

HAY SAMPLING PROTOCOLS AND A HAY SAMPLING CERTIFICATION PROGRAM

Dan Putnam and Steve Orloff¹

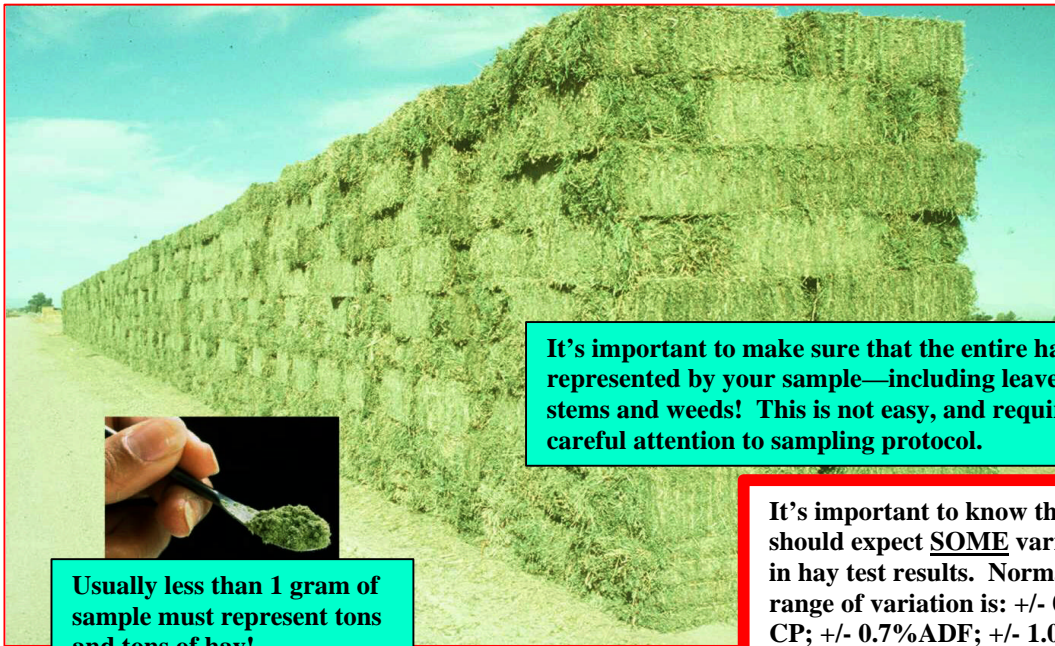
ABSTRACT

Laboratory testing of forages has a profound effect hay crop value in most western states. Hay sampling contributes the largest share the variation in hay testing, typically more than the variation between labs. An internet-based hay sampling self-certification program was developed in 2002, as part of an effort to standardize hay sampling, and to create greater uniformity in the industry. This process consists of three parts: 1) Publication of a protocol for hay sampling, 2) An interactive on-line exam to assure that participants learn details of this protocol, and 3) Self-certification by participants. The exam consists of a series of questions about sampling and hay testing (with hints provided), which address many of the common misunderstandings about hay sampling. Participants take the exam until all questions are answered correctly. At the end of the exam, the name and email address of the candidate are stored electronically, and can be later used to verify that the individual has taken the exam. After this process, the participant prints out a certificate that attests that they have completed the certification process, and can certify that they have taken a given sample according to the protocol as published. This certificate may accompany lab results to communicate the integrity of the sample to buyers or sellers. It takes about 20 minutes to complete, is free of charge, and is endorsed by the National Forage Testing Association (NFTA). The certification exam and materials can be accessed at: <http://alfalfa.ucdavis.edu>.

INTRODUCTION

Forage quality determines between 20% and 50% of hay value in California, particularly alfalfa hay destined for dairy markets. Consequently, lab results are often subject to scrutiny by buyers and sellers, and can be the cause of dispute. While efforts have been made towards lab uniformity and certification (e.g. NFTA lab performance certification), few efforts have targeted standardization of sampling protocols.

