The Value of Forages in a High Commodity Price Environment

A Report Prepared by:

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For

The Ontario Forage Council

with funding from the Farm Innovation Program (FIP)

Agricultural Adaptation Council

Third Draft

February 6, 2012

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A. Executive Summary

With today's high prices for commodities like corn and soybeans, forages are being dropped out of crop rotations. Many producers are not aware that hay prices have also risen to historic levels due to high demand and reduced supply in the U.S. and globally. Do forages still have a place in sustainable crop rotations?

On an annual basis it costs roughly half as much to produce an acre of hay as it does to produce corn on that same land ($242 vs $539). With a hay yield of 3.5 tonnes the current net return can be similar to a 160 bushel corn crop. Depending on the legume level a hay crop can contribute up to $70 worth of nitrogen to a following corn crop. A yield increase of 5 to 20% in corn following a forage crop can be noted. In today's market that is worth an additional $ 48 to $ 192, plus there would also be some benefit into the second year of corn.

The most frequent purchasers of Ontario hay are dairymen and horse owners in Ontario and the eastern U.S. It is vital to establish the requirements of the customer for quality and bale size before attempting to market hay. Factors such as plant species and stage of maturity affect the type and quality of hay that is produced and must be considered when planting forages.

Forages also bring improvements in areas such soil quality and health, reductions in herbicide resistant weeds and increased carbon sequestration. These benefits last for several years after the forage crop is taken out.

Forages have a definite place in crop rotations even with today's high commodity prices.

B. Foreword

''Having forages in my crop rotation as compared to just growing row crops is like driving a 4 wheel ATV versus a 3 wheeler. The inclusion of forages makes a much more stable rotation that works better for me and my farm in the long run.''(F. Trautsmandorff,1)

This quotation neatly summarizes the motivation of the Ontario Forage Council in initiating this report. It is possible in times of high commodity prices for some producers, especially those with short memories, to overlook the long term benefits of keeping forages in their rotation.

For the purpose of this report forages will be defined as legumes and grasses but not corn for silage. References are provided in section (H) in the order that they appear in the report.

C. Value of forages as a cash crop

i. Current markets for Ontario forages

Canada exports between 400 and 700,000 tonnes of hay and other forms of forages per year. Japan is the largest consumer of Canadian forage exports, with the U.S. being second and Korea third. China is rapidly expanding its imports of hay and may become an important market. The Middle East is also a major importer with the UAE currently purchasing hay from Canada. Saudi Arabia is expected to become a major importer in the next few years.

At the present time Ontario does not have the infrastructure or industry scope to ship to these markets. Western Canada has a significant freight advantage to the Far East so that is unlikely to ever become a market to Ontario hay.

The major markets for Ontario hay currently are within Ontario and the United States. Since exports of hay to the U.S. are not inspected or monitored by the Canadian government the statistics on exports to the U.S. are of doubtful reliability. U.S. hay stocks are reported as being the lowest they have been since 1988 due to the drought in the southwest in 2011. Although Ontario hay is unlikely to be shipped to the southwestern U.S., the low stocks increase demand across the country. There is also increasing global demand for hay from both the Middle East and China. These factors have driven hay prices to historically high levels.

There are 3 major markets for hay in both Ontario and the U.S., dairy, horses and other livestock farms.

a: Dairy

Dairy producers purchase hay for one of three purposes:

- As a high quality nutrient source to replace other sources of protein and energy. These producers are interested in high protein, high Relative Feed Value (RFV) hay (see section E for more details on terminology). RFV is the main criterion on which hay trades in the dairy market in the U.S.
- As a fiber source to ensure good rumen health in high producing cows. Some of these herds will use straw or grassy hay interchangeably depending on price and supply. These herds prefer mature hay with little or no legume content. The hay will generally be fed at approximately 1 kg per cow per day.

- As a source of low potassium forage for close up dry cows. This can be an important part of a successful herd health program to ensure that cows calve and successfully begin a new lactation. Hay for this market will have little or no legume content.

b. Horses

The second major market is the horse industry, which is virtually unlimited if quality is acceptable. There are over 350,000 horses in Ontario in operations ranging from one or two animals, to commercial boarding and training facilities with several hundred animals, to race tracks with may house over a thousand. The U.S. has many more horses spread across similar types of operations.

Horse owners are much more concerned about the physical attributes of hay rather than the chemical composition. Colour and freedom from mould and dust are the primary criteria. The proportion of grass to legume is also important depending on the type of horse being fed. At present there are no accepted tests for these attributes so the decision is made based on a physical examination of the forage. Further details on quality standards for horse hay are described by J. Bagg in reference (2).

c. Other livestock

There is a significant beef cattle industry in Ontario which consumes a major share of forage production. Although the majority of these producers produce their own forages some will make some purchases for specialty needs. There is also a growing dairy goat and sheep industry which has specific forage needs.

ii. Factors influencing forage quality

The three main factors influencing forage quality are weather, stage of growth and the proportion of different plant species.

Weather

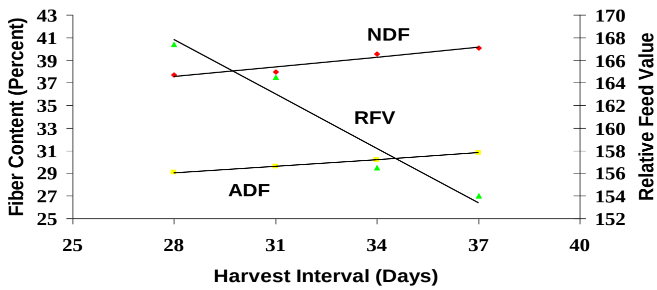
Obviously producers cannot control the weather, but the recent move to wide swathing forages has reduced the time required between cutting and harvest for silage or dry hay.

More detailed information on wide swathing is available (3).

Stage of Growth

There is a difference between grasses and legumes in the rate at which their quality declines with stage of growth. Figure 1 shows the change in RFV of alfalfa as the cutting interval increases.

