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We have read this dissertation
and recommend its acceptance:

Accepted for the Council:

Associate Vice Chancellor and
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CONSERVATION RESERVE PROGRAM ABANDONMENT IMPACTS UNDER GENERAL EQUILIBRIUM CONDITIONS

A Dissertation
Presented for the
Doctor of Philosophy
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Jose A. Velasquez
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DEDICATION

This dissertation dedicated to my parents

Mr. Hector Velasquez Maravi
and
Ms. Maria Campos de Velasquez

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ABSTRACT

Over the years, soil erosion has resulted in reduced on-site productivity damage and increased environmental off-site damages. To address these concerns public policies such as the Food Security Act of 1985 (FSA85) is established in part to reduce soil erosion. The 1996 farm bill, Federal Agriculture Improvement and Reform Act (FAIR) of 1996, allows for continuance of the CRP for 10 additional years. By the year 2005, all of this land may be available for agricultural production.

This study evaluates the impacts of the returning CRP lands to cropping activities. The present land situation is compared with the projected situation, for the year 2005. The same levels of technology and input prices are assumed for both situations. A model capable of addressing an approximate market equilibrium for farm prices, quantity demanded by consumers, and production patterns is developed and focuses on the following commodities; barley, corn, oats, sorghum, soybean, and wheat. The analysis evaluates the impacts from two separate methodologies, a supply-oriented linear programming model and a general equilibrium Tatonnement model. Finally, changes in water and wind erosion levels are explored.

Data, from 1950 through 1992, are used to estimate the seventeen demand equations. Six equations are related to feed-demand for livestock, five equations are related to food-demand for industrial and human consumption. Seemingly Unrelated Regression Equations (SURE) are used to address this concern. The remaining equations

are indirectly obtained from their own price elasticities. The demand equations are mostly significant at 1% level.

The results show that prices are higher when lands are enrolled in the CRP. The increase in available lands, due to the CRP termination, cause prices to be lower. The two first linear programming runs determine the boundaries for the optimal solution. The results show that on the aggregate prices fall within these boundaries. Since LP assumes that either demand or prices are fixed, the Tatonnement model is used to provide flexibility. In this process, all the demand and supply equations for feed, food, and export (except barley-feed) converge toward the equilibrium point. Convergence is present when the absolute value of the difference between supply and demand gradually diminish with every iteration.

Lands currently use for production of crops, livestock in Crop Producing Areas (CPA), and water and wind erosion are estimated. These results are at two levels a) Baseline and b) Optimum with CRP. Performing these two runs produce in estimates for land use, sheet and rill erosion, and tons per acre erosion for both the Baseline and Optimum with CRP. The difference between these runs is estimated in percentages, and the comparison of the runs reveal that erosion for wind and water are generally increased. There are some CPAs with negative signs for the amount of percentage in land use, sheet and rill erosion, and per acre erosion. This might occur because some CPAs adjacent to the CPAs with negative erosion are producing their crops at lower costs. This cost efficiency may induce farmers to increase their cropping activities, and export their crops to less cost efficient CPA's. Prices were the driving force in the operation of the

Tatonnement model. Prices allow the iteration between the demand and supply equations in an effort to establish equilibrium. At this point, prices for the commodities prove to be in the neighborhood of the second run of the LP (Iteration I) and between the first run (Baseline) and the second run of the LP(Iteration I). If CRP lands are allowed to be planted in crops, expected prices in the future will be lower than the current prices. Using only a linear programming methodology results in reduced production level estimates and lower prices than when using the Tatonnement modeling method

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CHAPTER I

INTRODUCTION

For many years, soil erosion has resulted in reduced on-site productivity damage and increased environmental off-site damages. To address these concerns the government intervened by passing Title XII of the Food Security Act (FSA85) which established the Conservation Reserve Program (CRP). Public policies such as CRP and the Highly Erodable Land (HEL) of the Food Security Act of 1985 (FSA85) were established in part to reduce soil erosion. The Food Agriculture Conservation Trade Act (FACTA) of 1990 included the Agriculture Water Quality Protection Program, Environmental Easement Program and Wetlands Reserve, and Integrated Farm Management Program. In particular, the CRP was designed to address issues about on-site productivity damaged and the environmental or off-site costs associated with soil erosion. In addition, several other secondary goals were attached to the CRP. This program has undergone several amendments from 1985 to the present.

Currently, 24 million acres of land placed into CRP during the years 1985 to 1987 are ready to come out from contract. Next year an additional amount of land will be available for crop production. The 1996 farm bill, Federal Agriculture Improvement and Reform Act (FAIR) of 1996, allows for continuance of the CRP for 10 additional years. By the year 2005, all of this land may be available for agricultural production.

Farm Bill 1985

Land eligible for enrollment in this program included Highly Erodable Land (HEL), land with cropping history, and land environmentally sensitive. Enrollment in this program was entirely voluntary. Farmers enrolling in this program were required to maintain and conserve the lands for the ten-year contract. The purpose of this program under the 1985 bill was primarily the reduction of crop land erosion. Secondarily, it focused upon reducing surplus commodity production, increasing farm income, increasing wildlife benefits, ensuring food and fiber production, increasing water quality, and reducing sedimentation. Presently, approximately 36 million acres are enrolled in the CRP. Nearly two 33 percent of this cropland has a crop base history. The majority of land has been enrolled in the Great Plains and the majority of the cropland has been wheat base (Farrar, 1994).

In 1986, lands meeting program requirements were bid by producers into the CRP through the Agricultural Stabilization Conservation Service (ASCS). The bids were different among the production regions. At the county level, the average rental rates for lands in the in the Corn Belt Production Region vary from $68.01 to $999.00. Counties on the north part of the Pacific Production Region have average rental rates of $51.01 to $102.00. The remaining production regions have average rental rates of $0.01 to $51.01. Lands enrolled in the program were restricted to not more than 25 percent from any county. To establish the perennial vegetation, the government financed 50 percent of its cost. Contract holders were required to honor their agreement of planting one or more of the following crops, perennial grasses, grass and legume mixture, and trees and shrubs.

In addition, no grazing, haying, or cropping were permitted unless approved as an emergency. Approximately, 1510 counties were approved for haying and grazing from the years 1988 to 1996; these counties were located in the Northeast, Appalachian, Southeast, Delta States, Mountain, Pacific, and some on the Southern Plains production regions. The remaining 1208 counties, which obtained approval for emergency haying and grazing of CRP lands, were located on the Corn Belt, Northern Plains, Mountain, and some in the Southern Plains production regions. Public recreation and hunting on the CRP lands were allowed at the discretion of the landowners. The CRP regulations allowed participating landowners to charge hunting fees.

Farm Bill 1990

Between 1990 and 1992, significant revisions and extensions were made to the CRP, and additional sign-ups resulted in 2.6 millions acres being accepted. The new legislation under the Food Agricultural Conservation and Trade Act (FACTA) focused primarily on water quality and wildlife habitat. With these considerations came the changes in the objectives of the program. FACTA, as modified in 1990, allows the Secretary to extend contracts signed prior to end of 1990 by 10 additional years. The emphasis in the last three sign-ups was on water quality, whereas the emphasis on the previous sign-ups was on land with wind and water erosion. However, June 1992 witnessed no further enrollments. Johnson (1989) and Dicks and Coombs (1994) pointed out that the Environmental and Benefit Index (EBI) with respect to government cost was introduced in the bidding process. The purpose of this was to enroll land with the highest

conservation and environmental benefits. The EBI seeks to improve both surface water quality and ground water quality, tree planting, preservation of soil productivity assistance to farmers impacted by conservation compliance, and enrollment in establish conservation priority areas.

The CRP provided most contract holders with the flexibility of choosing the allocation of their lands. This resulted in the following pattern of conserving practices (Table 1.1).

Table 1.1. Conserving Uses in CRP Lands.

Type of Conserving Use	Acres of CRP (Millions)	Percent of Acres
Grass	31.83	87.40
Trees	2.37	6.50
Wildlife Habitat	1.97	5.40
All Others	0.25	0.70
TOTAL	36.42	100.00

Source: Johnson B. "How Some Potential CRP Participants Were Taught to Bid and Ensuing Land Market Distortions." Journal of Soil and Water Conservation, 1989.

According to Osborn (1993), enrollment contracts numbered approximately 377,000 spanning 8 percent of U.S. crop land with 60 percent of the land located in the Great Plains (North Dakota, South Dakota, Nebraska, Kansas, Oklahoma, and Texas). The majority of the CRP acres were planted with grass; as a result, soil erosion reduction was 700 millions tons per year. CRP also includes 2.4 million acres of trees, 2 million acres of special wildlife practices, 410,000 acres of wetlands, and 5,200 miles of filter

strips along waterways. The Federal Government payments are $1.8 billion per year, with annual rental payments averaging $50 per acre (Table 1.2).

Table 1.2. Final status of 1985-1995 CRP.

Contracts	377,000
Enrollment (acres)	36.5 million
Total erosion reduction (tons/year)	700 million
Average erosion reduction (tons/acres/year)	19
Total rental cost ($/year)	1.8 billion
Average rental cost ($/acre/year)	50
Acres planted in trees (%)	6
Base reduction (acres)	23.3 million

Source: Tim Osborn, "The Conservation Reserve Program: Status, future and policy options." Journal of Soil and Water Conservation, 1993.

Even though farmers enjoyed freedom of land allocation, they will have to comply with conservation practices following the expiration of the ten-year contract. If the Erodability Index (EI) exceeds 8, compliance is necessary if farmers seek government program assistance. Lands with EI between 8 and 15 are subjected to conservation practice. As a result, 26 percent of the CRP acres are not under compliance (EI < 8), and 64 percent of the land are subjected to conservation compliance. Crop lands with EI greater than 15 are not cost efficient and requires costly practices e.g. terrace and crop rotation. Pressure-groups (farmers) proposed that the USDA employ a more flexible approach and reduce its criteria to the Tolerance level(T). On some lands reducing erosion to T was not economically feasible. Therefore, states were given discretion to

develop alternative production practices. These practices allowed erosion to exceed "T." At end of 1995, initial contracts were fully paid. Large amounts of acreage (1995 to 2002 would be 2,043,000, 13,670,000, 875,600, 5,355,000, 4,098,000, 475,000, 998,000, 1,027,000 acres, respectively) may not be enrolled in the CRP unless contracts are renewed. Taylor (1994) stated that of the 36.42 million acres enrolled in the CRP approximately 19.2 million would return to crops, unless new funds are secured to extend CRP contracts.

The CRP continued to be closely monitored by interest groups holding contrasting views and positions about CRP contracts. One group, who is in favor for the continuation of the CRP, proposed maintaining the contracts under the present legislation. The other group, who is in favor for the termination of the CRP, advocated other programs which are more cost efficient, for example the Agricultural Conservation Program (ACP). Currently, contracts that expire are not extended. A new set of lands are being bid into CRP.

According to Dicks and Coombs (1994), the environmental and conservation groups have listed wildlife enhancement, soil savings, reduced input use, and supply control cost savings as benefits for continuing the CRP. Producers in favor of the continuation of the CRP declare increased economic gains related to annual rental payments, or increased crop prices as a result of lands retired in the CRP. Producers against the continuation of the program contend that the benefits of CRP may be changing over time because land use is constantly changing. In addition they suggest that

cash rental rates, and land values have increased, and that CRP lands have increased pest problems.

Post Contract Era

The post contract era refers to the period immediately following the expiration of the 10-year CRP contracts. The Soil and Water Conservation Society's 1990 study suggested that 46 percent of subjects reported that they planned to recrop their lands following the expiration of their contracts with CRP. In this survey the respondents reported that the economic condition, which is directly related to the demand of crops, was the determining factor influencing their decision.

According to Huang (1989), and Osborn (1993), policy makers projected that it will cost $2 billion dollars/year in payments to the contract holders to maintain the CRP. They contended that focusing on larger issues such as environmental goals are more important and more cost-effective than merely reducing soil erosion. Policy makers also pointed out that CRP lands enrolled during the early years may not currently add benefits to environmental concerns, such as wildlife or water quality. They charged that the decision to keep all enrolled lands in CRP may not be the right approach.

Robert Taylor(1994) proposed that several factors will influence what lands are brought back into production from the CRP lands. These factors include: a) characteristics of the land, b) regulations in force at the time, and c) prevailing economic conditions. Ray (1994) agreed that it is important to identify the potential uses of current land and the likely constraints of developing those alternatives base on physical land and

socioeconomic characteristics. In Taylor's study the Agricultural Simulation Model (AGSIM) was used to evaluate the agricultural impacts of CRP lands that were returned to production. This model uses econometric and simulation models to estimate supply and demand. The supply side represents producers who respond to changes in prices, production costs, expected yields, and farm programs, whereas the demand functions respond to changes in output prices.

In considering the estimation of acres and price effects of lands being recropped it is necessary to make efficient comparisons. The comparison is made between two cases a) all lands in the CRP, and b) all lands leaving the CRP. These cases are not without their problems. Where lands are kept out to production , rental payments will be maintained, which may not be realistic. In contrast, returning all lands for recropping, terminates rental payments but would require a substantial increase in international demands. However, this increase in international demands is unlikely to occur. Therefore caution must be employed when interpreting these results.

Several attempts were made to explore possible uses of land being retired from the CRP. The Soil and Water Conservation Society (SWCS) conducted a national survey of CRP participants in 1990, in an attempt to estimate post CRP land use (Nowack, Schnepf, and Barnes,1991). A simulation model based upon the national CRP data was developed to estimate the post contract used in the Southern Plains (Dicks, et al.1990). Heimlich and Kula(1990) used economic relationships developed from a country survey to determine post CRP land nationally. Konyar and Osborn(1989) used the national CRP data from the first three sign-up periods to estimate post-CRP land use. These studies

indicate that 50% or more of the current CRP acreage would be returned to previous crop land use. The results of these studies demonstrate that the fate of the CRP croplands will depend on the relative profitability of alternative enterprises and various socioeconomic characteristics of the CRP participants. Further the studies describe vastly different cropping alternatives and cost associated with developing alternatives between regions and areas within regions.

The Federal Agriculture Improvement and Reform Act of 1996

Environmental Conservation Acreage Reserve Program (ECARP) was established as the umbrella encompassing the Conservation Reserve Program (CRP), the Wetland Reserve Program (WRP), and the Environmental Quality Incentives Program (EQIP). CRP is authorized through the year 2002 with up to 36.4 million acres enrolled at any time. Except for lands that are determined to be of high environmental value, the Secretary can allow participants to terminate any contract entered into prior to January 1, 1995, upon written notice provided the contract has been in effect for at least 5 years. The Secretary maintains discretionary authority to conduct future early outs and future sign-ups of lands that meet eligibility criteria. WRP is authorized through the year 2002, not to exceed 975,000 acres in total enrollment. EQIP, a new program, is established to assist crop and livestock producers in dealing with environmental and conservation improvements on the farm. Program funding will be $200 million annually through the year 2002 except 1996 in which case is $130 million.

Early outs are permitted for less environmentally sensitive land that has been enrolled for at least 5 years. New enrollment of environmentally sensitive land is permitted to replace the early outs and contracts that expire. An EQIP is authorized at $1.3 billion over 7 years to provide technical, educational, and cost-share assistance and incentives payments to crop and livestock producers in implementing structural and management practices to protect soil and water resources. At least half of this $1.3 billion is allocated to livestock practices. EQIP is to be operated to maximize the environmental benefit per dollar expended. Conservation compliance provisions are retained. Under conservation compliance provisions, producers are allowed to modify practices in their plan if they can demonstrate that the modification will provide greater erosion control. Failure to comply with highly erodable land conservation provisions will cause farmers to lose their programs benefits.

Objectives

Close to the expiration of the CRP contracts, policy makers and contract holders did not know exactly what would be the future of the CRP. Interest groups were polarized; one group wanted the termination of the CRP, whereas the other group fought for the continuation of the program. The end result of this debate was the extension of the CRP until the year 2002. However, after the completion of this program, the future of the lands in the CRP will be readdressed. The objectives of this study would focus on the following:

a) estimate the impacts of CRP termination on farm prices, quantity demanded by

consumers, production patterns, and wind and water erosion.

b) comparison on linear programming model with general equilibrium Tatonnement model.

Because CRP lands returning to recropping would increase crop production, the objective of this study is to develop a model capable of addressing an approximate market equilibrium for these two scenarios. The scope of this model should be broad enough to include equilibrium farm prices, quantity demanded by consumers, and production patterns. The study will focus on the following commodities; corn, oats, sorghum, soybean, and wheat. In addition, the impact on water and wind erosion would be addressed. Finally, the analysis will evaluate the impacts from two separate methodologies, a supply-oriented linear programming model and a general equilibrium Tatonnement model.

CHAPTER II

LITERATURE REVIEW

Before developing an economic model for CRP lands, this chapter focus in some essential issues to have a basic understanding of some effects of 1) CRP lands returning to production, and the repercussions on costs and supplies, 2) the nature of agricultural commodities, 3) general equilibrium models, 4) spatial models used in agriculture, and 5) Tatonnement model. This chapter reviews several equilibrium models that provide a mathematical framework for developing the two different scenarios for CRP lands by the year 2005.

Lands Returning to Production, and the Repercussions on Costs and Supplies

Ervin, Johnson, and Lee (1994), indicates that since 1956, national policy makers have twice engaged in long-term farm retirement programs: Soil Bank and CRP. Title I of the Agricultural Act of 1956 established the Soil Bank Program. According to Ervin and Lee (1994), the principal objective of the Soil Bank was: a) to help agricultural producers manage the problem of surplus commodities and b) to retire and improve soils on lands not needed for crop production. The program consists of two sections: the Acreage Reserve and the Conservation Reserve. The Acreage Reserve focused upon reducing surpluses of six crops; corn, cotton, peanuts, rice, tobacco, and wheat. This was accomplished by a temporarily acreage adjustments below the established allotments. The objective of the Conservation Reserve was to obtain an enduring shift from croplands

to conservation uses. Consequently, the Conservation Reserve was considered to be the first long-term land retirement program. Participants in the Conservation Reserve contracted to retire their croplands for a period of 3 to 15 years. In return, the producer were eligible for an annual cash payment, and up to 80 percent of the cost of establishing the conservation practice. The Food Security Act (FSA) of 1985 established the Conservation Reserve Program (CRP), which was the second long-term land retirement program. Under this long-term retirement program 40 to 45 million acres of highly erodable cropland were retired from crop production. The objectives of the CRP were threefold: a) to reduce land damages caused by water and wind erosion, protect long-term capability to produce food and fiber, reduce sedimentation, improve water quality, create better habitat for fish and wildlife through improved food and cover, curb the production of surplus commodities, b) to provide needed income support for farmers, and c) to reduce government costs of farm programs.

Farmers were compensated for substituting crop production with permanent vegetative cover (Siegel and Johnson, 1991). According to Huang (1989), the amount of land potentially affected by CRP was less than the amount eligible in the conservation compliance program; however, expansion of the CRP requires an increase of government payments for the additional cropland enrolled and cost-sharing for establishment of vegetation. Because the CRP was a more effective tool in reducing surplus commodities than conservation compliance, the CRP was implemented and rental payments increased. Farmers that have low yielding lands (Hickman, Rowell, and Williams, 1989) and a larger than the average proportion of their land classified as highly erodable land signed

up in the CRP rather than comply with the conservation provisions (Richardson, et. al. 1989). Finally, policymakers used the estimated costs to examine the tradeoff between the extension of the CRP and the implementation of the conservation compliance program in reducing soil erosion and government cost (Huang,1989).

Nature of Agricultural Products

In general, most agricultural commodities have the characteristics of a perfectly competitive market. Of the large number of farms in the agricultural sector, most of them tend to produce a similar commodity. In this pure market competition, most farmers are price takers striving to maximize their profits. Transaction costs are non-existent between buyers and sellers. Finally, prices are known by all producers and consumers. In this study, prices are important and they are the only force seeking convergence with the use of the Tatonnement model. The Tatonnement model is characterized by changing prices under the presence of excess demand or supply with the goal of reaching equilibrium. That is, if there is excess demand, prices would increase, whereas if there is an excess supply, prices would decrease.

Tomek (1987), proposes that the market price is influence by many factors. The scope of these factors span from free competitive market conditions to government regulated market conditions. The evaluation of agricultural prices require a variety of models and institutions that determine prices. Unlike the non-agricultural markets, with more stable prices for their goods and services, agricultural production demonstrates much fluctuation in prices. This fluctuation is attributed to climatological, biological,

and seasonal variations in conditions, thus influencing the crop yields from month to month and year to year.

The time differential that exists between the farmer's decision to produce and the final output also affects the stability of agricultural prices. This instability is evident when prolong periods of high or low prices persists, and farmers are unable to respond to price signals due to the decision/final output time lag. In addition, for some farm commodities, the nature of the demand for those commodities prove to be an influencing factor in price instability. A price change, for many foods, tends to have minimal effect on consumer purchases, however a change in supply evokes a relatively large price change for many farm products.

Price determination, for the first handler level, proves to be more decentralized and competitive for farms than other markets. This price situation emerges because there are a large number of crop producing units, and they are widely dispersed throughout the USA. Of interest is the fact that although farms continued to increase in size, their dispersions is considerably greater than most service and manufacturing industries. As a result of this dispersion of farms and the number of farms, it is difficult to estimate supplies and more troublesome to control the total output. The fact that price-making is not limited to national boundaries requires a consideration of world views to better understand why prices vary.

Ray and Plaxico(1988), suggest that the highly unstable, and chronically low farm prices and incomes are the cause of farm problems. They attribute nature; weather, pest and other hazards; and market structure as the two-fold source of the cause. Greater

clarification and differentiation between non-farm product producing industries and farm product producing industries provide a better understanding of the market structure. A few hundred or thousand firms typically constitute a non-farm industry, whereas hundreds of thousands of independently operate units comprised a farm industry. Only extremely small amount of the nation's agricultural output is produced by a typical farm. These small farms have no impact on commodity prices because there are no leading firm to balance the supply and demands for farm goods. Unlike farms, leading firms in the non-farm industry, are able and do influence commodity prices by controlling supply to match demand.

Since technology governs the capacity in the farming industry, many observers of the impact of new technology incorporate it into production, thus increasing profits and reducing cost before the prices fall. This results in an increase output and a decrease in prices. The cutting of cost is the avenue used by farmers to increase per unit net returns.

Demands for agricultural commodities are more inelastic than the non-agricultural goods, meaning that for any percentage decrease in price the quantity demanded increases by a smaller percentage. An important factor of demand for goods and services is income. Income elasticities for non-food commodities are elastic, whereas food demands shows little elasticities to income, that is, it has low income elasticity. In addition, the income elasticity in developed countries has almost no effect on the aggregate demand for agricultural products. (Ray and Plaxico, 1988).

General Equilibrium Models

Quantity demand equal quantity supply (competitive markets)

Takayama (1985), contends that competitive markets require two economic agents, a producer and a consumer, interested in commodities. A commodity bundle is considered to be an element of R^n, which is an n-dimensional vector whose components are real numbers. The competitive market theory assumes that in comparison to the size of the economy, each economic agent is relatively small. As a result, the economic agent can not influence the price that exist in the economy (specifically, the effects of this action, as a producer or a consumer, on market prices is minuscule). Therefore, the implications of the competitive market theory suggest that there are numerous producers and numerous consumers. This theory is also interested in the interaction of many agents in the economy. A competitive equilibrium is contingent upon the existence or non-existence of a price vector that could support a competitive equilibrium. Consequently, consistency of the concept of competitive equilibrium is the chief concern, that is, can many producers and many consumers be consistent in their interaction with each other. Helmberger and Chavas (1996), and Nicholson (1995) notes that competitive price theory suggests that the intersection of demand and supply function dictates both the level of output and the price level. The demand curve demonstrates how much consumers are willing to purchase at alternative prices. Whereas, the supply curve demonstrates how much producers are willing to supply at alternative prices. At the intersection of the demand and supply curves the equilibrium price is obtained. When the equilibrium price is established, consumers are able to buy as much as they desire, given their utilities and

budget constraints. Producers, given their desire to maximize profits, are able to sell as much as they want within the constraints imposed by production functions and input prices. Market participants achieve their constrained objectives at the equilibrium price. This achievement is significant because the consumer strives to maximize utility and the firm strives to maximize profits. In addition, any shifts in demand and supply functions are attributed to exogenous variables.

Doll and Orazem (1984), notes that classification of markets are established by the number and size of the firms which sell the product. In addition, markets are dictated by the number of buyers and quantities purchased, the similarity or lack of similarity among products sold, by the firms, and the easy entrance or exit into market production. In the agricultural sector many sellers exist and farmers produce and sell similar agricultural products. Since products are similar and sellers are numerous, a single farmer can not impact the price of this product. If a farmer holds his product off the market, prices will not increase due to reduce supply, because of the insignificant product contribution each farmer makes to the market. On the other hand, the farmer does not have to sell his product at a lower price than the market price because he can sell all he has at the market price. These conditions hold true for farmers functioning independently or as a part of a very small group of farmers. Because a farmer purchasing power is viewed as an infinitesimal quantity relative to the total quantity of inputs sold, the farmer must also regard the price of input as a given. In this economy, the farmer is viewed a price taker, implying that the farmer takes the market price as given.

As described above, a market with many buyers or sellers and a homogenous product is known as a pure competitive market. If pure competition is to exist two additional conditions must be met. First, business must be free to enter and leave production as they please and the market must be free of patents or other legal barriers inhibiting prospective producers. Second, there should be no artificial restrictions placed on the supply or demand for products. Therefore, in this market, prices are allowed to vary so that equilibrium of price and quantity occurs. This equilibrium is attained where aggregate demand equals aggregate supply.

Spatial Models

Agriculture is land extensive meaning that agricultural production takes place over large areas of land. Production differs for any two producers because of variations in soil and weather characteristics. Farm location impacts costs. Farmers away from transportation infrastructure receive lower prices than others with better locations. Therefore, the development of supply components to natural agricultural models are typically spatial in nature (English, et al. 1989). The linear programming used in his study is a spatial model, because this model has the capacity to accommodate optimal production possibilities, production regions, transportation flows and restraints of resource uses.

A number of factors influence the price difference between regions, especially where the economic forces are likely to cause prices in one region to change in relation to those in another. Spatial price equilibrium models are used to ascertain the geographic

price relationships in a formal way (Tomek, 1987). With these models the direct and indirect effect of changes in production can be estimated in one or more regions for the volume and direction of trade. In addition, determining the impact of decreasing or increasing trade barriers between regions this analytical model is employed. Spatial prices are established mainly by transfer costs between regions, given competitive conditions persist. Transfer costs includes loading or handling and transportation charges. They are frequently high in relation to the farm value of agricultural commodities, especially perishable products. The variation in farm prices is contingent upon the location of the farm, that is, the distance between the producing areas and the marketing places. The principles that determine spatial price differences within a country apply equally to international prices, provided no barriers exist to the movement of commodities between countries. However, the conditions need for the free trade of many agricultural products, currently do not exist between countries. Price difference between countries should not exceed transfer costs. When price difference is greater than transfer costs a cycle is established, where buyers purchase commodities from the low-priced market, thereby raising prices in the former and reducing them in the latter. This cycle can be prolonged until it is no longer profitable to ship commodities between markets, that is until the price difference between them no longer exceeds transfer costs. An average transportation rate is insufficient to estimate the transport cost between any two regions rather the transportation cost is comprised of a fixed charge which is unrelated to the distance traveled, and a variable charge directly related to the distance over which the commodity is moved. Since transportation costs per mile decline as the distance traveled

increases, the cost of moving commodities between two points is not necessarily a linear function of the mileage.

Helmberger and Chavas (1996) proposes that shifts in demand and supply conditions lead to shifts in transportation systems and farm programs. Many farmers and marketing firms in some areas of the country discover that they can no longer compete with their counter parts in other areas. Spatial patterns of prices and product shipments are inherent in these competitive conditions. Price differences escalate and product shipments become increasingly restricted with higher transportation cost. Both individuals and society can benefit from the savings when regional patterns of competitive production are anticipated and bad investments in farming and marketing facilities are prevented.

Input-output

The input-output analysis is another type of equilibrium model, however it is limited in its flexibility and scope. Regional transactions are rigid in manipulating the linear functions when input-output analysis is used. In contrast, the Tatonnement model permits flexibility in the demand and supply functions.

Penson and Hovav (1988) suggests that early studies on input-output analysis reveal that multisector planning models are base mainly on a mathematical structure of linear functions. However, the recent use of input-output analysis suggests that it is possible to specify and implement models, making extensive use of nonlinear functions in a general equilibrium framework.

Siegel and Johnson (1991) conclude that general equilibrium approach is based on an accounting system of intersectoral purchases and sales. The assumptions of input-output analysis includes fixed proportion of production functions, no input substitutions, homogeneous sector output, and no resource constraints. The economic impact is divided into direct, indirect, and induced economic impacts. The direct impact addresses the gross revenues received by producers for final purchases of goods and services from consumers, government and exports. The indirect impacts deals with the expenditures for factors of production. Finally, the induced economic impacts refers to the subsequent impacts resulting from income received by economic agents during the direct and indirect impacts that are, in turn, spent on other goods and services. Farm lands use for recreation have significant income potential. As a result, enrollment in the CRP becomes more attractive. With increase enrollment, payments to CRP participants may be reduced. From the regional perspective, if increased CRP enrollment was accompanied by increased on-farm and/or off-farm recreational activity, then there is a potential to offset negative regional economic from decrease crop production.

Tatonnement Model

Several studies have been conducted using the Tatonnement model for assessing market equilibrium. The basic theory behind this model assumes that all traders gather in one place, and that there is an auctioneer. The auctioneer quotes a price for the *ith* commodity, then each trader writes on a piece of paper the amount of that commodity that the trader is willing to buy or sell. The quantities on the papers are added to see if

there is an equal demand and supply. When excess demand is present for the *ith* commodity, the auctioneer quotes a higher price, and when there is an excess supply for the *ith* commodity, the auctioneer reduce the price. This process will continue until supply and demand converge (Schatzer, English, and Heady, 1982, Takayama 1985; Varian 1992). Joyce (1984) affirms Takayama and Varian approach and adds that changes in the price follow the same sign as the excess demand. In addition, he states that no transactions are performed at non-equilibrium price, and strong convergence is achieved by separating buyers from sellers.

The auctioneer in the Tatonnement model is best understood by considering two issues: a) the nature of social organization in which it operates to ensure the attainment of equilibrium magnitudes b) once equilibrium magnitudes are obtain how is trade organized. In relation to point a) before monetary exchange take place, agents must assemble in a place or at least participate in a communication that facilitates the exchange of information. An auctioneer is required to coordinate and monitor private decisions. The auctioneer's role is to implement price adjustment by announcing and changing price and holding transactions stationary until adjustment is completed, thereby preventing exchanges at false prices. The auctioneer is an outsider to the economy, and does not engage in exchange of commodities. Unlike economic agents who are price takers, the auctioneer services are free of cost to the traders. The auctioneer is the only agent able to change prices. Participants are fully informed of the quality of goods and services, so that prices are the unique and sufficient means of information. To ensure that preferences of exchangers are independent or not influenced by other agents, exchangers are isolated

from each other. Tatonnement also implies that specification of the time-structure wherein the price formation process takes place. Before production and consumption occurs, Tatonnement must take place, otherwise the structure of the equilibrium vector will become different. Interpersonal transactions are not permitted, therefore exchanges take place only when equilibrium prices occurs involving all participants of the exchange community. Once price equilibrium is obtained goods and services still have to circulate, and the circulation is assumed to be costless. Therefore transaction costs are excluded (De Vroey, 1990).

Wu and Rozek (1987) describes the Tatonnement process as he focuses upon the exchange of a homogeneous product in a centralized market. In this market setting, traders meet at a determined location to conduct transactions. Traditionally, the auctioneer announces a price, obtains all the information concerning the buyers' and sellers' decisions, calculates the market excess demand, and then modifies the price in an effort to clear the market. Once the auctioneer determines the equilibrium price "p_e", trade begins. In some markets, such as the future-markets and option trading markets, trading occurs without an auctioneer. Deliberations proceed though brokers of potential buyers and sellers at a central location. Each broker is able to set a price, and trade may take place at non-equilibrium prices (non-Tatonnement). This non-Tatonnement market exchange mechanism is referred to as bidding process.

The above studies have shown the impact of the Tatonnement models as they operate in the restrictive market of the buyers, sellers, and auctioneer. Ginsburgh and Waelbroeck (1979) introduce a shift from this view of the Tatonnement model to that of a

larger competitive equilibrium model which uses sophisticated algorithms. They acknowledge that although convergency is achieved under limited conditions, model builders has considerably more flexibility than the theoreticians in obtaining convergency with large competitive equilibrium models.

Hahn and Wien (1992) expand upon the traditional equilibrium of two-good model. They indicate that all the questions of equilibrium analysis, that is existence, uniqueness, and stability of a market clearing price vector can be extensively discussed. They also suggest that when one of the assumptions of equilibrium is slightly changed , the two-good model behaves dynamically as strange as the n-good model. Therefore their model addresses the pitfalls of equilibrium economics.

$S_{+}^{k-1} = (p \text{ in } E^{k}: \|p\| = 1, p \geq 0), \quad E^{k},$ 2.1

r(p) represents the unit vector of excess demands, 2.2

r(p) homogeneous of degree 0 in prices.

$r(p): S_{+}^{k-1} \rightarrow R^{k}, \; r(p), \quad E^{r}, r \geq 1$ 2.3

$p.r(p) = 0$ for p in S_{+}^{k-1},(Walras' Law) 2.4

$r_i(p) > 0$, if $p_i = 0$, $i = 1,2,3 \ldots k$ (Desirability) 2.5

Assumption (1) defines the price space of the equilibrium model it becomes a differentiable manifold with the mathematically nice properties of a sphere. Assumption (2) excludes money illusion. Assumption (3) makes sure that the excess demand function *r(p)* meets certain differentiability requirements. Assumption (4) expresses Walras' Law, which guarantees that *r(p)* lies in the tangent space of the sphere S_{+}^{k-1}. Assumption (5)

excludes not only boundary equilibria but prove the existence of at least one equilibrium point.

Central to the standard equilibrium is the excess demand function *r(p)*. This function and its properties are elemental for finding answers to the three questions of equilibrium analysis: the question of equilibrium price, the question of uniqueness, and the question of adjustment process leading the economy from a non-equilibrium price to an equilibrium price. With assumptions of general equilibrium theory, only the existence problem has been resolved satisfactorily, the uniqueness and stability question remains still open and there is no hope that there will be ever an analytically satisfactory answer to both problems. All that can be hope for is local uniqueness. If consumers are assumed to have smooth indifference curves, then there are a finite number of price equilibria. Varian (1992) adds that equilibrium economists are use to ruled out the possibility of equilibrium at a zero price by making some sort of desirability assumption.

Alligham's (1972) theoretical advances have been made on the systematic investigation of stability in a general equilibrium framework. This purely deductive approach has restricted the scope of this work in some interesting directions. Firstly, it investigates theoretical perfectly competitive rather than actual imperfectly competitive economies; secondly, it is concerned with demonstrating that the system eventually converges to some stable equilibrium and gives no indication of the path towards equilibrium or the time taken to achieve it; and finally, though separate conditions may be obtained for local and global stability, there is no indication of any(finite) range in which the weaker local conditions may be sufficient. The authors have no immediate applicable

results on whether an actual system will converge to an equilibrium position within an acceptable time when subjected to the type of disturbances it is likely to encounter. This study uses a theoretical model of equilibrium based on Walras' concept of Tatonnement together with an empirical multisectoral model of equilibrium behavior, from which the adjustment process is simulated. By simulating this imaginary exchange of Walras' tickets, the main obstacle to an inductive approach, that of the observation of this imaginary ticket, is removed. They treat each sector in the equilibrium model as a decision making agent, supply it with any information (in the form of some arbitrary initial parameters) that the sector requires, and simulate its behavior. Then, they use the disequilibrium model to generate a new set of parameters from the simulated behavior of all the agents at the previous stage and repeat the process until this parameters converge.

Anderson, and Stanford (1993) employs a Tatonnement-type modeling process to demonstrate the dynamic adjustment of investment company share prices in estimating the underlying value of the shares. Their work introduces a dynamic adjustment model for security price behavior, and empirically determines if the model accurately describes such price behavior.

