# Agricultural Economics Report

REPORT No. 478 JUNE 1986

# "AN ASSESSMENT OF HAY MARKET INSTITUTIONS, CONDUCT AND PERFORMANCE."



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# AN ASSESSMENT

# of

# HAY MARKET INSTITUTIONS AND COORDINATION FUNCTIONS*

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Agricultural Economics Report Number 478
1986

* Michigan Agricultural Experiment Station
Journal Article Number 11976

This report was written by Jeffrey Miller while a graduate research assistant under the supervision of J.D. Shaffer. Funding for the research came from the Michigan Agricultural Experiment Station Project MC 1173 and a cooperative agreement with the Agricultural Marketing Service of USDA 12-25-A-3007, entitled "Potential Contributions to Orderly Marketing of Agricultural Commodities" represented by Dr. Harold Ricker.

Reviews by Dr. Donald Ricks and Leslie Berger were appreciated.

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## I. INTRODUCTION

Southern Michigan suffered through one of the driest Julys on record in 1984. Yields of second cutting alfalfa were drastically reduced. Prices remained in the $80-100/ton range throughout the autumn. But as winter progressed, prices weakened and it became apparent that there was a surplus of hay. By March, prices for first cutting alfalfa had fallen as low as $30/ton. Farmers had barns filled with unsalable hay.

The experience of Michigan farmers illustrates the dilemma faced by hay growers: while hay production has received a great deal of attention, hay marketing has been neglected. Supplies of high quality hay can be expanded within the span of a single growing season, but the marketing system generates prices which do not always clear the market and which do not serve as accurate signals to guide planning decisions.

More fundamentally, there are no effective market mechanisms to generate those prices, to match buyers and sellers, or to move hay cheaply from surplus to deficit regions. Sorenson (1985) describes the hay marketing system in this way:

> Hay marketing remains almost primitive. It is traded farmer-to-farmer, farmer-to-dealer, or farmer-to-trucker. There is no national market, no uniform quality standards, no countrywide communications network for hay.

Clearly, this is not because hay is a minor crop. From 1981-1983, the U.S. hay crop was valued at over $9 billion annually and was grown on over 59 million acres. By way of comparison, over 61 million acres of wheat were planted, but the value of the crop was about $8.6 billion. Soybeans were also grown on about 61 million acres and were valued at just under $13 billion. These national figures may understate the importance of hay for individual states such as Wisconsin, where hay is a mainstay, if only indirectly, of the state's farm economy. In Michigan, hay is the second largest crop grown on a per acre basis.

### TABLE I. U.S. HAY PRODUCTION, YIELD, DISPOSITION, 7 VALUE, 1969-1983

| Year | Area harvested | Yield per acre | Production | Used on farms where produced | Sold | Season average price per ton received by farmers | Value of production |
|---|---|---|---|---|---|---|---|
| | *1,000 acres* | *Tons* | *1,000 tons* | *1,000 tons* | *1,000 tons* | *Dollars* | *1,000 dollars* |
| 1969 | 60,716 | 2.11 | 128,026 | 102,678 | 23,348 | 24.70 | 2,936,788 |
| 1970 | 61,467 | 2.07 | 126,969 | 102,619 | 24,350 | 26.10 | 3,076,382 |
| 1971 | 61,356 | 2.10 | 129,132 | 104,064 | 25,068 | 25.10 | 3,235,209 |
| 1972 | 59,040 | 2.16 | 128,566 | 102,792 | 25,773 | 31.30 | 3,729,522 |
| 1973 | 61,828 | 2.17 | 134,217 | 107,002 | 27,216 | 41.50 | 5,003,991 |
| 1974 | 60,195 | 2.10 | 126,384 | 100,897 | 25,487 | 50.90 | 5,790,715 |
| 1975 | 61,353 | 2.16 | 132,397 | 106,874 | 26,523 | 52.10 | 6,458,070 |
| 1976 | 60,277 | 1.99 | 120,125 | 94,675 | 25,450 | 60.20 | 6,814,924 |
| 1977 | 60,988 | 2.17 | 132,211 | 106,133 | 27,078 | 53.70 | 6,828,411 |
| 1978 | 62,113 | 2.32 | 143,817 | 115,544 | 28,273 | 49.80 | 6,663,678 |
| 1979 | 61,279 | 2.40 | 147,307 | 118,846 | 29,001 | 50.60 | 7,345,466 |
| 1980 | 58,870 | 2.22 | 130,740 | (2) | (2) | 70.90 | 8,080,646 |
| 1981 | 58,599 | 2.39 | 142,520 | (2) | (2) | 67.30 | 9,181,300 |
| 1982 | 59,812 | 2.50 | 149,241 | (2) | (2) | 68.95 | 9,479,206 |
| 1983 [1] | 59,697 | 2.36 | 140,734 | (2) | (2) | 76.21 | 9,779,991 |

[1] Preliminary. [2] Series discontinued.

Statistical Reporting Service.

Apart from the direct economic value of hay, it has some important indirect benefits. Acreage sown to hay is far less susceptible to soil erosion than land that has been planted to row crops. Kissiwa (1983) notes that soil erosion rates were found to be seven times higher on certain types of soil when planted to row crops rather than alfalfa. Also, alfalfa hay, which accounted for 58% of all hay grown in the U.S. in 1983, rejuvenates the soil and increases yields in subsequent crops. Kissiwa found that corn following alfalfa needed only 20% as much nitrogen as corn following corn. Kissiwa cites studies where alfalfa increased nitrogen in the soil by as much as 110 kg/ha. (98 lbs./acre). In addition, alfalfa increases the soil tilth and water holding capacity. The value of legumes is not limited to the direct cash receipts they generate for producers. Hay, especially alfalfa hay, increases the future productivity of the soil through the control of soil erosion and increased fertility.

Given the economic importance of hay, why hasn't more effort been devoted to creating more orderly markets? The vast majority of hay is used on the farm where it is produced. Table I illustrates how little hay moves off the farm. To some extent, this aggregate data masks regional differences. In Arizona, 78% of the hay is sold, while in Wisconsin, only 7% moves off the farm. But Arizona is the exception rather than the rule, even among western states. While there are commercial hay producers, most of the hay moving to market is surplus production from dairy and cattle feeding operations. Consequently, there has been relatively little producer pressure or effort to improve hay markets.

A more compelling reason for this neglect is the heterogeneity of hay. Hay quality depends on stand quality, rainfall, humidity, drying conditions, time and number of cutting, bale type, and whether or not the operator used artificial drying agents and preservatives. A hay dealer may handle a dozen or more different types of hay. The problem, at least according to some dealers, growers, and buyers, is one of complexity. Any uniform national grading standard must be versatile enough to describe numerous types of hay made under highly variable conditions which have a dramatic effect on quality and palatability. This uniformity is easier to achieve in hay grown in the west than in hay grown in eastern states. Not only can growing conditions be controlled through the use of irrigation in western states, drying conditions are nearly ideal. Western hay farmers can produce uniform, high quality lots of hay because of these factors.

Yet another reason that so little effort has been devoted to improved hay marketing is as old as humankind: resistance to change. Dealers are satisfied with the present system. Horse buyers want "green hay with no dust (i.e. mold)." Growers make little effort to produce more salable hay by tailoring their products for market. Loosely packed, 40-50 lb. conventional bales and large round bales, two common hay packages, are the bane of hay dealers, who say that they simply cannot ship such packages.

In light of the disorganized and fragmented nature of hay markets, the potential for improved economic performance through institutional change is significant. The objectives of this paper include: 1) describing the present market structure, 2) identifying obstacles to more orderly marketing, and 3) identifying and quantifying opportunities for improved

economic performance potentially available from reducing the obstacles to more orderly marketing.

## II. PRESENT MARKET STRUCTURE

To talk about "The Hay Market" is misleading. There are in fact three distinct markets: the dairy and cattle market, the "fancy horse" market, and the damaged hay market. Each of these markets is unique; each is characterized by different pricing mechanisms and institutional arrangements. Even this division is an oversimplification, for the hay marketing channels in the east and west are also different because the structure of the dairy industry in these regions is quite different, and because the hay produced in the west is easier to market.

By far the largest and most important user of hay is the dairy industry; it is also the industry served by the most primitive marketing system. At least in the east, dairymen tend to produce hay for on-farm use. The only hay movement is surplus hay moving off the farm to other dairy farms or to local pleasure horse owners. A study in New York (Kelleher and Lazarus, 1985) found that two-thirds of the farms surveyed sold no hay at all, while only 7% sold all their hay. The remaining farms sold 15% or less of their hay. In essence, there are a small number of commercial growers, but the majority of hay is grown and used by dairymen.

This surplus hay moves primarily through person to person sales and through local auctions. Because of the lack of information on prices, the prices paid in direct grower-user sales is highly variable. Local auction markets are a "quick and dirty" barometer of local supply and demand situations, and many direct sales utilize prices published by auction markets. However, the prices received at auction markets are frequently lower than the prices received in direct sales. Since this is essentially surplus hay, it is often not of premium quality. Many of the pleasure horse buyers at auctions are not interested in buying the hay with the highest feed value. These markets are extremely responsive to local conditions, but may not respond to supply and demand conditions in broader markets. More important, hay auction markets are very thin markets. An Illinois Department of Agriculture survey found that only 1.5% of the total tonnage sold in the state moved through auctions. This fact alone leads one to suspect the price setting ability of auctions.

One hay dealer noted that in the spring of 1985, first cutting alfalfa was selling for $24/ton in auction markets because of traditionally weak spring demand. At the same time, he was selling the same hay for over $50/ton to race tracks. Naturally, there is an incentive for brokers to buy in auction markets and then resell to their own customers. This does in fact occur. To take advantage of the lower auction market prices, another broker acts as a buying agent for his customers -- and charges them $20/ton for his services.

Ironically, it is within the context of this rather primitive market that the greatest efforts are being made to price hay on the basis of its feed value rather than by its visual characteristics. This effort is being

driven by the ongoing need to control feed costs. Kelleher and Lazarus conclude:

> Hay pricing on the basis of chemical analysis of nutritional value may hold more promise for dairy than for the horse market. One reason for this assertion is that pleasure horse owners with only one or a few horses may have less knowledge of and interest in nutrition than an experienced manager of a commerical dairy farm. Hence, they may be less willing and able to compare lots of hay on the basis of nutritional quality. They may also be less concerned with cost and more concerned with the aesthetics of a sweet-smelling, green bale of hay. The competitive nature of horse racing and the higher value per animal compared to dairy and other livestock may also make trainers less willing to experiment with new hay pricing schemes than, say dairy farmers, for whom feed costs are a more important part of total operating costs.

Hay dealers and brokers may buy in local auction markets, but they serve a much different market, namely, the "fancy horse" market. "Dealer" is actually a more accurate term for these individuals and firms, because they actually buy the hay and resell it rather than merely arrange for the transfer of hay (i.e. broker the hay) from grower to buyer. However, dealers sometimes refer to themselves as brokers.

According to one large hay dealer in southern Michigan, only 10% or less of his business is with dairymen. He notes that large dairy farms frequently pay less for delivered hay than he does for hay on the farm. His clients are the race tracks in the south and midwest, as well as horse farms in the south.

This is a business based on trust. It is also a business which is intensely competitive in respect to quality and reliability. Customers are willing to pay a premium for the very best, green, sweet-smelling hay available. The reputation of the dealer depends on his ability to deliver top quality hay on a timely basis. The dealer cannot afford to deliver any loads of inferior quality hay. It is this need to be absolutely sure of the hay quality that is at the root of hay dealers' disdain for hay grading. They know exactly what their customers want, and they won't take any chances in providing any less. If brown or carmelized (heat damaged) hay reaches their customers, regardless of its feed value, they will be out of business rapidly.

It is not that these dealers are opposed to more scientific grading standards; they simply refuse to rely on them completely. One dealer said that if his customers ever wanted an analysis, he would provide it, but that in 20 years in business, no one had ever asked for one. His implicit point: his customers relied on his judgement.

At present, hay dealers in the midwest are under pressure from Canadian dealers. The strength of the dollar and the Canadian government's aggressive export expansion programs have allowed Canadian dealers to undercut the prices of their American counterparts and to take over their markets. Profit margins are growing thinner and customer loyalty is being weakened to some extent.

For their services, dealers charge a $5-15/ton premium for the hay, a figure that is well below the 15% commission charged by the National Hay Exchange (NHE), a true brokerage firm based in Texas, and on a par with the 10% commission charged at many auction markets. Hay dealers could probably survive even without a premium on the hay, because they are really in the transportation business. The bulk of their profits or losses come from shipping hay.

Paradoxically, in a business based on trust, the single largest problem is non-payment of debts. The survey in New York found that 7 out of 34 hay sellers reported that they were not paid for their hay at some point in the past. Hay dealers confirm that indeed, bad debts plague the industry.

Prices in the "fancy horse" market are set by the dealer for all practical purposes. He decides what the market will bear and his customers are not apt to quibble. Frequently, transportation charges are greater than the price of the hay, so the quoted hay price may not be all that important to a buyer anyway. The dealer's price setting power is even greater when he is far enough from other dealers to have a local monopoly on the hay produced in a region. Growers have no choice but to accept the dealer's price.

The hay dealer network is at once competitive and oligopolistic. No comprehensive list of hay dealers exists, but the National Hay Association lists 300 members, most of whom are hay dealers. While these dealers compete quite vigorously for contracts, the industry as a whole is more akin to an oligopoly and performs like an oligopoly in many respects. Once a dealer obtains a contract, the buyer is essentially "his customer" and will remain his customer even in the face of lower prices by other dealers within limits of course. Even if dealers compete on the demand side, from the perspective of supplies -- hay growers -- shipping hay is definitely an oligopolistic industry. Many farmers would be happy to sell their hay at the price quoted by dealers, but dealers simply refuse to purchase it. Typically, there are only one or two dealers within a reasonable driving distance of the farmer, so if the dealer refuses to buy the hay, the farmer must rely on auction markets or on private treaty sales.

