Appendix B: Walnuts

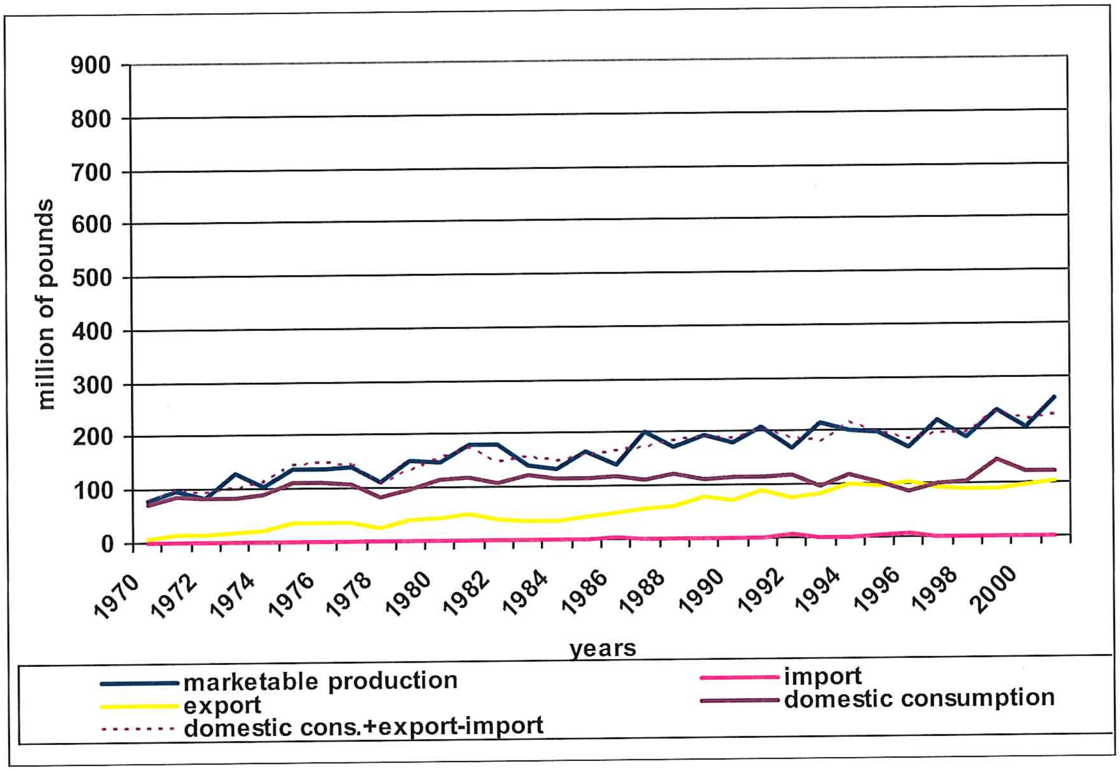


Figure 1B: *California marketable production, US domestic consumption, export and import of Walnuts. Years 1970-2001*

