Economic Impacts of the Central Valley Project Improvement Act

Dr. David L. Sunding
Director, Center for Sustainable Resource Development
UC Berkeley

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The economic impacts of the Central Valley Project Improvement Act ("CVPIA") on California agriculture depends on three policy choices: how much water is reallocated to the environment, how the initial cuts are allocated within agriculture and the extent of water trading in the Central Valley. This testimony addresses two issues. First, I summarize the results of several economic studies of CVPIA impacts conducted at UC Berkeley and UC Davis. These studies calculate the costs of agricultural water supply cuts, measured in terms of farm profit, farm revenue, agricultural employment and acres farmed. Using three distinct models of agricultural water use, these studies demonstrate that *how* water is reallocated from agriculture to the environment is generally more important than *how much* water supplies are reduced. In particular, water trading can go far toward mitigating the negative impacts of the CVPIA.

Given the importance of water trading, I will then move to a more detailed, farm-level analysis of water marketing. Water marketing is an established practice in some areas of the Valley, and it is important to understand the experiences of growers who routinely trade water. Perhaps the most developed water market within California agriculture is the market operating among landowners in Westlands Water District. Working under a Challenge Grant from the Bureau of Reclamation, I have been directing a team of UC Berkeley researchers examining water trading patterns and the benefits of water marketing in this innovative District. This analysis shows that i) participation in the Westlands market is extensive (measured both in terms of numbers of landowners and volume exchanged), ii) the water market helps growers cope with supply variability and iii) water trading has especially important benefits to small landowners.

I. Reallocating Water from Agriculture: The Importance of Water Markets

Growers in California's Central Valley, who produce nearly half of all fresh fruits and vegetables consumed in the United States, operate under a variety of conditions in terms of weather, soil quality, pest control problems, labor supplies, marketing channels, and water rights. These differences imply that water productivity varies widely among California growers. A study by Sunding et al. (1995), for example, shows that the bottom 20 percent of total water used by California growers produces less than 5 percent of agricultural farm sales, while the top 20 percent produces about 60 percent of total value. This large disparity in water productivity suggests that water reform that transfers the less productive water to the environment is much more efficient than reform that removes water used to produce high value crops.

Alternative Impact Models

Policy impacts are likely to vary with the length of the planning horizon considered. The immediate impacts of supply reduction may differ from longer run impacts since in the short run growers' flexibility is much more limited. Ideally, an impact assessment model should be sufficiently versatile to generate various types of impact estimates. Unfortunately, a model that accounts for heterogeneity among growing regions and all possible grower responses to water supply changes does not exist and would be quite costly to construct. Instead, researchers at UC Berkeley and UC Davis have measured policy impact estimates using three models, each emphasizing different aspects of Central Valley agriculture. The results of these various models provide a range of impacts within which the actual outcomes are likely to lie (Sunding et al., 1997 and Sunding et al., 1998).

The three impact models discussed below differ in their assumptions regarding production technologies and the set of responses that growers have in adjusting to changes. They also differ in the degree of detail in the data they use, in particular, the type and number of basic units of analysis they assume.

The models simulate the impact of several multidimensional policy scenarios. First, two levels of aggregate water supply reductions to agriculture are considered. The lower level of 0.8 MAF corresponds to requirement of annual enhancement of instream flows. The higher level of annual reduction is 1.3 MAF, and was derived by the U.S. Environmental Protection Agency and the U.S. Fish and Wildlife Service in the context of their work on endangered species protection.

The second dimension of the water allocation policies considered by the UC studies is the allocation of the aggregate cutback among growers. To a large extent, the final allocation of the supply reduction is an open question, depending on what state or federal agency takes responsibility for the decision. If the State of California makes the decision, then all water users in the State which consumption affects Bay/Delta flows are potential targets for cutbacks. However, if the federal government implements the reduced diversions, then CVP users are mostly liable for the reductions. Thus, the allocation of the cuts is treated as a choice variable, and a variety of initial allocation schemes are considered.