¹ Daniel H. Putnam, PhD. Extension Forage Agronomist, Department of Agronomy and Range Science, University of California, One Shields Ave., Davis, CA 95616. Email: dhputnam@ucdavis.edu Steve B. Orloff, UC Cooperative Extension Farm Advisor, Siskiyou County, 1655 S. Main Street, Yreka, CA 96097 sborloff@ucdavis.edu. IN Western Alfalfa & Forage Conference, Reno, NV, Univ. of California Cooperative Extension, University of California, Davis, CA 95616. see: <http://alfalfa.ucdavis.edu>
ABBREVIATIONS: ADF = Acid Detergent Fiber, NDF = Neutral Detergent Fiber, CP=Crude Protein, TDN = Total Digestible Nutrients, RFV = Relative Feed Value.



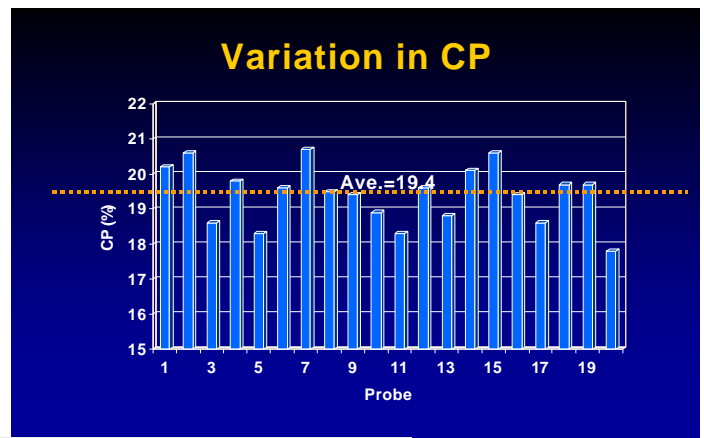
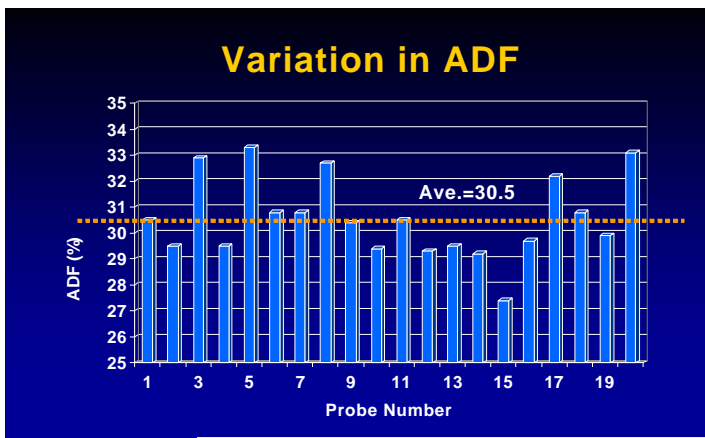
It's important to make sure that the entire hay lot is represented by your sample—including leaves, stems and weeds! This is not easy, and requires careful attention to sampling protocol.

Usually less than 1 gram of sample must represent tons and tons of hay!

It's important to know that we should expect SOME variation in hay test results. Normal range of variation is: +/- 0.5% CP; +/- 0.7% ADF; +/- 1.0% NDF within a lab—not including sampling and lab to lab variation.

In practice, hay sampling produces more variation in results than does lab error. While lab-to-lab variation on a ground split sample may be in the range of 1–3 percentage points of an analysis (CP, ADF, or NDF—see abbreviations, page 1), natural variation in hay may be 3-8 points (see graph). Variation is caused by differences between leaf and stem in different parts of a bale, the presence of weeds, baling conditions and other factors. However, if sampling protocol is carefully followed, sampling variation can be reduced to an acceptable level, and the potential forage quality successfully predicted.