Figure 1
Effect of Harvest Interval on Alfalfa Quality...



Proportion of different plant species

Grasses start out at higher feed value than legumes when immature but decline more quickly as they mature. This results in a greater range of digestibility (NDFD) values for grass forages than legumes as illustrated in Figure 2. (For more information on the use of NDF digestibility as a measure of forage quality see section E(i). It is a measure which indicates how much energy that livestock can derive from the forage)

Figure 2: Range of NDFD values in forages

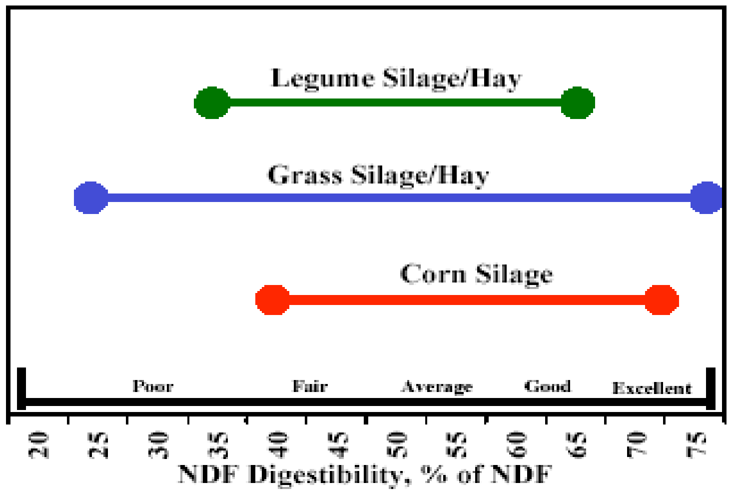


Figure 2. Ranges of NDF digestibility for common forages. The NDF digestibility ranges and guidelines are based on a 48 h in vitro true dry matter digestibility assay. (Marshfield Soil and Forage Analysis Laboratory, University of Wisconsin-Madison: 2001 Nutrient Requirements of Dairy Cattle).

Forage quality in pastures

The previous discussion has focussed on harvested forages. There is a renewed interest in grazing forages from economic and animal welfare perspectives. Forage quality is also very important for grazing and is summarized in the following quotation from J. Kyle, OMAFRA grazing specialist (4):

''The key to maximizing both forage and livestock production is to manage the forage for optimum growth and optimum bite size for the animals grazing. If the grazing animal cannot get a big bite of quality forage, then production is going to suffer. When we feed stored feed, great effort is made to have optimum forage quality with appropriate length and excellent palatability. Pasture managed with the same diligence that is given to managing a feed bunk will give excellent returns. In the pasture situation you are not only managing animal intake, but also managing the forage growth to optimize yield and quality.''

iii. Factors required to maximize value from hay sales

Since the markets outlined in section (i) have different selection criteria, there is no one set of standards for saleable hay. For offshore markets hay trades in lots of 10,000 tonnes so there would need to be suitable infrastructure in place to acquire, assemble and process large quantities of hay in one location. The Ontario Forage Council is currently conducting a feasibility study on locating a hay compressor in Ontario to process hay for export.

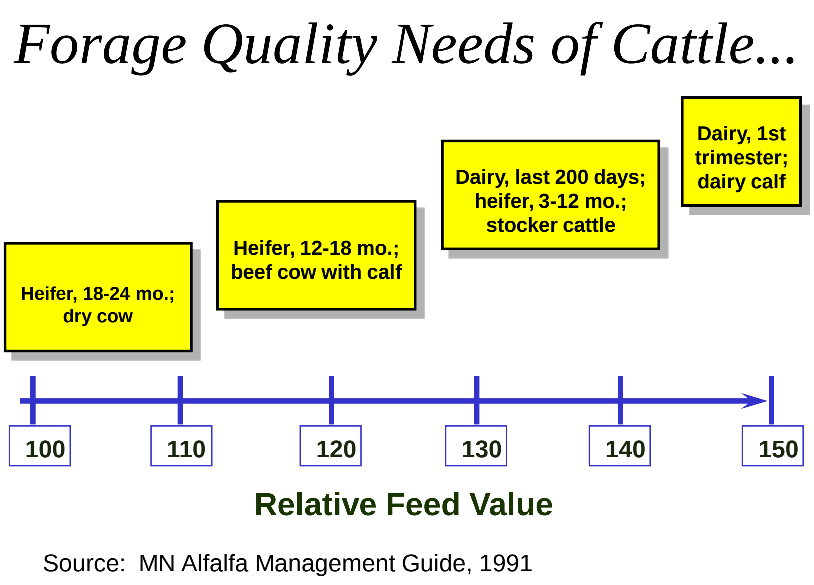
For domestic and U.S. markets the producer needs to talk to the intended client or broker to determine their purchasing criteria. Having a consistent supply of hay of any given quality is necessary to develop a sustained market. Most dairy producers will require a chemical analysis of hay, especially if they are using it for the first or third purposes outlined earlier.

A producer with a larger acreage of hay will generally have fields at different stages in their life cycle with varying legume and grass content. By segregating these fields, as well as the different cuts, the producer will be able to satisfy several market niches.

A major exporter of hay to the U.S. (D. Rowntree, 5) emphasises that consistent quality of hay is vital for exports. When competing with nice green hay from irrigated areas like Nebraska, even a few bales of hay that are off quality in appearance can cause the rejection of an entire load.

The forage needs of cattle in different production stages are shown in Figure (3)

Figure 3: Forage needs of different cattle types



Although not as well defined, different classes of horses also require different types of hay. Brood mares, growing foals, high performance horses and mature horses used for light recreational use are the major categories. The requirements for energy and protein range from quite high to very low, but all require that the hay be free of dust and mould. It is vital to talk to a potential client to determine the needs of their stock before attempting to market hay to them. The sheep and goat markets also put a significant emphasis on freedom from dust and moulds.

