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Hay Price Forecasts at the State Level

by

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Practitioner's Abstract

Higher prices for major crops (e.g., corn, soybeans and wheat) have received considerable attention by analysts, researchers, and producers. A common perception is that acres can be readily bid away from other crops to quickly return to equilibrium price levels. Seldom mentioned are crops that do not trade on a national platform. Principal among these crops probably would be hay from alfalfa and grass. A balance sheet model is developed at the state level for South Dakota. As a state with typically large carryover stocks of hay and multiple markets served, South Dakota presents a stark contrast to states with more stable production, supply, and use. Several structural relations and equations are presented to forecast acres, supply, and price through an inverse demand function. A discussion follows on how to update the price forecast as additional information is obtained. Suggestions are also offered on extending the model to other states.

Key Words: alfalfa price, feed demand, perennial crop, hay stocks

Introduction

In May of 2007 the national price for alfalfa hay, from National Agricultural Statistics Service (NASS), reached an all-time high level of $145 per ton. Acreage changes at the state level can be substantial enough to affect local prices (and thus returns from producing alfalfa and other crops). However, the acreage response to price changes among alfalfa and competing crops is not well understood. While some national models acknowledge alfalfa and other hay, prices tend to be established at relatively local levels.

The objective of this study is to develop a state level model of hay prices for the purpose of forecasting prices within and across marketing years. Without a better understanding of local hay prices producers may unknowingly abandon a profitable crop choice and buyers may incur additional expenses using inefficient sources of hay. As a perennial crop, hay presents challenges as it requires relatively more advanced planning to seed and establish compared to annual crops.

The modeling effort will focus on South Dakota, which tends to be a hay surplus area. Acreage can easily be brought out of production, but reestablishing acres historically results in a lag in production growth. Preliminary modeling efforts focusing on supply suggested ending stocks and current yield predict price at an overall level. Balance sheet analysis suggests that prices and consumption patterns during the year affect price levels by the end of the marketing year.

In several states growing dairies and feedlots buy larger volumes of hay than their smaller predecessors. Several dairies in eastern South Dakota are continuously in the market for hay. They have stated quality preferences and are not located near a major auction site. Ad-hoc calls for and methods to source hay during droughts or because of quality shocks continue unabated.

Various parties now take for granted that Conservation Reserve Program (CRP) acres will re-enter crop production at the end of current contract periods. However, not all CRP acres are prime cropland and could be used as hayland or pasture. There is also general uncertainty on the logistics of biomass fuels. Knowing more about merchandising an existing crop (e.g., alfalfa hay) would lead to better understanding of how a biomass crop could be procured.

As the general price level has increased various examples of unscrupulous dealings have also emerged. The sharp increase in prices also suggests tighter stocks at a given state level. As hay sellers emerge or grow they cannot afford to maintain high stocks with eroding quality. They will ship supply regularly suggesting more interstate movement over time. Thus the need to understand price behavior exists.

The paper begins with a literature review which includes additional justification for the modeling efforts. Then, an overview of national modeling efforts is presented to set the stage for local modeling. For South Dakota annual models of acreage and inverse demand are presented, followed by models of fall and winter disappearance. A method to update the forecast model is given. The result is a state-level model of the overall price level with adjustments to model prices within a given marketing year. Finally, potential extensions, modifications and adjustments are suggested to adapt the procedure to other states.

Literature Review

Earlier modeling efforts provide insights into building a state-level model. Blank, Orloff, and Putnam (2001) model how producers can adjust production within a crop year to realize increased returns. Konyar and Knapp (1990) model demand as a function of alfalfa, feed, and livestock prices and of animal inventories. They model acreage response as a function of lagged acres and production costs. Blake and Clevenger (1984) model supply based on lagged acres and production trends. They model demand as a function of corn prices and a trend. With few existing studies to work from, the full extent of market inefficiencies is difficult to assess related to hay prices.

Common merchandising methods are discussed in Miller (1986). There has been renewed interest in direct selling methods and most-recently single source auctions, where a large hay producer chooses an auction setting to sell hay at the origination point. Numerous popular press stories have documented the popularity and growth of hay auctions in Sauk Centre, Minnesota and Rock Valley, Iowa. Several authors suggest that auctions are increasing in scope and volume. The most recent strain of literature is on hedonic modeling of quality attributes (Hopper, J.A., H.H. Peterson, and R.O. Burton, 2004; Rudstrom, 2004). Quality characteristics have value, but planning to supply different market segments would be facilitated by a sound understanding of the underlying price level.