Third, the extent of water trading is currently a policy choice, particularly for the State of California. Trading is highly active within small units such as water districts, and a large volume of water is traded between neighboring districts within the CVP system. There is, however, controversy about how much water can and should be traded among growers, between growers and urban areas, and between basins. Further, there are physical constraints on conveyance that are, at present, hard to define precisely due to hydrological uncertainties and constantly changing regulatory restrictions on pumping. Thus, the scope of the water market is treated here as a policy variable, and the impact models are used to examine a wide array of trading scenarios.

The following sections describe each of the three impact models in more detail and discuss how each model calculates the economic consequences of agricultural water supply reductions.

CARM Model

CARM is a nonlinear programming model developed at the University of California which has been applied to analyze the impact of numerous policies and events. The basic units of analysis in the model are clusters of water districts with similar growing conditions and water rights; there are 27 basic units and 34 crops in the model. Within each of the basic units, growers maximize profits by choosing land allocation among

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crops and the amount of fallowed land. Costs of production are quadratic in land area, reflecting the fact that land quality varies within each of the clusters and the lowest-quality land will come out of production first. Farm profits are maximized subject to linear resource constraints on arable land and surface water supplies; ground water pumping is held constant in the model to reflect constraints on pumping capacity. The impacts of water supply policies are modeled precisely by changing the various regional constraints on available surface water. The CARM model measures the impacts of water supply reductions on net income and revenue in each of the basic units and also estimates changes in State product and employment, both of which are estimated using revenue multipliers.

The CARM model considers four policy scenarios: two "Proportional Allocation" scenarios in which the total supply reduction is allocated proportionally among some set of basic units with no trading, and two "Local Market Allocation" scenarios in which there is trading among the basic units suffering the supply reduction. Within each type of scenario, there is a further breakdown based on the region facing the initial cutback. In the "Delta-Mendota" scenarios, all cuts come from the basic units in the Delta-Mendota region, and in the "San Joaquin" scenarios all initial cuts come from the basic units in the entire San Joaquin Valley. Thus, the "Local Market Allocation - San Joaquin" scenario models a policy in which all growers in the San Joaquin Valley have their surface water allocation reduced proportionally to their base allotment and there is trading among all basic units in the San Joaquin Valley. This configuration of scenarios allows consideration to consider the effects of both the initial allocation of the water supply cuts and the scope of the water market on CVPIA impacts.

The Agroeconomic Model

This model has the least detail in terms of number of crops (11) and regions (4) among the models discussed here, but has the most advanced specifications of water productivity (Sunding et al., 1996). This specification allows consideration of the impacts of the CVPIA on irrigation technology choices.

The model specifies a set of generic production functions for each crop, relating yield to the amount of applied water, water quality (salinity), and water application uniformity. Functions are adjusted to location-specific conditions in each regions (precipitation, evaporation, temperature, maximum crop yields). Irrigation technology choices in the agroeconomic model are captured in terms of the uniformity of applied irrigation water. Higher efficiency is also associated with greater irrigation hardware and/or management costs, and the agroeconomic model assumes that the marginal cost of irrigation is increasing in uniformity and that there are no scale effects with regard to the size of the irrigated field.

The analysis considers four agricultural production regions in the Central Valley—Sacramento, San Joaquin, Fresno, and Kern. Surface and groundwater use are provided by DWR for each hydrological region and was adjusted to provide constraints for water use in production regions.

The agroeconomic model is used to examine three policy scenarios. The "Proportional" scenario assumes that the cuts in surface water deliveries are allocated proportionally among growers in both the Sacramento and San Joaquin Valleys and that there are only markets for water within each of the four regions. The "San Joaquin" scenario assumes that all cuts come from the San Joaquin Valley, and that there is trading among the basic units in this area only. Finally, the "Efficient" scenario assumes that there is a market for surface water encompassing all four regions so that water is allocated according to its marginal value in the entire Central Valley.

