Major Markets for Alfalfa Hay: Implications for Oklahoma

Clement E. Ward, Solomon Kariuki, Raymond L. Huhnke*

Alfalfa hay is an important field crop as a cash farm enterprise in Oklahoma and is an important livestock feed. Cash receipts from the sale of alfalfa ranked seventh in Oklahoma among all farm enterprises for 1995. Alfalfa growers harvested 1.444 million tons from 380,000 acres at an average marketing year price (1994-95) of $90.00 per ton, for a total value of $130 million dollars.

Alfalfa growers in Oklahoma expressed a concern about marketing in the early 1980s. From that concern came HAYMARKET, a computer-assisted marketing program for alfalfa hay (Cuperus, Rommann, and Ward 1989). HAYMARKET began in 1983 and was a joint effort between the Oklahoma Alfalfa Hay and Seed Association and Oklahoma State University. At about the same time, several individuals at Oklahoma State University with various interests in alfalfa formed an ad hoc team to address integrated management issues for alfalfa. The interdisciplinary Alfalfa Integrated Management (AIM) group has involved agronomists, animal scientists, agricultural engineers, plant pathologists, entomologists, and agricultural economists; and their efforts have involved both research and extension education.

HAYMARKET and its outgrowths have increased information about alfalfa buyer preferences for alfalfa hay and alfalfa marketing and pricing (Ward 1994; Ward, Huhnke, and Cuperus 1995). However, despite these efforts, when commercial alfalfa producers in Oklahoma are asked to identify their most pressing needs, marketing is usually near the top of their list. Among the interests of alfalfa growers are finding potential markets for alfalfa hay, both in the U.S. and internationally.

One objective of recent research was to determine the market potential for Oklahoma alfalfa. Specifically, the study: (1) identified the leading states in the U.S. for alfalfa production; (2) estimated the consumption of alfalfa in the U.S., both for higher quality alfalfa and lower quality alfalfa; and (3) determined potential markets for alfalfa in light of transportation costs from supply to demand locations. This article reports results of the research.

* Professor and Extension Economist, Graduate Research Assistant, and Professor and Extension Agricultural Engineer, respectively, Oklahoma State University

48 Oklahoma Agricultural Experiment Station
Procedures

Data on alfalfa production were collected for each state for three years (U.S. Department of Agriculture 1996a). Years selected included the largest production year for alfalfa in the U.S. since 1980 (1986), smallest production year (1988), and a recent year (1995). Inventory or marketing data for each state were also collected for the same years for dairy cows, beef cows, fed cattle, horses, and sheep (U.S. Department of Agriculture 1996a, 1996b).1

Limited data were available on daily consumption of alfalfa by animal species from published research. Therefore, animal scientists with a specialty in livestock nutrition at Land-Grant Universities were surveyed for estimates on daily alfalfa consumption and related marketing and usage information. Seventy-one animal scientists from 42 states responded to our survey. Forage agronomists at Land-Grant Universities were similarly surveyed for additional marketing and usage information. Thirty-eight agronomists from 36 states responded to our survey. A telephone survey of alfalfa exporters provided information on various aspects of exporting alfalfa. Individuals from eleven exporting firms provided useful information.

Several least-cost transshipment models were estimated under alternative assumptions to determine the least-cost movement of alfalfa from supply to demand points. Results reported here are from the model for 1995, which considered two qualities of alfalfa, higher quality for dairy cattle and lower quality for other livestock species. Higher quality alfalfa is often harvested in larger bale sizes (Ward, Huhnke, and Cuperus 1995). Therefore, the model used two transportation rates. Higher quality alfalfa was assumed to be transported at a lower rate, as a proxy for more efficient harvesting, handling, and shipping. The model also allowed for exports of higher quality alfalfa hay to Japan.