There is a third market for hay which deserves to be mentioned, at least in passing. In some areas, hay that is damaged by rainfall or mold can be shipped to alfalfa mills where it is processed into filler for animal feeds. The per ton price varies of course, but is usually half the going price for first cutting alfalfa hay. This price is well below the cost of production but it is apparently high enough to attract all of the hay that these mills can process. The low prices paid by such processors usually make it uneconomical for individual growers to ship small lots to processors. Thus, these mills are served primarily by hay dealers who want to get rid of bales that have been removed from otherwise salable lots and by large commerical hay growers.

While it is difficult to estimate the actual size of each of these markets, the survey conducted by the state of Illinois in 1974 gives some indication of the relative size of each of these markets. This survey found that, in terms of tons, 87.5% of the hay was sold on a private treaty basis, 5% through hay dealers, 1.5% at auction, and 6% through other channels

(farm sales, feed stores, shares, etc.). This study also confirms that much of the hay marketed is surplus production. Fully 67% of those surveyed sold hay only once or twice during the year, indicating that few growers produced hay for the market; rather, they sold off their surplus hay all at once to get rid of it. Of all the hay sales reported, only .1 of 1% was sold on the basis of a grade -- the vast majority was sold on appearance, though some was sold solely on the basis of which cutting it was.

To date, public sector efforts to improve hay marketing have been modest. Several universities have taken the lead in promoting grading standards, developing better ways of handling hay, and facilitating buyer-seller contact. There has been, however, little direct government involvement in hay marketing. Depending on one's perspective, hay was either neglected by the government or spared from government meddling. To be sure, there are and have been government programs that affect hay production. The Soil Conservation Service presently has a cost sharing program designed to encourage hay seeding on erosible land. The program pays one half of the producer's variable cost of establishing an alfalfa seeding. Since the bulk of hay production cost is in harvesting the crop, it is unlikely that this program encourages much additional hay acreage. Indeed, it may serve only those who already intended to plant the acreage. The exact economic effect of this program is difficult to determine because benefits are measured in thousands of acres protected. The SCS lists just over 1 million acres as having "Cropland Protective Cover" in 1983, so the program is relatively minor and had little effect on overall hay supplies or hay marketing.

Even more difficult to quantify, but perhaps more significant for hay production, are extension agents who promote hay production. One dealer noted that a concerted effort on the part of one extension agent in Illinois prompted many farmers to expand production. Supplies subsequently burgeoned and prices in the area fell because there was simply no market for the hay.

During the late 1970's, when drought conditions necessitated the shipment of hay to dairy farms in Wisconsin from other regions, the USDA did establish a marketing program under which the cost of transporting hay into the area was subsidized by the government. Predictably, fraudulent claims were made. Reimbursement claims were made for hay ostensibly shipped from western states, when in fact the hay was shipped from nearby areas. This was an emergency program and has long since been discontinued.

These efforts have not been directed toward making hay markets better. There is, however, a need to improve these markets, and the government can play a critical role in facilitating these improvements. Some growers and dealers are adamant in their opposition to government intervention of any kind. Their feeling is that hay markets already adjust rapidly to supply fluctuations and that a normal profit can be realized in the industry.

## III. ORDERLY MARKETING: OBSTACLES

### A. Buyer-Seller Contact

One aspect of hay marketing is strikingly different from the marketing of other commodities. If a farmer has corn to sell, he can be sure that he will find a buyer only a few miles from his farm. He will incur minimal transportation costs in getting his product to market. A phone call will lock in a fixed price for next year's crop. There is no risk that he will be unable to sell his crop.

Hay marketing is fundamentally different. The grower must find a buyer, negotiate a price, and arrange transportation. The risk of overproduction falls on the individual grower, whereas overproduction risk in many other commodities is spread over the entire system in the form of lower prices or that risk is assumed by the government, as is the case with support prices for crops or with dairy products.

There is simply no well-developed cash market for hay -- no meeting ground for buyers and sellers. Local auction markets are available, but they do not redistribute the hay beyond the local market. Surplus hay remains for the most part in the same area, driving down prices, while areas where shortages exist do not benefit from that surplus. Selling hay at auctions, or even to a dealer, requires unnecessary handling of the hay, with its attendant losses and transportation costs. The elimination of this added handling and freight cost makes direct buyer-seller sales attractive. Auction markets are preferable to no market at all, but there is no established network of such markets. Any orderly marketing program must begin by developing better contacts between growers and their customers.

Numerous efforts are underway in various states that are designed to increase these contacts. Perhaps the most ambitious program of this type is in Oklahoma. Oklahoma has established a program called Haymarket, a computer-based listing of available hay. Alfalfa hay is graded by a third party based on crude protein (CP), moisture, and a variety of subjective criteria, including maturity, foreign material, and color. A summary of the results of this program for 1984 is given in the appendix. Oklahoma State University compiles a list of growers who have hay for sale; this list is then mailed to some 900 prospective customers. Customers also have access to the list via microcomputer. Under this program, buyers and sellers negotiate the price themselves. A record of the transaction is voluntarily submitted to OSU.

This program was undertaken with the objective of making "more information available to buyers and sellers...Growers often have insufficient information about potential buyers, their hay needs, and how much they are willing to pay." (Cuperus, 1984). To join the program, growers must pay a $10/lot fee. A lot is defined as a cutting made at the same time, same state of maturity, and harvested within a 48 hour period. In the 1984-85 marketing year, this program listed over $3 million worth of alfalfa.

Several results of this program are noteworthy. Growers were rewarded for growing high quality alfalfa. The price increase per point of

protein was $1.21/ton in 1983 and $3.17/ton in 1984. Growers also received a premium for small square bales (17.90/ton) and an even larger premium for large square bales (21.46/ton) over large round bales, indicating that transportation and handling problems remain a significant barrier to orderly marketing.

Also of interest is the fact that very little of the hay actually moved out of the region. This may be due to the fact that Oklahoma was experiencing hay shortages, but it may also indicate that a national market is still far from operative.

The success of the Oklahoma program has sparked interest among private firms in the establishment of such a market. Centrol (Control Data and Cenex) are interested in beginning a program similar to Haymarket in Minnesota.

The National Hay Exchange (NHE), based in San Antonio, Texas, already has undertaken a similar marketing program. Members list their crop with NHE; the minimum quantity for listing and sale is a semi-truck load. The NHE, in turn, matches buyers and sellers through a computer. If necessary, the NHE negotiates the price between the two parties.

The unique feature of the NHE is that it actually buys the hay from the grower and simultaneously sells it to the final user. Hence, while NHE is a brokerage firm, it takes on an added degree of responsibility for delivering hay of the specified quality. The NHE is not, however, a hay dealer, who buys hay to fulfill contracts. Once a deal is made, the NHE arranges transportation. If a dispute arises over the hay, the NHE arbitrates the dispute. For its services, the NHE charges a 15% commission on the total price of the hay. The commission is divided evenly between the buyer and seller. Interestingly, the NHE claims to eschew grading, noting:

> The Exchange is opposed to it. We feel there are too many varieties of hay and too many conditions of hay to describe under a few simple categories.

Instead, the Exchange asks for a description of each lot. This is largely a question of semantics. The description is virtually identical to the descriptions proposed for grades.

Wisconsin researchers have suggested a Tel-o-auction. Sorenson (1985) summarizes the concept this way:

> Hay buyers would be linked by a conference call telephone network to a central sales facility. The auctioneer would describe the hay and accept telephone bids along with bids from ringside. The advantage of a telephone auction is that producers receive a competitive price, established by buyers over a wide geographical area.

This type of auction is not yet a reality, nor is it likely to come a reality any time soon. This type of auction market assumes that hay buyers want a reasonably large volume; otherwise, the auction is not worthwhile. But hay buyers, unlike livestock buyers, are not typically in the market for large

volumes. And there is still a problem in arranging transportation. Given that such auctions are not in operation for commodities that have even better marketing networks, it is unlikely that such an auction will become a reality for hay in the near future.

It should be noted that numerous electronic marketing schemes have been devised for a number of commodities and products. Most of these have failed despite their theoretical advantages because large producers and buyers were unwilling to work through these markets. Apparently, these large producers and users already had developed channels through which to market their products. Small producers were unable to bear the full cost of such markets (Peach, 1984).

Some less sophisticated, but possibly equally effective marketing efforts have been undertaken by the National Hay Association and several states. The NHA publishes a list, available to its members, of surplus and deficit areas. Missouri publishes the names of growers with hay available. This list simply gives information concerning the amount and type of hay available. Quality information is not included. New York also publishes an annual hay directory, which lists both buyers and sellers. Michigan has gone a step beyond this by computerizing the lists of producers with surplus hay and buyers looking for hay. Each county extension office has access to the list through terminals located in the county office. Buyers and sellers must go through the extension office to obtain the list.

The biggest problem with all of these services is that few people are aware of the service. New York's 1983 directory contained only 98 names. In July, 1985, Michigan's list contained 29 buyers and, because of a computer malfunction, only 3 sellers. In New York, only half of the hay producers interviewed were even aware of the existence of the directory. Given the design of Michigan's program and the fact that unless one actually goes to the extension office there is no way of learning about the program, it is unlikely that even half of the producers in Michigan are aware of the program.

Hay marketing efforts are also proceeding on the local level. In Hillsdale County, Michigan, a local hay marketing corporation has been formed. Growers purchase stock in the corporation, which entitles them to participate in company sponsored auctions. Grading of hay is voluntary, but graded hay is sold before ungraded hay. Grading costs $10 per load. This program is being developed under the auspices of the county extension office and local producers and brokers.

Though these efforts at the state and local levels are promising, a genuinely national market development effort does not exist. Such a market might develop from cooperation of state, local, and national marketing organizations. The danger of such a piecemeal approach to development, however, is that incompatible systems will develop that will ultimately require these various groups to make difficult compromises.

At present, no fewer than nine states have initiated marketing programs for hay. There is a solid foundation for the development of a national market. Despite some examples of private interest in facilitating buyer-seller contacts, the motivating force in this area is state extension

offices. Coordination of future efforts of the various extension offices is critical if hay marketing is to develop on an orderly basis.

At the heart of any national marketing network is a system for grading hay. Without hay grades, buyers will insist on visual inspection of the hay, and it will be impossible to have a national market. Without grades, there will continue to be only local markets, where buyers can inspect the hay themselves, and regional markets, where dealers guarantee the quality of the hay.

## B. Price Information

In many respects, a hay market and hay price information have a chicken and egg relationship. Markets generate price information, but price information also induces the movement of commodities from surplus to shortage areas and facilitates the operation of orderly markets. Thus, it is perhaps an artificial distinction to separate the lack of buyer-seller contact from the lack of price information. From another perspective, these are two very different problems. Price information is generated each time there is a transaction, yet there is at present no organized, up-to-date reporting of prices paid and received.

While auction markets frequently report price ranges for hay, this information is of limited usefulness. Frequently, prices are reported on a per bale basis. This puts producers of heavy bales at a disadvantage vis-a-vis buyers in negotiations because the grower receives less per ton. Also, without quality information, it is difficult to interpret these prices. As noted above, these are thin markets that generate prices which are likely to be inaccurate.

The Illinois survey indicates how important such price information is for farmers. Eighty percent of the respondents cited price and availability of information as being a problem. Almost 20% said that they would like to see prices reported by the ton. In contrast, only 3% felt that a new grading system was needed.

Accurate price reporting would minimize the significant spatial differentials that develop. Any conclusions concerning hay prices must be considered tentative because of the lack of data. Richard Allen, the head of the Estimation Division of the Statistical Reporting Service calls the data on hay the "weakest series" that the SRS publishes. The quality of the data varies considerably from state to state. In Utah, for example, nearly all hay sales are a matter of public record, so the data on hay prices is very accurate. In other states, the SRS surveys "knowledgeable individuals" about hay prices, but does not have actual data on hay sales. According to Allen, the SRS does not take into account how much hay moved at a particular price. Thus, a hay price of $100/ton may be recorded for a state, even if very little volume moved at that price. In contrast, $60/ton may be recorded for another state, at which price a great deal of hay was bought and sold. These problems are compounded by the fact that prices are broken into only two categories: alfalfa and "other" hay. However, actual hay prices vary by type, cutting, mixture, quality, bale type, and a variety of other factors.

The SRS data does show substantial spatial differentials. Alfalfa prices varied from $59/ton in Minnesota to $124/ton in Kentucky in January, 1984. More remarkably, hay was $65/ton in Michigan in that month, while across the border in Ohio, it averaged $111/ton. These price differentials persisted throughout the year. Price data for 1984 are shown in Table II. Price data for 1981-1983 is included in the Appendix A, Table A1.

Transportation costs, while significant, do not completely explain these differentials. Transportation costs from Michigan to Kentucky average about $22/ton. Handling costs approximately $7/ton each time the hay is handled. Even if dealers or truckers receive a $10/ton premium, the price differential between Michigan and Kentucky is greater than the cost differences.