Source: USDA

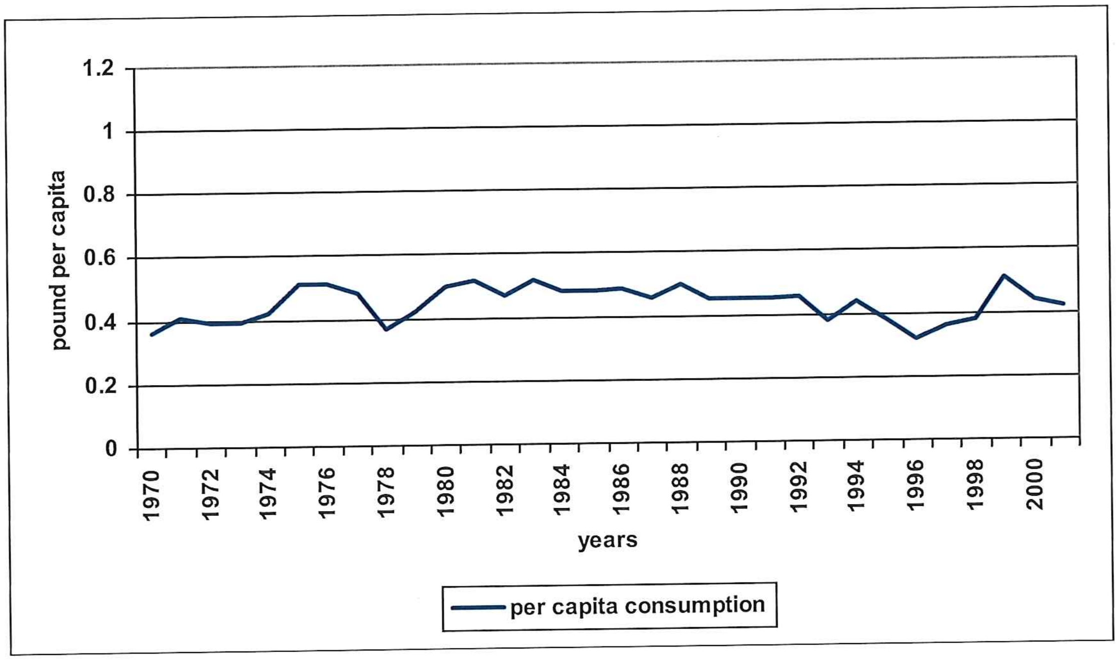


Figure 2B: *US per capita consumption of Walnuts. Years 1970-2001*

Source: USDA

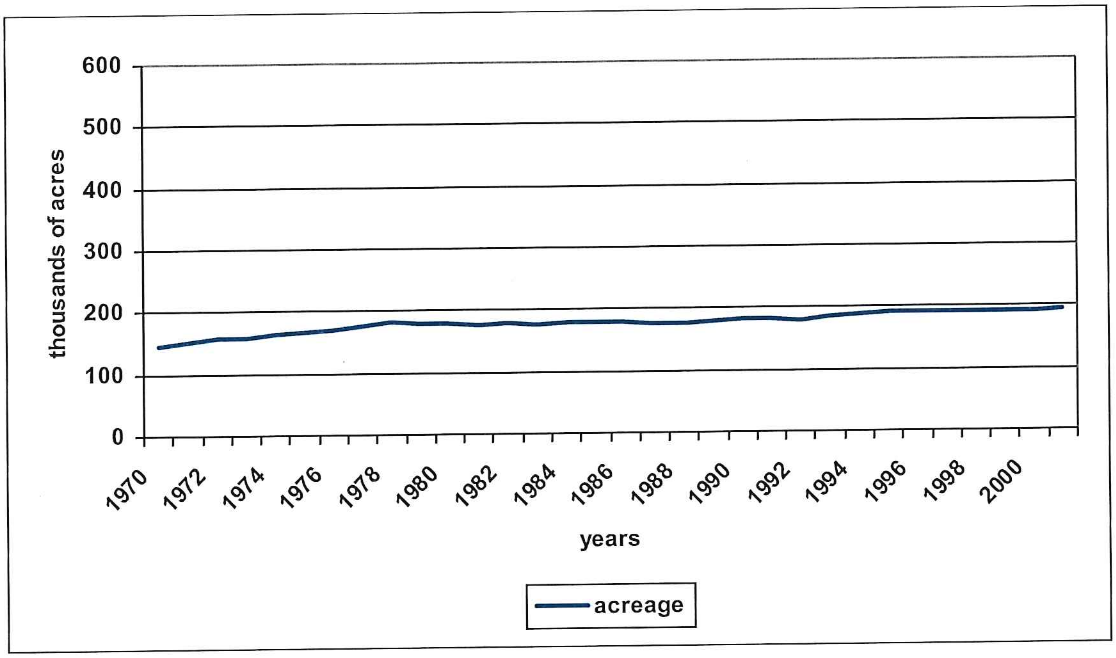


Figure 3B: *Walnut acreage in California. Years 1970-2001*

Source: USDA

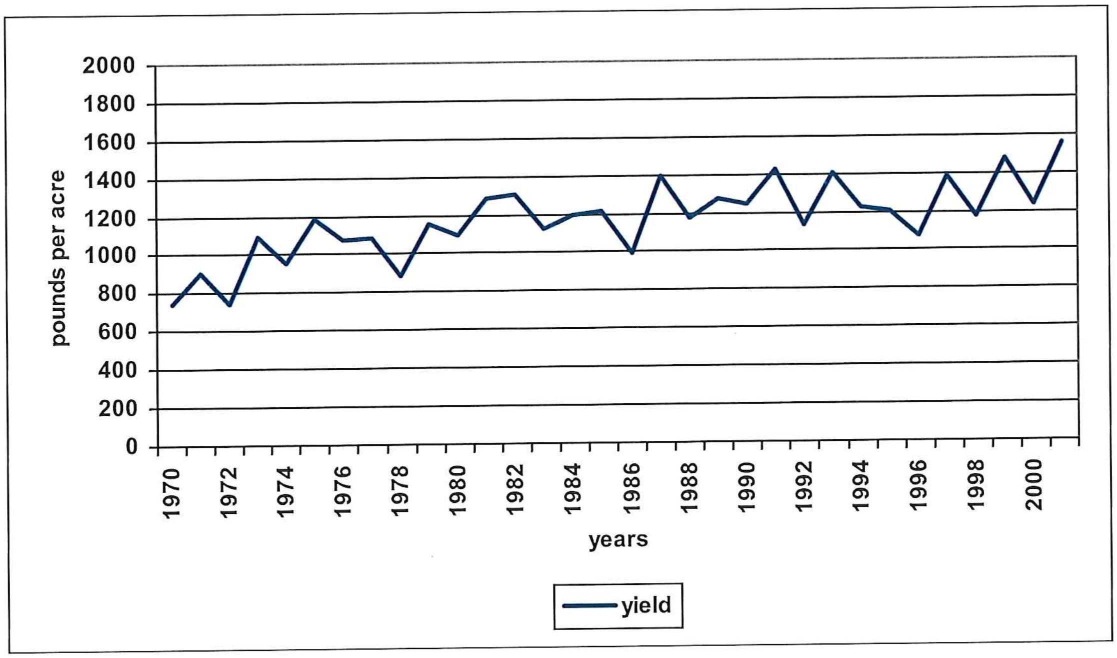


Figure 4B: *Per acre yield of Walnuts in California. Years 1970-2001*

Source: USDA

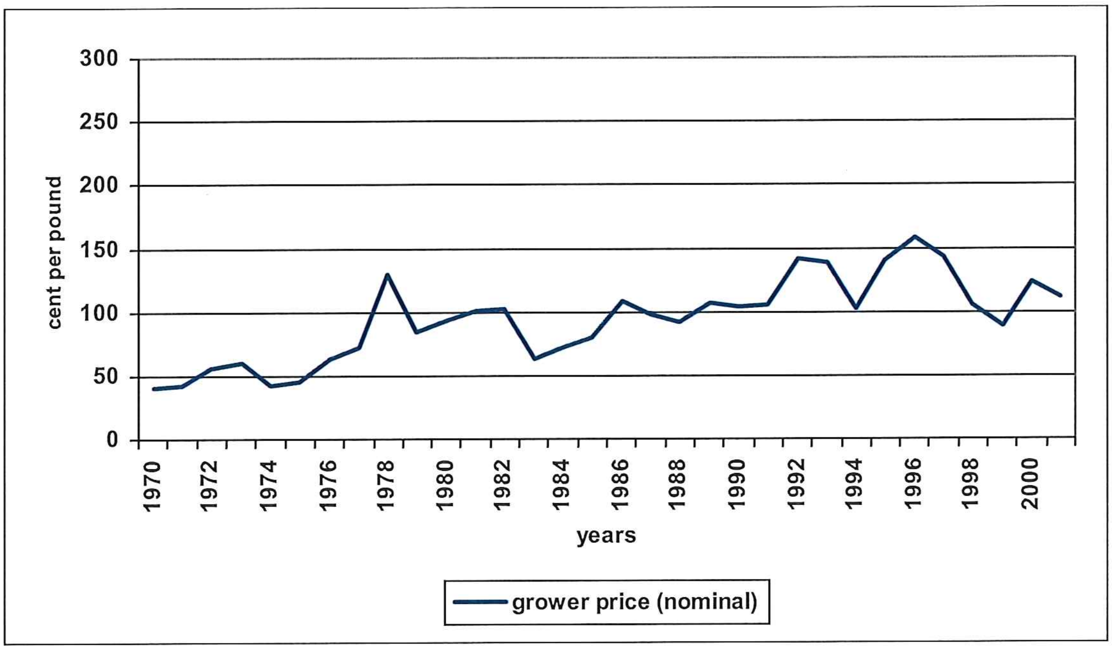


Figure 5B: ***Grower price for walnuts in California (nominal values). Years 1970-2001***

Source: USDA

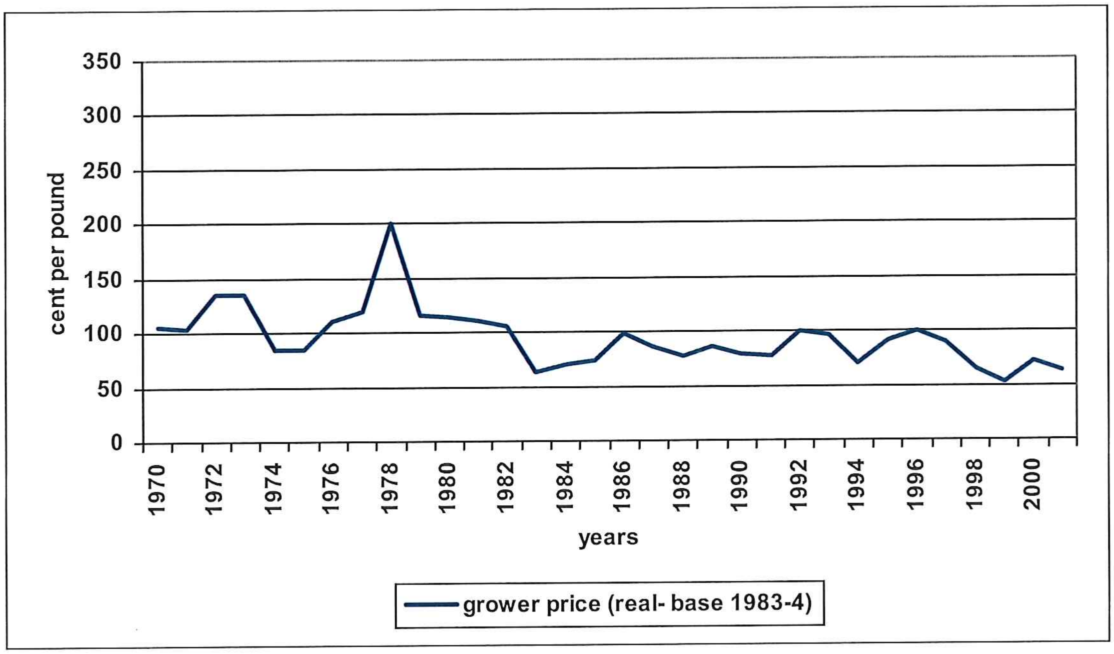


Figure 6B: *Real grower price for walnuts in California (real values). Years 1970-2001*

Source: USDA

APPENDIX C: Almond Yields, Walnut Yields, and Walnut Production, 1970-2001

Year	Almond Yields (Pounds/Acre)	Walnut Yields (Pounds/Acre)	Walnut Production (Millions Lbs)
1970	877	740	108000
1971	863	900	135000
1972	759	740	116000
1973	726	1100	174000
1974	995	950	155000
1975	748	1190	198000
1976	1100	1080	183000
1977	1130	1090	192000
1978	588	880	160000
1979	1160	1160	208000
1980	985	1100	197000
1981	1250	1290	225000
1982	1250	1310	234000
1983	1020	1130	199000
1984	672	1200	213000
1985	1550	1220	219000
1986	1140	1000	180000
1987	601	1400	247000
1988	1580	1180	209000
1989	1410	1280	229000
1990	1190	1250	227000
1991	1610	1430	259000
1992	1210	1140	203000
1993	1370	1410	260000
1994	1190	1230	232000
1995	1700	1210	234000
1996	885	1080	208000
1997	1190	1390	269000
1998	1720	1180	227000
1999	1130	1480	283000
2000	1130	1240	239000
2001	1740	1560	305000

Source: USDA.

ALFALFA AND COTTON

Introduction

Historically, from 1950-2002, alfalfa and cotton have been among California's top commodities in terms of total value (Johnston and McCalla). In 1950 cotton was ranked third in terms of value of production in California with a value of $202 million. By 2001, cotton had slipped to the eighth most valuable commodity in California in value of production. The trend has been downward during the period 1950-2002. Hay (85% alfalfa) was ranked fifth in 1950 in California with a value of production of $121 million. In 2001, hay was ranked seventh in value of production just ahead of cotton.

Models are developed for California alfalfa and cotton acreage, production, and consumption. Both single equation and systems of equations are estimated. The data consist of 33 annual observations from 1970 to 2002. In some models, there were slightly fewer observations due to lags in the specifications. A brief description of the alfalfa market is given prior to reporting the estimations of the models. In addition, some issues related to the nature of the data are discussed.

Alfalfa

Alfalfa hay acreage in California has averaged about a million acres per year during the past 30 years (Figure 1A). Alfalfa contributes about 85 percent of the value of all hay production in California. Alfalfa is influenced by profitability of alternative annual crops such as cotton, tomatoes, trees, and vines. The demand for alfalfa hay is determined to a large degree by the size of the state's dairy herd, which consumes about 70 percent of the supply. Horses consume about 20 percent. Alfalfa is a perennial crop with a three to five-year economic life. Since it is a water intensive crop, its profitability is strongly influenced by water and water costs. In addition, alfalfa is important in crop rotations because of its beneficial effects on the soil (Johnston, p. 87).

Alfalfa production in California has been increasing annually since the mid nineties (Figure 2A). It reached a peak in 2002 at 8.1 million tons. The increase in production has been primarily due to the upward trend in yields (Figure 3A) and not to increases in acreage. Alfalfa real grower price in California, using a 1983/84 base, has exhibited a downward trend since the early eighties (Figure 6A). In 2002 the real grower price was about \$60 per ton.

Model for Alfalfa Acreage

A partial adjustment model of alfalfa acreage is based on the following equation:

$$\begin{aligned} \ln A_t = \beta_0 + \beta_1 \ln A_{t-1} + \beta_2 \ln P_t + \beta_3 \ln risk_t + \beta_4 crit_t + \beta_5 crit_t * \ln A_{t-1} \\ + \beta_6 crit_t * \ln P_t + \beta_7 crit_t * \ln risk_t + \varepsilon_t \end{aligned} \quad (1)$$

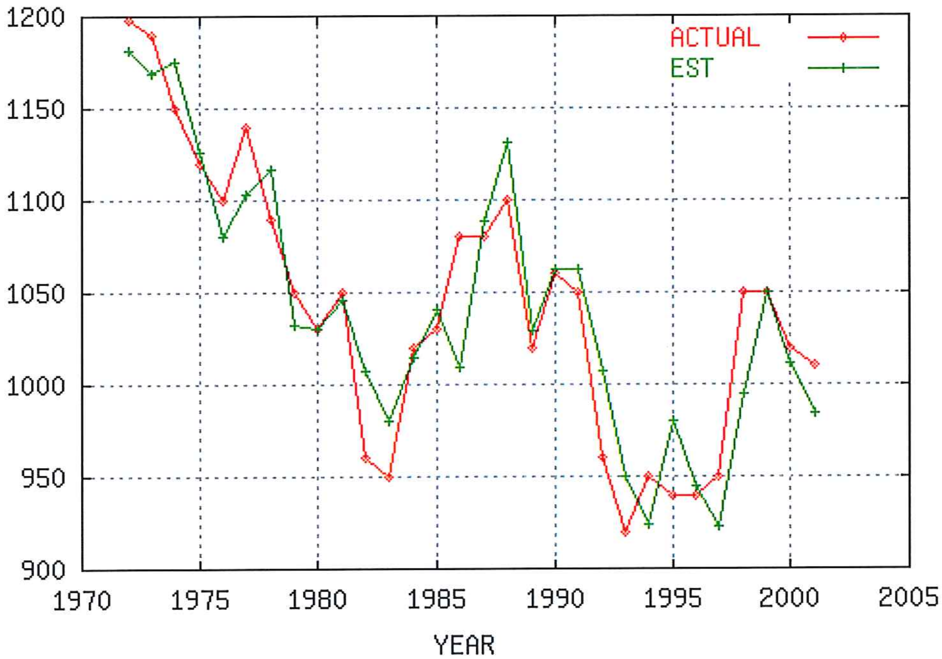
where A_t represents planted alfalfa acreage in thousands of acres, P_t is alfalfa price per ton, $risk_t$ is the variability in alfalfa price (measured by the standard deviation), and $crit_t$ is a dummy variable identifying the *critical years* for water scarcity (i.e., the year when the *Four river index* fell below the value of 5.4). The *Four river index* is an index to measure the water availability in California based on four river flows. The higher the value the more water available. Two interaction terms are also included in the model to capture the effects of water scarcity on prices and risk.