Major States for Alfalfa Production

U.S. alfalfa production varied by 22.2 million tons between the largest production year, 1986, and the smallest production year, 1988. The variation was 24.3 percent of the largest production year. Table 1 shows the ten leading states for each of the three years in the study. The rankings of the leading states differed somewhat between 1986 and 1988, and for 1995 compared with the two earlier years. However, eight states were among the ten leading states in all three years (California, Wisconsin, Minnesota, Iowa, Nebraska, Idaho, Michigan, and Kansas). Differences in leading states between 1986 and 1988 resulted in large

---

1 Horse inventory numbers were obtained from the American Quarter Horse Association for quarter horses and from The Jockey Club for thoroughbred horses, for the years 1986, 1987, and 1994.

<table>
<thead>
<tr>
<th>State</th>
<th>Percent of U.S. Total</th>
<th>State</th>
<th>Percent of U.S. Total</th>
<th>State</th>
<th>Percent of U.S. Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wisconsin</td>
<td>10.32</td>
<td>California</td>
<td>10.48</td>
<td>California</td>
<td>8.12</td>
</tr>
<tr>
<td>Minnesota</td>
<td>8.31</td>
<td>Iowa</td>
<td>8.14</td>
<td>South Dakota</td>
<td>7.65</td>
</tr>
<tr>
<td>California</td>
<td>7.79</td>
<td>Minnesota</td>
<td>6.58</td>
<td>Wisconsin</td>
<td>7.04</td>
</tr>
<tr>
<td>South Dakota</td>
<td>6.83</td>
<td>Wisconsin</td>
<td>6.26</td>
<td>Minnesota</td>
<td>5.87</td>
</tr>
<tr>
<td>Iowa</td>
<td>6.64</td>
<td>Nebraska</td>
<td>5.84</td>
<td>Iowa</td>
<td>5.72</td>
</tr>
<tr>
<td>Michigan</td>
<td>5.51</td>
<td>Idaho</td>
<td>5.04</td>
<td>Nebraska</td>
<td>5.56</td>
</tr>
<tr>
<td>Nebraska</td>
<td>5.09</td>
<td>Michigan</td>
<td>4.88</td>
<td>Idaho</td>
<td>5.31</td>
</tr>
<tr>
<td>Idaho</td>
<td>4.57</td>
<td>Colorado</td>
<td>3.93</td>
<td>Michigan</td>
<td>5.07</td>
</tr>
<tr>
<td>Kansas</td>
<td>3.83</td>
<td>Kansas</td>
<td>3.57</td>
<td>Montana</td>
<td>4.71</td>
</tr>
<tr>
<td>North Dakota</td>
<td>3.56</td>
<td>Pennsylvania</td>
<td>3.51</td>
<td>Kansas</td>
<td>3.80</td>
</tr>
</tbody>
</table>

part from geographic differences in rainfall patterns between the two years. Differences between 1995 and the two earlier periods may represent production trend differences in some states and regional production shifts over time.

Major States for Alfalfa Consumption

Konyar and Knapp (1986) developed a demand estimation model for California but data needed to expand the model to the U.S. were not available. Buzby (1986) used a feed-mix model to estimate alfalfa usage for selected animal species. However, her estimates tend to overstate actual alfalfa hay usage because they do not consider grazing alternatives in the feed mix during the forage growing season. Skaggs (1992) estimated per animal usage of alfalfa from a survey of end users and secondary sources and found that purchasing and usage patterns among end-users of alfalfa varied widely.

For this study, alfalfa consumption estimates from the survey of animal scientists served as a proxy for estimated alfalfa demand. Alfalfa consumption was estimated by summing for each state the inventory of each livestock species times the respective estimated annual consumption of alfalfa from survey results. Animal scientists surveyed were asked to estimate daily consumption of alfalfa hay for each species during the winter months and also summer months when grazing is possible on growing forages. Average consumption per head per day varied considerably between winter and summer months and among states as expected. Estimated average daily alfalfa hay consumption (lbs/head/day) over a twelve-month period by species was: dairy cattle, 12.3; beef cattle, 3.6; feedlot cattle, 1.6; horses, 6.2; and sheep, 1.6. These were the amounts used in developing the transshipment model.

