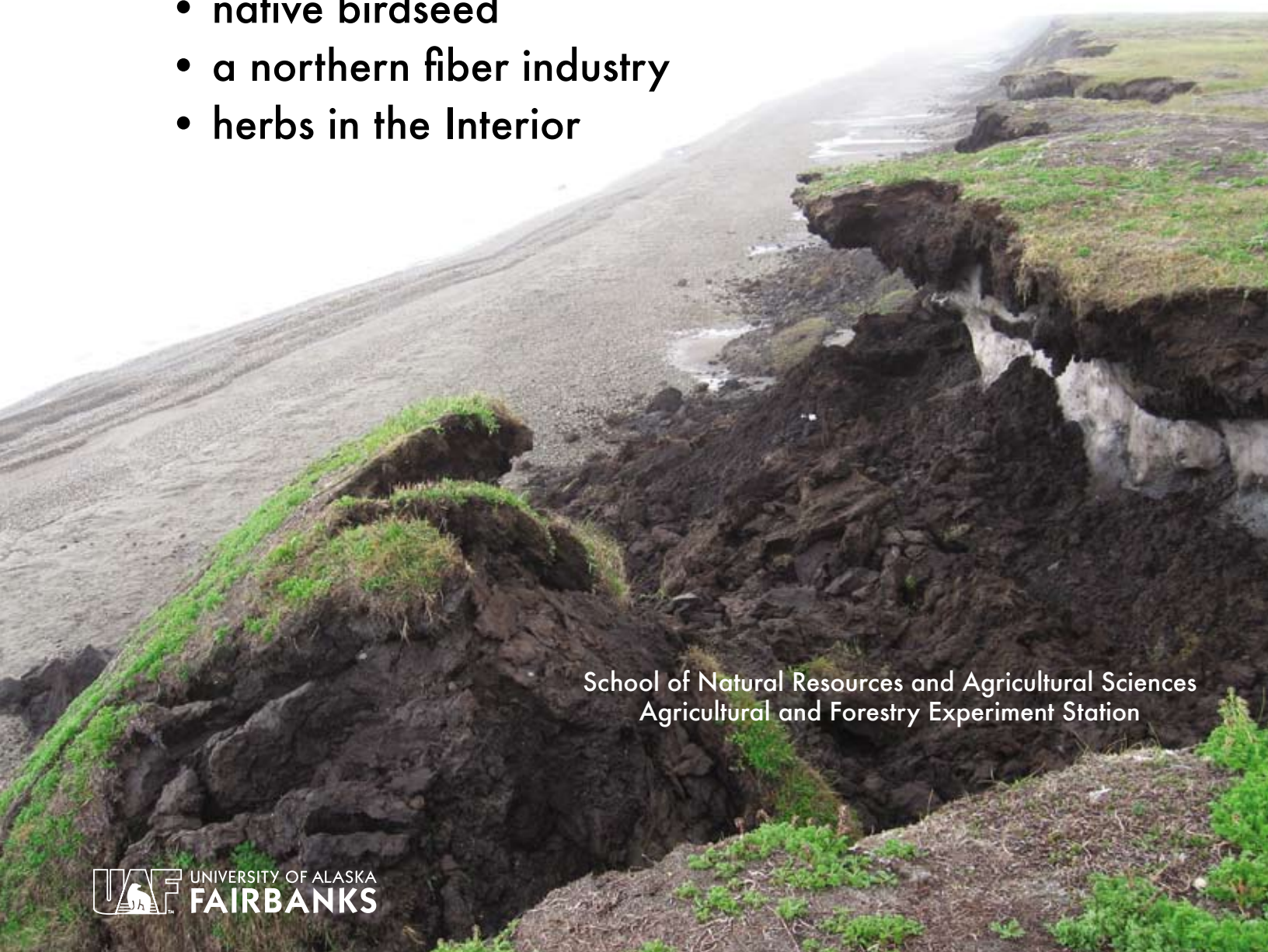




volume 39 number 1
summer 2007

coastal erosion & carbon also:

- wasp catching
- native birdseed
- a northern fiber industry
- herbs in the Interior



School of Natural Resources and Agricultural Sciences
Agricultural and Forestry Experiment Station



Turfgrass experiments at the Matanuska Experiment Farm: some varieties survive, others don't.
—PHOTO BY G. ALLEN MITCHELL



Vespula species in flight.
—PHOTO COURTESY WIKIMEDIA



Muskox cow and calf at the Robert G. White Large Animal Research Station.
—PHOTO BY CHRIS TERZY

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Wave action has resulted in this slumping coastline and exposed ice lense on the Beaufort Sea.

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—PHOTO BY GARY MICHAELSON



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Calendula, an edible flower used as a culinary herb.

—PHOTO COURTESY WIKIMEDIA



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DEAN CAROL E. LEWIS

letter from the dean:

Agricultural experiment stations throughout the United States do practical research, both applied and basic, that is relevant to the people they serve. In Alaska, the people of the state play an important role in determining the research conducted at the Agricultural and Forestry Experiment Station at the University of Alaska Fairbanks. People tell us what they see as useful, and we listen and act. Often the information that our researchers discover is disseminated by working with Cooperative Extension Service specialists and agents. In other cases, the experiment stations provide their own outreach, such as this magazine.

This magazine, *Agroborealis*, brings our research to you, illustrating the new directions we are taking. We build on the foundation laid by our researchers, past and present. For example, our turfgrass work will continue after Dr. Allen Mitchell's retirement. We look forward to working with the Cooperative Extension Service to keep bringing better greens and fairways to golfers and to extend this work to other sports field needs. People wanted to know about wasps, birdseed, and local herbs. Our partner, the USDA Agricultural Research Service, tells us about Interior wasp populations. Our practical-minded agronomists tell us that mint may be the answer to the desires of Alaska birds and, of course, those who provide feed for them. Farmers and chefs helped us gather information on chef preferences for the herbs they use and thus on the financial opportunities for farmers. Basic research on carbon cycling and coastline erosion tied to climate change is helping us all prepare for the future. We hope you enjoy this issue of *Agroborealis*, the magazine that brings our people-oriented research to readers.

Sincerely,

Carol E. Lewis

Dean and Director

Recent publications from SNRAS & AFES:



Many of our publications are available as PDFs on line:

AGROBOREALIS:
WWW.UAF.EDU/SNRAS/AFES/PUBS/AGRO/
BULLETINS:
WWW.UAF.EDU/SNRAS/AFES/PUBS/BUL/
CIRCULARS:
WWW.UAF.EDU/SNRAS/AFES/PUBS/CIR/
NATURAL RESOURCE NEWS:
WWW.UAF.EDU/SNRAS/AFES/PUBS/NRN/
SENIOR THESES:
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VARIETY TRIALS:
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Electronic publications include variety trials and senior student theses. Recent variety trials are:

VT 2007-01 Annual Flowering Plant Evaluations 2006

VT 2007-02 Vegetable Trials 2006

VT 2007-03 Herb Evaluations 2006

ST 2006-03 Preliminary Investigation into the Use of a Dehumidifying Kiln for Drying Wild Herbal Teas in Southeast Alaska, by Daniel Joseph Slakey

Recent senior theses are:

ST 2007-01 Producing Fresh Herbs for Fairbanks Restaurants: a market survey, by Jacquelyn Denise Goss (see story on p. 38)

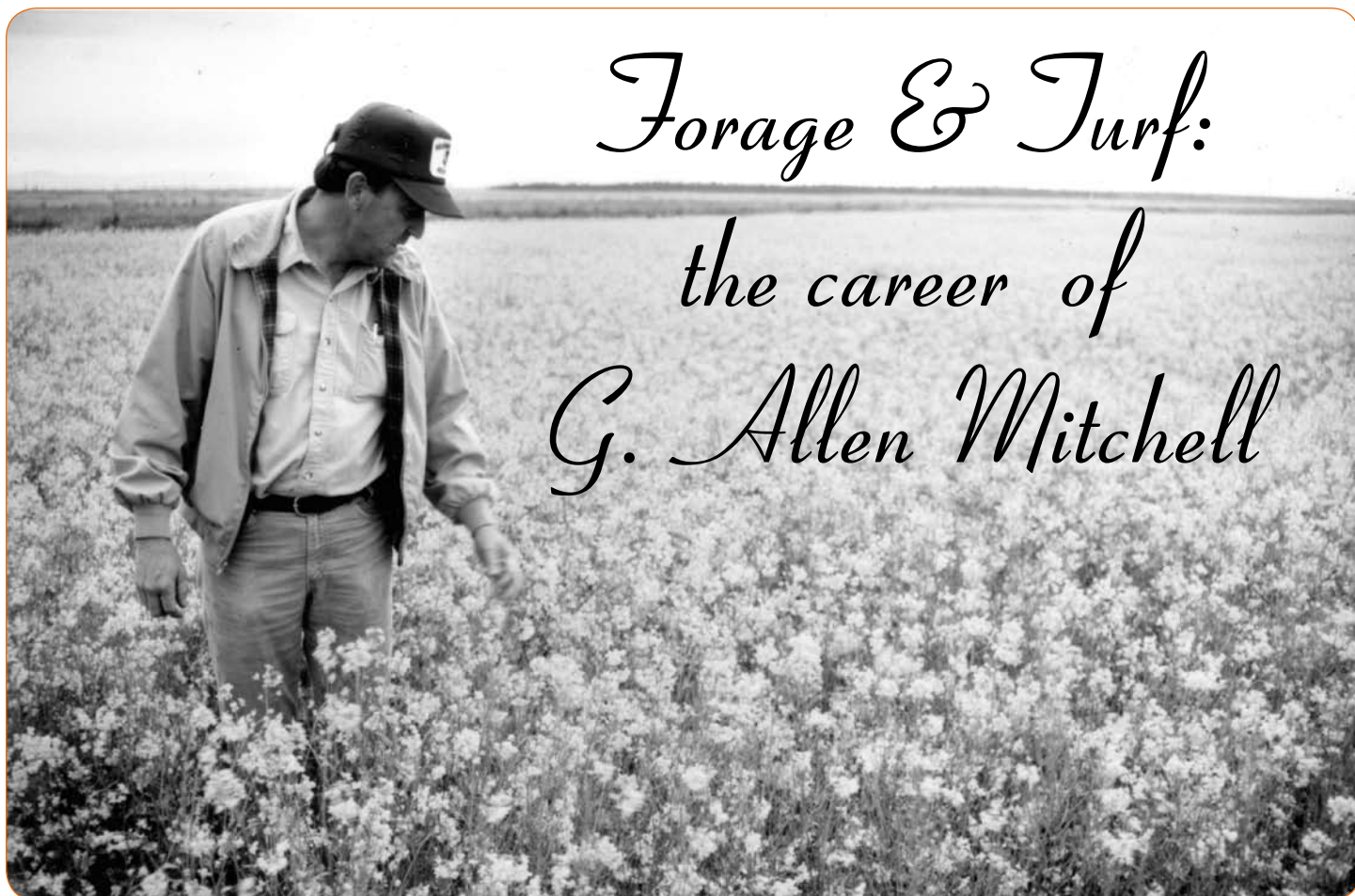
ST 2006-04 Native Plant Materials for Economic Development in Southeast Alaska, by Jason Downing

