Section A. Background

- Introduction
- Forage and Alaska
- Forage Types
- Forage and Animals

Introduction

Photo: Casey Dinkel, AK PMC

Hay field near Fox River flats - Homer, Alaska

The Alaska Forage Manual was created through a joint agreement between the USDA Natural Resource Conservation Service (NRCS) and the Alaska Plant Materials Center (PMC). The project was designed to synthesize and build upon existing information about forage crops in Alaska. A wealth of knowledge from many different sources has been compiled in this publication to serve present and future managers of livestock and wildlife operations, as well as local agencies.

The goal of this manual is to introduce grasses, legumes and cereal crop species which are commonly planted to provide forage for grazing livestock. Forage species are those seeded on a pastureland and then grazed fresh or harvested for hay, silage or haylage.

An important distinction can be made between pastureland and rangeland. Generally, pastureland is managed and agronomic inputs such as fertilizer and irrigation are applied to maintain native or introduced species. This is most often not the case with rangeland.

For the purposes of this manual, Forage is defined as: "**Herbaceous grasses and legumes available and acceptable to grazing animals, or that may be harvested for feed purposes**" (TN Plant Materials NO. 28, 2001). Depending on location, climate, soil type, and management goals, a different forage species may be better adapted to the site than what was traditionally used.

It is the authors' intention that those who have traditionally used only brome and timothy as their primary forage species will consider trying something different with their next planting.

Target Audience

The intended audience for this manual is primarily managers of livestock and wildlife operations. This manual may also be useful to local organizations and government agencies interested in the conservation value of forage species. This book is prepared with the assumption that the primary goal of planting will be to improve and increase forage for livestock or wildlife.

Content of Manual

This manual has been designed to take the user through sequential order from briefly introducing agriculture in Alaska, forage types and animals, and then proceeding to crop establishment and finally forage species profiles.

Section A. Background

- Introduction
- Forage and Alaska
- Forage Types
- Forage and Animals

Section B. Crop Establishment

- Planning
  - Goals & Objectives
  - Evaluating Site Conditions
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- Appendix A: Nutrient Study
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- Appendix C: Noxious Weeds
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- Works Cited

Section A - Background:

A brief introduction to Alaska agriculture, along with the forage types and animals found consuming forage in Alaska.

Section B - Crop Establishment:

Organized to allow a user to understand cultural practices essential for a successful crop stand. The project planning chapter covers determining goals and objectives and evaluating site conditions like soil pH and texture. This section also will guide the reader through some introductory principles to ensure a successful planting such as site preparation, application methods to apply plant material, weed control, and time of planting.

Section C - Plant Profiles:

Twenty-four plant species make up the foundation of this manual. Species were chosen based on their forage attributes and ability to survive and thrive in Alaska's diverse regions. The forage value, general morphological characteristics and management of each individual species is detailed. Also accompanying each profile is a table listing plant characteristics such as average height, drought tolerance and pH range. The regions of Alaska to which a plant species is adapted are shown on a color-coded map.

Section D - Additional Information:

Glossary, works cited and appendices, including a nutrient study of forage grasses during different growth stages and State of Alaska Prohibited & Restricted Noxious weeds.

Forage and Alaska


Photo: Casey Dinkel, AK PMC

Hay bales are stored in a pole barn in Delta Junction, to protect them from weather. Approximately 20,000 acres of hay are harvested each year in Alaska.

Alaska is a vast state, with a diversity of environmental conditions. It is also an enormous state - 1/5th the size of the contiguous lower 48 states. There is not an abundance of producing farmland, however. Of the 366 million acres in Alaska, about 900,000 acres are farmland. The majority of this farmland - 737,746 acres, is used as pasture.

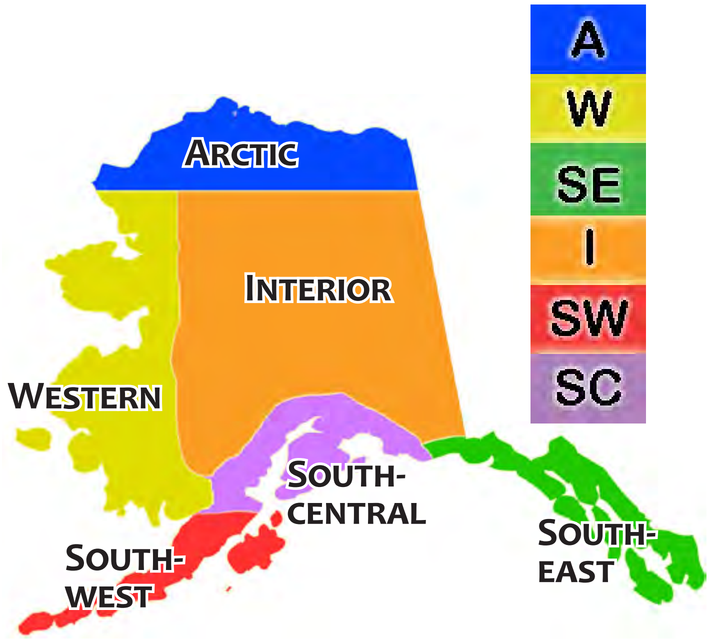
From an agricultural standpoint, Alaska ranks near the bottom of U.S. agricultural production. The top 5 agriculture commodities reported in Alaska for 2010 were:

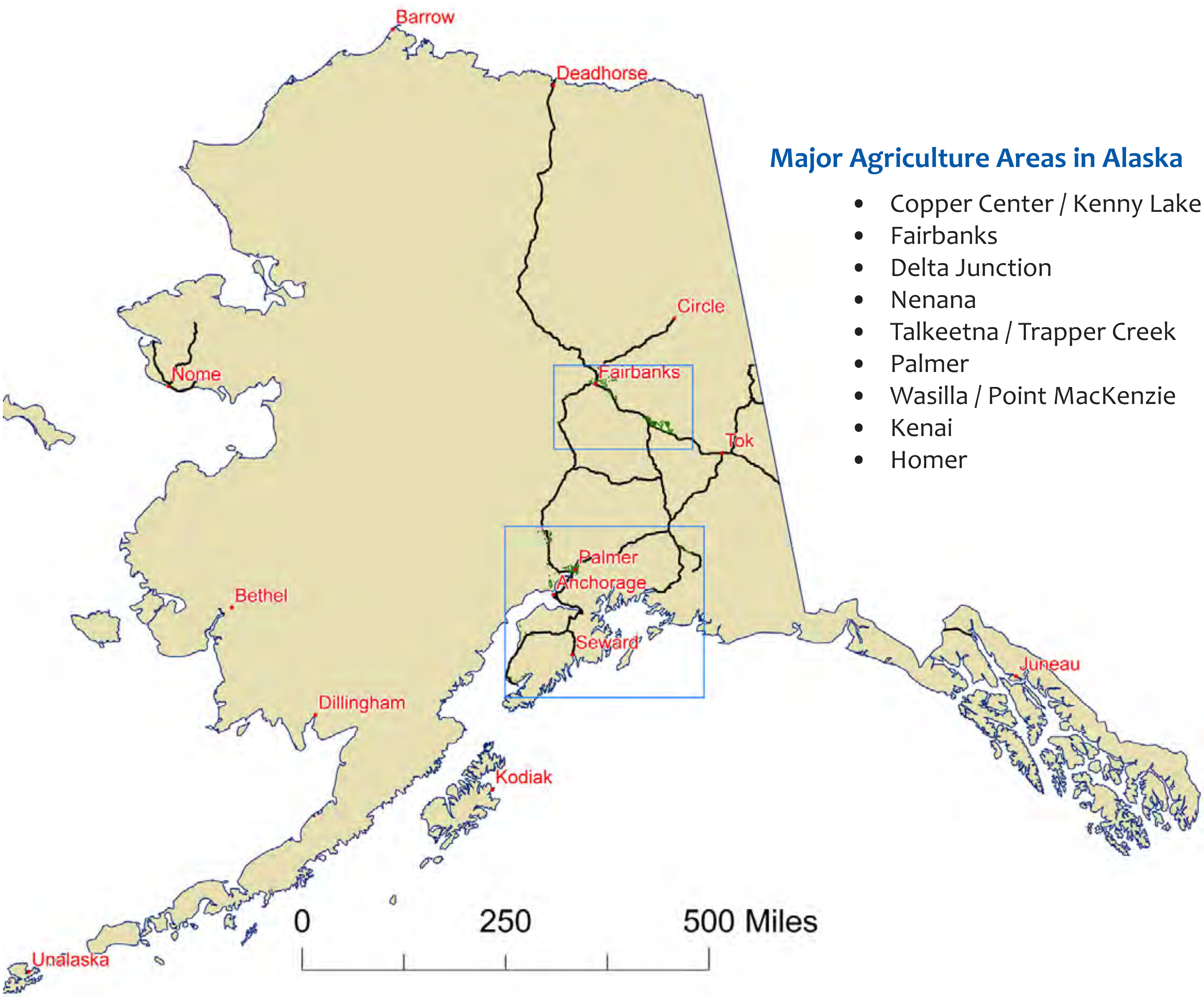
Ag. Commodity Type	Value of Receipts	% of AK Total Farm Receipts
Greenhouse/nursery	$13.0 million	42.3%
Hay	$4.1 million	13.2%
Cattle and calves	$2.4 million	7.9%
Potatoes	$2.4 million	7.7%
Dairy products	$1.6 million	5.2%
- All other commodities -	$7.3 million	23.7%
All Commodities	**$30.8** million	100%

Data: Alaska Agricultural Statistics 2010 - USDA National Agricultural Statistics Service

Regions

For the purposes of this manual, Alaska is broken into several regions: Arctic, Western, Interior, Southcentral, Southwest and Southeast. These regions vary widely in climate. Agricultural lands are located in primarily two regions; the Matanuska and Susitna Valleys in Southcentral, and the Tanana Valley east of Fairbanks in the Interior. The Matanuska Valley has mild summers and moderate winters, while the Tanana Valley is more extreme with hot summers and very cold winters.

