Wildlife Nutrition

A Publication of Canada's Accredited Zoos and Aquariums
Nutrition Advisory and Research Group (CAZA-NARG)

Forage Edition, July, 2013

Let's "Make Hay"

This season's forage crops are promising and not only are producers making hay, but institutions are in the process of reserving and buying their forage for the coming year. Therefore, a timely topic is a review of forage basics in this special edition of Wildlife Nutrition.

In addition to reviewing some forage basics, I have added some current, timely information that may be useful. We cannot overestimate the importance of forage in the diet of herbivores.

As always, any questions . . . . . .

Deb McWilliams

Photo courtesy: CBC

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In This Issue . . .

***"Wildlife Nutrition" is published three times yearly (January, May and September*)**
This is a special forage edition of Wildlife Nutrition

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Forages: Hay Basics

Forages are bulk feeds of plant origin fed to herbivorous species. The term "forages" can include fresh or dried hay and/or foliage from trees, bushes and herbaceous plants.

When possible, wild browse similar to, or identical to, the wild diet of a species is the best choice to feed to an herbivore. However, limits in staff, time and/or the availability of wild forage often requires substitutions. In Canada, substitutions for wild browse include greenhouse plants, harvesting local plant varieties and/or hay. Typically, the variety of hay most often available is either alfalfa or timothy or a mix of timothy and alfalfa.

In general, however, because we classify herbivorous wildlife as grazers or browsers, there are really only two types of forages:

1) **Grasses:** Cultivated versions include brome grass, canary grass, Indian grass, Kentucky blue grass, orchard grass, ryegrass, sorghum, Sudan grass, tall fescue, timothy and, triticale. Wild versions include sweet grass, quack grass, rice grass, switch grass and many other species.
2) **Legumes:** Cultivated legume forages include alfalfa, birdsfoot trefoil, clover, sainfoin and crown vetch. Wild species of legumes include birdsfoot trefoil, wild white clover, wild crown vetch, black medick and many other species.

Fit for Grazing or Browsing. The nutrients – in form and function - in grasses make them suitable as forage for grazers and the nutrients – in form and function – in legumes make them suitable for forage for browsing species. There are many differences in nutrient levels between grasses and legumes, but major differences (Table 1) include fibre and protein. For example, **grasses** are higher in acid detergent fibre (ADF) and neutral detergent fibre (NDF), cellulose and silica but are lower in protein than legumes. The protein analyses of grass hays show averages of 7% to 12% protein depending on grass species and stage of cut. **Legumes** are lower in ADF and NDF, cellulose and silica but are higher in protein than grasses. Legumes are high in plant protein because of a symbiotic relationship with rhizobia (bacteria) that results in the fixation of atmospheric nitrogen in root nodules of the plant. The nitrogen in the root nodules increases both soil nitrogen and nitrogen in the plant. Legume hays show averages of 16% to 25% protein depending on legume and stage of cut.

Table 1. A Comparison of Some Relative Differences between Grass and Legume Forage

Nutrient	Grass	Legume
Protein	Low	High
ADF	High	Low
NDF	High	Low
Cellulose	High	Low
Silica	High	Low

Browsing, Grazing and Intermediate Species

Before we look at a detailed comparison of grass and legume forages, it is helpful to review the classification of species into nutritional niches such as browsers, grazers and intermediate feeders. These classifications apply to all herbivorous species, both ruminants and monogastrics. Essentially, the classifications are based on the feeding ecology and gastrointestinal tract (GIT) including dentition, salivary glands, gut design and function.

An important understanding regarding the classification of nutritional niche is that all species will have some degree of dietary flexibility, although some species will be more or less limited than other species. For example, browsing species may sometimes eat grass in the wild especially if preferred foods are not available and grazing species may sometimes ingest browse. However, most species have evolved within a dietary niche that best supports their physiology.

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Browsing Species. The browsing nutritional niche includes antelope species, caribou (reindeer). deer, elk, giraffe, goat species (most including ibex and mountain goat), moose, mountain sheep, musk oxen, tapir, black rhino, pygmy hippo, capybara, rock hyrax, beaver and porcupine. This list is not exhaustive and other species are also classified as browser.

Grazing Species. This list is also not exhaustive. Species included in the grazing nutritional niche include bison (buffalo), camel, equine species, some goat species, llama, Nile hippo, some sheep species, white rhino, wildebeest, groundhogs, rabbit species and, macropods.

