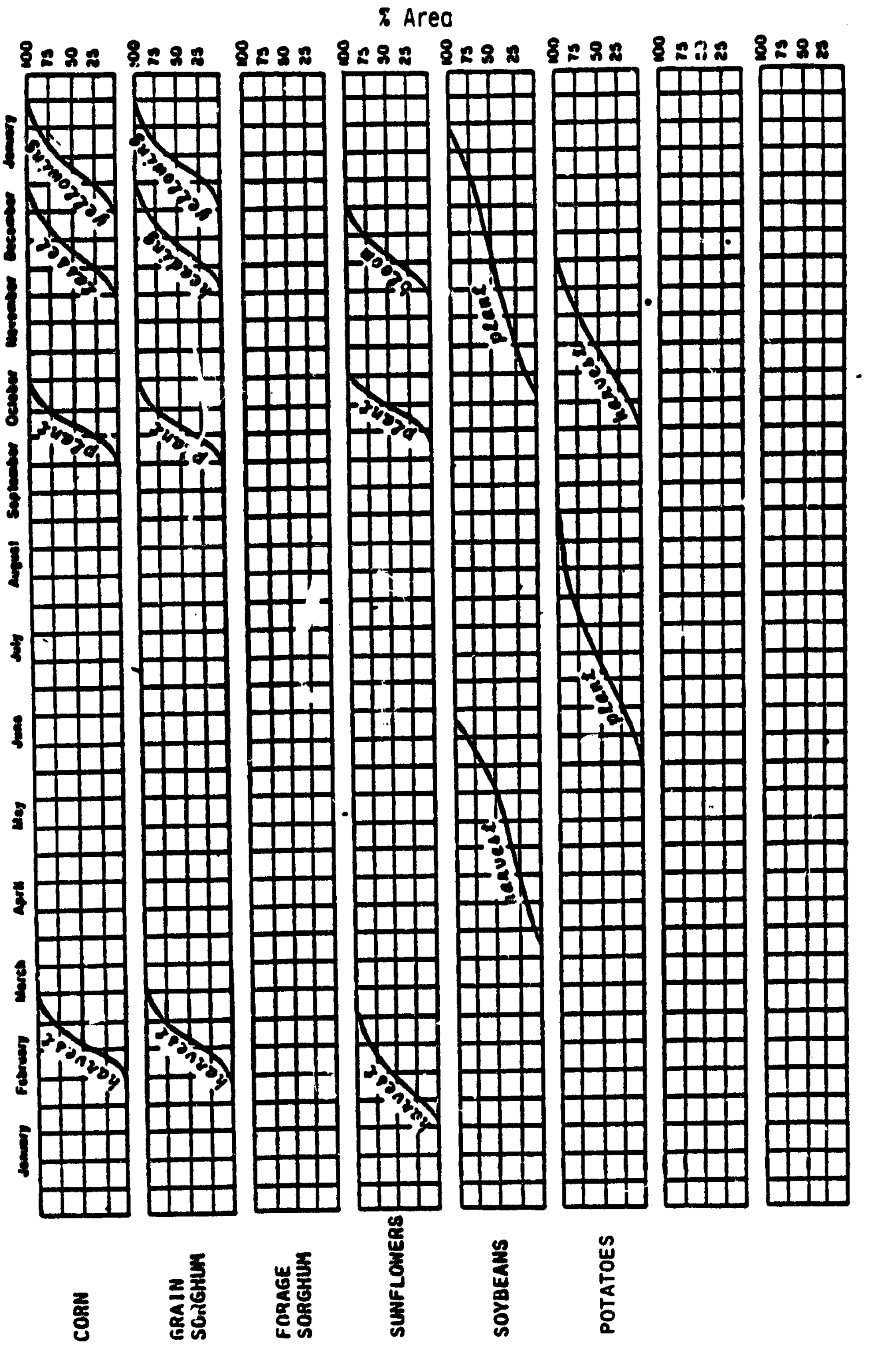
Buenos Aires, the third-ranking soybean producer has crop calendar dates that are different from either Santa Fé or Córdoba. Because of northern Buenos Aires' slightly higher latitude, planting time is about two weeks later, October 15 to January 15, but the harvest time is somewhat longer and extends from March 25 to June 15. Late October and November are key soybean planting times while April and May are principal harvest months for the three-province area which accounts for about 90% of Argentina's soybeans.

Southern Buenos Aires is not a major soybean production zone, but is more important for wheat and winter forage crops. Soybean planting in southern Buenos Aires is much later again due to higher latitude than the regions previously discussed. Planting is from November 15 to January 25, four to six weeks later than the major zone of production in southern Santa Fé, southeast Córdoba or northern Buenos Aires. Harvest is earlier, however, since the winter wheat must be planted beginning June 1. Normally those soybeans that are produced are harvested from March 15 to June 1. Double-cropping of soybeans and winter wheat in the south gives wheat priority and soybeans must be harvested earlier.

In Entre Ríos the planting cycle is about the same as southern Santa Fé but begins ten days later. However, harvest time is slightly earlier. This too, is basically a function of latitude of the production zones in each province. Harvest time for soybeans in Entre Ríos approximates northern Santa Fé.