The other major factor in meeting market needs is size and type of bale. Hay producers prefer to produce large square or round bales for ease of handling and speed of harvest. Many smaller customers are not equipped to handle large bales and round bales are very difficult to ship any distance. F. Trautsmandorff has solved this problem by installing equipment that converts large square bales to small squares. As stated earlier it is critical to determine the needs of the end user to maximize value from hay sales.

iv. Economic comparison of forages to other cash crops

The values in Table 1 are derived from the 2012 OMAFRA crop budgets (6). They are for illustration purposes and reflect market conditions as of January, 2012.

Table 1: Calculated net returns for corn and alfalfa (per acre)*

Item	Corn (Conventional Tillage)	Alfalfa (After establishment Year)
Seed	103.6	0
Est year cost**	0	24.35
Fertilizer	123.85	59.35
Pesticides	13.05	0
Tillage	49.75	0
Tractor & Machine exp	0	37.25
Planting	19.9	0
Spraying	10.2	0
Fertilizing	10.2	20.45

Harvesting & Trucking	76.9	0
Baling, wrapping	0	61.7
Drying	75.2	0
Operator labour	0	26.25
Crop Insurance	13.45	7.9
Interest @ 4 %	9.55	5
Marketing & other	32.95	0
Total costs (excl rent)	538.6	242.25
Expected yield (tonnes)	4 (160 bus)	3.5
Price/tonne $	240 ($6/bus)	198 (8 cents/lb)
Gross return $	960	693
Net return	421.11	450.75

*Slightly different criteria are used for each crop. A zero in a column indicates that no value was calculated for that line for that crop

**Establishment year costs less hay sales that year, divided by 4

Based on these figures hay can be very competitive with corn as a cash crop even at today's high corn prices. Many cash crop producers would not have the equipment necessary to harvest and store hay but there are many custom operators available to perform these tasks. Another perspective on the relative value of different crops comes from a commercial hay producer, F. Trautsmandorff (1). He indicates that for hay to be competitive with corn as a cash crop the hay must be worth 1.3X the price of corn. With corn at $240/tonne ($ 6.00/bus) hay would need to sell for $ 312/tonne to be competitive.

v. Producing hay as a cash crop

Is hay production as a cash crop for you? An excellent summary of issues relating to this question from the Manitoba Forage Council are provided in Table 2 (7):

Table 2: Advantages and disadvantages of producing hay as a cash crop

Advantages

- A good option for diversification.
- Less inputs.
- Good residual effects of nitrogen in the soil if crop is taken out.
- Less acreage required than cereal for same income (better returns per acre).
- Protection from wind and water erosion.
- Spreads workload out over the entire growing season.
- Provides summer employment for older children.
- Potential for excellent returns

Disadvantages

- Initial equipment investment is high.
- Steep learning curve; potential for mistakes.
- Ties up the entire summer.
- Long hours.
- Crop insurance currently does not address export alfalfa.
- Narrower window than grain for harvest.
- Low quality in poor growing years makes crop hard to sell.
- Need something to utilize lower quality end of crop each year.

D. Value of forages from an agronomic and environmental standpoint

(i) Benefits for soil structure

The benefits that forages have on soil structure were summarized very clearly and concisely by B. Ball (8). This article is reproduced here with additional supporting data.

(*Start quote*) The benefits that growing forages have on soil were clearly demonstrated during this year's challenging growing season. Pounding rains, flooding, and traffic too soon, caused crusting and compaction of some soils in the spring of 2011. With root growth limited and shallow, crops were water and nutrient deficient where dry weather followed. Forages help soil resist damage from adverse conditions. With forages, soil has better tilth and more resilience against structure breakdown. The tendency for crusting and compaction is less; drainage, capacity to hold water, and root growth are improved with forages.

How it works

a. Soil Stability

Soil after forage is more stable. Forages increase biological activity. There are more roots, more microbes, and more soil animals, such as worms. Fibrous roots of grasses promote granular structure. Root exudates, hyphae of fungi, and slimes from bacteria and worms, glue soil particles together. They form water stable aggregates. Water stable aggregates are granules that resist destruction and erosion. In the years after the forage, the water stable aggregates help soil resist breakdown and erosion as shown in Table 3 (9).

Table 3. Effect of forage crops in rotation on aggregate stability - Haldimand clay

Cropping System	**Water-stable Aggregates >0.25 mm (%)**	**Corn Yield (%)**
Corn, oats, hay, hay rotation	74*	100
Continuous corn	22	90

* Measured in the second hay crop of the rotation

In the years when the forage is grown, continuous ground cover and intact roots prevent erosion. Over the rotation, a 60 to 70% reduction in erosion is typical. Less erosion means more topsoil and better soil quality.

b. Porosity

Large deep pores created by forage roots and soil animals improve infiltration and drainage. These deep pores allow excess water to drain away quickly because water above field capacity is held at low tension in large pores. While large pores facilitate drainage of water at very low tension, tiny pores created inside the aggregates by organic matter and microorganisms hold plant available water at higher tension during drier times. Increased water retention or holding capacity means that soil is less droughty.

