University of Wisconsin-Madison
Department of Agricultural & Applied Economics

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Cranberry Price Forecasting

By

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Cranberry Price Forecasting

Ed Jesse[1]

In 2000, rapidly-falling grower prices for cranberries led the cranberry industry to seriously consider invoking its federal marketing order for the first time since the early 1970s. The Cranberry Marketing Order permits volume control through producer allotments (grower delivery quotas) or handler withholding (processor set-asides).

Possible deployment of volume controls motivated interest in the probable price effects, in particular, what level of production (given inventories and projected imports) would yield an acceptable grower price. As the public member of the Cranberry Marketing Committee and as the Committee's ad hoc staff economist, I agreed to develop a price forecasting model to shed light on this question.

Forecasting grower cranberry prices proved challenging because of the rapid changes in demand that occurred beginning in the mid 1970's. Prior to then, cranberries had been consumed primarily as fresh fruit and cranberry sauce. Cranberry "cocktail" (heavily diluted sweetened cranberry juice) had been marketed since the 1950s, but consumption was small. The introduction of blended juices containing cranberry in the 1970s stimulated demand markedly. Later, research demonstrating the benefits of cranberry in preventing urinary tract infection yielded even larger demand shifts.

A scatter plot of season average grower prices against seasonal supply of cranberries (beginning inventory plus production plus foreign acquisitions) illustrates a problem for the price analyst. The 1954-2002 time period shows no apparent relationship between price and quantity. In fact, a simple linear regression yields a positive (though insignificant) slope coefficient.

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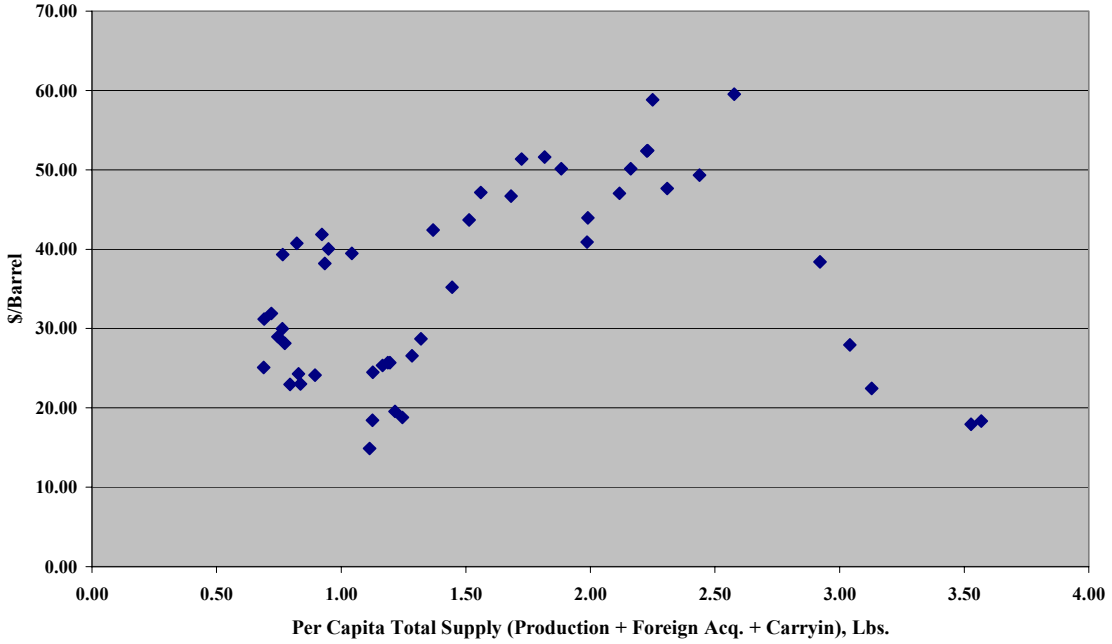
Scatter Plot - Deflated Season Average Price versus Total Available Supply, 1954-2002