Circular 134: Reproductive Management of Alaska Livestock, by Milan Shipka and Jan Rowell

AN OVERVIEW OF REPRODUCTION MANAGEMENT FOR DIFFERENT SPECIES, INCLUDING ALTERNATIVE LIVESTOCK SUCH AS ELK AND BISON

Bulletin 115: Aboveground Biomass Equations for the Trees of Interior Alaska, by John Yarie, Evan Kane, and Michelle Mack
BIOMASS EQUATIONS FOR WHITE & BLACK SPRUCE, PAPER BIRCH, ASPEN, & BALSAM POPLAR

Forage & Turf: the career of G. Allen Mitchell



Forage for animals, turfgrasses for people briefly sums up the soil fertility research interests of agronomy professor G. Allen Mitchell, who retired in June 2007, after a 36-year career. Most recently he was the associate director of the UAF Agricultural and Forestry Experiment Station, where he directed operations at the Palmer Research and Extension Center and the Matanuska Experiment Farm.

Mitchell's early work centered on soil fertility for producing agronomic crops throughout Alaska. A natural extension of that work was research on a variety of grasses for forage and revegetation.

"Working with Allen over the years, I've relied on his advice and expertise in soil fertility for our research on small grain and oilseed production in a variety of cropping sequences and tillage scenarios in interior Alaska," said Carol Lewis, AFES director and dean of the School of Natural Resources and Agricultural Sciences. "He has also contributed to soil fertility

recommendations for field horticultural crops and to early work that was done in controlled environment settings throughout Alaska."

Mitchell's most recent interest has been in establishing and managing grasses for various turfgrass applications, particularly for golf greens and fairways. "Grasses for ground cover...must possess the same survival characteristics as related forage grasses," he said in a recent report on turfgrass performance, which is important for lawns, sports fields, and golf course fairways and greens.

Grass varieties used and available in Alaska have historically come from outside the state. In AFES studies these imported varieties were shown to be more than twice as likely to suffer winterkill as adapted species are. Varieties of two adapted species, initially identified as potential forage crops and revegetation species, have performed well: Nugget Kentucky bluegrass (*Poa pratensis* L.) and Arctared creeping red fescue (*Festuca rubra* L.). The most

Above: Mitchell in a canola field, 1989.

—PHOTO BY STEPHEN LAY

Below: Mitchell in his office at the Palmer Research and Extension Center.

—AFES FILE PHOTO



recent comparison of these and other cultivars was made by Mitchell for golf course fairways and greens in Research Progress Report 40.

Mitchell began his career at land-grant institutions in 1971 as research assistant at the University of California Riverside, where he earned BS and MS degrees, and, in 1977, a PhD in soil science with an emphasis in soil fertility. After two years as an assistant professor of agronomy at the Coastal

Plain Experiment Station, University of Georgia, he joined the UAF faculty in the same capacity, first at what was then the School of Agriculture and Land Resources Management and then at the AFES facility at Palmer, Alaska. After two years in Palmer, he went to the University of Arkansas as an associate professor of agronomy and directed the Arkansas Southeast Research and Extension Center. Mitchell returned to UAF in May 1984 as an associate professor of agronomy and extension agronomy specialist with the Cooperative Extension Service. In 1987, he became associate director of the Agricultural and Forestry Experiment Station, and in 1996 was promoted to professor of agronomy. He continued as associate director of AFES until his retirement.

“Because his extensive outreach efforts in the community in southcentral Alaska and his work with the Alaska Legislature and our congressional delegation, Allen was instrumental in retaining funding for the school and experiment station during the budget crises of the mid-1990s,” said Lewis. “In more recent years, he’s served as my mentor and colleague as we once again face budget challenges at UAF and national changes in the mission of land-grant universities.”

Writing in 1998 about Alaska’s land-grant endeavors on the occasion of the experiment station’s centennial, Mitchell said: “Over these many years, agricultural research at the stations developed numerous northern-adapted varieties of grains, grasses, potatoes, and berries [and made possible]...the adoption of other crop varieties from around the circumpolar north and elsewhere.

“The experiment stations helped Alaska feed its people from the boom days of the gold rush in the Interior through the construction of the Alaska railroad, survived the Great Depression barely intact, and served Alaska agriculture through the Second World War and the post-war period.”

He also commented on the more recent diversity of AFES activities: aid-

ing oilfield and transportation development by supplying environmental and reclamation backup in plant ecology, wildlife habitat restoration, and bioremediation; incorporating research in such land resource areas as forest ecology, forest products industries, and rural and economic development; and providing information for reindeer and other alternative livestock enterprises, along with continuing more traditional research in agronomy and horticulture.

“Working with the community and the University of Alaska Land Management staff, Allen also has been central to establishing a strategic plan for the Palmer Research and Extension Center,” said Lewis. “This effort is focused on ensuring that appropriate development takes place and making sure that any property transfers occur with minimum disruption to our research, outreach, and education programs.”

The USDA Agriculture Research Service left Alaska in 1993, after a presence dating back to 1948. “When the ARS returned in 2002 to work in both Fairbanks and Anchorage, Allen’s support for their presence in southcentral Alaska, and his assistance, made possible the state-of-the-art laboratories that are now in place at the Matanuska Experiment Farm,” said Steve Sparrow, associate dean.

Mitchell has also contributed to development of the SNRAS educational program. “Through our Palmer facility, we deliver the natural resource management BS option in plant, animal, and soil sciences in southcentral Alaska,” Sparrow said. “Allen was instrumental in establishing this program, and once it was established, he recruited students and served as their advisor and mentor. He worked tirelessly to assure that the distance-delivered courses ran efficiently and with as little interruption as possible—not an easy task in Palmer, where electronic access is limited. He’s the reason this degree program exists and the reason it has potential to continue and expand in the future.”

“Allen is the writer of our nationally-mandated Plans of Work, authored in 1997–1998 and again in 2007 and

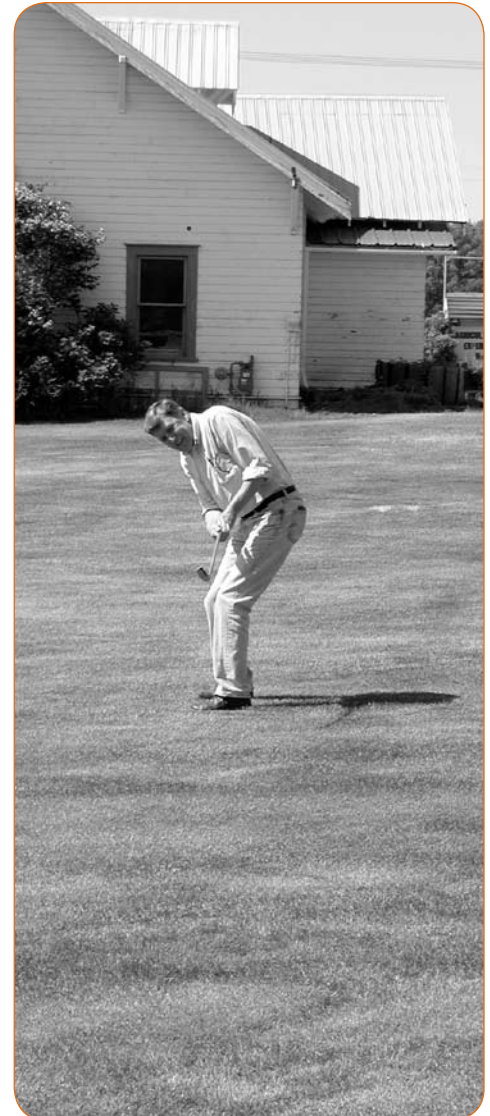


The patchwork of grass survival is clearly visible in this photo of test plots taken at the Palmer Research and Extension Center.

—PHOTO BY G. ALLEN MITCHELL

Mitchell practicing his golf swing on the Fairbanks Experiment Farm’s lawn at his retirement party in June 2007.

—PHOTO BY CONNIE HARRIS



the annual reports that speak to these plans.” said Lewis. “In the ten-year history of the plans of work, our annual reports have continued to be accepted without change and used as examples of excellence. He will be missed.”

—Doreen Fitzgerald



Red fescue, *Festuca rubra* L.

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WASPS: The Good, the Bad, and the Not-So-Bad

7

by Peter J. Landolt,*
Alberto Pantoja,**
Aaron Hagerty,**
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and Susan Emmert**

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introduction by Deirdre Helfferich

*Pictured: nest of aerial yellowjackets,
Dolichovespula arenaria.*

—PHOTO BY HAL REED AND RICH ZACK

A well-loved social feature of summers in Alaska is the barbecue: human tastebuds are made happy with meals in the outdoors. But those delicious grilled meats attract not only the neighbors, but the wasps. The yellowjacket is as much a feature of summer outdoor cooking as the mosquito, and in recent years, has been quite plentiful in the Fairbanks area, causing consternation and painful confrontations.