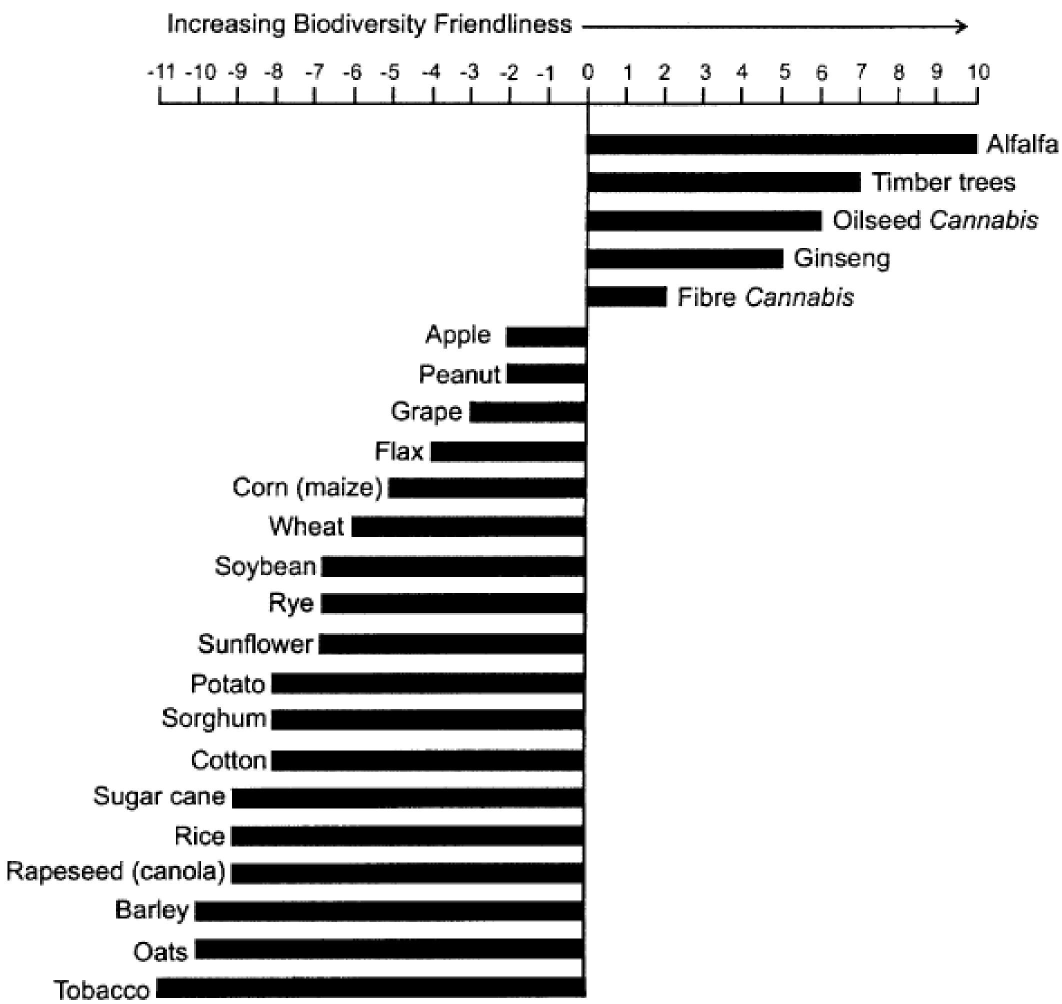
c. Root room

Crops after forages have more ‘root room’. Tap roots of legumes such as alfalfa, help break up plow-pans and create channels. The root channels remain in the subsoil for several years. Roots of subsequent crops use these channels to explore deeper layers. Earthworm pores are also re-used by crop roots.

d. Root health

Crops following forages have healthier roots because of fewer pathogens. When the host crop is not present the number of pathogens decreases. Rotating into forages also enables beneficial organisms to consume pathogens. Fewer pathogens help subsequent crops to cope with adverse weather conditions. Forages rank highly in biodiversity. A study that assessed 21 major crops over 25 different criteria defining ecologically friendliness, ranked alfalfa the most biodiversity-friendly out of all the crops (see Figure4)(10).

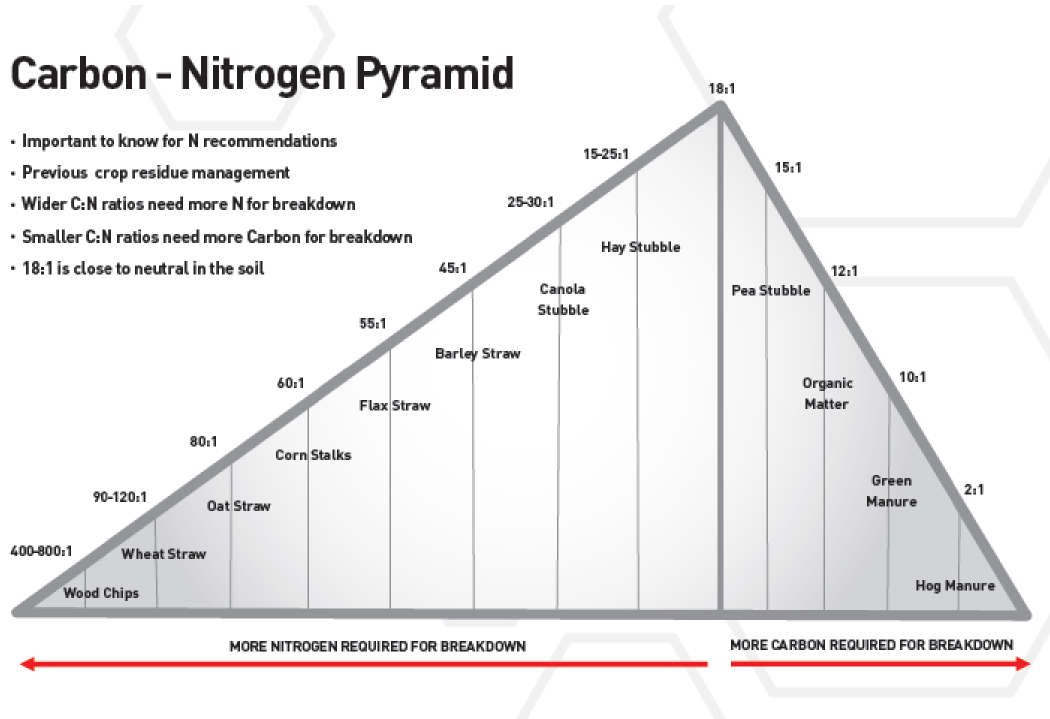
Figure 4. Crude mean evaluation of biodiversity friendliness of selected major crops and fibre and oilseed *Cannabis.*



e. Nutrient availability

After a forage crop soil has better nutrient availability. This is a result of more abundant and healthier crop roots, and the addition of high quality residues. The narrow carbon to nitrogen ratio typical of forage residues increases active organic matter and easily mineralizable nitrogen. (This is illustrated graphically in Figure 5)(11). Other crop residues like corn stalks and grain straw actually reduce available nitrogen in the following year due to their wide carbon:nitrogen ratio. Reduction in nitrogen fertilizer requirement is up to 112 kg/ha (100 lb/ac). Higher organic matter also increases availability of phosphorous, sulphur and some micronutrients.