In the Walras' basic Tatonnement process some commodity i with price p_i identified with each agent $i=0...n$, and the excess demand for a commodity at stage s in the process is given by the function;

$$E_i(s) \equiv E_i\{p_0(s)....p_n(s)\}, \qquad 2.6$$

equilibrium being identify where the vector $E(s) = 0$. In this adjustment process the sectors (or markets) are considered to be ordered, adjustment of p_i taking place in the

order $p_0 \ldots p_n$. The process commences in stage s with some arbitrary price vector $P(s)$, for which in general $E(s) \neq 0$. Prices are then adjusted in order, $p_i(s+1)$ being chosen so that.

$$E_i \{p_0(s+1), \ldots p_i, p_{i+1}(s), \ldots p_n(s)\} = 0 \qquad 2.7$$

$p_j(s+1)$ and $p_k(s), j < i < k$, being taken as given, 2.8

so that we have the process

$$E_0 \{p_0(s+1), p_1, \ldots p_n(s)\} = 0, \qquad 2.9$$

$$E_i \{p_0(s+1), p_1(s+1), \ldots p_n(s)\} = 0, \qquad 2.10$$

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$$E_n \{p_0(s+1), p_1(s+1), \ldots p_n(s+1)\} = 0 \qquad 2.11$$

Thus each sector is in turn placed in equilibrium and then disturbed from it, the change in p_i upsets equilibrium. At the end of this stage only sector n is in equilibrium, though if the process is stable all other sectors are nearer equilibrium.

Plott and George (1992) introduces another approach related to the Walrasian model, which views price as changing in response to excess demand at that price. The author in this study uses an approach called the secant Tatonnement model. In this process the experimenter (price adjuster) announces a price. Agents respond with quantity offers at that price. If excess demand is zero, or of some other stopping rule is involved, the process stops and trade takes place at the announcement price. If conditions

for stopping are not satisfied then the secant method for finding a new price is used and a new price is announced.

Price changes were determined by the secant formula

$$p_{t+1} = p_t + \left| \frac{p_t - p_{t-1}}{ED_t - ED_{t-1}} \right| ED_t \qquad 2.12$$

where ED_t is the excess demand at t; i.e. it is the sum of amounts demand minus the sum of amounts supplied at p_t. If $ED_t - ED_{t-1} = 0$ then $p_{t+1} - p_t = p_t - p_{t-1}$. Notice that the process is potentially unstable. If excess demand is positive, then prices will increase, or if excess demand is negative, price will decrease. This quality is exactly the unstable behavior that underlies the Walrasian concept.

The process stopped according to two rules:

a. If excess demand is zero, then the price change is zero and process stops.

b. If $\left| \frac{p_t - p_{t-1}}{ED_t - ED_{t-1}} \right|$ is small enough, then the rounding procedure will treat the quantity as zero and the process stop even though excess demand is not zero. This latter property can be important in cases of horizontal demand or supply curves. The secant process as opposed to a process often referenced in the literature as the proportional adjustment rule (that is. $\dot{X} = \alpha * ED$) is chosen as the first to study because the natural stopping rules listed above could be applied in the presence of discontinuities.

Kallio, and Salo (1994), capitalize on the fact that precision requirements for solutions of most economic models in practice are moderate only. They introduce an iterative algorithm similar to the simplex method to solve linearly constrained partial

equilibrium models. This algorithm is capable of solving models of large magnitude, within a sensible tolerance, efficiently even in a micro computer environment. Linearly constrained convex optimization problems are presented. Comparison of this approach with the simplex method and with Karmakar's algorithm is reported. For moderate precision requirements these preliminary results are highly encouraging. The intent of this study is to present a clear and effective algorithm for solving partial equilibrium models and linearly constrained convex optimization problems. This algorithm solves problems where high precision is not required.

Samuelson (1952), triggers a major effort to prove that, under reasonable assumptions, competitive economies will reach equilibrium following a Tatonnement process, in which each price is adjusted to excess demand for the same good. The purpose of this study is to explore the locations of a major difference between the modus operandi of Tatonnement in a decentralized economy a solving models on the computer. In a decentralized economy, it is difficult to imagine that a price would respond to scarcity of another good. The model builder is free to set up the calculations as he likes. This paper examines how the assignments of variables to be adjusted to equilibrium can be guided by the diagonal dominance criterion, which implies that the Tatonnement process will converge (possible subject to an appropriate change of units) if the adjusting variable has a greater effect on the disequilibrium to which it responds than all other variables taken together.

Tatonnement finds its origins in the analysis of competitive equilibrium model. In which $f(x)$ represents excess demand of commodity j $(J=1...N)$ at a given vector of

prices x; in this context, it seems natural to increase the price of commodity j if $f(x)>0$ and to decrease its price otherwise, i.e., to set up a system of differential equations $dx_j/dt=f_j(x)$ $j=1..n$. It would make a little sense to assume either that the price of j drops when excess demand is positive, i.e., $dx_j/dt=-f_j(x)$, or that the price of commodity i is adjusted in proportion to the excess demand for commodity k, that is $dx_i/dt=f_k(x)$.

Blad's (1978) study focuses (in the general equilibrium framework) in determining a dynamic price adjustment process, with the property that the prices determined by this process eventually converge to equilibrium price. In other words, the problem posed was to describe a reasonable adjustment process with respect to which the price equilibrium is stable. This problem was first approached by Walras' Tatonnement process which states that given a price system each agent informs an auctioneer of his demand a supply of each commodity. Having computed the total excess demand of each commodity the auctioneer then informs a new price vectors which is obtained from the previous one by increasing the price of commodities with positive excess demand, and visceversa. This process is repeated until equilibrium is reached. A fundamental feature is that no agent is allowed to trade any commodity until equilibrium is achieved. Given the assumption of no-trade out of equilibrium, the convergence should be fast, that is, the organization of the market prior to trade should not take long. The author provides a partial answer to the speed of adjustment by showing how a well known result in the theory of ordinary differential equations gives, directly, an estimate of the speed of adjustment of the Tatonnement process in the limit.

Hands (1983) points out that almost all of extensive literature on the stability of the Walrasian Tatonnement models focus on the process in continuous rather than discrete time. Since the motivation for the use of continuous time model does not imply that stability of its discrete time analogue, it is of interest to investigate the stability of the Walrasian Tatonnement modeled in discrete time. The question is of particular importance since much of the recent literature on topics such as expectations, disequilibrium trading , and temporary equilibrium utilizes discrete time. This study demonstrates that for a certain class of models, conditions known to be sufficient in a discrete time formulation of the price adjustment mechanism. Excess demand functions having the properties of gross substitution, dominant diagonals, and the Morishima system of complementary commodities, are analyzed.

Eden (1990), proposes that the standard formulation of a spot market subject to uncertain excess demand uses a Tatonnement process that restricts trade until the market clearing price is found. The author presents a model in which there is no restriction on trade during the process of the resolution of uncertainty about the aggregate excess demand. The idea is to enlarge the commodity space and define goods by the probability that they will sell, in addition to other characteristics. A failure to distinguish goods by the probability of the sale characteristic can lead to the rejection of the competitive paradigm even when everyone is a price taker and the allocation is efficient.

Walker (1988) shows that Walras gave many accounts of markets undergoing repeated price adjustments that bring them progressively closer to equilibrium. In this paper the author is attempting to establish the general character of the mathematical

technique by which Walras believed that the theorist can solve a set of simultaneous equations, and thereby to lay the foundation for distinguishing his economic theory of Tatonnement from that technique. The author also shows that Walras was concerned with real markets in his economy theory in general and in his theory of economic Tatonnement in particular.

According to Lerner (1970) the Tatonnement model has two concepts, a) the Walrasian Tatonnement process so as to distinguish from the b) the Walrasian Tatonnement price adjustment equation. The purpose in formulating the problem in this way is to further refine a loose end in the traditional treatment of the correspondence principle between dynamic stability and comparative static stability. This study demonstrates an interest in the price adjustment equation concept rather than the process. Here, the speed of convergence of a stable general equilibrium can be profitably investigated via an economizing model. If the cost of economic change is a monotically increasing function of the speed of change, then the motion that minimizes the sum of the static and dynamic costs of equilibrium can be defined. This conceptualization of dynamic methodology has been used in this research to investigate some feature of Walrasian Tatonnement price adjustment model. The illustration outlined in this paper suggest at least two general areas in which the extension of this methodology may prove useful. a) It may be possible to predict lags of the behavior of micro and macro units from the measurement of costs, rather of past lag behavior. b) when dynamic systems are subject to design by policy makers, they may be organized with some consciousness of the costs of different speeds of adjustment rather than only the stability property.

Ginsburgh, and Waelbroeck (1979), show their motivation to write this paper due to their recent experiences which suggest that Tatonnement process may prove quite efficient in computing equilibria. These processes are in fact today the only effective method of solving equilibrium models of realistic size. Their weakness relative to Scarf (1960) type of algorithms is that convergence is not guaranteed.

General equilibrium problems can be solved by several Tatonnement processes. Price Tatonnement is of course well known. Mantel (1971) has proposed a welfare weight adjustment process, and compare its stability properties with those of price Tatonnement. Dixon (1975), introduces a utility adjustment process, and applied it to a simple model. Ginsburgh and Waelbroeck (1979) suggest a fourth process, and applied this one and Dixon's to an equilibrium model of the world economy. The fourth process is generated from one optimizing model by means of minor changes, and it is easy to switch to another process when one approach has failed to converge. It appears worthwhile to make the minor investment in additional programming which permits switching among the four processes instead to be restricted to only one.

Turner(1992) demonstrates the use of a basic program which represent the process of Tatonnement and recontracting in the search of the of the Walrasian equilibrium vector of market prices. It is argued that this program can provide to students with intuitive understanding of the economic model, because of the parallels between the behavior of the hypothetical Walrasian auctioneer and the interactive search procedure embedded in the algorithm. The program also facilitate the rapid calculation of a wide range of numerical examples and facilitates the demonstration of a number of important points

relevant to general equilibrium theory. Preferences and endowment are highlight as important in the determination of equilibrium. Theory emphasizes that Walrasian Tatonnement process is logically equivalent to a computer search algorithm for the market clearing vector of prices. In addition, Jones, and Judge (1990), utilize spread sheets package with graphic capabilities in teaching of dynamic economic models, demonstrating how spreadsheet can be used to assist in the development and understanding of dynamic models and their properties.

Walter (1988) and Joyce (1984) outlines the results of experiments analyzing the Walrasian Tatonnement mechanism, and identifies the following characteristics: only one price exists at a time; there is an information mechanism notifying all traders of the price; there is a mechanism for determining quantities offered for sale and purchase at the price; and transactions at nonequilibrating prices are forbidden. In addition, the auctioneer uses the Walrasian pricing rule and the change in price has the same sign as the excess demand. The treatment variable used in the experimental design is the degree of segregation of buyers and sellers. Complete segregation results in limited information that is sellers are unable to discover the number of buyers, likewise buyers are unable to discover the number of sellers at the announced price. The results show that the auction mechanism is stable, exhibits strong convergence properties and efficiency levels averaging better than 97%. A significant evaluation of demand relative to supply occurs when buyers are segregated from sellers. In a Walrasian Tatonnement market, the Walrasian pricing rule must be followed: $P'=dp/dt$ has the same sign as the excess demand ($E(p)=D(p)-S(p)$).

Vickrey(1961) points out that in a market where the auctioneer relies upon the buyers and sellers for information on quantity that is needed to revise price, both have an incentive to misinform the auctioneer. The misinformation provided by both sellers and buyers tend to under-reveal their quantity, given the quantity on the other side of the market. This differential reduction in quantity will cause the price to move in favor of the side which is more restrictive. Given the payoff structure, every cent the price rises(falls) for sellers (buyers) is an additional cent they will be paid if the market clears. Since the induced supply and demand schedules are symmetric, neither side has a larger potential pay off than the other, and one would expect the under revelation of quantity to be the same on both sides of the market. If this is the case, the expected result is that the market-clearing price is at the theoretical equilibrium, but quantity is less.

Schatzer and Heady (1982), develop a model to address the future of US crop production. A model based in the theory of Tatonnement market convergency is developed to estimate approximate equilibrium prices and quantities for barley, corn, oats, sorghum, soybeans, and wheat. This model attempts to answer whether the real problem is represented by the quantity of crop production, or by the price of the quantity that is available. Schatzer, English, and Heady (1985), add that the effects of future yields on agricultural commodity may affect the adjustment process between prices and quantities. They suggest that future price-quantity relationships may be influenced by the level of crop yields. This Tatonnement model uses a national interregional linear programming in conjunction with an econometric model of demands. The Tatonnement

model links the demand and supply equations to solve for approximate equilibrium prices and quantities for the year 2000.

Saari, and Williams (1985), declare that for certain informational decentralized economic models, the associated dynamically process need not be locally stable. In addition they identify the causes of the conflict between the local stability of the process and the decentralization of information. This motivates a resolution for this problem. The method describes how approximate, local information about the economy can be used to modify a decentralized dynamic procedure to achieve local stability. Procedural guidelines are provided for establishing the decentralized systems with which the agents communicate appropriate information. This approach provides a partial response to the well-known convergence problems with the Tatonnement model. For a dynamic, economic mechanism to be meaningful, it should satisfy certain economic properties such as the appropriate incentive constraints. A most basic requirement is that it converges to an equilibrium, failure to achieve this convergence, results in the invalidation the mechanism's objective. This study successfully describes procedures that achieve local stability through decentralized communication.

Saari (1985) point out that a mechanism is not always effective if an iterative price mechanism depends upon a finite or limited amount of information from the market as given by the aggregate demand function in pure exchange economies where this mechanism will not find a price equilibrium. This statement already holds in the case of two commodities. The approach used to reach this conclusion extends to other iterative systems used to determine the zeros of a function. However, Friesz, Bernstein, and

Mehta (1994) adds that more information increases the processes of adjustments toward an stable equilibrium point.

Arrow & Hurwicz (1958) states that central to the ordinary economic theory is the equilibrium of supply and demand. However, this is the result of a process, not as a state holding at every instant of time. On the contrary, inequalities between supply and demand are usually regarded as an integral part of the process by which the price on a market reaches its equilibrium tenant. This observation implies that a fundamental aspect of the theory of price equilibria is to understand those natural economic processes which will terminate at an equilibrium position. One of the difficulties in the design of an economic process is to justify the form of the dynamic. To circumvent this problem all possible forms of dynamics are considered and are a) based upon the commonly accepted notions of what constitutes an equilibrium, and b) the price adjustment process is based upon the reaction of the people in the market as reflected by the inequalities of supply and demand.

Flaschel (1991) concludes from his examination of the price-quantity disequilibrium that a cross-dual dynamic structure occurs when production enters the market as Walras approach suggests. This structure closely parallels the classical process of equalizing profit rates and fluctuates as a result of price changes. Some of the propose changes to cross-dual dynamics greatly improves its stability. This suggests that a chain effect is set in motion where the direction and degree of change impacts the future price and quantity fluctuations. If changes are sufficiently strong the whole economy will move toward equilibrium. Furthermore, this integration of additional economic forces

gives rise to a dynamic system which provides a new example for the abstract discussion of so-called Generalized Newton Methods, i.e. depending on the strength of the derivative terms the new dynamics will have fairly universal stable properties.

CHAPTER III

METHODOLOGY AND DATA

This chapter focuses upon the procedure used to determine the availability of the CRP lands after the termination of their contracts. The primary interest of this study are prices, quantity demanded by consumers, and crop production, not livestock production. Therefore, the location of livestock production is fixed. To accomplish this endeavor, the models and data utilized in developing an economic model for the CRP lands are presented. This chapter shows the framework for developing a technique to reach equilibrium on the supply and demand models by documenting; the choice of demand models, the estimation of the demand models, the data used to obtain different estimations, the forecast of values for the commodities, the estimation of the supply models, and the Tatonnement model used to link the demand and supply models. The Tatonnement model is the mathematical tool used to find the equilibrium point. This mathematical tool requires both demand and supply equations.

An econometric approach is employed in developing the eleven demand equations. However, in developing the supply equations a linear programming model is used. These set of equations are combined to obtain equilibrium by using the Tatonnement model.

Demand Models

The demand equations are explained by a set of independent variables. These variables are selected following information provided by the USDA Economic Research Service (ERS). Corn feed is positively related to cattle on feed or more general to the number of units (includes pork and poultry). Corn feed is also related to prices of competing feed grains such as feed wheat, and soybean meal. Barley use is directly related to corn prices, because barley may be substituted by corn in the feed ratio. Barley grain is positively related to the number of animal units and the feeding rate. Sorghum faces strong competition from other energy feeds (feed grains). This competition is basically in prices. Soybean meal is the major protein meal fed to livestock and poultry. Demand of soybean meal is related to supply and prices of other competing meals (cottonseed). Wheat and corn have a moderated substitution effect. Feed used of oats are positively related to the grain consuming animal units. The selection of variables for the food equations are also provided by ERS. English, Short, and Heady (1981), and Schatzer and Heady (1982), show that the relationship between the independent variables and the dependent variables are in compliance with the economic theory. The feed and food equations are estimated using the above information.

Eleven demand equations are obtained for the crops. These demand equations are determined for feed, food, and export at the national level. Because the export demand equations are difficult to estimate using the time series data, elasticities used by APAC (1994) are employed to estimate the demands. The parameters of the models satisfy the economic theory, that is the direction of the sign is inversely related to its own price,

directly related to its competitive price, and inversely related to its substitute price (Nicholson, 1992).

The classical assumptions of the normal linear regression model indicates that the least squares estimators of the regression coefficients are found to be unbiased and efficient (Kmenta, 1986, Green, 1993, Johnston, 1984, and Madala, 1985). The linear regression models are satisfied when perfect collinearity does not exist, heteroscedasticity is not present, and there is no autocorrelation. If any of these three assumptions are violated, then the result concerning the properties of the square estimators can not longer be considered established. If the error term of one model is correlated to an error term of another model, then Seemingly Unrelated Regression Equations (SURE) approach is the preferred technique to estimate the demand equations. Using matrix notation, linear regression is expressed as follow:

$$Q_1 = Y_1 * \beta_1 + \varepsilon_1 \qquad 3.1$$

$$Q_2 = Y_2 * \beta_2 + \varepsilon_2 \qquad 3.2$$

.

.

$$Q_M = Y_M * \beta_M + \varepsilon_M \qquad 3.3$$

or

$$Q_m = Y_m * B_m + \varepsilon_m \qquad (m=1,2,.....,M) \qquad 3.4$$

Where:

$Q_m = (T * 1)$ vector of endogenous demands, the assumption is that the Q vector is a stochastic variable

$Y_m = (T * K_m)$ vector of prices and other exogenous variables, the Y variable is assumed to be nonstochastic

$\beta_m = (K_m * 1)$ vector of parameters for the independent variables

the β parameters are assumed to be linear

$\varepsilon_m = (T * 1)$ vector of error terms of each demand equation

the error term ε_m is assumed to be normally distributed

$E(\varepsilon_{mt}) = 0$ $\qquad$ $(t=1,2,.....,T)$

the expected value of the ε_m is assumed to be equal to zero.

The above assumptions are related to classical linear regression models. Initially, simple regression models were run obtaining satisfactory results in most of the equations. But Seemingly Unrelated Regression Equations (SURE) was conducted in order to further improve the results.

$$E(\varepsilon_m \varepsilon'_m) = \sigma_{mm} I_T \qquad 3.5$$

Where:

$I_T = T * T$ is an identity matrix $\qquad$ 3.6

$\left(\frac{Y'_m Y_m}{T}\right)$ is nonsingular $\qquad$ 3.7

This means that each equation was expected to satisfy the assumption of the classical linear regression model within each model. Because the error terms were correlated among the equations, SURE, as used below, were employed to obtain the demand equations.

$$E(\varepsilon_m \varepsilon'_p) = \sigma_{mp} I_T \qquad (m,p = 1,2,.....,M) \qquad 3.8$$

where: σ_{mp} is the covariance of the disturbances of the mth and p^{th} equation,

The only link between the mth and p^{th} equation is the covariance, which was assumed to be constant over all observations. Because the demand functions estimated in this study have a subtle error term link among them, SURE is the ideal model to used. Variables used to estimate the demand equations, variables identification, description, and sources are presented in the following tables (Table 3.1 and Table 3.2).

Estimated Demand Models

After selecting the independent variables for each of these demand equations, the estimated parameters were observed to determine if they comply with the economic theory. Information provided by the ERS, English, Short, and Heady (1981), and Schatzer, and Heady (1982), was also used to determine variable selection. The signs of the parameters in these equations comply with those of the economic theory. Using the results of these studies as a base, the models estimated in this study were improved.

The following are the eleven demand equations used to iterate with the supply equations:

$$BRDFED_{1i} = \alpha_1 + \beta_{11} BRTPR_{1i} + \beta_{12} CNTPR_{1i} + \beta_{13} SMTPR_{1i} + \beta_{14} MKTPR_{+1i} \varepsilon_{1i} \qquad 3.9$$

$$CNDFED_{2i} = \alpha_2 + \beta_{21} CNTPR_{2i} + \beta_{22} SMTPR_{2i} + \beta_{23} BLTPR_{2i} + \beta_{24} PKSPDN_{2i} + \varepsilon_{2i} \qquad 3.10$$

$$GSDFED_{3i} = \alpha_3 + \beta_{31} GSTPR_{3i} + \beta_{32} CNTPR_{3i} + \beta_{33} BFSPDN_{3i} + \varepsilon_{3i} \qquad 3.11$$

$$SMDDOM_{4i} = \alpha_4 + \beta_{41} SMTPR_{4i} + \beta_{42} WHTPR_{4i} + \beta_{43} BFTPR_{4i} + \beta_{44} LMSTPR_{4i} + \varepsilon_{4i} \qquad 3.12$$

Table 3.1. Variable identification, description, and sources of the data used to estimate the demand equations.

Variable ID	Variable Description	Data Sources
BFSPDN	Beef production, carcass weight, U.S.(mil.lbs.)	AgStat 72, p 417;AgOutYr 490, p. 16 1960-87; AgOut 791, p. 44 1988;AgOut 892, p. 46 1989; AgOut 993, p. 50 1990-91; WorldAgS&D 1093, p. 27 1992
BFTPR	Beef liveweight average price received by farmers, U.S. ($/cwt)	AgStat 72, p. 367; AgStat 86, p. 264 1971-73; AgStat 89, p. 267 1974-87; AgOut 791, p. 40 1988-89; AgOut 993, p. 47 1990-92
BLTPR	Broilers: Average price received by farmers, U.S. (cnt/lb.)	AgStat 72, p. 481; AgStat 86, p. 355 1971-73; AgStat 89, p. 358 1974-86; AgOut 1290, p. 49 1987-88; AgOut 992, p. 43 1989; AgOut 993, p. 47 1990-92
BRDFED	Barley feed demand and residual, U.S. (mil. bu.)	HistCom 790, Table 4; AgStat 492, p. 47 1986-89; WorldAgS&D 493, p. 9 1990; WorldAgS&D 1093, p. 9 1991-92
BRDOTH	Barley other domestic demand (food,seed, and industrial), U.S. (mil. bu.)	HistCom 790, Table 4; AgStat 492, p. 47 1986-89; WorldAgS&D 493, p. 9 1990; WorldAgS&D 1093, p. 9 1991-92
BRTPR	Barley season average price received by farmers, U.S. ($/bu)	HistCom 790, Table 4; AgOut 492, p. 47 1986-89; WorldAgS&D 493, p. 9 1990; WorldAgS&D 1093, p. 9 1991-92
CNDFED	Corn feed demand and residual, U.S. (mil. bu.)	HistCom 790, Table 2; FdSitYr 292, p. 32-34 1975-89; WorldAgS&D 493, p. 8 1990; WorldAgS&D 1093, p. 8 1991-92
CNDOTH	Corn other domestic demand (food, seed, industrial), U.S. (mil. bu.)	HistCom 790, Table 2; FdSitYr 292, p. 32-34 1975-89; WorldAgS&D 493, p. 8 1990; WorldAgS&D 1093, p. 8 1991-92
CNTPR	Corn seson average price received by farmers, U.S. ($/bu.)	FdSitYr 292, p. 28 1975-89; WorldAgS&D 493, p. 8 1990; WorldAgS&D 1093, p. 8 1991-92
CPIFO	Consumer price index for all food, U.S. (1982-1984=100)	EconRptPres 193, p. 414 1950-91; AgOut 993, p. 47 1992
CPIFS	Consumer price index for fish and seafood, U.S. (1982-84=100)	EconRptPres 193, p. 414 1950-91; AgOut 993, p. 47 1992
GSDFED	Grain sorghum feed demand and residual, U.S. (mil. bu.)	HistCom 790, Table 3; AgOut 492, p. 47 1986-89; WorldAgS&D 493, p. 9 1990; WorldAgS&D 1093, p. 9 1991-92
GSDOTH	Grain sorghum other domestic demand (food, seed, and industrial), U.S. (mil bu.)	HistCom 790, Table 3; AgOut 492, p. 47 1986-89; WorldAgS&D 493, p. 9 1990; WorldAgS&D 1093, p. 9 1991-92
GSTPR	Grain sorghum season avearge price received by farmers, U.S. ($/bu.)	HistCom 790, Table 3; AgOut 492, p. 47 1986-89; WorldAgS&D 493, p. 9 1990; WorldAgS&D 1093, p. 9 1991-92
LMSPRD	Lamb and mutton production, carcass weight, U.S. (mil. lbs.)	AgStat 72, p. 417; AgOutYr 490, p. 17 1960-88; Ag Out 892, p. 46 1989; AgOut 993, p. 50 1990-92
LMTPR	Lambs: Liveweight avearge price received by farmers, U.S. ($/cwt.)	AgStat 72, p. 393; AgStat 86, p. 286 1971-73; AgStat 89, p. 289 1974-86; AgOut 1290, p. 49 1987; AgOut 791, p. 41 1988-89; AgOut 993, p. 47 1990-92
MKTPR	Milk average combined price, U.S. ($/cwt.)	HistCom 790, Table 17; AgOut 993, p. 51 1985-92

Table 3.1. Continued.

Variable ID	Variable Description	Data Sources
OTDFED	Oats feed demand and residual, U.S. (mil. bu.)	HistCom 790, Table 5; AgOut 492, p. 47 1986-89; WorldAgS&D 493, p. 9 1990; WorldAgS&D 1093, p. 9 1991-92
OTDOTH	Oats other domestic demand (food,seed, and industrial), U.S. (mil. bu.)	HistCom 790, Table 5; AgOut 492, p. 47 1986-89; WorldAgS&D 493, p. 9 1990; WorldAgS&D 1093, p. 9 1991-92
OTTPR	Oats season average price received by farmers, U.S. ($/bu.)	HistCom 790, Table 5; AgOut 492, p. 47 1986-89; WorldAgS&D 493, p. 9 1990; WorldAgS&D 1093, p. 9 1991-92
PERCAP	Per capita disposable personal income in 1987 dollars, U.S. (bil 1987 $)	EconRptPres 193, p. 377; SurCurBus 293 p. 12 1992
PERDIN	Personal income, disposable in 1987 dollars, U.S. (bil. 1987 $)	EconRptPres 193, p. 377; SurCurBus 293 p. 12 1992
PESDIN	Personal disposable income, U.S. (bil. $)	EconRptPres 193, p. 377; SurCurBus 293 p. 12 1992
PKSPDN	Pork production, carcass weight, U.S. (mil. lbs.)	AgStat 72, p. 418; AgOutYr 490, p. 16 1960-87; AgOut 1290, p. 52 1988; AgOut 892, p. 46 1989; AgOut 993, p. 50 1990-91; WorldAgS&D 1093, p. 27 1992
SMDDOM	Soybean meal domestic demand, U.S. (thou. tons)	Fat&OilSit 1158, p. 13; Fat&OilSit 1165, p. 12 1958-59; AgOutYr 490, p. 31 1960-64; Fat&OilSit 690, p. 28 1965-85; AgOut 492, p. 47 1986-87; AgOut 793, p. 50 1988-90; WorldAgS&D 1093, p. 17 1991-92
SMTPR	Soybean meal season average price, U.S. ($/ton)	Fat&OilSit 1158, p. 13 1950-56; Fat&OilSit 1165, p. 11 1957-64; OilSit&Out 690, p. 28 1965-85; AgOut 492, p. 47 1986-87; AgOut 793, p. 50 1988-90; WorldAgS&D 1093, p. 17 1991-92
SYTPR	Soybean season average price received by farmers, U.S. ($/bu.)	HistCom 790, Table 7; AgOut 492, p. 47 1986-89; WorldAgS&D 992, p. 17 1990; WorldAgS&D 1093, p. 17 1991-92
TKSPDN	Turkey production, U.S. (mil. lbs. ready to cook)	AgOutYr 490, p. 19; AgOut 1290, p. 52 1988; AgOut 992, p. 46 1989; AgOut 993, p. 50 1990-91; WorldS&D 1093, p. 27 1992
TKTPR	Turkey average price received by farmers, U.S. (cnt/lb.)	AgStat 72, p. 490; AgStat 86, p. 361 1971-73; AgStat 89, p. 364 1974-86; AgOut 1290, p. 49 1987-88; AgOut 992, p. 43 1989; AgOut 993, p. 47 1990-92
WHDFED	Wheat feed demand and residual, U.S. (mil. bu.)	HistCom 790, Table 1; WhtSitYr 392, p. 46 1983-89; WorldAgS&D 493, p. 6 1990; WorldAgS&D 1093, p. 6 1991-92
WHDOTH	Wheat other domestic demand, U.S. (mil. bu.)	Computed (WHDDOM-WHDFOD-WHDFED), 1950-59; WhtSit 890, p. 41 1960-83; WhtSitYr 392, p. 52 1984-1989; WorldAgS&D 493, p. 6 1990; WorldAgS$&D 1093, p. 6 1991-92
WHTPR	Wheat season average price received by farmers, U.S. ($/bu.)	WhtSitYr 392, p. 53; WhtSitYr 392, p. 51-52 1983-1989; WorldAgS&D 493, p. 6 1990; WorldAgS$&D 1093, p. 6 1991-92

Agricultural Policy Analysis Center (APAC), 1994

Table 3.2 Source abbrevation and source citation of the data used to estimate the demand equations.

Source Abbreviation	Source Citation
AgOut 1290	U.S. Department of Agriculture. Agricultural Outlook. December 1990.
AgOutYr 490	U.S. Department of Agriculture. Agricultural Outlook Yearbook. April 1990.
AgOut 492	U.S. Department of Agriculture. Agricultural Outlook. March 1992.
AgOut 791	U.S. Department of Agriculture. Agricultural Outlook. July 1991.
AgOut 793	U.S. Department of Agriculture. Agricultural Outlook. July 1993.
AgOut 892	U.S. Department of Agriculture. Agricultural Outlook. August 1992.
AgOut 992	U.S. Department of Agriculture. Agricultural Outlook. September 1992
AgOut 993	U.S. Department of Agriculture. Agricultural Outlook. September 1993.
AgStat 72	U.S. Department of Agriculture. Agricultural Statistics 1972. U.S. Government Printing Office (Washington, D.C.: 1972).
AgStat 86	U.S. Department of Agriculture. Agricultural Statistics 1986. U.S. Government Printing Office (Washington, D.C.: 1986).
AgStat 89	U.S. Department of Agriculture. Agricultural Statistics 1989. U.S. Government Printing Office (Washington, D.C.: 1989).
EconRptPres 193	Economic of the President: Transmitted to the Congress, Feburary 1993. U.S. Government Printing Office (Washington, D.C.: 1993).
FdSitYr 292	U.S. Department of Agriculture. Feed Situation and Outlook Yearbook. USDA Economic Research Service Report No. FdS 321. Feburary 1992.
Fat&OilSit 1158	U.S. Department of Agriculture. The Fats and Oils Situation. USDA Agricultural Marketing Service Bulletin No. FOS-193. November 1958.
Fat&OilSit 1165	U.S. Department of Agriculture. The Fats and Oils Situation. USDA Agricultural Marketing Service Bulletin No. FOS-230. November 1965.
HistCorn 790	U.S. Department of Agriculture. Historical Commodity Data Series 1950-87. USDA Agricultural Stabilization and Conservation Service, Program Analysis Division Report. July 1990.
OilSit&Out 690	U.S. Department of Agriculture. Oil Crops Situation and Outlook Yearbook. USDA Economic Research Service Report No. OCS-26. July 1990.
WhtSitYr 392	U.S. Department of Agriculture. Wheat Situation and Outlook Yearbook. USDA Economic Research Service Report No. WS-296. March 1992.
WhtSit 890	U.S. Department of Agriculture. Wheat Situation and Outlook. USDA Economic Research Service Report No. WS-290. August 1990.
WorldAgS&D 493	U.S. Department of Agriculture. World Agricultural Supply and Demand Estimates. USDA Economic Research Service and Foreign Agricultural Service Report No. WASDE-277. April 1993.

Agricultural Policy Analysis Center (APAC), 1994.

$$WHDFED_{5i} = \alpha_5 + \beta_{51} WHTPR_{5i} + \beta_{52} CNTPR_{5i} + \beta_{53} LMTPR_{5i} + \beta_{54} TKSPDN_{5i} + \varepsilon_{5i} \quad 3.13$$

$$OTDFED_{6i} = \alpha_6 + \beta_{61} OTTPR_{6i} + \beta_{62} WHTPR_{6i} + \beta_{63} BFTPR_{6i} + \beta_{64} PKSPDN_{6i} + \varepsilon_{6i} \quad 3.14$$

$$WHDOTH_{7i} = \alpha_7 + \beta_{71} CNTPR/WHTPR_{7i} + \beta_{72} SYTPR_{7i} + \beta_{73} PESDIN_{7i} + \varepsilon_{7i} \quad 3.15$$

$$CNDOTH_{8i} = \alpha_8 + \beta_{81} CNTPR_{8i} + \beta_{82} MKTPR_{8i} + \beta_{83} CPIFO_{8i} + \beta_{84} PERDIN_{8i} + \varepsilon_{8i} \quad 3.16$$

$$BRDOTH_{9i} = \alpha_9 + \beta_{91} BRTPR_{9i} + \beta_{92} SYTPR_{9i} + \beta_{93} MKTPR_{9i} + \beta_{94} CPIFS_{9i} + \beta_{95} PERCAP_{9i} + \varepsilon_{9i} \quad 3.17$$

$$GSDOTH_{10i} = \alpha_{10} + \beta_{101} GSTPR_{10i} + \beta_{102} OTTPR_{10i} + \beta_{103} LMTPR_{10i} + \varepsilon_{10i} \quad 3.18$$

$$OTDOTH_{11i} = \alpha_{11} + \beta_{111} OTTPR_{11i} + \beta_{112} WHTPR_{11i} + \beta_{113} TKTPR_{11i} + \beta_{114} PESDIN_{11i} + \varepsilon_{11i} \quad 3.19$$

The five export demand models are derived from their own price elasticities. These elasticities were used because of the complexity involved in first estimating and secondly forecasting a significant set of export demand models.

Data

The next step, in studying CRP lands for the year 2005, is the obtaining of data for the estimation of the demand equations. The demand equations, as mention before, are selected based on the ERS information, the economic theory, and studies such as English, Short, Heady (1981) and Schatzer, and Heady (1982). The data use in this study were time series data which is obtained from the Agricultural Policy Analysis Center (APAC, 1994), (Appendix A, Table A1). This data covered the period from 1950 to 1992, and included livestock, and crops. Livestock consisted of quantities and prices for beef, pork, mutton, turkey, poultry, eggs, and dairy products. In similar manner, Crops consisted of quantities and prices for corn, barley, soybeans, sorghum, oats, and wheat.

In addition, macroeconomics time series data were obtained for the consumer price index for all food (CPIFO), consumer price index for fish and seafood (CPIFS), per-capita disposable personal income (PERCAP), disposable personal income (PERDIN), and personal disposable income (PESDIN), all in 1987 US dollars. The above variables were employed in determining the demand models, and the forecast values.

Three types of demand equations were considered: a) demand equations for feed, b) demand equations for food, and c) demand equations for export. Feed equations were estimated for corn-feed, barley-feed, oats-feed, soybean meal-feed, wheat-feed, sorghum-feed. Food equations are corn-food, barley-food, soybeans-food, oats-food, and wheat-food. Export equations are obtained indirectly from the price elasticities used in the National Agricultural Policy Simulator (POLYSIM).

The supply model is represented by an inter-regional linear programming model. In addition, linear programming has the capability to deal with optimal pattern of production, production location, transportation flows, and supply prices. The model used in this study was based in models previously developed at the Center for Agricultural and Rural Development (CARD), and the model is used for the year 2005.