At the farm level, better knowledge of price behavior would improve production and procurement decisions. Several alfalfa studies have focused on different production and policy concerns. As a perennial crop a longer-run outlook of prices is essential for planning purposes. The perennial nature also means substantial lagged effects or trends are likely in acreage. Once the basic relationships are understood more advance risk management strategies, e.g., Blake and Catlett (1984), can be further developed.

Disaster mitigation is a large cost of not knowing price levels in advance. During a drought or similar natural disaster it becomes expensive to source hay as normal distribution patterns become disrupted. Le Roy and Klein (2003) discuss a specific example of both the price disruption and inefficient responses by policymakers. Various hay lists are generated by public and private sectors, there are calls for feed donations, and various subsidy measures are implemented.

National Models

An early study by Dismukes and Zepp (1996) covers a regional breakdown of supply and use, an overview of production problems, and documentation of the extent of disaster payments and crop insurance tied to forage. NASS data are available for hay. Acres are reported in March (*Prospective Plantings*), in June (*Acreage*) broken out by alfalfa and other hay, and in August, October and January (annual) (*Crop Production*) again broken out by type. Production is reported by type in August, October, and January (annual), while stocks are reported in January and May. Marketings are reported (for all hay) in August (*Agricultural Prices*).

U.S. producers harvested 61.6 million acres of hay in 2007. The value of all hay production in 2007 was $17 billion, behind only corn ($52 billion) and soybeans ($27 billion). Hay typically ranks third in terms of acres and value among crops. Recent *Census of Agriculture* figures show that less than 20 percent of farms producing hay also sold hay and ERS figures projected only $4.7 billion in sales revenue. In 2008 NASS projects producers will harvest 60.6 million acres of all hay.

NASS reports monthly prices for 27 states. The marketing year average prices (most recently the preliminary prices for 2007) are available for the continental U.S. The trends in the U.S. and South Dakota follow a similar pattern with South Dakota having more relative variability (figure 1). Prices vary substantially across the U.S. and clear regional price pockets are evident over time. National price changes carry over to individual states. In recent years transportation costs have increased the price spread among locations. Spot prices are available in National Hay, Feed & Seed Weekly Summary, Livestock, Hay, & Grain Market News, USDA, Moses Lake, WA.

Economic Research Service (ERS) routinely presents the national situation, but only from a historic perspective. Commentary and charts are provided in various editions of *Feed Outlook* and *Feed Yearbook*. ERS reports RCAU - roughage consuming animal units - as a proxy for demand. Background on RCAU is also available in Baker (1998). ERS updates *Yearbook* tables that contain annual alfalfa production, other hay production, harvested acreage, yield, May 1 stocks, December 1 stocks, supply per RCAU, and disappearance per RCAU. They have a separate table with monthly U.S. prices from NASS. Most notable, however, is the absence of hay and forages in the baseline projections.

Livestock Marketing Information Center (LMIC) maintains a balance sheet similar to (or based off of) the ERS balance sheet (table 4.110 All Hay Supply and Demand Balance Sheet). The

LMIC staff includes projections for the current marketing year presumably based on trend acres, yields, and disappearance. Then, as firm estimates (from NASS) become available the balance sheet projections are updated.

FAPRI has long-run projections and a local disclaimer that "Hay markets are more fragmented than markets for most other agricultural commodities, so trends in national average prices may not reflect local conditions." (FAPRI-MU, page 20). FAPRI models harvested area, yield, production, disappearance, ending stocks, all-hay prices, and alfalfa prices out for ten years. A slight trend in yield growth leads to a projected increase in production and use over time with hay prices leveling off in a few years. Harvested area is projected to fluctuate slightly around 61 million acres annually. FARPI also models land use which includes CRP stabilizing at just less than 30.0 million acres annually from the 34.5 million acres in 2008.

Various demand segments include: dairy cattle, cow-calf operations, beef feedlots, sheep, equine processing and exports. Supply shocks are weather related with dry conditions affecting quantity (yield), wet conditions affecting quality (rained-on hay) and poor winter conditions causing winter kill. Acreage will likely continue to be pressured by returns to other crops and land in CRP.