Figure 5: Carbon – nitrogen ratios of different crop residues



f. Soil Health Summary

Under average conditions, yield increases range from 5 to more than 20% in the case of corn after alfalfa, with effects lasting into the 2nd year of corn. Adverse conditions, such as beating from rains or other forces, are better tolerated by soil with forage in the rotation. The soil environment is more conducive to healthy crop root growth due to physical and biological changes. Soil holds more water, but drains quicker. Extremely wet or dry weather has less impact on crops. (*end quote).*

g. Soil Compaction

As mentioned previously 2011 was a year when soil compaction was a major issue. A recent article on this topic (12) contained the following quotation:

‘Alfalfa is another crop that will help break up compaction if it can be worked into a management system, adds Doug Aspinall. Alfalfa will push down through the compacted layer the OMAFRA land resource specialist says. If left for a few years a strong rooted plant, such as alfalfa, will begin the process of restoring soil structure to the compacted layer’.

(ii) Value to following crops in rotation

A University of Guelph (W. Deen et al, (13)) study examined the impact of alfalfa and red clover in a number of different rotation scenarios as summarised in Table 4. The figures are based on 20 years of data under Ontario growing conditions. Red clover was under seeded in either barley or wheat and not harvested as forage. The alfalfa was harvested as a forage crop.

Table 4: Rotation and tillage effects on first and second year corn

Rotation	1st Year net revenue $/ha	2nd Year net revenue $/ha	2 Year total net revenue $/ha
C-C-C-C	73	107	180
C-C-B-B	113	85	198
C-C-Brc-Brc	94	99	193
C-C-S-S	80	68	148
C-C-S-W	82	79	161
C-C-S-Wrc	86	89	175
C-C-A-A	112	130	242

C=Corn, B=Barley,rc=underseeded red clover, S=soybeans, W= winter wheat, A=alfalfa

The results indicate that the rotation including alfalfa was competitive with the other rotations in the first year corn crop and yielded the highest revenue, by a substantial margin, in the second year and over the 2 years combined. The authors also noted that the revenue from the more complex rotations was less variable, reinforcing the comment made by Trautsmandorff at the beginning of this paper.

A similar conclusion was reached in a study in Wisconsin using different price scenarios in an economic simulation as shown in Table (5) (14). In this study E represents the establishment year for the alfalfa crop and C represents corn which was harvested for silage. The study assumed that the producer had 210 acres of land available for crop production.

Table 5:
Income, Costs, and Profit ($) per Acre for Selected Rotations

Rotation	Gross Income	Direct Costs	Fixed Costs	Total Costs	Profit
EAAAACCC	350.24	168.72	121.84	290.57	59.67
EAAAACC	359.13	158.32	121.95	280.27	78.86
EAAACC	364.90	167.23	122.46	289.69	75.21
EAACC	361.49	179.70	123.19	302.89	58.60
EAAC	379.87	164.25	123.70	287.95	91.91
EAC	360.01	184.04	125.32	309.36	50.65

The 4-year rotation is the most profitable.
The 3-year rotation is the least profitable.

These studies confirm the statement in section E(i) that corn following alfalfa will show a yield increase of 5 to 20 %, often into the second year.

Another author actually calculated the N credits that would be available to the following crop following various forage crops as shown in Table (6) (Jokela and Russelle, 15).

Table 6 Nitrogen credit for various forages

Crop	Stand Density	Typical	Range	$ @.40	$ @.80
		lb/acre		$/acre	
Alfalfa	Good	130	110-150	52	104
	Fair	100	70-120	40	80
	Poor	70	40-90	28	56
Red Clover /Trefoil	Good	90	80-120	36	72
	Fair	70	60-90	28	56
	Poor	50	40-70	20	40
Grass	Good	70	---	28	56
	Fair-Poor	40	---	16	32
2nd Year		50	0-75	20	40

[1]Extension recommendations from WI, MN, PA, and VT. Costs are per lb of fertilizer N.

Ontario data are summarized in the crop budgets outlined in Publication 60 crop recommendations as shown in Table 7 (6).

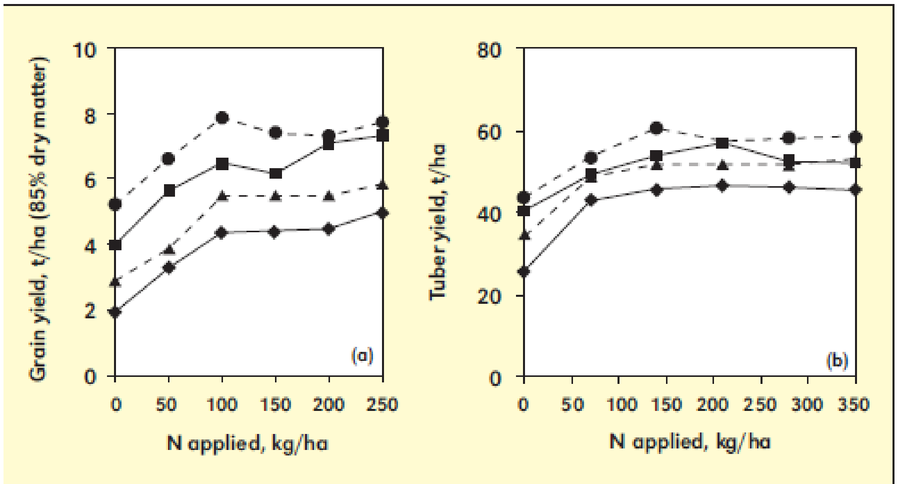
Table 7. Adjustment for nitrogen requirement to crops following a legume crop

Type of Crop	N Requirement Reduction (lb/ac)	
	Corn	N Value $*
Less than 1/3 legume	0	0
1/3 to 1/2 legume	48	35
1/2 or more legume	97	70
Perennial legumes seeded/ploughed in same year	70.4	51
Soybean and field bean residue	26.4	17

*Using a value of $0.72/lb for N

Johnston (16), in England examined the effects of 3 different soil organic matter (SOM) additions on the yield and N responsiveness of wheat and potatoes. As shown in figure 6 plowing down a grass clover mix gave the highest yield with no applied N and at each level when N was applied.