Unlike crop production, the location of livestock production was exogenously determined. However, no estimation of livestock product demands, water demands, and nitrogen supplies were included. The regional product demands were converted to feed demands, through a set of rations, water demand through a set of water use coefficients, and nitrogen supply through a procedure developed at (CARD) by Short and Dvoskin (1982).

Forecasting Model

The estimation of the demand equations include prices and other explanatory variables. Since the available data ranged from 1950-1992, and the study projects to the year 2005, forecasting was required. The livestock and crops values were forecasted by using an extrapolation procedure. This extrapolation was conducted by using the double exponential smoothing method, PROC FORECAST SAS. The advantage of using the double exponential method is that the recent data is more heavily weighted than early data. Because observations of the data indicate a linear trend, a double exponential method was selected. The method is presented below:

$$F_{t+1} = w * X_t + (1-w) * F_t \qquad 3.20$$

where: w is the smoothing constant

F_{t+1} is the smoothed value of the time series for time $t+1$

X_t is the actual value of the time series for period t

F_t is the forecast of the time series for period t

After obtaining the smoothed series, an exponential smoothing is used to produce a further smoothing (equation 3.20 and 3.21), which is called double smoothing.

$$F^2_{t+1} = w * F_{t+1} + (1-w) * F^2_t \qquad 3.21$$

The values forecasted in the area of livestock were beef, pork and milk. Values forecasted in the crop area were related to corn, wheat, oats, sorghum, barley, and soybeans. In addition, some macroeconomics indicators were also forecasted. As

indicated above, Time series data for the years 1950-1992 were obtained from the Agricultural Policy Analysis Center (APAC, 1994).

Supply Model

The spatial Linear Programming model (LP) is used to portray the supply side of the model. This model is composed of livestock, and crops, where livestock are estimated outside the model, and crops are estimated within the model. Because LP models have limitations in analyzing aggregate equilibrium conditions, both prices and quantities can not be solved by a linear programming model, therefore one of these conditions should be assumed fixed. Linear models can determine the optimal pattern of production including resource use, production location, transportation flows, and supply prices given quantities of demand is fixed. Or, given a fixed level of prices, the supply quantities can be determined along with resource use, production location, and transportation flows (English, 1989; Schatzer and Heady, 1982) . To overcome these restrictions, the Walrasian Tatonnement approach is utilized.

Linear Programming: Objective Function

The model used in this study was an inter-regional model with seven sectors. These sectors were integrated to represent the production processes, and driven forces of the US agriculture (English, Smith, Atwood, and Oamek, 1989). Crop production, livestock production and pasture/range production comprised the production processes in this study. The resource availabilities were defined by irrigation and other inputs, and

land availability. The final sector consisted of transportation, and demands. The description of variables used in the mathematical formulation for the sectors and objective function are presented (Table 3.3 and Table 3.4).

Following English et. al (1989) study, the objective function in this model was to minimize the cost of the crop sector, water sector, range/forest sector, livestock sector, land conservation sector, fertilizer sector, and transportation sector. The costs are expressed in each summation operator by coefficients and the activities. The coefficients are variables beginning with C and the activities are variables beginning with X.

***Crop Sector*:**

$$\sum_{i=1}^{I}\sum_{J=1}^{J}\sum_{k=1}^{K}\sum_{m=1}^{M}\sum_{w=1}^{W}\left(CI_{i,j,k,m,w} * XI_{i,j,k,m,w}\right)+\sum_{i=1}^{I}\sum_{J=1}^{J}\sum_{k=1}^{K}\sum_{m=1}^{M}\left(CD_{i,j,k,m} * XD_{i,j,k,m}\right)+ \qquad 3.22$$

***Water Sector*:**

$$\sum_{i=1}^{I}\sum_{w=1}^{W}\left(CWA_{i,w} * XWA_{i,w} * \frac{WEO_{i,w}}{WEI_{i,w}}\right)+ \qquad 3.23$$

***Range/Forest Sector*:**

$$\sum_{e=10}^{E}\sum_{f=1}^{F}\sum_{g=1}^{G}\sum_{h=1}^{H}\left(CG_{e,f,g,h} * XG_{e,f,g,h}\right)+ \qquad 3.24$$

***Livestock Sector*:**

$$\sum_{p=1}^{P}\sum_{q=1}^{Q}\left(CA_{p,q} * XA_{p,q}\right)+\sum_{p=1}^{P}\sum_{n=1}^{N}\sum_{u=1}^{U}\left(CJ_{p,n,u} * XJ_{p,n,u}\right)+ \qquad 3.25$$

***Land Conservation Sector*:** 3.26

$$\sum_{i=1}^{I}\sum_{r=1}^{R}\left(CLP_{i,r} * XLP_{i,r}\right)+\sum_{i=1}^{I}\sum_{w=1}^{W}\left(CMIDC_{i,j,w} * XMDIC_{i,w}\right)+\sum_{i=1}^{I}\sum_{w=1}^{W}\left(CMIDC_{i,j} * XMDIC_{i,w}\right)+$$
$$\sum_{i=1}^{I}\left(CMWET_{i} * XMWET_{i}\right)+\sum_{i=1}^{I}\sum_{j=1}^{J}\left(CC_{i,j} * XCRSD_{i,j}\right)+\sum_{i=1}^{I}\sum_{j=1}^{J}\sum_{W=1}^{W}\left(CC_{i,j,w} * XCRSI_{i,j,w}\right)+$$
$$\sum_{i=1}^{I}\sum_{j=1}^{J}\left(CID_{i,j} * XIDD_{i,j}\right)+\sum_{i=1}^{I}\sum_{j=1}^{J}\sum_{w=1}^{W}\left(CID_{i,j,w} * XIDI_{i,j,w}\right)+$$

Table 3.3. Description of variables used in the mathematical expression of the linear programming model.

Variable Name	Variable Description
$CA_{p,q}$	unit cost of livestock production in CPA (p) for livestock type (q) (dollars per cwt of primary product)
$CBC_{i,j,k,m}$	sale of crops from in the producing area (i), land group (j), rotation (k) employing tillage practice(m) (dollars per acre)
$CBL_{p,q}$	sale of livestock production from CPA (p) for livestock type(q) (dollars per cwt of primary product)
$CD_{i,j,k,m}$	cost of dryland cropping practices in producing area (i), on land group(j), rotation (k), and employing tillage practice (m) (dollars per acre)
$CE_{p,c}$	cost of exporting commodity (c) from Great Lakes region to east coast CPAs (p) (7,10, and 11) (dollars per unit)
CF_p	unit cost of fertilizer in CPA (p) (dollars per pound)
$CG_{e,f,g,h}$	unit cost of forage production in ecosystem (e), productivity class (f), condition class (g), with management strategy (h) (dollars per acre)
$CJ_{p,n,u}$	unit cost of feeding crop (n) for livestock type (u) in CPA (p) (dollars per unit)
$CLP_{i,r}$	cost of converting potential cropland into producing area (i) and conversion type (r) (dollars per acre)
$CMDIC_{i,j}$	cost of converting an acre of nonirrigated land to irrigated land in producing area (i) on land group (j) (dollars per acre)
$CTA_{t,u}$	unit cost of transporting endogenous commodity (u) over transportation route (t) (dollars per cwt)
$CTC_{t,n}$	unit cost of transporting endogenous commodity (n) over transportation route (t) (dollars per unit)
$FA_{p,q}$	amount of manure (expressed in nitrogen equivalents) produced in CPA (p) by livestock type (q)
$FD_{i,j,k,m}$	amount of nitrogen required by a dryland cropping practice in producing area (i), land group (j), rotation (k), and conservation tillage practice (m) (pounds)
$JA_{p,q,z}$	amount of nutrient (z) required by the livestock production activity type (q) in CPA (p)
$JJ_{p,n,v,z}$	amount of nutrient (z) supplied by one unit of commodity (n) to major livestock type (v) in CPA (p)
$MAXR_u$	maximum percent roughage that can occur in the ration and maintain the level of yield for livestock type (u)
$MINR_u$	minimum percent roughage that can occur in the ration and maintain the level of yield for livestock type (u)
$NA_{p,q,u}$	amount of replacement stock required of major livestock type (u) for livestock production activity (q) in CPA (p)

Table 3.3. Continued.

Variable Name	Variable Description
$PDRY_{i,j}$	percent of dryland in land group (j) and producing area (i) that is converted when one dryland acre is converted to irrigated land
$PLR^{e}_{i,j,r}$	percent of land in ecosystem (e) having potential of (r) in producing area (i) and land group (j)
$RB_{p,b}$	amount of feed required by the exogenous livestock in CPA (p) for feed type (b)
$RCRS_{i}$	amount of land in the Conservation Reserve for producing area (i)
$RDC_{p,n}$	amount of commodity (n) demanded in CPA (p)
$RDCN_{n}$	amount of crop commodity (n) demanded at a national level (This RHS value exists only for those crops with no transportation network)
$RDL_{p,u}$	amount of livestock commodity (u) demanded in CPA (p)
$REX_{s,c}$	level of exports for commodity (c) in exporting region (s)
RF_{p}	level of fertilizer available (required) by exogenous agriculture in market (p)
$RLCRP_{n,p}$	amount of land that is planted in crop (n) in CPA (p)
$RLCTL_{i}$	maximum quantity of land available for conservation tillage cropping practices in producing area (i)
$RLDY_{i,j}$	amount of land available for endogenous dryland cropland production in land group (j) and producing area (i)
$RLG_{e,f,g}$	quantity of grazing land in ecosystem (e), productivity class (f), and condition class (g)
RLIN	minimum number of acres irrigated
$RLTER_{p}$	amount of land required to be in terraces in CPA (p)
$RLTOT_{i}$	total amount of land required to come into solution in producing area (i)
$RLZTL_{i}$	amount of zero or no tillage that can come into the solution in producing area (i)
RPR^{a}_{p}	quantity of pasture available in CPA (p) and ownership category (a) (when the grazing sector is endogenous and a = 1, this value is 0)
RPRT	maximum tons from the range sector
$SWDD_{i,j,k,m}$	per acre wind erosion coefficient for dryland farming in producing area (i), and group (j), rotation (k), and conservation tillage practice (m)

Table 3.3 Continued.

Variable Name	Variable Description
$SWID_{i,j,w}$	per acre sheet and rill erosion coefficient from land not used in the production of commodities in producing area (I), land group (j), and, if from irrigated cropland, water source type (w)
$SWTD_{i,j,k,m}$	per acre sheet and rill erosion coefficient for dryland farming in producing area (i), land group (j), rotation (k), and conservation tillage practice (m)
$SWTI_{i,j,k,m,w}$	per acre sheet and rill erosion coefficient for irrigated land farming in producing area (i), and group (j), rotation (k), and conservation tillage practice (m)
$WTC_{n,i,j,k,m}$	percentage of crop (n) in producing area (i), land group (j), rotation (k), and conservation tillage practice (m)
$XA_{p,q}$	activity level of livestock production type (q) in CPA (p)
$XB_{p,n}$	activity level to transfer crop (n) so that exogenous livestock needs can be met in CPA (p)
$XBC_{i,j,k,m}$	activity crop sale for producing area(i), land group (j), rotation (j), and conservation /tillage practice (m)
$XBL_{p,q}$	activity livestock sale for the CPA (p), and production type (q)
$XCRSD_{i,j}$	activity level of land moving into the Conservation Reserve in producing area (i), land group (j)
$XD_{i,j,k,m}$	activity level of dryland crop production in pro=producing area (i), land group (j), rotation (k), and conservation/tillage practice (m)
$XE_{p,c}$	amount of commodity (c) transferred from the CPA (p) final demand constraints to the exporting regions
XF_{p}	level of nitrogen purchasing activity in CPA (p)
$XG_{e,f,h}$	level of range activity in ecosystem (e), productivity class (f), condition class (g), under management level (h)
$XIDD_{ij}$	activity level of idle land in producing area (i) and land group (j)
$XCRSD_{i,j}$	activity level of idle land in producing area (i) and land group (j)
$XJ_{p,n,u}$	level of crop (n) used for major endogenous livestock type (u) in market region (p)
$XLP_{i,r}$	quantity of potential land type (r) in producing area (i) that is converted to cropland
$XTA_{t,u}$	amount of major livestock type (u) transported on route (t); a superscript I indicates an Import into a region, E an Export
$XTC_{t,n}$	amount of crop (n) transported on route (t); a superscript I indicates an Import into a egion, E an Export
$XWE_{i,d}$	amount of water exported in producing area (i) to destination (d)

Table 3.3 Continued.

Variable Name	Variable Description
$XWO_{i,d}$	amount of water outflow in producing area (i) to destination (d)
$YA_{p,q,u}$	yield for major livestock type (u) in livestock category (q) in market region (p)
$YD_{n,i,j,k,m}$	dryland yield for crop (n) in producing area (i), land group (j), rotation (k), and tillage practice (m)
$YG_{p,e,f,g,h}$	proportion of pasture/range yield in CPA (p) that is in ecosystem (e), productivity class (f), condition class (g), under range management practice (h)

Burton English, et al. Technical Report 89-TR11, Center for Agriculture and Rural Development, 1989

Table 3.4. The definition for each of the subscripts in the mathematical representation of the linear programming.

Subscripts Definition	Ranges
a	1, 2 for the two pasture/range ownership categories (1 private and 2 public)
b	1, ..., 3 for the three exogenous crop categories
c	1, ..., 6 crop and 7, ... ,10 livestock exporting activities
d	1, ...D destinations of water outflows and exports
e	10, ..., 44 ecosystems
f	1, ..., 4 Range/Forest productivity classes
g	1, ..., 3 Range/Forest condition classes
h	1, ..., 90 Range/Forest strategies management
I	15,18,19,20,21,31,33,34,35,36,37,38,43,44,45 crop production areas
J	1, ..., 8 land groups
K	1, ..., 500 single crop and 509, ..., 516 double crop rotation sequences
M	1, ..., 12 conservation tillage possibilities
n	1, ..., 16 endogenous crops
P	1..31 on needed CPA
Q.	1, , 14 livestock types
r	1, ..., 4 potential land conversion activities
s	1, ..., 3 for the three exporting regions
t	1, ..., 967 transportation routes
u	1, ..., 7 for the seven major livestock production categories: dairy, pork, grain-fed beef, roughage-fed beef, calves, yearlings, and feeder pigs
v	1, ..., 5 for five livestock production categories: dairy, pork, cow/calf/yearling, grain-fed beef, and roughage-fed beef
z	1, ..., 6 for the six nutrient types

Burton English, et al. Technical Report 89-TR11, Center for Agriculture and Rural Development, 1989.

Fertilizer Sector:

$$\sum_{p=1}^{P}\left(CF_p * XF_p\right. \qquad 3.27$$

Transportation Sector:

$$\sum_{t=1}^{T}\sum_{n=1}^{N}\left(CTC_{t,n} * XTC_{t,n}\right)+\sum_{t=1}^{T}\sum_{u=1}^{U}\left(CTA_{t,u} * XTA_{t,u}\right)+\sum_{c=1}^{C}\sum_{p=7,10,11}\left(CE_{c,p} * XE_{c,p}\right. \qquad 3.28$$

Linear Programming: Constraints

Fertilizer Constraints (CPA):

In this study, the fertilizer constraint was used to balance the amount of nitrogen required for dry land (*FD*) and irrigated land (*FI*) production practices. The amount purchased was represented by the activity (*XF*). The amount produced was indicated by the endogenous livestock (*FA*), and the amount required/supplied was represented by the exogenous commodities (*RF*). This constraint was estimated for livestock producing areas and market regions (Figure 3.1 and Figure 3.2).

$$\sum_{i\in P}\sum_{j=1}^{J}\sum_{k=1}^{K}\sum_{m=1}^{M}\left(FD_{i,j,k,m} * XD_{i,j,k,m}+\left(\sum_{w=1}^{W}FI_{i,j,k,m,w} * XI_{i,j,k,m,w}\right)\right)-\sum_{q=1}^{Q}\left(FA_{p,q} * XA_{p,q}\right)- \qquad 3.29$$
$$XF_p \leq RF_p$$

Water Sector Constraints (CPA):

This section focused upon information about water sources, that is, ground water and surface water. Water requirements (*WR*) represented the amount of water needed for rotation in a production area. The incidental efficiency of water (*WEI*) was more effective when water supply was required to meet the rotation needs. The yearly supply

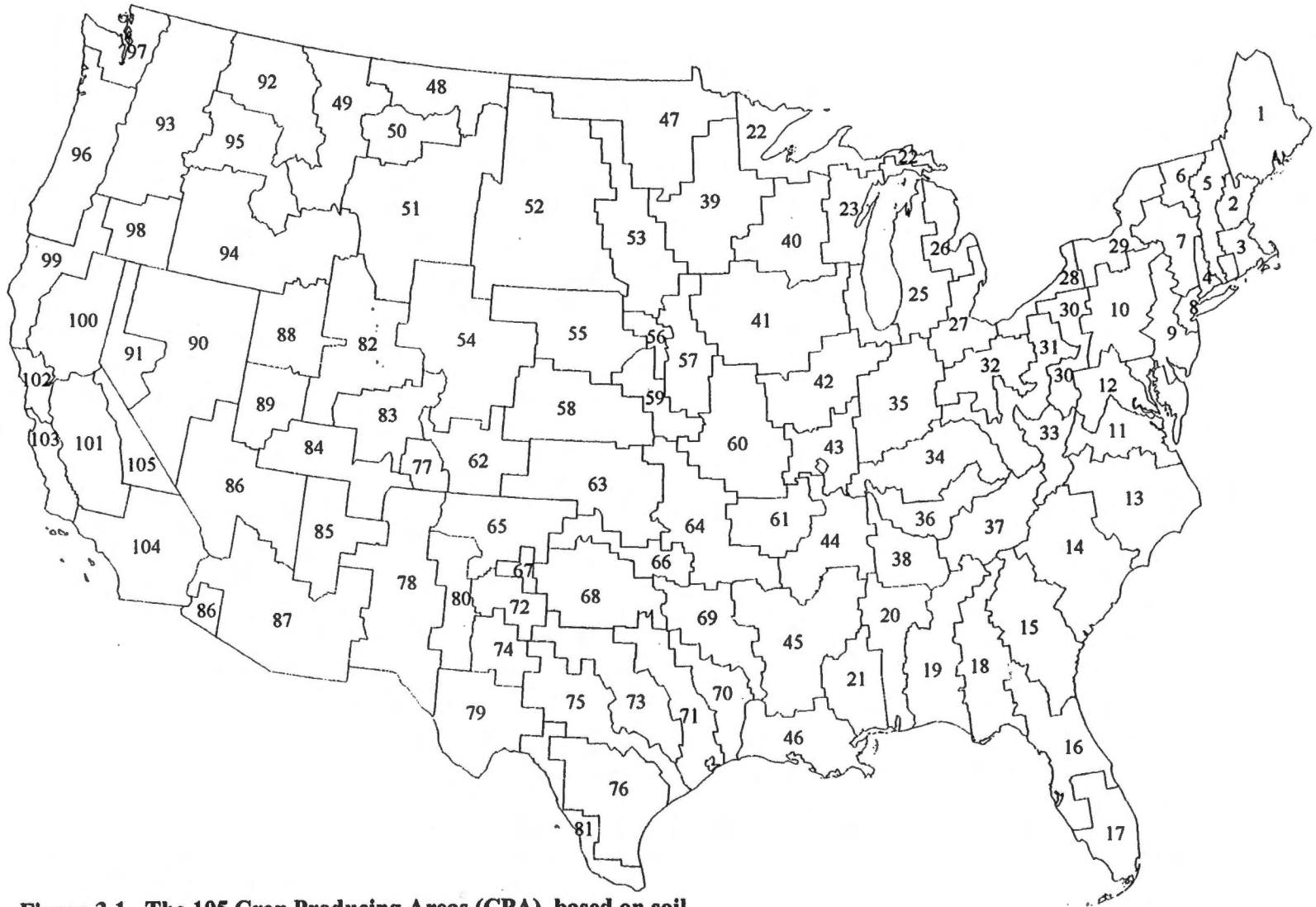

Figure 3.1. The 105 Crop Producing Areas (CPA), based on soil characteristics

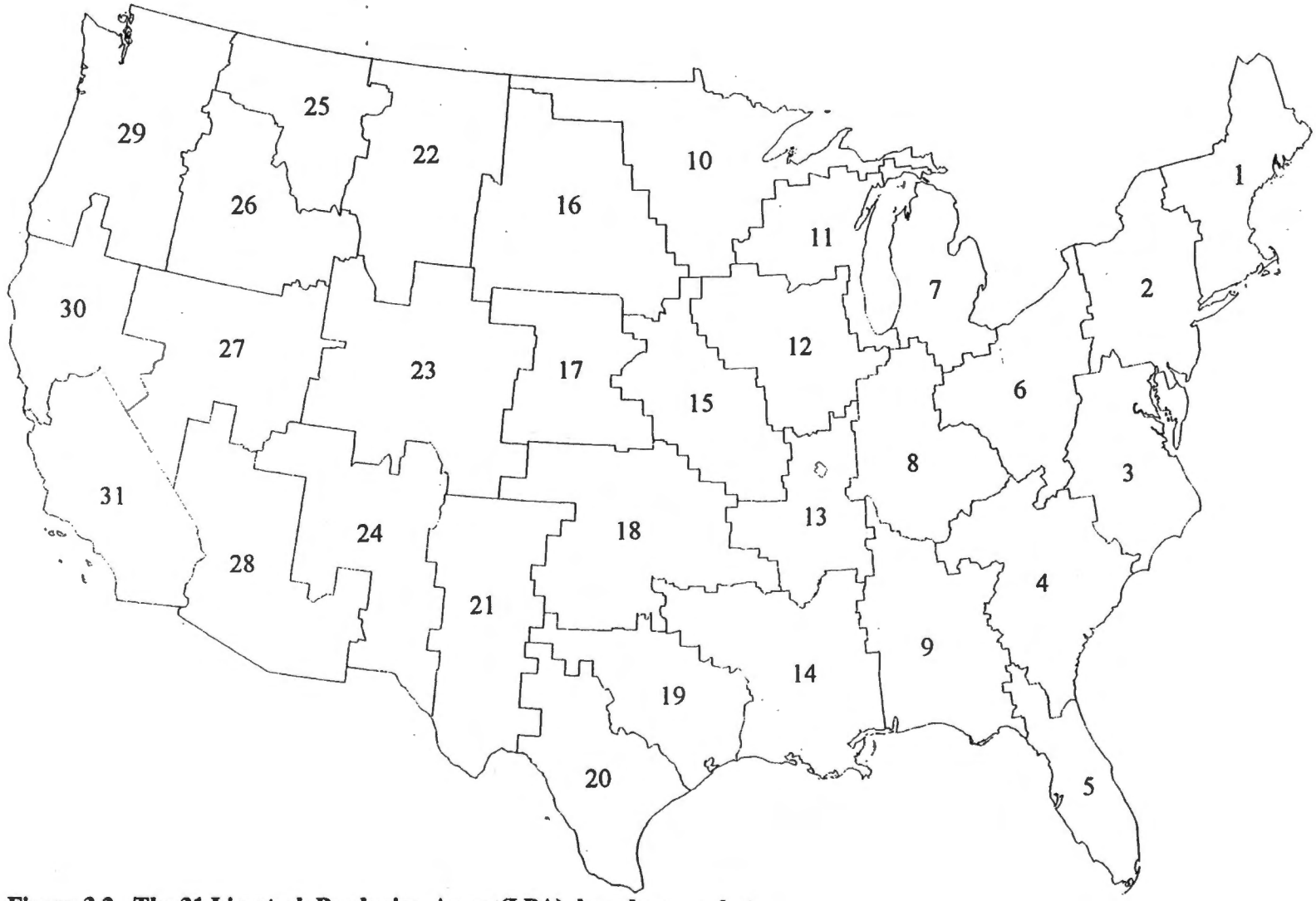

Figure 3.2. The 31 Livestock Producing Areas (LPA), based on market regions

of ground water sources were not restricted. However in moving from one period to the next, the costs of acquiring groundwater were adjusted to reflect increases in depth to water. The amount of water available to surface source irrigation activities was limited by what was available minus the net amount of water exported from the region. The water constraint takes the following form:

$$\sum_{j=1}^{J}\sum_{k=1}^{K}\sum_{m=1}^{M}\left(\left(XI_{i,j,k,m,w} * WR_{i,k,w}\right) - \left(WEI_{i,w} * XWA_{i,w}\right)\right) \geq 0$$

when {w = 1, XWA_i is uncostraint 3.30

when {w = 2, $XWA_{1,2} + \sum_{d=1}^{D} XWE_{i,d} + \sum_{d=1}^{D} XWO_{i,d} \leq RWS_{i,2}$

Erosion Accounting Rows (CPA):

The erosion constraintaddressed two types of erosion, water (sheet and rill) and wind erosion. These equations accounted for the erosion that occurred under both dry and irrigated crop production activities, idle land, and conservation land.

$$\sum_{j=1}^{J}\sum_{k=1}^{K}\sum_{m=1}^{M}\left(SWTD_{i,j,k,m} * XD_{i,j,k,m} + \left(\sum_{w=1}^{W} SWTI_{i,j,k,m,w} * XI_{i,j,k,m,w}\right)\right) + \sum_{j=1}^{J}\left(SWCR_{i,j} * XCSRD_{i,j} + \sum_{w=1}^{W}\left(SWCR_{i,j,w} * XCSRI_{i,j,w}\right)\right) + \sum_{j=1}^{J}\left(SWID_{i,j} * XIDD_{i,j} + \sum_{w=1}^{W}\left(SWID_{i,j,w} * XIDI_{i,j,w}\right)\right) \geq 0 \quad 3.31$$

Wind Erosion (CPA):

$$\sum_{j=1}^{J}\sum_{k=1}^{K}\sum_{m=1}^{M}\left(SWDD_{i,j,k,m} * XD_{i,j,k,m} + \sum_{w=1}^{W}\left(SWDI_{i,j,k,m,w} * XI_{i,j,k,m,w}\right)\right) \geq 0 \quad 3.32$$

Land Constraints(CPA):

In the model, the land constraint accounted for ten different types of land, which were active at various regional levels. Land availability or shift restrictions were defined

by seven of these constraints. Two of the three remaining constraints, at the market region, are restricted land-area patterns for crop and terraced land. One of these constraints, which is the ecosystem constraint, defined the amount of resource available for grazing. The last constraint was defined at the national. This constraint indicated that the irrigated land be at least equal to the pre-specified quantity of land. These constraints were expressed in the following form:

Total Land Constraint (CPA):

$$\sum_{j=1}^{J}\sum_{k=1}^{K}\sum_{m=1}^{M}\left(XD_{i,j,k,m}+\sum_{w=1}^{W}\left(XI_{i,j,k,m,w}\right)\right)+\sum_{j=1}^{J}\left(XCRSD_{i,j}+\sum_{w=1}^{W}\left(XCRSI_{i,j,w}\right)\right)+ \sum_{j=1}^{J}\left(XIDD_{i,j}+\sum_{w=1}^{W}\left(XIDI_{i,j,w}\right)\right)\geq RLTOT_i \qquad 3.33$$

Dryland Constraint (CPA):

$$\sum_{k=1}^{K}\sum_{m=1}^{M} XD_{i,j,k,m}-\left(PDRY_{i,j}*XMDIC_i\right)+XCRSD_{i,j}+XIDD_{i,j}+ \sum_{w=1}^{W}\left(PIRR_{i,j,w}*XMIDC_{i,w}\right)+\sum_{r}\left(PLR^{e}_{i,j,r}*XLP_{i,r}\right)\leq RLDY_{i,j} \qquad 3.34$$

Conservation Tillage Land Constraint (CPA):

$$\sum_{j=1}^{J}\sum_{k=1}^{K}\sum_{m=9}^{M}\left(XD_{i,j,k,m}\right)\leq RLCTL_i \qquad 3.35$$

Zero Tillage Land Constraint (CPA):

$$\sum_{j=1}^{J}\sum_{k=1}^{K}\sum_{m=13}^{M}\left(XD_{i,j,k,m}\right)\leq RLZTL_i \qquad 3.36$$

Terraced Land Constraint (CPA):

$$\sum_{i \in p} \sum_{j=\alpha} \sum_{k=1}^{K} \sum_{m=\beta} \left(XD_{i,j,k,m}\right) \geq RLTER_p \qquad 3.37$$

$$here: \ \alpha = 4,8,12,16 \ \ and \ \ \beta = 2,3,4,8$$

Crop Acreage Constraint (CPA):

$$\sum_{i \in p} \sum_{j=1}^{J} \sum_{k=1}^{K} \sum_{m=1}^{M} \left(WTC_{n,i,j,k,m} * XD_{i,j,k,m}\right) \geq RLCRP_{n,p} \qquad 3.38$$

Conservation Reserve Constraint (CPA):

$$\sum_{j=1}^{J} \left(XCRSD_{i,j}\right) \geq RCRS_i \qquad 3.39$$

Grazing Land Constraint (ecosystem):

$$\sum_{h} XG_{e,f,g,h} + \sum_{i \in e} PLR^{e}_{i,j,r} * XLP_{i,r} \leq RLG_{e,f,g} \qquad 3.40$$

Final Demands

Within the model, there were several different types of demand-defining constraints. Basically, the domestic consumption was less or equal to the regional production plus the imported production minus the exported production and minus the internal feed consumption. Three commodities, such as cotton, peanuts, and sunflowers did not have transportation networks, therefore a national demand was defined. These demands were presented in the following form:

Crop (CPA):

$$\sum_{i \in p}^{I} \sum_{j=1}^{J} \sum_{k=1}^{K} \sum_{m=1}^{M} \left(YD_{n,i,j,k,m} * XD_{i,j,k,m}\right) - XE_{p,c} - XB_{p,n} + \sum_{t \in p} \left(XTC^{I}_{t,n} - XTC^{E}_{t,n}\right) - \sum_{u=1}^{U} XJ_{n,p,u} \geq RDC_{p,n} \qquad 3.41$$

Other Demands

Export demands for the Atlantic, the Gulf, and the Pacific coast were additional constraints in the linear programming model. Feed grains, other concentrates, and roughages were needed by the exogenous livestock. Even though livestock obtained most of their food from endogenous sources, federal lands provided some of their food through grazing. Furthermore, private grazing lands could be included either exogenously or endogenously.

There were several other demand defining constraints required for the LP model. Export demands were identified for three coasts; Atlantic, the Gulf, and the Pacific. Exogenous livestock required feed represented in the defining of feed grains, other concentrates, and roughages. Finally, livestock do not get all feed from endogenous sources; some were produced on federal lands and harvested through grazing. In addition, private sources of grazing land could be represented either exogenously or endogenously. These equations were accounted for in the following form:

Export Demands (rest of nation):

$$\sum_{p \in s} XE_{p,c} \geq REX_{s,c}$$

$$where: \begin{cases} s = 1, p = 1,2,3,4,5,7,10,11 \\ s = 2, p = 9,14,19 \\ s = 3, p = 29,30,31 \end{cases} \qquad 3.42$$

Exogenous Feed Demands (CPA):

$$\sum_{n \in b} XB_{p,b} \geq RB_{p,b}$$

$$where: \begin{cases} b = 1, n = 1,2,3,7,10,11 \\ b = 2, n = 12 \\ b = 3, n = 3,5,6,11 \end{cases} \qquad 3.43$$

Roughage:

Roughage limiting constraint (CPA):

$$\sum_{n=\lambda} XJ_{n,p,q} * (1 - MINR_u) - \sum_{n=\theta} XJ_{n,p,q} * (MINR_q) \geq 0$$

$$\sum_{n=\lambda} XJ_{n,p,q} * (1 - MAXR_u) - \sum_{n=\theta} XJ_{n,p,q} * (MAXR_q) \geq 0 \qquad 3.44$$

$$where: \begin{cases} \lambda = 1,2,7,10,12,15,16 \\ \theta = 3,5,6,8,9,11,14 \end{cases}$$

To determine the exogeneity of livestock, the average weight for beef, pork, and milk were estimated over a four years span from 1990 to 1993. A weighted value (equation 3.45 and 3.46) is used to update this four year-average.

$$TSUM = \sum_{i=1}^{i} State_i \qquad \text{i=Alabama,...Wyoming} \qquad 3.45$$

$$STATE = \frac{State_i}{TSUM} * FORCAST \qquad 3.46$$

In order to project the consumption of food-stuffs required for beef production in the year 2005, the values from feed-stuffs required for beef production were multiplied by the upgraded average for livestock carcass weight for the year 2005. This product was then weighted by weights used to allocate livestock production from state to market region.

Livestock Production Areas (LPA) for beef were obtained following English et. al (1989). The final step in developing the rations per hundred pound live-weight was to weight the state values to the 31 livestock producing areas (LPA), and then sum over LPA providing the amount of feed required at the LPA level to meet the assumed projections levels.

The entire procedure used for projecting rations for beef was repeated a second and third time for projecting rations for pork and milk production. The rations needed for beef, pork and milk were converted to a common unit, that is "feed grain equivalent", using the following three equations (English, Disney, and Schraufnagel 1989): Equations 3.47, 3.48, and 3.49 aggregated feedgrains for beef pork, and milk respectively. The commodities aggregated were corn, sorghum, oats, barley, corn silage, corn silage, and sorghum silage.

$$FGRAIN = C + 0.96 * SG + 0.92 * O + 0.94 * B + 0.125 * CS + 0.11 * SGS \qquad 3.47$$

$$FGRAIN = C + 0.90 * SG + 0.90 * O + 0.90 * B \qquad 3.48$$

$$FGRAIN = C + SG + 0.90 * O + B + 0.10 * CS + 0.90 * SGS \qquad 3.49$$

where: C = corn fed

SG = sorghum fed

B = barley fed

CS = corn silage fed

SGS = sorghum silage fed

The results of these aggregations were used in the LP to estimate the livestock feed requirements.

Pasture demands:

Private (grazing sector exogenous):

$$\Sigma XJ^{a}_{p,8,u} \leq RPR^{a}_{p} \qquad 3.50$$

The prices utilized in equation 3.51 and 3.52 are the shadow prices of the linear programming (LP). The first solution of the LP was used as a baseline for the estimation of the export demand equations.

$$\varepsilon = \left(\frac{Q_2 - Q_1}{P_2 - P_1}\right) * \frac{P_2}{Q_2} \qquad 3.51$$

$$Q_2 = \frac{P_2 * Q_1}{P_2 - \varepsilon * (P_2 - P_1)} \qquad 3.52$$

where:

ε = the own price elasticity

P_2 = new price

P_1 = baseline price

Q_1 = baseline quantity

Q_2 = new quantity

P_1 and Q_1 were the shadow prices obtained from the first LP run. ε is the own price elasticity for the export demand equations. Q_2 represented the new export demand value. This new export demand was fed back in the LP to obtain the new iteration.

Tatonnement Model

Tatonnement model was used to link the demand models and the supply model. The Walrasian and Marshallian theories describe processes of adjustments or Tatonnement, which under some reasonable set of assumptions will restore markets to equilibrium. These two models assume that the markets function similar to an auctioneer. In the Marshallian system, the process begins at some non-equilibrium point. The auctioneer calls out a quantity and buyers and sellers respond with the price at which they would be willing to remove or produce that quantity. In the Walrasian system, the auctioneer calls a price and the consumers and suppliers reply with quantities they would be willing to purchase or sell given that price. But the sales are not final. If the quantities supplied and demanded do not equal then a new price different by the previous price in proportion to the differences in quantities is called.

In this study the Walrasian Tatonnement model was the selected model. This model allowed the iteration of the demand models and the supply models. In a general form the Tatonnement model operates as follow:

The estimated demand equations (3.9 through 3.19) and the export demand equations (3.51 and 3.52) were expressed as $Q(p)$, which mean Q as a function of price. These demand equations were used as constraints in the spatial linear programming. Next the supply equations (3.22 through 3.50) in the LP were denoted S as function of price, $S(p)$. The supply equations provided the shadow prices, which were substituted in the demand equations to obtain the new quantity demanded.

The Tatonnement model seeks to produce an equilibrium price, p^*, where demands and supplies clear the market ($Q(p^*)=S(p^*)$). For p^* to exists, the supply and demand curve must intersect.

Another important requirement for the existence of equilibrium is that of stability. To address the issue of stability, observation of the price path is noted, to see if the price, p, for a commodity converges to equilibrium price, p^*. The stability problem is overcome by assuring that when an excess demand occurs the price, p, increases, and when excess supply exists, the price, p, decreases. In order to achieve this stability, the MPSX (IBM, 1972) program was used to execute the linear programming model, where SURE was used to obtain the demand equations. Next Lotus 123 was utilized to link the supply and demand equations.