Alaskans are familiar with both the distinctive black-and-yellow-striped common yellowjackets (*Vespula vulgaris*) and the nests of bald-faced hornets (*Dolichovespula maculata*) and aerial yellowjackets (*Dolichovespula arenaria*), but may not be familiar with their distinctive features. As Ned Rozell

pointed out in his Alaska Science Forum column, common yellowjackets are scavengers, nesting in ground cavities, with “a taste for garbage and good barbecues.” Because people may not realize the difference in nesting habits among yellowjackets and hornets, they “often make the mistake of destroying the gray, paper-maché-looking, tree-hanging nests of *vulgaris*’ cousins, *maculata* and *arenaria*, who prefer insects to unattended steak.” Agricultural Research Service scientists Landolt, Pantoja, Hagerty, Green, and Emmert have been studying social wasps in Alaska, because even though yellowjackets and their relatives are a fact of life in the North, not much is known about them.



A bald-faced hornet, *Dolichovespula maculata*, perched at the entrance to its hive. These wasps are the largest in Alaska, and have a taste for sweets and insect prey.

—PHOTO BY HAL REED AND RICH ZACK

Wasps of Alaska

Wasps of the subfamily Vespinae are commonly referred to as yellowjackets and hornets. In proper usage, the term *yellowjacket* refers to all members of the genus *Vespula* Thomson and *Dolichovespula* Rohwer, whereas the term *hornet* refers to members of the Old World genera *Vespa* L. However, many people refer to any species with an aerial nest as a hornet, and any species with an underground nest as a yellowjacket. This group of social insects is of importance to man as both beneficial predators of pest insects and as pestiferous scavengers. Miller, in a 1961 article, and Akre et al., in their 1980 handbook, *Yellowjackets of America north of Mexico*, report ten species of yellowjackets from Alaska; *Dolichovespula albida* (= *D. norvegica*), *D. arctica* (Rohwer), *D. arenaria*, *D. norvegicoides* (Sladen), *D. maculata* (L.), *Vespula vulgaris* (L.), *V. acadica* (Sladen), *V. austriaca* (Panzer), *V. consobrina* (Saussure), and *V. rufa* L. (= *intermedia* (Buysson)).

A technical bulletin on stinging insect management published in 2002 by the company IPM of Alaska lists

three species, *Vespula maculifrons* (Buysson), *V. squamosa* (Saussure), and *Dolichovespula maculata* (as *V. maculata*) as common pests in Alaska. (However, the listing of *V. maculifrons* and *V. squamosa* as pests in Alaska was in error, since both species are restricted to the eastern United States and lower latitudes.)

Brian Barnes, et al., of the UAF Institute of Arctic Biology, reported in 1996 on the overwintering habits of *V. vulgaris*. There is little else known of Alaska's wasp species.

The Good

Yellowjackets and hornets serve as important predators of other insects. They are well known to prey on caterpillars, grasshoppers, flies, and myriad other types of insects of farm, garden, and forest. In this manner, they help keep populations of many insect species in check. They in turn are food for some birds and mammals that will eat them singly or dig up the nest to consume the larvae. Although not a common benefit, there are also flower species, such as Trilliums, that are pollinated by visiting wasps.

The Bad

Yellowjackets can be a pest in Alaska in areas inhabited by people and animals, in particular when they build their nests on or near human structures. Many *Vespula* and *Dolichovespula* species pose stinging hazards to humans, pets, and farm animals. The two recent yellowjacket-related human fatalities in Fairbanks in summer 2006 clearly illustrate the potential danger of stings, particularly for those who are allergic to the yellowjacket's venom. Most unpleasant human-yellowjacket interactions occur when the wasps are either defending their nests from disturbance or scavenging for food.

The Not-So-Bad

All species of yellowjackets will respond with aggression and defend their nest if the nest is disturbed; however, not all species exhibit scavenging behavior. Food-gathering behavior of yellowjackets varies widely. Members of the *V. rufa* species group (*V. rufa*, *V. acadica*, and *V. consobrina* in Alaska) primarily are hunters of live insect prey; *V. vulgaris* wasps are



Vespula vulgaris.

—PHOTO BY DEREK SYKES, UA MUSEUM OF THE NORTH

commonly scavengers and hunt insect prey; members of the genus *Dolichovespula* (*D. arenaria*, *D. maculata*, and *D. norvegicoides*) fall somewhere in between. *V. austriaca* and *D. adulterine* are social parasites in the nests of other yellowjackets; a queen invades the nest of another yellowjacket species (*D. arenaria*, *D. norvegicoides*, *V. rufa*, and *V. acadica*) and relies on that nest's workers to raise her young.

Trapping the Wasps

To find out more about the local populations of wasps, we used attractant-baited traps to collect data on species composition, distribution, and pest status of eight species of wasp captured in Fairbanks, Delta Junction, and Palmer, Alaska, from May to September. Our study was conducted during 2003 and 2004 to assess the relative abundance and species diversity of vespine wasps in Alaska agricultural habitats. Organic and low-chemical-input farms producing potatoes, rhubarb, and other vegetable crops near Fairbanks, Delta Junction, and Palmer were chosen as study sites.

The chemistry of attractants useful in trapping and monitoring yellowjacket wasps has been discussed by several authors (see references below); heptyl butyrate and acetic acid plus isobutanol have been reported as attractive to various yellowjacket species. In an article published in 2005 by Landolt, Pantoja, and Green in the *Journal of the British Columbia Entomological Society* we reported in detail on the responses of Alaska wasps to chemical attractants; we found that the different species of yellowjackets were attracted in varying degrees to different chemical attractants. *V. acadica*, *V. consobrina*, and *V. rufa* were attracted to heptyl butyrate; *V. vulgaris* and *D. maculata* were attracted to acetic acid plus isobutanol. It appeared that *D. arenaria* and *D. norvegicoides* were poorly attracted to either lure.

Yellowjacket Species in Alaska

Vespula vulgaris L.

Known worldwide as the common wasp, *vulgaris* is an underground nester that increases in abundance from June into September. It is a serious pest because it can be very abundant and is a scavenger of both meats and sweets. Because it hides its nest underground and will defend it vigorously, an unsuspecting person or animal can be in real trouble by stepping on or near the nest site.

V. acadica (Sladen)

This species is similar in appearance to *vulgaris*, and is also an underground nester. However, it is far less abundant, peaks in numbers in early August, and occurs in smaller colonies. It generally does not scavenge and is not a pest unless a nest is disturbed.

V. consobrina (Saussure)

Consobrina is similar in biology to *acadica*, with small underground colonies, a short colony cycle, and small populations. It also does not scavenge and is not routinely in contact with people. It is noteworthy in being white and black, rather than yellow and black.

V. rufa (L.) (=intermedia [Buysson])

The name *rufa* refers to the red markings on the fore part of the abdomen of this wasp, which is otherwise black and yellow. It also is not generally a pest, nests underground, and does not scavenge. It is most abundant in late July and early August.

V. austriaca (Panzer)

This species is a social parasite of *acadica* and *rufa*. Only the queens and males are encountered because there is no small female worker caste. Its principle significance is probably its suppression of populations of *acadica* and *rufa*.

Dolichovespula maculata (L.)

The bald-faced hornet is noteworthy in several regards: it is the largest species of social wasp in Alaska, is strikingly white and black rather than yellow and black, and makes aerially placed nests that are round or oval. Disturbance of interlocking shrub or tree branches can easily bring this insect to attack. It is more often seen as a scavenger of sweets than meat.

D. arenaria (F.)

This species is referred to as the aerial yellowjacket because it is the most common yellow and black wasp to place nests above ground; in shrubs and trees, or attached to eaves of buildings. Again, it is a stinging threat if the nest site is disturbed. One must be alert walking through tall brush, because the nest is hard to see and a hiker can disturb the nest without even knowing it is there. Like *maculata*, it is more of a scavenger of sweets, and is generally not seen on your ham sandwich.