Intermediate Species. Species described as intermediate foragers are thought to do equally well on browse or grass. For example, the elephant, muskoxen and many goat and deer species are often considered to be intermediate feeders. However, browse is most often the preferred food of these species and - in captivity - these species appear to do best when fed as browsers.

Comparing Browse to Grasses

Table 2 (page 5) compares the nutrients in two types of browse and two types of grass. Each classification includes a cultivated species and a wild species for comparison. Major differences in composition are highlighted in red.

First, you will notice that browse and grass species are similar in nutrient composition to each other within each classification whether they are a cultivated species or a wild species. In other words, a wild grass is similar to a domesticated grass and a wild browse is similar to a domesticated browse.

Second, you will also notice important differences in nutrient compositions when browse species are compared to grass species (there are also some similarities) and these differences are highlighted in red. As an example, look at the silica levels of the forages in Table 2. You will notice that the silica levels are low in browse and relatively high in grasses. Silica is highly abrasive and the high silica level in grass is one of the reasons why grass forage should not be fed to browsing species, but can be fed to grazing species. Grazing species can be fed grasses without damage to their dentition from abrasive silica because they have evolved dentition with high teeth crowns and adaptations for teeth shear needed to chew grasses. These dental characteristics also protect the teeth of grazing species from the abrasive silica. Browsing species, however, are prone to excessive tooth wear when fed high silica forages like grass because they lack the dentition adaptions of grazers.

Other Classifications of Forage

Two other types, or forms, of forage are silage and chopped hay. This article will not discuss these forages in detail, but they can be considered for forage depending on season and species. Silage is usually a grass species and chopped hay products most often refer to legumes (most often alfalfa). Both are fermented, high moisture, green forage.

Wood as Forage

A common misconception about the wild feeding ecology of browsing species is the ingestion of wood. In general, browsing species use their long tongues and large mouths to strip foliage from trees. While this may result in eating the tips of some small branches, the intake of woody material is minimal and would include only small diameter (<1/4") new growth.

Some browsing and grazing species have been reported eating bark from trees. However, these reports are usually in winter when food is scarce: in other words, the bark is probably ingested as a "survival" food. The key word is "survival", meaning the wood provides minimal nutrition during a season when foods are scarce.

Wood does not provide adequate nutrition. For example, the digestibility of tree wood in adult moose is only 29.3% for willow, 27.7% for ash and 8.8% for birch. The digestibility of bark averages at about 18.3%. These low percentages of digestibility mean that the animals can only extract and absorb limited nutrition from the wood that is already low in nutrients. Young animals with immature GITs will have even lower percentages of digestibility.

Senescent (Fallen) Leaves as Forage

Another common misconception about the wild feeding ecology in browsing and grazing species is using fallen leaves as a food source. Fallen leaves, for example, are used by many wild, North American species in the winter as survival food when other foods are not available. However, the key word is "survival", meaning fallen leaves provide an extremely low density of nutrients during seasons when foods are scarce. For example, the digestibility of fallen leaves in caribou and moose is only 21% for birch (*Betula sp*) and 33% for willow (*Salix sp*).

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Table 2. Comparisons of the nutrient composition (dry matter; DM) of two browse species (cultivated and wild) to two grass species (cultivated and wild).

	Sample forage for browsing species		Sample forage for grazing species	
Ingredient	Quality Alfalfa Hay (Legume)	Birdsfoot Trefoil (Legume)	Timothy Hay (Grass)	Switch grass (Grass)
Crude Protein %	16.3-24.0	16.0-18.1	7.0-11.0	7.0-9.0
Crude Fat %	2.7	2.7-3.3	2.0 – 3.8	1.9
Calcium %	1.35	1.60	0.3-0.5	0.10-0.9
Phosphorus %	0.21	0.20	0.2-0.5	0.2-0.5
Sodium %	0.05	0.01	0.01	*
Potassium %	1.8	2.0	2.0	0.1-1.5
Magnesium %	0.30	0.35	0.15	0.10 -0.30
Zinc ppm	17.3	28.0	17.0	*
Manganese ppm	24.5	36.0	63.0	*
Copper ppm	12.1	5.5	5.0	*
Sulfur	0.25-0.30		0.13-0.21	0.11-0.20
Selenium %	0.29	0.14	0.20	8.3-14.0
Iron mg/kg (ppm)	162.0	178.0	92.0	40.0-58.0
Crude Fibre %	32.8	28.0 - 32.0	36.0	31.5-32.8
Cellulose %	25	24.0	32.0	37.0-44.0
Hemicellulose %	10	12.0	27.0	29.0
ADF %	29.0 – 35.0	26.0-31.0	38.0-45.0	41.0-48.0
Silica %	0.04 - 0.7	negligible	4.0-7.0	3.4-5.1
NDF %	36.0 - 44.0	32.0-38.0	65.0-72.0	70.0-77.0
Lignin %	8.5	10.0-13.0	4.0	9.0
Sugars %	4.5	*	11.5	*
Starch %	0.43	*	1.6	1.0
Pectin %	12-14	4	7.5	*