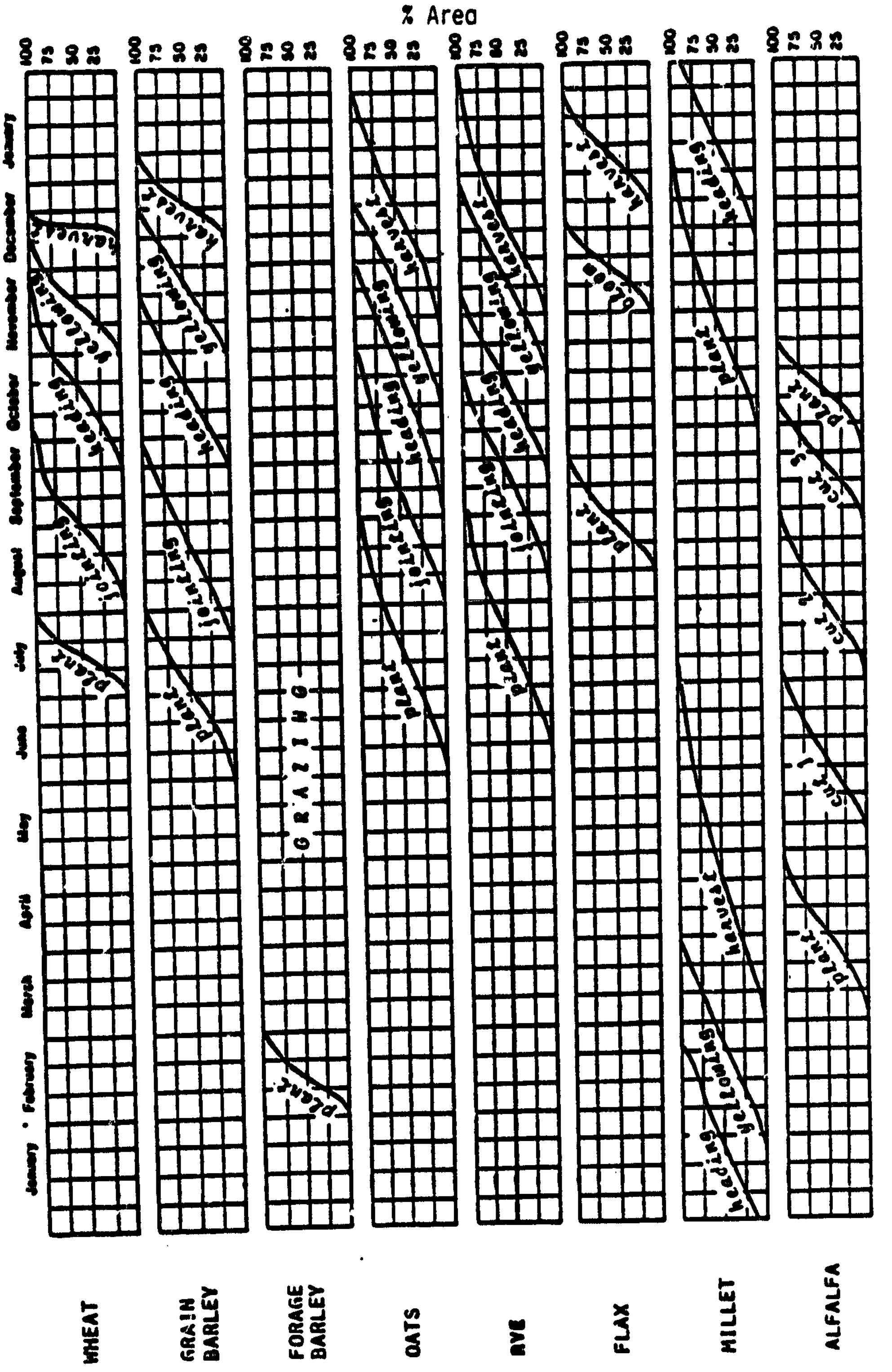
ARGENTINA CROP CALENDARS

BUENOS AIRES - NORTH



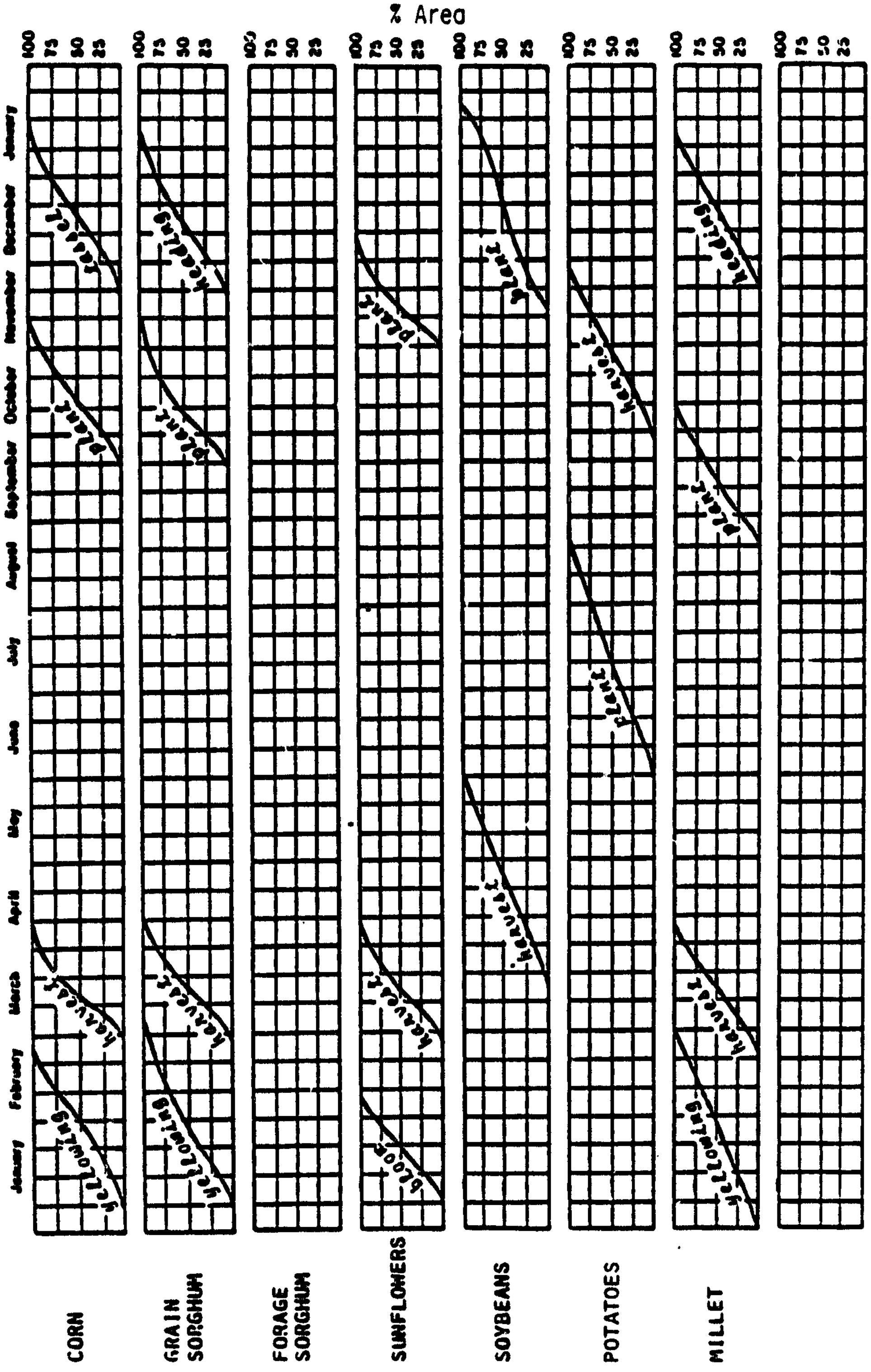
ARGENTINA CROP CALENDARS

BUENOS AIRES - NORTH



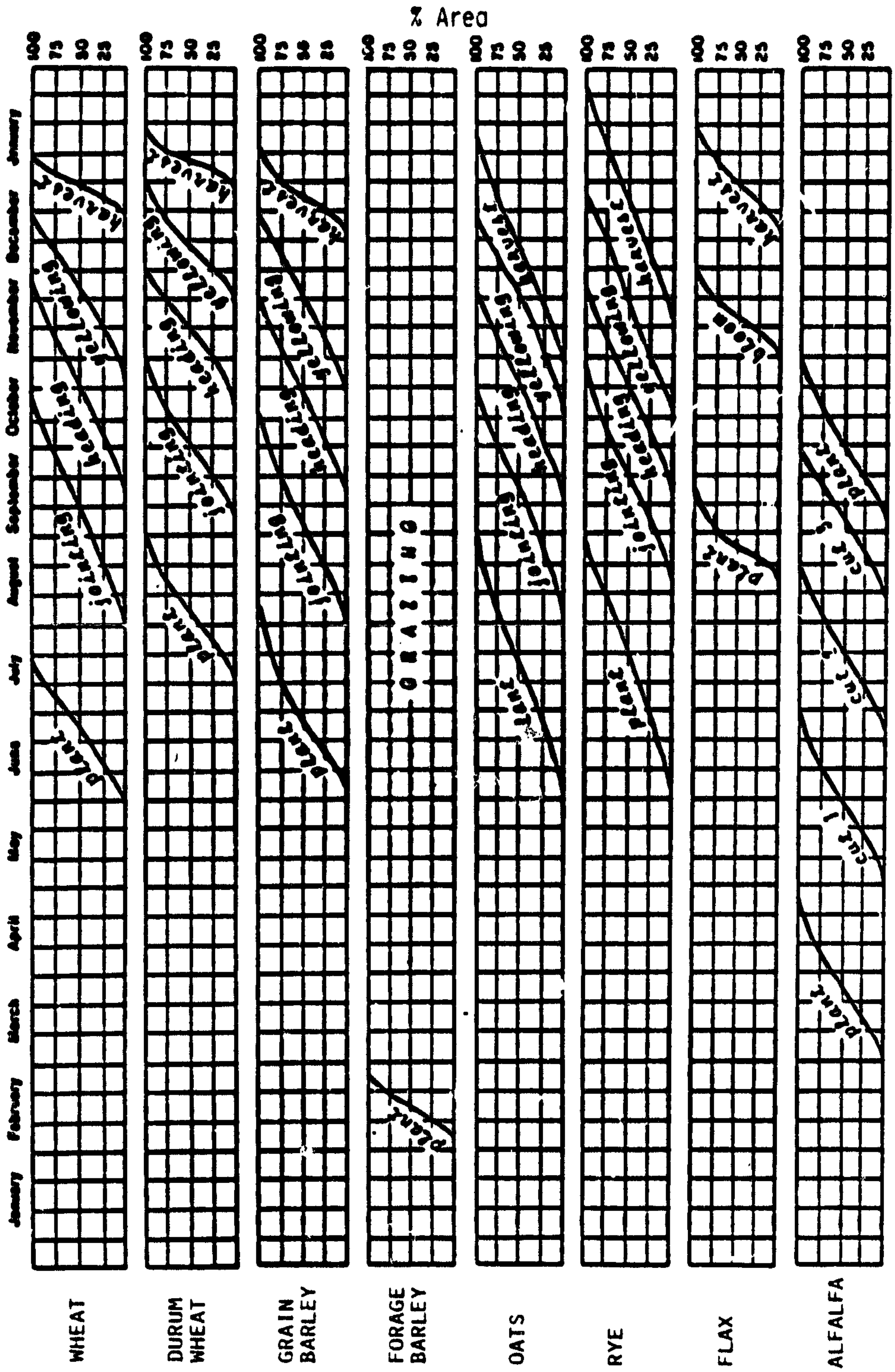
ARGENTINA CROP CALENDARS

BUENOS AIRES - SOUTH



ARGENTINA CROP CALENDARS

BUENOS AIRES - SOUTH