D. norwegica (=albida [Sladen])

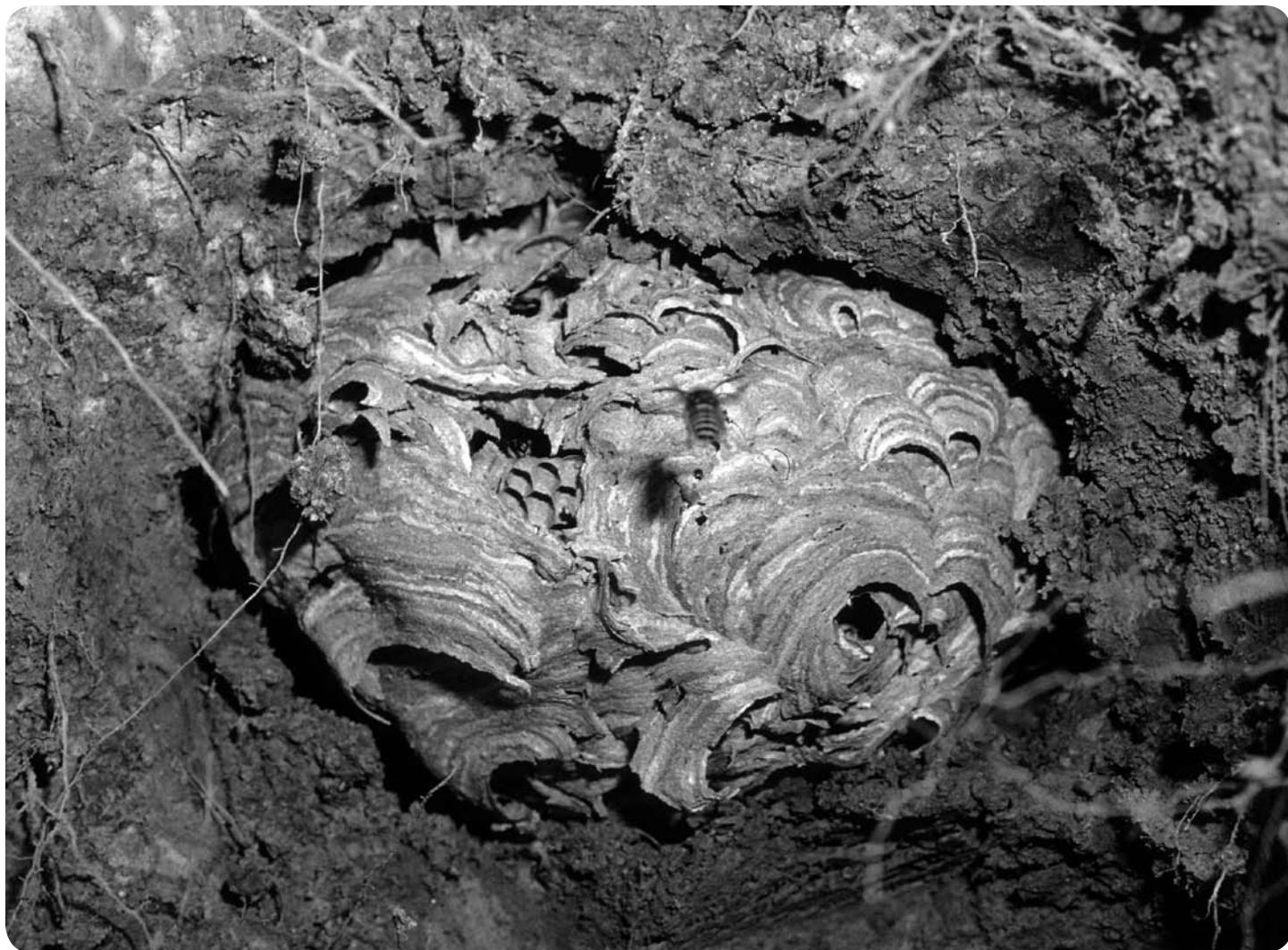
This wasp is an aerial nester but is much less abundant than *arenaria* and is not much of a pest threat. Many specimens have small red markings on the abdomen and are otherwise white and black.

D. adulterina (Buysson)

Adulterina, previously known as *Dolichovespula arctica*, is a social parasite of *D. arenaria*. Only queens and males are seen, with no worker caste. It is white and black, and looks similar to *Vespula consobrina*. It has no pest status. Rather, it may reduce numbers of the more pestiferous aerial yellowjacket.

D. norvegicoides (Sladen)

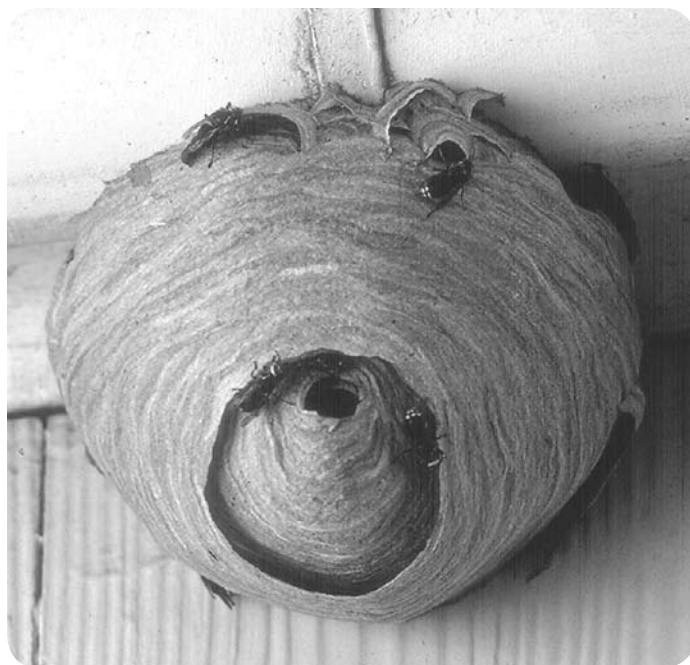
This species looks like a dark version of *arenaria*. It also makes aerial nests, but is not quite as common as *arenaria*.



Above: Worker Vespula vulgaris, or common yellowjacket, coming in for a landing (center) to its underground nest.

Below: nest and workers of Dolichovespula maculata, the bald-faced hornet, under the eave of a building.

—PHOTOS BY HAL REED AND RICH ZACK



We captured the wasps using commercial traps (Agrisense Dome or Trappitt). The traps are pear-shaped with inverted funnels beneath and with clear plastic tops and opaque yellow bottoms, within which is placed a drowning solution (0.125% soap and 2% boric acid in water). Wasps enter the trap from below through the inverted funnel and become trapped in the drowning solution. Chemical attractants were heptyl butyrate and acetic acid with isobutanol, dispensed from 15 ml polypropylene bottles with 6 mm holes in the lid for chemical release. Bottles were suspended inside the trap from the top with wire. Traps were placed 20 m apart, at a height of 1.5 m on vegetation or on fences. We checked the traps weekly, replacing the drowning solution each week. The chemical lures were replaced every thirty days. Insects were identified by descriptions, illustrations, and keys in Miller's 1961 article, in the USDA handbook *Yellowjackets of America north of Mexico*, and following the taxonomy of Carpenter and Kojima. From these captured wasps we took voucher specimens for deposit in the James Entomological Collection at Washington State University in Pullman and with the USDA ARS Subarctic Agricultural Research Unit in Fairbanks. (A voucher specimen is any specimen that serves as a basis of study and is retained as a reference.)

Dolichovespula and Vespula species captured in Fairbanks, Palmer, and Delta Junction, Alaska 2003–2004.

Genus/Species	Fairbanks	Delta Junction	Palmer	Habits
<i>D. norvegica</i>	n	n	x	B, S
<i>D. adulterina</i>	x	n	n	P
<i>D. arenaria</i>	x	x	x	B, S
<i>D. norvegicoides</i>	x	x	n	B, S
<i>D. alpicola</i>	r	r	r	B, S
<i>D. maculata</i>	x	n	x	B, S
<i>V. vulgaris</i>	x	x	x	S
<i>V. austriaca</i>	n	n	x	P
<i>V. rufa</i>	x	x	x	B
<i>V. acadica</i>	x	x	x	B
<i>V. consobrina</i>	x	x	n	B

x = indicate presence of that species in locality
 r = indicates reported from Alaska, but not collected during this study
 n = not collected from this locality
 P = social parasites
 B = beneficial
 S = scavenger/potentially pestiferous

The lures:

heptyl butyrate

This synthetic chemical has a fruity odor and is structurally similar to natural fruit esters.

isobutanol

This chemical is produced naturally during the fermentation of carbohydrates. It may also be a byproduct of the decay process of organic matter.

acetic acid

This corrosive chemical is found in vinegar and other substances, and is best recognized for its sour (vinegary) taste and pungent smell.

Pestiferous Populations?

Ten species of yellowjackets were collected: *Vespula vulgaris* L., *V. acadica* (Sladen), *V. consobrina* (Saussure), *V. rufa* (L.) (= *intermedia* [Buysson]), *V. austriaca* (Panzer), *Dolichovespula maculata* (L.), *D. arenaria* (F.), *D. norvegica* (= *albida* [Sladen]), *D. adulterina* (Buysson), and *D. norvegicoides* (Sladen).

The common yellowjacket, *V. vulgaris*, was the most abundantly trapped species during both years and at all three study locations (see table and figure). Queens were captured in late May and early June; workers were captured between mid-June and early October, and males were captured from late July into late September. Most of the samples consisted of workers that were abundantly trapped from mid-July into late August.

Vespula acadica queens were captured in late June and again in mid-September. Workers were captured from mid-June to mid-September. Worker *V. consobrina* were captured in traps from early July to August in Delta Junction and from June to July in Fairbanks. Workers of *V. rufa* were captured from June to July in Delta Junction, from June to July in Fairbanks, and August in Palmer. Few *Vespula austriaca*, *D. adulterina*, *D. arenaria*, *D. norvegicoides*, or *D. norvegica* wasps were captured in this study.

Although Miller and Akre report that *V. consobrina* is absent from most of Alaska, this species was captured at Fairbanks and Delta Junction, and although they indicate the presence of *Dolichovespula alpicola* wasps, none were collected during our study. Their absence from trap catches could have been the result of their absence from the study area, low population density, or a lack of response to the chemical attractants.

The seasonal pattern of wasp captures in traps indicates a broad period of activity—early July to early September—during which they could be pestiferous.