***Not available**

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Forages: Wild Browse versus Legume Hay

In general, recommendations for captive browsing herbivores are to provide browse forage using plant species similar to, or the same, as their wild diet. When this is not possible, legume hay is recommended. Alfalfa hay is the most common legume hay available in Canada. Other legume hay includes clover and sainfoin.

Forage is important in the diet of herbivores because it provides a wide range of nutrients, a variety of fibre, phenolics (phenols) and polyphenolics (polyphenols). Phenols and polyphenols in plant species have roles as anti-inflammatories, antioxidants, growth regulators, phytohormones and they maintain plant health in response to environmental stressors such as a less-than-optimum climate, toxins and insects.

Some common phenols include methyl salicylate and salicylic acid. Common polyphenols include condensed flavonoids, isoflavones and tannins. Ingestion of plants with phenols and polyphenols is thought to provide health benefits to the animal that eats the plant and there is much research in both human and animal nutrition to support this belief. For example, phenols and polyphenols can protect the gastrointestinal tract (GIT) in addition to supporting general immune function and enhancing or decreasing absorption of nutrients.

Plants are complex! We cannot discuss the many types of phenols and polyphenols in this article because they are too numerous. For example, there are over 8,000 phenolic compounds. As well, the types and amounts of phenols and polyphenols may vary in plants depending on species, growing season, soil and environmental stressors. To add to the complexity, quantifying the types and amounts of phenols and polyphenols in forage is achieved by a variety of analytic tests that often produce differing results depending on the test. Finally, at this time, most of the research on phenols and polyphenols is for human health and food industries. The focus on human health and food industries means we lack research on comparisons of phenols and polyphenols between wild browse and cultivated forages such as legume hay.

Wild browse or hay? Wild browse plant species is often viewed as superior to legume hay. In general, wild browse is considered superior because of the nutrients provided and the amount and variety of plant phenolics and polyphenolics. However, one of the reasons why legume hay is an acceptable substitute for browse is that the nutrient profile is similar to most wild browse plant species and it also contains a wide variety of beneficial phenols and polyphenols.

For example, the research by Karimi et al. (2013) found that legume hay - alfalfa in their research - contained a variety of phenolics, flavonoids and isoflavonoids that act as antioxidants and anti-inflammatories. They recommend alfalfa for use in the pharmaceutical, human food and animal feed industries as beneficial supplements and an excellent source of antioxidants and anti-inflammatories.

How much browse forage? The best forage will not benefit an animal if that animal is not fed an adequate amount. An "adequate amount" of forage will depend on the species, life stage and season. We can estimate an amount of forage to feed an animal and, once we obtain the estimate, we begin feeding that amount and then adjust the amount as needed. To estimate forage needs, we start with a daily kilocalorie (calorie) and nutrient requirement based on the metabolic requirements and life stage of the animal. We then formulate the diet into a ratio of forage to pelleted feed. In general, larger herbivores should have a diet of 60-70% forage and 30-40% pelleted feed. Smaller herbivores should start at a 50% ratio of forage to pellets. As with any diet calculation or change, we then monitor the animal to ensure the ratio and forage is appropriate and adjust the diet when necessary.

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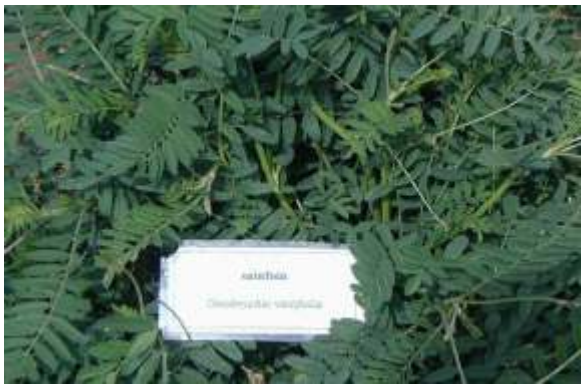
Fibre length. There is emerging research about the appropriate fibre length for herbivores. Fibre length refers to the particle length (size) of forage. Shorter fibre lengths require less chewing and longer fiber lengths require more chewing. Chewing is important because it produces saliva that is essential to digestion especially for herbivores because saliva also assists in maintaining gut pH. A normal gut pH is needed to support gut microbes and to prevent the formation of phytobezoars (masses of undigested plant material) that can form an obstruction within the gastrointestinal tract. In general, look for a fibre length of at least > 1 inch (2.5 centimetres). Most chopped hay, including the newer fermented hay products, should have an adequate fibre length, but one must verify with your supplier when ordering these feeds.