Proper sampling of hay and forage is of tremendous importance to assure an accurate forage test. Here's the dilemma: Hundreds of thousands of pounds of highly variable plant material must be represented in a single, tiny, thumbnail-sized sample (see figure)!! This sample must not only represent the proper leaf-stem ratio, but also reflect the spotty presence of weeds.



Variation in ADF and CP in a seemingly uniform stack of alfalfa hay.

A lab test is only as good as the sample provided to the lab. Often, when we hear of disputes among parties as to the true quality of a lot of hay, the problem can be traced to differences in sampling. There is a general consensus among researchers about the best recommendations for hay sampling across the US, however, it is not clear that these have been universally adopted or promoted. An on-line education project, which includes a standardized protocol for hay sampling, as well as a technique to encourage adoption, may be helpful in controlling the variation caused by hay sampling technique.

THE THEORY

The difficulty with standardizing sampling methods is that people with many different backgrounds and experience sample hay, with varying degrees of understanding of the process. The key concepts may be missed by some due to lack of knowledge, available publications, or lack of exposure to public discussion. Others regularly pay close attention to the details of sampling method. Habit as well as suggestions and ideas from peers play an important role in the practices actually used.

The theory of a self-certification program is that some individuals will wish to use more accurate hay sampling procedures, as well as improved professionalism in the hay testing process. Others will follow as clients begin to demand a more rigorous sampling protocol. A certification process should provide some pressure to hay samplers to stick to a standardize protocol for sampling. Additionally, in situations where disputes arise, a sample obtained using a standardized protocol may carry more weight. The major objective is to create a better understanding of the principles of hay sampling throughout the industry. Certification is a mechanism for achieving that.

A HAY SAMPLING PROTOCOL

Across the USA, most forage researchers recommend a standardized protocol for sampling hay. Some of the recommendations are based upon research efforts and data, while others are based up on experience and common sense. Although there may be specific points of small disagreement between experts in different regions, it is likely that this protocol is very similar to protocols recommended in many regions of the United States. If followed carefully, this protocol should provide consistent representative samples. As with all methods, a small amount of variation between samples is normal—but a uniform sampling method will help control variation. These methods are recommended by the University of California.

1. **Identify a single 'lot' of hay.** This is a key first step to proper hay sampling, and one frequently ignored. A hay lot should be identified, which is a single cutting, a single field and variety, and generally less than 200 tons. The sampler should identify the lot correctly with farm, field, cutting, date, and other important distinguishing features. Combinations of different lots of hay cannot be represented adequately by a forage sampling method; different lots must be sampled separately. Don't mix cuttings, fields, or hay types. If lots are very

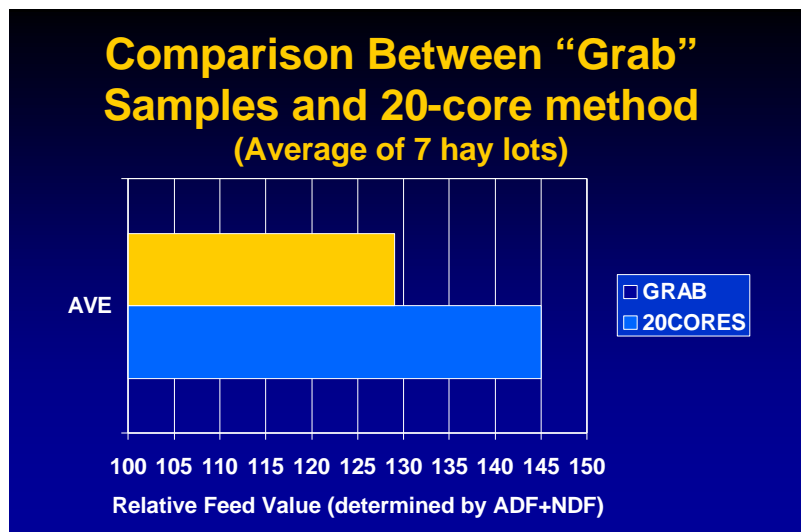
large, divide into smaller units—it is highly likely that very large lots may represent different cutting days or other distinct groupings, which should be sampled separately. In some cases it is necessary to group hay lots for commercial or feeding purposes, but in those cases, they should be sampled separately, and the quality of the combined lot estimated by mathematical weighting.