The results of the estimation are (equation 2):

$$\begin{aligned} \ln \hat{A}_t = \underset{(1.66)}{4.08} + \underset{(0.17)}{0.67} \ln A_{t-1} + \underset{(0.16)}{0.35} \ln P_t - \underset{(0.27)}{0.61} \ln risk_t - \underset{(10.95)}{23.80} crit_t + \underset{(1.26)}{2.56} crit_t * \ln A_{t-1} \\ + \underset{(0.59)}{0.31} crit_t * \ln P_t + \underset{(0.58)}{0.67} crit_t * \ln risk_t \end{aligned} \quad (2)$$

where the numbers in parentheses are estimated standard errors. The estimation supports the hypothesis that alfalfa acreage is influenced by prices, ceteris paribus. The short-run price elasticity of acreage is 0.35 and significant when ample water is available and 0.66 when there is a shortage of water. Acreage increases with price expectations and decreases with increases in perceived risk, as anticipated. Also the availability of water has a significant impact on acreage. An F-test on the joint significance of the variable "crit" and its cross products allows us to reject the null hypothesis of no impact at a 90% confidence level (p-value: 0.0787). The signs of the coefficients are consistent with a reduction of planting of new crop acreage during critical years of water scarcity. Furthermore, the estimated coefficient on lagged acreage is 0.67 and significant supporting the partial adjustment framework.

The regression R^2 is 0.847, indicating a good fit. The Durbin h test indicates that there is no autocorrelation in the disturbance terms. Graph 1 depicts the actual and estimated values for alfalfa acreage:



Graph 1: ***Actual and estimated values of alfalfa acreage (in thousands of acres).***

Model for Alfalfa Yield

Alfalfa yield is modeled by the following equation:

$$\ln Y_t = \beta_0 + \beta_1 \ln P_{t-1} + \beta_3 \ln CP_{t-1} + \beta_4 FRI_t + \beta_5 D_t + \varepsilon_t \quad (3)$$

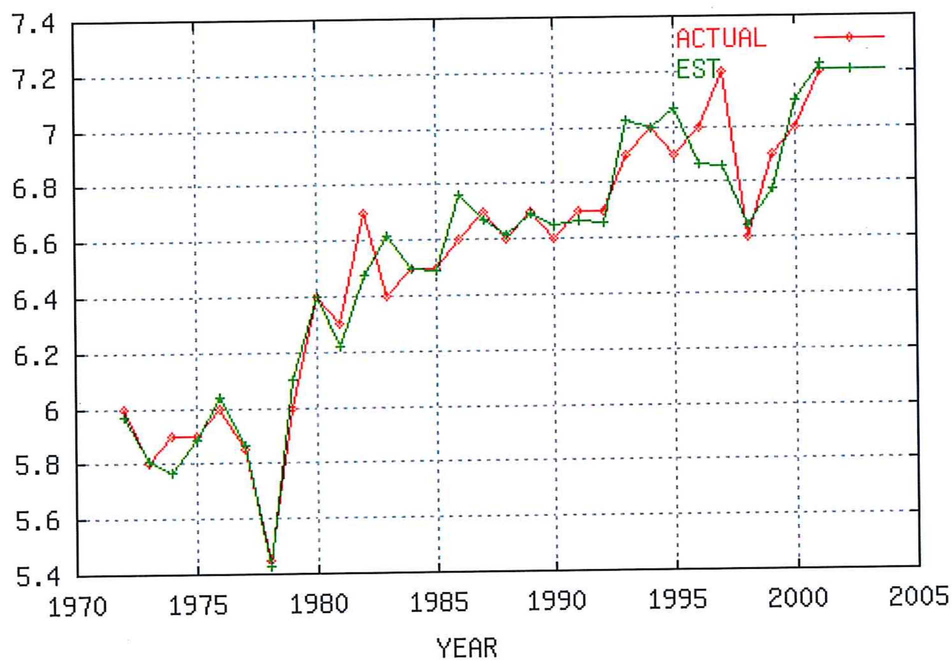
where Y_t is alfalfa yield in tons, P_{t-1} is lagged alfalfa price per ton, CP_{t-1} is lagged cotton price \$/lb.(the rotation crop), FRI_t is the value of the *Four River Index* (approximating the availability of water) and D_t is a dummy variable identifying the year 1978 as an outlier. The model includes a moving average component of order two.

The estimated yield equation is:

$$\underset{}{\ln \hat{Y}_t} = \underset{(0.02)}{1.31} + \underset{(0.00)}{0.08} \ln P_{t-1} - \underset{(0.01)}{0.14} \ln CP_{t-1} + \underset{(0.00)}{0.01} FRI_t - \underset{(0.03)}{0.12} D_t \quad (4)$$

where numbers in parentheses are standard errors. The estimated equation indicates that yields respond positively to changes in prices and water availability. Both of these estimated coefficients are highly significant. Alfalfa yields are negatively related to last year's cotton price since they compete for the same irrigated land.. The estimated coefficient is also highly significant. The 1978 dummy coefficient is negative and significant as expected as it was a major drought year. Including a dummy variable for one year is equivalent to eliminating the 1978 observation.

The regression exhibits a good fit (R^2 is 0.93) and the tests ruled out autocorrelation (the Durbin-Watson statistics is 2.00) in the disturbance terms. . Graph 2 describes the actual and estimated alfalfa yields.



Graph 2: ***Actual and estimated values of alfalfa yield (tons/acre).***

Production

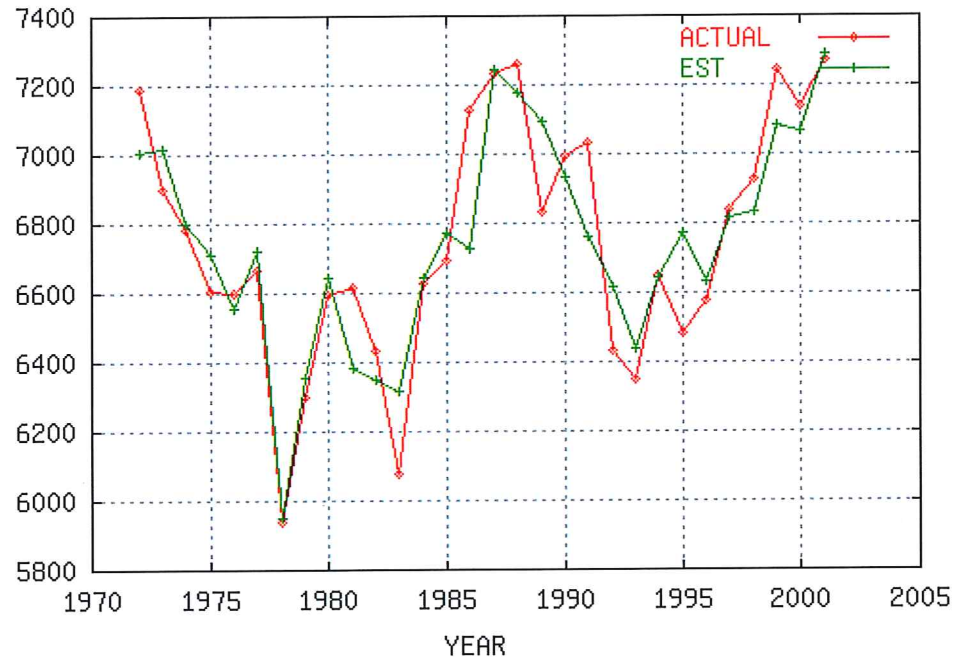
The estimated alfalfa production equation (Table 1) is presented in tabular form in order to better facilitate interpretations of estimated coefficients:

Table 1. Alfalfa Production Equation

Variable	Coefficients	Standard errors
Constant	4.87	1.98
Lag of Log Production	0.69	0.21
Lag of Log Alfalfa Price	0.44	0.17
Lag of Log Alfalfa Risk	-0.75	0.28
Lag of Log Cotton Price	-0.07	0.03
Dummy for *critical years*	-12.07	5.77
Crit*Lag of Log Production	1.33	0.74
Crit*Lag of Log Alfalfa Price	-3.87	1.27
Crit*Lag of Log Alfalfa Risk	3.61	1.02
Crit*Lag of Log Cotton Price	0.13	0.08
Dummy for outlier (1978)	-0.08	0.03

The estimated own-price elasticity is 0.44 and significant at the usual 5% significance level which suggests that alfalfa production is relatively inelastic. Alfalfa production is negatively related to risk (price volatility) and cotton prices. Both estimated coefficients are significant. Water shortages have a negative impact on alfalfa production (see the estimated coefficient of -12.07 on the dummy variable for critical years and is significant).

The regression R^2 is 0.817. The Durbin h statistics (-0.62) indicates that there is no problem with autocorrelation in the errors. Graph 3 plots actual and estimated values of alfalfa production.