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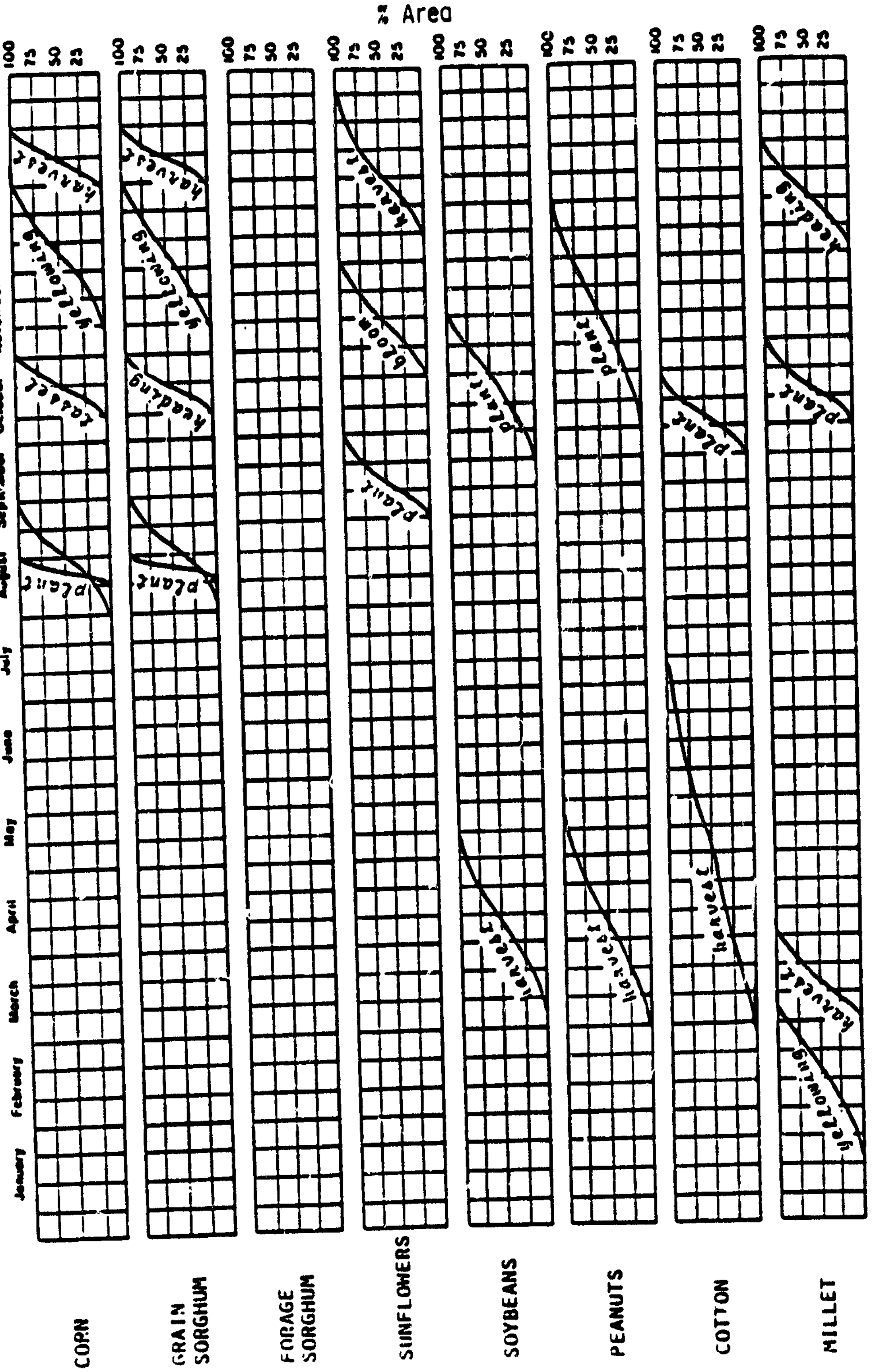
ARGENTINA CROP CALENDARS

SANTA FE - NORTH



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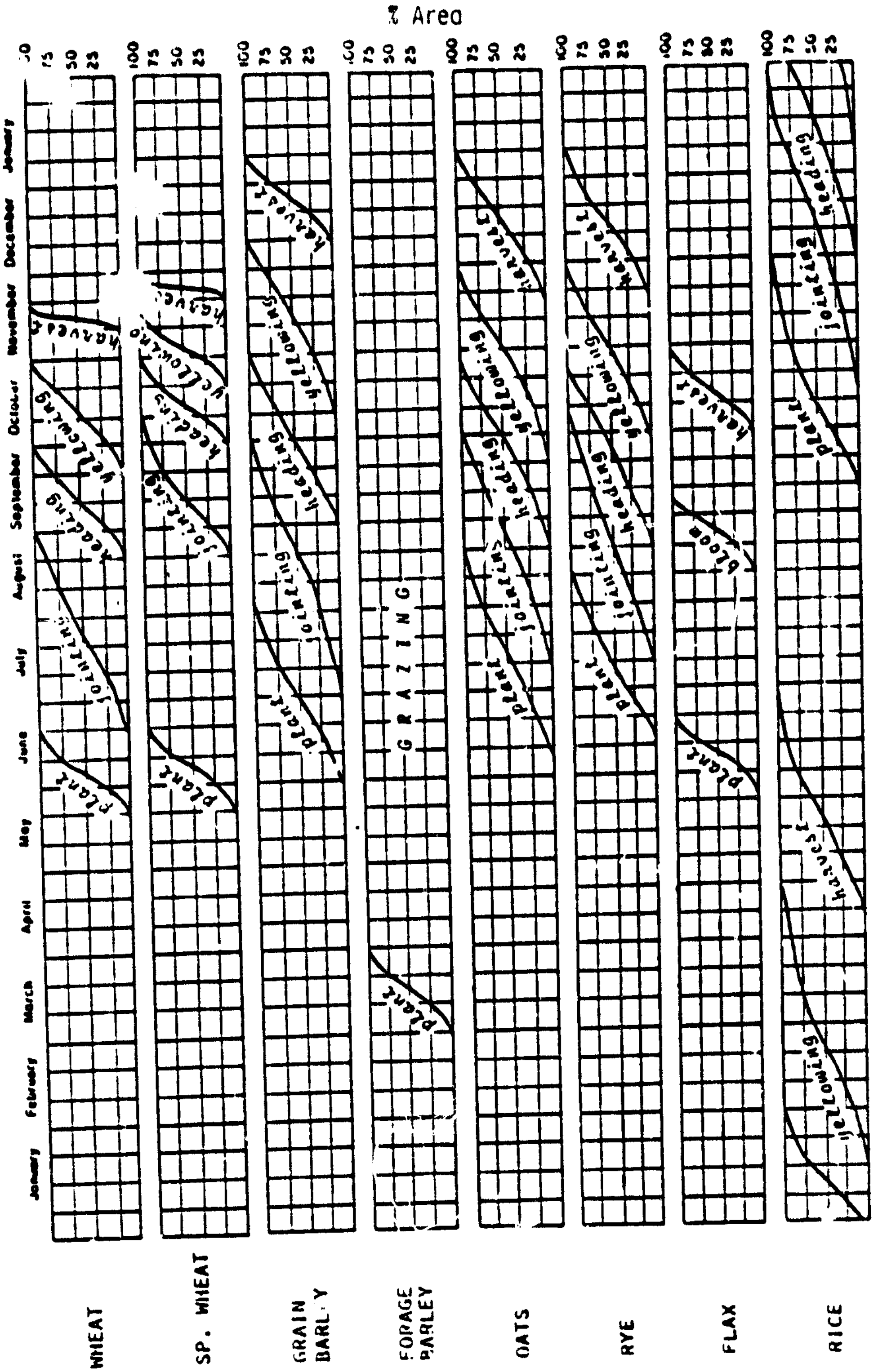
ARGENTINA CROP CALENDARS

SANTA FE - NORTH



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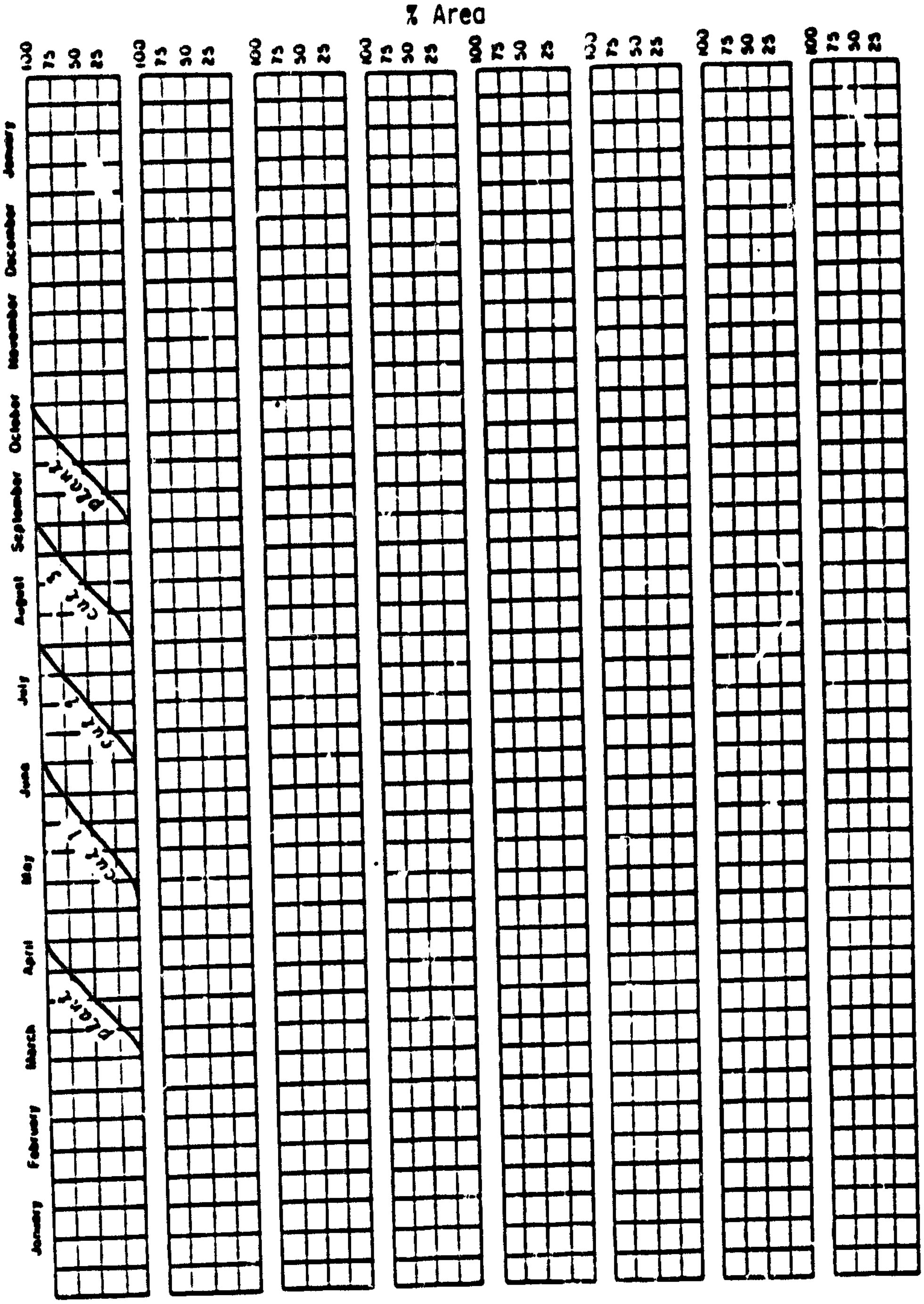