2. **When to Sample?** It is important to sample the hay either as close to feeding, or as close to point of sale as possible. Dry matter measurements are especially subject to changes after harvest and during storage, but other measurements may also change. Hay immediately after harvest normally goes through a process of further moisture loss known as a ‘sweat’. During this period, hay may heat up due to the activities of microorganisms, driving residual moisture from the hay. Thus, moisture content is likely to be reduced in the days and weeks after harvest. If the hay has been baled with excess moisture, further biological activity may result in molding, or even (under very high moisture conditions) spontaneous combustion. However, after hay has equilibrated to about 90% DM (10% moisture, depending upon humidity), it is typically quite stable. ‘As received’ dry matter measurements should be used to adjust quantity (tonnage, yield), not quality parameters, which should be compared on 100% DM basis.

3. **Choose a sharp, well-designed coring device.** Use a sharp coring device 3/8-3/4” diameter. Never send in flakes or grab samples, it is nearly impossible for these samples to represent a hay lot. “Hand-grab” samples from bales have been shown to be significantly lower in quality than correctly sampled forage. The corer should have a tip 90° to the shaft, not angled—studies have shown that angled shafts push aside some

components (mostly stems) of hay, providing a non-representative sample of the entire mix. Very small diameter tips (<3/8”) do not adequately represent the leaf-stem ratio of the hay. Too-large diameter or too-long probes (e.g. > 24”) provide good samples, but give too much forage in a 20 probe composite sample—thus the sampler may stop before 20 cores are completed or the lab

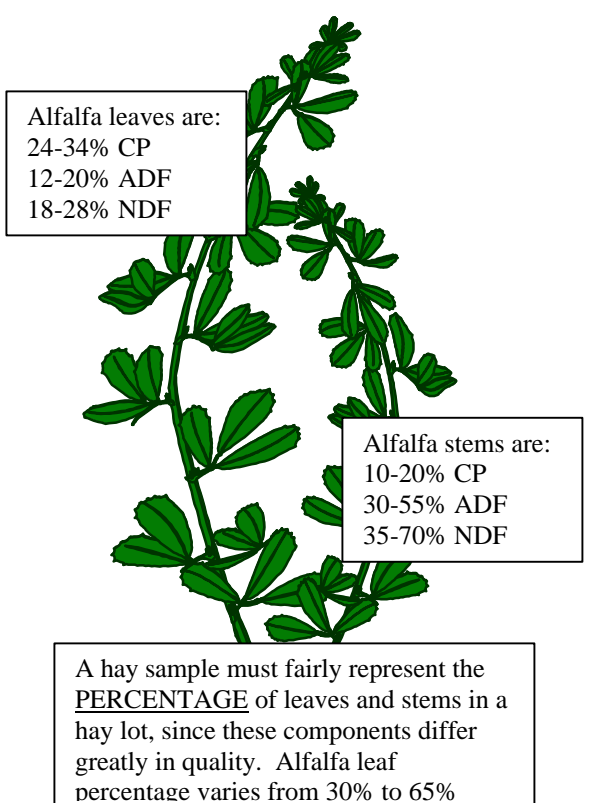
may not grind the whole sample (see below). The length of probe should allow probing to a depth of 12”-24”. Studies have shown this depth to successfully characterize the variation in hay, even in large (1 ton) bales. No significant differences were seen between a 32” and 12” probe. A range of probe tip designs have been used successfully, from serrated to non-serrated tips—it is important that the tip be sharp (and maintained sharp), and not create ‘fines’ during the