**TABLE II. PRICES RECEIVED FOR ALFALFA HAY BY STATE, 1984**

| | DOLLARS PER TON | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1984 | | | | | | | | | | | |
| | Jan | Feb | Mar | Apr | My | Jn | Jly | Aug | Sept | Oct | Nov | Dec |
| ARIZ | 102.00 | 102.00 | 97.00 | 95.00 | 91.00 | 84.00 | 77.00 | 71.00 | 79.00 | 82.00 | 91.00 | 94.00 |
| ARK | 110.00 | 105.00 | 110.00 | 100.00 | 75.00 | 70.00 | 90.00 | 95.00 | 90.00 | 100.00 | 110.00 | 110.00 |
| CALIF | 94.00 | 98.00 | 93.00 | 91.00 | 96.00 | 92.00 | 75.00 | 76.00 | 77.00 | 76.00 | 85.00 | 96.00 |
| COLO | 72.00 | 73.00 | 77.00 | 76.00 | 76.00 | 75.00 | 73.00 | 73.00 | 73.00 | 74.00 | 79.00 | 79.00 |
| IDAHO | 75.00 | 76.00 | 80.00 | 80.00 | 80.00 | 80.00 | 74.00 | 70.00 | 68.00 | 70.00 | 68.00 | 68.00 |
| ILL | 110.00 | 108.00 | 115.00 | 120.00 | 80.00 | 82.00 | 80.00 | 77.00 | 75.00 | 75.00 | 77.00 | 80.00 |
| IND | 106.00 | 109.00 | 118.00 | 114.00 | 94.00 | 68.00 | 68.00 | 68.00 | 72.00 | 79.00 | 74.00 | 72.00 |
| IOWA | 84.00 | 88.00 | 84.00 | 85.00 | 85.00 | 79.00 | 66.00 | 59.00 | 57.00 | 60.00 | 62.00 | 63.00 |
| KANS | 80.00 | 83.00 | 88.00 | 85.00 | 86.00 | 68.00 | 70.00 | 76.00 | 80.00 | 81.00 | 84.00 | 83.00 |
| KY | 124.00 | 126.00 | 126.00 | 127.00 | 115.00 | 111.00 | 106.00 | 104.00 | 106.00 | 106.00 | 104.00 | 104.00 |
| MICH | 65.00 | 60.00 | 63.00 | 70.00 | 70.00 | 54.00 | 50.00 | 50.00 | 55.00 | 50.00 | 62.00 | 50.00 |
| MINN | 59.00 | 68.00 | 54.00 | 71.00 | 64.00 | 53.00 | 45.00 | 51.00 | 48.00 | 59.00 | 50.00 | 70.00 |
| MO | 88.00 | 90.00 | 92.00 | 90.00 | 85.00 | 82.00 | 77.00 | 81.00 | 81.00 | 81.00 | 82.00 | 83.00 |
| MONT | 70.00 | 72.00 | 72.00 | 75.00 | 75.00 | 90.00 | 85.00 | 75.00 | 70.00 | 75.00 | 75.00 | 78.00 |
| NEBR | 62.00 | 66.00 | 65.00 | 61.00 | 60.00 | 57.00 | 52.00 | 50.00 | 51.00 | 53.00 | 52.00 | 54.00 |
| NEV | 95.00 | 98.00 | 95.00 | 90.00 | 80.00 | 80.00 | 84.00 | 75.00 | 70.00 | 70.00 | 75.00 | 80.00 |
| N MEX | 99.00 | 99.00 | 102.00 | 102.00 | 103.00 | 101.00 | 100.00 | 99.00 | 98.00 | 100.00 | 102.00 | 103.00 |
| N Y | 90.00 | 95.00 | 96.00 | 96.00 | 92.00 | 83.00 | 83.00 | 85.00 | 88.00 | 87.00 | 87.00 | 90.00 |
| N DAK | 46.00 | 45.00 | 46.00 | 45.00 | 48.00 | 49.00 | 47.00 | 47.00 | 47.00 | 49.00 | 49.00 | 48.00 |
| OHIO | 111.00 | 111.00 | 111.00 | 100.00 | 106.00 | 78.00 | 74.00 | 90.00 | 90.00 | 90.00 | 93.00 | 85.00 |
| OKLA | 110.00 | 113.00 | 97.00 | 108.00 | 70.00 | 93.00 | 100.00 | 103.00 | 105.00 | 111.00 | 120.00 | 120.00 |
| OREG | 93.00 | 91.00 | 88.00 | 80.00 | 84.00 | 83.00 | 85.00 | 85.00 | 85.00 | 84.00 | 85.00 | 85.00 |
| PA | 116.00 | 118.00 | 125.00 | 128.00 | 134.00 | 119.00 | 104.00 | 94.00 | 109.00 | 106.00 | 102.00 | 97.00 |
| S DAK | 40.00 | 40.00 | 51.00 | 39.00 | 44.00 | 49.00 | 39.00 | 40.00 | 47.00 | 48.00 | 45.00 | 45.00 |
| TEX | 106.00 | 110.00 | 122.00 | 117.00 | 127.00 | 115.00 | 117.00 | 120.00 | 114.00 | 115.00 | 124.00 | 114.00 |
| UTAH | 83.00 | 82.00 | 84.00 | 88.00 | 86.00 | 83.00 | 73.00 | 71.00 | 72.00 | 72.00 | 74.00 | 75.00 |
| WASH | 82.00 | 83.00 | 79.00 | 75.00 | 88.00 | 84.00 | 97.00 | 82.00 | 72.00 | 76.00 | 73.00 | 78.00 |
| WIS | 80.00 | 85.00 | 96.00 | 90.00 | 85.00 | 78.00 | 65.00 | 58.00 | 60.00 | 62.00 | 56.00 | 75.00 |
| WYO | 71.00 | 69.00 | 79.00 | 79.00 | 76.00 | 78.00 | 60.00 | 61.00 | 65.00 | 66.00 | 67.00 | 67.00 |

Some east-west price variation might be expected. Western alfalfa generally has a higher protein content that eastern hay. Moreover, since much western hay is irrigated, one would expect less rain damaged hay. In addition, a fourth cutting of alfalfa -- the highest quality cutting - in northern tier states that produce most of the alfalfa in the east can only be taken after a frost if at all. Under irrigation, it is possible to speed alfalfa growth and take a fourth or even a fifth cutting. But where one would expect a price differential, none exists. Indiana and Texas experienced the same price in January, 1984, while Michigan's price was $39/ton less than

Indiana's and Ohio's was $6/ton higher. There appears to be no significant east-west price variation.

The obvious question is why these differentials do not result in greater arbitrage activities. One possible explanation for this is that price information and market contacts are limited for individual growers. Dealers are aware of these differences and obtain a substantial economic profit during spot shortages in regional markets. Competition among brokers would theoretically drive prices down, but this does not take into account the nature of the brokers' business. As noted above, brokers do not actively try to "steal" one another's customers. And since buyers purchase service as well as hay, they are unwilling to change dealers unless the dealer with whom they work has substantially higher prices.

The lack of price information prevents farmers from planning production decisions efficiently. Though once again the data is limited, returns to growers are consistently negative or at least barely adequate. One large hay grower in Michigan noted that his hay operation was solidly profitable only when hay was around $65/ton. Snyder (1985) estimates that only 3 out of 15 farms in his survey found hay to be a profitable enterprise. The Telfarm data from Michigan State University (Nott, et al, 1984) shows that in Michigan, variable cost of production, excluding family labor draw, total approximately $20/ton. Assuming that labor is paid minimum wage, the labor cost/ton totals approximately $13.50/ton. Hence, producers need at least $35/ton just to cover variable costs. Since fixed costs represent the bulk of farm production costs in such highly mechanized operations as hay, it is unlikely that most dairymen and cattlemen make a profit on hay sales. Apparently some growers are willing to suffer losses on their hay operation because it is a critical input in their dairy or cattle feeding operation. Their hay marketing program is designed to recoup variable costs and as much fixed cost as possible.

In addition to better price reporting, growers would benefit from a forward contract in hay which would enable them to plan their production better. Kauffman and Shaffer (1985) note:

> The spot market produces prices which may be substantially higher or lower than producer costs. It reflects all of the errors in production decisions based upon inaccurate estimates of future prices...Spot market prices may provide some insight into future prices. However, they cannot be used by all producers to estimate future prices and thus to allocate resources efficiently.

Growers cannot count on the spot market price as a guide to marketing already produced hay because it is subject to rapid changes. This price information is not even readily available. The consequence of this is that producers who plan on the basis of previous prices find that seemingly profitable hay enterprises turn out to be unprofitable. Kauffman and Shaffer observe that a forward contract would produce information about future planning intentions and prices, thereby setting the stage for more efficient production.

Informal forward contracts do exist, but they are not uniform and are signed only between individual producers and final users. In fact,

Haymarket in Oklahoma found that its success may be its own undoing due to these informal forward contracts. Buyers and sellers who were put in contact through Haymarket subsequently signed contracts for future production, eliminating the need for producers to list their crop.

The fact that such informal contracts do exist tend to support the contention that the development of a forward contract for hay is possible even if spot markets remained comparatively primitive. The key is buyer confidence that the product delivered is in fact the product specified in the contract. In that regard, the development of a forward contract for hay is no more or less problematic than a forward contract for corn or some similar commodity. To be sure, there is an added burden on the grower to produce uniform quality hay. The occasional bale of alfalfa hay with an excessive amount of weeds in it will undoubtedly be a cause for dispute. The success of a forward contract hinges on the development of an accurate grading system and an objective sampling process. These problems are considered in the next section.

The problem of planning based on past prices is compounded by the fact that hay prices fluctuate on a seasonal basis (see Table II). Demand is typically weakest during the principal growing months; however, it is costly to store hay. A hay barn currently costs approximately $4.60/square foot. A 54 x 60 foot barn can store approximately 176 tons of hay. (14 x 18 x 42 inch bales, stacked 10 feet high by automatic bale wagon, 30 bales/ton). A $15,000 building amortized over 25 years at 11% interest costs $1781.00/year. Hence, storage costs approximately $10/ton/year. At present, seasonal price variations are great enough that the producer has no way of knowing if he can cover production costs, much less whether or not he can justify storage. In sum, a forward contract would eliminate at least some of this uncertainty and facilitate planning decisions.

### C. Grading Standards

While the development of an orderly marketing system for hay hinges on the establishment of adequate grading standards for hay, adequate grading standards depend upon being able to test hay for quality on some objective basis.

Federal hay grades were established in the Agricultural Marketing Act of 1946, but they are subjective and outdated. According to Marble (1985):

> Alfalfa hay has been marketed for the last half century, at least, on an "equivalent to" USDA No. 1, No. 2 Leafy, No. 2, etc., basis in the principle hay marketing areas of the U.S. Federal hay grade standards were developed many years ago and provide only a rough approximation of quality in negotiating prices between producers and consumers.

For the most part, these federal standards are ignored. Buyers simply want green, mold-free hay. One dealer tells growers from whom he buys that his customers want hay that is "green like money." However, it is virtually impossible to judge feed value or palatability by color since the maturity of the alfalfa affects quality more than rain damage or windrow bleach

(Rohweder, 1977). This fixation with color may be a matter of some indifference to horse owners, but it has important economic consequences for dairy farmers. A slight error in the assessment of forage's value can have a significant impact on the profitability of an enterprise. Shenk (1977) says:

> If the dairy farmer overestimates the protein content of the grain ration by 1% because he does not have available an accurate analysis of the protein of his corn grain, it will cost him between $500 to $1000 per year for protein supplement (fro 60 cows) that was not needed. If he underestimates the protein of the grain ration by 1%, his cows will not produce at their maximum level; and his losses will be even greater. Couple this with the expected large error in judging the nutritional quality of his roughage, and the dairy farmer's yearly losses will probably be in the thousands of dollars.

There is, then, both structural and economic incentives to develop grades that convey quality information.

Research on the development of objective evaluation techniques have led to the development of a variety of measures of hay's feed value. Cattle and horses need three major components in their diets: protein, energy, and fiber. The value of the feed depends on how much of each of these components it contains. To produce 60 lbs. of milk/day, the dairy cattle ration must include 16% protein, .76 Mcal energy, and 18% fiber. Both protein and fiber can be measured directly, and these two components are inversely related. The common measure of protein content is Crude Protein (CP), while fiber content is typically measured as Acid Detergent Fiber (ADF), though other measures, such as Modified Crude Fiber (MCF) and Neutral Detergent Fiber (NDF) exist. Energy content is calculated from the fiber and protein content and is expressed in a variety of ways depending on what equation is used. Common measures include Digestible Dry Matter (DDM), Total Digestible Nutrients (TDN) and Net Energy (NE). TDN and NE are used most frequently. While the energy, protein, and fiber content per pound of feed is important, the total intake of feed is also important. Thus, for example, while corn silage has more net energy than alfalfa hay, cattle won't eat as much corn silage as they will hay, so total energy intake may be lower. Consequently, Dry Matter Intake (DMI) is also an important measure of a feed's value.

There are direct methods of measuring all three components of a feed, but they are unusable for hay grading because they are cumbersome, costly, and slow. Typically, the estimation of these components is done through one of two different, indirect methods: chemical analysis or near infrared reflectance (NIR). Several different methods of chemical analysis have been developed. California, the first western state to use chemical analysis, tested for MCF, which was then used to predict TDN. MCF was determined on a 90% dry matter basis. Nevada developed an alternative system, one which was used more widely. This system measured ADF and CP on a 100% dry matter basis. These numbers were then used to predict TDN.

Marble (1985) noted in a speech before the Eleventh Annual Oregon Hay Growers Conference that:

> Here in Oregon you are all aware of the "tri-state" system of predicting quality based on an analysis of a standard hay for dry matter, CP and ADF. You do predict your own TDN, which is not comparable to the TDN numbers reported by California, which in turn were not in any way related to the numbers reported by Nevada. A few years ago, Utah added a new prediction system using ADF to predict a numbered ranking, which classified hay as No. 1, No. 2, No. 3, etc.

To overcome these difficulties, researchers from California, Oregon, and Nevada joined together to assess "every known parameter for predicting forage quality, including MCF, ADF, NDF, CP, and in vitro techniques." (Marble, 1984) Gradually, this group was joined by other western states and the Western Regional Coordinating Committee (WRCC-48) was formed.