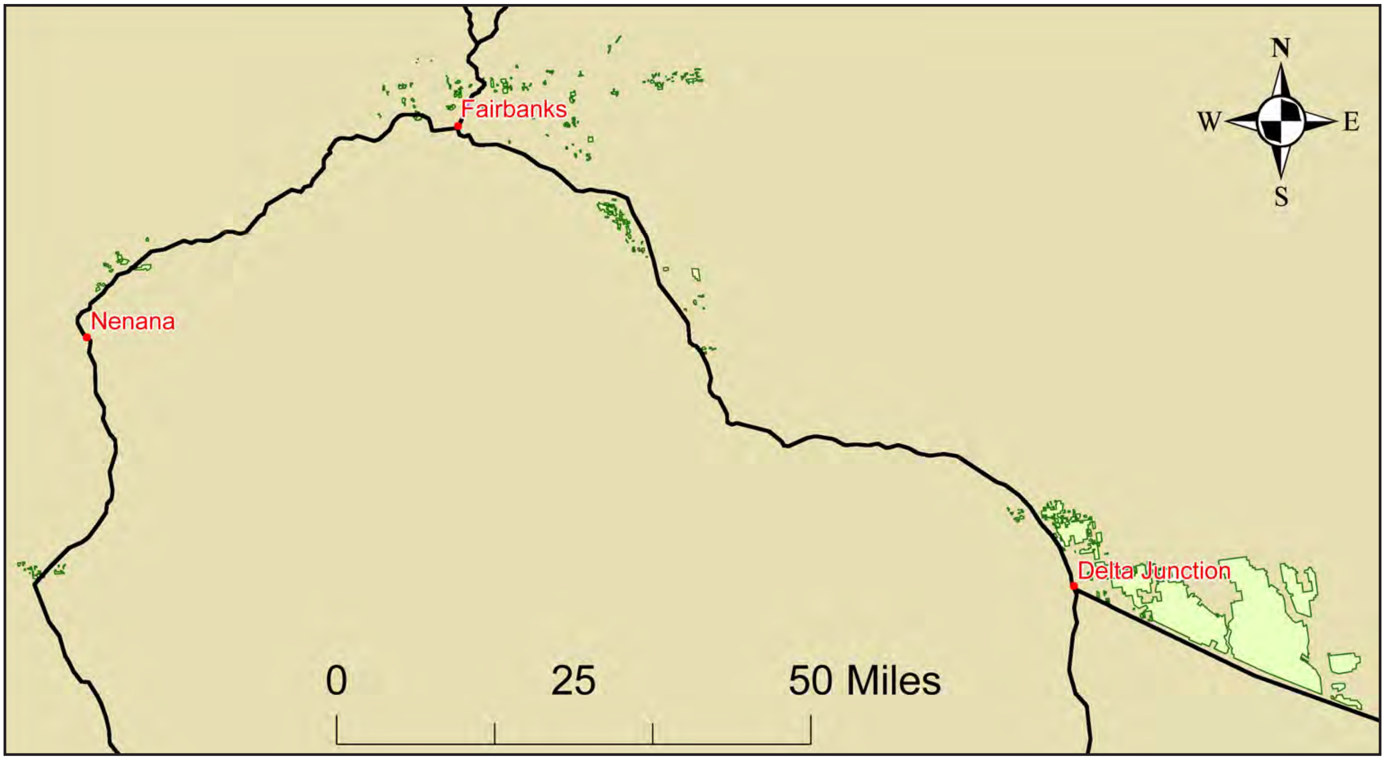




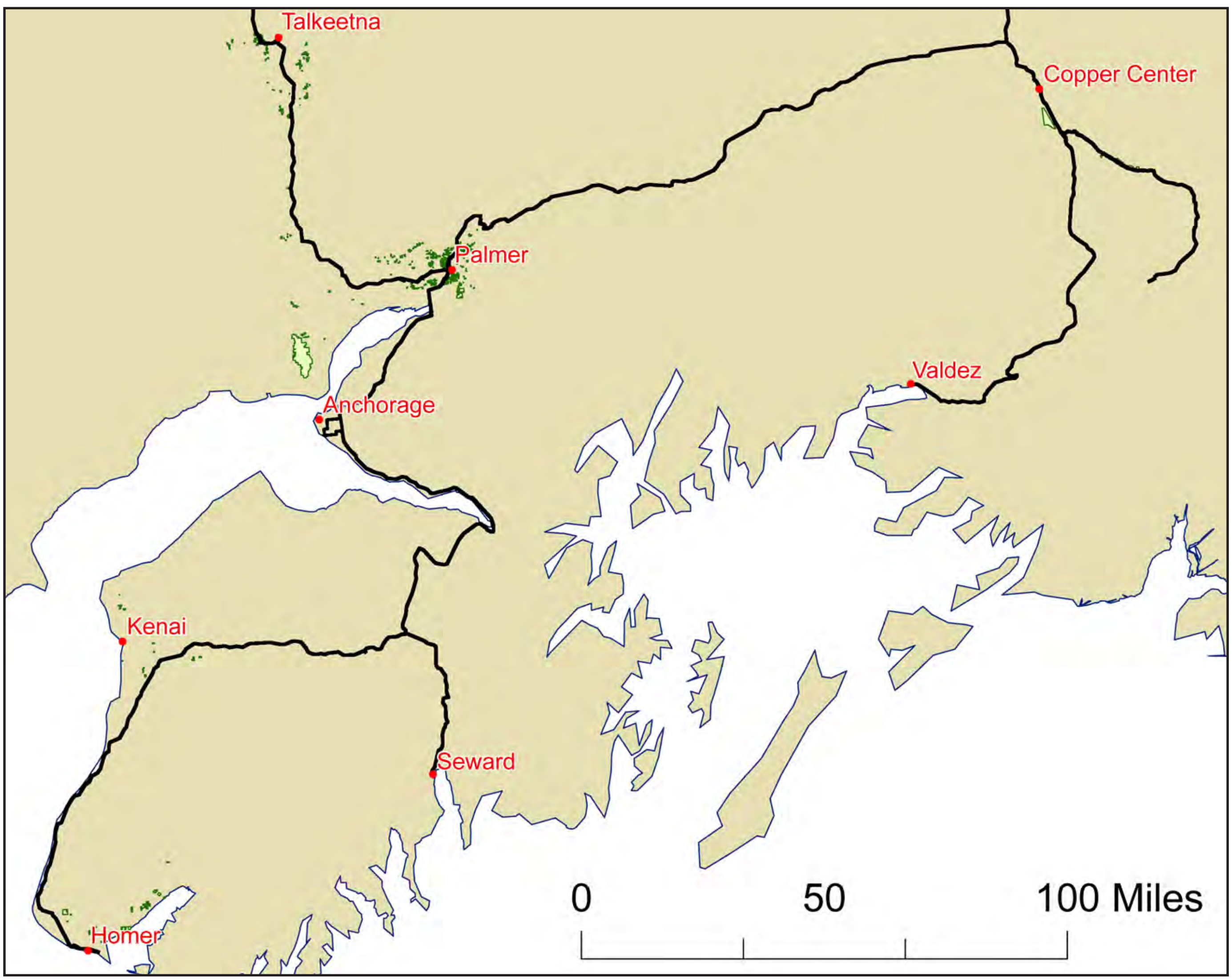
Major Agriculture Areas in Alaska

- Copper Center / Kenny Lake
- Fairbanks
- Delta Junction
- Nenana
- Talkeetna / Trapper Creek
- Palmer
- Wasilla / Point MacKenzie
- Kenai
- Homer

Agricultural parcels in Alaska are clustered around the Matanuska, Susitna and Copper river drainages in the south and the Tanana and Yukon flats in the north. Farms also exist on Kodiak Island and on the Kenai Peninsula.



Agricultural parcels in Interior Alaska are centered around Fairbanks, Delta Junction, and Nenana.



Agricultural parcels in Southcentral Alaska cluster around Palmer and Talkeetna, as well as Copper Center and Homer.

Forage Types

A farm near Palmer

Forage crops can be consumed fresh when grazed by animals in a pasture setting. Forages can also be harvested, cured, and preserved in many forms for future use. Forage can be baled into different shapes and sizes and/or stored as silage. Hay is a major source of fodder for the livestock industry during the dormant season.

Animals prefer plants in the early growth stage (vegetative or boot) when the nutritional content of the plant is the highest. For hay and silage purposes, the best compromise between quality and yield occurs when the hay is harvested before flowering. The leaves of most forage species have the highest nutritional content. The stem is of lower quality due to higher concentrations of lignin, cellulose and hemicelulose.

Crops for use as silage are placed in a pit or silo to begin the ensiling process. An anaerobic environment is necessary to maintain the good feed quality that can be achieved with silage.