Figure 6: Impact of different soil treatments on wheat and potato yields



Treatment and % SOM: No organic amendment, 0.65% SOM (◆); incorporating straw, 0.85% SOM (▲); adding FYM, 1.06% SOM (■); incorporating a grass/clover ley, 0.90% SOM (●).

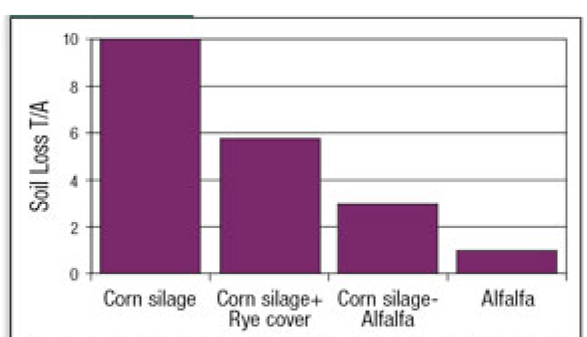
(FYM = Farm yard manure)

(iii) Environmental Benefits

a. Reduced soil erosion

As outlined in section E(i) growing forages reduces soil erosion as compared to row crops. This has the benefit of not only reducing soil loss but also reducing nutrient transfer, especially of phosphorus, into waterways. This is shown graphically in Figure (7) which is taken from reference (9).

Figure 7 Effect of crop type on soil loss



Cropping system effect on soil loss. Rotation is 2-yr corn and 3-yr alfalfa. Estimates by Brian Hillers, USDA-NRCS, were based on the RUSLE2 equation for a Miami silt loam soil in Dodge County, WI.

b. Carbon sequestration

Another benefit is the increased sequestration of carbon as outlined in the following quotation from Meyer-Aurich et al (17)
'Integration of alfalfa into a corn rotation can mitigate more than 2000 kg CO_2 eq ha^{-1} per year. Even though legumes contribute considerably to the emissions of GHG by fixing nitrogen in the soil, these emissions are more than offset by reduced emissions from less fertilizer use, the reduced induced emissions from manufacturing the fertilizer and increased carbon sequestration in the soil. This cropping practice seems to be a win–win situation since it provides benefits for the farmer and the environment.'

c. Species at risk

Recent Species at risk legislation in Ontario has highlighted the importance of forages in providing habitat for certain bird species. A recent press release (18) reports on a farm that is able to support bird habitat while providing high quality forages to their beef cow herd.

d. Prevention and/or reduction of herbicide resistant weeds

There are two ways in which forages can have this effect. Due to frequent cutting of forages before plants go to seed, the soil bank of weed seeds is reduced. Established forages can generally out compete weeds and prevent the development of plants after germination. The other effect is that by using different, or no herbicides as compared to growing row crops, the opportunity for herbicide resistance to develop is reduced. A producer in Manitoba, as reported in (19) reduced the population of herbicide resistant wild oats by 96% by changing his crop rotation to include 3 years of alfalfa in a 6 year rotation.

e. Pollination of other crops

Forage crops serve as a reservoir for bees and other beneficial insects which pollinate crops such as canola. A report from Saskatchewan (20) summarized research indicating that this could be worth as much as $ 23 per hectare of forage crops.

f. Rotation benefits summary

The benefits of a good crop rotation including forages are summed up by T. Kilcer (21).
'The other rotation limitation is that it takes effort to implement. This is where that bottom field produces nice corn so we leave it in year after year. Costs meanwhile skyrocket as we have to buy ever more expensive stacked varieties to control all the pests that attack it. Nutrients get further out of line as manure is poured on in an attempt to maintain yields. Weather seems to take an ever bigger chunk out of production as it is too wet, or too dry, but rarely just right. Meanwhile the cost of producing forage has crept up, robbing you of potential profit in high forage diets. Across the road, the upland field is in "alfalfa" for 7 – 8 years. It is 98% alfalfa on 5% of the field yet it remains because we are too busy to figure how to get more forage off of it. You can't buy the benefits you get from rotation.'

E. Value of forages and importance of forage quality in commercial livestock operations

(i) Measurement of forage quality

Laboratory analysis is the only way to get a true assessment of the quality of forages. Analyses using wet chemistry, where the samples are put through an actual chemical process, are considered the ''gold standard''. In recent years the technology called Near Infrared Spectroscopy (NIRS) has been developed as a much faster and more inexpensive method of determining nutrient content. It is most accurate when the composition of the sample is clearly identified and works better for some components than others.

The results of lab tests are only as good as the samples that are submitted. It is important that representative samples are collected and properly stored. Detailed guidelines for sampling are available (22).