South Dakota Situation

Preliminary modeling in South Dakota focused on explaining the August price as a function of supply and a trend. A model of price as a function of current yield had slightly better explanatory power, but is more difficult to forecast. Price changes within a marketing year are largely in response to deviations from expected yield. Yield in South Dakota does not have a strong trend, but substantial weather-induced variation is present (figure 2). A model with the August U.S. price (in place of trend) had better explanatory power, but is also difficult to forecast.

Production risk is high in South Dakota. A recent balance sheet of hay production, supply, stocks and prices is available (table 1). The coefficient of variation of production (ration of production variance to average production) is the highest in South Dakota of all states. South Dakota also has relatively high stocks of hay compared to many states. Thus South Dakota is a residual supplier. However, many stocks are maintained by beef operations as a drought-mitigation strategy. The cost of maintaining excess stocks is perceived to be less than the cost to liquidate, forego revenue, and rebuild a cattle operation.

Blake and Clevenger (1984) model New Mexico hay acres, production and inverse demand. Production is modeled based on lagged production and price is modeled as a function of production and corn prices. Bazen et al. (2008) model Tennessee hay acres, yield, and inverse demand. Steady yield increases are present and they find low acreage response to price changes. Skaggs et al. (1999) look at the relative alfalfa supply and reasonable shipments to expect under a changing policy scenario. Ward, Kariuki, and Huhnke (1998) examined the national production and consumption patterns and identify South Dakota as a leading hay surplus state.

Hay is produced and used throughout South Dakota. Alfalfa, alfalfa/grass mix and grass stands are commonly harvested. Beef cattle operations are the largest use category within South Dakota. Outshipments are probably the second largest use category (with various end destinations and uses). Hay farmers (those selling a large portion of their production) are scattered throughout the state with notable pockets in Clay and Yankton counties in the southeast corner of South Dakota. Dairy operations are probably the third largest use category and are predominantly in the eastern third of the state. There are pockets of irrigation throughout the state.

Conceptually, demand is a function of livestock inventories and the price of substitutes such as corn and grazing fees. Dairy and on-feed inventories are stable over time suggesting constant demand. During production shocks (such as drought years) there tends to be early weaning of calves and some liquidation of herds. Often such lower demand is offset by higher demand by feedlots.

Ultimately, an inverse demand model would be available to use to forecast the price of hay in August. Ideally, the forecast model would be available at any point during the year. The earliest feasible time would be in the winter when planting decisions are made for the following year that would involve changing hay acres. Waiting until winter also lets producers incorporate some usage (or demand) effects from the prior year. Initially, a model is designed to be implemented or used in January following the final production estimates and ending stocks releases for the prior year.

Strong inverse relationships exist between stocks and prices in South Dakota. Seasonal use or disappearance is also evident. Fall use is highly variable and has been negative in an extreme drought situation, i.e., hay was brought into South Dakota (figure 3). Historically high December stocks are associated with low prices (figure 4). Winter use is relatively more consistent as in-state feed use dominates disappearance (figure 5). May stocks and prices also have in inverse relationship (figure 6).

Model Specification

Supply is expected to be more relevant at explaining price compared to just using yield. Given the nature of production and marketing of hay in South Dakota a model is developed that uses total supply for the coming marketing year to explain price. Expected supply in year t (QS_t) is a function of expected acres (A_t) times trend yield (Y_t) plus May 1 stocks (M_t):

(1) Supply $QS_t = A_t * Y_t + M_t$.

Acres for the current year are a function of the acres harvested in the prior year and an allowance for the price level in December (P^{Dec}) to be estimated as:

(2) Acres $A_t = f_1(A_{t-1}, P^{Dec}) + e_{1t}$.

Yield fluctuates widely in response to acreage mix, weather conditions, and the distribution of acres within the state. Y_t is thus expected to equal the moving ten-year average. May 1 stocks are assumed known, but could be forecasted as discussed below. Using expected or known values of Y_t and M_t and estimated values for (2) allow the derivation of (1).

Demand is expected to depend on the price of hay in South Dakota and the price of hay in the United States. As the general hay price changes it reflects national demand that may differ substantially from conditions within South Dakota. Demand (QD_t) could thus be stated as a function of the August price (P_t) and the U.S. price (P^{US}). However, realizing $QD_t = QS_t$, the inverse demand can be specified as:

(3) Price $P_t = f_2(QS_t, P^{US}) + e_{2t}$.