The spatial linear programming assumes fixed demands; therefore, the adjustment procedure will not be possible unless the LP is modified. Consumers must modify their actions. These modifications are represented by the demand equations. The producer's actions are represented by the spatial linear programming model. The modified steps were as follow:

1. A first run was conducted to obtain a set of baseline values. This baseline presented the initial quantity supply, and the shadow prices. The objective function of the SLP was to minimize costs, and the quantities of demand were represented at the regional level.
2. These national shadow prices, obtained from the first run, were used in the demand equations to determine the new quantities demanded.

3. The quantities demanded and supplied for each commodity were compared. This study was accepted to be in equilibrium, if the difference in absolute value, between quantities demanded and supplied were within the 5% range.
4. If the 5% range was not accomplished, a new set of national production quantities were determined by the shadow prices. Commodities in excess demand, and supply increase or decrease their shadow price respectively.
5. The procedure continue until convergence was attained. The process was completed when the quantity supply and demand were within the 5% range.

To observe the behavior of the Tatonnement model, for the case of an isolated market and for a single commodity, the starting point is the acquisition of the shadow prices, $P(t)$, which were used to calculate the demand, $D(t)$. This equation was written as follow:

$$D(t) = D(P(t)) \qquad 3.53$$

The new quantity demanded was used by the LP, as a constraint value (right hand side value (RHS)). This RHS value determined the new shadow price (supply price). The theoretical LP supply curve was presented in the following form:

$$S(t) = S(P(t)) \qquad 3.54$$

The absolute value of the difference between supply and demand equations (3.53 minus 3.54) was very small; this suggests a movement toward the equilibrium prices and quantities, as presented below:

$$\left|\frac{D(t)-S(t)}{D(t)}\right| \geq \mu, \qquad 3.55$$

where: μ was the selected accuracy value. The iteration procedure continues until the accuracy value was very small (5%).

$$p' = g[D(p(t))-S(p(t))] \qquad 3.56$$

where:

the function g represents some fixed monotone increasing differentiable real-valued.

Equation 3.55 represented in a more simply manner is presented as follows:

$$p' = k[D(p(t))-S(p(t))] \qquad 3.57$$

where:

$k>0$ symbolizes the speed of adjustment of the market.

The above equation presents two important conditions. The first condition is that the predominant market price is not affected by either suppliers or demanders. In other words they are both price takers. The second condition indicates that the price is the only adjustment parameter of the market. The adjustment procedure is understood to be instantaneous. The equations 3.56 or 3.57 (differential equations) indicates how the price moved. Excess demand varies with changes in prices, and stability is only obtained when the excess demand disappeared.

In summary, the Tatonnement model in this study, examines the adjustment of the supply and demand equations. The spatial linear programming portion of the model generated the shadow prices, this shadow prices were used in demand equations to adjust

the quantity demanded. With this adjustment, a comparison of the supply and demand was made to determine if equilibrium was achieved.

CHAPTER IV

RESULTS

Several modifications to the model developed by English et. al (1982) were required for use in this analysis. This modification required the updating of the livestock sector and changes to the land base. This chapter focuses upon the results of the updating of the data to be used for forecasting livestock, and crop values for the year 2005. In addition, the results of the estimation of the demand equations, and supply equations were presented, as accomplished by the linking of these set of equations through the Tatonnement model.

Livestock Sector

The updating of the data for livestock (beef and pork) and milk was conducted in the following manner. An estimation of a four-year average was performed. The data for these years were compiled from the United States Department of Agriculture (USDA) for the years 1990 to 1993. The averages were estimated at the state level, and the units of these data was carefully observed, (Table 4.1). The three states with the largest live-weight beef production were Texas, Nebraska, and Kansas. The leading areas for pork live-weight production were concentrated in Iowa, Illinois, and Minnesota. Finally the states with the largest milk production were Wisconsin, California, and New York.

Livestock, crops, and macroeconomic indicators were forecast for the year 2005, as indicated in Table 4.2. After obtaining the average live-weight for the four years, the

Table 4.1. State average production for beef, pork, and milk, 1990-93.

States Name	Beef (live-weight)	Pork (live-weight)	Milk
	Thousands of pounds	Thousands of pounds	Million of pounds
Alabama	642855.00	252548.00	531.33
Alaska	1623.25	465.00	14.00
Arizona	520535.00	44079.50	1818.98
Arkansas	591902.50	328106.75	816.95
California	1918602.50	85240.00	22640.58
Colorado	1934906.25	149959.50	1432.43
Connecticut	20630.00	2302.50	549.55
Delaware	10372.75	14094.25	139.48
Florida	428577.50	35618.00	2631.23
Georgia	412822.50	423831.00	1538.08
Hawaii	54835.00	8553.50	149.55
Idaho	834485.00	23166.25	3169.83
Illinois	775690.00	2392626.25	2776.48
Indiana	396392.50	1737402.50	2360.38
Kansas	3123265.00	657890.00	1237.08
Kentucky	758910.00	325649.50	2257.55
Louisiana	264075.00	18780.00	975.78
Maine	31850.00	5146.00	658.20
Maryland	103745.00	68714.75	1460.78
Massachusetts	16437.50	7548.50	488.28
Michigan	409337.50	472218.75	5534.65
Minnesota	1183386.25	1847770.25	10200.10
Mississippi	385177.50	61031.00	774.05
Missouri	1197922.50	822684.97	3035.23
Montana	1013110.00	92978.25	333.63
Nebraska	3757675.00	1747770.00	1290.88
Nevada	169842.50	4713.25	354.80
New Hampshire	12410.00	2346.75	331.23
New Jersey	20349.25	2442.75	369.40
New Mexico	619942.50	9806.00	2132.93
New York	325350.00	34299.00	11719.23
North Carolina	309580.00	1634762.75	1575.98
North Dakota	668897.50	97681.00	1046.93
Ohio	536826.25	802370.25	4842.20
Oklahoma	1893037.50	111913.25	1283.65
Oregon	532924.50	28051.75	1730.05
Pennsylvania	591332.50	315117.50	10519.78
Rhode Island	1709.00	1394.25	34.70
South Carolina	227288.75	157000.25	436.65
South Dakota	1736632.50	782345.75	1728.33
Tennessee	661402.50	246893.75	2149.93
Texas	6468268.75	207733.00	5814.50
Utah	345122.50	13184.75	1348.38
Vermont	59022.50	2607.50	2539.23
Virginia	562582.50	172547.25	2096.35
Washington	691000.00	18105.00	4838.83
West Virginia	158862.50	14641.00	283.30
Wisconsin	1171225.00	487264.75	24680.00
Wyoming	535140.00	12821.25	113.48

Table 4.2. A comparison of FAPRI and SAS forecast values for variables used in analysis, 2005.

Variables	Variable description	Units	SAS	FAPRI
BFSPDN	Beef production, carcass weight, U.S.(mil.lbs.)	(M. lbs.)	27477.29	26911
BRTPR	Barley season average price received by farmers, U.S. ($/bu)	($/Bu.)	2.378	2.36
WHTPR	Wheat season average price received by farmers, U.S. ($/bu.)	($/Bu.)	3.364	3.36
CNTPR	Corn seson average price received by farmers, U.S. ($/bu.)	($/Bu.)	2.552	2.57
CPIFO	Corn seson average price received by farmers, U.S. ($/bu.)	(82-84=100)	186.32	na
CPIFS	Consumer price index for fish and seafood, U.S. (1982-84=100)	(82-84=100)	217.153	na
BLTPR	Broilers: Average price received by farmers, U.S. (cnt/lb.)	(Cents/Bu	38.533	na
BFTPR	Beef liveweight average price received by farmers, U.S. ($/cwt)	($/Cwt)	76.842	na
GSTPR	Grain sorghum season avearge price received by farmers, U.S. ($/bu.)	($/Bu.)	2.419	2.39
LMSPRD	Lamb and mutton production, carcass weight, U.S. (mil. lbs.)	(M. Lbs.)	356.502	na
LMTPR	Lambs: Liveweight avearge price received by farmers, U.S. ($/cwt.)	($/Cwt)	69.532	na
MKTPR	Milk average combined price, U.S. ($/cwt.)	($/Cwt)	13.816	12.92
OTTPR	Oats season average price received by farmers, U.S. ($/bu.)	($/Bu.)	1.497	1.54
PERCAP	Per capita disposable personal income in 1987 dollars, U.S. (bil 1987 $)	($)	16333.93	na
PERDIN	Personal income, disposable in 1987 dollars, US (bil. 1987 $)	($)	4547.04	na
PESDIN	Personal disposable income, U.S. (bil. $)	($)	6662.57	na
PKSPDN	Pork production, carcass weight, U.S. (mil. lbs.)	(M. Lbs.)	18462.29	20291
SMTPR	Soybean meal season average price, U.S. ($/ton)	($/Ton)	223.344	222.91
SYTPR	Soybean season average price received by farmers, U.S. ($/bu.)	($/Bu.)	6.351	6.22
TKSPDN	Turkey production, U.S. (mil. lbs. ready to cook)	(M. Lbs.)	6518.56	6459
TKTPR	Turkey average price received by farmers, U.S. (cnt/lb.)	(Cents/Bu)	41.1	na
BRDFED	Barley feed demand and residual, U.S. (mil. bu.)	(M Bu.)	230.963	234
CNDFED	Corn other domestic demand (food, seed, industrial), U.S. (mil. bu.)	(M Bu.)	5564.09	5503
GSDFED	Grain sorghum feed demand and residual, U.S. (mil. bu.)	(M Bu.)	457.134	417
OTDFED	Oats feed demand and residual, U.S. (mil. bu.)	(M Bu.)	140.314	141
SMDDOM	Soybean meal domestic demand, U.S. (thou. tons)	(Th. tons.)	31336.72	31423
BRDOTH	Barley other domestic demand (food,seed, and industrial), U.S. (mil. bu.)	(M Bu.)	184.621	182
CNDOTH	Corn other domestic demand (food, seed, industrial), U.S. (mil. bu.)	(M Bu.)	2106.35	2067
GSDOTH	Grain sorghum other domestic demand (food, seed, and industrial), U.S. (mil bu.)	(M Bu.)	8.439	8
OTDOTH	Oats other domestic demand (food,seed, and industrial), U.S. (mil. bu.)	(M Bu.)	126.147	125
WHDOTH	Wheat season average price received by farmers, U.S. ($/bu.)	(M. Bu.)	1149.1	986

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total individuals sums for beef, pork, and milk were calculated these results were weighted by the forecast values for the year 2005. The procedure was conducted as indicated in equations 3.45 and 3.42. The new state values were obtained by multiplying the average state value by the forecast value and then this product was divided by the aggregated sum (*SUM*), (Table 4.3).

The forecast value for beef and pork were estimated at carcass weight level, therefore a conversion to live-weight was needed, (see Table 4.2). The conversion factors used to change the carcass-weight to live-weight were 0.561 and 0.579 (USDA) for beef and pork respectively. This conversion was accomplished by dividing the carcass-weight by the conversion factors, (see Table 4.3). These table shows beef and pork values converted to live weight values, which were updated to the year 2005. Milk was only weighted and updated to the year 2005.

Forecast values were estimated using PROC FORECAST, (see Table 4.2). These estimated parameters reflected the values of the different commodities for the year 2005. This table also compared the forecast values with those of Food and Agricultural Policy Research Institute (FAIR). FAIR values were included to have a measure of comparison with the values obtained by SAS. The results demonstrated that both values were almost similar. In this study, location of production of the livestock sector was considered to be exogenous. To obtain rations per hundred pound live-weight at the 31 livestock production areas (LPA), the feed requirements for beef, pork, and milk were estimated (see, Table 4.4 through Table 4.6). These estimations were derived by multiplying the feed requirements for beef in measures of pounds per hundred weight, at the state level,

Table 4.3. Beef, pork, and milk forecast production by states, 2005.

State Name	Beef (live-weight)	Pork (live-weight)	Milk
	Thousands of pounds	Thousands of pounds	Million of pounds
Alaska	1934.5470	652.7628	15.6232
Alabama	766137.8033	354524.6057	592.9282
Arkansas	705413.9443	460593.2978	911.6694
Arizona	620360.0213	61878.4047	2029.8718
California	2286540.3626	119659.1436	25265.5836
Colorado	2305970.7462	210511.7942	1598.5042
Connecticut	24586.2953	3232.2287	613.2663
Delaware	12361.9726	19785.3811	155.6461
Florida	510767.4739	50000.2273	2936.2962
Georgia	491991.0762	594970.1370	1716.4035
Iowa	2395227.1619	8322169.5507	4754.8364
Idaho	994517.4337	32520.5729	3537.3430
Illinois	924447.0879	3358747.1604	3098.3869
Indiana	472410.2312	2438949.9670	2634.0432
Kansas	3722225.6751	923540.0512	1380.5048
Kentucky	904449.1220	457143.8324	2519.2964
Louisiana	314717.6897	26363.1947	1088.9090
Massachusetts	19589.7833	10596.5163	544.8869
Maryland	123640.5821	96461.1466	1630.1411
Maine	37957.9984	7223.9084	734.5135
Michigan	487837.7442	662896.4242	6176.3521
Minnesota	1410328.8332	2593883.2195	11382.7268
Missouri	1427652.7564	1154877.7445	3387.1371
Mississippi	459044.4871	85674.7676	863.7954
Montana	1207398.0446	130522.0292	372.3064
North Carolina	368949.3605	2294865.2112	1758.6977
North Dakota	797174.5748	137123.7072	1168.3083
Nebraska	4478298.9479	2453503.7700	1440.5425
New Hampshire	14789.9140	3294.3465	369.6281
New Jersey	24251.7048	3429.1104	412.2292
New Mexico	738831.2841	13765.5744	2380.2220
Nevada	202413.8567	6616.4179	395.9365
New York	387743.6347	48148.6270	13077.9832
Ohio	639775.5076	1126360.1237	5403.6176
Oklahoma	2256072.6632	157102.8115	1432.4798
Oregon	635125.5038	39378.7938	1930.6366
Pennsylvania	704734.6331	442359.1057	11739.4657
Rhode Island	2036.7416	1957.2356	38.7232
South Carolina	270876.7975	220395.5356	487.2764
South Dakota	2069673.2681	1098249.9111	1928.7116
Tennessee	788242.2295	346587.2205	2399.1930
Texas	7708713.8025	291613.7127	6488.6486
Utah	411307.9840	18508.6332	1504.7092
Virginia	670471.1338	242220.2741	2339.4064
Vermont	70341.4744	3660.3850	2833.6295
Washington	823515.7572	25415.6358	5399.8513
Wisconsin	1395835.3730	684017.8634	27541.4650
West Virginia	189328.1794	20552.9038	316.1466
Wyoming	637765.8789	17998.3552	126.6316

Table 4.4. Estimated feed uses for Beef production, 2005.

LPA	Corn	Sorghum	Oats	Barley	Wheat	Oilmeal
			bushels			
1	472637.79	164032.20	73894.35	61962.36	29400.16	4531525.29
2	1429367.26	853150.19	216844.57	171718.99	104942.34	30980900.77
3	2011603.79	1090413.52	218724.69	275039.83	124554.99	30256064.15
4	2274297.99	1012437.19	467817.93	292347.91	100231.96	40757865.10
5	1177234.61	0.00	580735.64	135730.98	41512.32	14444146.83
6	1990421.90	950124.82	260398.46	235799.64	134538.22	42416920.87
7	1277587.43	837383.36	159393.48	175082.87	104570.82	27379097.65
8	5543612.81	1172282.76	971826.42	758769.06	386896.81	31329965.28
9	3076881.01	447275.55	1266651.94	372579.07	124639.15	41745866.84
10	2944063.17	2084610.92	341943.19	403477.51	253179.07	63261629.90
11	2636774.76	2078397.23	298915.10	408125.53	349713.16	48450239.15
12	7928293.25	1153459.78	2439733.08	1129006.31	534995.42	107317884.03
13	1866167.55	690742.10	551865.60	240300.87	107946.62	29700139.00
14	3484150.83	1533073.99	531104.34	459126.66	232444.26	45939656.61
15	10722489.30	5635329.46	2061268.62	1175512.26	547678.71	151295682.51
16	7046166.71	4335664.77	833885.65	907094.20	352386.56	131993557.52
17	10935306.53	8223670.90	1943564.74	860327.52	356082.52	135561466.66
18	12409141.95	1706144.61	3190323.77	1630110.94	622294.49	200420988.91
19	5582731.60	4008213.77	453366.01	811161.89	290729.58	106092731.45
20	4773773.27	3455857.97	386011.92	694266.04	246973.57	91812627.11
21	5285074.20	3141397.87	568519.03	701287.78	246312.69	105765005.85
22	1624303.57	634612.82	232687.16	172153.95	116501.56	33023959.29
23	6541704.87	6333010.60	2588219.52	741727.16	306779.24	85299735.79
24	1080175.07	691070.15	361908.50	119006.67	38575.05	17950724.79
25	850540.46	189816.70	150136.44	75293.86	32145.84	17684285.72
26	2527935.34	140954.27	1100486.82	286100.73	89380.52	35827919.87
27	967387.53	503302.60	139642.02	122939.62	45067.23	18525720.22
28	1535042.66	1503767.45	710913.05	174200.39	54281.47	20074032.74
29	2215800.48	1287441.33	209875.62	283263.68	97833.00	47216519.38
30	1730550.55	1824551.00	804026.04	193474.40	59658.58	23094375.05
31	3767744.88	4282286.52	1862301.38	432523.69	131267.08	46440049.80

Table 4.5. Estimated feed uses for pork production, 2005.

LPA	Corn	Sorghum	Oats	Barley	Wheat	Oilmeal
			bushels			
1	161883.65	5850.31	6617.47	3116.67	2469.18	4387150.40
2	2475600.41	241511.14	111058.40	49217.36	29548.14	75779739.70
3	13504619.61	539291.07	463559.21	217903.89	207388.04	341445219.22
4	5410812.32	178598.43	212644.37	93758.35	106957.46	151798775.88
5	731971.28	0.00	27203.58	11910.30	6861.04	20886501.28
6	5941662.36	201251.02	149846.93	84974.55	59277.29	147579184.58
7	7766116.80	473756.52	276490.45	153997.85	90275.68	227502102.65
8	20221060.46	101719.07	609049.82	283776.13	183645.50	525557399.36
9	3851054.62	52578.64	164425.29	71443.71	60176.43	107609842.19
10	11761557.68	1097385.04	486413.57	276859.06	157094.80	349544292.50
11	5310872.01	333079.89	196440.57	106816.33	59055.07	142905204.36
12	63869726.78	305524.56	2011612.70	947833.69	533047.67	1428624036.99
13	6496844.46	170889.04	238997.06	111494.97	79816.95	174707829.11
14	823834.25	45793.72	35946.41	18404.20	11420.42	24994330.86
15	26276400.88	673745.23	808384.54	421919.75	252438.82	765766378.42
16	11593384.94	603514.52	493159.47	222527.56	329626.86	332691211.97
17	6251003.09	179231.87	169320.42	94845.44	62736.02	251819847.65
18	4523803.30	57192.58	164792.11	79473.43	48626.95	159712160.21
19	515671.83	39044.64	29922.99	12482.59	25080.91	16618359.81
20	548623.88	41668.93	31887.08	13295.25	26781.80	17698430.91
21	351790.39	23300.93	17712.59	7807.73	13388.92	12350906.98
22	408811.30	18475.48	12008.01	7287.18	4835.50	11338207.14
23	1296509.01	13304.87	46444.72	21474.42	12959.13	46000211.90
24	189499.62	1306.36	7788.99	3483.95	2362.60	7297289.85
25	300470.45	13195.25	8960.40	5314.49	3989.93	8306071.58
26	200679.23	2578.65	7607.04	3471.16	2815.88	4864027.52
27	84400.87	5770.07	4491.96	1928.01	3596.35	2635079.48
28	226172.88	69.64	9467.19	4275.54	2426.70	9142017.92
29	304719.43	15243.15	10477.86	5291.85	6734.60	8349621.24
30	199420.27	1043.96	8076.10	3677.33	2170.21	7417851.13
31	462921.44	0.00	19576.32	8640.33	4974.52	17838332.91

Table 4.6. Estimated feed uses for milk production, 2005.

LPA	Corn	Sorghum	Oats	Barley	Wheat	Oilmeal
	bushels					
1	2771.15	80.93	813.34	223.35	90.53	50413.20
2	16454.35	875.16	5972.61	1686.20	439.92	422186.64
3	2425.28	116.45	777.19	221.15	80.04	51858.67
4	2314.82	49.18	716.14	174.28	69.40	44543.17
5	1394.88	0.00	563.70	125.03	30.27	33759.20
6	5301.82	354.16	1854.37	526.62	145.94	144105.30
7	3710.18	257.70	1541.60	456.68	110.51	102765.15
8	2297.81	38.89	773.77	216.01	62.39	49268.11
9	1051.75	16.78	366.51	86.58	30.55	21887.52
10	4859.96	388.16	1937.46	595.59	134.22	125636.02
11	12909.31	992.08	3457.50	1083.48	269.17	235706.59
12	6074.53	264.25	1916.19	526.93	133.11	124096.80
13	1007.73	36.09	406.66	106.45	28.29	25263.18
14	1614.92	68.17	528.45	150.87	57.54	32832.60
15	1809.85	98.16	723.91	207.65	50.29	47570.52
16	1957.41	61.21	573.25	149.36	64.53	36118.22
17	322.74	11.84	110.85	29.33	7.38	7684.66
18	1580.02	53.78	556.48	148.34	44.38	38162.66
19	1748.01	65.31	456.65	118.43	78.91	26106.97
20	626.67	23.72	161.90	41.63	28.72	9206.70
21	819.03	21.25	270.93	66.80	23.20	17987.87
22	65.62	3.97	22.85	6.37	1.71	1608.62
23	768.11	4.89	312.99	72.04	18.67	18498.96
24	930.80	20.66	324.16	78.91	23.22	21735.35
25	191.01	7.47	68.55	17.80	6.15	4482.23
26	1582.40	5.91	635.96	141.20	32.57	37759.11
27	697.29	25.41	241.94	61.32	34.50	14320.90
28	1052.52	3.15	424.18	95.35	24.53	25050.75
29	2418.54	136.47	925.87	255.06	131.44	60088.73
30	1967.95	6.21	793.01	178.46	45.58	46977.23
31	10407.57	0.00	4252.67	945.04	240.07	248134.84

(Appendix B, Table B1) by the upgraded value for beef for the year 2005 (see Table 4.3). This result provided the feedstuff required for beef production at the national level (see Appendix B, Table B3). Feedstuff needed for beef production is multiplied by weights (percentages) for beef (see Appendix B, Table B2). These weights were used for distribution of livestock production from state to market regions. Finally, weighted values were added over the LPA's, thus providing the amount of feed demanded at the LPA level for the year 2005. In order to project rations for milk and pork this entire procedure was repeated a second and third time.

These estimations were derived by multiplying the feed requirements for pork in measures of pounds per hundred weight, at the state level (see Appendix C, Table C1) by the upgraded value for pork for the year 2005 (see Table 4.3). This result provided the feedstuff required for pork production at the national level (Appendix C, Table C2). Feedstuff needed for pork production is multiplied by weights (percentages) for pork, (see Appendix B, Table B2). These weights were used for distribution of livestock production from state to market regions. Then, weighted values were added over the LPA's, thus providing the amount of feed demanded at the LPA level for the year 2005.

Finally, in order to estimate feedstuff requirements for milk production at the national level for the year 2005 (Appendix D, Table D2), measures of pounds per hundred weight was multiplied by at the state level (see Appendix D, Table D1) by the upgraded value for beef, pork, and milk for the year 2005. This result provided the feedstuff required for beef production at the national level (see Appendix D, Table D2). Feedstuff needed for beef production is multiplied by weights (percentages) for milk (see

Appendix B, Table B2). These weights were used for distribution of livestock production from state to market regions. Finally, weighted values were added over the LPA's, thus providing the amount of feed demanded at the LPA level for the year 2005.

The commodities listed in these tables (see Table 4.4 through Table 4.6) were converted to a common unit (feed grain equivalent). The results of the these aggregations were used in the LP, to represent livestock feed requirements.

Forecasting Model

Results from the forecasting model, which involved the double exponential method, revealed values for various crops, and livestock. In addition, the macroeconomic indicators were obtained to be used in the export demand equations (see Table 4.2). This table contains values for various commodities and prices. Included in the table were forecast values by FAPRI. These values by FAPRI when compared with the values forcasted by SAS showed much similarity. Values that were not price related were fixed in the demand equations, whereas prices were constantly changing in the iteration procedure.

Demand Model

The eleven demand equations for crops and concentrate showed the estimated parameters for feed and food. The values in parenthesis were the standard errors (Table 4.7 and Table 4.8). The results for the feed demands demonstrated that:

1) For the demand of barley-feed: the price of barley has a negative sign, and it is

Table 4.7. Estimated parameters for the feed demand models.

Variables	INTERC[a]	BRTPR	CNTPR	GSTPR	SMTPR	WHTPR	OTTPR	LMTPR	MKTPR	BFTPR	BLTPR
BRDFED[b]	241.04	-127.36	70.24		-0.11				9.78		
	(16.02)[c]	(22.50)*	(21.48)*		(0.11)				(2.28)*		
CNDFED	1110.15		-388.31		5.86						42.05
	(465.62)		(120.44)		(1.08)*						(9.04)*
GSDFED	217.86		328.50	-479.13							
	(84.00)		(106.9)*	(116.2)*							
SMDDOM	15666				-10.71	-993.99				215.52	
	(1591.8)				(4.65)*	(253.16)*				(16.29)*	
WHDFED	37.47		204.38			-195.25		3.02			
	(44.96)		(42.37)*			(28.70)*		(1.03)*			
OTDFED	833.60					68.57	-180.65*			-9.50	
	(141.23)					(21.82)*	(39.04)			(1.09)*	

a *INTER intercept, BRTPR price of barley CNTPR price of corn, GSTPR price of sorghum, SMTPR price of soybean meal, WHTPR price of wheat, OTTPR price of oats, LMTPR price of lamb, MKTPR price of milk, BFTPR price of beef, and BLTPR price of broiler; TKSPDN production of turkey, LMSPRD production of lamb, BFSPDN production of beef, and PKSPDN production of pork*

b *BRDFED barley-feed, CNDFED corn-feed, GSDFED sorghum-feed, SMDDOM soybean meal-feed, WHDFED wheat-feed, OTDFED oats-feed*

c *values in parenthesis are the standard error*

* *1% significance level.*

Table 4.7. Continued.

Variables	TKSPDN	LMSPRD	BFSPDN	PKSPDN
BRDFED				
CNDFED				0.12
				(0.03)*
GSDFED			0.02	
			(0.004)*	
SMDDOM		-10.58		
		(1.78)*		
WHDFED	0.05			
	(0.02)*			
OTDFED				0.012
				(0.01)*

Table 4.8. Estimated parameters for the food demand models.

	INTERC[a]	BRTPR	CNTPR	GSTPR	SYTPR	OTTPR	MKTPR	WHTPR	TKTPR	RATIO
BRDOTH[b]	54.91	-3.64			0.88		3.74			
	(5.26)[c]	(1.94)*			(0.71)		(0.40)*			
CNDOTH	-27.05		-42.68				-44.26			
	(38.82)		(16.74)*				(5.02)*			
GSDOTH	11.99			-5.28		3.61				
	(1.82)			(1.49)*		(1.86)+				
WHDOTH	539.70				6.78					-26.27
	(14.98)				(1.65)*					(18.47)*
OTDOTH	140.91					-32.07		9.15	-1.76	
	(6.61)					(6.26)*		(3.57)*	(0.31)*	

a *INTER intercept, BRTPR price of barley CNTPR price of corn, GSTPR price of sorghum, SYTPR price of soybean, OTTPR price of oats, MKTPR price of milk, WHTPR price of wheat, TKTPR price of turkey, Ratio of corn and wheat prices, LMTPR price of lamb, CPIFS consumer price index of fish, CPIFO consumer price index for all food, PESDIN personal disposable income, PERDIN personal income, PERCAP per capita personal disposable income*

b *BRDOTH barley-food, CNDOTH corn-food, GSDOTH sorghum-food, WHDOTH wheat-food, OTDOTH oats-food*

c *values in paranthesis are the standard errors*

* *1% significance level*

\+ *5% significance level.*

Table 4.8. Continued.

	LMTPR	CPIFS	CPIFO	PESDIN	PERDIN	PERCAP
BRDOTH		-0.11				0.007
		(1.67)*				(0.001)*
CNDOTH			13.14		0.12	
			(0.63)*		(0.03)*	
GSDOTH	0.14					
	(0.04)*					
WHDOTH				0.08		
				(0.002)*		
OTDOTH				0.014		
				(0.002)*		

significant at the 1% level. This implies that as the price of barley increases the quantity demanded for barley decreases. The price of corn has a positive sign indicating that corn is a substitute for barley. The parameter is also significant at the 1% level. Although the price of soybean meal has the correct sign, it is not significant at the 5% level. Finally, price of milk has the correct sign and is also significant at the 1% level.

2) For the demand of corn-feed: the price of corn has a negative sign, and it is significant at 1% level. This indicates that as the price of corn increases the quantity demanded decreases. The second parameter in this equation is soybean meal price, which has a positive sign, and 1% significance level. This implies that soybean meal is a substitute for corn-feed. The price of broilers has a positive sign, and it is significant at the 1% level. Finally, pork production has a positive sign, and it is significant at the 1% level. This indicates that increases in pork production would require increases in the demand for corn.

3) For the demand of sorghum-feed: the price of sorghum has negative sign, and it is significant at the 1% level, showing that as price of sorghum increases, the quantity demand for sorghum decreases. The price of corn has a positive sign, indicating that corn and sorghum are substitutes, and the corn parameter is significant at 1% level. Finally, the production of beef is positive related to the demand for sorghum, indicating that as the production of beef increases the quantity demand for sorghum also increases.

4) For the demand of soybean meal: the partial derivative soybean meal with respect to

its own price has negative sign, indicating that quantity demanded of soybean meal decreases as the price of soybean meal increases. The parameter of the soybean price is significant at the 1% level. The parameter of wheat price has a negative sign, and it is significant at the 1% level. This negative relation indicates that soybean meal and wheat are complements. Finally, the production of lamb has a positive sign, and it is significant at the 1% level. This positive relation indicates that as lamb production increases quantity demanded of soybean meal also increases.

5) For the demand of wheat-feed: price of corn has a positive sign, and it is significant at the 1% level. This positive relation indicates that wheat and corn are substitutes. The price of wheat is inversely related to the demand of wheat-feed, showing that as the price of wheat increases the quantity demand of wheat decreases. Finally, the production of lamb has a positive sign, and it is significant at the 1% level. This suggests that as the production of lamb increases the quantity demanded for wheat also increases.

6) For the demand of oats-feed: The price of oats has a negative sign, and it is significant at the 1% level. This implies as price of oats increases the quantity demanded for oats decreases. The price of wheat is positive, and the significance level is 1%. This indicates that that wheat is a substitute for oats. The price of beef has a negative sign, and it is significant at the 1% level. This shows that as the quantity of beef production decreases, the quantity of oats-feed also decreases. Finally, The production of pork has a positive sign, and it is significant at the 1% level. This indicates that as the production of pork increases the quantity of oats-feed also increases.

The results for the food demand equations revealed that 1) As price of barley, and consumer price index for seafood increase, the quantity demanded for barley-food decreased, likewise as price of soybean, price of milk, and per capita disposable personal income increased quantity of barley-food increased, 2) As price of corn, and price of milk increased the quantity of corn-food decreased, similarly as consumer price index for all food, and disposal personal income increased the quantity of corn-food increased, 3) As price of sorghum increased the quantity of sorghum-food decreased, likewise as price of oats, and price of lamb increased the quantity of sorghum-food increased, 4) As the ratio increased the quantity of wheat-food decreased, similarly as the price of soybeans, and personal disposable income increased, so the quantity of wheat-food increased, and 5) As price of oats, and price of turkey increased the quantity of oats-food decreased, likewise as price of wheat, and personal disposable income increased so the quantity of oats-food increased.

The export equations were indirectly obtained using equations (4.1 and 4.2). The elasticities used for these equations (Table 4.9) were their own price elasticities. These elasticities were obtained from the Agricultural policy Analysis Center (APAC).

$$\varepsilon = \left(\frac{Q_2 - Q_1}{P_2 - P_1}\right) * \frac{P_2}{Q_2} \qquad 4.1$$

$$Q_2 = \frac{P_2 * Q_1}{P_2 - \varepsilon * (P_2 - P_1)} \qquad 4.2$$

Because the elasticities were their own price demand elasticities, the export demand equation would decrease as their prices increase. The results of the export demand

Table 4.9. Feed and export demand elasticities and adjustment coefficients.

	Corn	GSorgh	Oats	Barley	Wheat	Soybea	Cotton	Rice
Direct/Own Price	-0.26	-0.59	-0.79	-1.08	-0.62	-0.16	-0.05	-0.33
Lvst Price Ind	0.23	0.00	0.00	0.00	0.00	0.19	0.00	0.00
Sbean Meal Price	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lvst Prod Inde	1.02	0.66	0.00	0.00	0.00	1.00	0.00	0.00
Corn Price	0.00	0.59	0.79	1.08	0.19	0.02	0.00	0.00
Food Demand	0.00	0.00	0.00	0.00	-0.02	0.00	0.00	0.00
Export Demand	-0.42	-0.50	-0.35	-0.50	-0.38	-0.57	-1.00	-0.72
Export Adj Coe	0.50	1.00	1.00	1.00	0.50	0.50	1.00	1.00
Feed Adj Coef	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Source: Agricultural Policy Analysis Center (APAC), 1994

showed that: 1) a 1% increase in the price of corn would reduce the corn-export demand by 0.26%, 2) a 1% increase in the price of soybean would cause the reduction of soybean-export demand by 0.16%, and 3) 1% change in the price of sorghum, oats, barley, and wheat, would reduce the sorghum-export, oats-export, barley-export, and wheat-export demands by 0.59%, 0.79%, 1.08%, and 0.62% respectively.

Supply Model

The supply model as shown in chapter III is a national and interregional spatial linear programming (SLP). This model computes the shadow prices for each commodity (see Table 4.10). The values of quantity demand of commodities were considered fixed. However, the changing values were the shadow prices provided by the SLP. The results of this table portrayed the price of barley declining for the shadow prices I through III indicating that an excess supply existed. The shadow prices for IV and V revealed a slight increase suggesting that excess demand was occurring. For the commodity, corn, the shadow price fluctuated indicating an ongoing adjustment for the presence of excess supply and excess demand. The shadow price for sorghum revealed a steady decline during iteration I through II, however for iteration III through V a slight increase was observed. This could suggest that initially an excess supply of sorghum existed for shadow prices I and II. The shadow price III indicated that demand for sorghum was in excess. In response, shadow prices III through V adjusted by reducing the excess demand in an effort obtain equilibrium. For the commodities wheat, oats, and soybeans, the

shadow prices fluctuated indicating that excess demand, and excess supply were present at various times. But the changes in these prices were minimal (see Table 4.10).

Table 4.10. Initial forecast values for barley, corn, sorghum, wheat, oats, soybeans, baseline price, and shadow prices obtained from each iteration.

Commodities	Forecast Values	Baseline Price	Shadow Price I	Shadow Price II	Shadow Price III	Shadow Price IV	Shadow Price V
BRTPR ($/bu)	2.38	2.90	2.65	2.62	2.50	2.53	2.58
CNTPR ($/bu)	2.55	3.37	2.90	2.98	2.84	2.87	2.93
GSTPR ($/bu)	2.42	3.06	2.65	2.42	2.60	2.61	2.67
WHTPR ($/bu)	3.36	3.61	3.48	3.64	3.63	3.66	3.50
OTTPR ($/bu)	1.50	2.32	1.93	1.98	1.96	1.97	2.01
SYTPR ($/bu)	6.35	7.53	6.10	6.36	5.92	6.04	6.21

Tatonnement Model

This model as defined in chapter III, demonstrated the processes of the demand equations and supply equations moving toward the equilibrium point. Five iterations were needed to accomplished this goal, The equilibrium points were obtained when the difference of the absolute value between supply and demand were within the 5% range. For the commodity barley-feed the expected convergence at the 5% level was not obtained. In the case of the commodity corn-feed, the difference between supply and demand was 2.9%, indicating that convergence was achieved. The convergence level for the sorghum-feed commodity was obtained at the 5% range. Barley-food showed a convergence point at the 0.01% level. For corn-food the level of convergence occurred at the 0.12% level. Sorghum-food produced converged at the 1.19% level. Oats-food

showed convergence at the 0.63% level. Finally, the last demand for the commodity wheat-food yielded a convergence at the -0.093% level (Table 4.11).