Summary: Forage is an essential dietary component for any herbivorous species – wild or captive. When possible, in captivity, a variety of wild browse forage should be fed. When it is not possible to feed wild browse forage, legume hay such as alfalfa, clover or sainfoin can be used for browsing species and a variety of legume hay is best if one can purchase a variety of legume species.

Please contact me if you have questions, or if I can assist you in forage decisions.

Arctic Willlow (Ottawa)
Photo Courtesy: Makeitgreen.ca

Alfalfa
Photo Courtesy: Alfalfagreen.ca



Sainfoin
Photo Courtesy: uwyo.edu

Assessing for Quality in Alfalfa Hay

Last year, due to a poor crop season, it was very difficult to source and purchase quality alfalfa hay. So far, many of this season's crops appear promising and we can look forward to a better product.

There are several important indices to assess if ***your*** alfalfa hay is a quality product. One of the important tools in assessing your hay is a nutrient analysis. This article cannot discuss all aspects of a hay analysis, but we will look at the percent crude protein and acid detergent fibre (ADF) numbers as tools in assessing your hay.

The protein is important in alfalfa hay because alfalfa hay, a legume, is used for browsing species that require higher protein levels (> 15%). The ADF is important because it predicts the digestibility of the hay – the higher the ADF, the lower the digestibility of the hay. For browsing species, we do not want to exceed a 30% ADF (< 30%) level. Table 1 describes the protein and ADF levels in alfalfa hay cut at various stages.

Table 1. The protein and ADF levels (dry matter; DM) in alfalfa hay cut at various stages.

Stage	Description	CP % Avg	ADF % Avg
Pre-bud Vegetative	No buds	22	25-28
Bud	Stems have buds	20-22	25-31
Early bloom (1/10 bloom)	Very few flowers	19-17	32-34
Mid-bloom (1/2 bloom)	50% stems have flowers	16	34-38
Full-bloom	75+ % stems have flowers	14-16	39-41
Mature (seed pod)	See pods have formed	<13	>42

Here are some other factors that can assist you when assessing alfalfa hay:

1. **Stage of Cut:** For browsing species, you should purchase only hay (usually second or third cut) that is pure alfalfa. Often, hay sold as alfalfa is actually a mixed hay. Ask this question of your hay provider. It is recommended that you speak with your hay provider and get a detailed description of the hay you purchase.
2. **Growing Conditions:** Your hay provider can also tell you about the growing conditions that will affect the quality of your hay. For example, if the growing conditions are hot and the plant grows fast, the alfalfa can be of lower quality (less leaf, more woody) than hay grown slower in cooler conditions.
3. **Hay Analysis:** Most hay providers can give you an analysis of their current hay crops. If your hay provider does not provide a nutrient analysis, it is recommended that you purchase a nutrient analysis of your hay (each delivery). General hay analysis information is also on the internet if you know where your hay is grown. For example, most provincial ministries of agriculture will provide seasonal information on hay crops with warnings about average nutrient excesses or deficiencies in the current year's hay crops for the province. For an analysis, the minimum nutrient information you need is crude protein, calcium and phosphorus and ADF. However, most laboratories also have mineral packages that give the percent calcium, phosphorus, potassium, magnesium and sodium as well as the parts per million (ppm) of zinc, manganese, copper and selenium. This data can be important for you to know if the hay in your agricultural rregion has deficiencies or excesses of some nutrients. Some of these tests would be standard in an analysis, but some tests may have to be added to a "package" and these tests would be additional to the package price. There are two methods that your laboratory can use: wet chemistry or near infrared (NIR) analysis. Your laboratory can help you decide what analytic package is best for you.