<table>
<thead>
<tr>
<th>State</th>
<th>Percent of U.S. Total</th>
<th>State</th>
<th>Percent of U.S. Total</th>
<th>State</th>
<th>Percent of U.S. Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Texas</td>
<td>10.77</td>
<td>Texas</td>
<td>11.47</td>
<td>Texas</td>
<td>12.32</td>
</tr>
<tr>
<td>Wisconsin</td>
<td>7.56</td>
<td>Wisconsin</td>
<td>7.46</td>
<td>California</td>
<td>7.16</td>
</tr>
<tr>
<td>California</td>
<td>6.09</td>
<td>California</td>
<td>6.13</td>
<td>Wisconsin</td>
<td>6.76</td>
</tr>
<tr>
<td>Nebraska</td>
<td>4.56</td>
<td>Nebraska</td>
<td>4.75</td>
<td>Nebraska</td>
<td>4.68</td>
</tr>
<tr>
<td>Minnesota</td>
<td>4.46</td>
<td>Minnesota</td>
<td>4.13</td>
<td>Kansas</td>
<td>4.43</td>
</tr>
<tr>
<td>New York</td>
<td>3.85</td>
<td>Kansas</td>
<td>3.93</td>
<td>Minnesota</td>
<td>3.46</td>
</tr>
<tr>
<td>Kansas</td>
<td>3.80</td>
<td>New York</td>
<td>3.54</td>
<td>Iowa</td>
<td>3.42</td>
</tr>
<tr>
<td>Iowa</td>
<td>3.63</td>
<td>Iowa</td>
<td>3.54</td>
<td>Missouri</td>
<td>3.40</td>
</tr>
<tr>
<td>Missouri</td>
<td>3.23</td>
<td>Missouri</td>
<td>3.40</td>
<td>Oklahoma</td>
<td>3.37</td>
</tr>
<tr>
<td>Pennsylvania</td>
<td>3.23</td>
<td>Oklahoma</td>
<td>3.32</td>
<td>New York</td>
<td>3.17</td>
</tr>
</tbody>
</table>

Table 2 lists the leading states for estimated alfalfa consumption for the three years in the study. Nine of the ten leading states also remained unchanged for the three years. Texas is the largest alfalfa-consuming state. Others among the ten leading states for all three years are California, Wisconsin, Nebraska, Kansas, Minnesota, Iowa, Missouri, and New York.

**Alfalfa Surplus-Deficit States**

The difference between alfalfa production and estimated consumption in each state was used as an indicator of alfalfa surplus or deficit in each respective state. The smallest estimated deficit occurred as expected in 1986, the year in which alfalfa production was the lowest since 1980. The largest surplus occurred two years earlier, 1986, the year alfalfa production was the highest since 1980. Surplus-deficit conditions varied in some states, depending largely on rainfall patterns from year-to-year. Figure 1 shows the estimated alfalfa surplus and deficit in each state and identifies the leading surplus and deficit states for 1995. Major deficit states are most consistently in the southern region of the U.S. Texas is by far the largest deficit state. Alfalfa surplus states tend to be in the northern and western states. As expected due to year-to-year rainfall changes, both the leading states and ranking among the leading surplus states changed considerably.

**Alfalfa Buyer Preferences**

Ward, Huhnke, and Cuperus (1995) conducted a detailed survey of dairy operators in Texas and Oklahoma to determine various aspects of buyer preferences for alfalfa. Skaggs (1992) had conducted an earlier
Figure 1. Estimated Alfalfa Surplus or Deficit by State, 1995
(1,000 tons)
survey of alfalfa buyers and hay brokers in New Mexico. Animal scientists surveyed in this study were asked selected questions about a broad group of alfalfa buyers. While there are many measures of alfalfa quality, subjective and objective, Ward, Huhnke, and Cuperus found the most commonly used measure by dairy operators was still crude protein. Average estimates by animal scientists surveyed for preferred crude protein by animal species were (in percent): dairy cattle, 19.8; beef cattle, 16.3; feedlot cattle, 16.4; horses, 16.7; and sheep, 17.2. Clearly the better quality alfalfa as measured by crude protein was in greatest demand for dairy cattle. Lower quality alfalfa could be used adequately by other livestock species.