The last set of equations (Table 4.12) showed the convergence level for the export equations. The commodity barley-export met equilibrium at the 0.53% level. Similarly, the corn-export converged at the 0.44% level. Convergence of oats-export occurred at the 0.26% level. convergence for the commodities sorghum-export, soybeans-export, and wheat-export occurred at 0.35%, 1.06%, and 0.34% levels respectively.

The Linear Programming-Tatonnement Model and CRP Lands

The evaluation of this study, using linear programming, would be the results presented in columns label Baseline Price and Shadow Price I (see Table 4.10). The column, Baseline Price, was obtained by running the linear programming with lands enrolled in the CRP. The column, Shadow Price I, was the second run with all the CRP lands returning to cropping activities. The prices for the crop commodities on Baseline Price were higher than those on Shadow Price I. Because the lands returning from the CRP would increase crop production, the prices for these crops would decrease. Similarly, the values of the objective function using linear programming alone are presented in rows label Base (CRP lands out) and Iteration I (Table 4.13). The row, Base (CRP lands out), was achieved by running the linear programming with lands currently enrolled in the CRP, whereas the second row, Iteration I, was the second run with all CRP lands available for cropping activities. The results of these two runs showed that the values of the objective function on both extremes, i.e., Base (CRP land out) had the

Table 4.11. Production estimates for feed-demand and food-demand, along with final estimates of convergence (%).

Dependent Variables	Base		Iteration I		Iteration II		Iteration III		Iteration IV		Iteration V		Change
	Demand[a]	Supply[b]	Demand	Supply	Demand	Supply	Demand	Supply	Demand	Supply	Demand	Supply	%
BRDFED[c]	219.44	1614.52	218.62	911.91	227.15	683.77	232.45	366.90	231.16	397.54	229.96	467.37	50.79616
CNDFED	4966.63	5613.76	5147.19	5994.29	5116.90	4906.81	5172.82	5195.39	5161.03	5188.96	5136.25	5293.13	2.96396
GSDFED	407.51	312.92	449.76	542.96	587.98	268.72	455.87	562.72	457.07	548.83	450.58	475.04	5.147844
WHDFED	495.48	0.00	424.92	0.00	410.56	0.00	383.85	0.00	383.67	0.00	388.70	0.00	na
OTDFED	117.52	0.00	177.89	0.00	180.46	0.00	183.47	0.00	183.06	0.00	179.30	0.00	na
BRDOTH	184.95	186.84	184.60	186.84	184.92	184.60	184.97	184.92	184.98	184.87	184.96	184.98	0.010869
CNDOTH	2166.08	2102.97	2185.93	2103.00	2182.60	2185.93	2188.75	2182.60	2187.45	2188.75	2184.73	2187.45	0.124476
GSDOTH	13.22	11.19	13.99	11.19	15.40	13.99	14.38	15.40	14.34	14.38	14.17	14.34	1.191924
OTDOTH	113.98	151.00	125.07	151.00	125.06	125.07	125.64	125.06	125.46	125.64	124.67	125.46	0.631565
WHDOTH	1065.84	997.00	1058.79	997.00	1060.95	1058.79	1058.92	1060.95	1059.66	1058.92	1060.64	1059.66	-0.09304

a quantity estimated from the demand side

b quantity estimated from the supply side

c BRDFED barley-feed, CNDFED corn-feed, GSDFED sorghum-feed, WHDFED wheat-feed, OTDFED oats-feed, BRDOTH barley-food, CNDOTH corn- food, GSDOTH sorghum-food, OTDOTH oats-food, and WHDOTH wheat-food.

Table 4.12 . Production estimation for export demand, along with final estimate of convergence (%).

Depend.	Baseline		Iteration I		Iteration II		Iteration III		Iteration IV		Iteration V		Change
Variable	Demand[a]	Supply[b]	Demand	Supply	Demand	Supply	Demand	Supply	Demand	Supply	Demand	Supply	%
Barley	147.78	161.00	168.98	161.00	169.76	168.98	173.97	169.76	174.91	173.97	177.34	178.28	0.53
Corn	2069.24	2280.00	2444.39	2280.00	2417.83	2444.39	2470.48	2417.83	2481.63	2470.48	2513.10	2524.27	0.44
Oats	1.78	2.00	2.15	2.00	2.13	2.15	2.14	2.13	1.20	1.20	2.14	2.15	0.26
Sorghum	372.90	412.00	446.21	412.00	468.99	446.21	426.86	441.41	453.19	451.59	967.15	970.54	0.35
Soybeans	815.34	888.00	1024.87	888.00	1001.09	1024.76	1045.53	1001.15	1057.07	1045.54	1080.34	1091.90	1.06
Wheat	1720.45	1765.00	1789.59	1765.00	1760.92	1789.60	1763.51	1760.92	1769.60	1763.51	1760.09	1766.10	0.34

a quantity estimated from the demand side

b quantity estimated from the supply side

c barley-export, corn-export, oats-export, sorghum-export, soybeans-export, and wheat-export.

highest objective function, $48,008,418 and Iteration I had the lowest objective function, $43,955,066.

Table 4.13. Values of the objective for each iteration

Iteration	Objective (thousands of $)
Base (CRP lands out)	48,008,418
Iteration I	43,955,066
Iteration II	45,742,815
Iteration III	46,263,746
Iteration IV	44,421,063
Iteration V	45,144,942

The availability of land from the CRP returning to cropping activities would increase production, and reduce prices. The results of these two runs were conducted under the assumption of fixed lands. The first run assumed lands to be fixed to the current situation (lands enrolled in the CRP), and the second run assumed lands to be fixed to the year 2005 (lands available from CRP). Since one of the goals of the CRP was to control soil erosion, the addition of new erodable lands for cropping activities would cause increases in soil losses. To overcome the assumption of fixed demands, the Tatonnement model was used. By using the Tatonnement model, it was possible to arrive at the optimal solution, i.e., Shadow Price V and Iteration V for the price of the commodities and the cost-minimizing objective, respectively . These values as noted fell between the Baseline Price and Shadow Price I, and Base (CRP lands out) and Iteration I verifying that adjustment at the aggregate level took place.

The purpose of using the Tatonnement model in this study was to investigate the impact of CRP lands 1) returning into production, and 2) remaining as is. The impact reflected in prices for each commodity and the changes in quantities consumed by

consumers, an additional objective of this study was to estimate the effects of the wind and water erosion as CRP lands are shifted into production.

Spatial linear programming was applied with the assumption that land currently enrolled in the Crop Reserve Program (CRP) would remain in the CRP. This was considered the baseline in this study. The second set of runs were performed assuming that all the lands in the CRP would return to production. Figure 4.3 provides the comparison of these two conditions. The shaded areas provides a scale in descending order signifying the percentage of land that would be recropped at the completion of the CRP. The greatest amount of land that would return to crop production would be 75% to 100% this area amounted to 70 Crop Producing Areas (CPA), followed by 50% to 75% with 4 CPA, then 25% to 50% with a single CPA and finally 0% to 25% being the smallest amount of land being recropped with 30 CPA. For land owners with the lowest percentage of land returning into crop production, the continuation of the CRP initial baseline might prove to be of little importance.

A primary goal of the CRP was to reduce soil erosion. Therefore, highly erodable lands were enrolled in this program. Because soil erosion may cause drastic reductions on crop production, increases on the price of crops, and environmental damages, close observation of the soil erosion may be needed.

The sheet and rill erosion, land use, and erosion per acre levels were obtained with the first run of the linear program (see Table 4.14 and Figure 4.4). The results revealed that the levels of water erosion, land use for cropping activities, and erosion per acre that occurred for lands enrolled in the CRP was generally lower than the optimal solution.

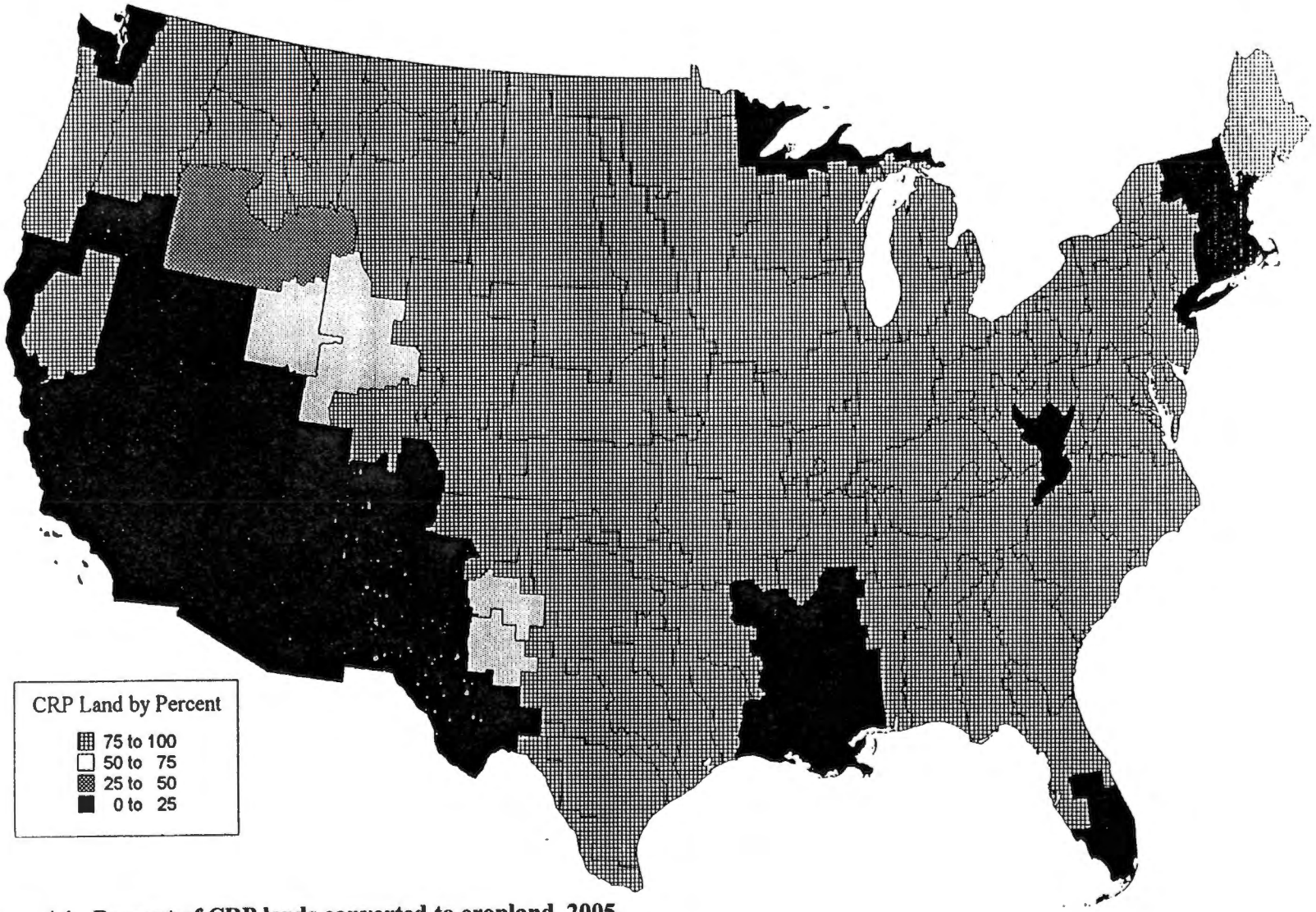

Figure 4.1. Percent of CRP lands converted to cropland, 2005.

Table 4.14. Percentage change of water erosion without CRP lands (Baseline) and with CRP lands (Optimal solution).

	Base without CRP lands			Optimun with CRP lands			Percentage Change		
CPA	Land use	Sheet and rill erosion	Per acre erosion	Land use	Sheet and rill erosion	Per acre erosion	Land use	Sheet and rill erosion	Per acre erosion
1	255.70	1195.92	4.68	278.70	1276.81	4.58	8.25	6.34	-2.09
2	19.10	83.74	4.38	18.29	81.66	4.46	-4.43	-2.55	1.80
3	57.80	636.76	11.02	37.60	155.11	4.13	-53.72	-310.53	-167.06
4	168.60	1864.24	11.06	89.00	423.09	4.75	-89.44	-340.63	-132.60
5	49.64	73.62	1.48	41.40	32.74	0.79	-19.90	-124.82	-87.50
6	83.70	323.88	3.87	38.80	173.16	4.46	-115.72	-87.04	13.30
7	748.40	5115.10	6.83	752.90	5132.89	6.82	0.60	0.35	-0.25
8	45.00	184.37	4.10	45.00	171.18	3.80	0.00	-7.71	-7.71
9	1010.80	4766.30	4.72	1015.30	4786.70	4.71	0.44	0.43	-0.02
10	2360.90	33710.31	14.28	2442.90	35289.64	14.45	3.36	4.48	1.16
11	1544.94	17016.13	11.01	1576.84	17492.79	11.09	2.02	2.72	0.72
12	853.58	5992.07	7.02	862.88	6522.33	7.56	1.08	8.13	7.13
13	831.03	3940.39	4.74	877.23	4191.91	4.78	5.27	6.00	0.77
14	1255.06	5807.48	4.63	1492.16	5567.17	3.73	15.89	-4.32	-24.02
15	1821.62	8335.45	4.58	2220.85	12563.00	5.66	17.98	33.65	19.11
16	906.70	8493.76	9.37	940.01	7446.14	7.92	3.54	-14.07	-18.26
17	391.82	349.31	0.89	377.51	248.80	0.66	-3.79	-40.40	-35.27
18	1998.46	3213.01	1.61	2159.06	5748.08	2.66	7.44	44.10	39.61
19	1347.97	6053.76	4.49	1635.37	7568.84	4.63	17.57	20.02	2.96
20	538.93	7606.65	14.11	646.93	9553.45	14.77	16.69	20.38	4.42
21	832.23	1037.00	1.25	832.23	1197.84	1.44	0.00	13.43	13.43
22	246.09	2769.80	11.26	246.09	2769.80	11.26	0.00	0.00	0.00
23	1510.40	16942.81	11.22	1589.20	17821.43	11.21	4.96	4.93	-0.03
24	1259.04	5673.73	4.51	1310.64	6372.63	4.86	3.94	10.97	7.32
25	3111.69	29309.77	9.42	3285.39	31945.66	9.72	5.29	8.25	3.13
26	1122.34	3299.53	2.94	1176.14	3640.75	3.10	4.57	9.37	5.03
27	1867.58	11866.95	6.35	1999.88	13133.23	6.57	6.62	9.64	3.24
28	733.13	3110.66	4.24	743.63	3147.39	4.23	1.41	1.17	-0.25
29	1614.22	10946.34	6.78	1651.12	11159.62	6.76	2.23	1.91	-0.33
30	736.00	10889.86	14.80	739.90	10914.22	14.75	0.53	0.22	-0.31
31	1539.77	13648.25	8.86	1556.07	17421.63	11.20	1.05	21.66	20.83

Table 4.14. Continued.

	Base without CRP lands			Optimun with CRP lands			Percentage Change		
CPA	Land use	Sheet and rill erosion	Per acre erosion	Land use	Sheet and rill erosion	Per acre erosion	Land use	Sheet and rill erosion	Per acre erosion
32	2366.10	10781.83	4.56	2564.90	11781.88	4.59	7.75	8.49	0.80
33	181.30	1049.02	5.79	0.00	.	0.00	0.00	0.00	0.00
34	3327.94	41115.21	12.35	3574.14	45157.72	12.63	6.89	8.95	2.22
35	8535.77	43247.98	5.07	8856.07	46318.06	5.23	3.62	6.63	3.12
36	954.22	7565.42	7.93	1056.62	16940.50	16.03	9.69	55.34	50.55
37	563.24	10872.92	19.30	564.44	10898.54	19.31	0.21	0.24	0.02
38	1283.77	15840.59	12.34	1435.87	17331.61	12.07	10.59	8.60	-2.23
39	677.18	912.23	1.35	765.88	1143.85	1.49	11.58	20.25	9.80
40	2443.77	31253.86	12.79	2507.03	42976.99	17.14	2.52	27.28	25.40
41	14786.53	187523.48	12.68	16097.33	224259.64	13.93	8.14	16.38	8.97
42	7910.52	49957.82	6.32	8296.82	57169.23	6.89	4.66	12.61	8.35
43	3441.92	51259.15	14.89	3689.12	51751.90	14.03	6.70	0.95	-6.16
44	2453.87	30296.81	12.35	2775.67	39620.95	14.27	11.59	23.53	13.51
45	8146.03	79183.34	9.72	8146.03	80280.71	9.86	0.00	1.37	1.37
46	2369.38	18687.92	7.89	2367.34	18422.81	7.78	-0.09	-1.44	-1.35
47	4620.34	5654.91	1.22	5361.64	7114.51	1.33	13.83	20.52	7.76
48	950.57	1223.11	1.29	1555.27	2405.43	1.55	38.88	49.15	16.81
49	1449.61	2089.62	1.44	1788.01	3300.85	1.85	18.93	36.69	21.92
50	824.70	690.37	0.84	1091.50	1120.12	1.03	24.44	38.37	18.43
51	2019.36	5392.83	2.67	2302.75	6587.79	2.86	12.31	18.14	6.65
52	6521.63	56776.35	8.71	8150.33	83769.78	10.28	19.98	32.22	15.30
53	5161.82	16633.64	3.22	6043.51	27472.66	4.55	14.59	39.45	29.11
54	2819.55	11259.66	3.99	3408.60	12151.37	3.56	17.28	7.34	-12.02
55	4498.35	33877.06	7.53	4784.35	39766.70	8.31	5.98	14.81	9.39
56	1378.17	14672.08	10.65	1507.31	15076.70	10.00	8.57	2.68	-6.44
57	4670.38	46695.95	10.00	5119.02	52917.45	10.34	8.76	11.76	3.28
58	5236.85	31458.16	6.01	6056.75	26221.01	4.33	13.54	-19.97	-38.76
59	3291.22	22902.34	6.96	3430.82	25437.99	7.41	4.07	9.97	6.15
60	3693.54	83233.47	22.53	4547.34	72550.00	15.95	18.78	-14.73	-41.25
61	288.08	1867.17	6.48	288.78	1868.11	6.47	0.24	0.05	-0.19
62	663.74	821.36	1.24	852.18	1058.52	1.24	22.11	22.40	0.37

Table 4.14. Continued.

	Base without CRP lands			Optimun with CRP lands			Percentage Change		
CPA	Land use	Sheet and rill erosion	Per acre erosion	Land use	Sheet and rill erosion	Per acre erosion	Land use	Sheet and rill erosion	Per acre erosion
63	5820.60	36749.02	6.31	6828.80	49517.90	7.25	14.76	25.79	12.93
64	1722.93	14686.29	8.52	1872.93	17398.63	9.29	8.01	15.59	8.24
65	215.48	225.07	1.04	1081.50	999.10	0.92	80.08	77.47	-13.07
66	827.87	4070.96	4.92	900.43	3836.95	4.26	8.06	-6.10	-15.40
67	802.60	979.90	1.22	909.43	1543.94	1.70	11.75	36.53	28.08
68	2883.46	13262.87	4.60	2804.73	9800.31	3.49	-2.81	-35.33	-31.64
69	354.55	4118.13	11.62	411.54	4438.05	10.78	13.85	7.21	-7.71
70	196.32	1050.54	5.35	196.52	996.49	5.07	0.10	-5.42	-5.53
71	1375.99	7017.33	5.10	1389.99	6642.08	4.78	1.01	-5.65	-6.72
72	2722.06	2463.36	0.90	3793.70	3575.47	0.94	28.25	31.10	3.98
73	2173.80	8681.90	3.99	2400.34	9932.24	4.14	9.44	12.59	3.48
74	1204.78	1357.01	1.13	1501.35	1888.36	1.26	19.75	28.14	10.45
75	2065.14	9178.22	4.44	2239.16	10002.52	4.47	7.77	8.24	0.51
76	2051.73	7505.95	3.66	2119.13	8046.46	3.80	3.18	6.72	3.65
77	329.02	.	0.00	328.46	.	0.00	-0.17	0.00	0.00
78	72.87	.	0.00	72.87	.	0.00	0.00	0.00	0.00
79	.	.	0.00	.	.	0.00	0.00	0.00	0.00
80	128.13	47.05	0.37	90.26	14.07	0.16	-41.97	-234.39	-135.54
81	718.08	1724.01	2.40	742.22	1724.32	2.32	3.25	0.02	-3.34
82	153.94	202.09	1.31	182.14	244.88	1.34	15.48	17.48	2.36
83	238.04	.	0.00	239.46	.	0.00	0.59	0.00	0.00
84	15.84	26.47	1.67	15.84	26.47	1.67	0.00	0.00	0.00
85	.	.	0.00	.	.	0.00	0.00	0.00	0.00
86	.	.	0.00	.	.	0.00	0.00	0.00	0.00
87	33283.95	.	0.00	13884.23	.	0.00	-140.42	0.00	0.00
88	124.10	50.13	0.40	388.20	660.75	1.70	68.03	92.41	76.27
89	96.18	125.05	1.30	96.18	125.05	1.30	0.00	0.00	0.00
90	.	.	0.00	.	.	0.00	0.00	0.00	0.00
91	15.91	7.66	0.48	16.42	9.95	0.61	3.08	22.98	20.54
92	914.09	2071.90	2.27	965.19	2239.54	2.32	5.29	7.49	2.31
93	1994.34	5518.12	2.77	2826.74	7371.17	2.61	29.45	25.14	-6.11

Table 4.14 Continued.

	Base without CRP lands			Optimun with CRP lands			Percentage Change		
CPA	Land use	Sheet and rill erosion	Per acre erosion	Land use	Sheet and rill erosion	Per acre erosion	Land use	Sheet and rill erosion	Per acre erosion
94	479.91	236.15	0.49	1192.39	966.90	0.81	59.75	75.58	39.32
95	1038.10	2112.94	2.04	1224.46	2171.37	1.77	15.22	2.69	-14.78
96	757.49	3181.14	4.20	775.64	3786.89	4.88	2.34	16.00	13.98
97	83.51	562.77	6.74	83.51	562.77	6.74	0.00	0.00	0.00
98	190.25	3477.71	18.28	.	.	0.00	0.00	0.00	0.00
99	101.09	586.67	5.80	101.09	616.95	6.10	0.00	4.91	4.91
100	139.13	40.27	0.29	353.23	389.81	1.10	60.61	89.67	73.77
101	2047.13	7488.91	3.66	2253.04	9154.85	4.06	9.14	18.20	9.97
102	143.80	932.93	6.49	143.80	936.95	6.52	0.00	0.43	0.43
103	166.29	656.06	3.95	166.29	815.72	4.91	0.00	19.57	19.57
104	.	.	0.00	5.47	.	0.00	100.00	0.00	0.00
105	4.89	5.28	1.08	4.89	5.28	1.08	0.00	0.00	0.00

When the optimal solution was obtained, new levels of water erosion, land use, and erosion per acre were established (see Table 4.14 and Figure 4.5). These levels were compared to the initial baseline and the results were expressed in percentage change of water erosion (see Table 4.14 and Figure 4.6). By placing more land into production, the water erosion would increase from 75% to 100% for a single CPA, 50% to 75% for 2 CPAs, 25% to 50% for 8 CPAs, 0% to 25% for 74 CPAs and -930% to 0% for 20 CPAs. The CPAs with negative sign probably suggest that they were less cost efficient than neighboring CPAs. As a result, it would be more advantageous for CPAs with negative signs to import than produce (see Figure 4.6). Comparing the results obtained in the baseline and the optimum, the quantity of land use in the optimum was relatively higher than the baseline solution. Similarly, the erosion per acre showed that the levels of erosion per acre were higher in the optimum than in the baseline (see Table 4.14). The wind erosion level was obtained with the first run of the linear program (see Table 4.15 and Figure 4.7). Results suggested that the level of wind erosion, land use, and erosion per acre that occurred for lands enrolled in the CRP were mainly lower than the optimal solution. When the optimal solution was obtained, a new level of wind erosion, land use, and erosion per acre were established (see Table 4.15 and Figure 4.8). These levels were compared to the initial baseline and the results were expressed in percentage change of wind erosion, land use, and erosion per acre basis (see Table 4.15 and Figure 4.9). By placing more land into production, the wind erosion would increase from 66% to 100% for 3 CPAs, 33% to 66% for 5 CPAs, 0% to 33% for 86 CPAs and -260% to 0% for 11 CPAs. The CPAs with negative sign probably suggest that they were less cost efficient

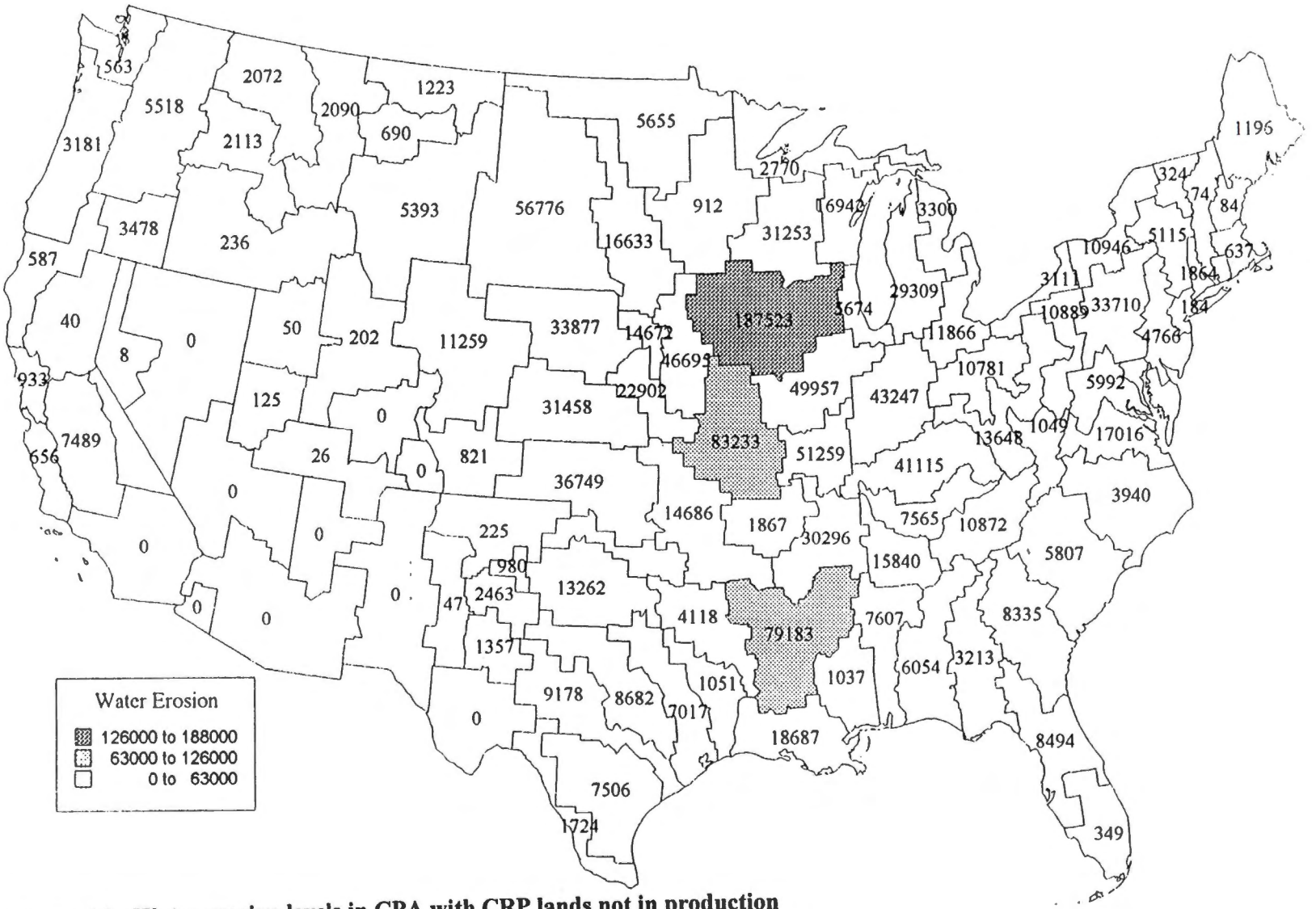

Figure 4.2. Water erosion levels in CPA with CRP lands not in production (1000 tons), 2005.

Table 4.15. Percentage change of wind erosion without CRP lands (Baseline) and with CRP lands (Optimal solution).

	Base without CRP lands			Optimun with CRP lands			Percentage Change		
CPA	Land use	Wind erosion	Per acre erosion	Land use	Wind erosion	Per acre erosion	Land use	Wind erosion	Per acre erosion
1	255.70	.	0.00	278.70	.	0.00	8.25	0.00	0.00
2	19.10	.	0.00	18.29	.	0.00	-4.43	0.00	0.00
3	57.80	.	0.00	37.60	.	0.00	-53.72	0.00	0.00
4	168.60	.	0.00	89.00	.	0.00	-89.44	0.00	0.00
5	49.64	.	0.00	41.40	.	0.00	-19.90	0.00	0.00
6	83.70	.	0.00	38.80	.	0.00	-115.72	0.00	0.00
7	748.40	130.15	0.17	752.90	130.94	0.17	0.60	0.60	-0.00
8	45.00	.	0.00	45.00	.	0.00	0.00	0.00	0.00
9	1010.80	201.05	0.20	1015.30	202.32	0.20	0.44	0.63	0.19
10	2360.90	.	0.00	2442.90	.	0.00	3.36	0.00	0.00
11	1544.94	2320.96	1.50	1576.84	2368.83	1.50	2.02	2.02	-0.00
12	853.58	39.14	0.05	862.88	39.56	0.05	1.08	1.08	0.00
13	831.03	915.57	1.10	877.23	988.87	1.13	5.27	7.41	2.27
14	1255.06	1128.99	0.90	1492.16	708.78	0.48	15.89	-59.29	-89.38
15	1821.62	926.78	0.51	2220.85	1443.36	0.65	17.98	35.79	21.72
16	906.70	2144.01	2.36	940.01	2252.68	2.40	3.54	4.82	1.33
17	391.82	407.58	1.04	377.51	405.04	1.07	-3.79	-0.63	3.05
18	1998.46	96.28	0.05	2159.06	686.34	0.32	7.44	85.97	84.84
19	1347.97	513.96	0.38	1635.37	633.86	0.39	17.57	18.92	1.63
20	538.93	454.00	0.84	646.93	544.98	0.84	16.69	16.69	0.00
21	832.23	61.40	0.07	832.23	61.40	0.07	0.00	0.00	0.00
22	246.09	899.89	3.66	246.09	899.89	3.66	0.00	0.00	0.00
23	1510.40	6730.43	4.46	1589.20	7029.43	4.42	4.96	4.25	-0.74
24	1259.04	1028.49	0.82	1310.64	1072.25	0.82	3.94	4.08	0.15
25	3111.69	1478.54	0.48	3285.39	1707.10	0.52	5.29	13.39	8.55
26	1122.34	2025.45	1.80	1176.14	2111.78	1.80	4.57	4.09	-0.51
27	1867.58	797.38	0.43	1999.88	853.86	0.43	6.62	6.62	-0.00
28	733.13	129.20	0.18	743.63	131.05	0.18	1.41	1.41	-0.00
29	1614.22	767.28	0.48	1651.12	785.00	0.48	2.23	2.26	0.02
30	736.00	.	0.00	739.90	.	0.00	0.53	0.00	0.00
31	1539.77	201.52	0.13	1556.07	203.66	0.13	1.05	1.05	-0.00

Table Continued.

	Base without CRP lands			Optimun with CRP lands			Percentage Change		
CPA	Land use	Sheet and rill erosion	Per acre erosion	Land use	Sheet and rill erosion	Per acre erosion	Land use	Sheet and rill erosion	Per acre erosion
32	2366.10	458.40	0.19	2564.90	496.52	0.19	7.75	7.68	-0.08
33	181.30	.	0.00	0.00	.	0.00	0.00	0.00	0.00
34	3327.94	28.83	0.01	3574.14	30.96	0.01	6.89	6.89	0.00
35	8535.77	1218.84	0.14	8856.07	1264.31	0.14	3.62	3.60	-0.02
36	954.22	.	0.00	1056.62	.	0.00	9.69	0.00	0.00
37	563.24	.	0.00	564.44	.	0.00	0.21	0.00	0.00
38	1283.77	455.83	0.36	1435.87	509.84	0.36	10.59	10.59	-0.00
39	677.18	640.19	0.95	765.88	724.86	0.95	11.58	11.68	0.11
40	2443.77	3164.93	1.30	2507.03	3263.70	1.30	2.52	3.03	0.52
41	14786.53	29065.79	1.97	16097.33	31650.52	1.97	8.14	8.17	0.03
42	7910.52	1577.94	0.20	8296.82	1655.10	0.20	4.66	4.66	0.01
43	3441.92	38.49	0.01	3689.12	43.18	0.01	6.70	10.85	4.45
44	2453.87	1862.16	0.76	2775.67	2106.37	0.76	11.59	11.59	0.00
45	8146.03	4285.80	0.53	8146.03	4288.69	0.53	0.00	0.07	0.07
46	2369.38	8081.71	3.41	2367.34	8073.71	3.41	-0.09	-0.10	-0.01
47	4620.34	11266.49	2.44	5361.64	13667.64	2.55	13.83	17.57	4.34
48	950.57	13594.28	14.30	1555.27	25692.08	16.52	38.88	47.09	13.43
49	1449.61	19222.84	13.26	1788.01	28102.34	15.72	18.93	31.60	15.63
50	824.70	11406.38	13.83	1091.50	17212.59	15.77	24.44	33.73	12.29
51	2019.36	11051.51	5.47	2302.75	14072.50	6.11	12.31	21.47	10.45
52	6521.63	22481.43	3.45	8150.33	43213.89	5.30	19.98	47.98	34.98
53	5161.82	11068.17	2.14	6043.51	14414.82	2.39	14.59	23.22	10.10
54	2819.55	28483.76	10.10	3408.60	39693.52	11.65	17.28	28.24	13.25
55	4498.35	22263.23	4.95	4784.35	23800.11	4.97	5.98	6.46	0.51
56	1378.17	1561.14	1.13	1507.31	1706.55	1.13	8.57	8.52	-0.05
57	4670.38	6044.71	1.29	5119.02	6494.79	1.27	8.76	6.93	-2.01
58	5236.85	23061.82	4.40	6056.75	54583.96	9.01	13.54	57.75	51.13
59	3291.22	4423.59	1.34	3430.82	4296.99	1.25	4.07	-2.95	-7.31
60	3693.54	1554.76	0.42	4547.34	1921.48	0.42	18.78	19.08	0.38
61	288.08	.	0.00	288.78	.	0.00	0.24	0.00	0.00
62	663.74	2129.15	3.21	852.18	2225.26	2.61	22.11	4.32	-22.85

Table Contuned

	Base without CRP lands			Optimun with CRP lands			Percentage Change		
CPA	Land use	Sheet and rill erosion	Per acre erosion	Land use	Sheet and rill erosion	Per acre erosion	Land use	Sheet and rill erosion	Per acre erosion
63	5820.60	33921.22	5.83	6828.80	40987.75	6.00	14.76	17.24	2.91
64	1722.93	896.17	0.52	1872.93	689.76	0.37	8.01	-29.93	-41.24
65	215.48	2845.59	13.21	1081.50	10529.41	9.74	80.08	72.97	-35.64
66	827.87	4618.58	5.58	900.43	5301.66	5.89	8.06	12.88	5.25
67	802.60	9455.42	11.78	909.43	11772.41	12.94	11.75	19.68	8.99
68	2883.46	21917.29	7.60	2804.73	20685.47	7.38	-2.81	-5.95	-3.06
69	354.55	350.85	0.99	411.54	468.64	1.14	13.85	25.13	13.10
70	196.32	823.05	4.19	196.52	870.65	4.43	0.10	5.47	5.37
71	1375.99	7550.02	5.49	1389.99	8527.56	6.13	1.01	11.46	10.56
72	2722.06	21938.06	8.06	3793.70	34402.18	9.07	28.25	36.23	11.13
73	2173.80	14381.67	6.62	2400.34	16349.88	6.81	9.44	12.04	2.87
74	1204.78	10823.88	8.98	1501.35	13925.59	9.28	19.75	22.27	3.14
75	2065.14	18083.71	8.76	2239.16	20627.09	9.21	7.77	12.33	4.94
76	2051.73	77871.55	37.95	2119.13	78339.87	36.97	3.18	0.60	-2.67
77	329.02	.	0.00	328.46	.	0.00	-0.17	0.00	0.00
78	72.87	.	0.00	72.87	.	0.00	0.00	0.00	0.00
79	.	.	0.00	.	.	0.00	0.00	0.00	0.00
80	128.13	320.59	2.50	90.26	89.08	0.99	-41.97	-259.88	-153.50
81	718.08	16146.79	22.49	742.22	16424.80	22.13	3.25	1.69	-1.61
82	153.94	1800.03	11.69	182.14	1944.47	10.68	15.48	7.43	-9.53
83	238.04	.	0.00	239.46	.	0.00	0.59	0.00	0.00
84	15.84	78.12	4.93	15.84	78.12	4.93	0.00	0.00	0.00
85	.	.	0.00	.	.	0.00	0.00	0.00	0.00
86	.	.	0.00	.	.	0.00	0.00	0.00	0.00
87	33283.95	.	0.00	13844.23	.	0.00	-140.42	0.00	0.00
88	124.10	1355.30	10.92	388.20	5081.25	13.09	68.03	73.33	16.56
89	96.18	1677.70	17.44	96.18	1677.70	17.44	0.00	0.00	0.00
90	.	.	0.00	.	.	0.00	0.00	0.00	0.00
91	15.91	7.09	0.45	16.42	7.49	0.46	3.08	5.36	2.36
92	914.09	2288.95	2.50	965.19	2470.63	2.56	5.29	7.35	2.17
93	1994.34	5913.64	2.97	2826.74	7793.34	2.76	29.45	24.12	-7.55

Table Continued.