Graph 3: ***Actual and estimated values of alfalfa production (thousands of tons).***

Demand

The estimated demand function for alfalfa is a derived demand. Dairies and horse enterprises demand about 90 percent of alfalfa. The assumption made in the estimations is that the market for alfalfa is in equilibrium, that is, that quantity demanded is equal to quantity supplied given the ease of storage this is expected.

The estimated demand equation for alfalfa is given by

$$\hat{Q}_t = -5.904 - 0.107\,price_t + 0.243\,milkps_t + 1.736\,cows_t + 0.105\,prmix_t - 0.606\,prmilk_t \quad (6)$$
$$(2.626)\;(0.107)\qquad(0.042)\qquad(0.288)\qquad(0.039)\qquad(0.113)$$

where Q_t is the quantity demanded of alfalfa in tons, $price_t$ is the real grower price of alfalfa in \$/ton, $milkps_t$ is the milk price support, cow_t is the number of cows, $prmix_t$ is the price of a combination of corn and soybeans, and $prmilk_t$ is the real price of milk. All variables are expressed in logarithmic form.

The coefficient of determination, $R^2 = 0.888$, indicates a good fit of the model with the data. The own-price elasticity of demand is -0.107 which is inelastic, but not statistically significant. The estimated coefficient of milk support price is 0.243 implying that the quantity demanded of alfalfa increases as the support price of milk increases. The estimated coefficient on real price of milk is negative. The coefficient on the number of cows is positive and statistically significant. This is reasonable given that about 70% of the demand for alfalfa is from dairies. All of the coefficients in the demand equation are statistically significant at the five percent level of significance except for own price.

System for Alfalfa

A three-equation system for alfalfa was developed and estimated. Iterative three-stage least squares are used to estimate a model consisting of acreage, production, and demand relationships for alfalfa. We assume that the market for alfalfa is in equilibrium, that is, that quantity demanded is equal to production. We further assume that stocks are included in the demand for alfalfa. Thus, the three endogenous variables are: acreage, production, and alfalfa price. The estimators will be asymptotically efficient given that the model is specified correctly. The gain in efficiency is due to taking into account the correlation across equations. And three-stage least squares will purge (asymptotically) the correlation that exist between endogenous variables on the right hand side of the equations in the model with the error terms.

The estimated alfalfa system is given by

$$
\begin{aligned}
\hat{A}_t &= 4.210 + 0.133 price_{t-1} - 0.277 risk_{t-1} + 0.532 A_{t-1} \\
&\quad (0.097)\ (0.159)\qquad (0.159)\qquad (0.111) \\
\hat{Y}_t &= 2.630 + 0.601 A_t + 0.037 price_{t-1} - 0.088 pr\cot_{t-1} + 0.199 Y_{t-1} - 0.109 D_t \qquad (7) \\
&\quad (0.834)\ (0.150)\ (0.015)\qquad (0.021)\qquad (0.128)\ (0.109) \\
\hat{Q}_t &= 3.962 - 0.020 price_t - 0.061 prcorn_t + 0.037 prsoy_t + 0.475 Q_{t-1} - 0.114 D_t + 0.091 cow_t \\
&\quad (1.227)\ (0.015)\qquad (0.036)\qquad (0.037)\qquad (0.108)\qquad (0.027)\ (0.101)
\end{aligned}
$$

where A_t represents acreage of alfalfa, Y_t denotes production of alfalfa, Q_t is the quantity demanded of alfalfa, and the remaining variables are defined above. The own-price elasticity is 0.133 in the acreage response equation but is not statistically significant at the five percent level of significance. Acreage response decreases as risk increases as measured by the standard deviation of alfalfa monthly prices. Production of alfalfa is positively related to alfalfa price, is negatively related to cotton prices, and positively correlated to past acreage and production. Alfalfa demand has a very low own-price elasticity of demand of -0.020. Alfalfa demand is negatively related to price of corn but positively related to soybean prices. Demand is positively related to the number of cows. Recall that about 70% of the demand for alfalfa is from dairies. The majority of the estimated coefficients are statistically significant at the 5% level.

Cotton

Cotton is the most important field crop gown in California. Growers in California grow two types of cotton: Upland, or Acala and Pima. Upland cotton makes up about 70 to 75 percent of the California cotton market and is the higher-quality cotton. Upland has a worldwide reputation as the premium medium staple cotton, with consistently high fiber strength useful in many apparel fabric applications. Export markets are important, attracting as much as 80 percent of California's annual cotton production in some years making it California's second highest export crop (Johnston, p. 84). Historically, California cotton, in terms of value of production, was the third highest ranking crop in California in 1950 below cattle and calves and dairy products. In 2001 cotton was ranked the eighth highest valued crop below milk and cream, grapes, nursery products, cattle and calves, lettuce, oranges, and hay (McCalla and Johnston).

There has been a downward trend in cotton acreage and production in California since 1979. California growers produced 3.4 million bales of cotton on 1.6 million acres in 1979. In 2002 they produced about 2 million bales of cotton on 700,000 acres (Figures 10A and 12A). Cotton yields have experienced an upward trend since 1979 (Figure 11A). Nominal producers' prices in California for cotton exhibit an upward trend since the 1970s, but real producers' prices in California has exhibit a downward trend since the mid seventies (Figures 13A and 14A).

Recently the World Trade Organization (WTO) ruled against U.S. cotton subsidies. U.S. cotton subsidies totaled about $10 billion in 2002 and the WTO ruled that the subsidies created an unfair competition for Brazil, which filed the complaint. California producers received about $1.2 billion in subsidies in 2002. California cotton is not as subsidized as cotton in other states, such as Texas, because subsidies are based on price and California's higher-quality cotton is more expensive (Evans, May 3, 2004).

Acreage, production, and demand equations are estimated for California cotton. Single equation and system of equations models are developed and estimated. In this report we aggregated the different cotton varieties. Disaggregated models of cotton were also estimated because of changes in the cotton industry and to allow for different impacts for subsidized and unsubsidized varieties. The number of observations in the disaggregated models present in the next section are limited due to the relatively recent introduction of Pima in California.

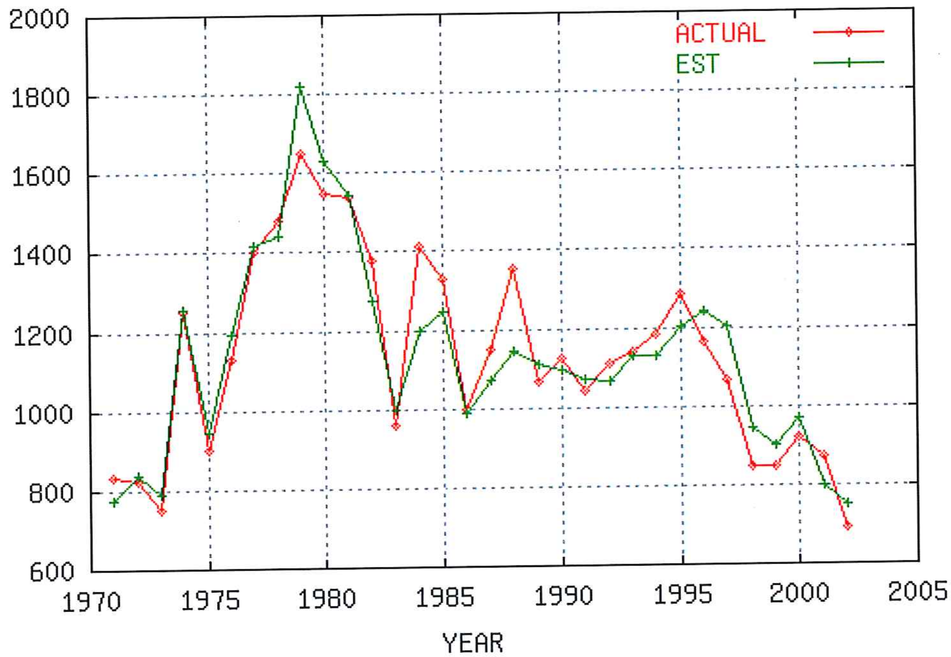
Acreage

The estimated planted acreage relationship, a partial adjustment model, for California cotton is

$$\underset{}{\ln \hat{A}_t} = \underset{(1.26)}{-4.19} + \underset{(0.06)}{0.53} \ln price_t - \underset{(0.03)}{0.05} \ln riskc_t - \underset{(0.26)}{1.47} \ln pricealf_t + \underset{(0.42)}{2.87} \ln riska_t + \underset{(0.07)}{0.27} \ln A_{t-1} \tag{8}$$

where A_t is cotton acreage in thousands of acres, $price_t$ is real cotton price in \$/lb., $risk_t$ is the standard deviation of monthly cotton prices and is a measure of risk, $pricealf_t$ denotes real alfalfa price in \$/ton, and $riska_t$ represents the standard deviation of monthly alfalfa price and is a measure of risk of growing alfalfa. All variables are expressed in logarithmic form.

The estimated coefficient of determination is R^2=0.899. The short-run own-price acreage elasticity of cotton is 0.53 and is highly significant. Cotton acreage decreases with an increase in risk in growing cotton and as price of alfalfa increases. All of the estimated coefficients are statistically significant at the 1% level except for the risk coefficient associated with cotton which is significant at the 10% level. A graph depicting the estimated acreage equation with the actual cotton acreage is given in Graph 4.



Graph 4: ***Actual and estimated cotton acreage (thousands of acres).***

The Durbin h statistics (1.12) fails to reject the null hypothesis of no autocorrelation in the disturbances.