Since November, 1982, the WRCC-48 and the National Hay Quality Testing Committee have worked together to develop a voluntary hay quality testing procedure. The highlights of this testing procedure are included in Appendix B.

None of these predictors is unambiguously superior to the others. NDF is a better predictor of feed intake than ADF because it contains all the fiber components that the animal eats; ADF is a better indicator of the digestibility of the forage because it measures only that portion of the forage which the animal cannot digest at all (Shaver and Mertens, 1985). Tests conducted at the University of California reveal that there is a high correlation between TDN predicted using ADF and TDN predicted using MCF or other techniques. While CP is a valuable predictor of TDN in legume hays, CP's correlation with digestible energy is limited when forages grown under widely varying climatic conditions are compared. More important, CP does not accurately predict the energy available in grass hay.

With the growing use of low moisture haylage and large hay packages, there is increased interest in forages damaged by heating in the bale. Heating in the bale results in the formation of indigestible compounds. According to Rohweder (1977):

> Two methods, Acid Detergent Insoluble Nitrogen (ADIN) and Pepsin Insoluble Nitrogen (PIN) are available to measure non-enzymatic browning and the reduction of N availability due to overheating of feeds.

A number of proposed grading systems for hay include one or more of these measures of protein, fiber, and energy as grading factors. In addition to the voluntary grades suggested by the western group, Oklahoma has developed a grading system for its marketing program based on CP. Rohweder also suggests several grades based on ADF and NDF as predictors of TDN.

A major drawback of chemical analysis is that it is too slow. Typically, samples must be analyzed at state university labs. This is not ideal for auction markets or for transactions conducted on short notice.

Near infrared reflectance eliminates this problem. Utilizing a portable infrared spectrometer, forages can be evaluated for ADF, CP, NDF, and trace minerals such as potassium and calcium in a matter of minutes. The NIR technology has been around for a number of years, but it is only with the advent of computers that it could be harnessed effectively. Essentially, as the name suggests, NIR equipment analyzes forages by recording the light reflected by the sample and comparing it with a sample with known ADF, NDF, CP and mineral content.

NIR is not without problems. Foremost among these problems is the cost of the equipment. Currently, there are two basic models on the market, one of which costs approximately $25,000, and the other about $50,000. The more expensive machine is more accurate and versatile, but according to Amos Snyder, who operates the only NIR equipment in Michigan at Litchfield Analytical Laboratories, the increased accuracy is not worth the higher cost. This price does not include the cost of the microcomputer to run the NIR software, the microwave to dry the samples, or the grinding equipment necessary to transform forage samples into a testable form.

The Litchfield lab charges $10/sample tested; at that price, Snyder says he is just breaking even. The major users of this service are feed manufacturers throughout the state who balance rations for their dairy customers. Because of the small volume of business (in May and June, this lab may only process one or two samples a day or less), owners of NIR equipment are reluctant to share data or information with competitors. NIR owners in Wisconsin see the Litchfield lab as a competitor. The cost of the equipment and the low volume of business will restrict the availability of NIR equipment unless hay growers find it necessary to get their hay graded. Even then, it is unlikely that NIR equipment will be widely available except at well-developed auction markets that can afford to invest in such expensive equipment and the highly skilled personnel needed to operate it. If the equipment is not widely available, however, its main advantage -- speed -- is eliminated.

Another problem which dims the bright promise of NIR is that the software that has been developed for it is fraught with problems. New NIR equipment gives inaccurate analyses of forages because the forages used to calibrate the equipment vary from those that are actually tested in a given area. Hence, new equipment must be recalibrated using wet chemistry analysis of local forages. In short, NIR must be used in conjunction with wet labs.

The problem of calibrating the NIR equipment to give accurate analyses is compounded by the fact that, while NIR is accurate for properly cured forages, moldy hay tests very high for CP. Similarly, NIR works well for legume hay, but it does not accurately evaluate the feed value of mixed hay and grass hay. This is not to say that these problems are insurmountable. A well-equipped lab can recalibrate the equipment so that it is extremely accurate. In the future, proper calibration of new equipment may be possible when an accurate calibration equation has been developed based on an "adequate representation" (Shenk, 1977) of hay samples from the population to be analyzed. Work has already been done on a national, "universal" calibration equation drawn from hay samples

throughout the United States. This would eliminate or reduce the need to recalibrate equipment on the local level. Marble notes:

> Laboratories may eventually acquire the needed spectra and equations from a centralized source that has universal data bases which can be updated with new samples to meet local needs.

Penn State University has begun to develop just such a data base.

Though the actual sampling of hay for grading would seem to be a minor hindrance, the sample that is taken can make the difference between mediocre and premium quality hay. Tests have been conducted in California to determine what the best sampling tool is, but an accurate sample really depends upon the sampler. Confidence in national grades will depend upon the accuracy of the grades in describing a lot of hay; the accuracy of the grade depends upon the accuracy of the sample.

A voluntary, uniform national grading system based on the relative feed value of the hay is critical for an orderly marketing system to be established. Grading is also likely to have a significant economic impact. As noted above, the information contained in such grades not only will help to establish a value for the hay, it also enables farmers to control feed costs more carefully. For growers, such grades can enable them to decide how to address an important economic tradeoff. Alfalfa cut before it blooms has considerably higher feed value, but cutting in the pre-bloom stage shortens stand life. Shaver and Jorgenson (1985) found that there was a 1 lb. decrease in 4% fat corrected (FCM) per cow per day for each day harvest was delayed once the alfalfa reached late bud or pre-bloom stage of maturity. If growers were rewarded for this high quality alfalfa, it would offset losses incurred due to reduced yield and stand life. This economic tradeoff is considered more explicitly in subsequent sections of this paper.

If grading standards describe hay quality objectively, they are equally useful for dairymen or horsemen. ADF, TDN, and CP describe the feed value of hay for both rumens and horses. Apart from the fact that horsemen traditionally consider alfalfa hay unsuitable for horses because it is "too rich," and because some horse owners believe it leads to health problems, there is no reason why horses can't be fed high-quality, pure alfalfa hay exclusively. Many of the present myths about alfalfa fed to horses stem from the fact that alfalfa hay often had mold in it because of the difficulty in curing it properly prior to the advent of modern hay making equipment. Rohweder and Antoniewicz maintain that "Ten pounds of early cut alfalfa will probably out-yield most horse 'conditioners' on every labelled ingredient except vitamin B-12 and will probably supply most of the horse's energy and protein needs." In fact, even when fed with oats, Timothy hay is nutritionally inadequate for brood mares and growing horses (Bradley and Pfander, 1984).

To be sure, some horse owners purchase grass hay <u>because</u> it has low feed value. Horses confined to box stalls or small pastures do not suffer from inadequate nutrition when fed pelletized hay or legume baled hay, but the comparatively small amounts of these types of feeds needed to meet the horse's nutritional needs may cause the horse to chew stall walls and

fences. Timothy hay can be fed in relatively large quantities without providing too much energy and protein.

Apart from its use as a "pacifier," there is no economic justification for growing or feeding grass hays except in areas where legume hay cannot be grown. Yields for grass hay is lower than legume hay, price per ton is lower, and feed value is decidedly inferior. One of the obvious and immediate effects of a system that adequately rewarded hay based on its feed value would be that grass hay would virtually cease to be grown in areas where alfalfa can be grown.

## D. Handling and Transportation

The number and diversity of hay handling systems which are currently available underscores the fact that the perfect hay handling system remains as elusive as ever. Large round bales, large square bales, small square bales, cubes, and stack wagons are all used to package the hay crop. When combined with a variety of mowers, rakes, obsolete balers (such as small round balers), and bale handling methods, there are dozens of different ways of handling hay. If the hay is to be shipped long distances within the U.S. or abroad, then it is often compressed or pelletized. The simple truth is that hay remains a bulky, labor and management intensive crop. While developing a system for accurately measuring quality is an important obstacle to orderly marketing, packaging, transportation, and handling are even bigger obstacles. Anderson (1977) states the problem succinctly when he writes, "Freight rates on baled hay are one of the biggest blockages we have in our industry today."

Conceptually, there are four distinct spatial hay markets defined by the modes of transportation that serve them: local, regional, national, and international. Local markets comprise those areas within a 150 mile radius of the grower. Within this range, it is still economically feasible to utilize farm trailers, pickups, and straight trucks to haul hay to the final user. Hay packaging is not particularly critical because transportation costs are minimal.

Regional markets extend 350-500 miles from the growing regions. Thus, for example, movement of hay from Michigan to Kentucky would be considered a regional marketing channel. The regional market is served by semitrucks owned by hay dealers or large growers. These semis usually haul only one way; backhauls are always welcome by dealers or growers, but they are not an economic necessity. Freight charges average about $1.25/mile for these trips.

Anything beyond this range is considered a national market by dealers. Freight costs relative to the price of the hay become so high beyond the 500 mile range that hay can only be shipped by rail or on semis that would otherwise be returning empty to the area where the hay is being shipped. Hay can only be shipped beyond 500 miles, in other words, as a backhaul load. Even then hay must be baled in packages that are 1.5 - 4 times more dense than conventional 40 - 50 lb. bales to be shipped economically. For Michigan hay dealers, the major national market is the race tracks in the south, especially in South Carolina and Florida. Hay brokers agree to deliver a certain quality and quantity of hay each week

during the racing season. The hay, usually in 65 - 70 lb. bales, is delivered in furniture vans returning from making deliveries in the Detroit, Toledo, or Chicago areas. According to hay dealers, the standard freight charge for the Michigan - Florida or South Carolina trip is approximately $1000 or between $.90 - 1.00/mile. With a relatively fixed freight cost, the number of tons that can be put on a truck is critically important. Bale density varies so much from grower to grower that anywhere from 8 - 24 tons can be loaded on a trailer. Freight cost per ton varies accordingly.

If a national hay market is to become a reality, growers are going to have to package their hay so that it can be transported. The conventional 50 lb. bale can be handled conveniently manually or with a kick baler but they are too expensive to ship. Large round bales, favored by many dairymen because they are easy to handle and can be stored outside, are difficult to transport, not to mention the fact that horse owners refuse to buy such unwieldy, browned packages. The proliferation of round bales in the midwest is perhaps a measure of how little attention farmers pay to marketing hay and how important reducing handling costs is. Spoilage in round bales left outside varies from 15 - 50%. Apparently growers are willing to incur significant losses in order to reduce handling. The irony of the situation is that growers frequently spend $1.30 per pound more for high yielding alfalfa varieties than for Vernal alfalfa, which is normally used as the base level in yield comparisons. These high-yielding varieties may increase production by 10 - 20%. At a seeding rate of 15 lbs./acre, the grower spends an additional $19.50/acre to get this increase. If hay is $60/ton and the grower achieves a 10% increase over the national average, the high-yielding variety is worth only $19.20. So growers spend money on high-yielding varieties to get a 10% increase, yet invest in packaging systems that cost them 15 - 50% of their crop.

There is also a small export market for hay. Three destinations account for most of the hay that is exported: Saudi Arabia, Europe, and Japan. Hay destined for Saudi Arabia and Europe is sold largely to thoroughbred horse owners who want only the highest quality alfalfa hay and are willing to pay virtually any price. Japanese buyers are primarily dairymen who have only recently begun to accept imported legume hays in place of homegrown grass hay. Regardless of where the hay is exported to, little midwestern hay is sold overseas. For the Japanese market, transportation costs for midwestern hay are prohibitive. The ideal growing and drying conditions in the west makes western hay superior to hay grown elsewhere, where growers must contend with fluctuating humidity levels, frequent rains, and a host of weed and pest problems. Dealers ship western hay almost exclusively because of its superior quality and uniformity. Hence, hay exports will remain a western phenomenon in any case.

This export market is not large. Hay exports in 1983, including pellets and cubes, amounted to only $86 million. By comparison, $5.7 billion worth of corn and nearly $6 billion worth of wheat were exported in 1983. As with all exports, hay exports are affected primarily by currency fluctuations. After an increase from 104,000 tons in 1967 to 411,000 tons in 1973, hay exports have shown little or no growth.

Hay must be compressed to be exported; otherwise, transportation costs become prohibitive. For that reason, pellets and cubes are usually

exported, though some compressed bales and 170 lb. three wire conventional bales are exported. As with the national market, the international market could be expanded if more growers were equipped to produce transportable packages. It is unlikely that any change in hay handling can be achieved at the farm level. According to C. Allen Rotz at Michigan State University, there is little research being done to improve on-farm handling other than research aimed at speeding drying and reducing spoilage using proprionic acid and anhydrous ammonia.

Any significant change will probably be made at the dealer level. Bale compacting equipment is not portable and may cost in excess of $100,000. Cubing equipment has the potential to revolutionize hay making, both on the farm and at the dealer level, but it also has limitations. On the plus side, hay cubes are 2 - 3 times as dense as baled hay. Hay cubes are approximately 1" x 1" x 2", so they can be handled as easily as corn or coal. Conventional augurs, elevators, and hopper cars can be used to handle it. Best of all, Rotz notes that dairy cattle actually consume more dry matter, a critical determinant of milk production, when they are fed cubes rather than hay. Cubing is also superior to pelletizing because the stem of the alfalfa remains long enough in the cubes to meet the rumen's roughage needs. This is not true of pellets.

On the negative side, cubing is expensive and requires nearly ideal drying conditions. Both self-propelled and stationary cubing equipment is much more energy intensive than baling. Moreover, self-propelled cubers cost in excess of $200,000. On the production side, hay must be dried to approximately 12% moisture before it can be cubed. It is nearly impossible for midwestern farmers to get hay dried to this level in the field.

Because of these limitations, hay is normally compressed or cubed by the dealer who arranges to ship the hay. While this makes the hay more transportable, it requires additional handling. (Hay can be cubed rather than baled in the field, but if the dealer has to do the cubing, he cubes previously baled hay.) Nevertheless, these are promising technologies. If hay cube and pellet use became more widespread, it would be possible to transport hay throughout the country as easily and readily as grain or livestock.