The most common analyses, and comments on them are as follows:

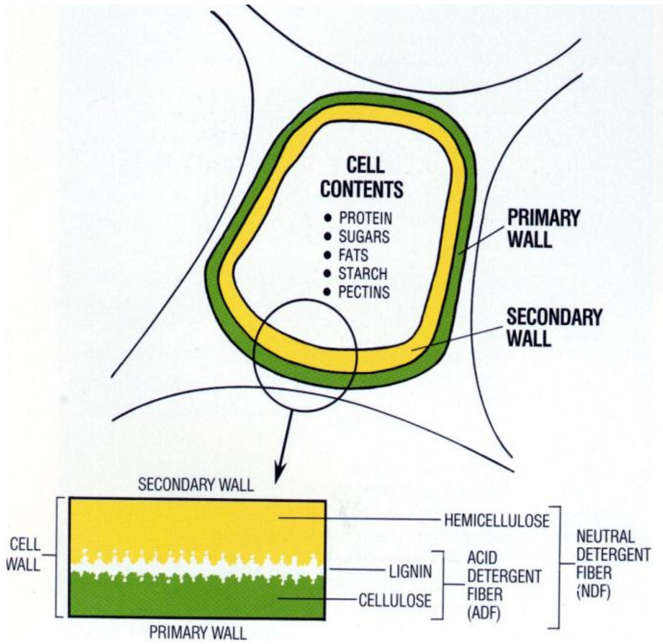
Protein: Crude protein is the most common and most discussed forage analysis. It indicates the amount of protein that will be available to the consuming animals and is affected by a number of factors that will be discussed later. There are 2 important additional aspects of crude protein content which should be considered:

Soluble protein: very immature forages will have a high content of soluble protein. Depending on the type of animal that the forage is being fed to this can be a positive or negative factor. A qualified nutritionist can best determine how to utilize this factor.

Bound protein (also called ADF protein): If forages are subjected to excessive heating during the curing or ensiling phase some of the protein may be heat damaged or bound to the ADF fraction . This could render some or all of this protein unavailable to livestock.

Fiber: The common and useful fiber analyses are for Acid Detergent Fiber (ADF) and Neutral Detergent Fiber (NDF). The structure of a plant cell and the location of the various fiber fractions are illustrated in figure 8.

Figure 8. Illustration of plant cell structure



NDF: This is the fraction of the plant left after the sample is processed through a neutral detergent, somewhat like what occurs in the rumen. The fraction that is removed during this test is the Neutral Detergent Solubles (NDS) which is comprised of the highly digestible cell contents. Some of the NDF is potentially digestible in the rumen depending on how long the forage resides there.

ADF: This is the fraction left after the sample is processed in an acid reagent, similar to what occurs in the true stomach and intestine of a ruminant animal. This fraction is largely indigestible and will pass out in the manure.

NDFD: As mentioned previously a portion of the NDF is digestible in the rumen and this can play an important role in the amount of energy that animals can derive from the forage. For a detailed discussion of NDFD see reference (23).

Minerals

Several minerals can be analyzed depending on the end use of the forage. One useful additional aspect of calcium analysis is that it can give an indication of the alfalfa content of a forage mixture as shown in Table 8.

Table 8: Estimation of alfalfa content based on calcium level in forage.

.75 % calcium	.85 % calcium	1.00 % calcium	1.25 % calcium	1.40 % calcium
0% alfalfa	16% alfalfa	37% alfalfa	73% alfalfa	95% alfalfa

% legume = (%Ca - .74)/0.00707. Source: Ruppel, K.A. 2001 Pioneer Dairy Update Vol.8, No.5

Ash: Ash content can give an indication of the amount of soil contamination that is present in the sample. This can occur either through improper setting of forage harvesting equipment or a heavy rain after forage has been cut. Since most ash has no nutritional value it dilutes the valuable nutrients.

Relative Feed Value (RFV): This is a calculated value commonly used to summarize the results of the fiber analysis of a forage sample and gives an indication of its value when fed to ruminant animals. The equations used to calculate RFV are shown in Figure 9.

As can be seen from the calculation of RFV the ADF content of a forage is the major indicator of overall digestibility and NDF is the predictor of how much of a forage that animals can consume.

Figure 9:

RFV Regression Equations…..

$$RFV = \frac{\%\,DDM \times \%\,DMI}{1.29}$$

%DDM = 88.9 - (0.779 x %ADF)

64.5% = 88.9 - (0.779 x **31%)**

%DMI = 120/%NDF

3.0% = 120/**40%**

Example with 31% ADF and 40% NDF

$$151\ RFV = \frac{64.5 \times 3.0}{1.29}$$

(100 RFV = Full Bloom Alfalfa)

Note that Crude Protein is not included in this calculation.

Relative Forage Quality (RFQ)

RFV has been used for many years and is still the major value on which hay is traded in the U.S. It has been felt in recent years that since it did not account for the digestibility of the NDF fraction that a more descriptive value was needed. This led to the development of the Relative Forage Quality (RFQ) calculation as shown in Figure 10.

Figure 10:
Proposed new RFV equation (RFQ)…..

- The *proposed* new equation should better predict cow performance:
  - **RFQ = Intake potential *TDN / 16.8 + 39.2**
    - where Intake Potential = (.0086 x body weight / %NDF) + ((**dNDF - lab average dNDF**) *.374)
    - The dNDF is 48 hour dNDF to be consistent with the new NRC.
    - TDN = 2001 NRC TDN equation.
    - The 16.8 factor is to make the new proposed equation a similar mean and range as the previous method.