Rationing Model
The rationing model measures immediate impacts from changes in water supply policy and relies on the most detailed micro level data. The basic unit of the rationing model is the individual water district. The water districts are grouped into five regions according to their proximity to various CVP facilities; districts within these regions have generally similar water rights and growing conditions. The model also captures the largest number of crops among the three impact models and is the only model to include both annuals and perennials.

Growers in the rationing model respond to reductions in surface water availability by ceasing production of the crops with the lowest marginal value of applied water. This approach is motivated by the fact that growers have a large degree of flexibility when they make long-term decisions regarding irrigation technology and cropping patterns but have only limited flexibility in the short run.

Another fact motivating the rationing analysis is the large degree of heterogeneity in California agriculture. The Central Valley consists of many production regions that vary both in terms of weather and land quality. Existing crop allocation patterns have evolved over time to maximize the overall benefits from agricultural production. At each location, farmers have invested substantial resources in production infrastructure, including equipment for harvesting, packing, and irrigation. As a result, crop mix choices are largely predetermined in the short run and appropriate for individual locations. Agronomic evidence suggests that, within a given production technology, a crop should either be irrigated with a certain amount of water, the "water requirement," or not irrigated at all. As a result of these considerations, water supply reductions that change the preconditions for a successful crop mix are likely to be met in the short run with the only response available to growers: reducing the amount of land cultivated while retaining the existing production technology on the land farmed.

The rationing model calculates the impacts of water policy changes on farm revenue, fallowing, state product, and employment. The latter measures are computed with revenue multipliers. Two policy scenarios are simulated by the rationing model. The "Proportional" envisions a pro rata supply cut affecting all CVP users in the Central Valley with no trading among regions. The alternative "Efficient" scenario assumes an interregional market for surface water incorporating both the Sacramento and San Joaquin Valleys.

Results of the Impact Analyses
Table 1 summarizes the impacts measured by the three models. The estimated impacts are quite consistent between models. This consistency is apparent by comparing the results of the agroeconomic model, which computes profit, with the results of the rationing model, which has impacts on revenue, and comparing them to the CARM model, which has impacts on both profit and revenue.

All of the models suggest that the incremental costs of removing water from the Central Valley increase as the quantity reallocated increases. Increasing the amount of water devoted to environmental protection from 0.8 MAF to 1.3 MAF more than doubles

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the cost of the regulation to growers. Experimental runs with higher levels of water supply reductions show that this tendency continues and incremental costs of water supply reduction increase as water scarcity increases. This result is attributable to the fact that profit-maximizing farmers will first reduce or cease production of low-value crops in response to reductions in water supply, and will only cease producing high-value crops if the reductions are drastic.

The results of Table 1 further suggest that the overall level of the water supply cut is not the most important factor affecting the social cost of protecting Bay/Delta water quality. Rather, the impacts depend more on the extent of a water market and, when trading is limited, on how supply cuts are distributed among regions. If a market mechanism is used to allocate an annual reduction of 0.8 MAF among a large body of growers in the Central Valley, both the CARM model and the agroeconomic model estimate the annual reduction in farm profits as around $10 million, and the CARM model suggests that the revenue reduction is approximately $19 million. Using a proportional allocation for the same region, the agroeconomic and CARM models both suggest that the annual reduction of profits is nearly $45 million, and the CARM model suggests that annual revenue reductions are around $85 million. The rationing model suggests that if the 0.8 MAF reduction applies to CVP contractors alone, under the market solution revenue reductions are close to $40 million, and under the proportional solution reductions total about $100 million. If the cuts are restricted to the Delta-Mendota Canal area, the most water-efficient region in the San Joaquin Valley, the CARM model suggests that with a market allocation, the revenue losses are around $110 million, and with proportional allocation, losses are close to $165 million.

When the overall water supply reduction is 1.3 MAF, then according to both the agronomic and CARM models, profit loss is close to $30 million if the cut applies to a large group of farmers in the San Joaquin Valley, and the revenue effect is about $52 million annually. If the allocation is proportional for a large region, both the CARM and agronomic models predict annual profit reductions of around $77 million and revenue reductions of around $145 million. When the cuts are targeted to the CVP contractors, revenue losses with a water market are around $100 million, and with a proportional allocation, about $224 million. When the cuts are aimed at growers in the Delta-Mendota Canal area, revenue losses can reach $276 million annually.