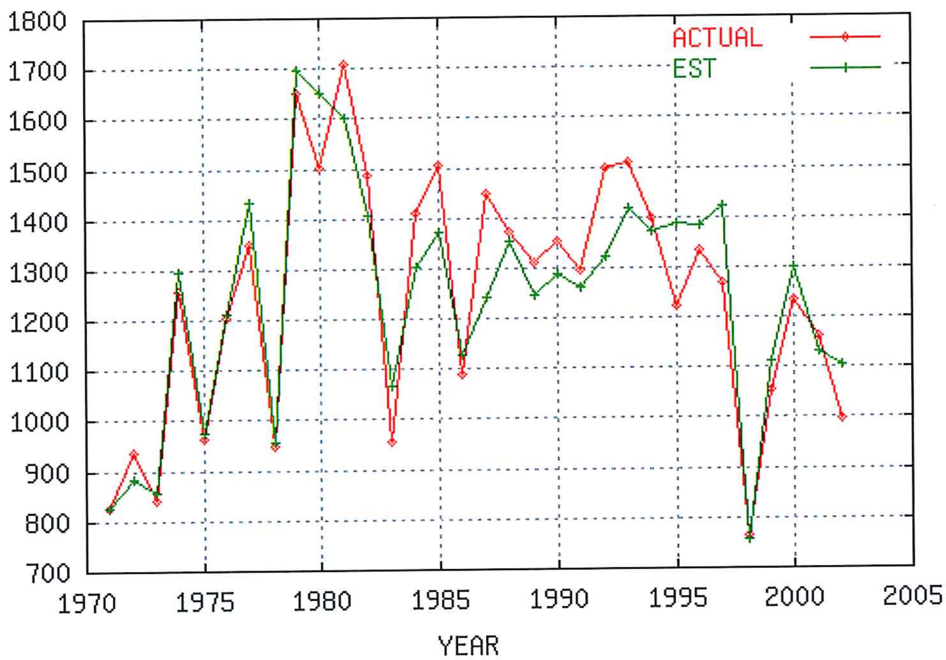
Production

The estimated production relationship for cotton, an adaptive expectations model, is (eq. 9)

$$\hat{Y}_t = \underset{(2.444)}{-7.066} \underset{(0.115)}{+0.497} pricec_t \underset{(0.036)}{-0.499} riskc_t \underset{(0.543)}{-1.844} pricea_t \underset{(0.880)}{+4.067} riska_t \underset{(0.009)}{+0.011} Y_{t-1} \underset{(0.081)}{-0.313} D_t$$

where Y_t denotes cotton production in 1000 bales, and D_t denotes a dummy variable for the drought year, 1978. The remaining variables are as defined above. An adaptive expectations models implies a moving average error process of order one and the production function was estimated with a MA(1) error scheme.

The goodness of fit yields an $R^2 = 0.878$. All of the estimated coefficients are statistically significant from zero at the 5% level except for the risk measure for cotton and lagged cotton production. The short-run price elasticity is 0.497 and the long-run price elasticity is 0.503 [0.497/(1-0.011)]. The estimate coefficients on risk and the dummy variable are negative as anticipated. A plot of the estimated production of cotton with the actual production of cotton is given in Graph 5.



Graph 5: ***Actual and estimated cotton production (1000 bales).***

Demand

The estimated demand function for cotton is given by (eq. 10)

$$\hat{Q}_t = -12.631 - 0.684prc_t + 0.360prus_t + 0.827prray_t - 0.064prpol_t + 0.000pop_t$$

(13.490) (0.228) (0.293) (0.493) (0.544) (0.000)

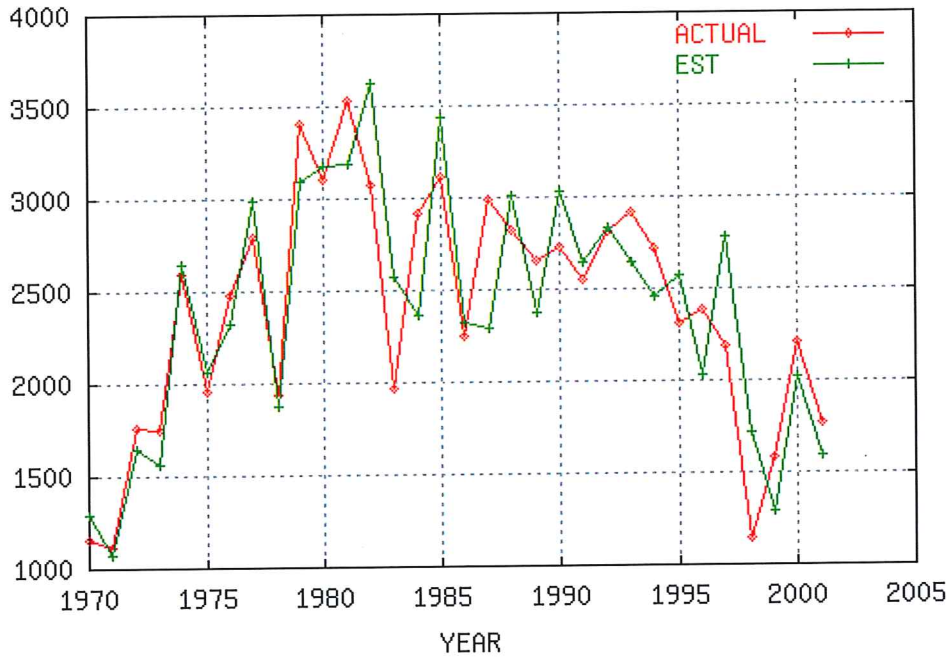
$$-0.217pop_t - 0.070t - 0.004t^2$$

(0.100) (0.117) (0.002)

where Q_t denotes the US disappearance plus US imports of cotton, prc_t denotes the real grower price of California cotton, $prus_t$ represents the United States price of cotton, $prray_t$ denotes the price of rayon, a substitute for cotton, $prpol_t$ denotes the price of polyester, a substitute for cotton, pop_t represents US population, D_t is a dummy variable for the drought year in 1978, and t denotes a time trend. All variables, except the time trend and dummy variable, are expressed in logarithmic form.

The overall goodness of fit was 0.756. The estimated own-price elasticity of California cotton is -0.684 and significant. The positive coefficient on rayon indicates that it is a gross substitute for cotton while the negative sign on polyester indicates a gross complement. There is a negative sign associated with the time trend indicating that the demand for cotton has been decreasing over the sample period

A plot of the estimated and actual demand series for cotton is depicted in Graph 6.



Graph 6: Actual and estimated cotton demand (thousands of bales).

System for Cotton

A two-equation system for cotton was developed and estimated by iterated three-stage least squares (3SLS). The estimated cotton production and demand system (eq.11) is

$$\underset{}{\ln \hat{Y}_t} = \underset{(2.49)}{-1.13} + \underset{(0.12)}{0.46 \ln Pc_t} - \underset{(0.05)}{0.49 \ln Riskc_t} - \underset{(0.52)}{0.82 \ln Pa_t} + \underset{(0.87)}{2.14 \ln Riska_t}$$
$$+ \underset{(0.03)}{0.03 \ln \mathrm{Y}_{t-1}} - \underset{(0.20)}{0.41 D_t}$$

and

$$\ln \hat{Q}_t = \underset{(1.96)}{6.89} - \underset{(0.99)}{0.95 \ln Pc_t} + \underset{(0.78)}{1.24 \ln \mathrm{Prus}_t} + \underset{(0.41)}{0.23 \ln \mathrm{Prray}_t} - \underset{(0.37)}{0.00 \ln \mathrm{Prpol}_t} - \underset{(0.04)}{0.05 \ln Pcin_t}$$
$$\underset{(0.23)}{-0.24\mathrm{D}_t} + \underset{(0.02)}{0.07\mathrm{t}} - \underset{(0.00)}{0.03\mathrm{t}^2}$$

where $pcin_t$ denotes per capita income and the remaining variables are defined above. The first equation represents the production equation for cotton and the second equation is the demand function for cotton. All variables are expressed in logarithmic form. The own-price elasticity is 0.46 for the production of cotton and the own-price elasticity of demand for cotton is -0.95. Both elasticities are inelastic and of the correct sign. The signs on the risk variables are as expected. The cross-price elasticity estimates of rayon and polyester indicate that they are both gross substitutes for cotton. The estimated coefficients on time and time squared indicates that the demand for cotton is trending upward at a decreasing rate. The sign on per capita income coefficient is unexpectedly negative, but not significant.

Modeling Variety Substitution

In California, currently two major varieties of cotton are grown: Upland (Acala) and Pima. Variety differentiation is a phenomenon that is relatively recent, because until late 1980s the so-called "law of one variety" allowed California farmers to grow only Upland (Acala). The bill was revised in 1988 and again in 1991 introducing a broader set of choices for farmers. In 2004, 550 thousand acres of Upland and 220 thousand acres of Pima were planted. Figures 7 and 8 summarize the acreage and production trends from 1970 to 2002.

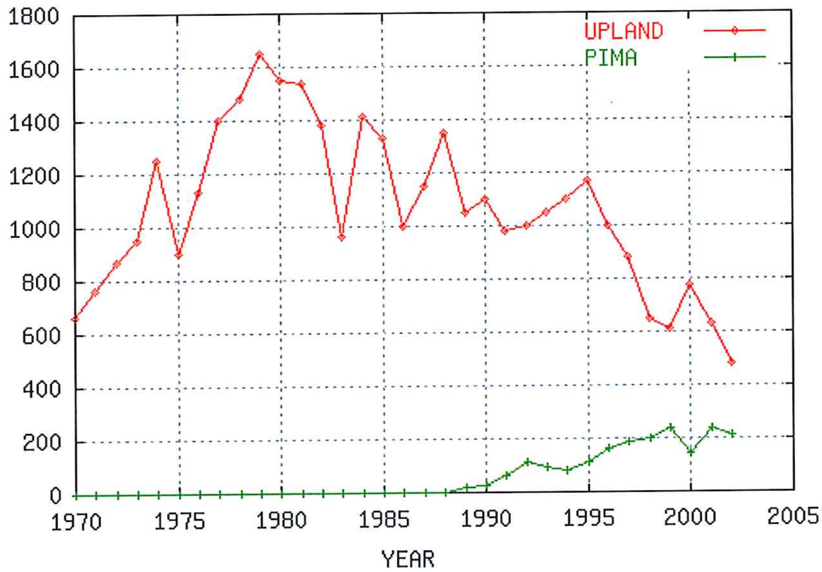


Figure 7: Upland and Pima planted acreage in California (thousand of acres).