P_t is an inverse demand function in reduced form.

Equations (2) and (3) can then be estimated. To forecast using (2) is straightforward as the necessary variables are available in January of a given year. To use (3) to forecast requires estimates of P^{US} and M_t which may or may not be available in January.

Use and stocks relationships are also specified for use as inputs into the other forecasts or on their own as point forecasts for prices at other times of the year. December 1 stocks (D_t) are related to supply in a given year less any fall disappearance or use (F_t):

(4) Dec stocks $D_t = QS_t - F_t$.

Fall use is dependant on supply from production and old stocks, with a large remainder amount expected to meet the winter feed needs. Fall use is defined as:

(5) Fall use $F_t = f_4(QS_t) + e_{4t}$.

Similarly, winter disappearance largely depends on feed use. As livestock inventory levels are fairly stable there would be reasonable levels of winter use with a tendency to have some final inventory of feed available at the end of the marketing year.

May 1 stocks are defined as the difference of December 1 stocks from the prior year and winter use (W_t):

(6) May stocks $M_t = D_{t-1} – W_t$.

To determine M_t, a forecast of winter use is needed. Winter use is expected to depend on December 1 stocks with some remaining stocks expected. Winter use is thus specified as:

(7) Winter use $W_t = f_3(D_{t-1}) + e_{3t}$.

Once estimated, equations (5) and (7) can be used to determine (4) and (6). Most necessary is the forecast of winter use to give an estimate of May stocks and ultimately supply.

Data and Estimation Results

All of the data used are from NASS (Table 2). *Crop Production* reports (or their electronic final adjusted equivalents) are the source for yield, stocks, final acres and final production. Acres used as the dependent variable in equation (2) are from *Acreage* reports. Equilibrium supply was computed as actual May 1 stocks plus final production. Fall and winter use were derived from stocks and supply. The August U.S., August South Dakota and December South Dakota prices are all hay prices from the *Agricultural Prices* report (or equivalents). The estimation occurs over slightly different time spans as denoted below.

Current year acres for June were estimated on actual acres from the prior year and the December South Dakota hay price from the prior year. In (8) the constant is significant at the 0.05 level and suggests a base amount of acres would be expected in South Dakota. In addition, the lagged actual yield has a positive effect on acres reported in June of the current year. The coefficient is also significant at the 0.05 level. The December price also has a positive effect on acres. The coefficient is significant at the 0.10 level. The model was estimated from 1976 through 2007. June acreage figures prior to that were not released until July. The model does not have substantial explanatory power, but the coefficients are consistent with theory. The perennial nature of hay suggests carryover use of acres and higher prices during the off-season may encourage increased acres.

(8)	A_t	= 1496	+ 0.58 A_{t-1}	+ 4.55 P^{Dec}
		(640)*	(0.13)*	(2.59)
		R^2 = 0.41	S.E. = 190	n = 32

South Dakota August price was estimated as a function of supply and the U.S. August price in (9). The model was estimated with the supply defined as reported May 1 stocks plus actual production. The model explains a substantial portion of the price. The intercept term is significant at the 0.10 level. The quantity coefficient has a negative sign, consistent with expectations, and is significant at the 0.05 level. The U.S. price coefficient has a positive sign, suggesting that demand from outside South Dakota can increase price. The coefficient is also significant at the 0.05 level.

(9)	P_t	= 28.0	- 0.0026 QS_t	+ 0.81 P_t^{US}
		(15.1)	(0.001)*	(0.13)*
		R^2 = 0.72	S.E. = 8.77	n = 26

One difficulty with the inverse demand specification is uncertainty of the forecast value of the U.S. price. Another specification in (10) with poorer explanatory power substitutes a time trend, T_t, for the U.S. price level. The trend variable started with 1982 as t=1. Equation (10) can be used in place of or until equation (9) is feasible.