An interesting ancillary conclusion of the agroeconomic model is that the CVPIA supply cuts generate little change in irrigation technology except in the most extreme scenarios. This result is consistent with the empirical research of Green and Sunding (1997) and Green et al. (1997) which demonstrates that irrigation technology choice is a complex phenomenon and that water availability is only one factor influencing the choice among irrigation systems. Another way to interpret these results is that water marketing reduces the need for farmers to make expensive capital investments in irrigation hardware to cope with water supply reductions.

II. Water Trading in Westlands Water District: Some Recent Research

Given the central role of water trading in determining the ultimate impacts of the CVPIA on Central Valley agriculture, it is worthwhile to take a more detailed look at water trading as it actually occurs among California farmers. I would like to summarize some recent research conducted at UC Berkeley and financed by a Challenge Grant from the

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Bureau of Reclamation. This research aims to understand water trading in westside agriculture, especially within Westlands Water District which has an active water market. There are three basic conclusions of our work: i) participation in the Westlands market is extensive, both in terms of numbers of landowners and volume exchanged, ii) the water market helps growers cope with surface supply fluctuations and iii) water trading has especially important benefits to small landowners.

Level of Market Activity

Figures 1 - 3 present the level of market activity within Westlands as measured by three different indicators: total volume exchanged, number of trades and the number of market participants. Figure 1 shows the volume of water traded in Westlands from 1993 through 1996. The volume of water ranged from a high of 410,493 AF in 1995 to a low of 284,540 AF in 1994. When measured in terms of the share of the CVP water supply, the market was actually more active in 1994 than in 1995. The volume traded in 1995 was only 27 percent of the district's CVP allocation for that year, while the volume traded in 1994 was 45 percent of the allocation for that year. In 1993, the volume traded was 51 percent of the CVP allocation, and in 1996 the volume traded was 28 percent of the allocation.

Figure 2 illustrates the number of trades made in each of the four water years. Even though the volume of water traded was greater in 1995 and 1996, farms made fewer trades in those years than in the water-short years of 1993 and 1994. Farms made 2,580 trades in 1994, the year with the most trades and the smallest water allocation. Farms made the fewest trades in 1996 (1,673 trades). The average size of a trade varies significantly from year to year. It was smallest in 1994 (110 AF per trade) and largest in 1996 (236 AF per trade).

Figure 3 measures market activity according to the number of farms (distinct decision-making entities) that participated in the market. When measured according to farm participation rates, the market was most active in 1993. A total of 226 farms sold water at least once during the year and 186 farms bought water at least once during the year. 153 farms both bought and sold water. As a share of the total number of farms in Westlands, 64 percent sold at least once, 53 percent bought at least once and 43 percent both bought and sold.

It is well known that Westlands growers operate under nearly continuous conditions of water scarcity. I believe that the Westlands water market is an adaptation to this scarcity, and the innovative behavior of these growers is a model for how other California farmers can respond to future changes in water supplies. Many Westlands growers obviously find merit in water marketing, and there is good reason to believe that landowners in other parts of the Valley can operate in this way as well.

Trading Patterns by Priority Area

Westlands is divided into three priority areas (1, 2 and 3). When Westlands receives its full allocation, land in priority area 1 receives 2.2 acre-feet per acre and land in priority areas 2 and 3 receive 1.5 acre-feet per acre. During dry years, supplies are first reduced from area 3, then area 2 and finally area 1. Thus, during some years, priority area 1 may receive its full 2.2 acre-feet per acre while the other two areas receive nothing. Priority area 1 has the most senior rights, followed by area 2 and then 3.[1]