The period when forage is actively growing and nutritious in Alaska is considerably shorter than the lower 48, due to Alaska's short growing season. Therefore the identification of species growth stages, and the proper timing of animal placement on pasture needs to be managed carefully. Improper management could result in a missed cutting for a hay crop, requiring supplemental feed to balance animal's diet. Animals placed on the pasture when the forage conditions are least favorable (flowering, seed ripening stage) may not get the full nutrient potential of the forage crop.

Grazing Pasture


Photo: Alaska Division of Agriculture

Cattle graze on pasture land in Southcentral Alaska.

Pasture is land with vegetation cover consisting of grasses and legumes used for livestock in a farm setting. Pastureland can also be used by wild animals for grazing or browsing purposes. In most cases, cultivated forage crops produce higher yields than most native forages. Crops are consumed during different stages of growth.

Control and regulation of grazing intensity, timing, frequency and selectivity are dictated by the producer to control the effects of grazing animals on plants (Holechek, Pieper & Herbel, 2004, p. 127). A study from Owen et al. 1998 found that a high intensity overgrazed pasture ultimately causes plant death. It was found that grasses can be grazed without damage if 50% to 70% of the leaf and stem material by weight is left intact as a metabolic reserve. The remaining 30% to 50% is considered "surplus" that can be consumed.


Photo: Cindy Gallagher, AK PMC

Hay Cropping


Photo: Casey Dinkel, AK PMC

Bales of hay typically contain 10 to 20% moisture.

Hay is a major source of fodder for the livestock industry during the dormant season. Grasses, legumes, or other herbaceous plants are often used as a hay source. At roughly 25% moisture content - plants are cut, left to cure or wilt in the field and then processed into bales. Hay is then used as animal feed when grazing pasture is unavailable due to cold temperatures or when animals are kept in a barn or other enclosed area.

Hay is sensitive to weather conditions which can play a large role in the quality of the product. If harvested in a drought year, plant quality and hay production may be diminished. In wet weather, the cut hay may spoil prior to baling or develop rot and mold once baled. Potential toxins then become a concern, as animals can become sick if they are fed spoiled hay. Musty and/or mildewy odors indicate the presence of mold within hay.

At left:
Hay bales can be subject to free grazing by moose if not protected or stored properly.

Silage Cropping

Photos: Casey Dinkel, AK PMC

Silage is stored in an anaerobic environment to promote fermentation. Typical moisture content ranges from 40% - 60%.

Ensiling is a process that involves taking fairly wet (moisture level between 40-60%) early growth green forage and putting it into silos or pits under airtight, anaerobic conditions. If moisture conditions get any higher, clostridial bacteria may grow. The harvested crop must be well chopped and placed in a pit and packed tightly together, driving out air so the anaerobic fermentation process can begin. Fermentation will produce lactic acid, converting the high moisture forage plants to a stored energy food source.

Producers may choose to routinely produce silage, or produce silage only when field drying is difficult or impossible. A more informative in-depth article about the ensiling process was written by the Iowa State University - Cooperative Extension Service, and can be located at the following address: www.extension.iastate.edu/Publications/PM417H.pdf.

Haylage

These large hay bales have an average moisture content between 20% and 40%. These bales are known as haylage or sometimes called 'Sweet Hay'.

The ensiling process for haylage follows silage and only really differs in the lower moisture content. Crops are ensiled at 20-40% moisture. Slight variations in moisture percentage may affect the desired outcome. When moisture content at harvest time is too low, the crop becomes too dry for harvesting and storage of haylage. At this stage, making the transition to a hay crop is advised.

Photo: Todd Paris, UAF

Individual round haylage bales stored for future use

Evaluating Silage

Advantages

- Lower chance of weather delays and weather related damage during harvest;
- Lower field, harvest, and storage loss; and
- Provides flexibility and is adapted for many feeding programs.

Disadvantages

- Forage content is high in moisture, resulting in heavier forage that is difficult to haul;
- Specialized equipment for harvesting, storing, and feeding may be needed;
- Potential for high losses if silage is not properly made; and
- Quality decreases rapidly after the pit is opened.

Forage and Animals


Photo: Franci Havemeister, AK Division of Agriculture

Dairy cattle on a farm in the Matanuska Valley

In this section, several classes of foraging animals and their basic nutritional requirements are discussed. Protein, carbohydrates, fats, minerals, and vitamins are a few nutritional components necessary for animals to function properly. Other factors such as body size, type of digestive system, and the size and shape of an animal's mouth are also discussed.

Classes of Animals

Livestock can be divided into three groups based on the type of forages they consume; **grazers**, **browsers**, and **intermediate feeders**.

Grazers

This group of animal has a diet that is dominated primarily by various grass species. Cattle, bison, elk, and musk oxen are all considered grazing animals. Horses are also grazers, but have an enlarged cecum. As a consequence, horses have a considerably less efficient digestive system than other grazers. Horses have to consume 50-60% more forage in comparison to cattle to meet the same nutritional requirements.