	Base without CRP lands			Optimun with CRP lands			Percentage Change		
CPA	Land use	Sheet and rill erosion	Per acre erosion	Land use	Sheet and rill erosion	Per acre erosion	Land use	Sheet and rill erosion	Per acre erosion
94	479.91	1236.77	2.58	1192.39	4451.96	3.73	59.75	72.22	30.98
95	1038.10	499.75	0.48	1224.46	653.72	0.53	15.22	23.55	9.83
96	757.49	1428.15	1.89	775.64	1461.92	1.88	2.34	2.31	-0.03
97	83.51	303.29	3.63	83.51	303.29	3.63	0.00	0.00	0.00
98	190.25	336.29	1.77	.	.	0.00	0.00	0.00	0.00
99	101.09	417.13	4.13	101.09	423.85	4.19	0.00	1.59	1.59
100	139.13	491.54	3.53	353.23	1460.22	4.13	60.61	66.34	14.54
101	2047.13	7930.21	3.87	2253.04	7722.67	3.43	9.14	-2.69	-13.02
102	143.80	985.64	6.85	143.80	1053.85	7.33	0.00	6.47	6.47
103	166.29	1130.07	6.80	166.29	821.33	4.94	0.00	-37.59	-37.59
104	.	.	0.00	5.47	.	0.00	100.00	0.00	0.00
105	4.89	9.22	1.88	4.89	9.22	1.88	0.00	0.00	0.00

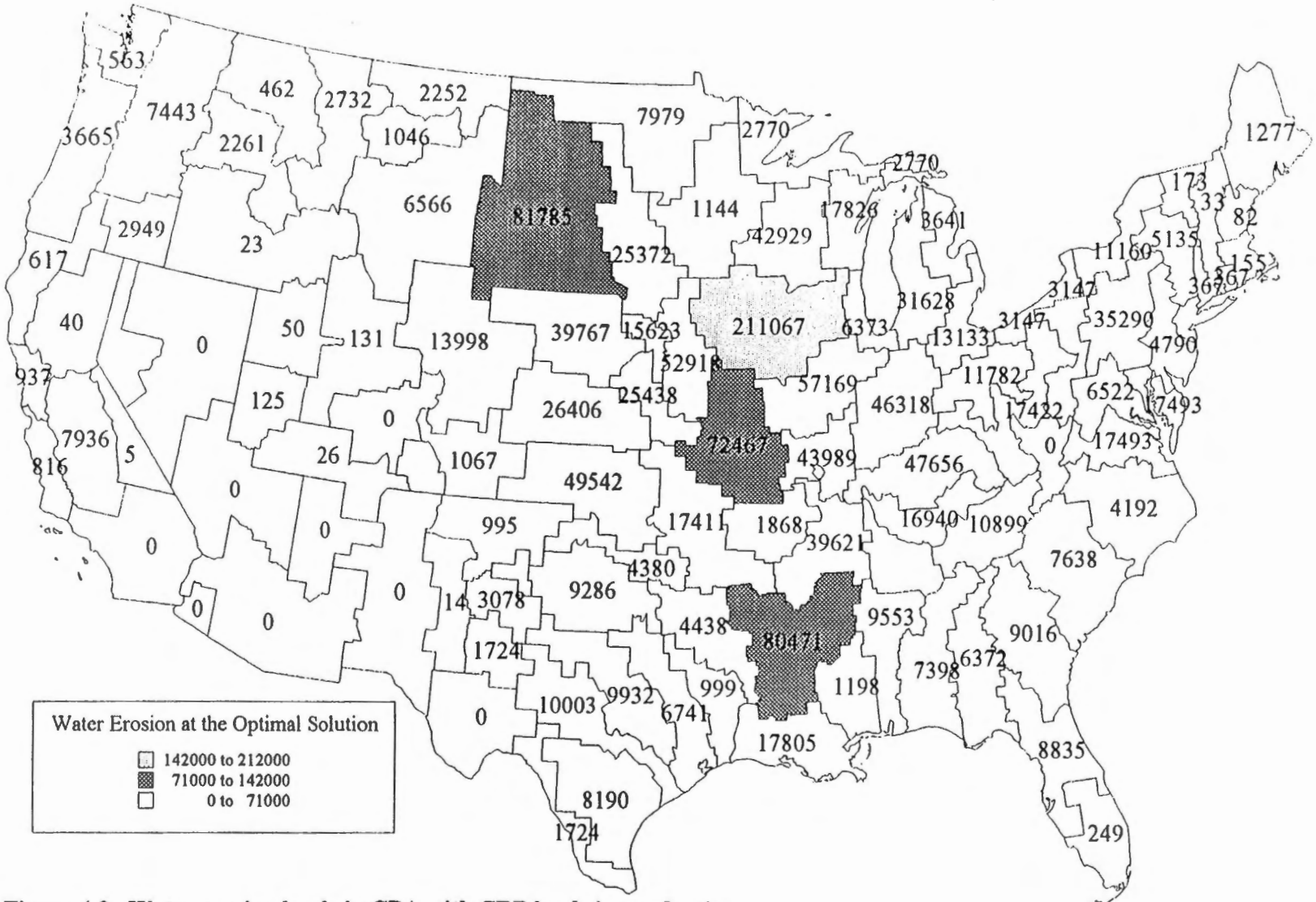

Figure 4.3. Water erosion levels in CPA with CRP lands in production (1000 tons), 2005.

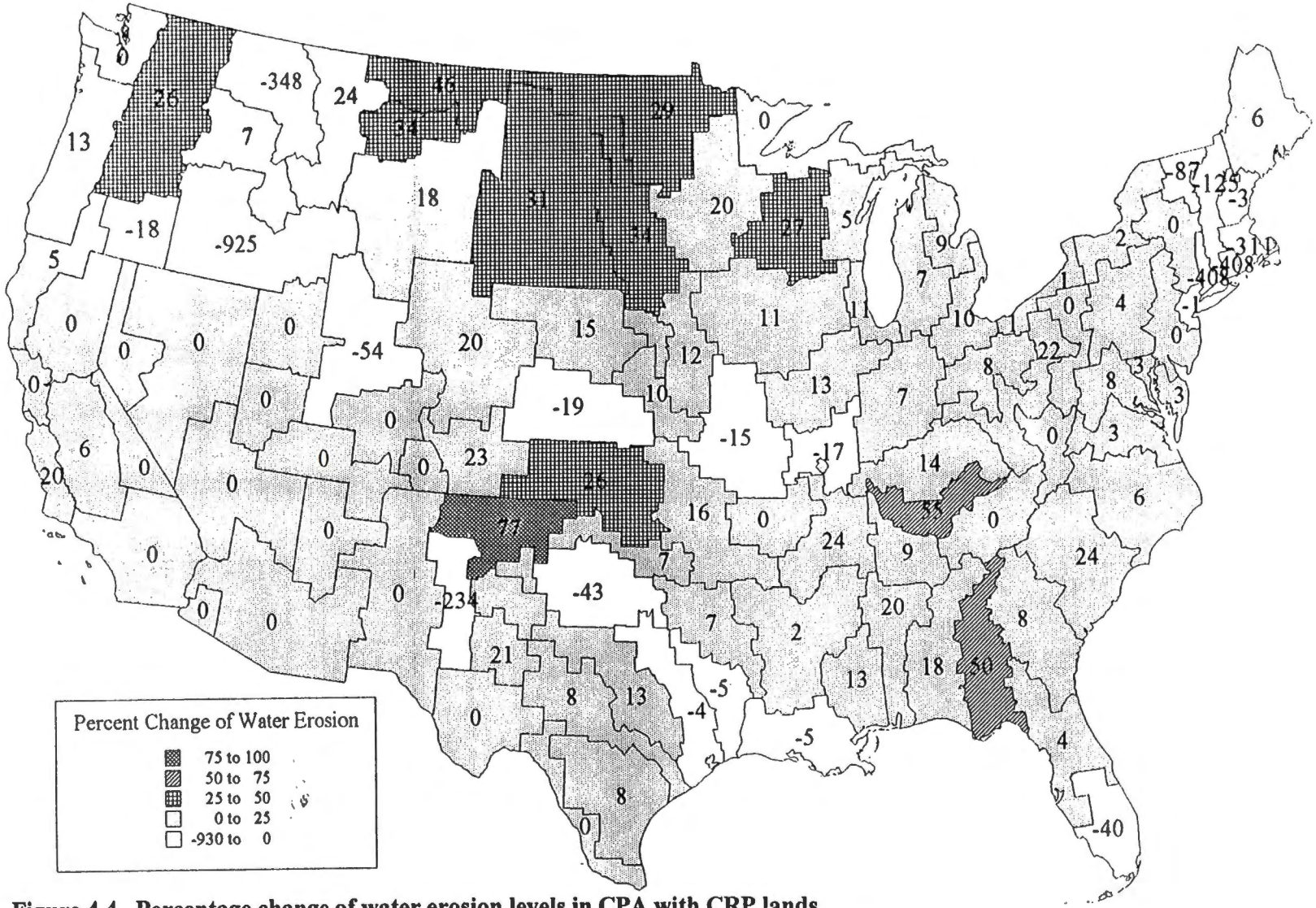

Figure 4.4. Percentage change of water erosion levels in CPA with CRP lands in and out of production (1000 tons), 2005.

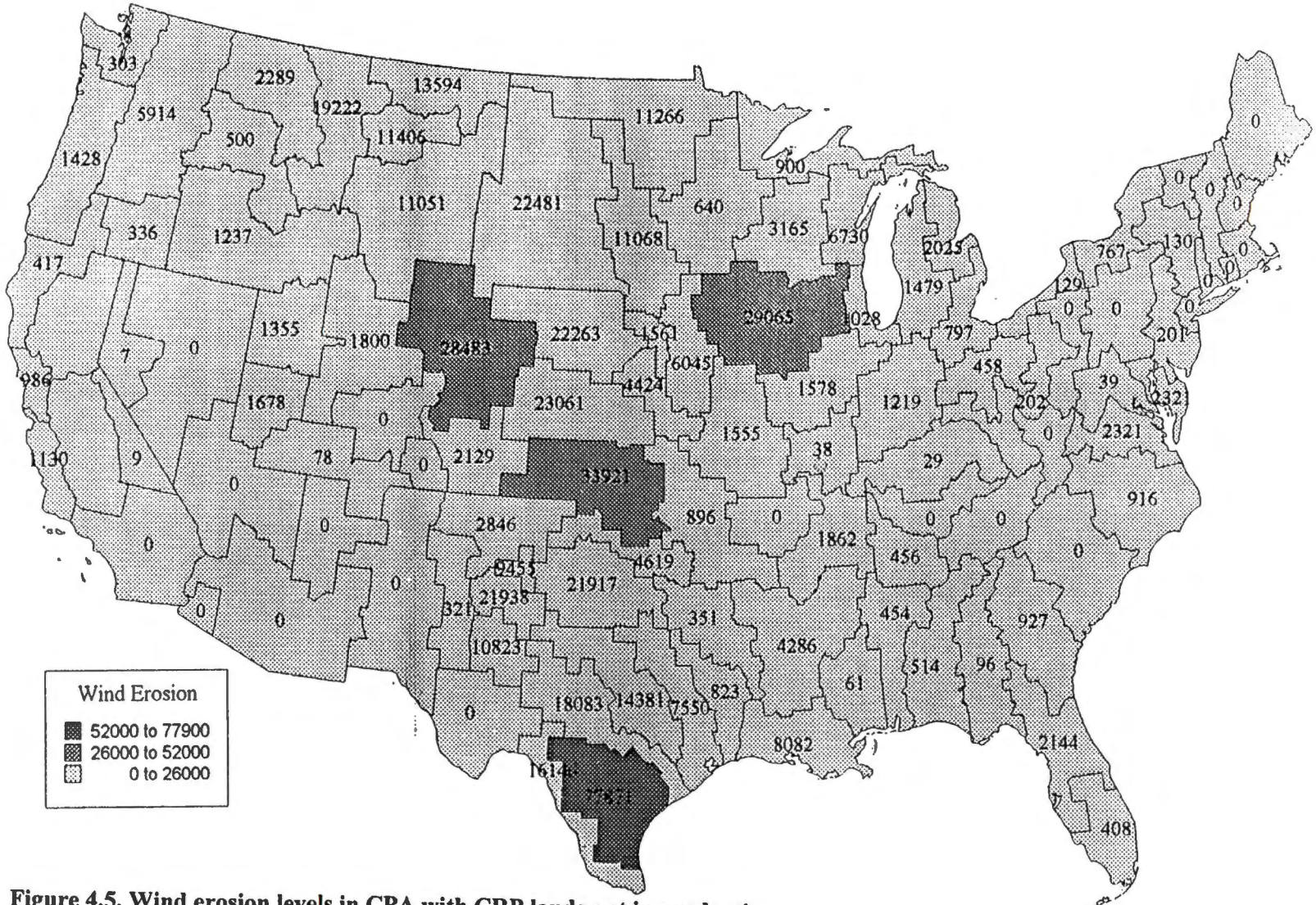

Figure 4.5. Wind erosion levels in CPA with CRP lands not in production (1000 tons), 2005.

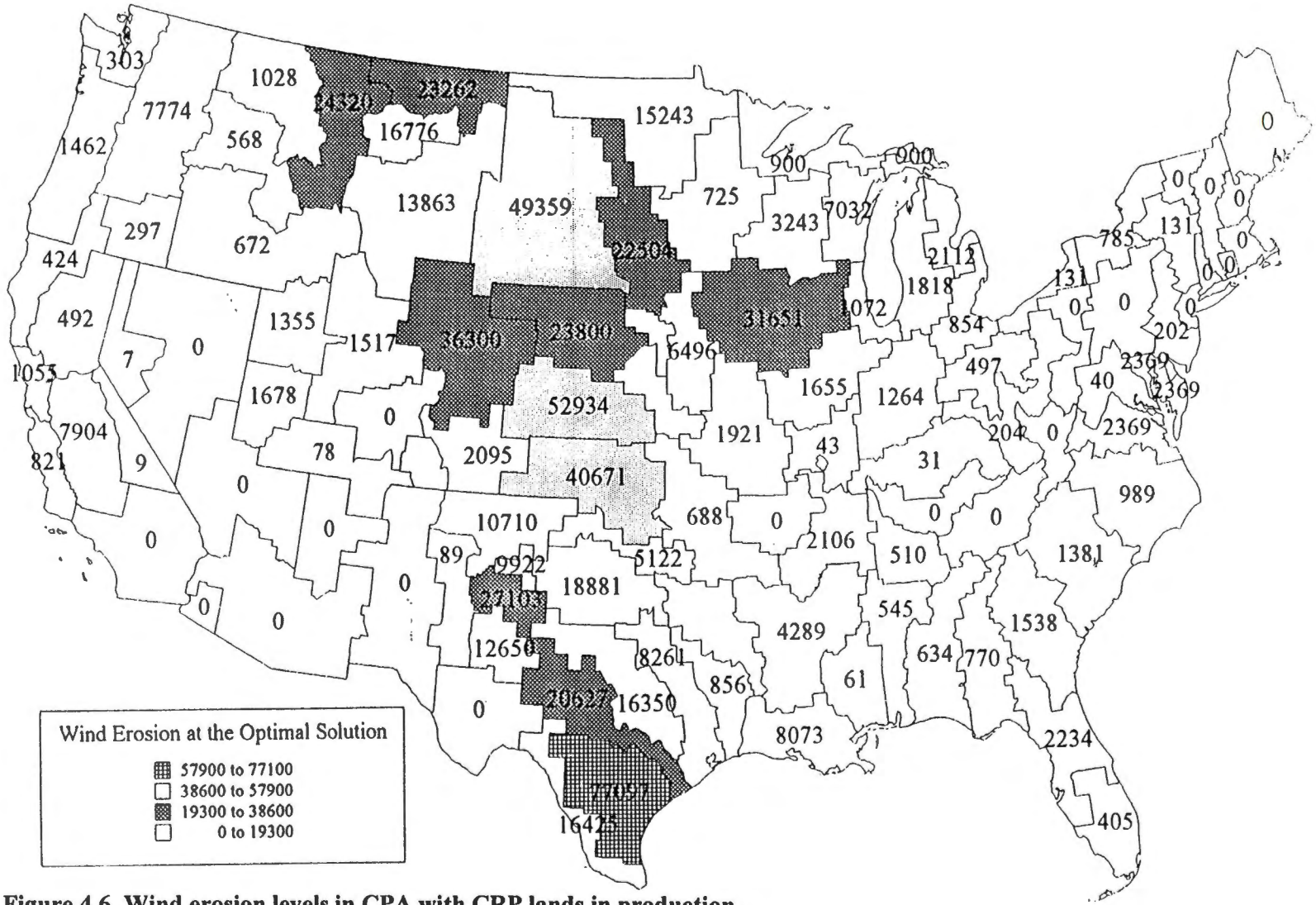

Figure 4.6. Wind erosion levels in CPA with CRP lands in production (1000 tons), 2005.

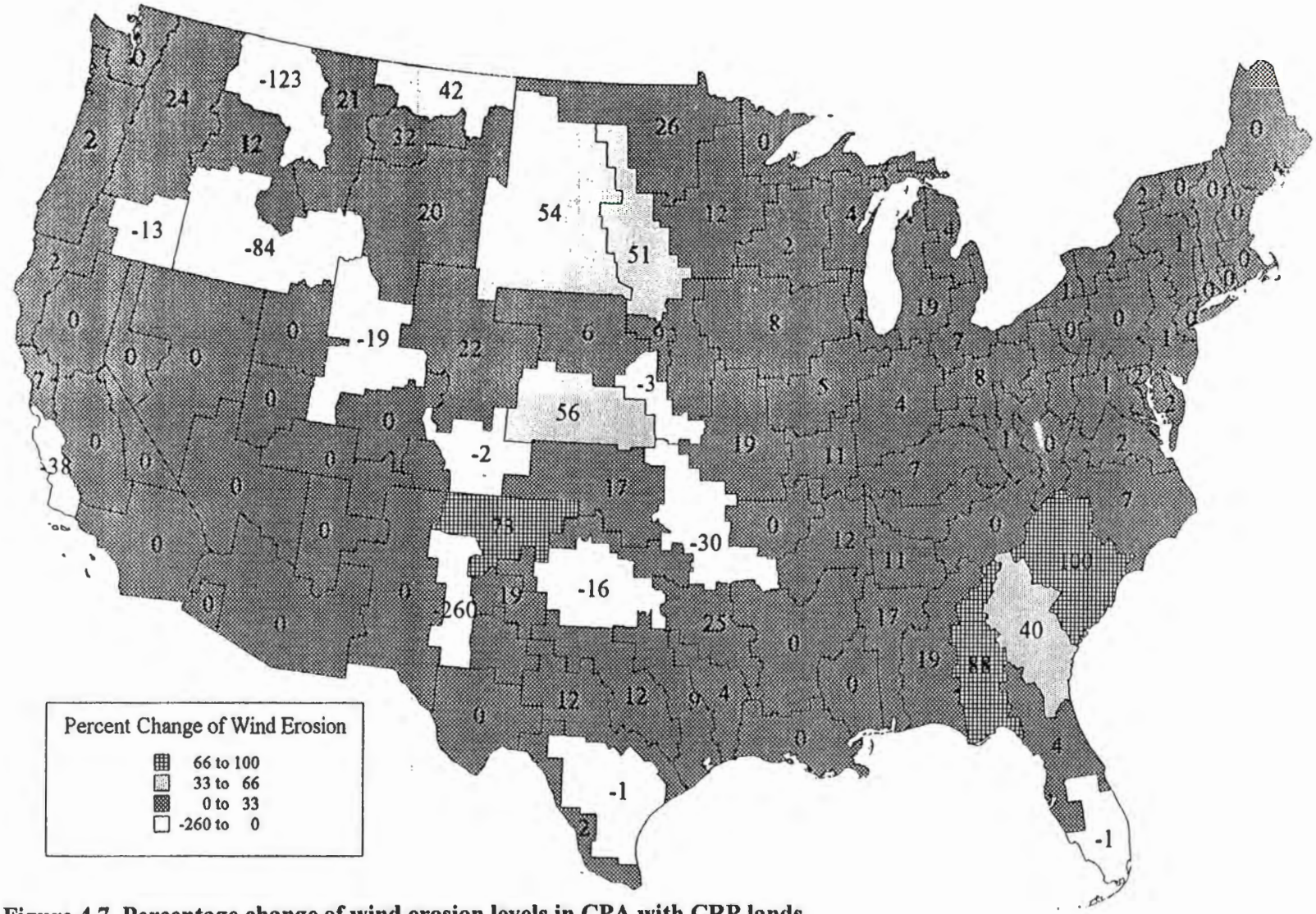

Figure 4.7. Percentage change of wind erosion levels in CPA with CRP lands in and out of production (1000 tons), 2005.

than neighboring CPAs. As a result, it would be more advantageous for CPAs with negative signs to import than produce (see Figure 4.9). Comparing the results obtained in the baseline and the optimum, the quantity of land use in the optimum was relatively higher than the baseline solution. Similarly, the wind erosion per acre showed that the levels of erosion per acre were higher in the optimum than in the baseline (see Table 4.15). Concluding, the results presented for CRP lands, land use, water, and wind erosion were reported in a percentage change because a direct comparison between the numbers would be misleading.

CHAPTER V

SUMMARY, CONCLUSION, AND LIMITATION

The central concern of this section is to discuss the results for projections made for croplands enrolled in CRP. More specifically, examining the impact of releasing land currently enrolled in the CRP for recropping. The present land situation was compared with the projected situation, for the year 2005. The same levels of technology and input prices were assumed for both situations. As CRP lands became available, an increase cropping activity occurred, production increased, and prices fell. In addition, soil erosion increased as a result of available highly erosive lands returning to production.

Through the use of linear programming, livestock was considered exogenous, while cropping activities such as barley, corn, sorghum, oats, and wheat were considered endogenous. This measure allowed livestock to remain within a region, thus preventing the movement of livestock among market regions. A four-year average for each of these commodities were weighted with the forecast values. The results of which suggested that beef production were mainly concentrated in Texas, Nebraska, and Kansas. In these areas lands available from the CRP showed 75% to 100% of these accessible lands would be recropped. Pork production was predominant in Iowa, Illinois, and Minnesota. In this corn belt areas, 75% to 100% of the CRP lands would return to cropping activities. Milk production was concentrated in Wisconsin, California, and New York. These results proved to be mixed. In Wisconsin and New York, 75% to 100% of the CRP lands

available for production would be recropped. However, in California, only 0% to 25% of CRP lands returning into production would be recropped.

Summary of Process

The analysis was conducted in five major steps. The first step required estimation of food, feed, and export demand curves for the endogenous crops. Once this was completed, the demand curves were used to forecast demand levels for the year 2005. This process required the forecasting of exogenous variables within the demand structure. Once demand were forecasted, they were placed in an interregional linear programming model and supply prices were provided. These prices were then placed into the demand equation an a new demand levels were estimated and placed in the linear programming model. The process continued until the criteria established for an equilibrium solution was attained. This process is known as Tatonnement programming.

The available data were for the years 1950 through 1992 and the study was projected to the year 2005. Therefore, forecast values were needed to estimate the demand equation in the year 2005. To forecast these values, double exponential smoothing approach was used rather than the ARIMA approach because the number of observations were limited. Some forecast values were used to update the livestock production up to the year 2005. These values were necessary in determining the feed requirements for the livestock. Whereas other values were kept constant and were used in the estimation of the demand equations during the iteration procedure. The estimated

forecast values were compared to forecast values of Food Agricultural Policy Research Institute (FAPRI) and the results were found to be similar.

In demand analysis, seventeen equations were estimated six equations were related to feed-demand for livestock, five equations were related to food-demand for industrial and human consumption. The remaining equations were obtained indirectly by using their own price elasticities. The former eleven equations were initially estimated using simple linear regression models, the results suggested that improvements in the equations were needed. Seemingly Unrelated Regression Equations (SURE) were used to address this concern. Since the parameters obtained from this analysis were mostly significant at the 1% level, the models were considered to be efficient and consistent.

The supply model was represented by an interregional spatial linear programming model, which provided the shadow prices. In this study, the assumption was that quantities demanded were fixed. The results in the column label, Baseline Price, were the shadow prices with lands enrolled in CRP. The results in the column label, Iteration I, were the shadow prices with lands available from the CRP. The results showed that prices were higher when lands were enrolled in the CRP. The increase in available lands, due to the CRP termination caused prices to be lower. These two linear programming runs determined the boundaries for the optimal solution. The results showed that on the aggregate the prices fell within these boundaries. Since LP assumes that either demand or prices were fixed, the Tatonnement model was used to provide flexibility. This flexibility was needed to obtain new shadow prices through iterations, which in the presence of excess demand and excess supply caused prices to adjust toward equilibrium.

The forecast prices may be lower because the values used to estimate them were a time series from the year 1950 to 1992, whereas the prices obtained from the Tatonnement model were prices obtained under the assumption that all supplies were consumed. Throughout the iteration process, the movement was either from excess supply or excess demand until equilibrium was achieved. When the price decline was continuous, excess supply persisted, as price increased excess demand was present.

In this process, all the demand and supply equations for feed, food, and export (except barley-feed) converged toward the equilibrium point. This convergency was obtained when the absolute value of the difference between supply and demand gradually diminished with every iteration. This suggested that the Tatonnement model behaved as expected, that is, to increase price in the presence of excess demand and to decrease prices in the presence of excess supply.

Summary of Results

Where lands were concern, most of the Crop Producing Areas (CPA) will use the currently enrolled land in the CRP for recropping activities. In light of this, significant effects will occur at the national level, for a varying percentage of CPA lands. Among these were increases in crop production, decreases in prices, increases in soil erosion (wind and water).

Lands currently use for production of crops and livestock in Crop Producing Areas (CPA) were estimated. These results were at two levels a) Baseline and b) Optimum with CRP. Performing these two runs produced in estimates for land use, sheet

and rill erosion, and tons per acre erosion for both the Baseline and Optimum with CRP. The difference between these runs was estimated in percentages, and the comparison of the runs revealed that erosion for wind was generally increased. There were some CPA's in which there were negative signs for the amount of percentage in land use, sheet and rill erosion, and per acre erosion. These effects could possibly be attributed to better management of the lands and crop rotations. Another possible explanation could be that the efficiency in the neighboring CPA's were higher than those with negative signs.

Water erosion was presented at the baseline and at the optimal level, a comparison of these two scenarios indicated that water erosion would increase for most of the CPAs. Some CPAs were showing no changes in water erosion, this may occur because more efficient cropping and management practices were implemented in these returning lands. This practices might be similar to the base line practices. Finally, a set of CPAs were shown to have less erosion, when CRP were lands returned to cropping activities. This might occur because some CPAs adjacent to the CPAs with negative erosion were producing their crops at a lower costs. This cost efficiency may induce farmers to increase their cropping activities, and export their crops to CPAs less cost efficient.

The current situation indicated that crop production was restricted to the lands not enrolled in the CRP. This production, even though plentiful, was less than the optimal solution in most CPAs. The increase in crop production caused by available lands would cause crop prices to decrease, that is more quantity supply would push prices down to clear the market. But the results of the Tatonnement model at its optimal solution

showed an increased in prices. This could be attributed to the increase in quantity demand. Demands may increase due to increases in demands for feed, food, and exports.

Additional lands in crop production might probably caused problems to the environment. Water pollution would increase due soils eroding into the streams, and chemicals leaching in the water sources. Another possible effect would be the reduction of wildlife habitat, which might cause a decline in reproductive areas, food supply areas, and protective areas.

Conclusion

The spatial linear programming in this study considered the livestock sector to be exogenous. However, when using LP alone, a convergency point cannot be obtained because LP assumes fix quantities. The Tatonnement model was used to address the issue of the equilibrium prices (shadow prices). This model was selected to overcome the limitation that a linear programming had, which was the assumption of fixed demand constraints. These constraints were altered by a set of demand equations, which were estimated using the seemingly unrelated regression equations approach.

When comparing the results of an LP based analysis to that of Tatonnement, several conclusions can be made. First, in this analysis there does not seem to be much difference between the change in prices projected by the linear programming and those projected by when using Tatonnement. Corn prices for instance started at $3.37/bushel and fell to $2.90/bushel when linear programming was assumed. However, under Tatonnement modeling the final equilibrium price was $2.93/bushel. Barley, on the other

hand, had a price of $2.90/bushel as the bases. The projected barley price fell to $2.65/bushel and $2.58/bushel under the LP and Tatonnement assumption, respectively.

This examination into the fate and impact of lands retiring from the CRP in the year 2005, has resulted in significant findings with the help of LP, SURE, and the use of the Tatonnement model. Results reveals a sizable increase in cropland production and soil erosion. Since the equilibrium point, achieved in the model, suggests a balance of both supply and demand, it would be reasonable to say that these crops will be consumed by livestock, industry and the human population. In addition, this study projects the areas of greatest and least production which may indicate a need for future planners to consider the cost and requirements of such an expansion. The efficiency and consistency of well managed CPA may be reflected upon by less productive CPA's and in so doing determine their course of action in terms of improve management or a decision to purchase from neighboring CPA's.

As production increases so does soil erosion for both stable (EI < = 8) and unstable (EI > 8) lands. Soil erosion is cause by the impact of both wind and water. The side-effects of soil erosion leads to high flooding and sedimentation, producing high cost to farmers that are affected. In addition, surface and underground water is susceptible to contamination, which in turn can affect both livestock and human consumption. In the long run, allowing soil erosion to continue may result in a reduction of productivity, thus increasing cost of production and increase in prices to the consumer.

Prices were the driving force in the operation of the Tatonnement model. Prices allowed the iteration between the demand and supply equations in an effort to establish equilibrium. At this point prices for the commodities proved to be in the neighborhood of the second run of the LP (iteration I). If CRP lands were allowed to be planted in crops, expected prices in the future will be lower than the current prices for all commodities.

Limitation

The assumptions imposed in the model created some limitations, the demands used in the linear programming were fixed, leaving price to be the only adjusting force toward the equilibrium point. In addition some sectors, such as livestock, were considered to be exogenous. A fully exogenous livestock was included in the model, because of this the flexibility of the supply equations were reduced. Possibly more favorable results could be obtained in future studies by providing more flexibility to the model, that is, to make livestock endogenous rather than exogenous. If the livestock sector were endogenous, the allocation of resources, and the quantity and price equilibrium most probably would have had different results.

The estimation of the demand equations were obtained with data for the years 1950 through 1992. The use of these equations for the year 2005 was assuming that the parameters (β 's) were not changing from the year 1992 through the year 2005. In other words, the assumption was that the demand equations behave in the year 2005 as they did in the year 1992. The export demand equations were obtained indirectly from their own price elasticities. This approach automatically excluded the possibility of changes in

quantity demanded due to the explanatory effect of other independent variables. Therefore, the export demands were assuming to have their elasticities constant all the way to the year 2005.

Even though most of the demand and supply equations converged to the equilibrium point, a problem was observed in this model. The equations for barley-feed did not converge to the equilibrium point at the 5% level. This lack of convergency might have occurred because the barley production steps of the LP were too wide. To address this issue, the additional barley production options may be necessary. Alternatively, improvement could be achieved by observing the absolute difference between supply and demand quantities, and the shadow prices. If the price increases, and the absolute difference also increases, then a heavy weight should be employed to the demand quantity, so that the quantity demanded used as constraints in the LP would force convergency.

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APPENDICES

APPENDIX A
U.S. Agricultural Data Base, 1950-1992

Table A1. U.S.A. agricultural database for the years, 1950-1992.

YEAR	CNDFED	CNTPR	BRDFED	BRTPR	GSDFED	GSTPR	OTDFED	OTTPR	WHDFED	WHTPR
	M.bu.	$ per bu.	M.bu.	$ per bu.	M.bu.	$ per bu.	M.bu.	$ per bu.	M.bu.	$ per bu.
1950	2482	1.52	142	1.19	142	1.05	1176	0.79	109	2.00
1951	2555	1.66	152	1.26	115	1.32	1209	0.82	110	2.11
1952	2312	1.52	135	1.37	77	1.58	1179	0.79	78	2.09
1953	2387	1.48	130	1.17	79	1.32	1101	0.74	87	2.04
1954	2242	1.43	184	1.09	124	1.26	1179	0.71	53	2.12
1955	2366	1.35	252	0.92	159	0.97	1278	0.60	51	1.98
1956	2378	1.29	219	0.99	172	1.15	1125	0.69	58	1.97
1957	2534	1.11	220	0.89	269	0.97	1056	0.61	43	1.93
1958	2783	1.12	230	0.90	269	1.00	1193	0.58	49	1.75
1959	3043	1.05	237	0.86	371	0.86	1009	0.65	49	1.76
1960	3092	1.00	251	0.84	416	0.83	934	0.60	30	1.74
1961	3213	1.10	247	0.98	411	1.01	928	0.64	44	1.83
1962	3156	1.12	225	0.92	391	1.02	879	0.62	35	2.04
1963	3009	1.11	231	0.90	472	0.97	816	0.62	28	1.85
1964	2956	1.17	250	0.95	412	1.05	783	0.63	55	1.37
1965	3362	1.16	201	1.02	568	0.99	742	0.62	146	1.35
1966	3333	1.24	209	1.06	601	1.02	749	0.67	100	1.63
1967	3524	1.03	205	1.01	531	0.99	686	0.66	36	1.39
1968	3607	1.08	226	0.92	614	0.95	736	0.60	156	1.24
1969	3825	1.16	247	0.89	638	1.07	736	0.58	188	1.25
1970	3593	1.33	288	0.97	680	1.14	778	0.62	193	1.33
1971	3982	1.08	270	0.99	681	1.04	740	0.60	262	1.34
1972	4292	1.57	243	1.21	648	1.37	715	0.72	200	1.76
1973	4181	2.55	236	2.14	690	2.14	669	1.18	125	3.95
1974	3180	3.02	184	2.81	425	2.77	579	1.53	35	4.09
1975	3582	2.54	186	2.42	494	2.36	564	1.45	38	3.56
1976	3602	2.15	174	2.25	411	2.03	488	1.56	74	2.73
1977	3730	2.02	177	1.78	448	1.82	515	1.09	192	2.33
1978	4275	2.25	215	1.92	538	2.01	530	1.20	158	2.98
1979	4563	2.48	202	2.27	495	2.35	495	1.36	86	3.80
1980	4232	3.12	168	2.79	323	2.91	437	1.79	59	3.99
1981	4245	2.47	198	2.48	416	2.25	458	1.89	135	3.69

Table A1. Continued.