In each of the four years considered, net transfers in area 1 were negative, and net transfers in areas 2 and 3 were positive. The movement of water from area 1 to areas 2 and 3 was greatest in 1996 and least in 1994. In 1996, the net loss to area 1 was 114,241 AF, the net gain to area 2 was 101,272 AF and the net gain to area 3 was 12,969 AF. In 1994, the net loss to area 1 was 44,532 AF, the net gain to area 2 was 36,018 AF and the net gain to area 3 was 8,514 AF. While the net transfers in each area varied significantly from year to year, the net transfers in terms of the share of the total annual CVP allocation were fairly constant. The loss to area 1 in 1996 represented eight percent of the total CVP allocation of 1,425,000 AF. The loss to area 1 in 1994 represented in seven percent of the total CVP allocation of 637,000 AF. In 1993 and 1995, the loss to area 1 represented six percent of the total allocation for the given year.

Significantly, priority area 2 is where most of the perennial crops are grown in the District. This allocation occurs despite the fact that this area has a less stable water supply than area 1. Without an active internal market, it is highly doubtful that growers would be able to produce tree and vineyard crops on area 2's high-quality soil. This is one sense in which water trading can help growers cope with supply fluctuations, as it provides a way to reallocate water supplies to those crops with the greatest level of capital investment in water-short years.

Market Trading Patterns by Farm Size

For purposes of this discussion, I consider a farm to be small, medium or large depending on its total acreage. Small farms are 960 acres of less, medium farms are 960 – 5,760 acres and large farms are greater than 5,760 acres. Depending on the year, 60 to 64 percent of the farms in the district were small farms, 27 to 30 percent were medium farms and 9 to 11 percent were large farm.

In each year considered, market participation rates were greatest among large farms and lowest among small farms. Among small farms, 21 to 32 percent bought in a given year and 30 to 47 percent sold on the market. Among medium sized farms, 43 to 66 percent bought water and 46 to 63 sold water. Finally, 75 to 85 percent of large farms bought water and 59 to 76 percent of large farms sold water.

Due to their smaller size, small farms traded less water in total than medium-sized farms; medium farms also traded less water than large farms. The average number of acre-feet traded was lower in 1994 than in the other years for each size group. The average number of acre feet traded was greatest for medium and large farms in 1995 and greatest for small farms in 1996.

While small farms bought and sold less in total than other types of farms, Figures 4a - 4d show that in terms of acre feet per acre, small farms actually traded more than medium and large farms in each year. Further, whether small farms buy or sell on the market is related to the type of water year. In the water-short year of 1994, small farms bought 0.40 acre feet per acre on average, and sold only 0.22 acre feet. In 1996, by contrast, small farms bought 0.48 acre-feet per acre on average and sold 0.90. In 1996,

[1] Priority area 3 encompasses a relatively small area of the district, and thus does not account for a large share of the trading activity.

medium farms bought 0.28 acre feet per acre and sold 0.21 acre feet. Large farms bought 0.29 acre feet per acre and sold 0.21 acre feet.

Market trades account for a significant fraction of the total water supplies of small farms. Assuming a farm is located in Priority Area 1, it received a CVP allocation of 2.2 acre feet per acre in 1996. Thus, if a small farm purchased 0.48 acre feet per acre, it increased its initial allocation by 22 percent. If a small farm sold 0.90 acre feet per acre, it reduced its initial supply by 41 percent. Of course, many farms both bought and sold water. If a small farm bought 0.48 acre feet per acre and sold 0.90 acre feet, these trades represent a net reduction in supply of 0.42 acre feet per acre which is a 19 percent decrease from its initial CVP supply.

This research indicates that small farms rely on the water market more than large farms. More important, we show that the market is an especially important supply source for small farms during water-short years. While these results are preliminary, they are highly suggestive, and indicate that water markets may have important equity consequences in addition to their efficiency benefits documented in the first section.