## IV. ORDERLY MARKETING: OPPORTUNITIES

Effecting changes in markets to facilitate the marketing of hay and to improve coordination of supply and demand are largely institutional and technological issues. The development of better communication and exchange mechanisms, more accurate and descriptive grading standards, and more economical, less labor intensive handling and packaging systems would fundamentally alter hay marketing. The development of a national market, or at least large regional markets, with more uniform prices, would be possible. More important, growers would be able to plan more accurately and market their crop more readily. But in addition to these institutional and technological issues is a more theoretical question: if these changes were effected, what economic opportunities and incentives might be created? This section explores a few of the more obvious opportunities.

## A. Better Quality Hay

As noted earlier, the stage at which alfalfa is cut is the single largest determinant of feed value. However, there is a tradeoff -- higher quality can be achieved only at the cost of reduced stand life. At present, hay is one of the few crops for which when sold there is no consistent penalty for inferior quality. This is especially true if nutrient content is the measure of quality. If a grading system were implemented, there would be an incentive, or at least no disincentive, to produce high-quality hay. More concretely, suppose a grower cuts at mid to full bloom, achieves yields of 3.2 tons/acre (the U.S. average in 1984), and receives an average of $60/ton. Properly managed, such a stand should last four years. Cut at this stage of maturity, the hay would have between 13 - 16% CP (Rohweder, 1977). Total revenue from the hay operation during the four years would be $768. If the grower were to cut the hay at the pre-bud or first bloom stage, he would experience a decline in both yield and stand life, but the CP content of his crop would be higher. Assuming a 10% decline in yield and a one year reduction in stand life, the grower would have a 3 year stand which yielded 2.9 tons/acre. However, according to Craven and Hasbargen (1979), alfalfa is worth $4/point of CP above 12%. Hay cut at the earlier stage of maturity may contain 20% or more CP. Assuming a 6% difference in CP, the hay cut at the pre-bud stage is worth approximately $24/ton more than hay cut at full bloom. The increase in CP does not account for the fact the fine stemmed, early-cut alfalfa may be more palatable along with being higher in feed value. Total revenue from the hay operation with a market that adequately rewarded hay quality would be $730.80. The present value of the four year stand at 12% interest is $583.17, while the present value of the three year stand is $585.09. In other words, the present value of hay produced with markets that rewarded quality would be roughly the same as the value of hay sold in current markets, but better quality hay would be produced. Cuperus (1984) found that in Oklahoma, which sold hay through its Haymarket program on the basis of CP, the quality premium amounted to $1.21/ton in 1983 and $3.17 in 1984. These figures are well below the premium needed to induce farmers to produce better quality hay. In states where hay is not sold on the basis of analysis, there is no incentive at all. Regardless of maturity or feed value, the only premium growers receive in such circumstances is for color.

## B. Shifts to Alternative Feeding Systems

Dairy cattle can produce up to 40 lbs. of milk per day on a ration of 100% high quality alfalfa. Beyond that point, alfalfa hay contains sufficient protein and fiber to produce 60 lbs. of milk per day, but has insufficient energy. Alfalfa hay contains between .55 - .68 Mcal NE, while the cow producing at the 60 lb. level needs about .76 Mcal NE. Corn silage, while it has a higher energy content that hay, still may contain inadequate energy for milk production at that level; moreover, silage has insufficient protein for even 40 lbs. of milk per day, and it has fewer minerals than hay. This necessitates the feeding of corn or soybean meal. A comparison of the feed value of silage and hay is included in the Appendix, Table A2.

Dairy operations frequently produce both silage and hay, not because they need both, but because producing both reduces risk and spreads the

workload. Corn silage, especially when it represents only a portion of a farm's total corn acreage, is a safe, low-risk crop. Dairy farms can always fill silos with uniform quality silage and harvest the rest of their crop as grain. Essentially, surplus silage is sold as grain. Hay, on the other hand, is a high-risk crop. A hard winter may eliminate entire stands. Even in a good year, only half of the hay crop may actually be high enough quality to get maximum milk production. Hence farmers maintain what amounts to duplicate forage systems.

Thomas and Bucholtz found that corn silage was the higher cost feed as long as the hay quality remained above the 18% CP. Below that, silage was the lower cost feed. They also found:

> For a 120 cow herd the 0 - 40% corn silage system had the lowest feed costs and less range due to variations in crop yield due to weather. In all these comparisons the 80% corn silage feeding practice had the greatest feed cost. Usually, the 0, 20, or 40% corn silage feeding practice was best even when the corn grain fed was purchased.

Details of the Thomas and Bucholtz study are included in the Appendix, Table A4.

The development of a more orderly marketing system would eliminate the risk of hay production and eliminate the need to maintain costly silage systems. If farmers found that they had insufficient high-quality hay, they would be able to purchase hay to meet their needs. And if prices reflected true feed value, dairymen would be able to purchase the quality of hay that met their needs and milk production goals while affording them the chance to control or at least predict their costs more accurately.

It is difficult to estimate the potential economic impact of eliminating a silage system because of the vastly different types of silage systems. Silage may be stored in bags, trench silos, or upright silos. At the very least, dairies could eliminate silage equipment such as choppers, blowers, silage wagons and the like. The cost of replacing this equipment might easily top $5,000 - 6,000/year. The economic question of whether or not farmers would eliminate their silage enterprises hinges on whether or not reduced equipment costs are greater than potentially higher feed costs associated with an all hay system. But if Thomas' and Bucholtz's study is accurate, an all hay system would only be more expensive if corn prices were comparatively high. If corn prices were low, not only would equipment costs be lower, the all hay system would be the lowest cost feeding system anyway, so there is a clear incentive to eliminate silage enterprises. This tradeoff would have to be evaluated on a farm-by-farm basis, but undoubtedly some farms would eliminate silage enterprises.

## C. Specialization

The impact of any change in hay marketing would be felt most by the dairy industry. How dairies would respond to these changes is difficult to predict. Carried to its logical extreme, however, there is no reason why dairies that are willing to eliminate silage enterprises because of their confidence in hay markets might not decide to eliminate crops production risk altogether and specialize completely.

From an economic perspective, two questions arise. First, will dairymen be willing to accept the risks associated with less diversified operations? The risk that feed costs beyond his control will rise precipitously provides an incentive to remain in crop farming. Diversified operations also spread risks and rewards. The dairy business may be unprofitable with decreased government support, but crop prices may be high enough to allow the farm to remain profitable. However, in a well-functioning market, hay and grain throughout the nation would flow to high price, deficit areas, so it would minimize the current regional price disparities that develop for hay. Dairymen wouldn't have to contend with the problem of how to dispose of low quality hay or the risk of complete crop failure. More important, if forward contracts were established, dairymen would be able to control actual feed costs more precisely. The problem of low quality hay and low yields, which raise actual feed costs, would be reduced.

The second question to consider is whether or not a more orderly market would result in efficiency gains; that is, would it be possible to produce the same quantity of milk at lower cost? Would specialized hay growers be able to produce at lower cost than diversified farms? Would increased transportation costs be greater than reduced production costs? These questions need further research, but certainly there is reason to believe that a specialized system would be more efficient. As hay producers expand, there are economies of scale in handling. Bale wagons, high-capacity balers, and large square balers that produce packages that can be loaded onto a semi easily with a forklift become more economical to use. Similarly, hay cubing equipment, which produces a package that has low handling costs and could be shipped on unit trains, becomes more practical as volume increases. Other efficiency improvements might be expected from more careful control of rations when the true feed value of the hay is known. This may include expanded herd size as more time is available for herd management and lower fixed costs, since there is no longer the need to store an entire year's hay crop on the farm.

### D. Economic Gains from Improved Soil Fertility

One of the factors restricting more extensive hay production is growers' uncertainty over whether or not hay will be profitable -- or even marketable. Alfalfa hay will not likely replace corn and soybean meal in fattening cattle because animals gain more slowly on an all hay diet and because it causes fat to develop a yellowish color. Corn and soybeans will continue to constitute at least half of the dairy ration. However, alfalfa hay, in an orderly market, may replace corn silage for dairy cattle and grass hay for horses. Growing additional alfalfa will result in significant improvements in soil fertility.

At current prices, the soil fertility improvement cited in Kisswa's study (98 lbs./acre) is worth $23.52/acre. The increased water holding capacity and tilth of the soil is more difficult to measure, but the economic value of these aspects of increased fertility are significant.

## V. CONCLUSION

The primary demand for hay is generated by two very different sources, namely, the dairy and cattle industry and the horse industry. While commercial growers supply some of this demand, much of the hay that is sold is essentially surplus hay from dairy operations. The packaging of hay by these dairymen often precludes its sale in all but local markets.

Dairy buyers typically buy their feed in local markets which are characterized by lack of information, poor coordination, and volatile prices. Local auction markets supplement farmer to farmer sales in this market. It is in this market that there is the greatest potential for improvement, because growers and dairymen want to improve it. There are incentives to adopt grades based on the relative feed value of the hay and to decrease transactions costs by eliminating unnecessary handling and transactions.

The "fancy horse" market is quite different. It is served by a network of dealers. In this market, there is little enthusiasm for change. Most horse owners aren't interested in feed value and most dealers aren't interested in going to the added expense of having hay graded. The dealers sell hay, but they also sell grading services and transportation.

The development of more orderly markets faces obstacles apart from entrenched interests. Variability of hay is a difficult problem. Western hay, in that regard, is much better suited to grading and shipping because it is more uniform and generally of better quality. Transportation is equally problematic. Hay is difficult and costly to transport. Improved packaging on the farm and beyond is important if a national market is to develop. However, the development and implementation of grades is the key to improving market coordination because such grades would significantly reduce transactions costs. Buyers wouldn't have to inspect hay visually before purchasing it. While there is still work to be done in this area, workable grading standards already exist. Simplicity is the key to operative grades. If grades describe all hays, they will be meaningless. Grades for pure alfalfa hay could be implemented as a first step. Once grades are established, it is possible to improve price infomation reporting and buyer-seller networks.

Developing confidence in new marketing mechanisms may be more difficult than actually developing the mechanisms. As Kauffman (1984) notes:

> The market is whatever people create through their technology and institutions. Once those are in place, prices and income streams will emerge. But the performance outcomes are a result of a weave of technology and institutions. The income distributions that emerge from this are inevitable. But since the distributions are not from holy writ, it requires thinking about the kind of institutional structure we want.

More orderly hay markets will emerge only when growers, dealers, and buyers understand the economic incentives to change and become confident in the fairness and accuracy of new structures.

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# APPENDIX A

## Table A1: MONTHLY PRICES RECEIVED FOR ALFALFA HAY, BY STATE, 1981 - 1983

1981

| | Jan. | Feb | Mar | April | My | Jn | Jly | Aug | Sept | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ARIZ | 96.00 | 98.00 | 94.00 | 88.00 | 79.00 | 71.00 | 71.00 | 62.00 | 63.00 | 69.00 | 75.00 | 75.00 |
| ARK | 75.00 | 90.00 | 92.00 | 91.50 | 85.00 | 90.50 | 85.00 | 85.00 | 80.00 | 70.00 | 70.00 | 68.00 |
| CALIF | 100.00 | 97.00 | 96.00 | 89.00 | 86.00 | 84.00 | 73.00 | 65.00 | 69.00 | 71.00 | 76.00 | 80.00 |
| COLO | 72.00 | 69.00 | 73.00 | 73.00 | 71.00 | 67.00 | 66.00 | 65.00 | 65.00 | 66.00 | 63.00 | 64.00 |
| IDAHO | 62.50 | 57.50 | 61.00 | 51.00 | 52.00 | 58.50 | 56.50 | 53.00 | 50.00 | 52.00 | 51.00 | 53.00 |
| ILL | 67.00 | 67.00 | 67.00 | 70.00 | 58.00 | 50.00 | 47.00 | 47.00 | 46.00 | 54.00 | 54.00 | 55.00 |
| IND | 65.50 | 64.50 | 66.00 | 65.00 | 64.00 | 63.00 | 61.00 | 64.00 | 66.00 | 71.00 | 83.00 | 80.00 |
| IOWA | 49.00 | 48.50 | 49.00 | 50.50 | 52.00 | 47.00 | 50.00 | 51.00 | 51.00 | 53.00 | 55.00 | 56.00 |
| KANS | 72.50 | 72.50 | 71.00 | 70.00 | 66.00 | 62.00 | 60.00 | 60.00 | 61.00 | 59.00 | 61.00 | 59.00 |
| KY | 86.00 | 89.00 | 88.00 | 90.00 | 87.00 | 83.00 | 85.00 | 85.00 | 85.00 | 85.00 | 86.00 | 83.00 |
| MICH | 40.00 | 42.00 | 40.00 | 40.00 | 43.00 | 37.00 | 35.00 | 50.00 | 50.00 | 60.00 | 65.00 | 68.00 |
| MINN | 64.00 | 60.00 | 54.00 | 60.00 | 58.00 | 65.00 | 63.00 | 66.00 | 71.00 | 70.00 | 74.00 | 74.00 |
| MO | 100.00 | 103.00 | 92.00 | 85.50 | 65.00 | 70.00 | 70.00 | 70.00 | 70.00 | 80.00 | 80.00 | 80.00 |
| MONT | 60.00 | 60.00 | 55.00 | 53.00 | 50.00 | 55.00 | 51.00 | 53.00 | 55.00 | 54.00 | 48.00 | 46.00 |
| NEBR | 59.50 | 60.00 | 59.50 | 59.00 | 57.00 | 59.00 | 62.50 | 64.00 | 58.00 | 58.00 | 54.00 | 56.00 |
| NEV | 97.00 | 99.00 | 93.00 | 90.00 | 85.00 | 84.00 | 80.00 | 74.00 | 70.00 | 70.00 | 75.00 | 74.00 |
| N MEX | 114.00 | 117.00 | 115.00 | 117.00 | 89.00 | 85.00 | 83.00 | 77.00 | 77.00 | 85.00 | 86.00 | 93.00 |
| N Y | 66.00 | 70.00 | 70.00 | 68.00 | 66.50 | 67.00 | 67.00 | 66.00 | 68.00 | 70.00 | 68.00 | 70.00 |
| N DAK | 82.00 | 85.00 | 88.00 | 88.00 | 94.00 | 90.00 | 81.00 | 66.00 | 64.00 | 69.00 | 60.00 | 64.00 |
| OHIO | 64.00 | 70.00 | 75.00 | 72.00 | 85.00 | 70.00 | 71.00 | 105.00 | 76.00 | 86.00 | 115.00 | 115.00 |
| OKLA | 118.00 | 112.00 | 109.00 | 97.50 | 95.00 | 95.50 | 88.00 | 75.00 | 73.00 | 73.00 | 74.00 | 77.00 |
| OREG | 90.00 | 90.00 | 85.00 | 65.00 | 70.00 | 80.00 | 75.00 | 70.00 | 70.00 | 70.00 | 65.00 | 65.00 |
| PA | 105.00 | 110.00 | 110.00 | 105.00 | 98.00 | 90.00 | 85.00 | 95.00 | 95.00 | 100.00 | 105.00 | 95.00 |
| S DAK | 69.00 | 72.00 | 74.00 | 66.00 | 85.00 | 80.00 | 70.00 | 70.00 | 70.00 | 70.00 | 70.00 | 65.00 |
| TEX | 115.00 | 110.00 | 115.00 | 118.00 | 105.00 | 92.00 | 90.00 | 96.00 | 93.00 | 89.00 | 89.00 | 87.00 |
| UTAH | 74.50 | 73.50 | 72.00 | 71.00 | 68.00 | 65.00 | 60.00 | 67.00 | 62.00 | 63.00 | 64.00 | 66.00 |
| WASH | 89.00 | 84.00 | 75.00 | 71.00 | 65.00 | 70.00 | 72.00 | 72.00 | 72.00 | 67.00 | 62.00 | 64.00 |
| WIS | 45.00 | 47.00 | 46.50 | 46.00 | 46.00 | 47.50 | 59.00 | 60.00 | 62.00 | 65.00 | 65.00 | 75.00 |
| WYO | 69.50 | 68.50 | 64.50 | 63.50 | 67.50 | 63.50 | 63.50 | 63.00 | 65.00 | 63.00 | 65.00 | 62.00 |