YEAR	CNDFED	CNTPR	BRDFED	BRTPR	GSDFED	GSTPR	OTDFED	OTTPR	WHDFED	WHTPR
	M.bu	$ per bu.	M.bu	$ per bu.	M.bu	$ per bu.	M.bu	$ per bu.	M.bu	$ per bu.
1982	4573	2.55	241	2.18	495	2.47	442	1.49	195	3.45
1983	3876	3.21	280	2.47	385	2.74	474	1.67	371	3.51
1984	4115	2.63	306	2.29	539	2.32	436	1.69	407	3.39
1985	4114	2.23	328	1.98	664	1.93	464	1.24	284	3.08
1986	4669	1.50	298	1.61	536	1.37	385	1.21	401	2.42
1987	4798	1.94	253	1.81	555	1.70	358	1.56	280	2.57
1988	3941	2.54	171	2.80	466	2.27	194	2.61	146	3.72
1989	4389	2.36	190	2.42	518	2.10	266	1.49	139	3.72
1990	4663	2.28	205	2.14	410	2.12	286	1.14	499	2.61
1991	4878	2.37	225	2.10	374	2.25	235	1.21	250	3.00
1992	5301	2.07	195	2.05	478	1.89	233	1.32	191	3.24

CNDFED corn-feed, CNTPR price of corn, BRDFED barley-feed, BRTPR price of barley, GSDFED sorghum-feed, GSTPR price of sorghum, OTDFED oats-feed, OTTPR price of oats, WHDFED wheat-feed, WHTPR price of wheat,

Table A1. Continued.

YEAR	BRDOTH	CNDOTH	GSDOTH	OTDOTH	WHDOTH	CPIFO	CPIFS	PERCAP	PERDIN	PESDIN
	M.bu.	M.bu.	M.bu.	M.bu.	M.bu.	82-84=100	82-84=100	B. 1987 $	B. 1987 $	B. dollars
1950	119	271	38	134	87	25.4	0.0	0	0.0	0.0
1951	109	246	14	140	88	28.2	0.0	0	0.0	0.0
1952	104	243	6	142	90	28.7	0.0	0	0.0	0.0
1953	115	241	7	151	68	28.3	0.0	0	0.0	0.0
1954	114	249	11	153	66	28.2	0.0	0	0.0	0.0
1955	87	258	11	145	72	27.8	0.0	0	0.0	0.0
1956	116	260	13	142	60	28.0	0.0	0	0.0	0.0
1957	113	263	12	133	60	28.9	0.0	0	0.0	0.0
1958	116	289	11	129	63	30.2	0.0	0	0.0	0.0
1959	116	290	14	121	61	29.7	0.0	7256	1284.9	346.7
1960	116	295	13	124	64	30.0	22.5	7264	1313.0	360.5
1961	116	315	11	119	56	30.4	23.0	7382	1356.4	376.2
1962	114	323	12	116	61	30.6	24.0	7583	1414.8	398.7
1963	115	339	13	110	65	31.1	23.9	7718	1461.1	418.4
1964	117	349	13	106	66	31.5	23.4	8140	1562.2	454.7
1965	122	360	13	105	62	32.2	24.1	8508	1653.5	491.0
1966	127	364	13	97	77	33.8	25.6	8822	1734.3	530.7
1967	129	362	13	101	71	34.1	26.5	9114	1811.4	568.6
1968	134	359	13	101	61	35.3	26.9	9399	1886.8	617.8
1969	139	365	9	103	56	37.1	28.4	9606	1947.4	663.8
1970	138	385	12	97	62	39.2	31.3	9875	2025.3	722.0
1971	140	409	13	94	63	40.4	34.5	10111	2099.9	784.9
1972	142	450	10	93	67	42.1	37.6	10414	2186.2	848.5
1973	143	472	11	89	84	48.2	43.1	11013	2334.1	958.1
1974	147	497	12	86	92	55.1	49.7	10832	2317.0	1046.5
1975	146	521	11	82	100	59.8	53.9	10906	2355.4	1150.9
1976	155	542	11	86	92	61.6	60.2	11192	2440.9	1264.0
1977	155	581	11	81	80	65.5	66.7	11406	2512.6	1391.3
1978	167	608	12	75	87	72.0	73.0	11851	2638.4	1567.8
1979	172	640	12	73	101	79.9	80.1	12039	2710.1	1753.0
1980	178	659	11	74	113	86.8	87.5	12005	2733.6	1952.9
1981	174	733	12	75	110	93.6	94.8	12156	2795.8	2174.5

Table A1. Continued.

YEAR	BRDOTH	CNDOTH	GSDOTH	OTDOTH	WHDOTH	CPIFO	CPIFS	PERCAP	PERDIN	PESDIN
	M.bu.	M.bu.	M.bu.	M.bu.	M.bu.	82-84=100	82-84=100	B. 1987 $	B. 1987 $	B. dollars
1982	170	855	10	85	97	97.4	98.2	12146	2820.4	2319.6
1983	172	930	10	70	100	99.4	99.3	12349	2893.6	2493.7
1984	170	1067	17	72	98	103.2	102.5	13029	3080.1	2759.5
1985	169	1153	28	77	93	105.6	107.5	13258	3162.1	2943.0
1986	175	1224	12	83	84	109.0	117.4	13552	3261.9	3131.5
1987	174	1243	25	81	85	113.5	129.9	13545	3289.6	3289.5
1988	175	1293	22	100	103	118.2	137.4	13890	3404.3	3548.2
1989	179	1356	15	115	100	125.1	143.6	14005	3464.9	3787.0
1990	176	1373	9	120	90	132.4	146.7	14101	3524.5	4050.5
1991	176	1454	9	125	98	136.3	148.3	13965	3529.0	4230.5
1992	172	1511	8	125	98	137.9	151.7	14219	3632.5	4500.2

BRDOTH barley-food, CNDOTH corn-food, GSDOTH sorghum-food, OTDOTH oats-food , WHDOTH wheat-food,CPIFO consumer price index for all food, CPIFS onsumer price index of fish, PERCAP per capita personal disposable income, PERDIN personal income,PESDIN personal disposable income, ,

Table A1. Continued.

YEAR	SYTPR	SMTPR	LMTPR	MKTPR	BFTPR	BLTPR	BFSPDN	TKSPDN	TKTPR	LMSPRD	PKSPDN
	$ per bushel	$per ton	$ per cwt	$ per cwt	$ per cwt	cts per lb	M. of lbs	M. of lbs	cts per lb	M. of lbs	M. of lbs
1950	2.47	64.45	25.10	3.89	23.30	27.4	9534	0	32.9	597	10714
1951	2.73	83.35	31.00	4.58	28.70	28.5	8837	0	37.5	521	11481
1952	2.72	67.55	24.30	4.85	24.30	28.8	9650	0	33.6	648	11527
1953	2.72	78.65	19.30	4.32	16.30	27.1	12407	0	33.7	729	10006
1954	2.46	60.70	19.10	3.97	16.00	23.1	12963	0	28.8	734	9870
1955	2.22	52.55	18.40	4.01	15.60	25.2	13569	0	30.2	758	10990
1956	2.18	47.45	18.50	4.14	14.90	19.6	14462	0	27.2	741	11200
1957	2.07	53.40	19.90	4.21	17.20	18.9	14202	0	23.4	707	10424
1958	2.00	55.80	21.00	4.13	21.90	18.5	13330	0	23.9	688	10454
1959	1.96	55.55	18.70	4.16	22.60	16.1	13580	0	23.9	738	11993
1960	2.13	60.60	17.90	4.21	20.40	16.9	14728	1166	25.4	769	13905
1961	2.28	63.60	15.80	4.22	20.20	13.9	15300	1495	18.9	833	13647
1962	2.34	71.30	17.85	4.09	21.30	15.2	15299	1294	21.6	808	13953
1963	2.51	71.00	18.10	4.10	19.90	14.6	16428	1350	22.3	769	14492
1964	2.62	70.20	19.90	4.15	18.00	14.2	18428	1453	21.0	715	14597
1965	2.54	81.46	22.80	4.23	19.80	15.0	18699	1515	22.2	651	12782
1966	2.75	78.83	23.40	4.81	22.29	15.3	19695	1674	23.1	649	12797
1967	2.49	76.93	22.10	5.02	22.30	13.3	20183	1870	19.7	646	14130
1968	2.43	74.12	24.40	5.24	23.40	14.2	20845	1611	20.5	602	14516
1969	2.35	78.45	27.20	5.49	26.20	15.2	21126	1606	22.4	550	14244
1970	2.85	78.51	26.40	5.71	27.10	13.6	21685	1729	22.6	551	14699
1971	3.03	90.20	25.90	5.87	29.00	13.8	21904	1772	22.1	556	16006
1972	4.37	228.99	29.10	6.07	33.50	14.1	22413	1909	22.2	543	14422
1973	5.68	146.35	35.10	7.14	42.80	24.0	21278	1933	38.2	512	13223
1974	6.64	130.86	37.00	8.33	35.60	21.5	23137	1921	28.0	464	14331
1975	4.92	147.78	42.10	8.75	32.20	26.3	23975	1803	34.8	411	11779
1976	6.81	199.80	46.90	9.66	33.70	23.6	25969	2059	31.7	371	12688
1977	5.88	164.20	51.30	9.72	34.40	23.6	25279	2023	35.5	350	13248
1978	6.66	190.06	62.80	10.60	48.50	26.3	24241	2098	43.6	310	13393
1979	6.28	181.91	66.70	12.02	66.10	26.0	21447	2344	41.1	291	15451
1980	7.57	218.18	63.60	13.05	62.40	27.7	21643	2432	41.3	318	16617
1981	6.04	182.52	54.90	13.77	58.60	28.4	22389	2577	38.2	338	15873

Table A1. Continued.

YEAR	SYTPR	SMTPR	LMTPR	MKTPR	BFTPR	BLTPR	BFSPDN	TKSPDN	TKTPR	LMSPRD	PKSPDN
	$ per bushel	$per ton	$ per cwt	$ per cwt	$ per cwt	cts per lb	M. of lbs	M. of lbs	cts per lb	M. of lbs	M. of lbs
1982	5.65	187.19	53.10	13.61	56.70	26.9	22536	2522	39.5	365	14229
1983	7.83	188.20	53.90	13.58	55.50	28.6	23243	2649	38.0	375	15199
1984	5.84	125.40	60.10	13.46	57.30	33.7	23598	2685	48.9	379	14812
1985	5.05	154.90	67.70	12.76	53.70	30.1	23728	2942	49.1	359	14807
1986	4.78	163.00	69.00	12.51	52.60	34.5	24371	3271	47.0	338	14063
1987	5.88	222.00	77.92	12.54	61.10	28.3	23566	3832	34.3	315	14374
1988	7.42	252.40	69.50	12.26	66.80	34.0	23589	3960	37.3	335	15684
1989	5.69	186.50	67.30	13.56	69.70	36.1	23087	4285	40.0	347	15813
1990	5.74	181.40	56.00	13.68	74.80	32.4	22743	4514	38.4	363	15354
1991	5.58	189.20	52.50	12.24	72.90	31.0	22917	4603	37.7	363	15999
1992	5.56	193.75	60.76	13.09	71.38	30.8	23086	4777	38.0	348	17234

SYTPR price of soybean, SMTPR price of soybean meal, LMTPR price of lamb, MKTPR price of milk, BFTPR price of beef, BLTPR price of broiler, BFSPDN production of beef, TKSPDN production of turkey, TKTPR price of turkey, LMSPRD production of lamb, and PKSPDN production of pork.Source: Agricultural Analysis Center (APAC), 1994 edition.

APPENDIX B
Beef Feedstuffs Requirements

Table B1 . Feedstuffs required for beef production, by state.

State Name	Corn	Sorghum	Oats	Barley	Wheat	Oilmeal	Legume Hay	Other Hay	Corn Silage	Sorghum Silage
	pounds per hundred weight (liveweight)									
Alabama	136.11	0.00	38.44	13.44	5.11	6.89	123.67	963.00	1429.44	0.00
Arizona	137.44	146.67	38.89	13.56	5.22	6.89	227.56	578.22	1356.67	0.00
Arkansas	130.22	0.00	36.78	12.78	4.89	6.56	207.56	569.44	975.89	0.00
Californi	131.00	148.89	37.00	12.89	4.89	6.67	172.22	393.56	1167.33	0.00
Colorado	149.67	147.78	42.22	14.78	5.67	7.56	160.89	241.33	1394.22	0.00
Connectic	136.56	0.00	38.56	13.44	5.11	6.89	151.00	329.78	1962.00	0.00
Delaware	131.89	0.00	37.22	13.00	5.00	6.67	525.33	539.22	1567.78	0.00
Florida	129.33	0.00	36.44	12.78	4.89	6.56	383.00	296.89	1281.78	0.00
Georgia	130.33	0.00	36.89	12.89	4.89	6.56	509.33	499.67	1348.78	0.00
Idaho	129.22	0.00	36.44	12.78	4.89	6.56	192.11	297.22	1199.78	0.00
Illinois	133.00	0.00	37.56	13.11	5.00	6.78	154.33	281.89	936.67	0.00
Indiana	195.44	0.00	34.44	24.56	12.33	10.00	580.33	105.22	978.33	0.00
Iowa	192.78	0.00	34.00	24.33	12.11	9.89	731.33	171.22	880.44	0.00
Kansas	192.33	0.00	33.89	24.22	12.11	9.78	529.78	127.22	706.33	0.00
Kentucky	221.00	50.11	13.89	25.33	19.01	0.11	266.00	361.89	536.11	0.00
Louisiana	221.22	50.11	13.89	25.44	19.01	0.11	254.22	193.67	475.89	33.78
Maine	226.11	51.22	14.22	26.00	19.35	0.44	297.44	110.78	474.00	16.00
Maryland	219.56	49.78	13.78	25.22	18.79	0.00	292.56	71.89	514.56	9.33
Massachussets	216.44	49.00	13.56	24.89	18.68	1.00	185.56	413.56	221.89	36.89
Michigan	119.56	97.56	6.67	14.78	12.00	10.78	518.11	394.00	339.33	1.11
Minnesota	118.89	96.89	6.67	14.67	11.89	10.78	370.22	186.56	588.89	29.11
Mississippi	117.22	95.67	6.56	14.44	11.78	10.67	288.56	134.00	402.33	51.00
Missouri	115.67	94.33	6.44	14.22	11.56	10.56	195.89	114.44	247.11	193.11
Montana	87.44	17.00	8.11	6.11	3.44	7.78	76.56	526.78	949.78	43.33
Nebraska	155.56	162.22	8.22	6.22	3.56	8.00	245.22	904.00	612.11	0.00
Nevada	89.00	17.33	8.22	6.22	3.56	8.00	16.11	262.22	865.00	162.67
New Hampshire	86.22	16.67	8.00	6.11	3.44	7.67	109.11	427.44	366.56	19.44
New Jersey	87.44	17.00	8.11	6.11	3.44	7.78	43.89	361.89	441.44	35.78
New Mexico	111.00	15.89	13.78	8.78	3.67	9.78	0.00	406.67	444.44	112.11
New York	109.56	15.67	13.56	8.67	3.67	9.67	3.67	310.33	299.56	75.67
North Carolina	106.33	15.22	13.22	8.33	3.56	9.44	0.00	100.67	44.00	0.00

Table B1 . Continued.

State Name	Corn	Sorghum	Oats	Barley	Wheat	Oilmeal	Legume Hay	Other Hay	Corn Silage	Sorghum Silage
	pounds per hundred weight (liveweight)									
North Dakota	111.22	15.89	13.78	8.78	3.67	9.89	1.22	270.22	122.22	46.11
Ohio	79.00	13.56	6.22	5.33	1.89	8.89	8.22	271.11	118.00	118.44
Oklahoma	73.67	12.67	5.78	4.89	1.78	8.33	47.11	290.00	19.22	52.89
Oregon	79.44	13.56	6.22	5.33	1.89	8.89	10.00	224.33	40.33	23.67
Pennsylvania	85.00	90.78	4.11	10.78	10.56	8.00	137.00	150.22	45.89	41.78
Rhode Island	83.00	88.67	4.00	10.56	10.22	7.78	30.67	136.22	47.44	22.89
South Carolina	126.56	91.56	5.78	15.78	7.00	10.11	415.78	254.22	165.00	0.00
South Dakota	124.11	89.89	5.67	15.44	6.89	9.89	862.89	118.33	347.22	0.00
Tennessee	127.89	92.56	5.89	15.89	7.11	10.11	309.78	212.11	167.22	0.00
Texas	120.33	87.11	5.56	15.00	6.67	9.56	195.00	92.22	448.00	19.00
Utah	122.22	88.44	5.56	15.22	6.78	9.78	238.11	27.00	114.56	16.56
Vermont	117.00	84.78	5.44	14.56	6.44	9.33	304.67	21.11	45.67	26.67
Virginia	128.11	92.78	5.89	16.00	7.11	10.22	749.11	106.89	622.44	0.00
Washington	124.11	89.89	5.67	15.44	6.89	9.89	490.44	264.44	38.44	0.00
West Virginia	127.11	104.11	7.44	17.33	20.11	9.33	566.44	214.22	338.11	0.00
Wisconsin	129.44	106.11	7.56	17.67	20.56	9.44	408.44	316.33	176.89	0.00
Wyoming	126.11	103.22	7.33	17.22	20.00	9.22	456.67	64.33	186.44	13.89

Source: Ceneter for Agricultural and Rural Development; Technical Report 89-TR12.

Table B2 . Weights used to allocate livestock production from state to market region.

State Name	LPA	Beef	Pork	Milk
		Percent		
Alabama	9	100.00	100.00	100.00
Arizona	24	9.82	32.57	1.01
Arizona	28	90.18	67.43	98.99
Arkansas	13	39.86	45.36	43.08
Arkansas	14	27.35	9.45	10.70
Arkansas	18	32.79	45.19	46.22
California	30	29.56	27.49	14.91
California	31	70.44	72.51	85.09
Colorado	17	11.41	9.70	7.22
Colorado	18	2.44	1.07	0.28
Colorado	23	80.02	84.31	88.59
Colorado	24	6.13	4.92	3.91
Connectic	1	100.00	100.00	100.00
Delaware	2	49.69	21.70	77.80
Delaware	3	50.31	78.30	22.20
Florida	4	0.53	2.74	3.60
Florida	5	89.85	67.68	89.87
Florida	9	9.62	29.58	6.53
Georgia	4	47.96	53.68	65.18
Georgia	5	10.25	15.80	4.17
Georgia	9	41.79	30.52	30.65
Idaho	25	2.30	6.01	1.87
Idaho	26	93.06	91.19	88.01
Idaho	27	4.64	2.80	10.12
Illinois	8	14.09	14.50	7.43
Illinois	11	2.81	1.75	12.10
Illinois	12	70.02	70.70	58.29
Illinois	13	13.08	13.05	22.18
Indiana	6	7.07	5.66	6.35
Indiana	7	8.30	11.49	34.43
Indiana	8	79.47	78.27	54.22
Indiana	11	2.21	1.74	4.72
Indiana	12	2.95	2.84	0.28
Iowa	12	59.83	74.24	82.04
Iowa	15	34.98	21.77	10.93
Iowa	16	5.19	3.99	7.03
Kansas	15	15.83	31.90	36.19
Kansas	17	23.56	26.61	0.16
Kansas	18	60.61	41.49	47.10
Kentucky	6	3.19	1.10	3.14
Kentucky	8	94.01	90.71	94.34
Kentucky	9	0.87	1.85	0.76
Kentucky	13	1.93	6.34	1.76
Louisiana	14	94.62	98.35	89.23
Louisiana	19	5.38	1.65	10.77
Maine	1	100.00	100.00	100.00
Maryland	2	3.94	1.08	600.00
Maryland	3	96.06	98.92	95.23
Massachus	1	100.00	100.00	100.00

Table A2 . Continued.

State Name	LPA	Beef	Pork	Milk
		Percent		
Michigan	7	95.60	99.68	95.03
Michigan	10	2.16	0.12	1.84
Michigan	11	2.24	0.20	3.13
Minnesota	10	71.96	71.21	73.25
Minnesota	11	18.05	14.91	22.17
Minnesota	12	2.55	7.17	2.18
Minnesota	16	7.44	6.71	2.40
Mississippi	9	13.49	20.10	16.44
Mississippi	13	1.48	2.45	2.28
Mississippi	14	85.03	77.45	81.28
Missouri	12	9.71	18.51	4.75
Missouri	13	19.99	20.57	23.88
Missouri	15	63.87	57.37	61.38
Missouri	18	6.43	3.55	9.99
Montana	16	2.10	1.09	0.67
Montana	22	59.06	56.82	29.52
Montana	25	38.84	42.09	69.81
Nebraska	15	31.60	56.24	50.16
Nebraska	16	4.60	10.04	10.72
Nebraska	17	58.04	32.01	37.73
Nebraska	23	5.76	1.71	1.39
Nevada	27	70.33	28.33	7.18
Nevada	28	3.89	0.86	33.31
Nevada	30	25.78	70.81	59.51
New Hampshire	1	100.00	100.00	100.00
New Jersey	2	100.00	100.00	100.00
New Mexico	21	63.10	79.45	42.69
New Mexico	24	28.42	19.87	56.48
New Mexico	28	8.48	0.68	0.83
New York	1	2.24	0.94	2.92
New York	2	86.47	85.21	87.09
New York	6	11.29	13.85	9.99
North Carolina	3	36.02	83.71	27.88
North Carolina	4	56.92	16.21	66.61
North Carolina	6	7.06	0.08	5.51
North Dakota	10	28.76	53.47	27.88
North Dakota	16	71.24	46.53	72.12
Ohio	6	83.93	66.96	83.38
Ohio	7	16.07	33.04	16.62
Oklahoma	14	9.44	6.75	5.82
Oklahoma	18	81.53	86.49	92.21
Oklahoma	21	9.03	6.76	1.97
Oregon	26	28.98	9.39	11.04
Oregon	29	63.64	89.96	85.86
Oregon	30	7.38	0.65	3.10
Pennsylvania	2	65.06	84.24	69.95
Pennsylvania	3	3.30	4.88	6.34
Pennsylvania	6	31.64	10.88	23.71
Rhode Island	1	100.00	100.00	100.00

Table A2 . Continued.

State Name	LPA	Beef	Pork	Milk
		Percent		
South Carolina	4	100.00	100.00	100.00
South Dakota	10	2.32	2.59	7.31
South Dakota	16	97.68	97.41	92.69
Tennessee	4	28.72	10.84	43.78
Tennessee	8	31.58	29.34	24.40
Tennessee	9	25.67	31.80	25.49
Tennessee	13	14.03	28.02	6.33
Texas	14	4.60	1.90	20.66
Texas	18	8.23	4.01	4.98
Texas	19	33.30	36.82	49.69
Texas	20	28.82	39.36	18.44
Texas	21	24.71	17.65	4.95
Texas	24	0.34	0.26	1.28
Utah	23	17.53	13.29	5.48
Utah	24	8.95	7.03	1.08
Utah	27	70.70	79.11	92.47
Utah	28	2.82	0.57	0.97
Vermont	1	95.89	98.92	98.25
Vermont	2	4.11	1.08	1.75
Virginia	3	73.98	94.94	76.28
Virginia	4	12.45	1.82	10.64
Virginia	6	13.57	3.24	13.08
Washington	25	3.59	10.03	2.40
Washington	26	6.42	17.55	0.28
Washington	29	89.99	72.42	97.32
West Virginia	3	25.35	57.81	32.15
West Virginia	6	74.65	42.19	67.85
Wisconsin	10	6.36	2.07	5.18
Wisconsin	11	61.21	55.78	74.11
Wisconsin	12	32.43	42.15	20.71
Wyoming	16	12.20	7.39	6.31
Wyoming	22	35.57	38.38	33.97
Wyoming	23	51.25	54.23	56.66
Wyoming	26	0.98	0.00	3.06

Source: Center for Agricultural and Rural Development; Technical Report 89-TR12.

Table B3. Feedstuffs required for beef production for the year 2005.

State Name	LPA	Corn	Sorghum	Oats	Barley	Wheat	Oilmeal
Alabama	9	1862125.29	0.00	920323.04	214518.58	65249.40	22818901.70
Arizona	24	149513.50	159554.32	74036.05	17209.72	5299.98	1814442.19
Arizona	28	1373027.24	1465235.05	679895.24	158041.99	48671.34	16662565.84
Arkansas	13	653839.27	0.00	323178.96	74863.64	22916.01	7973588.11
Arkansas	14	448632.81	0.00	221749.74	51367.80	15723.85	5471089.68
Arkansas	18	537867.27	0.00	265856.45	61585.02	18851.38	6559306.42
California	30	1581126.33	1797052.66	781510.91	181507.67	55085.96	19488470.64
California	31	3767744.88	4282286.52	1862301.38	432523.69	131267.08	46440049.80
Colorado	17	703211.83	694331.83	347142.42	81016.34	24864.01	8598641.79
Colorado	18	150380.09	148481.13	74235.54	17325.14	5317.11	1838798.07
Colorado	23	4931727.50	4869450.73	2434560.61	568179.47	174374.97	60303533.37
Colorado	24	377799.17	373028.40	186501.58	43525.87	13358.14	4619603.34
Connecticut	1	59955.44	0.00	29626.49	6884.16	2093.93	732286.35
Delaware	2	14467.07	0.00	7144.69	1663.64	511.89	177113.32
Delaware	3	14647.58	0.00	7233.83	1684.40	518.28	179323.23
Florida	4	6251.88	0.00	3082.67	720.76	220.63	76766.47
Florida	5	1059869.92	0.00	522600.36	122188.67	37402.35	13014089.15
Florida	9	113477.45	0.00	55953.43	13082.41	4004.57	1393383.84
Georgia	4	549152.25	0.00	272016.39	63364.80	19230.65	6691274.75
Georgia	5	117364.69	0.00	58135.28	13542.31	4109.97	1430057.68
Georgia	9	478504.43	0.00	237021.79	55212.99	16756.65	5830449.79
Idaho	25	52781.53	0.00	26047.65	6090.18	1864.22	648653.40
Idaho	26	2135586.46	0.00	1053910.76	246413.82	75428.08	26245080.65
Idaho	27	106480.99	0.00	52548.31	12286.27	3760.87	1308587.73
Illinois	8	309354.66	0.00	152886.33	35575.79	10854.55	3817608.33
Illinois	11	61695.29	0.00	30490.46	7094.96	2164.75	761354.11
Illinois	12	1537332.40	0.00	759765.85	176793.23	53941.49	18971535.49
Illinois	13	287179.49	0.00	141927.13	33025.64	10076.47	3543954.36
Indiana	6	116563.92	0.00	35946.11	17089.36	6863.58	1443800.98
Indiana	7	136843.07	0.00	42199.82	20062.48	8057.67	1694985.59
Indiana	8	1310231.19	0.00	404050.52	192092.16	77149.72	16228976.50
Indiana	11	36436.53	0.00	11236.34	5341.94	2145.47	451315.44

Table B3. Continued.

State Name	LPA	Corn	Sorghum	Oats	Barley	Wheat	Oilmeal
Indiana	12	48637.00	0.00	14998.73	7130.64	2863.87	602434.64
Iowa	12	4933324.23	0.00	1522630.94	726384.52	289240.17	61267565.80
Iowa	15	2884300.21	0.00	890216.12	424685.45	169106.15	35820482.23
Iowa	16	427945.06	0.00	132081.81	63010.79	25090.36	5314702.77
Kansas	15	2023683.64	0.00	624029.62	297314.79	118925.92	24910996.09
Kansas	17	3011875.33	0.00	928751.60	442497.57	176999.03	37075367.53
Kansas	18	7748292.18	0.00	2389288.40	1138360.68	455344.27	95379372.91
Kentucky	6	113862.07	25817.32	12523.54	15225.40	9141.25	13719.43
Kentucky	8	3355540.16	760842.16	369071.46	448695.95	269394.71	404314.67
Kentucky	9	31053.29	7041.09	3415.51	4152.38	2493.07	3741.66
Kentucky	13	68888.34	15619.88	7576.94	9211.61	5530.60	8300.47
Louisiana	14	1176360.57	266465.18	129257.68	157826.52	94348.49	141600.70
Louisiana	19	66886.70	15150.95	7349.46	8973.86	5364.56	8051.28
Maine	1	153262.20	34718.01	16867.59	20560.58	12241.45	72197.91
Maryland	2	19099.52	4330.36	2097.76	2559.54	1525.57	0.00
Maryland	3	465659.88	105577.28	51144.96	62403.29	37194.54	0.00
Massachusetts	1	75714.51	17141.06	8301.17	10158.12	6098.95	84683.39
Michigan	7	995706.11	812488.19	97209.60	143603.98	93274.58	21733049.82
Michigan	10	22497.13	18357.47	2196.37	3244.61	2107.46	491039.62
Michigan	11	23330.35	19037.38	2277.71	3364.78	2185.51	509226.27
Minnesota	10	2154610.84	1755910.87	211537.51	310170.45	201113.93	47293224.31
Minnesota	11	540449.22	440441.79	53060.76	77801.23	50446.17	11862739.00
Minnesota	12	76351.55	62223.08	7496.12	10991.31	7126.74	1675899.42
Minnesota	16	222766.88	181544.98	21871.03	32068.76	20793.32	4889683.00
Mississippi	9	129622.51	105792.40	12694.65	18629.13	12157.96	2856273.36
Mississippi	13	14221.00	11606.58	1392.74	2043.82	1333.86	313364.31
Mississippi	14	817034.97	666829.34	80016.73	117422.93	76633.91	18003626.65
Missouri	12	286335.06	233509.00	27898.30	41067.68	26708.43	6328114.95
Missouri	13	589478.66	480725.53	57434.29	84546.13	54984.71	13027705.24
Missouri	15	1883441.84	1535964.97	183508.17	270133.14	175681.52	41624789.09
Missouri	18	189612.20	154630.57	18474.36	27195.18	17686.43	4190502.49

Table B3. Continued.

State Name	LPA	Corn	Sorghum	Oats	Barley	Wheat	Oilmeal
Montana	16	39590.58	7697.16	6426.00	3227.53	1453.71	852742.65
Montana	22	1113437.98	216473.53	180723.57	90770.32	40883.79	23982371.78
Montana	25	732237.24	142360.85	118850.38	59693.86	26886.66	15771678.29
Nebraska	15	3931063.61	4099364.48	363514.72	183378.88	83965.12	48939415.10
Nebraska	16	572243.44	596742.93	52916.70	26694.39	12222.77	7124092.07
Nebraska	17	7220219.37	7529339.07	667670.71	336813.61	154219.48	89887457.35
Nebraska	23	716548.30	747225.93	66260.91	33426.02	15305.03	8920602.25
Nevada	27	226247.00	44054.61	36568.13	18447.18	8446.55	4923109.19
Nevada	28	12513.88	2436.69	2022.61	1020.33	467.18	272300.51
Nevada	30	82932.57	16148.56	13404.33	6761.96	3096.15	1804603.37
New Hampshire	1	22771.19	4402.64	3697.48	1882.63	847.96	490376.48
New Jersey	2	37867.30	7362.12	6146.29	3087.04	1390.43	815624.93
New Mexico	21	924080.04	132284.97	200758.47	85276.21	28516.06	19709795.30
New Mexico	24	416202.13	59580.65	90420.85	38408.08	12843.52	8877216.84
New Mexico	28	124186.98	17777.76	26979.90	11460.26	3832.27	2648796.58
New York	1	16992.48	2430.38	3680.46	1568.81	531.26	363067.85
New York	2	655955.13	93819.07	142075.71	60560.30	20508.08	14015391.50
New York	6	85645.12	12249.53	18550.19	7907.09	2677.65	1829926.80
North Carolin	3	252335.44	36119.11	54902.48	23062.92	7885.14	5423143.40
North Carolin	4	398748.85	57076.62	86758.72	36444.79	12460.35	8569831.27
North Carolin	6	49458.31	7079.43	10761.01	4520.38	1545.50	1062948.15
North Dakota	10	455341.45	65054.63	98728.28	41936.83	14023.52	9801831.57
North Dakota	16	1127904.20	161143.66	244555.02	103879.69	34736.99	24279641.21
Ohio	6	757502.20	130021.90	104372.30	59625.33	16914.35	20635510.52
Ohio	7	145038.25	24895.17	19984.07	11416.41	3238.58	3951062.24
Oklahoma	14	280173.93	48185.20	38468.29	21696.65	6318.21	7668999.38
Oklahoma	18	2419764.88	416158.83	332237.30	187386.43	54568.16	66234482.96
Oklahoma	21	268005.36	46092.41	36797.53	20754.32	6043.79	7335917.83
Oregon	26	261101.36	44568.66	35776.54	20438.26	5797.87	7073401.63
Oregon	29	573377.88	97872.66	78565.18	44882.36	12732.11	15533170.45
Oregon	30	66491.65	11349.78	9110.80	5204.77	1476.48	1801301.04

Table B3. Continued.

State Name	LPA	Corn	Sorghum	Oats	Barley	Wheat	Oilmeal
Pennsylvania	2	695938.03	743261.82	58888.64	102971.54	80696.06	15856169.66
Pennsylvania	3	35299.65	37700.03	2986.97	5222.96	4093.10	804263.14
Pennsylvania	6	338448.81	361463.33	28638.74	50077.15	39244.13	7711177.50
Rhode Island	1	3018.74	3224.96	254.59	448.08	346.92	68498.99
South Carolin	4	612181.56	442883.56	48927.12	89050.75	31602.29	11838361.17
South Dakota	10	106416.39	77074.93	8507.91	15445.28	5513.89	2052838.06
South Dakota	16	4480496.99	3245120.25	358212.32	650299.62	232153.59	86431560.94
Tennessee	4	517002.56	374179.04	41668.65	74942.26	26826.41	9893817.90
Tennessee	8	568486.80	411440.60	45818.11	82405.17	29497.84	10879065.79
Tennessee	9	462098.04	334442.06	37243.53	66983.56	23977.50	8843116.49
Tennessee	13	252560.79	182790.11	20355.54	36610.03	13104.96	4833226.50
Texas	14	761948.54	551594.26	61611.90	110812.76	39419.79	14654340.20
Texas	18	1363225.33	986874.08	110231.72	198258.48	70527.15	26218526.06
Texas	19	5515844.89	3993062.82	446016.54	802188.03	285365.02	106084680.18
Texas	20	4773773.27	3455857.97	386011.92	694266.04	246973.57	91812627.11
Texas	21	4092988.81	2963020.49	330963.03	595257.24	211752.84	78719292.71
Texas	24	56317.94	40770.01	4553.92	8190.51	2913.64	1083146.88
Utah	23	157363.25	113870.12	12527.77	22862.43	8147.56	3048291.77
Utah	24	80342.33	58136.77	6396.10	11672.49	4159.76	1556315.54
Utah	27	634659.53	459247.99	50525.59	92206.17	32859.81	12294023.30
Utah	28	25314.57	18317.95	2015.31	3677.81	1310.67	490369.81
Vermont	1	140923.24	102115.15	11466.57	20459.97	7239.68	2720414.32
Vermont	2	6040.20	4376.82	491.48	876.95	310.30	116601.34
Virginia	3	1134721.85	821789.81	91297.68	165338.18	58777.72	21913610.14
Virginia	4	190960.89	138297.96	15364.37	27824.55	9891.63	3687813.55
Virginia	6	208139.71	150739.22	16746.55	30327.64	10781.48	4019568.66
Washington	25	65521.69	47455.85	5238.41	9509.82	3394.96	1263954.02
Washington	26	117172.50	84865.33	9367.85	17006.42	6071.21	2260330.04
Washington	29	1642422.61	1189568.67	131310.44	238381.32	85100.90	31683348.93
West Virginia	3	108939.38	89227.28	11158.77	17328.08	16086.22	1935724.25
West Virginia	6	320801.77	262754.09	32860.04	51027.28	47370.27	5700268.83

Table B3. Continued.

State Name	LPA	Corn	Sorghum	Oats	Barley	Wheat	Oilmeal
Wisconsin	10	205197.37	168213.02	20973.12	32680.34	30420.28	3622696.35
Wisconsin	11	1974863.38	1618918.06	201849.83	314522.62	292771.26	34865604.33
Wisconsin	12	1046313.01	857727.70	106943.15	166638.93	155114.72	18472333.74
Wyoming	16	175219.57	143415.78	17822.77	27913.42	25935.81	3101134.88
Wyoming	22	510865.58	418139.29	51963.59	81383.63	75617.77	9041587.51
Wyoming	23	736065.82	602463.83	74870.23	117259.24	108951.67	13027308.40
Wyoming	26	14075.01	11520.28	1431.66	2242.23	2083.37	249107.56

Source: Ceneter for Agricultural and Rural Development; Technical Report 89-TR12.