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Table 1
Summary of Impacts on California Agriculture

Cuts in CVP Deliveries (acre feet)	Model	Decrease in Revenue ($million)	Decrease in Profit ($million)	Decrease in Gross State Product ($million)	Decrease in Labor (000 person years)	Acres Fallowed (000 acres)
800,000						
	CARM					
	Proportional Allocation					
	San Joaquin	85.96	45.50	90.26	2.15	
	Local Market Allocation					
	San Joaquin	18.88	9.82	19.82	.47	
	Agroeconomic					
	Proportional		53.05			127
	South of Delta		36.87			14
	Rationing					
	Proportional	97.38		102.86	4.49	243
	Efficient	40.21		46.25	2.02	132
1,300,000						
	CARM					
	Proportional Allocation					
	San Joaquin	145.83	76.95	153.12	3.65	
	Local Market Allocation					
	San Joaquin	52.43	26.69	55.05	1.31	
	Agroeconomic					
	Proportional		118.44			239
	South of Delta		59.14			39
	Rationing					
	Proportional	224.88		226.63	10.80	373
	Efficient	96.62		111.90	4.87	321

Summary of Market Activity

Figure 1. Acre Feet Traded (in Thousands)

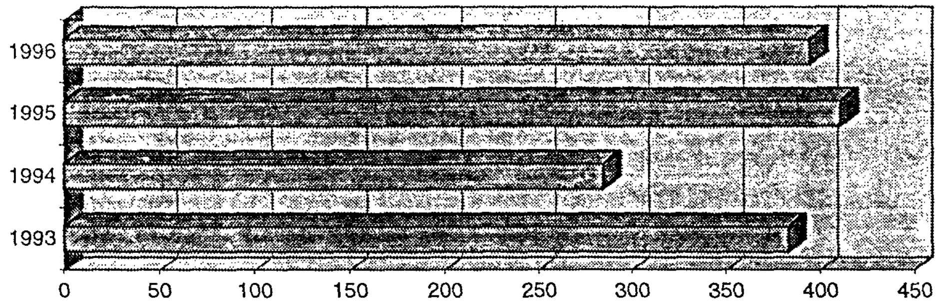

Figure 2. Number of Trades

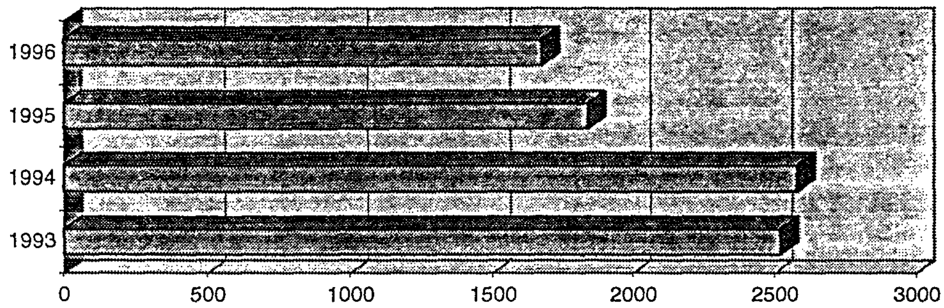

Figure 3. Farms Participating

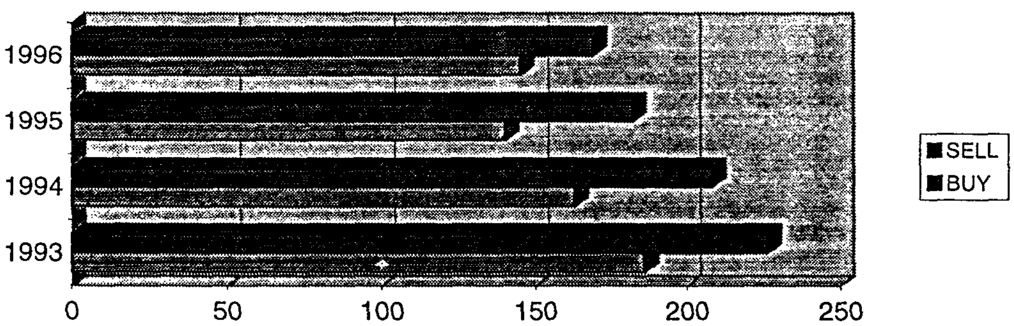

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Figure 4a. Average AF Traded per Farm 1993-94