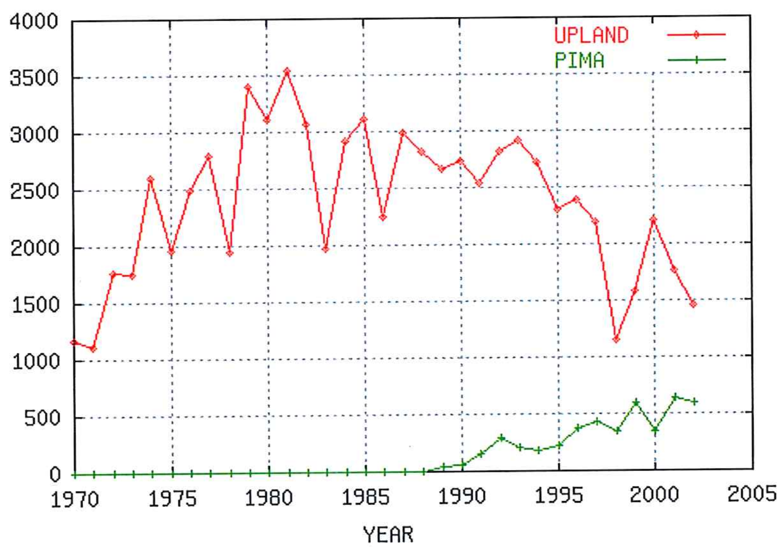


Figure 8: Upland and Pima production in California (thousand of bales).

The graphs show that pima acreage and production are gradually increasing over time. Farmers are gradually adopting the new variety. Since the abolishment of the law of one variety is relatively recent, we have no way to assess if the process has reached a steady state. However, pima cotton is more sensitive to rainfall conditions, and experts expect that the final crop pattern in California will be a mixture of pima and upland, depending on local weather conditions.

The rationale for the adoption of the new variety can be found, in part, in Figure 9, that reports the real grower prices for pima and upland.

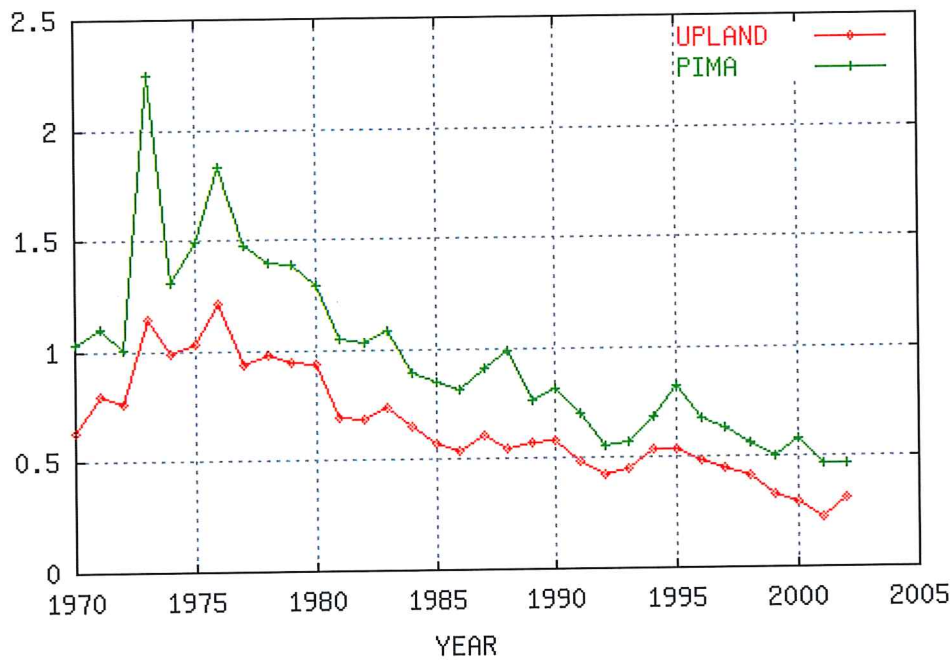


Figure 9: Real prices for Pima and Upland (dollars/lb.).

The graph shows that pima growers benefit from a price premium relative to upland producers. If weather conditions are favorable, pima is considered more profitable. The time trends also show that the price of upland and pima are cointegrated, suggesting a strong theoretical argument for modeling aggregate cotton production regardless of variety (as we did in the previous section).

In this section we adopted a partial adjustment model of the new variety based on relative prices. Given the relevance of the pima production, the model can provide useful indications, however it must be pointed out that: (i) the phenomenon is still too recent to allow reliable statistical analyses based on a time series approach, and (ii) the short time series poses a strong constraint in the number of explanatory variables that can be incorporated into the model.

We designed a model based on an equation for pima acreage and an equation for upland acreage. In both cases we assumed that farmers follow a behavior pattern based on partial adjustments of acreage.

The equations are

$$\begin{aligned} AP_t &= \beta_0 + \beta_1 AP_{t-1} + \beta_2 P_t^P + \beta_3 P_t^U + \varepsilon_t \\ AU_t &= \alpha_0 + \alpha_1 UP_{t-1} + \alpha_2 P_t^U + \alpha_3 P_t^P + u_t \end{aligned} \tag{12}$$

where AP and AU are pima and upland acreage, respectively, P^P and P^U are pima and upland real prices and ε and u are error terms. All the variables are in logarithm form. The model was estimated both as single equations and as a SUR system. The results of the estimation are the following.

Single-equation estimations:

Upland estimation:

$$\begin{aligned} A\hat{U}_t = {} & -0.66 + 0.91 AU_{t-1} + 1.76 P_t^U - 0.86 P_t^P \qquad R^2 = 0.81 \\ & (2.19)\ (0.32) \qquad (0.75) \qquad (0.39) \end{aligned} \tag{13}$$

Pima estimation:

$$\begin{aligned} A\hat{P}_t = {} & 4.49 + 0.74 AP_{t-1} + 2.98 P_t^P - 3.86 P_t^U \qquad R^2 = 0.96 \\ & (0.72)\ (0.08) \qquad (0.78) \qquad (1.14) \end{aligned} \tag{14}$$

where the number in parentheses are standard errors. The test statistics for a single coefficient possess a t distribution with 10 degrees of freedom.

Upland cotton prices have a positive impact on acres planted to Upland. When prices of Pima increase, the acres planted to Upland decrease. Thus, Upland and Pima are gross substitutes. Both price coefficients are significant. With respect to the Pima acreage equation, Pima prices have a positive effect on acres planted to Pima. Upland prices have a negative relationship, as expected, with Pima planted acres.

SUR estimation

Upland

$$\begin{aligned} A\hat{U}_t = {} & -0.74 + 0.71 AU_{t-1} + 1.92 P_t^U - 0.57 P_t^P \qquad R^2 = 0.78 \\ & (2.16)\ (0.32) \qquad (0.82) \qquad (0.40) \end{aligned} \tag{15}$$

Pima

$$\hat{AP}_t = \underset{(1.11)}{4.42} + \underset{(0.05)}{0.78} AP_{t-1} + \underset{(1.00)}{2.89} P_t^P - \underset{(1.72)}{4.26} P_t^U \qquad R^2 = 0.96 \tag{16}$$

The two procedures (single-equation approach and SUR) give similar estimations. In the SUR results the coefficient of Pima prices is insignificant in determining Upland acreage. However, it must be noted that the explanatory variables have a high degree of multicollinearity.

The model confirms the hypothesis that the relative prices of Upland and Pima are driving forces in the adoption process at the state level in California.

Conclusions

The estimated models indicate that the short-run own-price elasticity of alfalfa acreage is inelastic (0.35) but more elastic (0.66) when ample water is available. By applying water marginally through out the growing period, a producer can obtain more cuttings of alfalfa. Alfalfa yields are also responsive to increases in prices. The own-price elasticity of yields is 0.08 and highly significant. Alfalfa yields are negatively related to the previous year's cotton price. Production is positively related to own price with an estimated elasticity of 0.44 and significant. Production was negatively related to risk with an elasticity of risk equal to -0.75. Demand for alfalfa is a derived demand and is positively related to the number of cows and milk price support and negatively related to its own price.

The estimated own-price elasticity of cotton acreage is 0.53 and highly significant. Cotton acreage decreases with an increase in risk in growing cotton and as price of alfalfa increases. The short-run own-price elasticity of cotton production is

0.497 and the long-run estimate is 0.503. The own-price elasticity of cotton demand is -0.684. Rayon is a substitute for cotton. The empirical results support the fact that alfalfa and cotton are rotating crops in California.

In recent years there has been an increase in Pima acreage relative to the traditional Upland variety in California. Upland cotton prices have a positive impact on acres planted to Upland. When Pima prices increase, the acres planted to Upland decrease. A similar situation applies to Pima acreage. That is, an increase in Upland prices causes a decrease in Pima acreage. Thus, the empirical results support that hypothesis that relative prices of Upland and Pima have a significant impact on the adoption of the two varieties.

Future research needs to focus on the collection of more data related to the consumption of California cotton and alfalfa, stocks and inventories, and interstate trade of alfalfa between California and Oregon and Nevada.