## Table A1 Continued

1982

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ARIZ | 79.00 | 78.00 | 76.00 | 82.00 | 85.00 | 70.00 | 64.00 | 62.00 | 66.00 | 74.00 | 76.00 | 81.00 |
| ARK | 68.00 | 75.00 | 80.00 | 75.00 | 70.00 | 70.00 | 80.00 | 80.00 | 80.00 | 78.00 | 83.00 | 75.00 |
| CALIF | 80.00 | 78.00 | 85.00 | 86.00 | 93.00 | 90.00 | 83.00 | 79.00 | 81.00 | 82.00 | 91.00 | 96.00 |
| COLO | 64.00 | 66.00 | 63.00 | 64.00 | 66.00 | 64.00 | 68.00 | 67.00 | 66.00 | 65.00 | 64.00 | 65.00 |
| IDAHO | 53.00 | 56.00 | 58.00 | 64.00 | 70.00 | 68.00 | 63.00 | 68.00 | 66.00 | 64.00 | 78.00 | 72.00 |
| ILL | 60.00 | 61.00 | 61.00 | 58.00 | 56.00 | 59.00 | 61.00 | 66.00 | 64.00 | 76.00 | 75.00 | 74.00 |
| IND | 82.00 | 88.00 | 94.00 | 98.00 | 89.00 | 70.00 | 71.00 | 70.00 | 72.00 | 75.00 | 83.00 | 86.00 |
| IOWA | 59.00 | 62.00 | 66.00 | 66.00 | 60.00 | 59.00 | 53.00 | 50.00 | 50.00 | 52.00 | 53.00 | 53.00 |
| KANS | 58.00 | 58.00 | 58.00 | 58.00 | 54.00 | 53.00 | 50.00 | 54.00 | 54.00 | 57.00 | 60.00 | 60.00 |
| KY | 88.00 | 88.00 | 87.00 | 87.00 | 85.00 | 84.00 | 85.00 | 85.00 | 90.00 | 90.00 | 88.00 | 87.00 |
| MICH | 72.00 | 75.00 | 80.00 | 90.00 | 90.00 | 55.00 | 45.00 | 55.00 | 55.00 | 63.00 | 65.00 | 63.00 |
| MINN | 76.00 | 85.00 | 80.00 | 74.00 | 80.00 | 70.00 | 58.00 | 64.00 | 60.00 | 66.00 | 77.00 | 80.00 |
| MO | 80.00 | 82.00 | 77.00 | 74.00 | 74.00 | 70.00 | 66.00 | 66.00 | 64.00 | 70.00 | 73.00 | 74.00 |
| MONT | 48.00 | 48.00 | 46.00 | 45.00 | 45.00 | 47.00 | 47.00 | 45.00 | 48.00 | 50.00 | 55.00 | 52.00 |
| NEBR | 59.00 | 58.00 | 56.00 | 53.00 | 55.00 | 54.00 | 51.00 | 48.00 | 47.00 | 44.00 | 44.00 | 46.00 |
| NEV | 74.00 | 74.00 | 74.00 | 79.00 | 84.00 | 86.00 | 82.00 | 90.00 | 90.00 | 95.00 | 95.00 | 92.00 |
| N MEX | 98.00 | 94.00 | 93.00 | 86.00 | 81.00 | 75.00 | 68.00 | 68.00 | 73.00 | 78.00 | 78.00 | 81.00 |
| N Y | 74.00 | 78.00 | 81.00 | 82.00 | 79.00 | 78.00 | 77.00 | 79.00 | 81.00 | 83.00 | 82.00 | 81.00 |
| N DAK | 64.00 | 64.00 | 62.00 | 58.00 | 63.00 | 59.00 | 50.00 | 55.00 | 50.00 | 50.00 | 45.00 | 45.00 |
| OHIO | 109.00 | 115.00 | 109.00 | 130.00 | 110.00 | 88.00 | 90.00 | 85.00 | 91.00 | 120.00 | 115.00 | 106.00 |
| OKLA | 80.00 | 78.00 | 78.00 | 74.00 | 74.00 | 64.00 | 70.00 | 56.00 | 76.00 | 88.00 | 77.00 | 88.00 |
| OREG | 70.00 | 70.00 | 75.00 | 85.00 | 85.00 | 88.00 | 80.00 | 85.00 | 85.00 | 89.00 | 91.00 | 95.00 |
| PA | 105.00 | 110.00 | 115.00 | 130.00 | 120.00 | 115.00 | 100.00 | 90.00 | 95.00 | 97.00 | 90.00 | 105.00 |
| S DAK | 85.00 | 85.00 | 75.00 | 65.00 | 65.00 | 40.00 | 38.00 | 35.00 | 36.00 | 35.00 | 40.00 | 38.00 |
| TEX | 93.00 | 102.00 | 94.00 | 95.00 | 90.00 | 89.00 | 89.00 | 90.00 | 83.00 | 89.00 | 96.00 | 99.00 |
| UTAH | 63.00 | 65.00 | 62.00 | 61.00 | 65.00 | 64.00 | 68.00 | 72.00 | 66.00 | 69.00 | 72.00 | 73.00 |
| WASH | 66.00 | 69.00 | 62.00 | 67.00 | 62.00 | 81.00 | 71.00 | 73.00 | 79.00 | 78.00 | 80.00 | 79.00 |
| WIS | 80.00 | 88.00 | 90.00 | 90.00 | 80.00 | 69.00 | 69.00 | 63.00 | 65.00 | 68.00 | 67.00 | 75.00 |
| WYO | 62.00 | 61.00 | 63.00 | 62.00 | 56.00 | 55.00 | 51.00 | 50.00 | 53.00 | 51.00 | 52.00 | 55.00 |

## Table A1 Continued

| | 1983 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Jan. | Feb. | Mar. | April | My. | Jn. | Jly. | Aug. | Sept. | Oct. | Nov. | Dec. |
| ARIZ | 81.00 | 83.00 | 94.00 | 98.00 | 101.00 | 91.00 | 82.00 | 77.00 | 80.00 | 95.00 | 92.00 | 99.00 |
| ARK | 75.00 | 75.00 | 75.00 | 75.00 | 75.00 | 70.00 | 75.00 | 75.00 | 95.00 | 105.00 | 105.00 | 105.00 |
| CALIF | 97.00 | 98.00 | 96.00 | 96.00 | 95.00 | 99.00 | 95.00 | 92.00 | 91.00 | 91.00 | 91.00 | 93.00 |
| COLO | 66.00 | 69.00 | 70.00 | 66.00 | 67.00 | 65.00 | 66.00 | 64.00 | 64.00 | 70.00 | 70.00 | 71.00 |
| IDAHO | 75.00 | 77.00 | 72.00 | 72.00 | 72.00 | 70.00 | 73.00 | 71.00 | 71.00 | 72.00 | 73.00 | 73.00 |
| ILL | 74.00 | 76.00 | 74.00 | 76.00 | 75.00 | 65.00 | 70.00 | 75.00 | 85.00 | 100.00 | 115.00 | 112.00 |
| IND | 77.00 | 70.00 | 70.00 | 76.00 | 70.00 | 68.00 | 68.00 | 80.00 | 89.00 | 96.00 | 100.00 | 104.00 |
| IOWA | 56.00 | 57.00 | 58.00 | 57.00 | 59.00 | 57.00 | 55.00 | 56.00 | 70.00 | 74.00 | 72.00 | 74.00 |
| KANS | 62.00 | 64.00 | 62.00 | 63.00 | 62.00 | 60.00 | 60.00 | 63.00 | 73.00 | 78.00 | 81.00 | 81.00 |
| KY | 91.00 | 91.00 | 96.00 | 96.00 | 96.00 | 98.00 | 96.00 | 96.00 | 113.00 | 117.00 | 122.00 | 120.00 |
| MICH | 60.00 | 55.00 | 55.00 | 58.00 | 60.00 | 40.00 | 38.00 | 42.00 | 62.00 | 72.00 | 75.00 | 75.00 |
| MINN | 80.00 | 76.00 | 75.00 | 80.00 | 81.00 | 68.00 | 63.00 | 69.00 | 70.00 | 70.00 | 80.00 | 62.00 |
| MO | 75.00 | 74.00 | 74.00 | 71.00 | 69.00 | 69.00 | 70.00 | 75.00 | 76.00 | 79.00 | 81.00 | 82.00 |
| MONT | 52.00 | 52.00 | 49.00 | 50.00 | 50.00 | 55.00 | 50.00 | 54.00 | 60.00 | 65.00 | 65.00 | 65.00 |
| NEBR | 45.00 | 47.00 | 45.00 | 45.00 | 45.00 | 44.00 | 43.00 | 45.00 | 48.00 | 48.00 | 51.00 | 51.00 |
| NEV | 92.00 | 94.00 | 93.00 | 92.00 | 97.00 | 94.00 | 98.00 | 97.00 | 99.00 | 99.00 | 99.00 | 99.00 |
| N MEX | 81.00 | 86.00 | 90.00 | 91.00 | 92.00 | 87.00 | 89.00 | 87.00 | 87.00 | 90.00 | 92.00 | 100.00 |
| N Y | 84.00 | 86.00 | 87.00 | 85.00 | 84.00 | 82.00 | 82.00 | 82.00 | 86.00 | 88.00 | 87.00 | 89.00 |
| N DAK | 43.00 | 42.00 | 42.00 | 44.00 | 44.00 | 41.00 | 44.00 | 41.00 | 42.00 | 43.00 | 45.00 | 47.00 |
| OHIO | 109.00 | 120.00 | 105.00 | 98.00 | 108.00 | 80.00 | 80.00 | 88.00 | 102.00 | 113.00 | 113.00 | 117.00 |
| OKLA | 78.00 | 80.00 | 74.00 | 76.00 | 74.00 | 67.00 | 80.00 | 92.00 | 75.00 | 79.00 | 82.00 | 108.00 |
| OREG | 96.00 | 100.00 | 90.00 | 94.00 | 92.00 | 83.00 | 87.00 | 88.00 | 90.00 | 91.00 | 86.00 | 92.00 |
| PA | 110.00 | 108.00 | 99.00 | 113.00 | 113.00 | 104.00 | 84.00 | 92.00 | 115.00 | 111.00 | 119.00 | 117.00 |
| S DAK | 36.00 | 40.00 | 43.00 | 42.00 | 42.00 | 36.00 | 35.00 | 36.00 | 37.00 | 36.00 | 40.00 | 42.00 |
| TEX | 97.00 | 98.00 | 90.00 | 93.00 | 94.00 | 96.00 | 93.00 | 99.00 | 101.00 | 102.00 | 106.00 | 106.00 |
| UTAH | 75.00 | 75.00 | 72.00 | 77.00 | 81.00 | 77.00 | 81.00 | 81.00 | 82.00 | 76.00 | 82.00 | 84.00 |
| WASH | 100.00 | 97.00 | 96.00 | 99.00 | 88.00 | 88.00 | 80.00 | 77.00 | 79.00 | 85.00 | 79.00 | 84.00 |
| WIS | 75.00 | 65.00 | 72.00 | 75.00 | 73.00 | 70.00 | 77.00 | 80.00 | 68.00 | 75.00 | 85.00 | 80.00 |
| WYO | 57.00 | 54.00 | 53.00 | 57.00 | 54.00 | 55.00 | 57.00 | 57.00 | 60.00 | 60.00 | 63.00 | 65.00 |

YEAR

## Table A2

Table A2 Nutrients in good hay-crop forage or corn silage

| Nutrient | Alfalfa hay<br>Alfalfa haylage<br>Hay-crop silage | Corn silage |
|---|---|---|
| Dry matter, % | 35-89 | 35.0 |
| Effective crude protein,% DM | 18.5 | 8.3 |
| Net energy, Mcal/lb DM ○ Maintaince | .68 | .78 maintenance |
| TDN, % DM | .58 | .69 3x maintenance |
| Acid detergent fiber,% DM | 36.0 | 28.0 |
| Calcium, % DM | 1.2 | .30 |
| Phosphorus, % DM | .27 | .26 |
| Magnesium, % DM | .25 | .18 |
| Potassium, % DM | 2.20 | 1.00 |
| Sulfur, % DM | .22 | .11 |

## Table A3

Table A3 Milk production when three proportions of corn silage were fed for a complete lactation

| No. of lactations per feed | % corn silage | milk | % corn silage | milk | % corn silage | milk |
|---|---|---|---|---|---|---|
| 22 | 100 | 15,062 | 50 | 14,648 | 0 | 13,517 |
| 20-33 | 100 | 12,700 | 71 | 14.923 | 50 | 13,250 |
| 36-39 | 100 | 13,810 | 55 | 13,561 | 50 | 12,381 |
| 22-36 | 100 | 10,822 | 60 | 11,718 | 60 | 12,485 |
| 21 | 100 | 14,509 | -- | ------ | 0 | 13,715 |

Data of Vandersall and Hemken; Thomas et al.; Holter, Belyea and Grieve. Some 1st lactation cows in all trials.