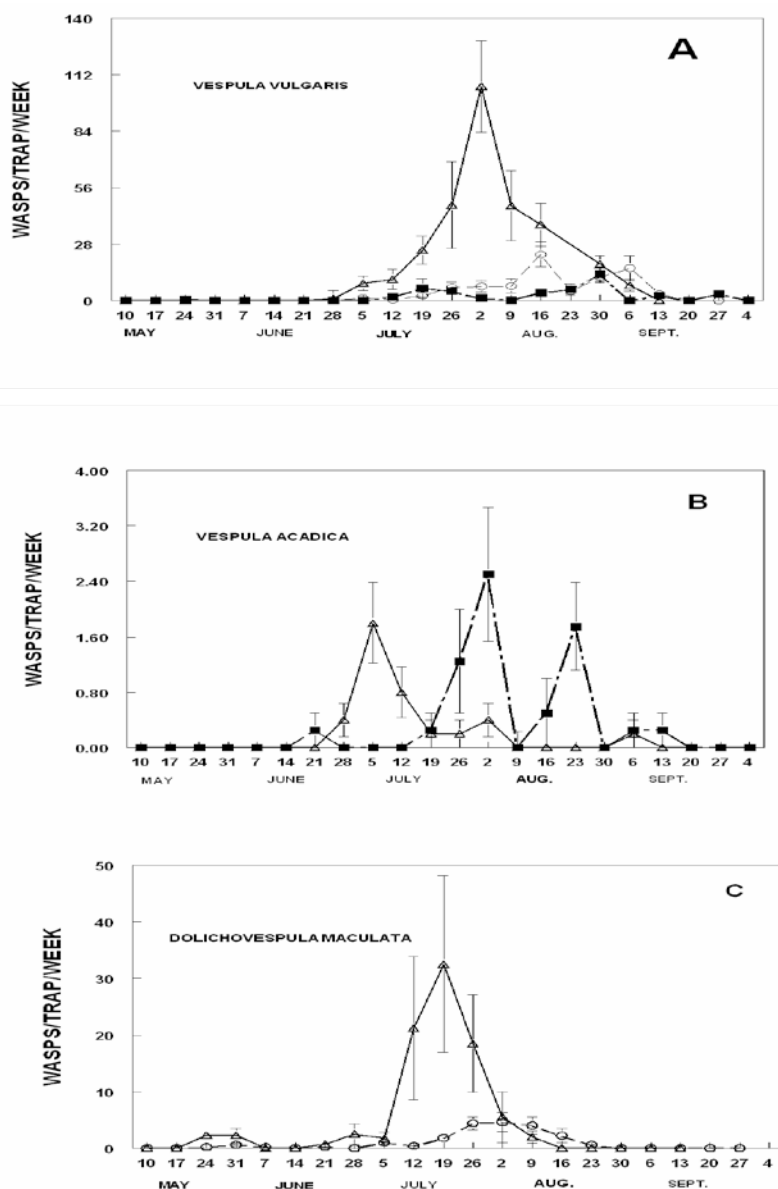


Figure 1. Population dynamics of yellowjackets in three localities of Alaska. Sites are Fairbanks (open triangle), Delta Junction (filled square), and Palmer (open circle).



A close view of the common western yellowjacket, *Vespula vulgaris*.

—PHOTO BY HAL REED AND RICH ZACK

Due to its abundance and the scavenging behavior that brings it into frequent contact with people, *V. vulgaris* is considered of particular importance. The bald-faced hornet *D. maculata* may also be pestiferous in Alaska due to its abundance during July and August. Other species of wasps captured, such as *V. acadica*, and *V. consobrina*, are less likely to be pestiferous because they are not known for scavenging habits, occur in smaller colonies, and do not occur in high densities, compared to species such as *V. vulgaris*.

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*Above: D. maculata queen (left) and workers on nursery combs.
Left: Hornet nest (D. maculata) on birch tree.*

—PHOTOS BY HAL REED AND RICH ZACK

Dragonhead mint

by Deirdre Helfferich, from a research report by
Charles Knight and Robert Van Veldhuizen, Misc. Pub. No. 2006-01

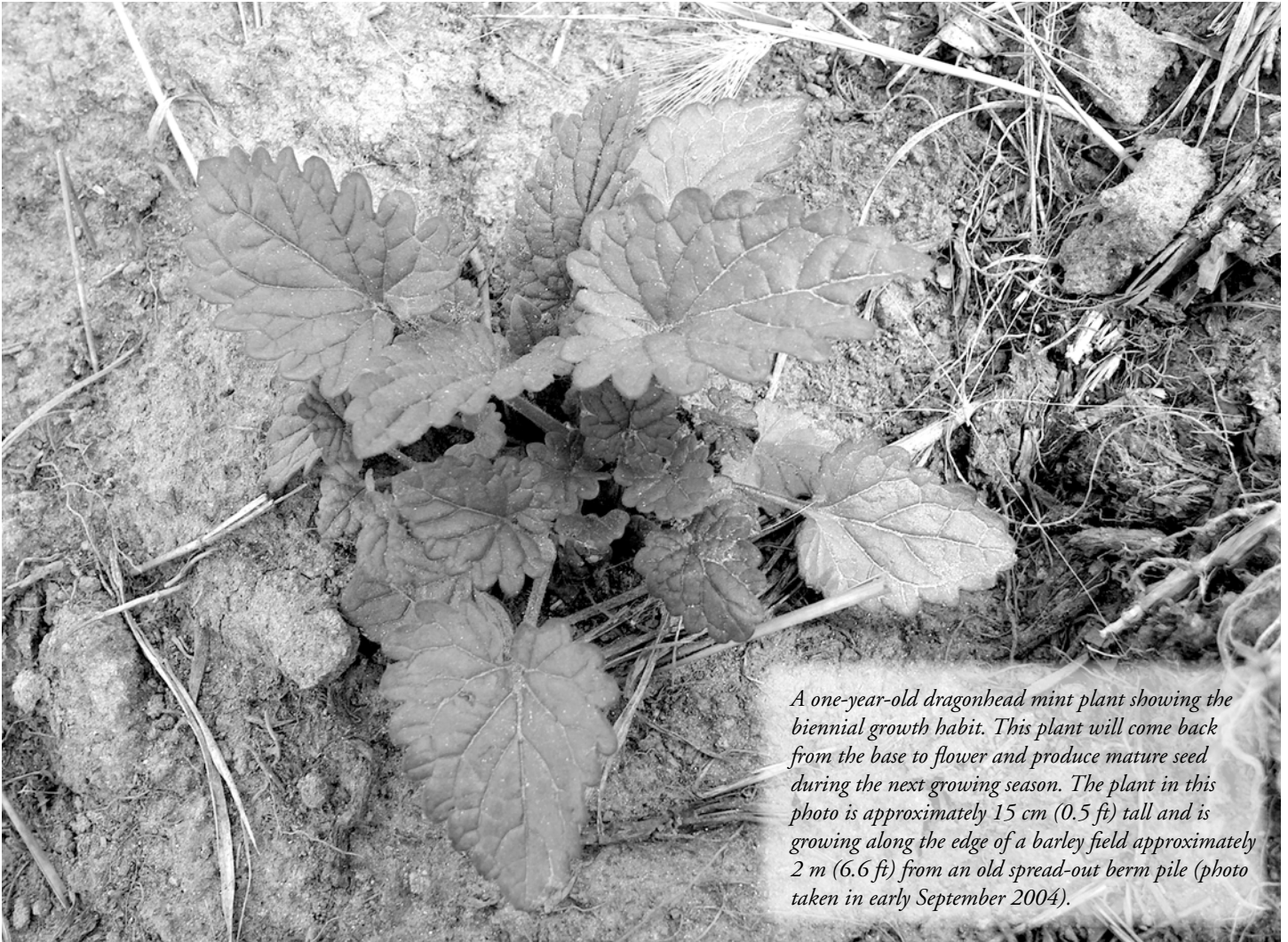
14 Q: When is a weed not a weed anymore?
A: When its virtues are discovered!

When Bob Van Veldhuizen and Charlie Knight noticed that wild birds (chickadees and other small seedeaters) were feeding on disturbed farmlands in the Delta Junction area, they decided to find out what was attracting them. “We were out there doing a wintertime canola seeding study,”* explained Van Veldhuizen, “and we saw all these birds in the fields, chowing down in the middle of an open field.” The fields had a variety of

dried-out plants poking through the snow, and the two men weren’t sure what the songbirds were feasting on, but “they were flitting from something to something,” and evidently eating well. The birds’ behavior piqued the interest of the two scientists. (Knight

it’s for the birds!

is an associate professor of agronomy emeritus; Van Veldhuizen is research assistant at the Agricultural and Forestry Experiment Station.) So later, when the opportunity arose, the men decided to do a little more bird- and weedwatching for science.



A one-year-old dragonhead mint plant showing the biennial growth habit. This plant will come back from the base to flower and produce mature seed during the next growing season. The plant in this photo is approximately 15 cm (0.5 ft) tall and is growing along the edge of a barley field approximately 2 m (6.6 ft) from an old spread-out berm pile (photo taken in early September 2004).

Birds in Alaska must produce tremendous amounts of energy to keep warm in the dead of winter. For example, according to Sue Guers at the Alaska Bird Observatory, a chickadee loses up to ten percent of its body weight at night in midwinter, using stored fat to keep warm, and needs high-energy food to regain it each day. Seeds high in oil, such as black sunflower seeds (handily found in backyard feeders), are the food of choice for seedeaters like chickadees or redpolls.

Dragonhead mint (*Dracocephalum parviflorum* Nutt.), it appears, is also a good food source for them. The plant is a wild mint that grows throughout the northern continental United States, Canada, and Alaska. It has oily seeds and looks similar to an invasive weed, the hempnettle. The leaves and seeds of dragonhead mint, like many wild mints, have traditionally been used as a flavoring for foods and medicinally as a treatment for diarrhea in children, or as an infusion for the treatment of fevers and headaches, and externally as an eyewash. It has not been used commercially, however.

Knowing that many Alaskans purchase bird seed imported from elsewhere, Van Veldhuizen and Knight decided to investigate dragonhead mint and other plants for their potential as ingredients in commercially sold food for wild birds. Commercial birdseed mixes include seeds high in oil content, such as sunflower (preferred by chickadees and pine grosbeaks) and canola or rapeseed (preferred by redpolls). The oilseeds provide an easily used energy source.

Since the birds appear to be selective in picking out from feeders only the seeds that supply them with the necessary energy to keep warm, the researchers assumed that they would also be choosy about what they gathered from wild or feral plants in the farm fields. To determine which plant species are likely to be preferred, they needed to identify which species with seeds available throughout the winter contain the highest amount of food energy (percent oil by weight).

From previous research on feeding wild birds, Van Veldhuizen and Knight

compiled a list of eighteen plant species found in the Interior (both native and escaped domestic plants). Each species had to occur as a common weed in and along agricultural fields in the Delta Junction area (the study site) in sufficient quantities potentially to attract birds. During the late summer and early fall, mature seeds were collected from these species for evaluation.

These seeds were analyzed for nutrients and percent oil content, along with oilseed sunflower and Polish canola as comparison standards (see table). Two members of the Mint family, hempnettle (*Galeopsis bifida* L.) and dragonhead mint turned out to have quite high oil content, thirty-five and twenty percent, respectively. The main stem on both species is stiff and remains upright throughout the winter, placing the seed heads above the snow layer. Most of the seeds remain in the seed head, making them available to the birds.