Browsers

Browsing animals have a diet that consists primarily of forbs and shrubs. Moose, deer and domestic goats are the primary examples of browsing animals in Alaska. They utilize a variety of succulent forbs throughout the entire growing season and persist on tall growing woody species during the winter. Moose can be found browsing on grass hay bales, birch limbs, and spruce buds throughout the winter months.

Photo: Brianne Blackburn, AK PMC

A pair of dall sheep graze within the Brooks Range.

Photo: Casey Dinkel, AK PMC

A Musk Ox at the Alaska Wildlife Conservation Center.

Photo: Casey Dinkel, AK PMC

Bison cow and calf graze on a ranch near Delta, Alaska.

Photo: USDA

At right: A sitka black tailed deer munches on fireweed, *Chamerion angustifolium*.

Photo: Franci Havemeister, AK Division of Agriculture

Domestic goats are browsers.

Photo: Casey Dinkel, AK PMC

A bull moose browses on Dwarf birch, *Betula glandulosa*, in Denali National Park.

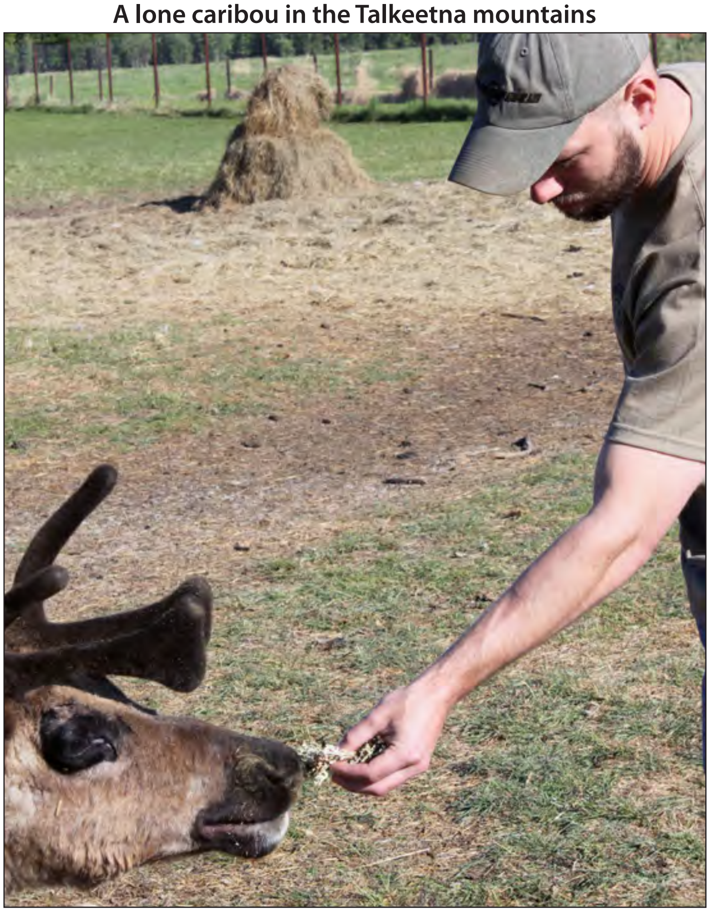
Intermediate Feeders

The intermediate feeders group includes the caribou and reindeer. Feeding on grasses, forbs, and shrubs allows the intermediate feeder to adapt its feeding habits to take advantage of available forage throughout the year. This adaptation allows these animals to survive in Alaska's diverse environment.

Photo: Casey Dinkel, AK PMC

A lone caribou in the Talkeetna mountains

Photo: Greg Finsted, UAF.



Feeding a reindeer hand-harvested lichen at the UAF Reindeer Farm. The reindeer's wide rounded muzzle allows them to selectively feed on available forage throughout the year.

Nutritional Components

All animals require food to carry out bodily functions for growth and structure. Alaska's extreme living environment can present unique nutritional challenges. Foraging animals in Alaska may be deficient in several minerals and vitamins. Animals require high energy and/or high quality feed in order to minimize stress and fight disease during the long winters. Therefore, it is important to have a basic knowledge of forage nutritional components that are essential to understanding an animal's overall health and maintenance.