cutting action. It must cleanly cut through a cross-section of hay. Some probes are power, hand-brace, or auger driven, whereas others are push-type, all of which may work well under different circumstances. Many (not all) probes can be used to successfully represent a hay lot as long as they adhere to the following principles: the probe easily penetrates the bale, fairly represents the leaf-stem ratio, can be easily sharpened, and produces approximately ½ lb (200 g) of sample in about 20 cores to a depth of 12”-24”. See a listing of probes at NFTA website (<http://www.foragetesting.org>).

4. **Sample at random.** The sampler should walk around the stack as much as possible, and sample bales at random. The sampler should assure that both sides of the stack are sampled if possible. This may be difficult, since some of the bales may not be available to the sampler (against walls of a barn or up too high for practical sampling). However, the sampler should make every attempt to sample in a random fashion—this means not to bias either for or against any bales in the stack. For example, the sampler may walk 15 steps, sample, walk 20 steps, sample, walk 5 steps, sample, while walking around stack—trying to represent all areas of the stack. Don’t avoid or choose bales because they look especially bad or good—If 20 cores are taken, they won’t make much difference anyway. Avoiding or choosing bales introduces bias.

5. **Take enough cores.** We recommend a minimum of 20 cores for a composite sample to represent a hay lot. This is the same for large (e.g. 1 ton bales), or small 2-tie or 3-tie bales. This is because core-core (and bale-bale) variation in forage quality is tremendous (e.g. up to 8 % points ADF or CP). Sampling a large number of locations and bales (a large number of cores) throughout the stack to create a composite sample is a key aspect of representing the full variation contained in a hay lot. It is recommended to take more than 20 cores (e.g. up to 35) with very large lots (100-200 tons), or with highly variable lots (e.g. lots that may have non-attached leaves or are from very weedy fields). The same recommendation is made with regards to large bales, round bales and small bales. For large bales, if more than 20 bale ends are available for sampling, these should be sampled in a random fashion, one core per bale, same as small bales. Do not sample from the same spot each time on the bale face, since considerable variation can occur across the face of large bales. Samplers should pay particular attention to moisture content of large bales. If fewer than 20 bales are accessible for sampling, the sampler may substitute by providing 2-3 cores from a single bale to sum up to 20 or greater total cores. With small bales,

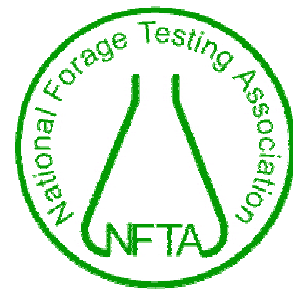


Alfalfa leaves are:
24-34% CP
12-20% ADF
18-28% NDF

Alfalfa stems are:
10-20% CP
30-55% ADF
35-70% NDF

A hay sample must fairly represent the PERCENTAGE of leaves and stems in a hay lot, since these components differ greatly in quality. Alfalfa leaf percentage varies from 30% to 65%