Animal scientists were also asked to indicate bale preferences by livestock species, both for smaller and larger livestock operators in their state. Smaller dairy operations preferred the traditional sized small rectangular bale. Larger dairy operations were split, some preferring larger bale sizes; but in fact, the most preferred sizes were evenly divided between small rectangular and large rectangular sizes. More smaller beef cattle operations preferred small rectangular bales but many preferred round bales. The reverse was true for larger beef cattle operations, more preferring round bales than any size rectangular bales. Similar results were found for cattle feeders. Smaller ones preferred small rectangular bales and larger ones were nearly split between round bales and large rectangular bales. The traditional sized small rectangular bale was the overwhelming choice for horse operations, both small and large. Smaller sheep operations overwhelmingly preferred small rectangular bales but some larger operations preferred larger size bales.

Animal scientists indicated that handling efficiency was the predominant reason for selecting bale size. That explains larger operations more frequently preferring larger bale types. Larger livestock operations are more likely to have larger equipment and substitute capital equipment for labor, which may be relatively difficult to find in some areas.

**Domestic and International Transportation**

Domestic truck size and transportation rates vary from state to state. Agronomists were asked to identify common load sizes and transportation rates for alfalfa hay. Since not all states allow the larger sizes, we chose a 44,000 size load to use in our least cost transportation model. Similarly, a relatively wide range of transportation rates were identified. We chose a low rate of $1.00/mile for higher quality alfalfa and $1.65/mile for lower quality alfalfa for use in the transshipment model.

Japan is the dominant export market for alfalfa, followed by Korea and Taiwan (Ford 1996). In these countries, double-compressed bales...
were the preferred bale size with continued movement in recent years to
double-compressed bales on pallets or in unitized shipments. Exporters
indicated that a bright green color for alfalfa hay is most important to
Japanese buyers, while Korean and Taiwanese buyers place more
emphasis on price.

Alfalfa is transported to export markets in 40-foot ocean containers.
Exporters said freight rates varied according to source and destination
port but exports to Japan cost about $55 to 60 per ton. For the
transshipment model, we chose an export ocean freight rate to Japan of
$55 per ton.

**Least-Cost Transshipment Models**

Several linear programming models were estimated using GAMS
(General Algebraic Modeling System) software (Brooke, Kendrick, and
Meeraus 1988). In all cases, the model found a least-cost movement of
alfalfa from production to consumption regions given the assumed set of
transportation costs. Selection of production points and consumption
points within each region were based on the authors' judgement. Pri-
mary consideration was the concentration of alfalfa production and
dairy cattle from census data for each state.

One model more than others was believed to most accurately reflect
the current alfalfa production, consumption, and transportation system.
Two qualities of alfalfa were assumed (Willett 1983). A survey of the
same agronomy specialists as discussed earlier was conducted to esti-
mate the percentage of alfalfa produced on average across states that
would be considered “dairy quality.” We defined dairy quality alfalfa as
alfalfa with a crude protein (CP) of 20 percent or more or a relative feed
value (RFV) of 150 or more. The average response for the 16 agronomist-
respondents was 33 percent. Therefore, in the model we assumed that
33 percent of each state’s total alfalfa production was dairy quality. The
model allowed dairy quality alfalfa to satisfy alfalfa demand by dairy
cattle with a domestic transportation freight rate of $1.00/mile. We
assumed that dairy quality alfalfa would be harvested in larger bale
packages thus enabling lower cost handling and transportation. Dairy
quality alfalfa also was allowed to satisfy the international demand for
alfalfa. Any dairy quality alfalfa remaining after satisfying the demand
by dairy cattle and the international demand could be used to satisfy the
alfalfa demand by other species and be shipped at the same domes-
tic rate. Lower quality alfalfa was allowed to satisfy only the demand by
other livestock species and a transportation rate of $1.65/mile was
assumed. Much alfalfa of lower quality is harvested in less efficient bale
packages for handling and long-distance transport.
Results from Least-Cost Alfalfa Transshipment Models