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4. **Hay Sampling:** If your hay provider cannot give you an analysis of your hay and you decide to have your hay analyzed (recommended), there is a sampling procedure you should follow. The correct method to sample hay is to use a hay corer. "Core samples" are taken from 10 to 20 bales selected randomly. For smaller bales (rectangles), the sample is taken from the small end about center and for larger bales (typically round), the sample is taken midpoint on the curve. The corer must be pushed as far into the bale as possible. You will need about 1 lb (1/2 kg) of hay total. All the samples should be put into a plastic bag that can be sealed and then sent immediately for analysis. If you do not have a corer or cannot borrow one, then the next best method is to collect your samples throughout one to two weeks of feeding. You need to sample 10 to 20 bales. For each bale that you feed out, select a sample from inside the bale as close to center as you can get. Each sample should be a mix of leaves and stem although – if your hay is extra-leafy – you will have a lot of leaf. The sample must be representative of your hay. Place the sample in a plastic bag that can be sealed and keep this bag in an area without temperature or light extremes. For example, the bag of samples should not be exposed to cold, heat or sunlight. Add your bale samples each day to the bag until you reach your goal of 10 to 20 samples. Mix together well and submit to the laboratory.
5. **Colour:** Quality alfalfa hay will be green and it is usually a darker green than quality grass hay. Alfalfa hay can sometimes be a very bright green colour and this bright green colour means the alfalfa hay has probably been treated with proprionic acid (or a similar biological) as a preservative and fungicide.
6. **Appearance and Odour:** In addition to 65%-75% leaf, good hay will have short stems that are pliable (easy to bend without breaking); no obvious mold (usually visible in flakes); and, no foreign matter (sticks, weeds, dirt, dust, stones, etc). Hay that is dusty and/or moldy will have a characteristic smell.

Feeding out Hay: Weighing Hay

It is not necessary to weigh your hay at every feeding. A simple method to estimate amounts for feeding out requires using the average weight of your hay bales. Most hay bales range in weight from 14 kg to 25 kg. Your supplier can get an average weight for you before delivery since most feed supply companies have larger weight scales.

If your supplier cannot tell you the average weight of your hay bales, then there is an efficient method to do this yourself. To get an average weight: weigh 3 average hay bales, add the weights of the 3 bales, divide by 3 and the amount you get will be what you will use for the average weight of your hay. I suggest getting an average bale on each new delivery of hay.

Example: Three hay bales are weighed and they weigh 20 kg, 22 kg and 25 kg.
20 kg + 22 kg + 25 kg = 67 kg
67 kg /3 = 22.3 kg average weight of a bale

To calculate the daily feed amounts:

Example: If the amount to Feed out = 6 kg
22.3 kg bale/6 kg amount to feed = 3.7 (round up to 4)
Therefore, ¼ of a bale is approximately 6 kg

Assessing for Quality in Grass Hay

Quality grass hay has as many similarities as differences to legume hay. As with legume hay, the nutrient analysis is the most important tool. This article cannot discuss all aspects of a hay analysis, but we will again look at the percent crude protein and acid detergent fibre (ADF) numbers as tools in assessing your hay.

Grazing species require less protein than browsing species, therefore the protein level in quality grass hay (13%) is lower than that of legume hay. The ADF predicts the digestibility of the hay for grass hay as well as alfalfa hay – the higher the ADF, the lower the digestibility of the hay. Quality grass hay has < 38% ADF. Table 1 describes the protein and ADF levels in alfalfa hay cut at various stages.

Table 1. Comparison of the Crude Protein and ADF Percentages (dry matter; DM) of Grass Hay

Hay Grade	Description	CP % Avg	ADF % Avg
Premium (pre-seed head)	Pliable, no seeds, green	13	<33
Good (early seed head)	Pliable, but some hard stems, no seeds, lighter green than premium	9-13	31-38
Fair (seed head)	Many hard stems, very light green or yellow, some seed, large diameter stems	5-8	39-41
Low (utility) (post seed head)	Hard stems, light yellow to bleached colour, mature seed heads, large diameter stems	<5	>41

Other factors to assist in assessing grass hay:

1. **Hay Grade:** In general, premium or good is the best nutrient value although some grazing species can do well on lower grades.
2. **Growing Conditions:** Your hay provider can tell you about the growing conditions that will affect the quality of your hay. Rapid growth due to high temperatures results in hay that matures too rapidly. Early season cuttings tend to be higher quality than later season cuttings because the temperatures are usually cooler.
3. **Hay Analysis:** Most hay providers can give you an analysis of their current hay crops. It is recommended that you purchase a nutrient analysis of your hay (each delivery) if your hay provider does not give you the nutrient analysis. Another option is to access hay analysis information on the internet. For example, most provincial ministries of agriculture will provide seasonal information on hay crops with warnings about nutrient excesses or deficiencies in the current year's hay crops for the province. Typically, the minimum nutrient information you need is crude protein, calcium and phosphorus and ADF. However, most laboratories also have mineral packages that give the percent calcium, phosphorus, potassium, magnesium and sodium as well as the parts per million (ppm) of zinc, manganese, copper and selenium. This data can be important for you to know if the hay in your agricultural region has deficiencies or excesses of some nutrients. Some of these tests would be standard in an analysis, but some tests may have to be added to a "package" and these tests would have individual pricing additional to the package price. There are two methods that your laboratory can use: wet chemistry or near infrared (NIR) analysis. Your laboratory can help you decide what analytic package is best for you.

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5. **Colour:** Quality grass hay is green, but slightly lighter green than alfalfa hay.
6. **Appearance:** In addition to pliable blades, good to premium grass hay will be pliable (easy to bend without breaking); have no obvious mold (usually visible in flakes); and, no foreign matter (sticks, weeds, dirt, dust, stones, etc). Hay that is dusty and/or moldy will have the characteristic smell.

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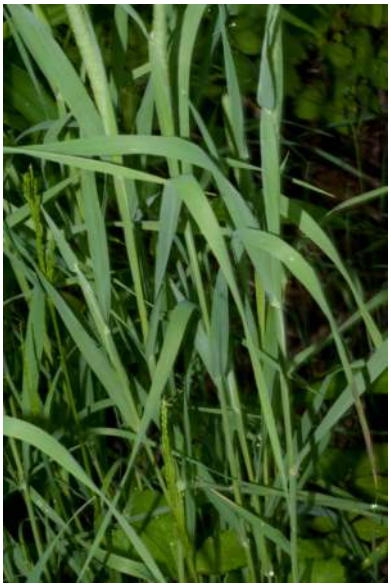
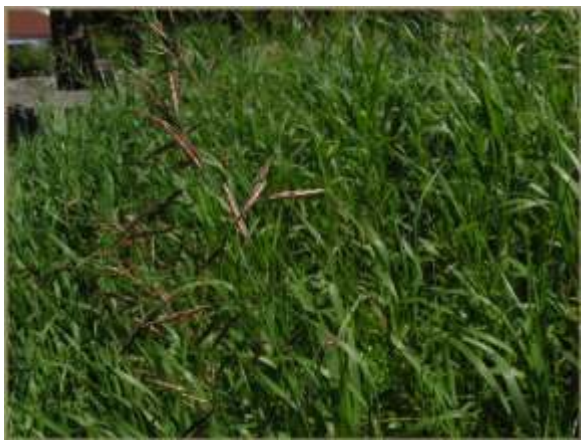
Timothy
Photo Courtesy: florafinder.com



Smooth Brome Grass
Photo Courtesy: s-weeds.net



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CAZA Wildlife Nutrition Ruminant Browser: **Our browser pellet has been formulated based on the wild feeding ecology of browsing ruminant species*. It is a low-sugar, low-starch pellet that offers the appropriate types and ratios of fibre recommended for browsing ruminant species. This product must be fed with forage (hay or browse).**

*Antelope species, caribou (reindeer), deer, elk, giraffe, goat species (most, including ibex and mountain goats), moose, mountain sheep, musk oxen

CAZA Rodent Herbivore with Vitamin C: **Our Rodent herbivore with vitamin C is formulated based on the wild feeding ecology of herbivorous rodent species including beaver, capybara, porcupine and rock hyrax. It is a low-sugar, low-starch pellet that offers the appropriate types and ratios of fibre recommended for browsing ruminant species. This product must be fed with forage (hay or browse).**

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Deborah McWilliams is a wildlife nutritionist and founder of the Canada's Accredited Zoos and Aquariums Nutrition Advisory and Research Group (CAZA-NARG). She has 15 years of experience in wildlife nutrition and has worked with zoological institutions and wildlife parks and preserves internationally as a consultant, workshop presenter and educator in wildlife nutrition. In addition, Deborah is a nutrition advisor for the CAZA Herpetology Taxon Advisory Group (TAG) and for the Association of Zoos and Aquariums Rodent, Insectivore and Lagomorph TAG (AZA RIL-TAG). Deborah published the first edition of "Applied Zoo Animal Nutrition" in 2010 and this book is used by zoological institutions in eight countries.