- sample 1 core per bale, >20 bales. With larger (e.g. 1 ton) bales, take up to 3-4 cores per bale, sampling >10 bales. A larger number of core samples are generally better at characterizing variation in hay in more variable hay lots.
6. **Use proper technique.** Sample butt ends of hay bale, between strings or wires, not near the edge. Probe should be inserted at 90° angle, 12”-24” deep. Do not sample in the same spot twice. Do not use any technique that is likely to misrepresent the leaf-stem ratio. The sides or the top of the bale should not be sampled, since these cores will only represent one flake from a single area of the field, and additionally misrepresent the leaf-stem ratio. With round bales, sample towards the middle of bale on an angle directly towards the center of the bale.
 7. **Sample amount: “not too big, not too small”.** Sampling should be done so that about ½ lb of sample is produced. Too-small samples don’t fairly represent the full range of variation in the hay lot. Very big samples (common with large length or diameter probes) are excellent at representing the hay but have practical disadvantages. Large samples cannot be easily ground by the labs—many labs will simply sub-sample such large samples before grinding, defeating the entire purpose of good sampling technique! The sampler should ensure that the entire sample is ground by the lab—this is important to check. If your lab is not grinding the whole sample, ask why—it could be that your sample is too large. Only work with labs that are willing to grind the entire sample (after a DM sample for field DM is taken). But you should also be sure that you are providing a reasonable ½ lb sample, so that it can be practically handled by the lab. If a probe is too big or small to produce about ½ pound in 20 cores—get a different one! (See list of probes on NFTA website)
 8. **Handle samples correctly.** Seal the composite 20-core sample in a well-sealed plastic bag and protect from heat. Double bagging is beneficial, especially for DM measurements. Deliver to lab as soon as possible. Do not allow samples to be exposed to excess sun (e.g. in the cab of a pickup truck). Refrigeration of hay samples is helpful, however, dry hay samples (about 90% DM) are considered fairly stable.
 9. **Never split samples without grinding.** It is important to occasionally check the performance of your lab by comparing with another (or several other) labs. However, never split un-ground samples and send them to two different labs—the samples are likely to be genuinely different! To test two labs, either grind and carefully split the sample, or better yet, ask for your ground sample back from the lab to send to another lab. Use several samples to test average potential bias between labs. Don’t work with labs that are unwilling to do this—good labs should be willing to test their performance and answer questions with regards to consistency of lab results. Ask for their NFTA results!
 10. **Choose an NFTA-Certified Lab.** The first step in choosing a high-quality hay-testing lab is to determine whether they participate in the NFTA proficiency certification program. The National Forage Testing Association, a volunteer group set up by hay growers, sends blind samples to labs, and they must match



the true mean within an acceptable range of variation. NFTA labs have demonstrated their commitment to good results, and are more likely to be interested in accuracy. Additionally, programs such as California's 'California Recognized', NIRS Consortium, or other voluntary programs provide an additional opportunity for labs to prove their proficiency. However, these programs only work if the clientele (you) pays attention to them. Choose a lab that chooses EXCELLENCE! Choose an NFTA lab (see www.foragetesting.org for a listing of NFTA-certified labs).

THE EXAM

The on-line exam consists of 30 questions, all multiple choice. It includes a number of questions about sampling protocol, including issues related to number of samples, types of probes, technique of sampling, as well as questions about the normal level of variation in hay stacks, within labs, and interpretation of results. Examples of questions are given below. The pop-up comments and answers to these questions, as well as the whole exam are linked to: <http://alfalfa.ucdavis.edu/SUBPAGES/ForageQuality.htm>

1. The first step in the hay sampling process is:
 - a. To walk around the outside of the haystack, visually rating the quality of the hay by color.
 - b. To use my hand or a short hook to 'grab' a sample from each bale, being careful to sample from 20 bales for lab analysis.
 - c. To test the strength of the fiber contained in the hay, by taking a handful of 100 stems and attempting to break the stems. Fiber is important since high fiber indicates low quality.
 - d. To assure that the 'hay lot' to be sampled has been correctly identified, named, and assuring that it is from a single variety, field, and cutting.
2. The probe tip should have the following characteristics:
 - a. It should be cut at a 45-degree angle to facilitate penetration into the bale.
 - b. Must be serrated. Only serrated tips can cut cleanly through hay bales.
 - c. Any tip design is suitable, provided the cutting edge is sharp, and it easily penetrates the bale.
 - d. The cutting edge must be at 90 degrees from the shaft, and the cutting edge maintained in sharp condition, allowing easy penetration into the bale.
3. True or False: Variation within hay stacks usually the largest and most important source of variation in predicting forage quality using laboratory testing:
 - a. True. Core-to-core variation within haystacks is plus or minus about 0.1 percentage points ADF, 0.2 percentage points NDF, and about 0.15 percentage points CP.
 - b. True. Core-to-core variation within haystacks can be as much as Plus or Minus about 0.7 percentage points ADF, 1.0 percentage points NDF, and about 0.5 percentage points CP.