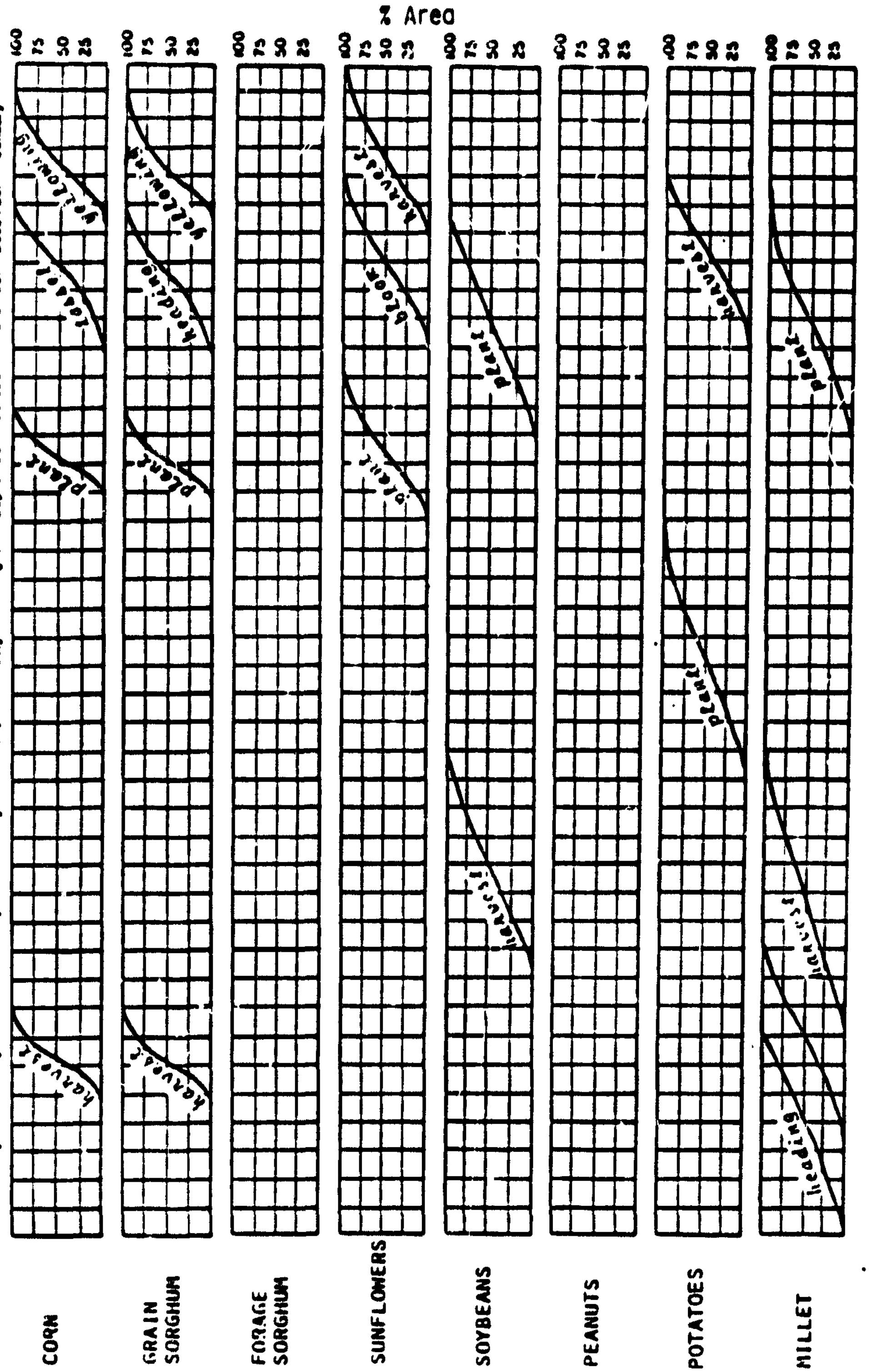
ARGENTINA CROP CALENDARS

SANTA FE - NORTH

ALFALFA

ARGENTINA CROP CALENDARS

SANTA FE - SOUTH



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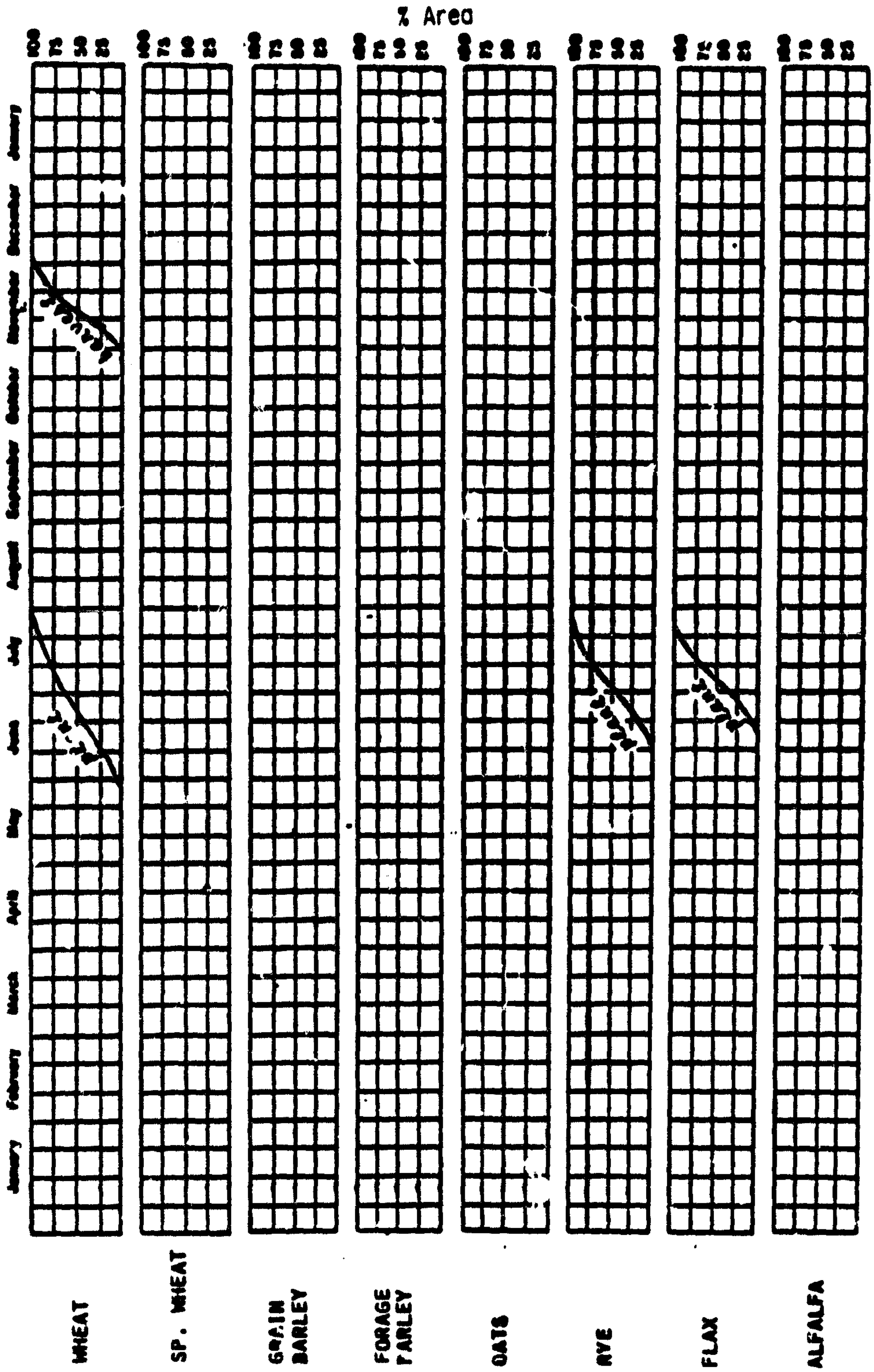
SANTA FE - SOUTH