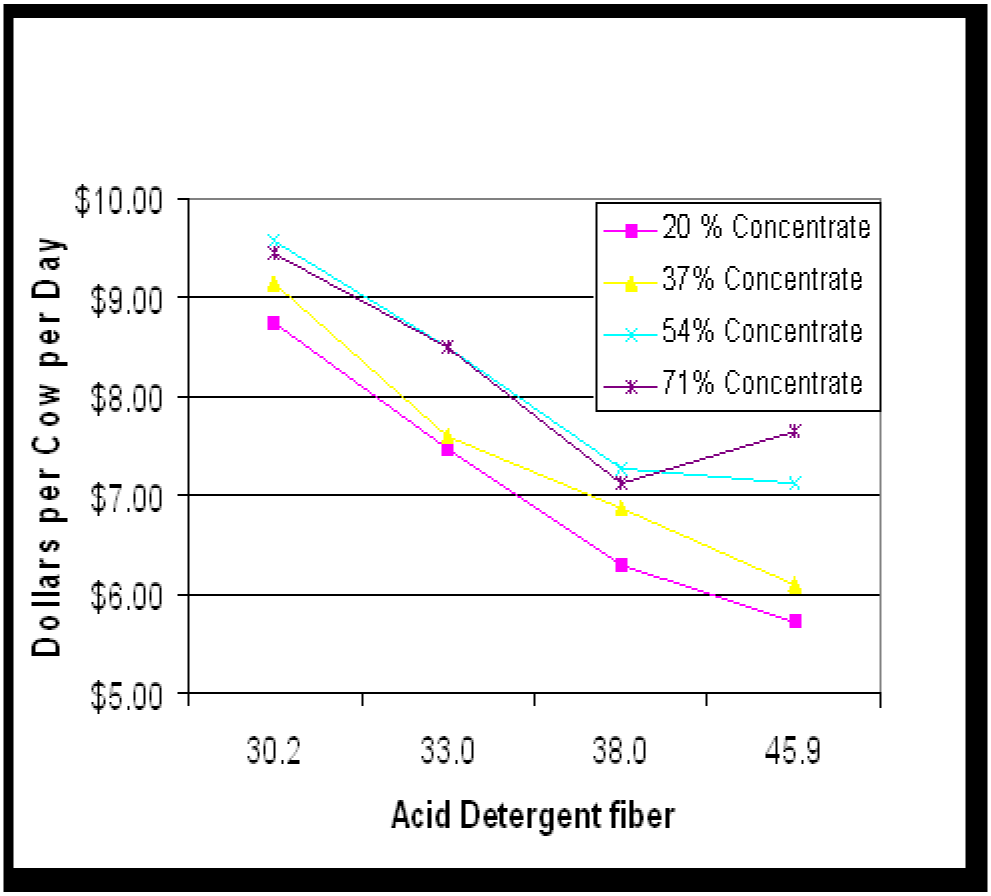
RFQ is used by some nutritionists but since it requires a more detailed and expensive analysis is has not replaced RFV as a common value for evaluating forages.

Milk per acre: The previously mentioned analyses only measure the value of forages after they have been harvested. To determine the value of a forage crop to a farming operation the yield must also be taken into account. Researchers at the University of Wisconsin developed a mathematical model to take into account both forage quality and yield to determine the potential milk production from an acre of forage. This is described in detail on their website (24).

ii. Economic importance of forage quality in feeding cattle

Modern high producing dairy cattle have the highest nutrient needs of any class of livestock and thus respond to forage quality. As shown in Figure 11 regardless of the forage level in the ration there is a decline in net income per cow with declining forage quality (25).

Figure 11: Effect of forage quality on income



A demonstration of the effect of forage quality on dairy ration cost in Ontario is shown in Table 9 (26). Reducing the quality of haylage increased the annual cost of feeding a 100 cow dairy herd by $ 16,000 using current ingredient costs.

Table 9: Effect of haylage quality on ration cost

	Ration with haylage A	Ration with Haylage B
Protein of haylage (%)	23	15.2
ADF of haylage (%)	30	30
NDF of haylage (%)	37	40
Daily ration cost ($)	4.59	4.99

Difference/cow/day ($)		+ 0.40
Difference/year/100 cows ($)		+ 16,000

Beef cattle producers typically rely heavily on forages for economical feeding of growing cattle and cows. Potter (27) points out that while dry matter intake is often calculated as a percentage of body weight, it is the NDF content of a forage that determines how much the animal can consume. A rule of thumb is that growing cattle can consume 0.9% of their body weight as NDF. An average quality forage containing 42% NDF would be consumed at the rate of 15 pounds per day by a 600 pound animal. If the hay were poor quality, containing 62% NDF the same animal could only consume 10 pounds. The difference in nutrient requirement would need to be made up with supplemental nutrients or the animal would gain much less weight.

F. Summary

Historically high prices for commodities like corn and soybeans have lead to some reduction in the acreage devoted to producing forages. This trend is occurring in spite of hay prices that are also at historic levels due to increased demand in the U.S., due to drought conditions, and internationally, due to growth in demand from growing dairy markets and changing government policies. In this report it is shown that hay can be competitive with cash crops from an economic standpoint and that it has long term benefits for soil health and the environment.

The major markets for Ontario hay are within Ontario and in the eastern U.S. The most frequent purchasers are dairymen and horse owners. The dairy market puts more emphasis on nutrient content while the horse market is more concerned with visual appearance and freedom from mould and dust. It is important to establish the requirements of the customer for quality, forage species and bale size before attempting to market hay.

On an annual basis it costs roughly half as much to produce an acre of hay as it does to produce corn on that same land ($242 vs $539). With a hay yield of 3.5 tonnes the net return can be similar to a 160 bushel corn crop. Depending on the legume level a hay crop can contribute up to $70 worth of nitrogen to a following corn crop. Research has also shown a yield increase of 5 to 20% in corn following a forage crop. In today's market that is worth $ 48 to $ 192 plus there would also be some benefit in the second year. A long term study showed a four year rotation including alfalfa to be the most profitable under Ontario conditions.

The yield benefit from forages can be caused by a number of factors including reduced soil compaction, improved soil structure and permeability and reduced erosion. Incorporating forages in a rotation also reduces the opportunity for weeds to develop herbicide resistance and increases carbon sequestration, thus reducing greenhouse gasses.

Forage quality is vital to achieving the highest possible price for hay when it is marketed. If marketing to dairy producers the terms RFV and RFQ should be understood and the appropriate analyses conducted. Forage quality plays a vital economic role in dairy production.

G. Bottom Line

Forage crops can give returns that are competitive with other cash crops even with today's high commodity prices. The cost of producing an acre of hay is half that of corn. A legume crop can contribute up to $ 70 worth of nitrogen to a following corn crop plus increase returns by $ 48 to $192 per acre in the first and second years of corn following forages.

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