Carbohydrates

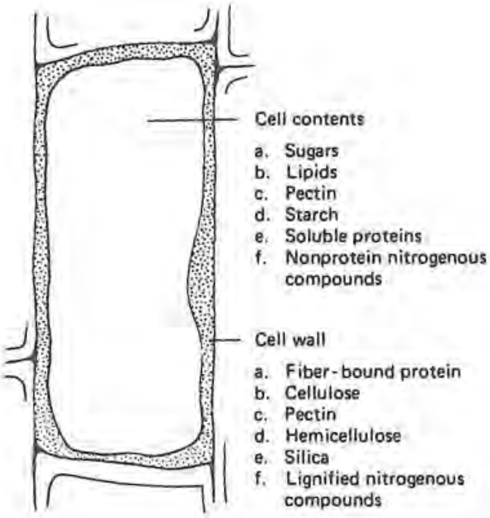
Carbohydrates are the basic energy source for all animals. There are two types of basic carbohydrates; those associated with cell content and those associated with the cell itself. Starches and sugars are found within the cell wall and are easily broken down by the digestive system. Cellulose and hemicellulose are found inside the cell and require microorganisms within the rumen or cecum to assist with digestion. Lignin is also found within the cell wall of a plant and cannot be fully broken down and digested. Lignin concentrations are typically higher in the stem of a plant as opposed to the leaf material and increases as the plant matures.

Fats

Range animals do not have the gastrointestinal system needed to break down fats, due to the absence of bile in the small intestine. Bile is produced by the liver and is the main component in the degradation of fat. A small amount of fat is necessary in an ungulates diet. Some fats can be found in the seeds of plants such as corn, peanuts, and sunflowers. Fats have about 2.25 times the energy levels in comparison to carbohydrates, making them the main source of stored energy in range animals.

Protein

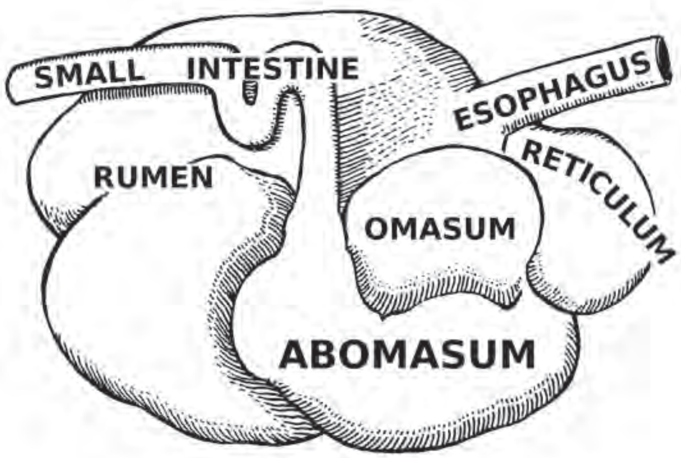
Like carbohydrates and fats, proteins are composed of nitrogen, carbon, hydrogen and oxygen atoms. More specifically, they are composed of chains of amino-acids called peptides. These peptides are responsible for carrying out many functions in an ungulate's body, such as the production of enzymes, hormones and antibodies. Proteins cannot be stored in the animal's body, so a consistent supply is required to maintain animal health.



The nutritional composition of a plant cell (Van Soest 1982)

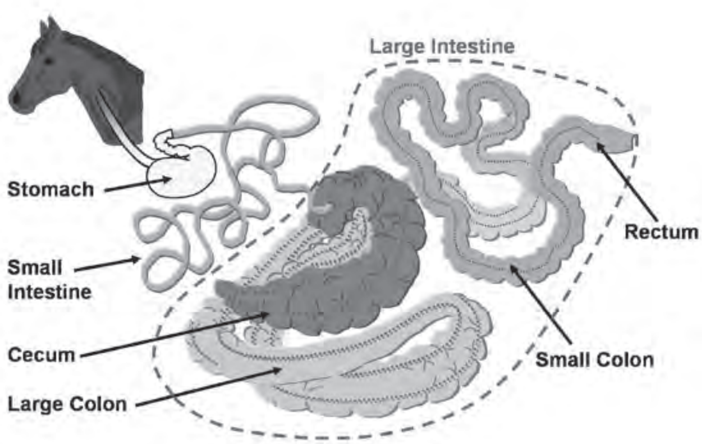
Protein levels in actively growing plants are typically higher than during dormancy. Leaves of grasses, forbs and shrubs contain higher concentrations of protein than other parts such as the stems. However, forbs and shrubs tend to have higher levels of protein on average in comparison to grasses.

Diagram: fitdaffy.blogspot.com



Ruminant digestive system

Diagram: seminolewellnessfeed.com



Cecal digestive system

Minerals

Minerals play an important role in many essential body functions, such as muscle movement, nerve transmission, and blood function. Mineral deficiencies can result in poor animal health, increased mortality, and low production. Minerals can be grouped into two separate categories: macro-minerals and micro-minerals.

Calcium, phosphorus, potassium, magnesium, chlorine, sodium, and sulfur are the main macro-minerals needed by grazing animals. These minerals generally encompass less than 5% of an animal's body. Micro-minerals/nutrients are required in substantially lower amounts in grazing animals than macro-minerals, making up of less than .01% of an animal's body. Micro-minerals required by grazing animals are iron, copper, cobalt, fluorine, zinc, molybdenum, selenium, and manganese.