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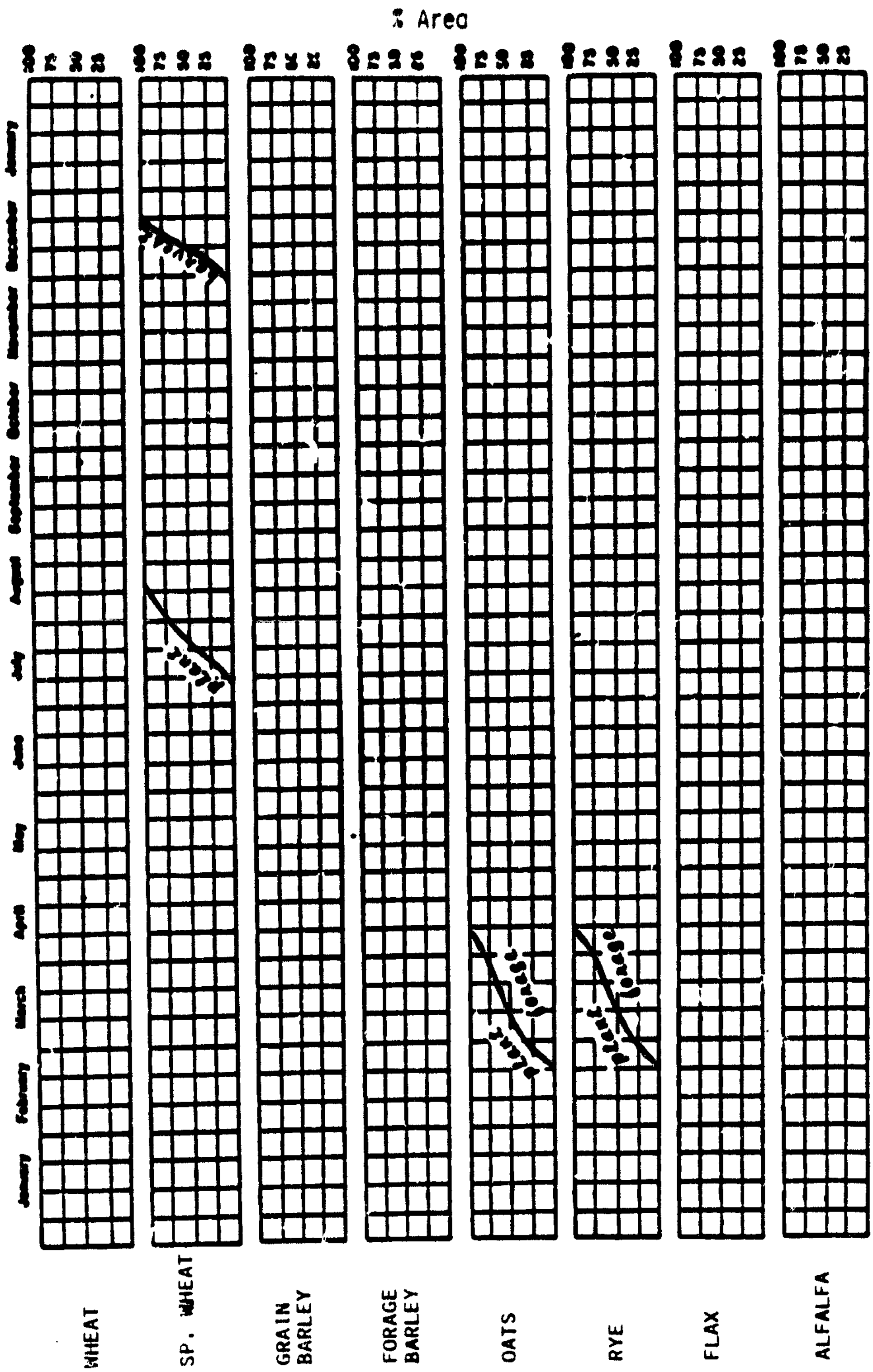
SANTA FE - SOUTH



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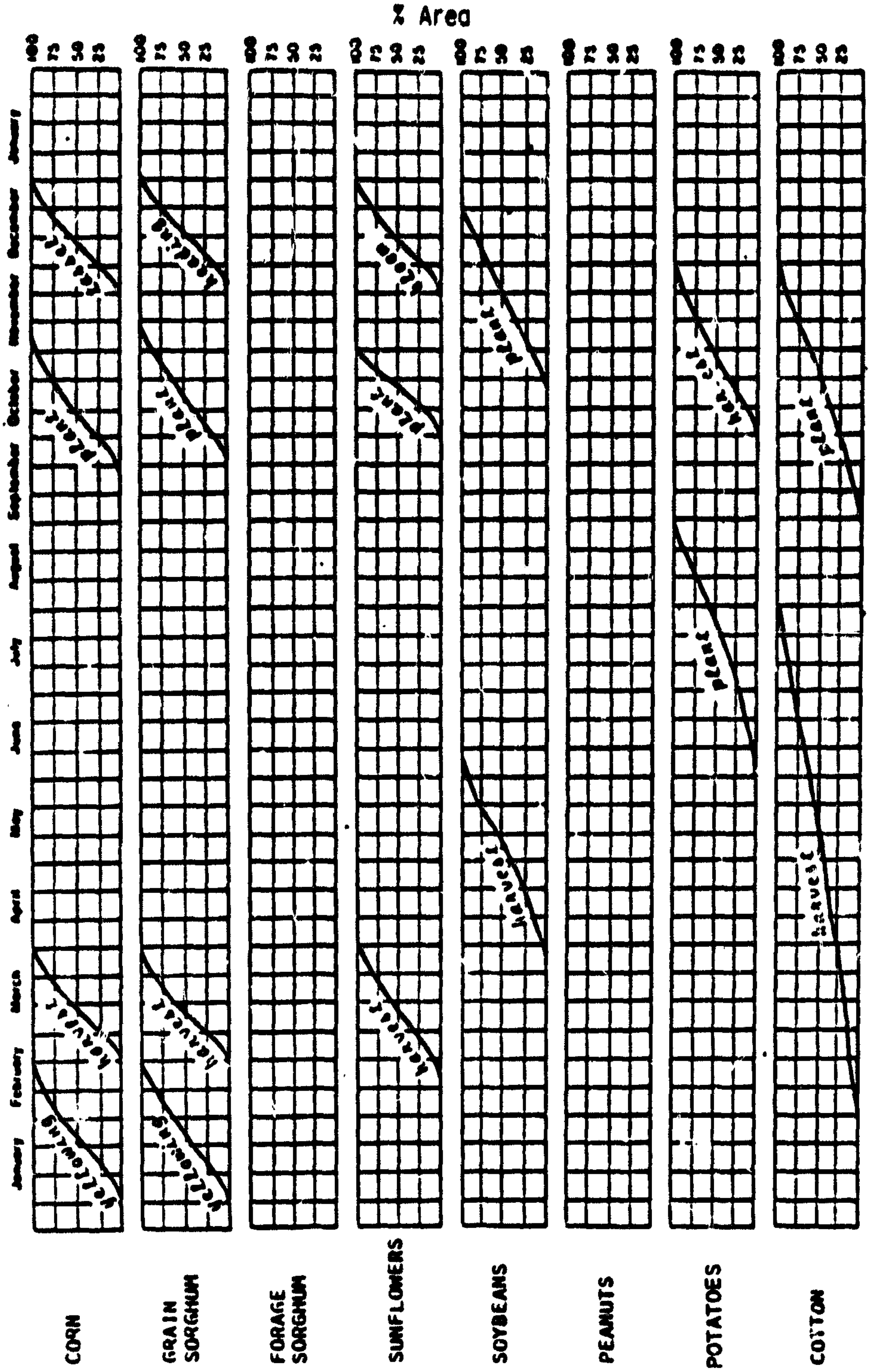
ARGENTINA CROP CALENDARS

CORDOBA



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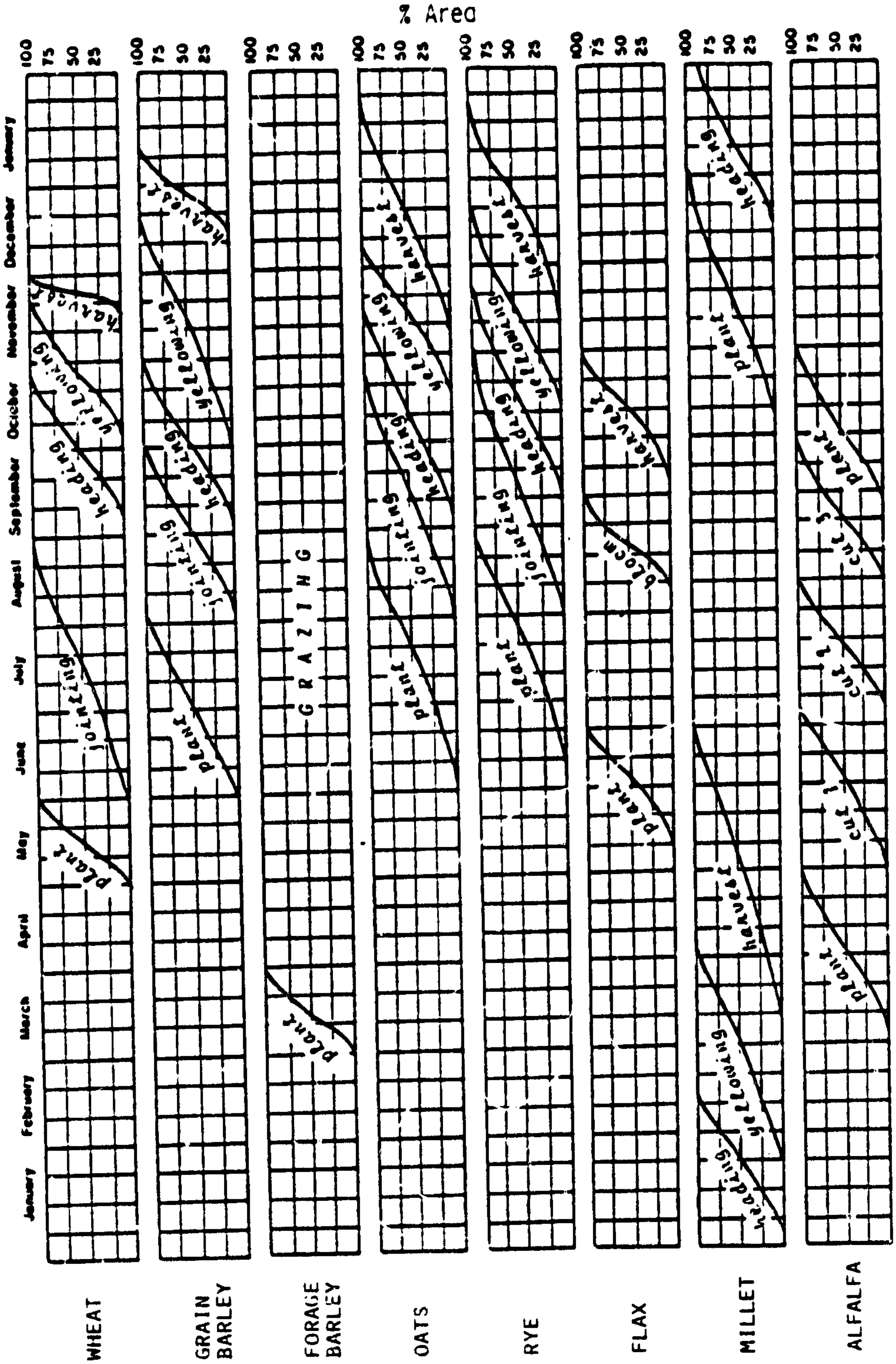
CORDOBA