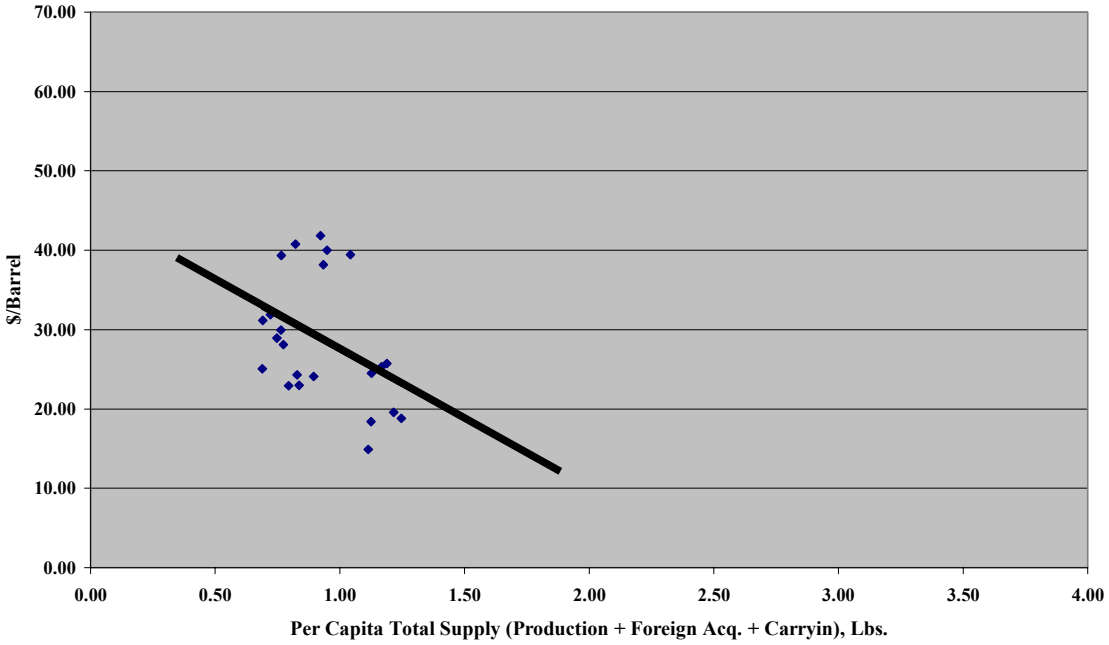


Segmenting time periods tells a different and more encouraging story. The period 1954-76, before the cranberry juice boom began, shows a fairly tight scatter plot and indicates a normal negative relationship between grower prices and total cranberry supply. Likewise, the price-quantity relationship since 1991 appears even more stable and predictable — an indication that cranberry demand may have stabilized.

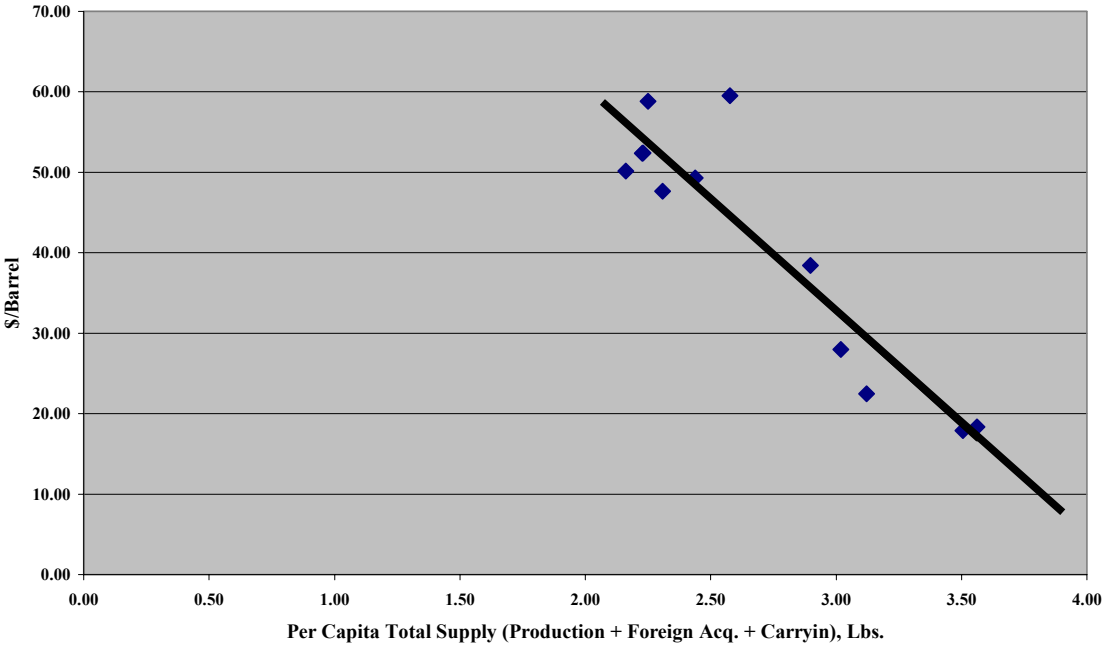
When isolated, the period, 1977-90, is clearly responsible for the apparent anomalous positive relationship between price and quantity. During this time, demand was increasing faster than supply, leading to price increases despite large year-to-year increases in production.