**Table A4: Net Feed Costs per Cow per Year for 5 Forage Systems**

A. (120 cows - 382 acres)

| % Corn Silage Fed | Average | Range Maximum Minus Minimum |
|---|---|---|
| 20 | 772 | 148 |
| 40 | 777 | 183 |
| 0 | 783 | 129 |
| 60 | 800 | 180 |
| 80 | 823 | 205 |

B. (80 cows - 254 acres)

| | | |
|---|---|---|
| 20 | 877 | 140 |
| 40 | 890 | 153 |
| 60 | 900 | 184 |
| 0 | 910 | 127 |
| 80 | 915 | 205 |

C. (120 cows - 251 acres - corn grain purchased)

| | | |
|---|---|---|
| 40 | 919 | 82 |
| 20 | 919 | 80 |
| 0 | 925 | 139 |
| 60 | 938 | 112 |
| 80 | 956 | 116 |

D. (120 cows - 251 acres - corn price = $2.50/bu)

| | | |
|---|---|---|
| 0 | 784 | 127 |
| 20 | 787 | 123 |
| 40 | 799 | 151 |
| 60 | 831 | 147 |
| 80 | 861 | 168 |

E. (120 cows - 251 acres - corn at $3.50/bu)

| | | |
|---|---|---|
| 40 | 754 | 216 |
| 20 | 757 | 178 |
| 60 | 768 | 214 |
| 0 | 782 | 134 |
| 80 | 783 | 244 |

F. (120 cows - 382 acres - change in machinery capacity)

| Number Rows In | | | | |
|---|---|---|---|---|
| Planter | Chopper | Picker-Sheller | Average | Range Maximum Minus Minimum |
| 8 | 2 | 3 | 823 | 205 |
| 6 | 2 | 3 | 827 | 216 |
| 8 | 2 | 2 | 834 | 291 |
| 8 | 3 | 3 | 843 | 205 |
| 6 | 2 | 2 | 838 | 301 |
| 4 | 2 | 2 | 867 | 299 |

Average is annual per cow feed cost as an average over 26 years of weather in South Central Michigan. The range is the difference between minimum and maximum net feed cost during the 26 years and is usually greater for high corn silage feeding practices due to weather influencing corn yields and acreage needed for feed more than it affects alfalfa.

# APPENDIX B

CR-477
0984

OSU Current Report

Cooperative Extension Service • Division of Agriculture • Oklahoma State University

# HAYMARKET: A First Year Summary

Clement E. Ward, Gerrit W. Cuperus,
and Loren M. Rommann

(Extension Economist, Extension IPM Coordinator,
and Extension Agronomist)

HAYMARKET is a computer-assisted marketing system for alfalfa hay (see OSU Current Report 465 for a detailed description of how HAYMARKET works). It was organized as a result of an interdisciplinary effort at OSU in conjunction with the Oklahoma Alfalfa Hay and Seed Association. The marketing program has been operating in Oklahoma since January 1983.

This Current Report summarizes several aspects of HAYMARKET's first full marketing year of operation.

## Brief Review

HAYMARKET is a computer listing service designed to help growers find buyers and to help buyers locate hay. Alfalfa hay is described using both objective measures (protein and moisture) and subjective measures (maturity, foreign material, and color). Other information about the sale lot includes the name and address of the grower, quantity for sale, cutting, bale type, and date harvested and sampled.

The computerized list is sent periodically to a HAYMARKET mailing list of over 500 people or businesses. Most of those are alfalfa buyers, sellers, or persons who regularly are in contact with buyers or sellers. Buyers can also access the list via microcomputer if they wish.

Buyers select the desired hay and contact growers directly to negotiate price and arrange delivery. Sellers report their sales voluntarily so that the lists are kept up-to-date. Sale data also allow analysis for developing follow-up educational information for alfalfa growers.

Information reported here would not be available without growers who willingly supplied their sale information. No comparable alfalfa hay sales information is available through other marketing channels. We are especially grateful for those growers who cooperated with OSU.

## Sales Summary

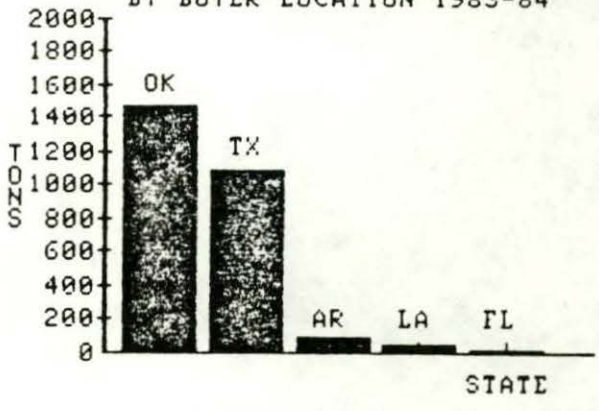
Sixty-eight lots of alfalfa hay totaling 3,773 tons were reported sold by 29 growers during the 1983-84 marketing year (May 1983-April 1984). Many more lots were listed on HAYMARKET during that period. Some hay was sold but not reported. Some hay was listed but was later fed by the grower rather than sold, due to below-normal hay supplies. A few lots remained unsold when the 1984 hay crop became available.

The average price for hay sold through HAYMARKET was $93.83 per ton. Thus, total dollar sales through HAYMARKET amounted to $354,020.59. No formal evaluation of HAYMARKET has been undertaken, but informal comments from growers suggest HAYMARKET's value to them. Grower comments indicate that exposure of their hay to more buyers created greater buyer interest than before HAYMARKET was started. Many growers indicated HAYMARKET helped them get a higher price for their hay in 1983-84.

## Sales by Buyer Location

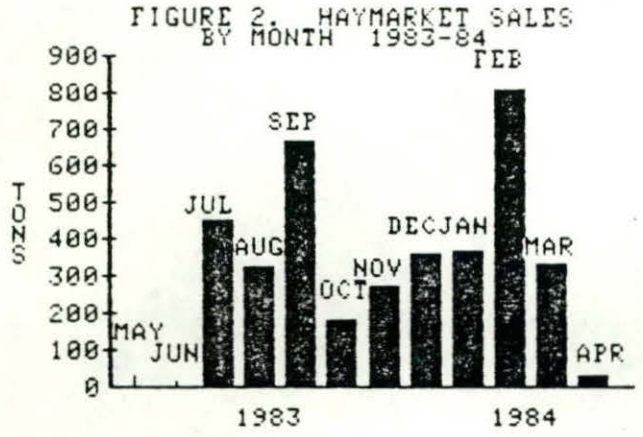
Nearly 95 percent of the alfalfa hay sold through HAYMARKET (2,552 tons), remained in Oklahoma or was shipped to buyers in Texas (figure 1). Small quantities of Oklahoma hay listed on HAYMARKET was reported sold to buyers in Arkansas, Louisiana, and Florida.

FIGURE 1. HAYMARKET SALES BY BUYER LOCATION 1983-84



Sales By Month

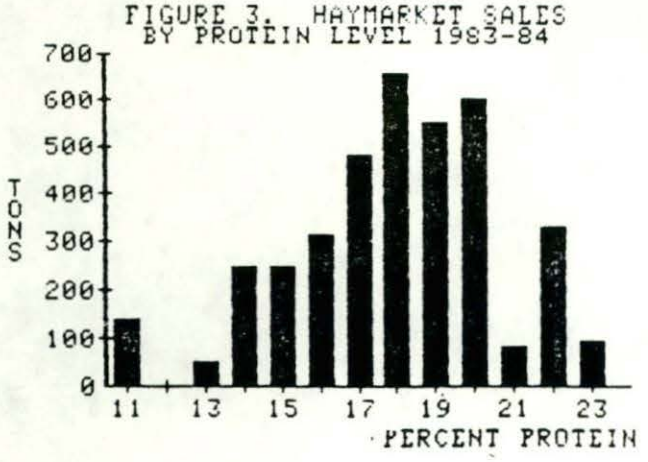
The first HAYMARKET list mailed for the 1983 crop year was in June 1983. The first hay reported sold from that HAYMARKET list was in July 1983. Figure 2 shows the distribution of sales by month throughout the 1983-84 year.




Sales by Protein

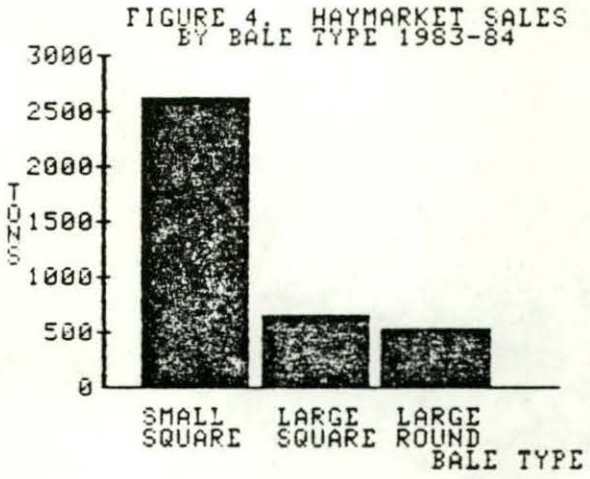
One of the objectives of HAYMARKET was for growers to market hay and buyers to purchase hay on the basis of quality. It was intended that higher quality hay was worth more and should earn a higher price. That rewards the better growers for producing a superior product. The best objective measure of quality that was available was protein on a dry matter basis. Thus hay listed on HAYMARKET was tested for protein by the OSU Forage Testing Laboratory.

Figure 3 shows the distribution of hay according to proteir content. Protein ranged from 11 to 23 percent. Sixty-eight percent of hay reported sold (2,293 tons), had a protein content of 17-20 percent. A later section in this report discusses what buyers paid for various hay attributes, such as protein, bale type, color, and amount of foreign material.



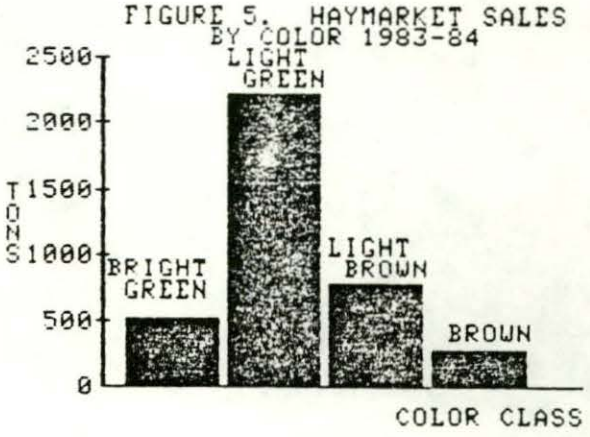

Sales by Bale Type

Seventy percent of the hay sold (2,628 tons) was harvested into small square bales (figure 4).



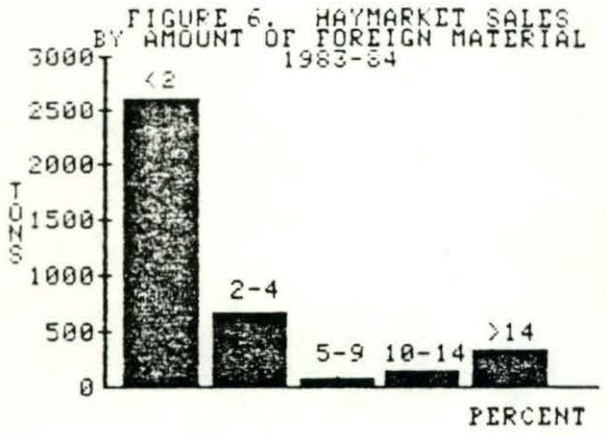

Sales by Color

Alfalfa hay listed on HAYMARKET was subjectively placed into one of four possible color classes. Figure 5 shows the distribution of hay tonnage by each color class. Fifty-nine percent of the hay reported sold throught HAYMARKET (2,212 tons) was judged to be light green. Both categories of green hay (bright green and light green) accounted for nearly three-fourths (72 percent) of all hay sold.