Selenium commonly creates more problems for range animal health than all other micro-minerals. Selenium deficiency can cause skin disorders and/or rapid hair loss in animals. Soils throughout Alaska typically contain lower amounts of selenium as compared to the western United States, where selenium levels are higher.

Cracked or flaking hooves are a symptom of selenium deficiency

Macro - Minerals :	Micro -Minerals :
Calcium (**Ca**)	Iron (**Fe**)
Phosphorus (**P**)	Copper (**Cu**)
Potassium (**K**)	Cobalt (**Co**)
Magnesium (**Mg**)	Flourine (**F**)
Chlorine (**Cl**)	Zinc (**Zn**)
Sodium (**Na**)	Molybdenum (**Mo**)
Sulfur (**S**)	Selenium (**Sl**)
	Manganese (**Mn**)

Vitamins

Grazing animals require organic compounds such as vitamins to carry out essential bodily functions. Vitamins are separated into two different groups based on their solubility properties. Fat soluble vitamins such A, D, E, and K are stored in the animal's body and used during periods of inadequate dietary supply. Water soluble vitamins, such as C and B complex, cannot be stored in the body and require a constant supply.

Fat Soluble Vitamins :	Water Soluble Vitamins :
Vitamin **A** Vitamin **D** Vitamin **E** Vitamin **K** Vitamin **B2** *(Riboflavin)* Vitamin **B12** *(Cobalamin)*	Vitamin **C** Vitamin **B Complex** *(Excluding B2 & B12)*

Vitamin D is derived from sunlight. Deficiencies of Vitamin D are rare in the contiguous United States, but can be a concern in Alaska. Vitamin E is obtained by consuming the leafy parts of a plant and is almost never deficient. However, in some cases foraging animals have displayed moderate to violent muscle spasms due to Vitamin E deficiency.

Photo: Liz Goldsmith, EquineInk.wordpress.com

This horse shows muscle weakness due to Vitamin E deficiency.

Endophytes

Endophytes are organisms that live inside plants; they can be bacteria, fungi, or nematodes. Many survive only inside living plants and are transmitted from mother plant to seed. There are endophytic fungi that have mutualistic associations with their plant hosts (benefiting both organisms), however, some of these fungi produce toxins. The toxins produced can discourage feeding and can weaken or kill grazing animals. Not all members of an endophyte species produce toxins; growing conditions and time of year can also affect toxin loads. Generally, toxins are at their highest concentration in the crowns and seed heads. Many of the toxins can persist in stored hay for several years.

Symptoms of Endophyte Poisoning In Animals

Clinical symptoms are related to the type of toxin present. The ergot alkaloids present in fescues cause constriction of blood vessels; symptoms include elevated body temperature (animals may stand in water), increased respiration, excessive salivation, restricted blood flow, "*fescue foot*" (dry gangrene in extremities) in cold weather, "*fat necrosis*", nervousness, arched back, reduced weight gain, lowered reproduction, reduced milk production, and roughened hair coat. Ergot alkaloids can also be present in perennial ryegrass. The predominant toxin is typically lolitrem B, a tremorgen that causes tremors and muscle spasms. Lolitrems are the cause of "*ryegrass staggers*," a condition in which the animal displays outstretched neck and limbs, tremors, stiff limbed gait, reluctance or inability to rise, disorientation, reduced weight gain and reduced prolactin levels. Tremors and disorientation are more pronounced when animals are excited.

How to Identify Endophyte Infected Grass

Endophyte infection does not generally cause outward symptoms in host plants, though they may appear more vigorous than neighboring plants, or may experience less grazing pressure. In cases of isolated toxin production in a pasture, the area may be fenced off or livestock may feed on limited quantities of infected grass. Toxin production often increases with plant stress (heat, drought, overgrazing). Lush growth from excessive nitrogen fertilization should be avoided. Avoid feeding crown tissue at any time of the year. Mow or graze infected areas before seed heads develop, since they can contain the highest concentrations of toxins.

Infected pastures should be avoided in the late summer or early fall when toxin levels are high. In more extreme cases of high toxin loads or widespread toxin production, pastures may need to be killed and replanted. Pastures should NOT be replanted with lawn mixes (endophytes can be desirable to protect lawns). Many pasture grasses are tested for fungal endophytes. "**E +**" or "**E -**" labels on seed mixes indicate the presence or absence of endophytes; other labeling systems indicate the percent of infected seed. There are also varieties of pasture grass containing endophyte strains that do not produce mammalian toxins, these provide nutritional and survival benefits to the plant without risk of livestock poisoning.

Laboratory testing is available to confirm the presence of endophytes and their toxins. Please contact the Alaska Plant Materials Center at (907) 745-4469 if you suspect you may have endophyte problems in your pasture.