Two figures are included in this article, one showing the least-cost movement of higher quality alfalfa for dairy cattle (Figure 2) and the other showing the least-cost movement of lower quality alfalfa for other livestock species (Figure 3). Results are for 1995. An overview of the two figures shows that more higher quality alfalfa moves longer distances than lower quality alfalfa.

Implications for Marketing Alfalfa from Oklahoma

Two applications of the two-quality model illustrate how the model might be used to assess market potential for alfalfa for an individual state, Oklahoma in this case. First, alfalfa production in Oklahoma was increased 20 percent above the 1995 production level, assuming a constant 33-67 percent split between higher and lower quality alfalfa, respectively, and no change in demand. This first alternative was to consider a supply change effect. Second, demand for alfalfa in Texas, the largest alfalfa-demand state and one of Oklahoma’s neighboring states, was increased 20 percent above the 1995 level, assuming no change in alfalfa production.

Results for an assumed 20 percent increase in Oklahoma alfalfa production are interesting in that total exports from Oklahoma increase, but the composition of exports changes. In the base model, Oklahoma ships 433 thousand tons of high quality alfalfa and 95 thousand tons of lower quality alfalfa to Texas for the Texas dairy demand. Another 1,006 thousand tons of lower quality alfalfa remain in Oklahoma to satisfy the alfalfa demand for non-dairy livestock.

With the assumed 20 percent increase in production, Oklahoma ships significantly more alfalfa to Texas, both for the dairy and non-dairy demand in Texas. The model indicates that 572 thousand tons of high quality alfalfa are exported to Texas to satisfy the dairy demand in Texas. Another 823 thousand tons of lower quality alfalfa are shipped to Texas to satisfy non-dairy demand, while 338 thousand tons remain in Oklahoma to satisfy its non-dairy demand for alfalfa.

Therefore, a 20 percent increase in Oklahoma’s alfalfa production, ceteris paribus, results in more alfalfa, both higher and lower quality, being exported to Texas than in the 1995 base model. This suggests that increases in alfalfa production would likely increase alfalfa exports to Texas, but not all at dairy-quality alfalfa prices.

If the Texas demand for alfalfa increased 20 percent (uniformly for dairy cattle and other livestock species), from where would the increased supplies be met? The demand for high quality alfalfa in Texas for the base model is met by Kansas, New Mexico, and Oklahoma. With
Figure 3. Shipments of Lower Quality Alfalfa, 1995

(1,000 Tons)
increased demand in Texas, Colorado also becomes a supplier of high quality alfalfa to satisfy the Texas demand for high quality alfalfa, more is shipped from Kansas, and less is shipped from Oklahoma. Some higher quality alfalfa from Colorado also is imported into Texas for its non-dairy demand. For lower quality alfalfa, suppliers of the Texas demand in the base model are Kansas, New Mexico, Oklahoma, Arkansas, Illinois, Iowa, and Missouri, along with Texas. With a 20 percent increase in demand, new supplier states of lower quality alfalfa to Texas include Nebraska and Wisconsin. Reduced shipments are noted for Kansas, Illinois, and Oklahoma. Thus, for Oklahoma, a 20 percent increase in alfalfa demand in Texas is not a significant benefit. Shipments from Oklahoma to Texas are reduced, both for higher quality and lower quality alfalfa. However, one caveat should be noted. We assumed a 20 percent increase in alfalfa consumption, both for higher and lower quality alfalfa. Model results would change had we assumed only an increase in dairy quality demand for alfalfa in Texas.