APPENDIX C
Pork Feedstuffs Requirements

Table C1 . Feedstuffs required for pork production, by state.

State Name	Corn	Sorghum	Oats	Barley	Wheat	Oilmeal	Legume Hay	Other Hay	Corn Silage	Sorghum Silage
	pounds per hundred weight (liveweight)									
Alabama	318.11	0.00	7.67	5.00	3.56	34.00	0.00	0.00	0.00	0.00
Arizona	301.89	0.00	7.22	4.89	3.44	50.44	0.00	0.00	0.00	0.00
Arkansas	339.89	0.00	8.22	5.44	3.89	36.33	0.00	0.00	0.00	0.00
Californi	298.78	0.00	7.22	4.78	3.44	47.56	0.00	0.00	0.00	0.00
Colorado	311.11	0.00	6.78	4.44	3.11	44.44	0.00	0.00	0.00	0.00
Connecticut	320.00	0.00	7.67	5.11	3.56	34.22	0.00	0.00	0.00	0.00
Delaware	392.89	0.00	7.00	4.67	3.33	31.11	0.00	0.00	0.00	0.00
Florida	285.33	0.00	6.89	4.56	3.22	30.44	0.00	0.00	0.00	0.00
Georgia	333.33	0.00	6.78	4.44	3.22	40.44	0.00	0.00	0.00	0.00
Idaho	294.44	0.00	6.22	4.22	3.00	27.89	0.00	0.00	0.00	0.00
Illinois	403.33	0.00	6.89	4.56	3.22	43.33	0.00	0.00	0.00	0.00
Indiana	405.56	0.00	6.44	4.56	3.33	43.33	0.00	0.00	0.00	0.00
Iowa	382.22	0.00	6.89	4.89	3.44	32.22	0.00	0.00	0.00	0.00
Kansas	333.33	0.00	6.56	4.67	3.33	55.44	0.00	0.00	0.00	0.00
Kentucky	322.11	8.56	7.00	5.11	3.89	33.78	0.00	0.00	0.00	0.00
Louisiana	315.67	8.33	6.89	5.00	3.78	33.00	0.00	0.00	0.00	0.00
Maine	319.33	8.44	7.00	5.00	3.89	33.33	0.00	0.00	0.00	0.00
Maryland	318.11	8.44	6.89	5.00	3.78	33.22	0.00	0.00	0.00	0.00
Massachussets	311.11	8.22	6.89	4.89	3.78	32.44	0.00	0.00	0.00	0.00
Michigan	298.44	33.33	8.22	7.00	4.78	42.56	0.00	0.00	0.00	0.00
Minnesota	333.33	32.33	8.00	6.89	4.67	41.11	0.00	0.00	0.00	0.00
Mississippi	282.67	31.67	7.78	6.67	4.56	40.33	0.00	0.00	0.00	0.00
Missouri	333.33	30.33	7.56	6.33	4.33	38.67	0.00	0.00	0.00	0.00
Montana	282.56	12.44	4.56	4.22	3.56	32.22	0.00	0.00	0.00	0.00
Nebraska	333.33	12.78	4.67	4.22	3.67	55.67	0.00	0.00	0.00	0.00
Nevada	267.67	11.78	4.22	3.89	3.44	30.44	0.00	0.00	0.00	0.00
New Hampshire	282.78	12.44	4.56	4.22	3.56	32.22	0.00	0.00	0.00	0.00
New Jersey	294.44	12.89	4.78	4.22	3.78	33.56	0.00	0.00	0.00	0.00
New Mexico	274.56	11.33	5.56	4.11	4.11	50.22	0.00	0.00	0.00	0.00
New York	277.44	11.44	5.56	4.11	4.11	31.78	0.00	0.00	0.00	0.00
North Carolina	333.33	12.11	6.00	4.33	4.33	33.78	0.00	0.00	0.00	0.00

Table C1 . Continued.

State Name	Corn	Sorghum	Oats	Barley	Wheat	Oilmeal	Legume Hay	Other Hay	Corn Silage	Sorghum Silage
	pounds per hundred weight (liveweight)									
North Dakota	388.89	11.44	5.56	4.22	4.11	44.89	0.00	0.00	0.00	0.00
Ohio	333.33	12.11	4.33	4.00	3.56	33.22	0.00	0.00	0.00	0.00
Oklahoma	275.00	12.67	4.56	4.11	3.56	44.44	0.00	0.00	0.00	0.00
Oregon	333.33	12.78	4.56	4.11	3.67	34.78	0.00	0.00	0.00	0.00
Pennsylvania	333.33	34.89	8.78	5.78	4.22	42.78	0.00	0.00	0.00	0.00
Rhode Island	238.78	33.00	8.22	5.56	4.00	40.33	0.00	0.00	0.00	0.00
South Carolina	274.22	20.89	9.11	5.56	14.33	36.44	0.00	0.00	0.00	0.00
South Dakota	333.33	22.67	9.89	6.11	15.56	39.67	0.00	0.00	0.00	0.00
Tennessee	277.11	21.11	9.22	5.67	14.56	36.89	0.00	0.00	0.00	0.00
Texas	267.67	20.33	8.89	5.56	14.00	35.67	0.00	0.00	0.00	0.00
Utah	270.22	20.56	8.89	5.56	14.11	36.00	0.00	0.00	0.00	0.00
Vermont	249.44	19.00	8.22	5.11	13.00	33.22	0.00	0.00	0.00	0.00
Virginia	297.11	22.56	9.89	6.11	15.56	39.67	0.00	0.00	0.00	0.00
Washington	285.56	21.78	9.44	5.89	14.89	38.00	0.00	0.00	0.00	0.00
West Virginia	333.33	16.00	6.56	5.22	3.67	33.33	0.00	0.00	0.00	0.00
Wisconsin	333.33	16.00	6.56	5.22	3.67	33.33	0.00	0.00	0.00	0.00
Wyoming	280.56	16.22	6.67	5.33	3.78	33.78	0.00	0.00	0.00	0.00

Source: Center for Agricultural and Rural Development; Technical Report 89-TR12.

Table C2. Feedstuffs required for pork production projected to the year 2005.

State Name	LPA	Corn	Sorghum	Oats	Barley	Wheat	Oilmeal
				bushells per cwt			
Alabama	9	2013889.68	0.00	84975.12	36929.65	21035.13	52106742.44
Arizona	24	108646.96	0.00	4547.20	2053.17	1155.48	4394409.94
Arizona	28	224932.89	0.00	9414.11	4250.69	2392.21	9097791.29
Arkansas	13	1268063.55	0.00	53667.64	23678.18	13545.31	32811393.96
Arkansas	14	264179.91	0.00	11180.76	4932.95	2821.94	6835707.08
Arkansas	18	1263311.11	0.00	53466.50	23589.44	13494.55	32688423.57
California	30	175502.83	0.00	7421.78	3275.72	1885.94	6762870.94
California	31	462921.44	0.00	19576.32	8640.33	4974.52	17838332.91
Colorado	17	113442.06	0.00	4326.41	1888.82	1058.42	3922751.89
Colorado	18	12513.71	0.00	477.24	208.35	116.75	432715.93
Colorado	23	986010.33	0.00	37604.10	16417.13	9199.51	34095588.89
Colorado	24	57539.68	0.00	2194.43	958.04	536.85	1989684.47
Connecticut	1	18469.88	0.00	774.72	344.10	191.78	478135.20
Delaware	2	30122.23	0.00	939.19	417.71	238.29	577394.69
Delaware	3	108689.89	0.00	3388.86	1507.24	859.80	2083410.35
Florida	4	6980.43	0.00	294.98	130.15	73.52	180275.13
Florida	5	172421.63	0.00	7286.21	3214.81	1816.09	4452927.25
Florida	9	75358.03	0.00	3184.49	1405.06	793.73	1946181.86
Georgia	4	1901052.24	0.00	67668.63	29542.65	17140.06	55832547.69
Georgia	5	559549.65	0.00	19917.37	8695.49	5044.95	16433574.02
Georgia	9	1080851.61	0.00	38473.30	16796.60	9745.06	31743840.45
Idaho	25	10276.41	0.00	379.90	171.83	97.72	235640.43
Idaho	26	155924.44	0.00	5764.29	2607.21	1482.78	3575382.76
Idaho	27	4787.68	0.00	176.99	80.05	45.53	109782.56
Illinois	8	3507662.61	0.00	104861.14	46266.74	26136.65	91222637.98
Illinois	11	423338.59	0.00	12655.65	5583.92	3154.42	11009628.72
Illinois	12	17102879.09	0.00	511288.44	225590.25	127438.70	444789000.37
Illinois	13	3156896.35	0.00	94375.02	41640.07	23522.99	82100374.18
Indiana	6	999738.48	0.00	27781.47	13114.23	7661.47	25856910.66
Indiana	7	2029504.45	0.00	56397.36	26622.36	15553.06	52490442.32
Indiana	8	13825005.49	0.00	384179.44	181351.78	105947.62	357565441.28

Table C2. Continued.

State Name	LPA	Corn	Sorghum	Oats	Barley	Wheat	Oilmeal
				bushells per cwt			
Indiana	11	307340.10	0.00	8540.59	4031.58	2355.29	7948944.27
Indiana	12	501635.56	0.00	13939.82	6580.29	3844.27	12974138.92
Iowa	12	42169641.02	0.00	1330282.16	629422.33	354227.04	860535284.48
Iowa	15	12365747.37	0.00	390089.47	184570.64	103872.88	252341771.86
Iowa	16	2266391.00	0.00	71495.50	33828.06	19037.80	46249135.04
Kansas	15	1753609.11	0.00	60394.90	28663.03	16350.81	70605456.03
Kansas	17	1462806.85	0.00	50379.57	23909.82	13639.35	58896902.35
Kansas	18	2280791.28	0.00	78551.24	37279.91	21266.31	91831359.58
Kentucky	6	28924.23	768.65	1100.00	535.33	326.02	734300.49
Kentucky	8	2385196.77	63386.06	90710.19	44145.63	26884.77	60553088.69
Kentucky	9	48645.29	1292.74	1850.00	900.34	548.31	1234959.92
Kentucky	13	166708.71	4430.25	6340.01	3085.47	1879.06	4232241.01
Louisiana	14	146156.35	3856.82	5582.67	2700.85	1633.48	3698749.89
Louisiana	19	2452.04	64.71	93.66	45.31	27.40	62053.25
Maine	1	41193.05	1088.75	1580.23	752.49	468.35	1040821.29
Maryland	2	5917.87	157.01	224.31	108.52	65.63	149604.42
Maryland	3	542033.12	14381.06	20544.98	9939.52	6011.42	13702656.76
Massachusetts	1	58869.32	1555.42	2281.56	1079.52	667.58	1485978.68
Michigan	7	3521459.60	393279.21	169736.62	96363.04	52641.75	121569309.08
Michigan	10	4239.32	473.45	204.34	116.01	63.37	146351.50
Michigan	11	7065.53	789.08	340.56	193.34	105.62	243919.16
Minnesota	10	10994558.15	1066372.86	461776.06	265136.42	143766.28	328252094.30
Minnesota	11	2302048.34	223277.90	96687.00	55514.45	30101.89	68729654.91
Minnesota	12	1107021.23	107371.06	46495.36	26696.08	14475.55	33051081.54
Minnesota	16	1035998.95	100482.54	43512.39	24983.36	13546.86	30930649.53
Mississippi	9	86924.20	9738.88	4186.77	2392.95	1308.77	3002242.98
Mississippi	13	10595.24	1187.08	510.33	291.68	159.53	365945.04
Mississippi	14	334939.25	37526.18	16132.59	9220.60	5042.99	11568344.22
Missouri	12	1272415.08	115778.21	50502.66	28190.64	15426.91	35734295.67
Missouri	13	1414023.67	128663.30	56123.16	31328.01	17143.79	39711208.10
Missouri	15	3943730.57	358843.63	156528.23	87374.22	47814.27	110755080.64

Table C2. Continued.

State Name	LPA	Corn	Sorghum	Oats	Barley	Wheat	Oilmeal
				bushells per cwt			
Missouri	18	244034.23	22204.90	9685.82	5406.63	2958.70	6853417.05
Montana	16	7178.49	316.04	202.73	125.08	84.41	198154.74
Montana	22	374203.38	16474.70	10568.17	6520.13	4400.32	10329497.76
Montana	25	277195.00	12203.80	7828.48	4829.85	3259.58	7651681.82
Nebraska	15	8213313.82	314901.60	201371.94	121311.86	84400.86	332064069.89
Nebraska	16	1466245.92	56216.43	35949.04	21656.67	15067.29	59280285.59
Nebraska	17	4674754.19	179231.87	114614.43	69046.81	48038.25	189000193.41
Nebraska	23	249729.14	9574.71	6122.80	3688.54	2566.24	10096542.67
Nevada	27	8959.45	394.30	247.19	151.91	107.47	246650.94
Nevada	28	271.98	11.97	7.50	4.61	3.26	7487.46
Nevada	30	22393.87	985.54	617.85	379.69	268.61	616496.75
New Hampshire	1	16635.27	731.82	469.44	289.63	195.46	458842.29
New Jersey	2	18029.77	789.31	512.22	301.48	216.03	497475.90
New Mexico	21	53621.32	2212.74	1900.26	936.46	749.17	2374288.95
New Mexico	24	13410.39	553.39	475.24	234.20	187.36	593796.37
New Mexico	28	458.94	18.94	16.26	8.02	6.41	20321.16
New York	1	2242.30	92.46	78.64	38.75	31.00	62177.65
New York	2	203261.69	8381.32	7128.52	3512.98	2810.38	5636337.48
New York	6	33038.07	1362.30	1158.67	571.00	456.80	916128.08
North Carolina	3	11434597.96	415423.10	360193.44	173293.07	138634.45	280519330.04
North Carolina	4	2214249.59	80444.49	69749.56	33557.29	26845.83	54321088.76
North Carolina	6	10927.82	397.01	344.23	165.61	132.49	268086.80
North Dakota	10	509168.44	14978.24	12739.36	6446.05	5022.42	14227905.08
North Dakota	16	443082.24	13034.18	11085.89	5609.41	4370.55	12381231.03
Ohio	6	4489304.74	163098.07	102054.14	62850.89	44749.84	108308106.52
Ohio	7	2215152.76	80477.30	50356.46	31012.45	22080.86	53442351.25
Oklahoma	14	52075.37	2399.25	1511.13	908.01	629.20	2037184.69
Oklahoma	18	667259.12	30742.45	19362.65	11634.57	8062.11	26103126.50
Oklahoma	21	52152.52	2402.81	1513.37	909.35	630.13	2040202.74
Oregon	26	22009.71	843.86	526.92	316.61	226.17	555937.80
Oregon	29	210861.96	8084.53	5048.09	3033.28	2166.84	5326109.08

Table C2. Continued.

State Name	LPA	Corn	Sorghum	Oats	Barley	Wheat	Oilmeal
				bushells per cwt			
Oregon	30	1523.57	58.41	36.47	21.92	15.66	38483.45
Pennsylvania	2	2218092.76	232170.09	102244.01	44872.47	26209.25	68913250.21
Pennsylvania	3	128493.50	13449.55	5922.97	2599.45	1518.29	3992125.61
Pennsylvania	6	286477.32	29985.88	13205.30	5795.49	3385.05	8900476.76
Rhode Island	1	8345.51	1153.37	502.76	226.71	130.48	341224.30
South Carolina	4	1079229.71	82215.41	62743.85	25529.15	52637.80	34717607.18
South Dakota	10	169311.83	11515.01	8791.18	3620.77	7376.65	4877887.33
South Dakota	16	6367824.64	433080.08	330636.68	136177.29	277436.16	183457530.86
Tennessee	4	185911.39	14162.57	10824.87	4437.96	9117.00	5991272.96
Tennessee	8	503195.59	38333.00	29299.05	12011.98	24676.46	16216231.42
Tennessee	9	545385.81	41547.02	31755.62	13019.12	26745.44	17575874.54
Tennessee	13	480556.93	36608.41	27980.90	11471.56	23566.27	15486666.81
Texas	14	26483.37	2011.46	1539.26	641.79	1292.82	854344.99
Texas	18	55893.85	4245.23	3248.66	1354.52	2728.53	1803117.58
Texas	19	513219.79	38979.93	29829.33	12437.28	25053.51	16556306.56
Texas	20	548623.88	41668.93	31887.08	13295.25	26781.80	17698430.91
Texas	21	246016.55	18685.38	14298.96	5961.92	12009.62	7936415.28
Texas	24	3624.04	275.25	210.64	87.82	176.91	116910.37
Utah	23	11869.40	903.10	683.36	284.93	578.46	382798.70
Utah	24	6278.55	477.71	361.48	150.72	305.99	202488.70
Utah	27	70653.75	5375.77	4067.78	1696.05	3443.35	2278645.98
Utah	28	509.07	38.73	29.31	12.22	24.81	16418.00
Vermont	1	16128.31	1228.50	930.11	385.47	784.52	519971.00
Vermont	2	176.09	13.41	10.15	4.21	8.57	5677.00
Virginia	3	1220081.83	92642.61	71073.23	29272.49	59637.31	39435789.75
Virginia	4	23388.97	1775.96	1362.47	561.15	1143.25	755984.17
Virginia	6	41637.51	3161.60	2425.50	998.98	2035.23	1345817.98
Washington	25	12999.04	991.45	752.01	312.81	632.62	418749.34
Washington	26	22745.08	1734.79	1315.83	547.33	1106.93	732706.96
Washington	29	93857.47	7158.62	5429.77	2258.57	4567.76	3023512.15
West Virginia	3	70723.30	3394.75	2435.73	1292.13	726.76	1711906.72

Table C2. Continued.

State Name	LPA	Corn	Sorghum	Oats	Barley	Wheat	Oilmeal
				bushells per cwt			
West Virginia	6	51614.19	2477.51	1777.61	943.00	530.39	1249357.28
Wisconsin	10	84279.93	4045.48	2902.63	1539.81	866.07	2040054.30
Wisconsin	11	2271079.46	109012.90	78216.76	41493.04	23337.85	54973057.30
Wisconsin	12	1716134.80	82375.29	59104.27	31354.10	17635.18	41540236.02
Wyoming	16	6663.69	385.25	277.24	147.69	83.79	194225.18
Wyoming	22	34607.92	2000.79	1439.84	767.05	435.19	1008709.37
Wyoming	23	48900.15	2827.06	2034.46	1083.82	614.91	1425281.64
Wyoming	26	0.00	0.00	0.00	0.00	0.00	0.00

Source: Center for Agricultural and Rural Development; Technical Report 89-TR12.

APPENDIX D
Milk Feedstuffs Requirements

Table D1. Feedstuffs required for milk production, by state.

State Name	Corn	Sorghum	Oats	Barley	Wheat	Oilmeal	Legume Hay	Other Hay	Corn Silage	Sorghum Silage
	Pounds per hundred weight (liveweight)									
Alabama	26.56	0.00	6.22	2.11	0.67	2.67	14.33	38.67	104.00	0.00
Arizona	27.11	0.00	6.33	2.11	0.67	2.67	13.89	36.44	87.78	0.00
Arkansas	26.44	0.00	6.22	2.11	0.67	2.67	11.89	33.78	114.11	0.00
California	27.11	0.00	6.33	2.11	0.67	2.67	13.67	16.11	105.22	0.00
Colorado	27.89	0.00	6.56	2.22	0.67	2.78	8.56	20.44	139.89	0.00
Connecticut	27.22	0.00	6.33	2.11	0.67	2.67	26.44	26.00	86.33	0.00
Delaware	27.00	0.00	6.33	2.11	0.67	2.67	32.11	22.89	105.22	0.00
Florida	28.89	0.00	6.67	2.22	0.67	2.89	24.67	20.78	69.33	0.22
Georgia	26.22	0.00	6.11	2.00	0.67	2.56	13.67	15.11	85.33	0.00
Idaho	26.22	0.00	6.11	2.00	0.56	2.56	10.78	18.33	72.00	0.00
Illinois	26.56	0.00	6.22	2.11	0.67	2.67	41.78	7.44	73.44	0.00
Indiana	27.22	0.00	5.78	2.22	0.67	2.56	47.67	10.00	53.44	0.00
Iowa	26.22	0.00	5.67	2.11	0.67	2.56	41.89	9.11	59.22	0.00
Kansas	27.11	0.00	5.78	2.22	0.67	2.56	17.33	18.67	29.33	0.00
Kentucky	27.33	0.67	5.33	2.44	0.78	2.56	15.67	11.22	28.67	1.00
Louisiana	28.33	0.67	5.56	2.56	0.78	2.56	23.11	7.22	28.44	0.89
Maine	28.67	0.67	5.67	2.56	0.78	2.56	23.44	4.67	39.44	0.44
Maryland	29.11	0.78	5.67	2.56	0.78	2.56	6.33	19.00	6.78	1.56
Massachussets	27.89	0.67	5.44	2.44	0.78	2.56	50.56	28.33	29.11	0.00
Michigan	26.11	2.22	6.56	3.00	0.89	3.11	32.00	15.11	30.11	2.44
Minnesota	24.89	2.11	6.22	2.89	0.78	2.89	24.78	10.22	29.22	4.11
Mississippi	26.22	2.22	6.56	3.00	0.89	3.11	13.89	8.78	15.78	14.56
Missouri	26.22	2.22	6.56	3.00	0.89	3.11	2.33	13.33	28.89	1.00
Montana	26.56	1.11	5.00	2.00	0.67	2.56	9.11	34.33	25.00	0.00
Nebraska	27.22	1.22	5.11	2.11	0.67	2.67	0.78	9.44	30.22	4.89
Nevada	26.33	1.11	5.00	2.00	0.67	2.56	4.89	19.33	16.89	0.78
New Hampshire	27.22	1.22	5.11	2.11	0.67	2.56	1.67	10.89	12.56	0.56
New Jersey	27.22	1.22	5.11	2.11	0.67	2.67	0.00	15.00	20.56	3.11
New Mexico	35.00	0.78	7.00	2.56	0.89	3.44	0.11	8.67	9.33	2.78
New York	34.56	0.78	7.00	2.56	0.89	3.44	0.00	2.89	1.44	0.00
North Carolina	33.44	0.78	6.67	2.56	0.78	3.33	0.00	16.67	7.33	2.56

Table D1. Continued.

State Name	Corn	Sorghum	Oats	Barley	Wheat	Oilmeal	Legume Hay	Other Hay	Corn Silage	Sorghum Silage
	Pounds per hundred weight (liveweight)									
North Dakota	37.56	0.78	7.56	2.78	0.89	3.67	0.33	14.22	9.78	5.11
Ohio	33.22	1.56	6.22	2.56	0.89	3.56	2.00	14.00	0.56	1.67
Oklahoma	31.22	1.44	5.89	2.44	0.89	3.33	0.33	11.11	2.22	1.44
Oregon	31.33	1.44	5.89	2.44	0.89	3.44	5.33	7.89	1.67	1.56
Pennsylvania	27.67	3.89	6.44	3.11	1.00	3.89	1.00	4.89	2.22	0.67
Rhode Island	26.44	3.67	6.11	3.00	1.00	3.78	18.56	10.22	9.11	0.00
South Carolina	36.00	1.11	4.56	1.78	1.44	1.89	51.67	7.89	20.67	0.00
South Dakota	32.44	1.11	4.22	1.67	1.44	1.78	29.11	18.33	19.11	0.00
Tennessee	32.00	1.00	4.11	1.56	1.33	1.78	13.89	7.00	31.33	1.44
Texas	29.33	1.11	4.33	1.67	1.44	1.78	8.78	0.89	2.89	0.67
Utah	20.78	1.00	3.89	1.56	1.33	1.67	20.44	1.44	4.22	1.33
Vermont	28.00	1.00	3.67	1.56	1.22	1.56	36.33	4.67	26.11	0.00
Virginia	27.78	1.00	4.11	1.56	1.33	1.78	19.22	9.56	0.33	0.00
Washington	15.89	1.00	3.78	1.56	1.22	1.56	24.67	9.00	16.33	0.00
West Virginia	30.78	2.44	4.44	2.11	0.67	2.22	16.33	11.56	7.11	0.00
Wisconsin	31.44	2.44	4.44	2.11	0.67	2.22	21.89	3.56	11.44	0.67
Wyoming	17.56	2.33	4.22	2.00	0.67	2.11	0.00	0.00	0.00	0.00

Source: Center for Agricultural and Rural Development; Technical Report 89-TR12.

Table D2. Milk Production Projected for the year 2005.

State Name	LPA	Corn	Sorghum	Oats	Barley	Wheat	Oilmeal
				bushells per cwt			
Alabama	9	281.22	0.00	115.25	26.06	6.62	6843.56
Arizona	24	9.93	0.00	4.06	0.90	0.23	236.63
Arizona	28	972.75	0.00	397.48	88.33	22.44	23192.09
Arkansas	13	185.43	0.00	76.34	17.26	4.39	4533.08
Arkansas	14	46.06	0.00	18.96	4.29	1.09	1125.90
Arkansas	18	198.95	0.00	81.90	18.52	4.71	4863.48
California	30	1823.68	0.00	745.18	165.60	42.07	43479.73
California	31	10407.57	0.00	4252.67	945.04	240.07	248134.84
Colorado	17	57.48	0.00	23.66	5.34	1.29	1386.96
Colorado	18	2.23	0.00	0.92	0.21	0.05	53.79
Colorado	23	705.28	0.00	290.30	65.50	15.81	17018.13
Colorado	24	31.13	0.00	12.81	2.89	0.70	751.11
Connecticut	1	298.09	0.00	121.31	26.96	6.85	7078.30
Delaware	2	58.38	0.00	23.95	5.32	1.35	1397.65
Delaware	3	16.66	0.00	6.84	1.52	0.39	398.81
Florida	4	54.53	0.00	22.03	4.89	1.18	1320.59
Florida	5	1361.36	0.00	550.04	122.05	29.47	32967.13
Florida	9	98.92	0.00	39.97	8.87	2.14	2395.41
Georgia	4	523.82	0.00	213.61	46.61	12.49	12380.62
Georgia	5	33.51	0.00	13.67	2.98	0.80	792.07
Georgia	9	246.32	0.00	100.45	21.92	5.87	5821.82
Idaho	25	30.97	0.00	12.63	2.76	0.62	732.03
Idaho	26	1457.65	0.00	594.43	129.72	29.06	34452.26
Idaho	27	167.61	0.00	68.35	14.92	3.34	3961.56
Illinois	8	109.19	0.00	44.75	10.12	2.57	2657.08
Illinois	11	177.81	0.00	72.87	16.48	4.19	4327.14
Illinois	12	856.58	0.00	351.05	79.39	20.17	20845.37
Illinois	13	325.94	0.00	133.58	30.21	7.67	7931.90
Indiana	6	81.30	0.00	30.21	7.74	1.87	1850.99
Indiana	7	440.82	0.00	163.81	41.94	10.13	10036.18
Indiana	8	694.20	0.00	257.96	66.05	15.95	15804.87

Table D2. Continued.

State Name	LPA	Corn	Sorghum	Oats	Barley	Wheat	Oilmeal
				bushells per cwt			
Indiana	11	60.43	0.00	22.46	5.75	1.39	1375.86
Indiana	12	3.58	0.00	1.33	0.34	0.08	81.62
Iowa	12	1826.44	0.00	691.19	171.48	43.56	43168.78
Iowa	15	243.33	0.00	92.08	22.85	5.80	5751.28
Iowa	16	156.51	0.00	59.23	14.69	3.73	3699.13
Kansas	15	241.86	0.00	90.24	23.11	5.58	5528.85
Kansas	17	1.07	0.00	0.40	0.10	0.02	24.44
Kansas	18	314.78	0.00	117.45	30.07	7.26	7195.61
Kentucky	6	38.61	0.95	13.18	4.02	1.03	875.42
Kentucky	8	1159.92	28.44	395.87	120.82	30.90	26301.69
Kentucky	9	9.34	0.23	3.19	0.97	0.25	211.89
Kentucky	13	21.64	0.53	7.39	2.25	0.58	490.68
Louisiana	14	491.54	11.62	168.82	51.82	12.63	10752.54
Louisiana	19	59.33	1.40	20.38	6.25	1.52	1297.82
Maine	1	376.04	8.79	130.15	39.17	9.55	8128.46
Maryland	2	5084.29	136.23	1733.04	521.65	127.15	108239.32
Maryland	3	806.96	21.62	275.06	82.79	20.18	17179.38
Massachusetts	1	271.37	6.52	92.63	27.70	7.08	6029.97
Michigan	7	2736.60	232.68	1203.22	366.84	87.06	78908.14
Michigan	10	52.99	4.51	23.30	7.10	1.69	1527.84
Michigan	11	90.14	7.66	39.63	12.08	2.87	2598.99
Minnesota	10	3705.88	314.16	1620.67	502.01	108.39	104164.66
Minnesota	11	1121.63	95.08	490.52	151.94	32.81	31526.70
Minnesota	12	110.29	9.35	48.23	14.94	3.23	3100.05
Minnesota	16	121.42	10.29	53.10	16.45	3.55	3412.90
Mississippi	9	66.49	5.63	29.11	8.88	2.11	1909.16
Mississippi	13	9.22	0.78	4.04	1.23	0.29	264.77
Mississippi	14	328.73	27.83	143.93	43.88	10.41	9438.95
Missouri	12	75.33	6.38	32.98	10.06	2.39	2162.99
Missouri	13	378.71	32.07	165.81	50.55	12.00	10874.17
Missouri	15	973.43	82.42	426.20	129.94	30.84	27950.44

Table D2. Continued.

State Name	LPA	Corn	Sorghum	Oats	Barley	Wheat	Oilmeal
				bushells per cwt			
Missouri	18	158.43	13.41	69.37	21.15	5.02	4549.12
Montana	16	1.18	0.05	0.39	0.10	0.03	27.60
Montana	22	52.13	2.18	17.17	4.58	1.23	1216.26
Montana	25	123.27	5.15	40.61	10.83	2.90	2876.25
Nebraska	15	351.22	15.74	115.39	31.76	8.07	8339.95
Nebraska	16	75.06	3.36	24.66	6.79	1.72	1782.38
Nebraska	17	264.19	11.84	86.79	23.89	6.07	6273.25
Nebraska	23	9.73	0.44	3.20	0.88	0.22	231.11
Nevada	27	13.37	0.56	4.44	1.18	0.32	314.60
Nevada	28	62.01	2.61	20.61	5.50	1.47	1459.52
Nevada	30	110.78	4.67	36.82	9.82	2.63	2607.50
New Hampshire	1	179.67	8.05	59.02	16.25	4.13	4090.47
New Jersey	2	200.37	8.98	65.83	18.12	4.60	4757.94
New Mexico	21	635.07	14.15	222.28	54.19	15.07	15110.22
New Mexico	24	840.22	18.72	294.08	71.70	19.94	19991.22
New Mexico	28	12.35	0.28	4.32	1.05	0.29	293.78
New York	1	235.67	5.32	83.54	20.37	5.66	5678.72
New York	2	7029.02	158.64	2491.48	607.45	168.95	169369.86
New York	6	806.29	18.20	285.79	69.68	19.38	19428.23
North Carolina	3	292.79	6.83	102.20	26.15	6.37	7058.25
North Carolina	4	699.53	16.32	244.18	62.48	15.23	16863.34
North Carolina	6	57.87	1.35	20.20	5.17	1.26	1394.94
North Dakota	10	218.47	4.54	76.95	18.86	4.83	5167.55
North Dakota	16	565.13	11.74	199.06	48.80	12.50	13367.43
Ohio	6	2672.75	125.51	875.76	240.30	66.83	69337.01
Ohio	7	532.75	25.02	174.56	47.90	13.32	13820.83
Oklahoma	14	46.48	2.14	15.35	4.24	1.24	1200.12
Oklahoma	18	736.40	33.97	243.13	67.15	19.59	19014.26
Oklahoma	21	15.73	0.73	5.19	1.43	0.42	406.23
Oregon	26	119.25	5.48	39.23	10.83	3.16	3169.54
Oregon	29	927.39	42.63	305.11	84.26	24.59	24650.09

Table D2. Continued.

State Name	LPA	Corn	Sorghum	Oats	Barley	Wheat	Oilmeal
				bushells per cwt			
Oregon	30	33.48	1.54	11.02	3.04	0.89	890.00
Pennsylvania	2	4057.49	570.42	1652.62	532.05	136.86	138087.47
Pennsylvania	3	367.76	51.70	149.79	48.22	12.40	12515.72
Pennsylvania	6	1375.31	193.35	560.16	180.34	46.39	46805.63
Rhode Island	1	18.28	2.54	7.39	2.42	0.65	632.75
South Carolina	4	313.25	9.66	69.44	18.07	11.69	3981.12
South Dakota	10	81.67	2.79	18.59	4.91	3.38	1084.86
South Dakota	16	1035.60	35.44	235.76	62.20	42.91	13755.89
Tennessee	4	600.21	18.76	134.91	34.14	23.28	8082.20
Tennessee	8	334.52	10.45	75.19	19.03	12.98	4504.47
Tennessee	9	349.46	10.92	78.55	19.88	13.56	4705.69
Tennessee	13	86.78	2.71	19.51	4.94	3.37	1168.58
Texas	14	702.12	26.57	181.39	46.64	32.17	10315.09
Texas	18	169.24	6.40	43.72	11.24	7.76	2486.41
Texas	19	1688.68	63.91	436.28	112.18	77.38	24809.15
Texas	20	626.67	23.72	161.90	41.63	28.72	9206.70
Texas	21	168.22	6.37	43.46	11.17	7.71	2471.43
Texas	24	43.50	1.65	11.24	2.89	1.99	639.08
Utah	23	30.60	1.47	10.02	2.68	1.83	595.28
Utah	24	6.03	0.29	1.98	0.53	0.36	117.32
Utah	27	516.31	24.85	169.14	45.22	30.84	10044.74
Utah	28	5.42	0.26	1.77	0.47	0.32	105.37
Vermont	1	1392.02	49.72	319.29	90.48	56.61	18774.52
Vermont	2	24.79	0.89	5.69	1.61	1.01	334.41
Virginia	3	885.24	31.87	229.20	58.00	39.56	13731.09
Virginia	4	123.48	4.44	31.97	8.09	5.52	1915.30
Virginia	6	151.80	5.46	39.30	9.94	6.78	2354.52
Washington	25	36.77	2.31	15.31	4.21	2.64	873.95
Washington	26	4.29	0.27	1.79	0.49	0.31	101.96
Washington	29	1491.14	93.84	620.76	170.79	106.85	35438.65
West Virginia	3	55.87	4.43	14.10	4.47	1.13	975.42

Table D2. Continued.

State Name	LPA	Corn	Sorghum	Oats	Barley	Wheat	Oilmeal
				bushells per cwt			
West Virginia	6	117.90	9.35	29.76	9.43	2.40	2058.54
Wisconsin	10	800.96	62.16	197.95	62.71	15.93	13691.10
Wisconsin	11	11459.31	889.34	2832.02	897.23	227.92	195877.90
Wisconsin	12	3202.30	248.52	791.41	250.73	63.69	54737.98
Wyoming	16	2.51	0.33	1.05	0.33	0.09	72.88
Wyoming	22	13.49	1.79	5.67	1.79	0.48	392.36
Wyoming	23	22.50	2.99	9.46	2.99	0.80	654.44
Wyoming	26	1.22	0.16	0.51	0.16	0.04	35.34

Source: Center for Agricultural and Rural Development; Technical Report 89-TR12.

VITA

Jose A. Velasquez was born in Lima Peru, the first child of Hector A.Velasquez and Maria Campos de Velasquez. He attended "San Martin de Porres" primary school in Huancayo. His secondary school was completed in "La Gran Unidad Escolar Santa Isabel" in December 1974. The following year, he was admitted to "La Universidad Agraria" Lima (Peru), for pursuing the degree in Fisheries Engineering. He attended this school until 1981 and merited the BS degree in Fisheries Engineering. In 1981 to 1983, he worked as a staff engineer in the "Ministerio de Pesqueria."

In December 1984, Mr. Velasquez was admitted to the English Language Institute, Knoxville (USA). He attended the University of Tennessee through December 1991 when he earned bachelor degrees in Agricultural Engineering, and Agricultural Economics. During this time, he also earned a master's degree in Agricultural Economics.

In 1992, Mr. Velasquez entered the doctoral program in Agricultural Economics with a focus on production economics at the University of Tennessee, Knoxville. In addition, he worked on research projects and taught graduate classes. His Doctor of Philosophy (PhD) degree was conferred in August 1997.

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