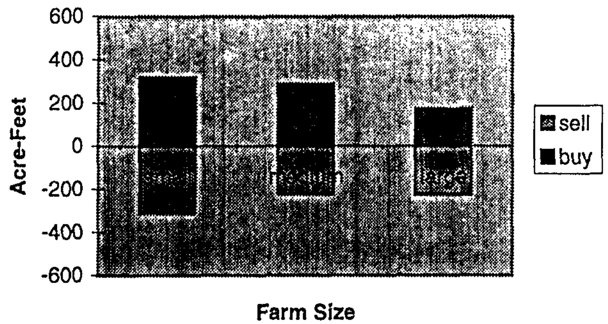

Figure 4b. Average AF Traded per Farm 1994-95

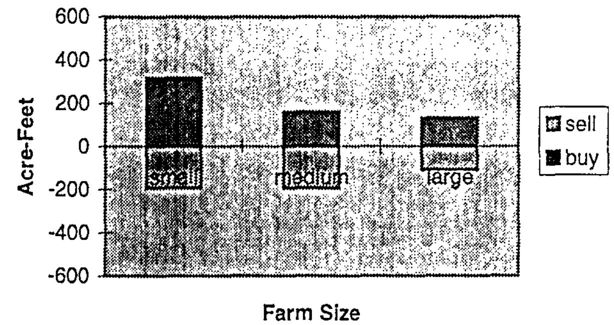

Figure 4c. Average AF Traded per Farm 1995-96

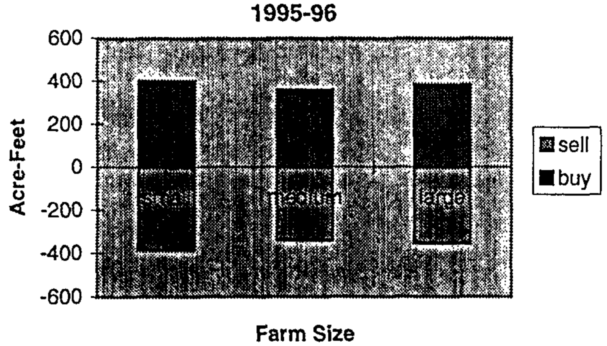

Figure 4d. Average AF Traded per Farm 1996-7

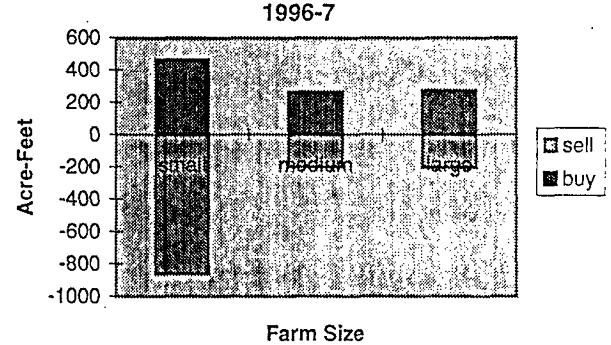

Figure 4b. Average AF Traded per Farm 1994-95

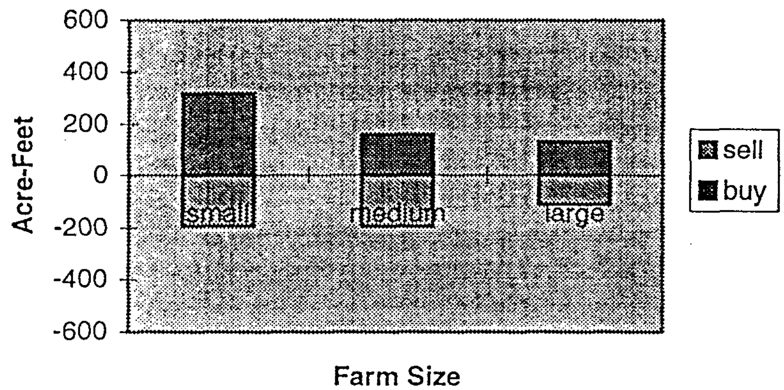

Figure 4d. Average AF Traded per Farm 1996-7