Reconfiguring the scatter plot to focus on the 1954-76 and 1991-2002 time periods shows clear similarities and emphasizes the shift in demand. It suggests that the observations from the two periods may be combined in a price forecasting model under the assumption that farm-level cranberry demand shifted between the periods but was the same during the periods. The assumption of consistency across the two time periods was critical when the price forecasting model was first developed (1999), since only eight post 1990 observations on season average cranberry price were available.

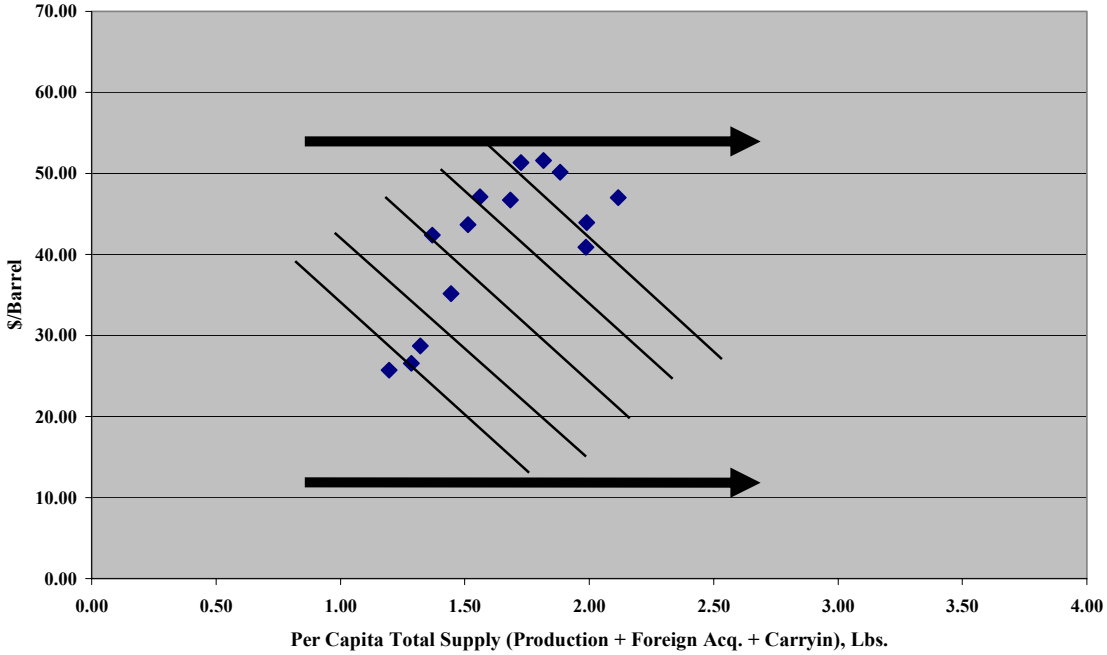
Scatter Plot - Deflated Season Average Price versus Total Available Supply, 1954-76