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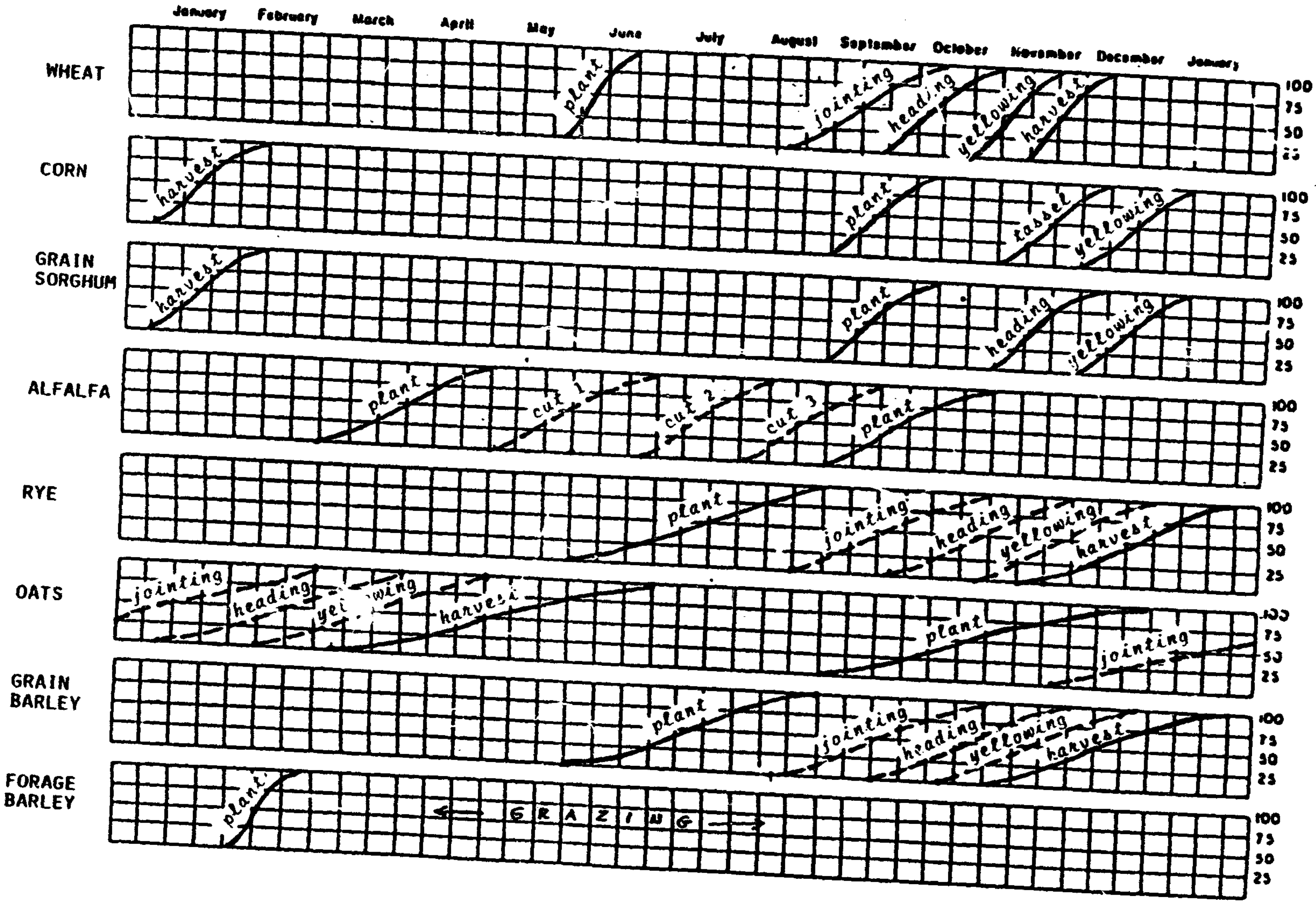
ARGENTINA CROP CALENDARS

ENTRE RIOS



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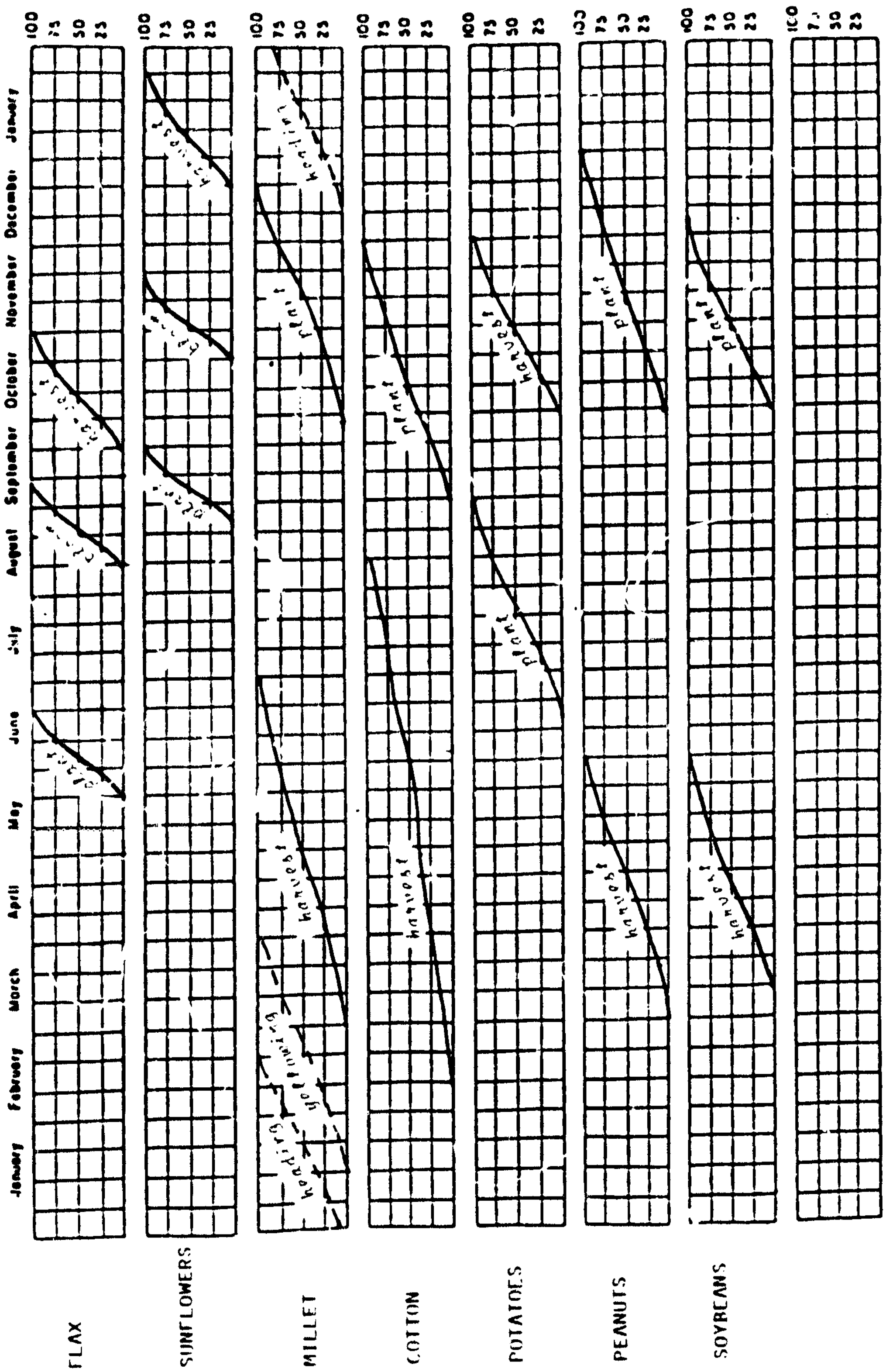
ENTRE RIOS



APPENDIX B

GENERAL SUMMARY OF CROP-LIVESTOCK ZONES IN ARGENTINA

(From: Cartogramas - A series of maps published by the Ministry of Agriculture and Livestock Raising, 1980)

Rice (wet) Corrientes province (immediately north of Entre Ríos) nearly all areas, northern and eastern Entre Ríos.