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ALFALFA HAY

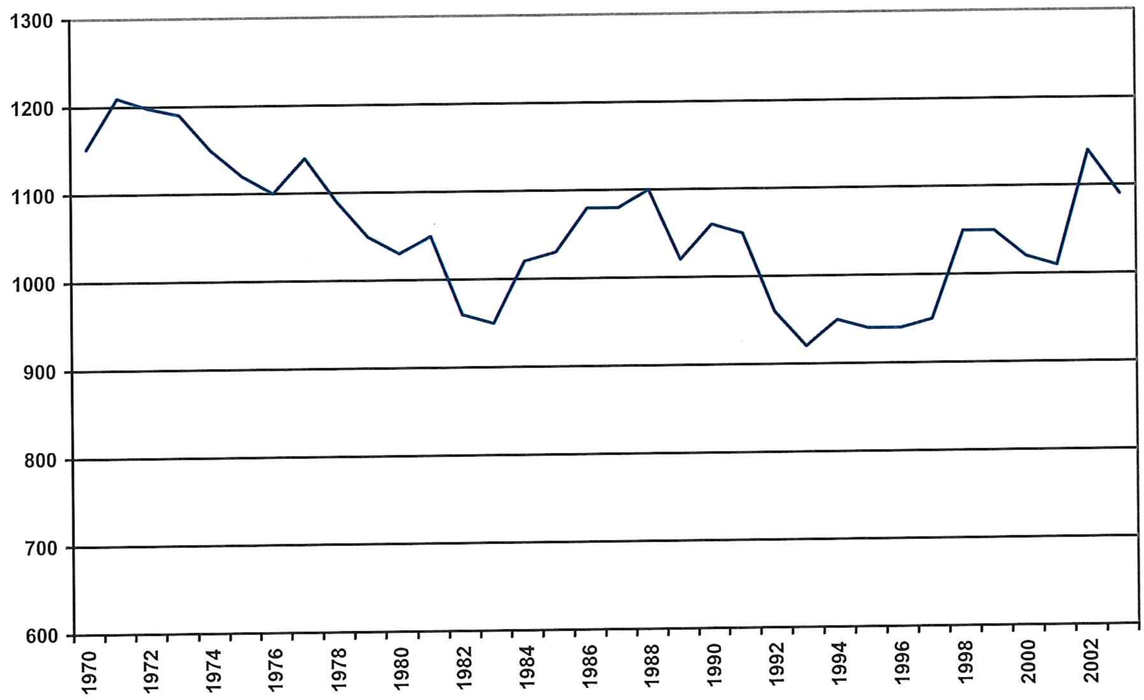

Figure 1A: Harvested Acreage for Alfalfa in California (Thousands of Acres).

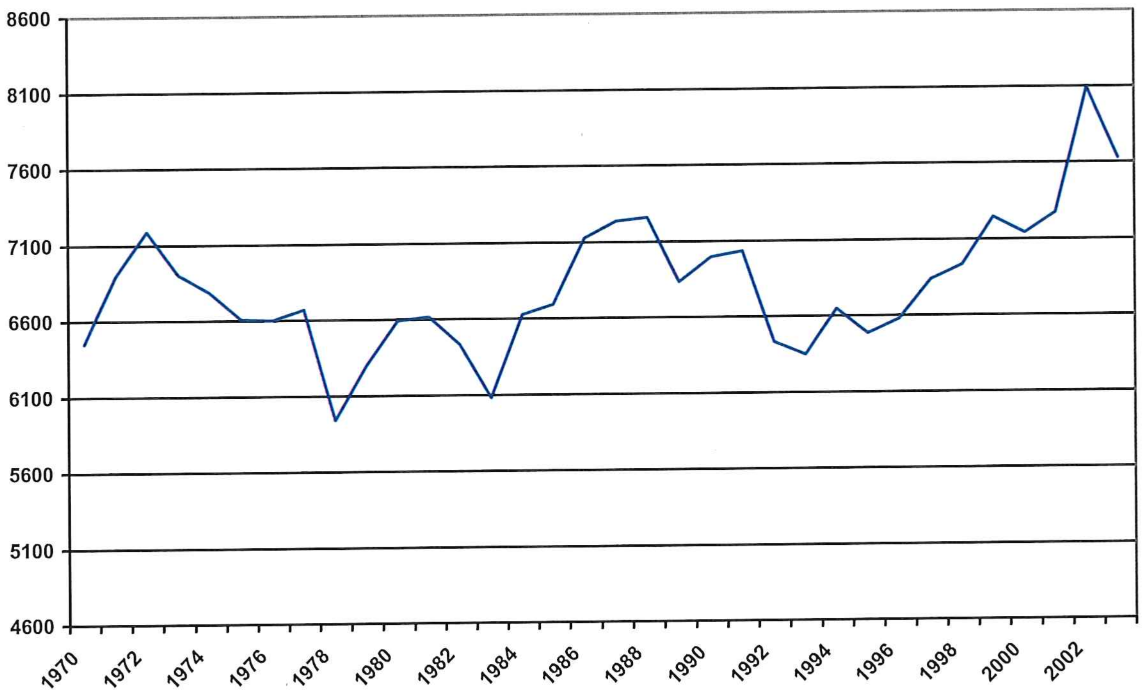

Figure 2A: Alfalfa production in California (Thousands of tons)

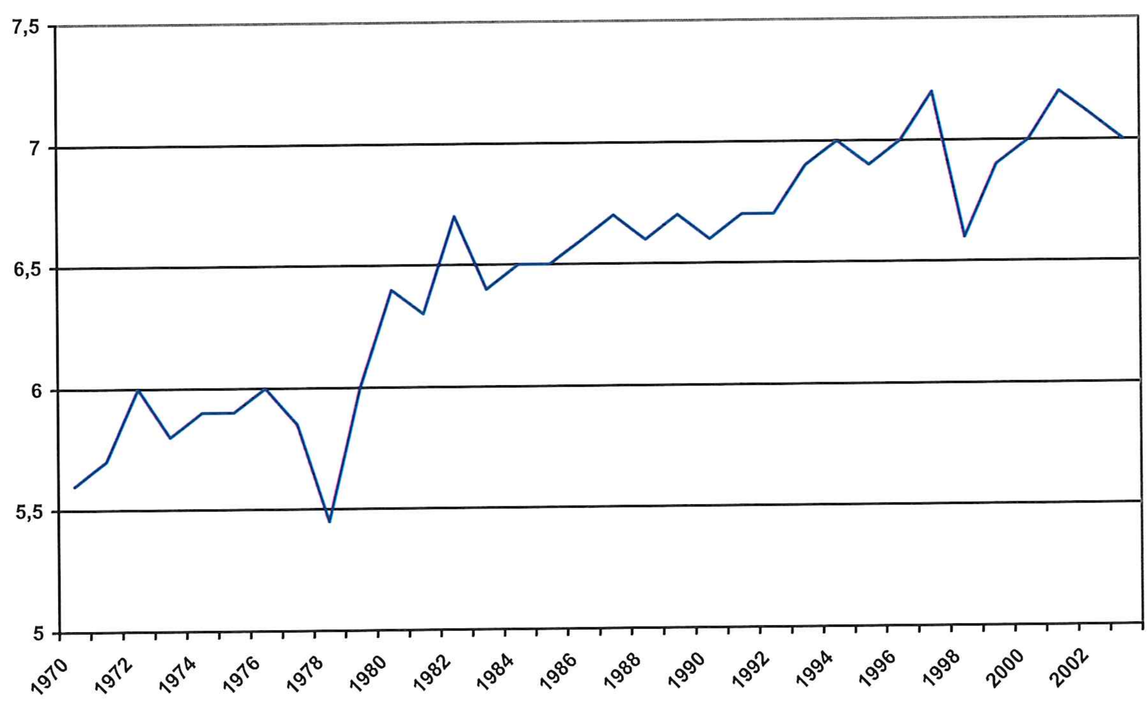

Figure 3A: Alfalfa Yield in California (tons)

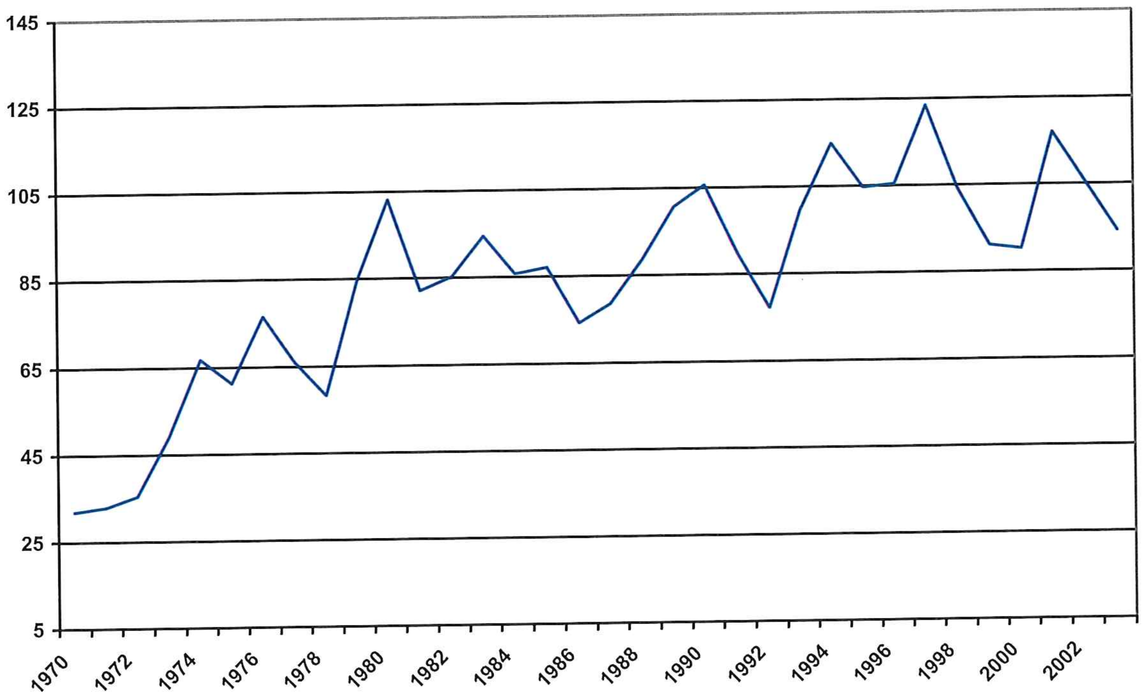

Figure 4A: Alfalfa Nominal Grower Price in California (12 month average)