Another important factor regarding the suitability of these species for bird food production is their potential to become invasive plants. Hempnettle is an introduced weed that is on the list of potentially invasive weeds for Alaska. It isn't common in Delta Junction, however, as it likes lower, damper areas. This limits its importance as a major food source for this area, so it was eliminated from further consideration, even though it has a good oil content.

Dragonhead mint, on the other hand, is a native species found in drier sites along fencerows and old berm piles in mechanically disturbed areas. In the natural environment, it will occur after forest fires and the seeds produced will then lie dormant until the next fire. In either situation, the seed can remain viable in the soil for perhaps hundreds of years. Every time buried seed is exposed by tillage, berm-pile management, or forest fire to conditions proper for germination, more dragonhead mint becomes available for bird populations.

The plants have either an annual or biennial growth habit, growing anywhere from a few centimeters to close to a meter tall (a few inches to over three feet). The stems, as in all members

of the mint family, are square in cross-section, purple, and very sturdy. They will often stand through the winter snows and high winds of the Delta Junction area until the following spring. The leaves are sharply toothed, dark green on the top with purple margins and veins. When crushed, they have a slight minty smell.

When blooming, there are clusters of many small pink-to-violet flowers in whorls at the ends of many branching stems on each plant. It flowers from mid-July through mid-August and is pollinated by insects.

When the plant is mature, the leaves turn brown, dry up, and fall from the stems, leaving only the seed heads (the old flower whorls) at the top of each stem. The mature seed heads are dense with sharp, spiny bracts. The mature seeds are dark brown to black, oval, and small, about 1/16 inch long. They are held in the seed head until the plant is disturbed, through tillage for example, or when the main stem has been broken (Moerman 1998).

Seed germination

For this research, a large quantity of dragonhead mint plants were hand harvested in the fall, dried for two weeks, hand threshed, and cleaned to obtain enough seed to plant in test plots the following spring. To determine the germinability of the seed, a test on 100 seeds was done on moist filter paper at 25°C (77°F), under eight hours per day of fluorescent light for twenty-one days. Only ten percent of the seeds germinated.

This low germination rate led Knight and Van Veldhuizen to believe that some sort of seed treatment was needed to overcome seed dormancy and facilitate germination. They tested various methods of scarification, stratification, and seed treatment to determine the most effective method of increasing germination, and also evaluated these treatments for their ease of use with large quantities of seed and with mechanical planting. Studies done on other species of dragonhead (for example *Dracocephalum thymiflorum*)

Seed analysis of 20 native and escaped domestic plant species found in the Delta Junction area, Alaska. (Polish canola and oilseed sunflower in bold type and darker rows are comparison standards.)

Plant Species (scientific name)	% Dry Matter	% N	% P	% K	% Crude Protein	% Oil	% Neutral Fiber	% Acid Fiber	% Hemi- cellulose	% Lignin	% Cellulose	% Ash
Alpine Milk Vetch (<i>Astragalus alpinus</i> L.)	95.38	5.44	0.52	1.24	34.00	2.24	23.88	14.19	9.69	2.13	12.06	3.98
Bird Vetch (<i>Vicia cracca</i> L.)	93.57	5.23	0.52	1.01	32.69	1.92	19.07	10.97	8.10	2.10	8.88	3.45
Cinquefoil (<i>Potentilla norvegica</i> L.)	97.25	2.15	0.39	1.37	13.44	22.00	44.85	22.57	22.28	9.29	24.28	8.13
Corn Spurry (<i>Spergula arvensis</i> L.)	97.06	2.05	0.50	0.61	12.81	9.50	41.04	29.53	11.51	5.09	24.44	21.50
Dragonhead Mint (<i>Dracocephalum parviflorum</i> Nutt.)	98.15	2.09	0.37	1.26	13.06	19.66	57.41	37.09	20.32	14.79	22.31	4.07
Eskimo Potato (with hulls) (<i>Hedysarum alpinum</i> L.)	96.02	4.43	0.45	1.09	27.69	6.92	36.21	24.21	12.00	8.59	15.61	4.84
Hempnettle (<i>Galeopsis bifida</i> Boenn.)	97.42	2.51	0.58	0.47	15.69	35.21	36.94	29.75	7.19	5.98	23.77	4.34
Indian Paintbrush (<i>Castilleja rupii</i> Pennell)	96.65	3.27	0.82	1.94	20.44	10.60	44.98	20.85	24.13	7.78	13.07	9.05
Lambsquarter (<i>Chenopodium album</i> L.)	94.87	2.95	0.47	1.58	18.44	7.34	26.88	18.09	8.79	4.39	13.71	5.41
Lupine (<i>Lupinus arcticus</i> S. Wats.)	96.25	6.13	0.66	1.06	38.31	7.02	27.76	17.03	10.73	2.26	14.78	5.48
Paper Birch (dewinged) (<i>Betula neoalaskana</i> Sarg.)	96.23	1.03	0.19	0.63	6.44	4.56	69.99	53.15	16.84	24.87	28.28	3.33
Polish Canola (<i>Brassica campestris</i> L.)	96.96	3.92	0.88	0.76	24.50	41.04	33.19	12.63	20.56	5.02	7.61	5.07
Red Clover (<i>Trifolium pratense</i>)	93.77	5.58	0.58	1.13	34.88	7.08	28.59	11.74	16.85	1.38	10.36	4.06
Sourdock (<i>Rumex arcticus</i> Trautv.)	94.44	2.39	0.40	0.90	14.94	4.08	14.53	8.02	6.51	5.14	2.88	3.51
Sunflower (hulled) (<i>Helianthus annus</i> L.)	96.21	3.60	0.76	0.63	22.50	51.06	18.83	11.95	6.88	3.91	8.04	3.59
Water Smartweed (<i>Polygonum amphibium</i> L.)	95.30	1.63	0.32	0.41	10.19	4.28	33.96	21.88	12.08	10.44	11.44	2.20
White Spruce (dewinged) (<i>Picea glauca</i> (Moench) Voss)	95.38	3.55	0.69	0.69	22.19	25.02	37.97	30.97	7.00	10.65	20.32	4.40
White Sweet Clover (<i>Melilotus albus</i> Desr.)	96.17	5.62	0.41	0.90	35.13	4.48	28.43	13.38	15.05	1.60	11.78	3.36
Yellow Alfalfa (<i>Medicago falcata</i>)	95.23	5.51	0.70	1.02	34.44	9.82	26.06	10.58	15.48	1.88	8.69	3.96
Yellow Oxytrope (<i>Oxytropis campestris</i> (L.) DC.)	95.51	5.44	0.73	1.13	34.00	4.12	30.44	18.50	11.94	3.61	14.88	5.24



The dark heads of mature dragonhead mint plants are clearly visible in this harvested barley field. The mint is an understory weed, approximately 15 cm (0.5 ft) tall and dispersed out from an old spread-out berm pile with the spring tillage. The seed heads still contain mature and viable seed (photo taken in early September 2004).

have shown that they require light for germination, so, after each treatment method was performed, the seed was allowed to germinate as described above.

Most dragonhead mint found in agricultural fields occurs where old berm piles have been burned and rolled over or moved in some way. Dragonhead mint seed is also found in soil cores from intact forests. These seeds remained after the forest last burned, suggesting that the plant is a successional species following forest fires. Because of this, Knight and Van Veldhuizen speculated that some sort of heat treatment might be the best way to reduce dormancy and still allow for ease in handling during planting. However, the best germination results came from a hot water soak (63 percent). The drawback to this method is that it produces wet seed that is very difficult to handle with traditional mechanical drills. Wet seed would stick to the sides of the seed boxes, bridge up over the openers, and plug up the feeder tubes. It would also require planting immediately after treatment to avoid any drying out that could further reduce germination.

There are seeders that use a water or gel injection system to plant moist or pre-germinated seed, but they are expensive and rare in interior Alaska. To avoid this expense, Knight and Van Veldhuizen tried fine-tuning the hot water soak treatment by drying the seed before planting time. The treated seed was blotted dry to remove enough water so the seeds no longer stuck to each other. The seed was left to dry further at 25°C (77°F) for two hours before the germination test started. (The researchers assumed that this would be the average time between treatment and seeding, at least for the parameters of their study.) The resulting 60 percent germination compares favorably to the hot water soak treatment. This means that the seed can still be treated with the best method for increasing germination and then dried to a point where it can be mechanically planted without any significant loss in germination.

Field studies

Seed treated with the hot water soak method followed by drying was planted

in six rows 30 cm (1ft) apart in four plots at the Fairbanks Experiment Farm, at a rate of 29 pounds per acre. An Almaco six-row plot cone seeder was used to plant on May 20. There were no fertilizer or pesticide applications to this area during the study. Before planting, the soil was tilled with an eight-foot Lely Roterra rotary harrow and packed with a six-foot Brillion pulverizer to obtain the firmest seedbed possible. Even with a firm seedbed and the cone seeder set to the shallowest depth, the dragonhead mint seed was planted too deep for good germination. This was evident after one month, when there was no significant emergence on the entire plot area, except for various weed species.

In late June, the researchers decided to remove the weeds from the plot area to prevent them from going to seed and to reduce competition for the few dragonhead mint seedlings that had emerged. The process of pulling the weeds by hand and knocking the soil from the roots turned over a significant amount of the top few centimeters of soil within the plot. This had the unexpected result

of exposing the dragonhead mint seeds to the surface and thus to the sunlight required for germination.

In the Delta Junction area, dragonhead mint has been observed at the seedling stage (one to two weeks after germination) late in the season (late August to early September) in agricultural fields that had not been redisturbed since that spring. This suggests that the seed can germinate over time when the conditions are right, which might explain some of the germinations observed in the Fairbanks test plot at the end of the growing season.

By the end of the growing season the plant cover in the plot areas was almost 95 percent dragonhead mint. It was a very healthy stand, with plants at about 1.4–2.0 feet tall, with some in first flower by the first killing frost in late September. Since these plants did not have time to produce much viable seed due to the late start, Knight and Van Veldhuizen decided to leave the plot as it was, to observe plant survival and whether more germination would occur during the next growing season.