Grain Sorghum and Corn

Growing area is large and forms a very large arc around Buenos Aires (city), extending about 600 km to west, southwest, and northwest. Northern limit penetrates into Chaco province, southeastern Santiago del Estero province northwest of AgRISTARS study area. Covers most of Córdoba province except for the northwestern part, the eastern half of San Luís province, much of La Pampa province (both west of AgRISTARS study area) except for the west and south central sections. Covers a small area of northeastern Rio Negro province (southwest of Buenos Aires province) and all of Buenos Aires province except for the very extreme south. This area is a sorghum-corn zone collectively. However, only sorghum is a major crop throughout. Corn production because of higher humidity requirements occupies the core area which is northern Buenos Aires, southern Santa Fé and southeastern Córdoba. However, corn and sorghum production overlap in one large area in southeastern Córdoba, and extreme southwestern Santa Fé. In addition, both corn and rice production overlap in Entre Ríos and northeast Santa Fé.

Winter Cereals

This zone approximates the summer cereals zone but is slightly smaller. Four crops (winter) dominate in the region: wheat (all winter wheat), oats, forage barley and rye. The production of these grains occurs in core areas some of which overlap. In addition, the core production areas with the exception of barley occur much farther south (mainly southern Buenos Aires).

Crop Production Core Areas

Rye Area - Southeastern and south-central Córdoba, northeast La Pampa and extreme northwest and extreme west-central Buenos Aires.

Forage Barley Area - Extreme west-central Buenos Aires just south of the rye zone and also southeast Buenos Aires immediately inland from the coastal city of Mar del Plata in southeastern Buenos Aires.

Wheat Area - Extreme south-central and southwestern Buenos Aires centered on the coastal city of Bahía Blanca in southern Buenos Aires.

Oats - Southern Buenos Aires overlaps with both wheat and barley zone.

Oilseeds - Again the pattern of production roughly approximates the summer and winter cereal production zones, although on the north the zone extends into Formosa province in the extreme north of Argentina. The production area for olives, however, is located outside the zone and outside the AgRISTARS study area. San Juan, Mendoza and the corner intercices of La Rioja, Catamarca and northwest Córdoba (western and northwestern Argentina).

The large oil plant production zone is important for sunflower, flaxseed, soybeans and peanuts, but as in other areas, certain core zones account for most of the production.

Flaxseed Area - Flaxseed production is concentrated mainly in Entre Ríos with the exception of the northeast. The second largest flaxseed zone is in southeast Buenos Aires inland from Mar del Plata.

A small flaxseed zone is found in extreme northeast Córdoba, extreme southeast Santiago del Estero and extreme western Santa Fé. However, Entre Ríos is the main production area.

Sunflower - Although sunflower is grown throughout the oil plant zone the core area is south central Buenos Aires, east of Coronel Suárez.

Soybeans - The production core area is in northwestern Buenos Aires, southern Santa Fé and eastern Córdoba. Corn, soybeans and sorghum are important in this core zone with corn being most important in Buenos Aires, and soybeans most significant in Santa Fé. In terms of sorghum, Córdoba and Santa Fé are the most important producers.

Peanut Zone - The peanut is found in north central Córdoba state. No other major peanut production zones are found elsewhere in Argentina.

Fruits - The AgRISTARS study area is basically a coarse and fine grain/oilseed plant production area. Argentina is also an important fruit producer but the nation's major fruit culture zones lie outside the study zone with the exception of the Buenos Aires market gardening area. For example, citrus production is concentrated in the extreme northwestern part of Argentina in northern Salta and central Tucumań provinces, as well as in Misiones (extreme northeast), western and extreme southeast Corrientes and eastern Entre Ríos. Grape and wine production is overwhelmingly concentrated in Mendoza and San Juan provinces in the west. However, northwest Río Negro and adjacent Neuquén form a second production zone. Fruit seed production is also important in this zone and extends eastward in a long band across northern Río Negro.

Beef Cattle Production - The generalized zone of beef cattle production approximates the geographical limits of the Pampa and agricultural production. Three zones of beef cattle production exist from intensive livestock production zones in the central Pampa westward to areas of more extensive (larger area) cattle production complexes. The innermost areas have the greatest animal densities. High cattle densities are found in central Santa Fé, east-central Córdoba, extreme southern Santa Fé, southeast Córdoba and northwest Buenos Aires. A second arc immediately to the west of the core area extends from the eastern Chaco south and covers most of Santa Fé, central and eastern Córdoba, northeast La Pampa and central Buenos Aires. This area constitutes a medium animal density zone. The third zone constitutes the outermost arc of cattle production. It includes the central portion of Chaco province, northwest Santa Fé, southeast Santiago del Estero, northern and western Córdoba, the eastern half of San Luís and La Pampa, extreme northeastern Río Negro and southern Buenos Aires. Another outlying zone having the same animal density extends from Salta (central portion south to southern Catamarca). Thus, three core zones (1) central Santa Fé, (2) east-central Córdoba, and (3) southeast Córdoba-southern Santa Fé and northwest Buenos Aires the nation's most important cattle areas.

Hog Production - The Argentine hog zone is small in comparison with the very large beef cattle zone and coincides closely with the production of corn and grain sorghum. Three concentric animal density zones can be observed. The hog production core area (where the highest animal densities are found) is centered in southern Santa Fé and a very small portion of extreme eastern Córdoba. The center of hog production is located on the northern margin of Argentine's corn production zone. This Pampa heartland zone is thus a center of soybean, corn, and sorghum cultivation and is also the area having the greatest density of beef and pork animals. This zone is a true crop-livestock production complex similar to the U.S. Corn Belt in some respects. A second hog production zone (medium density) is found in southern Santa Fé, extreme eastern Córdoba and extreme northern Buenos Aires. The outermost zone, where the lowest hog densities are found, begins in central Santa Fé and extends westward into central and southern Córdoba and then swings southeastward into central Buenos Aires.

Sheep/Wool Production - Sheep raising does not exhibit same zonal patterns as beef or hog raising which is oriented toward sources of feed production, i.e., alfalfa and corn producing areas. Rather, it is an activity important in areas that are often marginal for agriculture because of excessively cool summers, dryness, poor soils, and poor natural pastures. A major exception to this is the important production zone in southern Buenos Aires. This area in fact is the most intense sheep/wool production area (highest animal densities) along with northern Entre Ríos and southern Corrientes. Less intense areas of sheep ranching are found in central and southern Buenos Aires, eastern La Pampa, and in Patagonia along the Andean front in wester Chubut, southwestern Santa Cruz and the Argentine portion of Tierra del Fuego extreme south. A very extensive (low animal density zone) covers nearly all of southern Argentina and the dry Pampa margin in western Buenos Aires and Córdoba provinces and also parts of several neighboring provinces, including northeast San Luís, southern Santiago del Estero, and much of Entre Ríos. Such pastoral areas contrast sharply with the more intensive cattle /coarse grain land use practices of the Humid Pampa in northern Buenos Aires.

APPENDIX C
CROP NOTES AND COMMENTS

The following summary of notes on wheat, corn, sunflower and sorghum was prepared by Mr. Buzz Sellman (ERIM) on February 27, 1981 during the ERIM/UCB Argentina ground data collection effort. At that time conversations were held with Mr. Tomás Loewy, soil fertility and management specialist with the National Institute for Crop-Livestock Technology (INTA) at Bahía Blanca; Ms. Cecilia Espoz, an agronomist with the National Commission on Space Investigation's (CNIE) UN/FAO Remote Sensing Project (Buenos Aires) and Mr. Miguel Abraham of the Subsecretariat for Natural Resources and Ecology (Buenos Aires). The comments apply to southern Buenos Aires province.

Wheat

Short Cycle - Mexican germoplast (dwarf) - 60 cm at harvest
Long cycle - - 1 meter at harvest

Plant - mid June to mid August
Harvest - mid December

Following harvest, leave bare until May, then prepare (plow/disk) for July planting again, or

Leave fallow, put in oats, sunflower, barley, or

Seed to pasture for a year or two.

Question - What are the most typical cropping practices in the region?

Answer - Alternating years of grain (wheat) and pasture.

G - Grain
P - Pasture
W - Wheat
VW - Volunteer Wheat
C - Corn
S - Sunflower
O - Oats
N - Natural Pasture

Year 1	2	3	4	5	6	
G	P	G	P	G	P	
W	N	W	N	W	N	Most typical
W	O	W	N	W	N	
W	N	C/W	N	W	N	Corn is for forage
W	N	S/W	N	O	N	
W	VW	S/W	VW	S/W	VW	Volunteer wheat for pasture

Question - What do you or INTA recommend to farmers in the wheat growing regions of southern Buenos Aires province?

Answer - Four to six years of improved pasture followed by an equal number of years of alternating grain and forage crops, e.g., S/W, then W, then O, then W, then VW, then back to five years of pasture.

Tomás Loewy does not recommend wheat for the Tornquist area. The soils are very thin, so he recommends pasture.

Corn

Plant - end of October/November
Harvest - end of March through early May

Following harvest, go to wheat in June or,

Leave in stubble for grazing over the winter, then back to wheat.
Corn for forage always goes back to wheat.

Sunflower

Plant - November
Harvest - end of March through early May

In northern Buenos Aires province, sunflower and soybean are used as second crop after wheat.

Sorghum

Plant - end of October/November
Harvest - end of March through early May

APPENDIX D

FIELD PATTERNS AND APPROXIMATE AREA OF SAMPLE SEGMENTS VISITED BY ERIM/UCB CONSORTIUM TEAM DURING GROUND DATA COLLECTION IN ARGENTINA, FEBRUARY 1981

Segment 578 (Villarino) Diagonal field lines NW-SE - Fields generally large - but some smaller fields interspersed. 100-300 ha, many are 200.