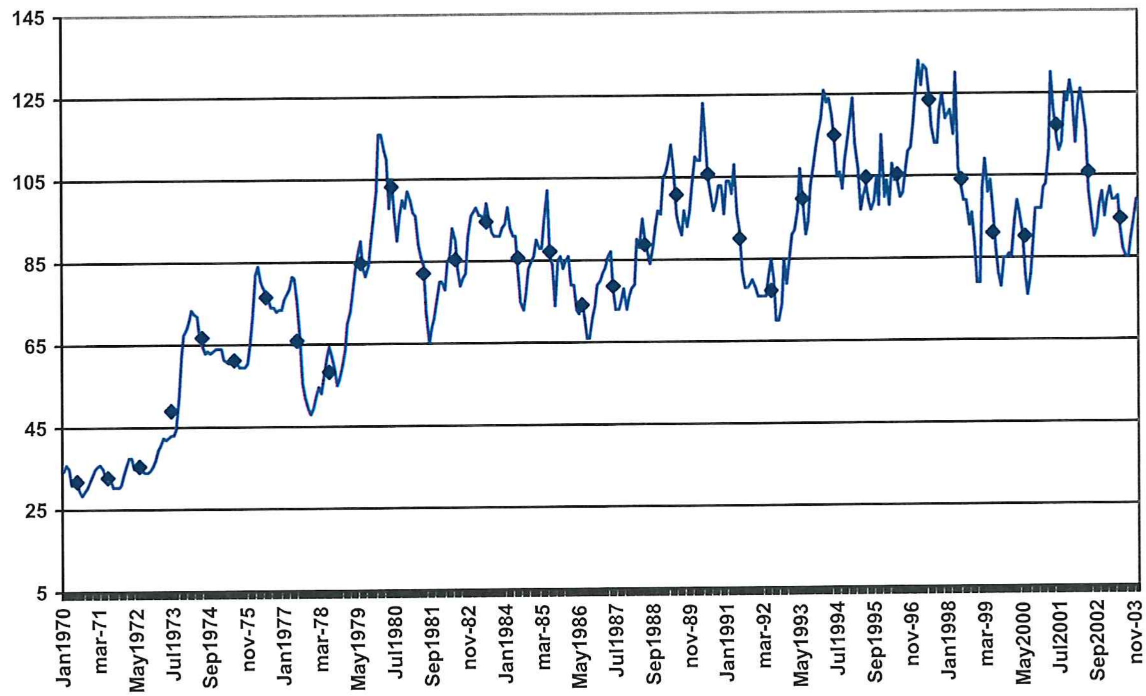

Figure 5A: Alfalfa Nominal Grower Price (Monthly- dollars per ton)

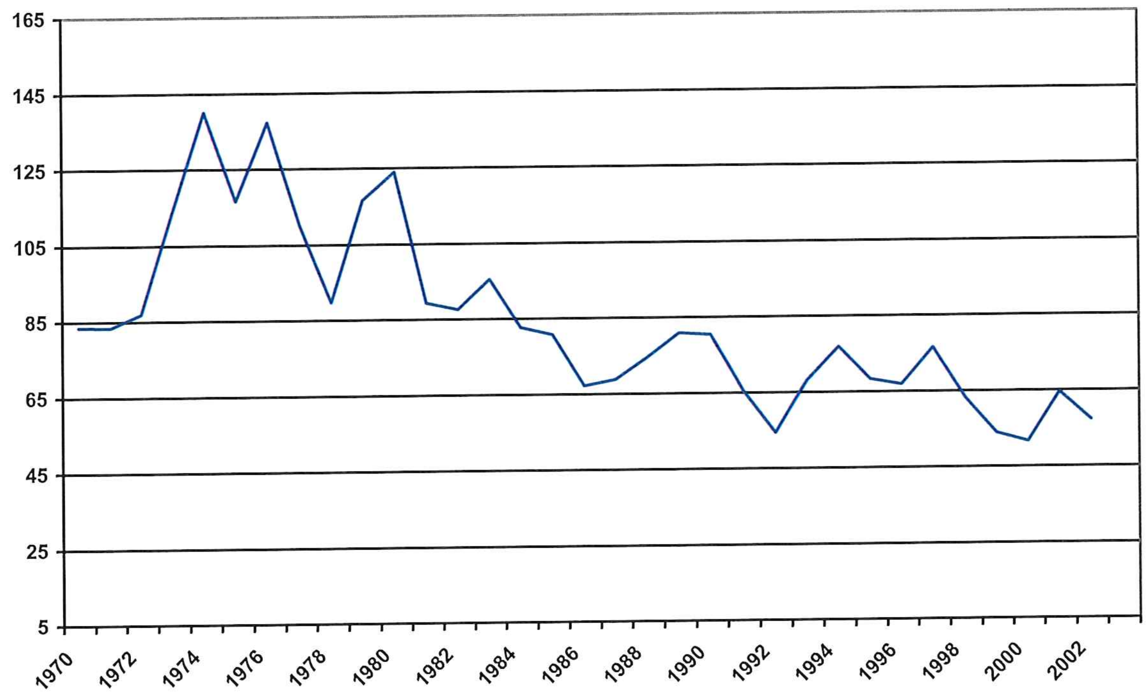

Figure 6A: Alfalfa Real Grower Price in California (12 month average, dollars per tons – base 1983/4)

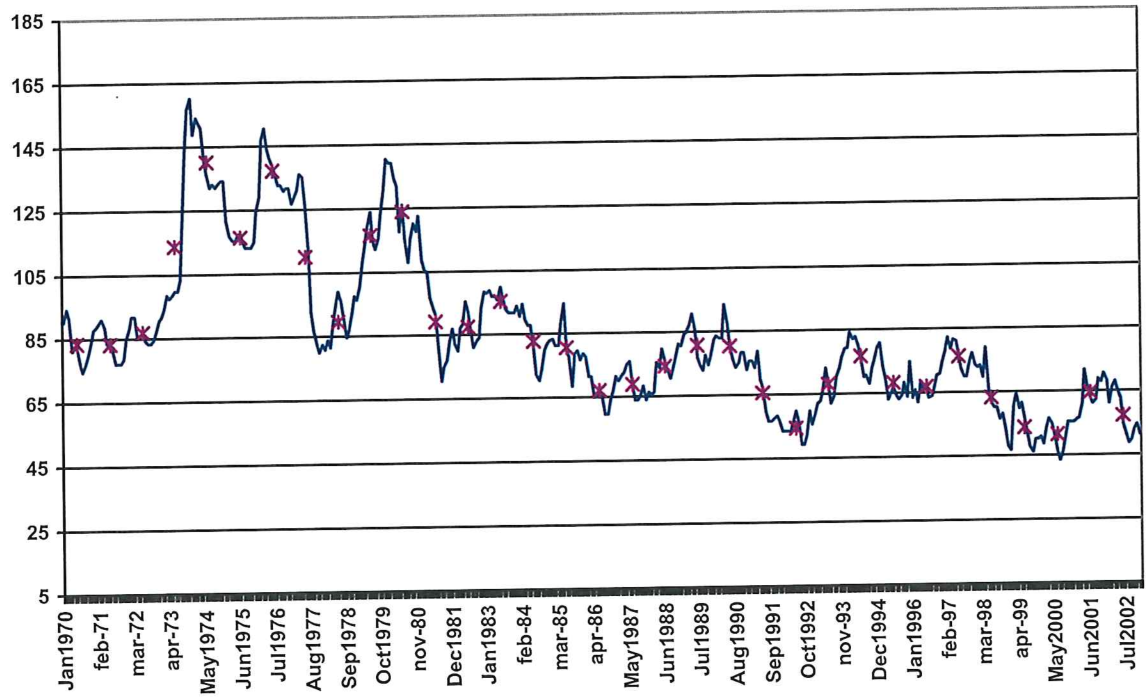

Figure 7A: Alfalfa Real Grower Price in California (monthly, dollars per tons– base 1983/4)

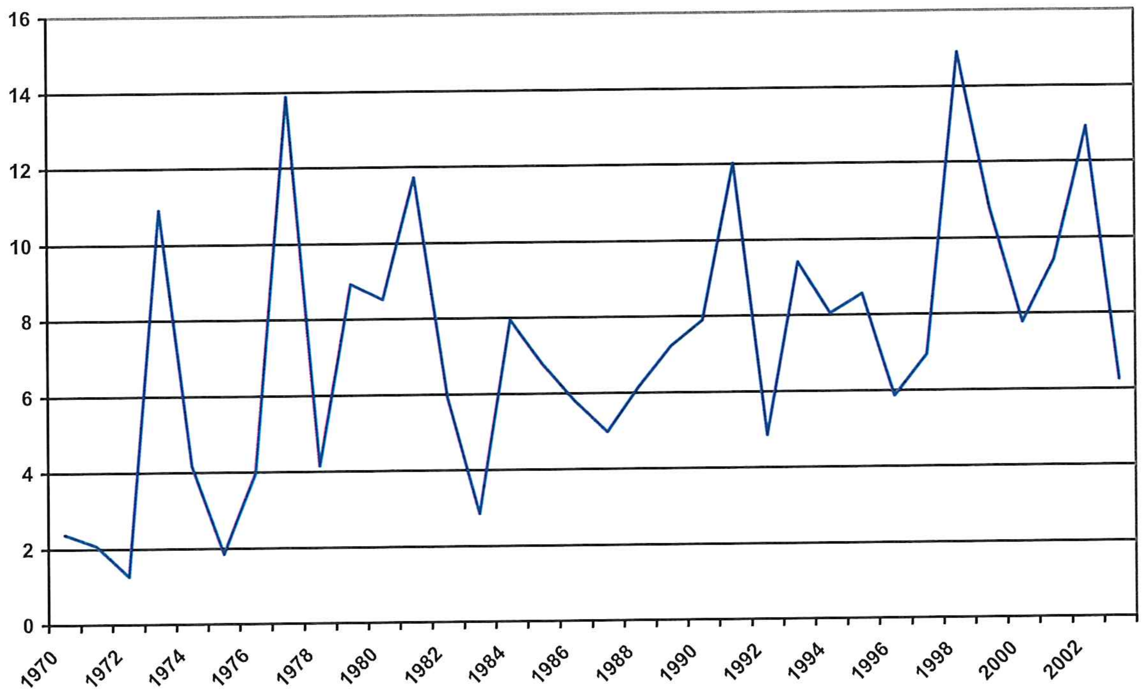

Figure 8A: Standard Deviation of Monthly Alfalfa Price (Nominal, $/month).