(10)	$P_t^{\sim}$	= 69.7	- 0.0032 QS_t	+ 1.25 T_t
		(11.0)*	(0.001)*	(0.24)*
		R^2 = 0.64	S.E. = 9.02	n = 26

The fall and winter use equations have a similar format. Both equations were estimated from 1973 to 2006. Fall use in (11) has a large (negative) intercept, although it was not statistically significant. The coefficient on the supply was positive and significant at the 0.05 level. Overall the model does not explain much of the variation in fall use.

$$(11)\quad F_t = -714 + 0.29\, QS_t$$
$$(787)\qquad (0.09)^*$$
$$R^2 = 0.26 \qquad S.E. = 940 \qquad n = 34$$

The intercept coefficient (not statistically significant) on the winter use in (12) is also negative, but smaller than in the fall use equation. Less feed would normally be necessary at the end of a feeding period compared to the beginning. The December stocks coefficient is positive and significant at the 0.05 level.

$$(12)\quad W_t = -297 + 0.75\, D_{t-1}$$
$$(530)\qquad (0.07)^*$$
$$R^2 = 0.76 \qquad S.E. = 689 \qquad n = 34$$

The primary interest is the winter use forecast that can be used to provide an input, M_t, into the inverse demand equation.

Marketing Year Adjustments

The state-level price can be affected by different factors throughout the marketing year. In spring the stock-out risk is greatest. A long, cold winter or little spring moisture may stress supply. In the summer price depends heavily on yields and acreage adjustments are possible as crops may be abandoned or acres from small grains are converted to hay. Fall brings demand (or lack there-of) from neighboring states that influences disappearance or use. Inflows are also possible, e.g., following the drought of 1976. Marketings are also seasonally large in the fall. Winter brings heavy feed use and another period of heavy marketings.

As of late January, 2008 it was possible to forecast May 1 stocks, acres, yield and thus supply and price for August (table 1). Equation (12) is used to obtain a forecast of May 1 stocks of 2.3 million tons. Equation (8) is used to obtain the forecast of 4.2 million acres (a very large increase from 2007). Trend yield is 1.80 tons per acre. These are combined using equation (1) to obtain a supply forecast of 9.9 million tons. Then by using the trend (instead of U.S. price) model in (10), the August South Dakota price is forecasted at $72 per ton.

As production reports become available, the balance sheet can be updated to improve forecasting accuracy. Each report does have a track record as there can be substantial revisions through the marketing year. The performance at the national level is monitored by NASS in their "Track Records". Released in March, the *Prospective Plantings* report provides intended area harvested as an initial indicator of hay acres and potential supply for a given year. Once observed, the intended acres can be substituted into the QS_t estimation in place of the forecasted acres. The latest such update for South Dakota is the 2008 harvest intentions of 3.5 million acres, substantially below the forecasted acres amount. The track record of changes (following Good and Irwin, 2007), shows the intentions have been below (above) the actual area harvested by as much as 500,000 (700,000) acres. The median change, however, is zero acres. These historic changes place bounds on the supply estimation or serve as qualifiers of the forecast.

June *Acreage* report provides another set of acres estimates, broken down by alfalfa and other hay acres. Using a weighted-average yield estimate does not seem to perform any better than an overall yield. Various supply aspects were examined to see if they explain price variability. Yield, aggregate production, total supply, and supply per head of cattle were examined. The current yield explained the greatest amount of price variability, with an included trend term. August yield estimates can be influenced by small grain yields if some crop is hayed instead of taken for grain. October production revisions are based on yield only. It may include some CRP adjustments.

Given a supply estimate, the fall use model can be used to obtain a forecast of December 1 stocks. The forecast is then used to gauge use relative to expectations, which has proved useful in explaining why price differences have occurred, may continue, or may be "corrected". The historic inverse relation between stocks and price can be used to obtain a price forecast for December. The December $/ton price can be modeled as $82 – 0.0034*D_t$. There is an inverse relationship between stocks and price – which could be considered a year-end aggregate supply curve for hay. Similarly, the May $/ton price can be modeled as $86 – 0.012*M_t$.

Some additional potential adjustments can also be made to the South Dakota forecasts. Such adjustments may also be appropriate for other states. New seedings of alfalfa acres have been available since 1997. Acres could be modeled as a function of lagged supply and could incorporate seeded acres with a 3-year lag to bring in the perennial nature of the crop. All haylage and greenchop are reported for major dairy states and several states were added in 2005 (e.g., South Dakota). The futures price of corn, e.g., the RMA spring crop insurance price, could be introduced as a demand factor. The relative price of alfalfa and corn (per ton) could be incorporated, but probably only in a simultaneous model.