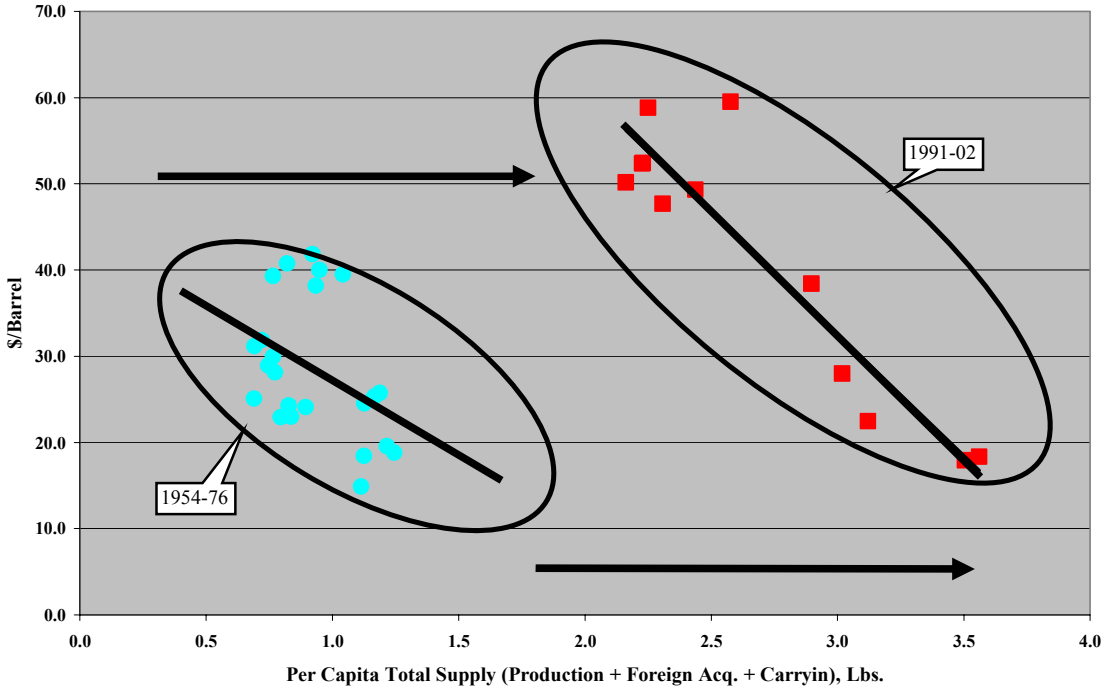
Scatter Plot - Deflated Season Average Price versus Total Available Supply, 1991-02



Scatter Plot - Deflated Season Average Price versus Total Available Supply
1977-1990



Deflated Season Average Price versus Total Available Supply



Experimentation with various specifications using an intercept shifter, a slope shifter, and both demonstrated that the shift in demand can best be captured using a slope shifter. This may seem surprising given the appearance of the scatter plots. But the shift in demand between the two periods is picked up in large part by changes in income.

The formulation ultimately selected for the split series price forecasting model was:

$P_t = f(P_{t-1}, \text{PC-Supply}_t, \text{PC-DispInc}_t, \text{SlopeDum}_t);$

Where:

$P_t =$ U.S. season average grower price per barrel (100 lbs.) for cranberries as reported by the National Agricultural Statistics Service deflated using the Index of Prices Received by Farmers, all Commodities, 1990-92=100.

$P_{t-1} =$ Lagged deflated season average cranberry price

$\text{PC-Supply}_t =$ Per capita cranberry supply defined as the sum of current year production, beginning inventory (all forms), and foreign acquisition of cranberries by U.S. handlers divided by U.S. total mid-year population.

$\text{PC-DispInc}_t =$ Per capita U.S. disposable personal income deflated using the CPI-U, 1882-84 = 100.

$\text{SlopeDum}_t =$ Dummy slope shifter variable equal to 0 for 1954-76 observations and PC-Supply for 1991-2002 observations.

This is a fairly conventional price forecasting specification that essentially estimates a demand relationship assuming supply is exogenously determined. This assumption is plausible in light of the 3-5 year lag between planting of cranberries and first commercial harvest. That is, there is no contemporaneous relationship between quantity supplied and price.

Including lagged price assumes that prices are "sticky:" that the total change in price in response to a change in supply occurs over two years rather than in the same year the supply change occurs. A lagged price response is common in commodity markets where stocks are important.

The model was estimated by ordinary least squares, initially over the discontinuous period 1954-76 and 1991-1999. Parameter estimates were updated annually as new data became available. Goodness of fit and parameter values are shown below for the initial (1954-99) and most current (1954-2002) estimates.

Split series Specification				
Statistic	***1954-99***	***1954-02***		
Multiple R	0.962	0.954		
R2	0.926	0.910		
Adjusted R2	0.915	0.898		
Standard Error	3.701	4.023		
Observations	32	35		
	1954-99		***1954-02***	
Coefficient	*Value*	*t Stat*	*Value*	*t Stat*
Intercept	17.876	3.301	13.309	2.514
Lagged Price	0.567	7.715	0.705	7.522
PC Supply	-45.895	-7.526	-49.856	-8.261
PC Disp. Income	4.548	5.546	5.075	6.220
Slope Shifter	22.611	6.802	22.405	6.891

All coefficients possess the a priori expected signs and are significant at high levels of confidence. The initial estimate gives a slightly higher R^2 and a slightly smaller standard error of estimate.

In 2003, an alternative specification was estimated limited to the 1991-2002 period. The advantage of the single period model is in confining the analysis to a more recent time period and, hence, lending more confidence that the relationship is stable. The disadvantage is in the limited number of observations, which results in a higher standard error of forecast.