Plant cover during the next growing season was about 75 percent. Many of the plants appeared to be the same ones as the previous year, supporting the reports of a biennial growth habit for this mint. The plots were again hand weeded throughout the growing season with a few more new germinations resulting. The plants reached full maturity with an abundance of seed-producing flowers by the end of September. They were then harvested with a Winterstiger plot combine equipped with a five-foot reel header with concave clearances, screens, and airflow settings similar to canola seed settings.

The harvested seed was hot force-air dried at 35°–40°C (95°–104°F) for two weeks and hand cleaned using a series of sieves. The final yield was about 96 pounds per acre. This yield works out to three times the original seeding rate. Assuming an average percent germination of 65 percent using the hot water soak method, then there would be about 63 pounds of pure live seed to plant the following year, or about enough to plant two acres at 30 pounds per acre.

“Assuming that we could duplicate the yields the next season, that would yield close to 200 pounds of dragonhead mint seed,” the researchers reported in their dragonhead mint study.

The test plot was tilled the following season and was maintained under fallow conditions throughout the remainder of the third growing season. Since this time the area has been planted to a barley/fallow rotation. No more dragonhead mint has shown up, either as a weed in the barley crop or as a volunteer plant when the field is left fallow. This suggests that a rotation of spring tillage effectively controls the spread of dragonhead mint. The likelihood of this plant ever becoming invasive like hempnettle is very small if traditional tillage practices are utilized.

“We do not feel that this short study shows the maximum potential of dragonhead mint,” say Knight and Van Veldhuizen: “Higher yields could be obtained.” They see the need for research to improve seeding methods (broadcast versus drill), and on seeding rates, fertilizer interactions, herbicide effectiveness and tolerance, plant growth (annual versus biennial), and on harvest and cleaning methods.

Seed-selling

Birdseed is a popular item in the Interior. Knight determined in 1992 that that year thirty tons of wild bird seed were sold in the Fairbanks area. By winter 2006, just one Fairbanks outlet alone sold almost seventeen tons (although the proprietor said that this was an exceptionally good year), indicating that birdseed sales for the entire Interior were substantially more. Dragonhead mint could provide a fair portion of that seed to feed wild birds throughout the winter, and so may have potential as an agronomic crop in Alaska. Most bird seed sold in the state is imported, as is the case with most agronomic crops used by Alaskans, but that may not have to be the case. A native plant, adapted to our northern climate, used as a local crop could be a boon to our local wildlife, birdwatchers, farmers, and feed suppliers all.

For more information:

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Cold Spot Feeds

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910 Old Steese Hwy #A
Fairbanks, AK 99701

Cold Spot is one of many feed and pet suppliers in the Fairbanks area, selling feed for all types of animals, and was one of the sources for this article. The company keeps information on hand for its customers about feeding wild birds, as well as a list of useful resources. According to their staff, the demand for birdseed seems to fluctuate with the redpoll population in the Fairbanks area, but is also affected by human demographics. Other Fairbanks feed stores can also provide information on local bird needs.

Creamer's Field Migratory Waterfowl Refuge

www.wildlife.alaska.gov/index.cfm?adfg=refuge.creamers

This refuge in Fairbanks, Alaska, features nature trails, a visitor's center, historic dairy buildings, guided walks, hunting and trapping on selected areas, winter recreation, wildfowl viewing areas, the fall Sandhill Crane Festival, and other events and activities for birdwatchers.

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COASTAL CARBON— what's happening as the arctic coastline erodes?

by Doreen Fitzgerald

Note: This article is based on a research report that was submitted by the principal investigators to the National Science Foundation.



Gathered at edge of the Beaufort Sea, researchers from several disciplines and two projects coordinate their activities during the coastal erosion research. From left to right: unidentified researcher from related project, Gary Michaelson, Yuri Shur, Sabine Fiedler, Vladimir Trumskoy (foreground), Fugen Dou, Joel Blum (standing, facing right) two unidentified researchers from a related project, Torre Jorgenson, and another unidentified scientist.

—PHOTO BY CHIEN-LU PING

As sea ice conditions result in more open water along Alaska's arctic coast, exposure to storm surges and wave action are accelerating coastline erosion. That the erosion occurs is well known, but basic research on the properties of coastal terrain is required before the effects of this regional change can be understood.

UAF researchers and others from several disciplines are involved in a three-year study, "Collaborative Research on Flux and Transformation of Organic Carbon Across the Eroding Coastline of Northern Alaska." The scientists want to better understand the transfer of soil materials (sediments, carbon, and nutrients) from terrestrial arctic tundra ecosystems to near-shore waters, the type and quantity



An aerial view of polygons and thaw ponds along the vulnerable coastline, where warming conditions have reduced ice and increased wave action.

—PHOTO BY GARY MICHAELSON



Working near Barrow in 2006, Chien-Lu Ping, Daniel Fortier, Lorene Lynn, and Fugen Dou were photographed by Inupiaq bear guard Billy Kittick of the Barrow Arctic Science Consortium, a nonprofit organization that provides logistical support for arctic research and education (www.arcticscience.org).

of material that’s eroding, and the effects of this transfer. Under the leadership of co-principal investigators Chien-Lu Ping and Torre Jorgenson, the ecologists, soil scientists, and geocryologists are working together on these questions.

“We’re discussing the whys and hows of the relationships between permafrost and coastal erosion,” Ping said. “People in each discipline are learning something from the others,



Fugen Dou and Daniel Fortier sample soil for carbon dating at a site near Barrow in 2006.
—PHOTO BY LORENE LYNN



Yuri Shur checks a sampling site along the slumping coastline.
—PHOTO BY GARY MICHAELSON



Torre Jorgenson, Fugen Dou, and Mikhail Kanevskiy use a Siple ice corer to collect permafrost samples at the edge of a coastal bluff near Barrow.

—PHOTO BY LORENE LYNN

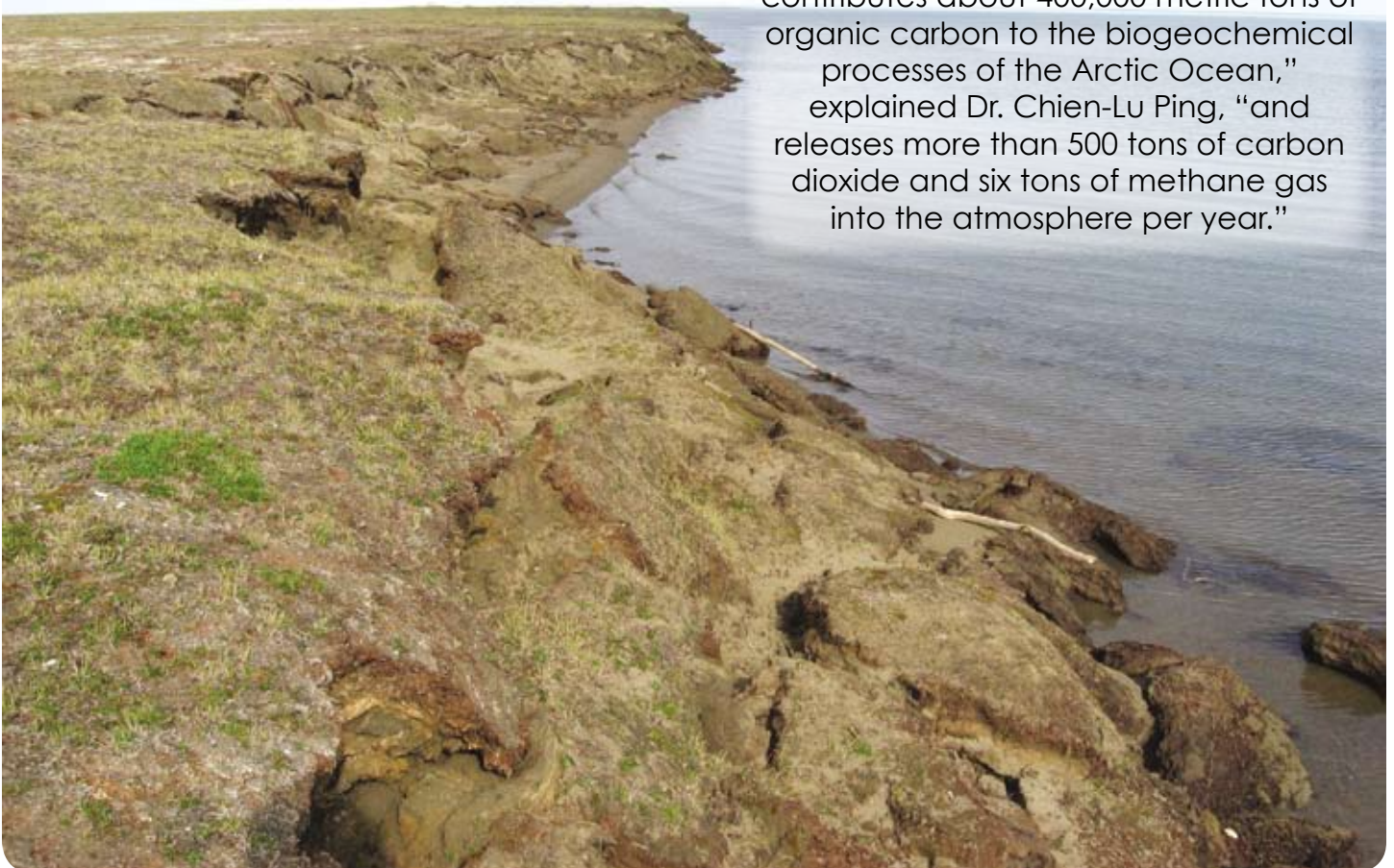
Ping is a professor of soil sciences at the UAF School of Natural Resources and Agricultural Sciences and the Agricultural and Forestry Experiment Station. Working with him are his research associate Gary Michaelson, and three other principal investigators: UAF associate professor Yuri Shur of the Civil and Environmental Engineering Department, and Laodong Guo, now a research associate professor at the Marine Science Institute of the Southern Mississippi University. Jorgenson is a senior scientist of Alaska Biological Research (ABR), Inc., is working with Shur on geomorphology and permafrost, as well as leading a subproject, “Community-based Coastal Monitoring” (NSF OPP-0436165), which is contributing to the International Polar Year project Arctic Circum-Polar Community Observatory Network, also known as ACCO-Net.