Field Size: Large to medium/small large dominates

Field Shape: Rectangular and square - largest fields rectangular

Field Pattern: Small fields clustered, occasional small fields in large field area

Segment 649 (Puán-West) 50-250 ha, most about 150-200 ha

Diagonal field lines superimposition of diagonals because provincial boundary.

Field Size: Medium, few really large fields

Field Shape: Mainly rectangular

Field Pattern: Uniform

Segment 556 (Puán-East) Diagonally oriented fields NW-SE 100-150 ha

Field Size: Medium - large

Field Shape: Mainly rectangular

Field Pattern: Evenly distributed - poor resolution on image

Segment 520 (Coronel Suárez) 100-200 ha, some 100

NW-SE diagonal field orientation

Field Size: Small - medium - few large properties

Field Shape: Predominantly square - some rectangular

Field Pattern: Some clustering of smaller fields

Segment 570 (Tornquist) NW-SE diagonal alignment 100-300 ha

Field Size: Large - medium - some small

Field Shape: Predominantly rectangular, some diagonal sides

Field Pattern: Smaller properties clustered

Segment 682 (Salto) NW-SE field diagonal ±100 ha

Field Size: Variable, many small, some very large

Field Shape: Rectangular and square

Field Pattern: Irregular

Segment 561 (Rojas) NW-SE alignment

Field Size: Medium, but variable, many small

Field Shape: Polygons, trapezoids, rectangles, some square

Field Pattern: Diverse

Segment 527 (General Arenales) NW-SE alignment 1-25 150-100 ha common 50-75-100 ha, some larger

Field Size: Medium with extensive empty areas

Field Shape: Rectangular with occasional diagonals

Field Pattern: Diverse

Segment 511 (Bragado) NW-SE diagonal - marshy areas break up pattern

Field Size: Variable, medium to large

Field Shape: Mostly rectangular, some squares

Field Pattern: Large fields together, pattern poorly developed because of marsh, poor imagery

Segment 681 (Junín) NW-SE alignment, 20-125 ha, also some east-west alignment 25-75 ha, a few are larger

Field Size: Medium, some small

Field Shape: Rectangular and square

Field Pattern: Diverse

Segment 611 (Río Cuarto) Fields have general north-south, east-west orientation, few diagonal

Field Size: Small to medium, 25-50-100 hectares very common, some larger

Field Shape: East-west long rectangular, some north-south rectangular fields, some square, occasional diagonal boundaries

Field Pattern: Groups of rectangles, groups of squares

Segment 604 (Juárez Celman) Fields generally east-west, north-south oriented, 50-100 ha area, large fields (200+ ha in area) common, also common, angular boundaries along road

Field Size: Medium to large

Field Shape: Square and rectangular, some fields angular on one side

Field Pattern: Clustered by size

Segment 616 (San Justo) East-west, north-south orientation, no diagonals, 25-50 ha common

Field Size: Small, some very small

Field Shape: Predominantly square, some rectangular

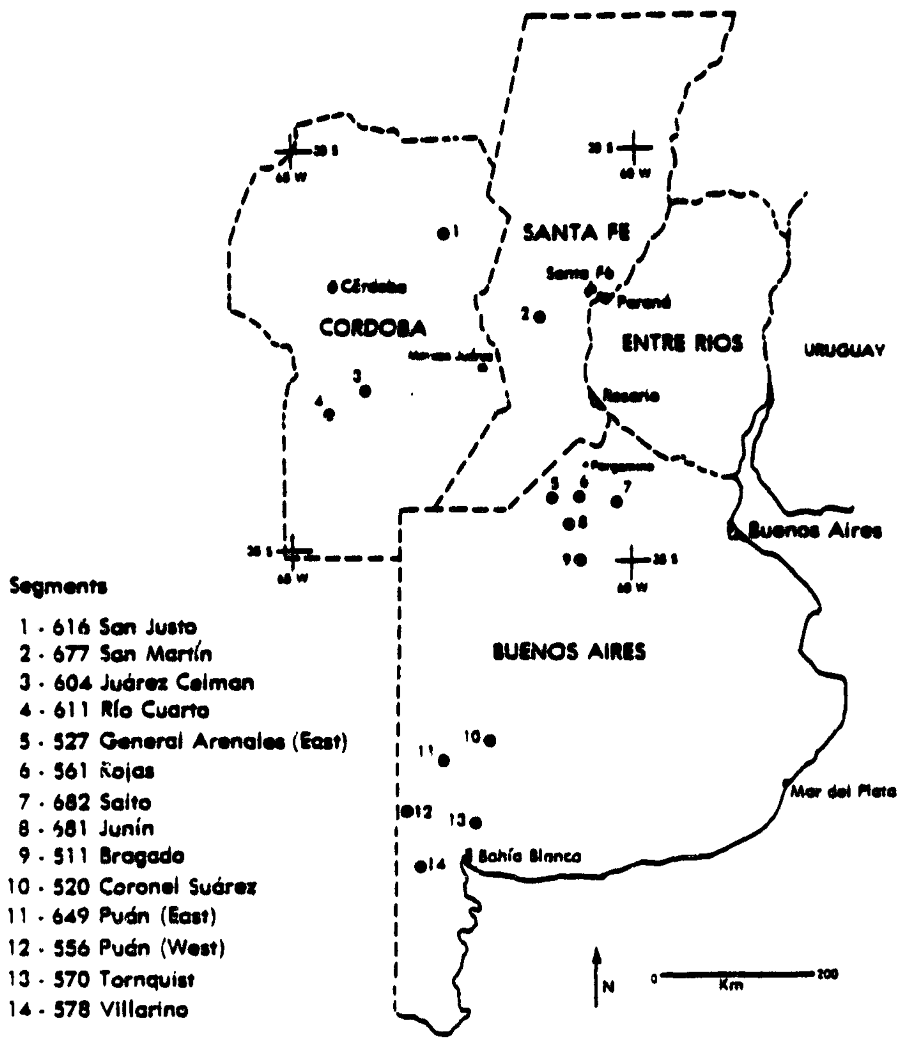
Field Pattern: Evenly distributed

Segment 677 (San Martín) East-west, north-south alignment, 15-20 ha common

Field Size: Very small

Field Shape: Predominantly square

Field Pattern: Very uniform



MAP 9. LOCATION OF ARGENTINA SEGMENTS WHERE GROUND DATA WERE COLLECTED, 18-26 FEBRUARY 1981

APPENDIX E

NOTES FROM INTERVIEW BETWEEN DR. A. J. M. SMUCKER, DEPARTMENT OF CROP AND SOIL SCIENCE, MICHIGAN STATE UNIVERSITY, EAST LANSING, AND DR. DAVID R. HICKS (ERIM), APRIL 24, 1981

Questions and Answers

(1) For what partidos is Johnson grass a major problem? Is its distribution more uniform or spotty?

After talking with Dr. A. J. M. Smucker it appears that Johnson grass is a problem along with pests and other weeds. Such factors lower yield by about 20% or perhaps more in some areas. In addition, Johnson grass is especially prevalent this year (1981) due to above normal precipitation in February, and is compounded by the difficulty of removing weeds in wet fields. Also, available information is that Johnson grass is uniformly distributed throughout the AgRISTARS study area.

(2) What is the rotation pattern for sorghum (grain and forage)?

Dr. Smucker had no firm answer to this question but indicated that sorghum could be followed by oats, and four months later by alfalfa or Love grass.

(3) Where is fertilizer used - for what crops predominantly is it used? Is it limited to certain areas, and if so, which areas?

Fertilization is not practiced as much as it could be due to the high cost of farm inputs in Argentina. The issue is thus one of economics, not of ignorance. Dr. Smucker indicated that only about 5% of crops are fertilized, but this is of course variable by area and crop type. Wheat fertilizer use tends to be higher. Information gathered in Argentina indicates that 25% of wheat is fertilized in eastern Córdoba, 40% in western Santa Fé. A discrepancy therefore exists but it appears that farmers use the natural fertility of the soil as much as possible and avoid spending money on fertilizers unless it's absolutely necessary.

With soybeans no nitrogen is needed, but phosphorous and magnesium are added, i.e., when fertilizer is used. Iron, zinc and phosphorous should be added in the case of corn, but these ingredients are commonly not added. Corn needs iron during the first few weeks of growth, but after this time the plant can recover and mature. The result is that corn plants in Argentina may look dead or brownish in their early development. Their spectral characteristics differ and area estimations may be erroneous if made during the early stages of growth. However, the plant recovers. This information is important for early season estimates.

(4) What is the reason for corn/soybean yield differences between provinces?

Four factors are important:

Water: The amount of water in the soil can be too much or too little, both problems occur in Argentina. Precipitation decreases from east to west rather radically and there is no area in the AgRISTARS zone that is super-humid. In addition, evapotranspiration rates are high in the north which reduces precipitation effectiveness.

Nutrients: Fertilization rates are low as already indicated. Pampa region deficient in nitrogen and especially phosphorous. Potassium surplus is also a problem. In the far northwest and southwest and especially central Buenos Aires, saline deposits can also affect production.

Soils: High potassium, dense, clay soils in north prevent water from percolating downward and tends to cause "innundation" and wet fields after only moderate rainfall. Corn and soybeans are subject to water stress during such times. Soils high in potassium, low in nitrogen. Low phosphorous level is a problem. Soils have not been completely classified in terms of nutrient availability. Poor drainage is a problem in Depressed Pampa.

Poor Management: The AgRISTARS zone is basically one of great potential for agriculture. Poor management is the most important factor keeping yields down. This problem is acute.

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