The 1991-2002 model includes lagged price and per capita total supply defined in the same manner as in the split series model. Income proved to be insignificant. The regression results are noted below.

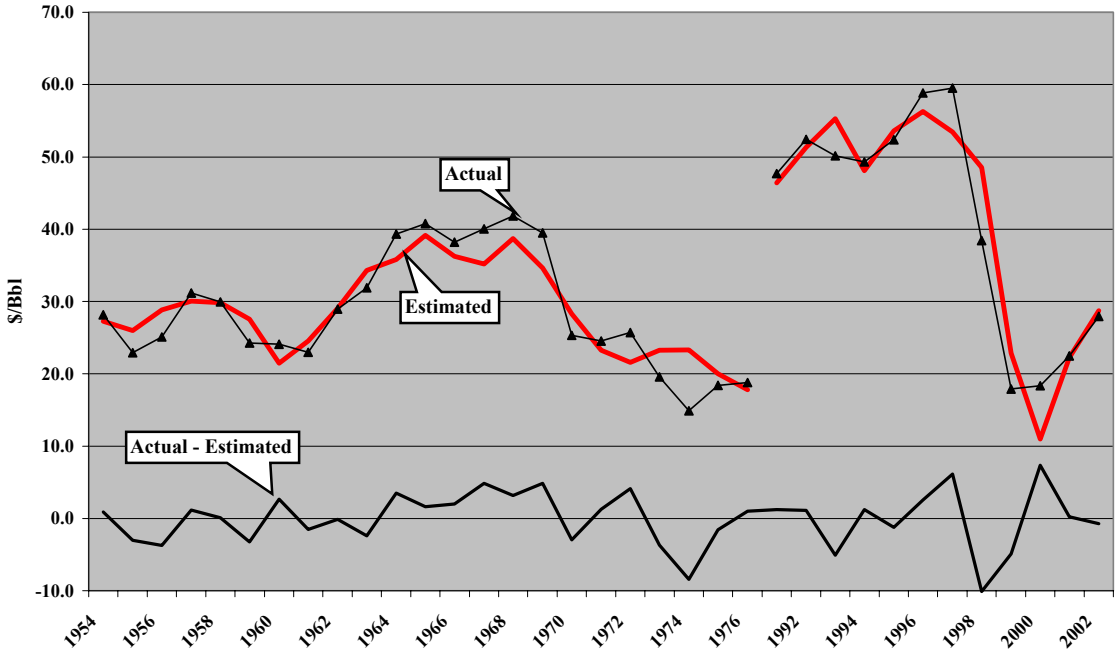
Regression Statistics—1991-2002 Specification	
Multiple R	0.958
R Square	0.918
Adjusted R Square	0.900
Standard Error	4.935
Observations	12

	Coefficients	*Standard Error*	*t Stat*
Intercept	82.759	15.048	5.500
Lagged Price	0.352	0.134	2.622
PC Supply	-20.932	3.893	-5.376

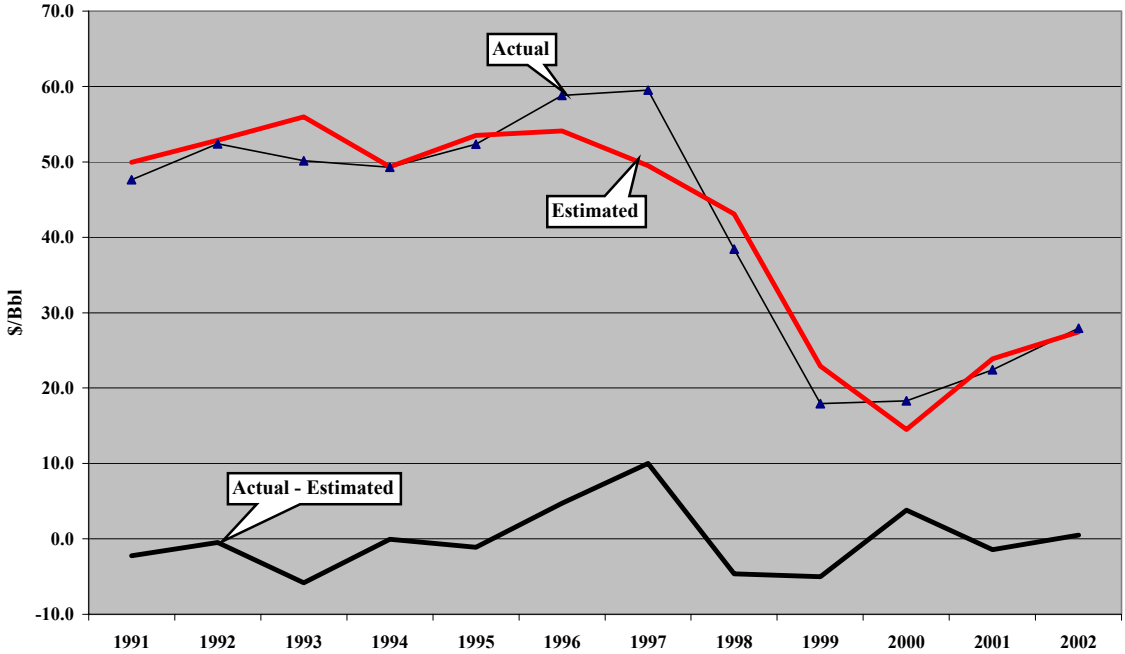
The goodness of fit for the 1991-2002 specification is nearly identical to the split series specification for 1954-2002. The coefficients are of expected sign and significant.