Subjective adjustments could also be made that account for any marketing year behavior linked to weather. Anderson and Brorsen (2005) and Hagedorn et al. (2005) present ways to model the marketing performance using monthly marketing data. In South Dakota producers tend to market 40 percent of the hay crop in the bottom 1/3rd and top 1/3rd of the price range. Finally, crop insurance statistics are available in the fall for acres for the coming year. These could be incorporated into forecasts where insurance usage is meaningful.

Following Konyar and Knapp (1990), it may be reasonable to test for corn, wheat or another competing feedsource. Within a given year there are sometimes indicators of quality and quantity to adjust expectations. Nationally there are range and pasture conditions reported weekly during the grazing period for most states. If combined into an index the conditions could serve as both a supply and demand proxy. Supply from a quantity of forage standpoint and demand as a substitute for poor pastures. Some states have harvest progress and quality ratings on alfalfa.

Summary

A balance sheet model was developed that can be used to forecast the price of hay in South Dakota. Equations that estimate acres, inverse demand, fall use and winter use are used with other relations to complete a balance sheet. The inverse demand and winter use equations explain relatively more variability than the acres and fall use equations. The balance sheet, and ultimately price, can be updated with other information during the marketing year. There are also supporting data sources to potentially refine the forecasts or allow modification for use in other states.

Improved price forecasts can aid both growers and end users in making optimal production and use decisions. Related input suppliers, such as seed dealers would also benefit from increased understanding of supply and prices. Myer, Bhattacharyya and Liu (1998), for example, discuss challenges faced by the alfalfa seed industry.

Finally, as more hay is merchandised advanced risk management tools may be demanded. This is especially a concern given the difficulty with relying on a local market for customers and suppliers. Futures contracts and revenue insurance could both be useful and feasible products to develop for hay.

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Table 1. South Dakota Hay Situation

Year	May 1 Stocks 1,000 tons	Harvested Acreage 1,000 acres	Yield tons / acre	Supply 1,000 tons	August Price $/ton	Dec. 1 Stocks 1,000 tons
1998	2,031	4,000	2.04	10,191	57	9,500
1999	2,000	4,000	2.36	11,440	43	9,500
2000	3,100	4,050	1.83	10,493	52	8,200
2001	1,550	4,700	1.95	10,700	65	8,235
2002	1,900	4,000	1.20	6,700	73	5,800
2003	1,154	4,300	1.68	8,364	58	7,210
2004	1,515	3,900	1.76	8,385	59	6,939
2005	2,100	4,000	1.89	9,660	59	7,935
2006	2,140	3,100	1.35	6,320	77	5,120
2007	1,150	3,800	1.99	8,693	89	7,816
2008	2,254*	4,230*	1.80*	9,868*	72*	

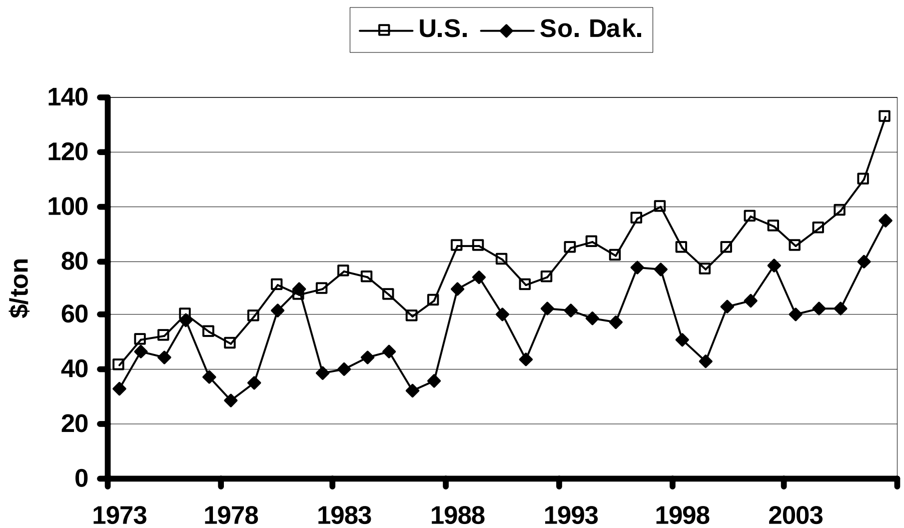
Source: USDA-NASS. Note: * Projected.