Similar models with varying changes in alfalfa production and/or demand could be run for other states. In addition, changes could be made to our base model in terms of percentage distribution of high and low quality alfalfa, average daily consumption rates by species, fixed exports to Japan or other countries, domestic and international transportation rates, etc.

**Summary and Conclusions**

Marketing continues to be a concern to alfalfa growers in Oklahoma and elsewhere. This study identified the leading states in alfalfa production, estimated the leading states in alfalfa consumption, both for higher and lower quality alfalfa, and developed a model to estimate the least-cost movement of alfalfa under various supply-demand and transportation rate conditions. Application of the model to determine the market potential for Oklahoma-produced alfalfa was illustrated. Several assumptions were made in developing the model because of voids in data and information. These assumptions were necessary in this model but all represent potential areas of further research and refinements to the models developed in this study.

The most realistic model used two qualities of alfalfa, higher quality for dairy cattle and lower quality for other livestock species. Higher quality alfalfa was assumed to be harvested in larger bale sizes and shipped at a lower transportation rate than lower quality alfalfa. Results of the model confirmed what one would have anticipated in some cases and produced some less obvious results. Higher quality alfalfa harvested and shipped in more efficient bale sizes moves longer distances than lower quality alfalfa harvested and shipped in less efficient
increased demand in Texas, Colorado also becomes a supplier of high quality alfalfa to satisfy the Texas demand for high quality alfalfa, more is shipped from Kansas, and less is shipped from Oklahoma. Some higher quality alfalfa from Colorado also is imported into Texas for its non-dairy demand. For lower quality alfalfa, suppliers of the Texas demand in the base model are Kansas, New Mexico, Oklahoma, Arkansas, Illinois, Iowa, and Missouri, along with Texas. With a 20 percent increase in demand, new supplier states of lower quality alfalfa to Texas include Nebraska and Wisconsin. Reduced shipments are noted for Kansas, Illinois, and Oklahoma. Thus, for Oklahoma, a 20 percent increase in alfalfa demand in Texas is not a significant benefit. Shipments from Oklahoma to Texas are reduced, both for higher quality and lower quality alfalfa. However, one caveat should be noted. We assumed a 20 percent increase in alfalfa consumption, both for higher and lower quality alfalfa. Model results would change had we assumed only an increase in dairy quality demand for alfalfa in Texas.

Similar models with varying changes in alfalfa production and/or demand could be run for other states. In addition, changes could be made to our base model in terms of percentage distribution of high and low quality alfalfa, average daily consumption rates by species, fixed exports to Japan or other countries, domestic and international transportation rates, etc.

Summary and Conclusions

Marketing continues to be a concern to alfalfa growers in Oklahoma and elsewhere. This study identified the leading states in alfalfa production, estimated the leading states in alfalfa consumption, both for higher and lower quality alfalfa, and developed a model to estimate the least-cost movement of alfalfa under various supply-demand and transportation rate conditions. Application of the model to determine the market potential for Oklahoma-produced alfalfa was illustrated. Several assumptions were made in developing the model because of voids in data and information. These assumptions were necessary in this model but all represent potential areas of further research and refinements to the models developed in this study.

The most realistic model used two qualities of alfalfa, higher quality for dairy cattle and lower quality for other livestock species. Higher quality alfalfa was assumed to be harvested in larger bale sizes and shipped at a lower transportation rate than lower quality alfalfa. Results of the model confirmed what one would have anticipated in some cases and produced some less obvious results. Higher quality alfalfa harvested and shipped in more efficient bale sizes moves longer distances than lower quality alfalfa harvested and shipped in less efficient
bale sizes. The lower quality alfalfa tends to satisfy more localized demands or moves shorter distances between states. In general, alfalfa moves from alfalfa surplus states in the north and west to alfalfa deficit states in the south and east. The two-quality model illustrated the need at times to ship alfalfa in cross directions. Higher quality alfalfa may move in one direction to satisfy a large dairy demand in one state, while lower quality alfalfa may simultaneously move in the opposite direction to satisfy non-dairy demand.

References