A comparison of actual prices with model estimates is shown in the following charts. Both models yielded very close estimates of actual prices in the last two years, but both underestimated the 2000 price — the split series model by $7.40 per barrel. The split series model overestimated the 1998 crop price by $10, indicating poor performance of the lagged price formulation when prices change dramatically (price fell by $21 per barrel between 1997 and 1998). Both models grossly underestimated the season average grower price for 1997. Grower prices in 1997 were much higher than could be justified on the basis of the historical relationship between supply and price. The market was clearly "overheated" from a scramble by some processors to secure enough fruit to meet sales commitments in the face of a short crop.

Split Series Cranberry Price Forecasting Model:
Actual versus Estimated Prices



1991-02 Cranberry Price Forecasting Model:
Actual versus Estimated Prices



The two price forecasting equations were used to derive a range of price estimates for the 2003 crop year for a range of total available supply. The resulting relationships are shown in the chart below. To construct the chart, deflated per capita disposable personal income was fixed at $15,000, which assumes no real (adjusted for inflation) growth in income from 2002. Total available supply (converted from per-capita pounds to barrels using projected mid-year 2003 U.S. population of 290 million) is ranged on the horizontal axis of the chart, and resulting price forecasts are on the vertical axis.

The price forecasts are subject to considerable forecast error[2], and should be viewed as only rough indicators of what prices might result from varying levels of total available supply in 2003. Nevertheless, the chart is valuable in demonstrating what prices are likely at various levels of total supply[3].

As an example, consider the likely season average price associated with the February 2003 Cranberry Marketing Committee (CMC) forecasts made as part the Cranberry Marketing Order Marketing Policy Statement. The CMC placed beginning (September 1, 2003) inventory at 2.5 million barrels, domestic production at 6.156 million barrels, and foreign supplies at 975,000 barrels. Shrink was estimated at 335,000 barrels, leaving total available supply at 9,296 barrels. The chart indicates this level of total supply would yield a season average price in the $24-26 per barrel range.

The chart can also be used to approximate what level of supply would be necessary to achieve specific price levels using volume regulation. For example, if growers are seeking a $40.00/bbl price for the 2003 crop year, then the chart shows that total available supply should be in the 7-8 million barrel range.

Another use of the model is to specify the industry level of production that would maximize total grower returns. Price flexibility/demand elasticity equal to -1.0 occurs at total supply of about 6.4 million barrels. Given the CMC estimates of 2003 foreign acquisitions and beginning inventory, domestic production would need to be cut to less than 3 million barrels to maximize industry profit. This would yield grower price of $47-50 per barrel.

One caveat regarding reported prices versus prices actually received by growers: The regression equation uses the U.S. season average grower prices reported by the National Agricultural Statistics Service (NASS), U.S. Department of Agriculture. The NASS price is an estimate based on a survey of cranberry handlers, and is reported before handler pools have closed. Hence, it is a "before the fact" estimate, and may not accurately represent growers' actual prices. To the extent that NASS prices are believed

[2] The standard error of forecast in this case ranges from about 110% to 220% of the standard error of estimate ($4.02/bbl for the split series model and $4.94/bbl for the 1991-02 model) over the range of total available supply shown in the chart.

[3] The forecast prices are deflated, but since the deflator (index of prices received by farmers for all commodities) will likely be very close to 100 in 2003, the nominal and real values for price are roughly equivalent.

to overstate industry average returns per barrel, the expected difference should be subtracted from the prices shown on the chart.