- c. True. Core-to-core variation within haystacks can be as much as Plus or Minus 8 percentage points ADF, 10 percentage points NDF, and 6 percentage points CP.
 - d. False. Core-to-core variation is typically smaller than within-lab and between-lab variation in forage quality testing. Lab-lab consistency is a major problem in hay testing.
4. You have received one forage quality analysis report from one hay lot (A) that shows a TDN value of 56.1, RFV of 175, and another hay lot (B) test report which has a TDN of 55.7, RFV of 170. The ADF level of “A” is 26.9 and “B” is 27.2. The protein levels of the two hay lots were 20.8% and 21.2%, for “A” and “B”, respectively. Which of the following is true?
- a. Hay lot “A” is superior to lot ‘B’ in forage quality, due to its higher TDN and RFV. Even though lot A is a little lower in CP, it has a higher TDN and RFV, which is more important than protein.
 - b. It is very likely that these two lots are very similar in forage quality, judging by the hay test.
 - c. Since “B” has a higher protein level, it should be priced slightly higher than lot “A”
 - d. The TDN levels of “A” are excellent, but the ADF levels are poor. Therefore, one should choose lot “B”, and price it higher than lot “A”.

These examples are an indication of the types of questions contained in the quiz. One answer (a, b, c, or d) can be chosen. After each page is taken, and if some answers are incorrect, the candidate may click on the answer itself, and a pop-up box will give them hints about that answer, as to whether it’s right or wrong, and why. Each pop-up box contains information about the subject, and seeks to improve the exam-takers knowledge of that subject area. After the candidate completes all 30 questions correctly, he/she is eligible for certification. (Answers to the above questions are: 1d, 2d, 3c, 4b).

SELF-CERTIFICATION

While certification by a separate body, such as a university or NFTA, may be desirable, questions of monitoring, examining, and confirming performance of those being certified arises. Individuals are difficult to monitor, and there are few entities with the resources or the time to be able to train, examine, and monitor candidates for certification. Liability issues also arise.

Instead, this program is proposed as a ‘self-certification’ program, as a voluntary effort on the part of the sampler. First, the candidate reads educational materials. Secondly, they take an on-line exam, which asks important questions of the candidate about hay sampling and forage quality testing. At the end of the process, the candidate is asked whether he/she understands the protocol completely, whether there are any further questions (if there are, they are guided back to educational materials). The candidate is asked to fill out a form, which will then store an electronic record of their having taken the exam successfully.

After completing the exam correctly, the candidate may print out a certificate. This consists of a brief statement, wherein the candidate states that he/she has read and understood the sampling protocols published, and has sampled a given hay lot according to the protocols published at the website. There is a line for a signature. Thus, it is an opportunity for the individual to self-certify that the samples was taken according to a given protocol, and reference that protocol. Their signature provides their guarantee that they have sampled according to a given protocol.

SUMMARY

A hay sampling certification program has been developed intended to standardize sampling protocols, and to improve public understanding of the hay sampling and analysis process. This is an internet-based exam, self-directed. It will likely take about an hour of time, and is available free to the public on a 24-hour a day basis. This process will enable those involved in the hay business to educate new employees, to improve skills of existing employees, and to upgrade both the real and perceived value of the samples they take. This program should be of greatest interest to those who value accuracy in hay testing, and will enable individuals, labs, and others to offer certified hay sampling services to their clients.

For further information on the Sampling Certification Program and hay sampling protocols, see:

<http://alfalfa.ucdavis.edu/subpages/ForageQuality/Sampling/intro.html>