Table 2. Variable Definitions and Sample Means

Variable	Description	Mean
QS_t	Quantity Supplied (1,000 tons)	7,682
A_t	Acres – final harvested (1,000 acres)	4,208
P^{Dec}	South Dakota December Price ($/ton)	56
M_t	May 1 Stocks (1,000 tons)	2,085
D_t	December 1 Stocks (1,000 tons)	6,979
Y_t	Yield (tons/acre)	1.74
P^{US}	United States August Price ($/ton)	68
P_t	South Dakota August Price ($/ton)	57
F_t	Fall Use or Disappearance (1,000 tons)	1,891
W_t	Winter Use or Disappearance (1,000 tons)	4,930
T_t	Trend for Year (base is 1982)	

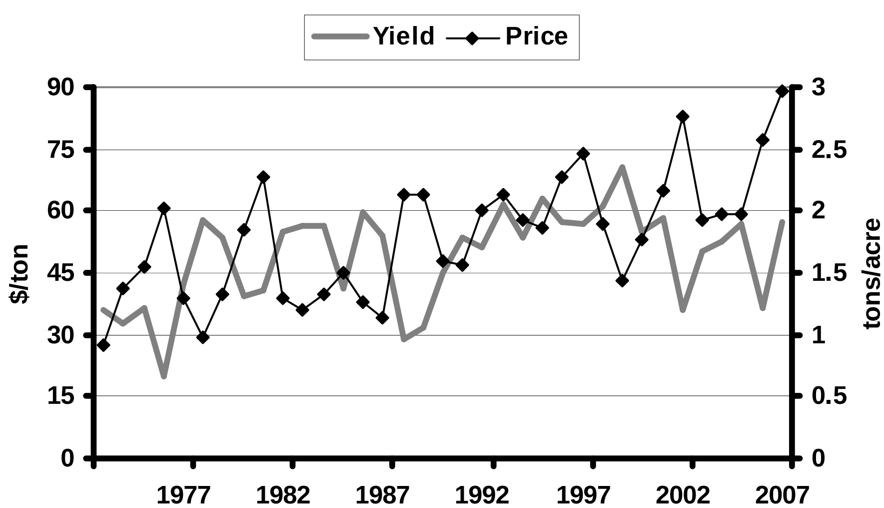
Source: USDA-NASS

Figure 1. Marketing Year Average Price - All Hay



Source: USDA-NASS

Figure 2. South Dakota August Hay Situation



Source: USDA-NASS

Figure 3. South Dakota Fall Hay Use

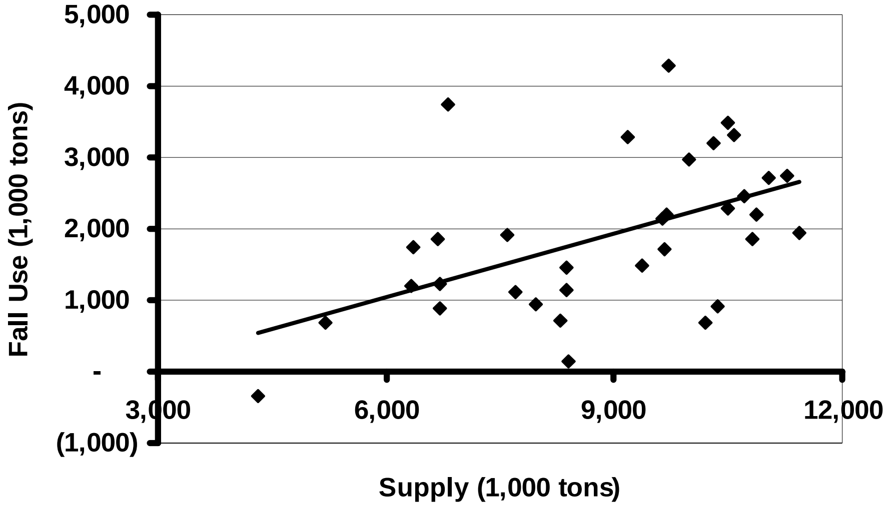
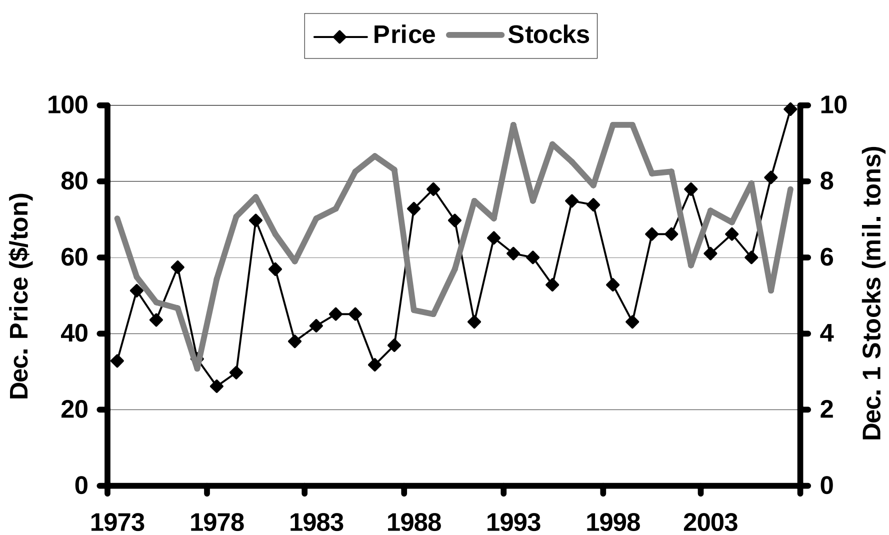