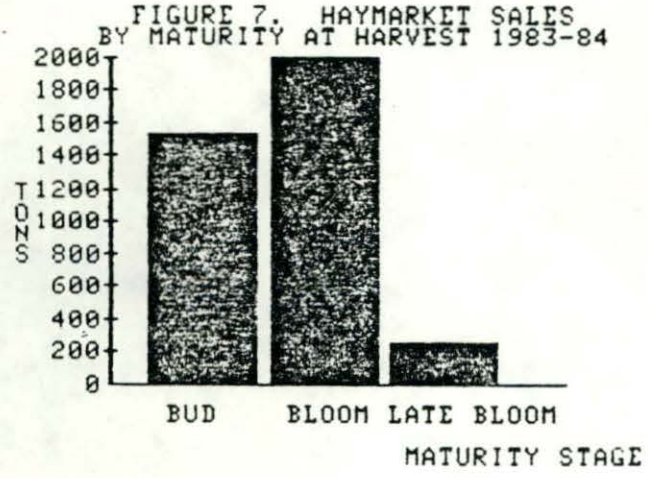

Sales by Amount of Foreign Material

Hay was subjectively evaluated for the amount of foreign material it contained (grass and broadleaf weeds). Seventy-seven percent of the hay reported sold (2,598 tons) was quite clean, having less than 2 percent of foreign material (figure 6).



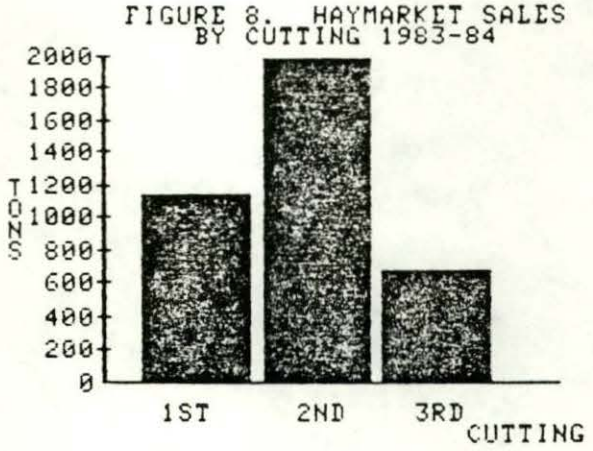

Sales by Stage of Maturity

Alfalfa hay should be harvested at the early bloom stage (about 10 percent of the plants in bloom). That harvest stage optimizes dry matter yield, protein level, and stand longevity. Hay was subjectively evaluated for its maturity at harvest and placed into one of three classes, bud, bloom and late bloom. Forty percent of the hay sold (1,528 tons) was harvested at the bud stage and another 53 percent (1,999 tons) was harvested at the bloom stage (figure 7). Thus, only a small percent was harvested well beyond the optimum maturity stage.



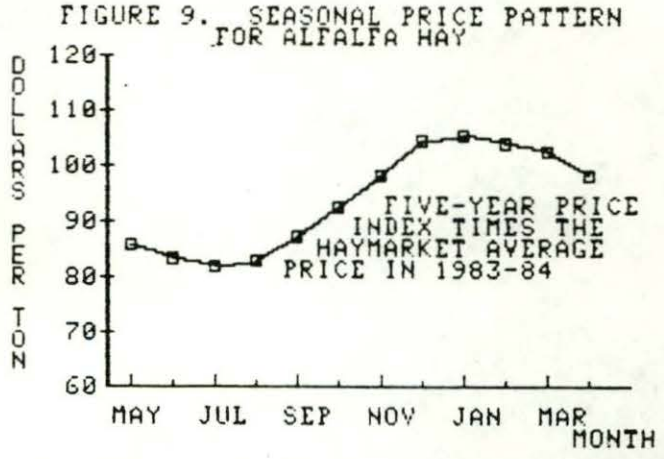

Sales by Cutting

More second cutting hay was marketed through HAYMARKET than either first or third cutting (figure 8). Fifty-two percent of the hay reported sold (1,978) was second cutting.




Price Analysis Results

First-year sales data were analyzed to determine (1) which factors were most important to buyers when purchasing hay, and (2) how important each factor was. The analysis confirmed a definite seasonal price pattern. Figure 9 shows prices for the 1983-84 marketing year, had prices conformed to the most recent 5-year seasonal price pattern. In fact, the 1983-84 price pattern was similar to that observed in Oklahoma the past few years. Prices were lowest during the harvest season. Then they increased as winter feeding approached and remained high through the winter feeding period. As spring and the new crop approached, prices began to decline.




Some growers market hay directly from the field. They incur less shrinkage during storage, reduce labor needs, require less storage facilities or space, and convert their alfalfa to cash rather than having their money tied up in the stored crop. Thus, for some growers marketing hay directly from the field has advantages which may offset the seasonally low prices during the harvest period. For growers with the necessary resources, storing hay for later sale may be an economical marketing strategy, because it enables them to capitalize on seasonally higher prices later in the marketing year.

It was found that growers received a $1.21 per ton price premium for each one percent higher protein level. Hay with 22 percent protein received a $6.05/ton more than 17 percent hay and $12.10/ton more than 12 percent hay. Growers have an economic incentive to produce higher quality hay.

Data suggest that some growers sold higher quality hay for less than the analysis indicated they should have gotten for it. Other growers sold lower quality hay for more than the analysis indicated they should have gotten for it. Both situations may be due to the fact that growers and buyers were inadequately informed as to the appropriate price and quality relationship. Thus, additional educational work is needed.

Bale type greatly affected sale price. Large square bales received a $21.46/ton premium over large round bales. Small square bales also received a premium compared to large round bales ($17.90/ton), but the price premium was less than the premium for large square bales. Square bales (large or small) fit better on flatbed trucks for long hauls. Thus, they reduce freight costs, compared to shipping large round bales. Those freight cost savings are translated into higher sale prices.

Growers were rewarded for keeping their alfalfa hay free of weeds and grasses. Hay with less than 2 percent of foreign material was worth $6.26/ton more than hay with more foreign material. At that premium level, growers may find it economical to invest in a planned weed control program.

Color was thought to be important to some buyers. The analysis confirmed that bright green and light green hay received a $8.62/ton price premium compared to light brown and brown hay. Growers face the difficulty of cutting hay at the proper stage and harvesting it without it being rain damaged. Results suggest it is worth some time planning when to harvest hay at the point of highest protein and to harvest it in a manner that retains the green color as much as possible.

## Conclusions

Feed-back from growers and buyers indicates HAYMARKET is working and filling a marketing void. In fact, a commercial firm in Texas recently began a marketing service (called the National Hay Exchange) which was based in part on HAYMARKET.

HAYMARKET is providing a useful service for alfalfa growers and buyers. In addition, it provides useful data which enables further analysis. That, in turn, generates more information and helps growers with their alfalfa management program.

One objective of HAYMARKET was to reward growers of high quality hay with higher prices. Research indicates buyers will pay premium prices for premium quality hay. Thus, growers have an economic incentive to produce the highest quality product they possibly can. More education is needed to help growers improve their hay quality and to inform them of its value. And more education is needed for alfalfa hay buyers to inform they of the value of alfalfa relative to other protein sources in their feeding program.

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NATIONAL ALFALFA HAY QUALITY TESTING PROCEDURE
PROPOSED BY WRCC-48

1. TAKING AN ADEQUATE SAMPLE. The validity of the test program resto on obtaining a representative sample that accurately reflects the quality of the whole hay population or lot. A minimum of 20 random cores (one core per bale) should be taken and composited, at least 12-18 inches into the end of the bale, at right angles. A lot is defined as that hay which is taken from the same field, cutting, stage of maturity, and variety, which is harvested over a 48-hour period. Samples should be placed in air-tight plastic bags and stored in a cool place until shipped to the laboratory. Samples should not be divided until after they are ground.

2. VISUAL STANDARDS HAVE BEEN DEVELOPED. To assist with the description of a lot of alfalfa hay, and to describe any physical conditions that may reduce quality, a description sheet has been developed to uniformly indicate quality factors that can be estimated visually. The "Alfalfa Hay Description Sheet" allows a sample to be identified for future reference, and comments to be included, including color, moldiness, foreign material, weediness, etc. Combined with chemical analysis, visual description...should allow hay to be transported and sold without the buyer seeing the sample.

3.A STANDARD ACID DETERGENT FIBER (ADF) METHOD HAS BEEN DEVELOPED. In addition, it is recommended that dry matter and crude protein be run on each sample, because collectively they represent the greatest part of the economic value of hay. Only ADF will be used to estimate digestible dry matter (DDM).

4. EITHER WET CHEMISTRY OR THE NEW, RAPID NEAR-INFRARED METHOD ACCEPTABLE. In addition to wet chemistry procedures, which have been described precisely in "Proceedings, National Alfalfa Hay Quality Testing Workshop, Chicago, Illinois, March 22-23, 1984", procedures have been approved for the NIR system to also be used as a way of speeding the analysis procedure. Studies to date have indicated that NIR is eqully as accurate as traditional wet chemistry methods when procedures are followed as published.

5. THE ADF ANALYSIS WILL PREDICT DIGESTIBLE DRY MATTER. DDM can be accurately predicted by ADF, using the equation: DDM% = 88.9 - .779ADF%. DDM can also be used to predict quality information that can be used in ration balancing, as digestible energy (DE). Two relationships were developed: DE Mcal/kg = -.027 + .0428 DDM% and DE% = -.628 + .984 DDM%.

Using these three equations, the true feeding ability of alfalfa hay can be accurately described. New research may indicate...the possibility of neutral detergent fiber (NDF) being used to estimate dry matter intake (DMI). This can be worked into the system at a later date. Intake is considered by some to be a greater factor than digestibility in hay quality determination.

6. A LABORATORY CERTIFICATION PROGRAM HAS BEEN DEVELOPED.

Table B1. Proposed market hay grades for legumes and legume-grass mixtures (Hay Marketing Task Force)

| Grades | State of maturity international term | Definition | Physical description | Typical chemical composition %[a] CP % | ADF % | NDF % | Relative feed value % |
|---|---|---|---|---|---|---|---|
| 1.Legume hay | Pre bloom | Bud to first flower; stage at which stems are beginning to elongate to just before blooming | 40 to 50% leaves*; green; less than 5% foreign material free of mold, musty odor, dust, etc. | >19 | <31 | <40 | >140 |
| 2.Legume hay | Early bloom | Early to mid-bloom; stage between initiation of bloom and stage in which 1/2 of the plants are in bloom | 35 to 45% leaves*; light green to green; less than 10% foreign material; free of mold, musty odor, dust, etc. | 17-19 | 31-35 | 40-46 | 124-140 |
| 3.Legume hay | Mid bloom | Mid to full bloom; stage in which 1/2 or more of plants are in bloom | 25 to 40% leaves*; yellow green to green; less than 15% foreign material; free of mold, musty odor; dust, etc. | 13-16 | 36-41 | 47-51 | 101-123 |
| 4.Legume hay | Full bloom | Full bloom and beyond | Less than 30% leaves*; brown to green; less than 20% foreign material; slight musty odor, etc. | <13 | >41 | >51 | 100 |

6.Sample grade**
Hay which contains more than a trace of injurious foreign material (toxic or noxious weeds and hardware) or that definitely has objectionale odor or is under cured, heat damaged, hot, wet, musty, moldy, caked, badly broken, badly weathered or stained, extremely overripe, dusty, which is distinctly low quality or contains more than 20% foreign material or more than 20% moisture.

a/Chemical analyses expressed on dry matter basis. Chemical concentrations based on research data from NC and NE states and Florida. Dry matter (moisture) concentration can affect market quality. Suggested moisture levels are: 1 and 2 < 14%, Grade 3 <18%, and Grade 4 <20%.
*Proportion by weight.
**Slight evidence of any factor will lower a lot of hay by one grade
CP = Crude Protin; ADF - Acid Detergent Fiber; NDF = Neutral Detergent Fiber; Relative Feed Value = Digestible dry matter intake. See Table 9.

LITCHFIELD ANALYTICAL SERVICES
535 MARSHALL /P.O. BOX 457
LITCHFIELD, MI. 49252
(517)542-2915

NIR ANALYSIS REPORT

| | |
|---|---|
| SAMPLE NUMBER | 1 |
| SAMPLE TYPE | Legume Silage |
| SAMPLE ID | EXAMPLE |
| DATE PROCESSED | 07-12-1985 |

| | |
|---|---|
| NAME | LITCHFIELD ANALYTICAL SE |
| ADDRESS | 535 MARSHALL P.O. BOX 45 |
| | LITCHFIELD, MI. 49252 |

COUNTY

| | ANALYSIS AS RECEIVED BASIS | ANALYSIS DRY MATTER BASIS |
|---|---|---|
| MOISTURE,% | 52. | |
| DRY MATTER,% | 48. | |
| CRUDE PROTEIN,% | 8.9 | 18.7 |
| HEAT DAM. PROTEIN,% | .9 | 2.0 |
| AVAILABLE PROTEIN,% | 8.8 | 18.5 |
| DIG. PROTEIN EST.,% | 5.5 | 11.6 |
| ACID DET. FIBER,% | 18.5 | 38.8 |
| NEUT. DET. FIBER,% | 19.4 | 40.7 |
| TDN EST.,% | 27. | 57. |
| ENE EST.,THERMS/CWT | 23. | 48. |
| NE/LACT,MCAL/LB | .277 | .582 |
| P,% | .18 | .37 |
| CA,% | .63 | 1.32 |
| K,% | 1.43 | 3.00 |
| MG,% | .14 | .30 |

A VALUE OF 0.0 FOR HEAT DAMAGED PROTEIN MEANS NO TEST WAS RUN.