Figure 4. South Dakota December Hay Situation



Source: USDA-NASS

Figure 5. South Dakota Winter Hay Use

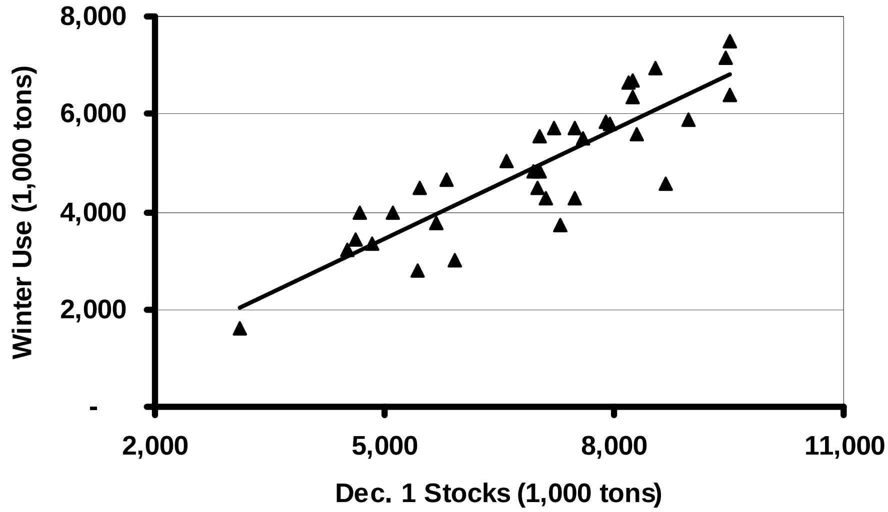
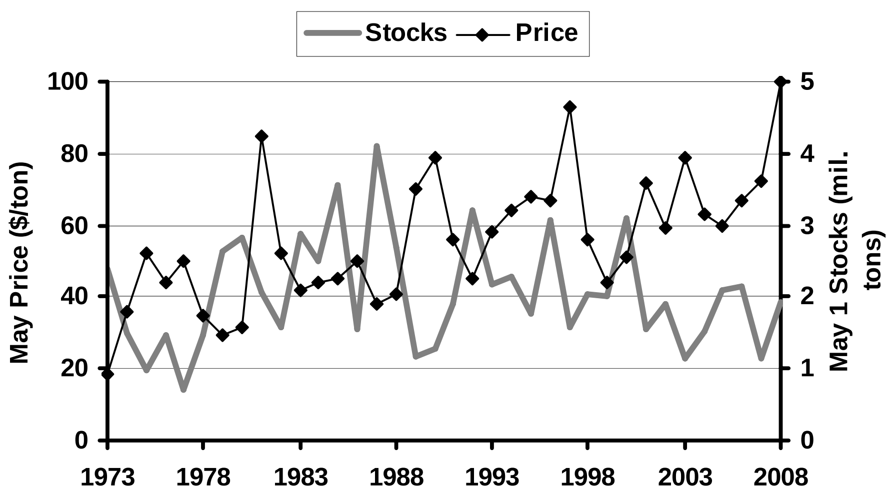


Figure 6. South Dakota May Hay Situation



Source: USDA-NASS