Significant carbon transfer

The active shore erosion that occurs practically everywhere along the coastline is associated with storms, rather than thermal erosion. In summer, thermodegradation occurs only

Along 1,900 miles of Beaufort Sea coastline about 2,000 acres of land are lost to the sea each year. “Erosion contributes about 400,000 metric tons of organic carbon to the biogeochemical processes of the Arctic Ocean,” explained Dr. Chien-Lu Ping, “and releases more than 500 tons of carbon dioxide and six tons of methane gas into the atmosphere per year.”

—PHOTO BY GARY MICHAELSON





Above, sampling at the Colville River Delta are Torre Jorgesson (at tripod) Mikhail Kanevskiy, and Fugen Dou. A hand auger like the one shown here is used to collect samples from soft sediments.

Left: Dou (in orange) and Mikhail Kanevskiy operate a Sipre corer with a gas power head.

—PHOTOS BY LORENE LYNN

at the upper parts of shoreline cutbanks where ice wedges and frozen soil are exposed to the atmosphere. This is a rather slow process in the absence of long-term direct contact between frozen soil and seawater.

“Based on our first year’s measurements, the average ice content of the soils measured to a depth of six feet is 60 percent ice, and the carbon content is 80 pounds per cubic yard,” said Ping. “Along the 1,900 miles of coastline this erosion contributes about 400,000 metric tons of organic carbon to the biogeochemical processes of the Arctic Ocean, and releases more than 500 tons of carbon dioxide and six tons of methane gas into the atmosphere per year.”

The estimate is based on an average coastal bluff depth of five feet and average annual erosion of six feet inland. This transforms to about 2,000 acres of land annually lost to the sea.

Sampling coastal soils

Fifty study sites were selected to represent the main coastline types. They include coastal bays, deltas, lagoons, tapped basins and exposed bluffs with an elevation up to eighteen meters,

and are located from the Elson Lagoon north of Barrow east to the Canadian border.

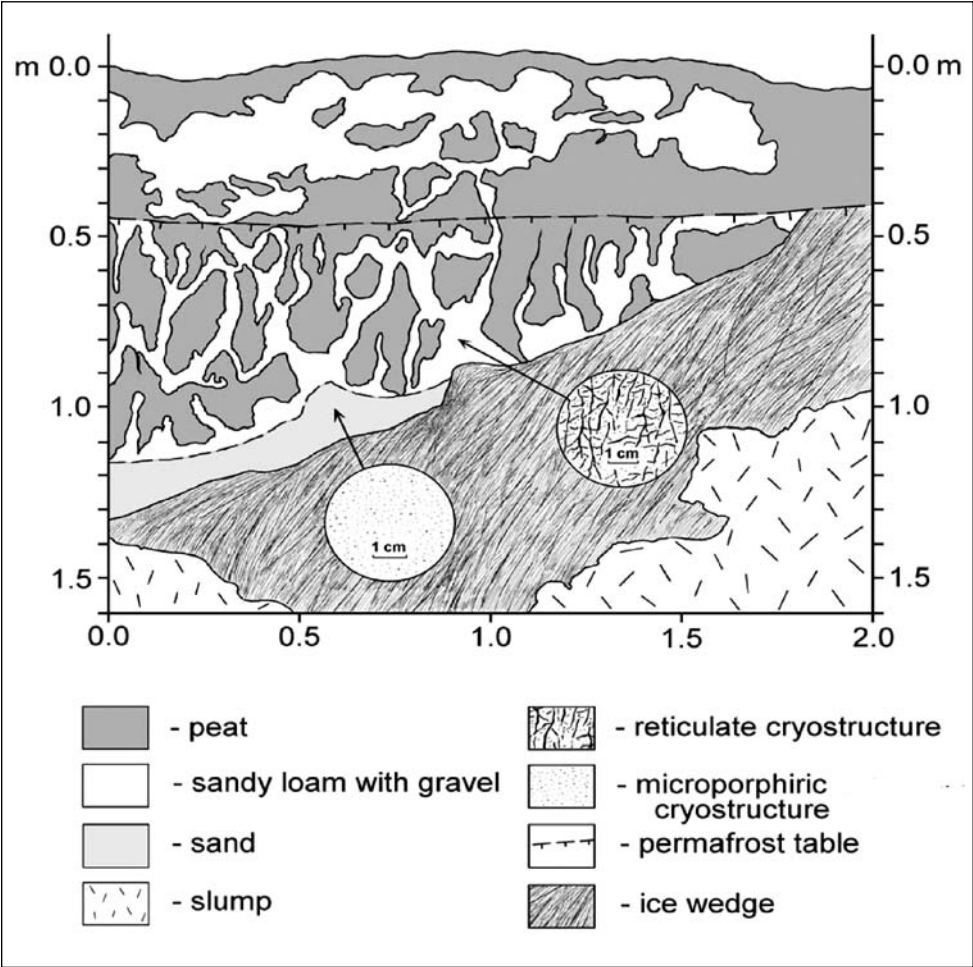
In 2005, the first field season of the study, 29 sites were sampled along the coast from Barrow to the Colville River delta. During the project's second year, 21 sites were sampled from the Colville River delta east to the Canadian border. Field locations selected for intensive study and longer-term monitoring include Prudhoe Bay, Barter Island, the Colville River Delta, and Barrow. During the 2005 field season, 289 samples were taken from soil thawed and permafrost layers; in 2006, 68 sediment samples were taken from four sites near Barrow, along with another 272 samples from soil thawed and permafrost layers from the various sites. In summer 2007, the researchers are again in the field doing additional sampling and monitoring the intensive study sites.

Evaluated and recorded for each site are its physiographic characteristics (landform, microtopography, GPS position, coastal bluff elevation, and vegetation community) and such site characteristics as permafrost, soil ice content, and soil morphology, which begins with an *in situ* examination of a soil profile, the vertical exposure of the coastal bluff and cores drilled on the river deltas.



Jorgenson installing a new battery and memory chip in the observation camera at a site in the Colville River Delta in 2005.
—PHOTO BY LORENE LYNN

Figure 1. The cryogenic profile of exposed bluff at Site BSC-4.



Field descriptions of soil are organized by subdividing the soil profile into reasonably distinct layers (horizons) that differ noticeably from the horizons immediately above and below in one or more soil features, such as horizon boundary characteristics, texture, color, structure, consistence, roots, pH or effervescence, and cryogenic structure and special features such as coatings, nodules, and concretions.

For the coastal research, samples of sediments are taken on the beach and in shallow water, and wave monitoring cameras were installed at one of the intensive sampling sites. Of the five types of coastline studied, lagoons are the most prevalent, accounting for more than half of the coast, followed by exposed bluffs, then delta. Both bay or inlet and tapped basins are of minor distribution.

The soil and permafrost samples are being analyzed in the laboratory for carbon content, bulk density, and particle size distribution. Another 100 samples were taken for an incubation experiment that was started at the Barrow Arctic Science Consortium (BASC) and continued in the university laboratory at Palmer and in the International Arctic Research Consortium (IARC) laboratory at Fairbanks. Also, sixteen samples were taken from seven sites for C-14 dating.

Lorene Lynn, a graduate student working with Ping, is participating in



Mikhail Kanevskiy measuring an ice wedge at Prudhoe Bay.
—PHOTO BY LORENE LYNN

all three field seasons. Her master's thesis research involves sampling at various depths and distances inland (0, 1, 5, 25, and 100 meters perpendicular to the coastline) at three very different sites. In 2006 she collected 390 soil or permafrost samples at Elson Lagoon, Prudhoe Bay, and Barter Island.

"I'm doing a full chemical and physical analysis of the soils for a geomorphological and pedological picture, relating the information to depth, distance from shore, and site, as well as physiographic features, mainly tapped basins," she said. One small part of her work involves looking at trace gasses stored in permafrost. Preliminary results show a higher volume of methane and carbon dioxide is stored at shallower permafrost depths (30-90 centimeters from the soil surface) than at deeper depths (90-160 centimeters from the surface). "I expect that the part of this work most relevant to policy and land management will be the overall carbon picture I come up with, as well as how people and industry in the High Arctic might expect the moisture regime in the soil to change with a warming climate."

Permafrost and geocryological work

This part of the research provides first comprehensive description of ground ice in typical terrain units along Beaufort Sea coast.

"The cryoturbated organic matter was 2.5 meters deep, which is nearly 150 percent deeper than that observed in

the Arctic Foothills of northern Alaska," Ping said. "This means that carbon storage in arctic tundra along the coastal regions of the Arctic is much greater than that estimated from previous soils studies programs." Ping and Michaelson have been involved in the studies of carbon in arctic soils since 1992 through the National Science Foundation's Carbon Flux, Land-Atmosphere Ice Interaction and Biocomplexity of Patterned Ground Programs.

Descriptions of soil stratigraphy along the coast from Barrow to the Colville Delta has confirmed the general classification of marine silts, eolian sands, and slightly pebbly sand deposits. The stratigraphic analyses performed for this study will provide the most comprehensive dataset developed to date.

"Based on these analyses, we will likely substantially revise the standard interpretations of genesis of the marine sands and slightly pebbly sand deposits in terms of glaciation of the continental shelf of the Beaufort Sea coast," Jorgenson said.

During the 2005 and 2006 field seasons, geocryological features were studied at 54 sites from Barrow to Canadian border by Shur and two postdoctoral fellows at the Institute of Northern Engineering, Daniel Fortier and Mikhail Kanevskiy, who are now research assistant professors. In May 2007, Jorgenson, Lynn, Fugen Dou, and Kanevskiy completed field work in the Colville delta and Prudhoe Bay areas. Dou, a UAF postdoctoral fellow at the International Arctic Research Center, has since May 2005 participated in six field trips to date.

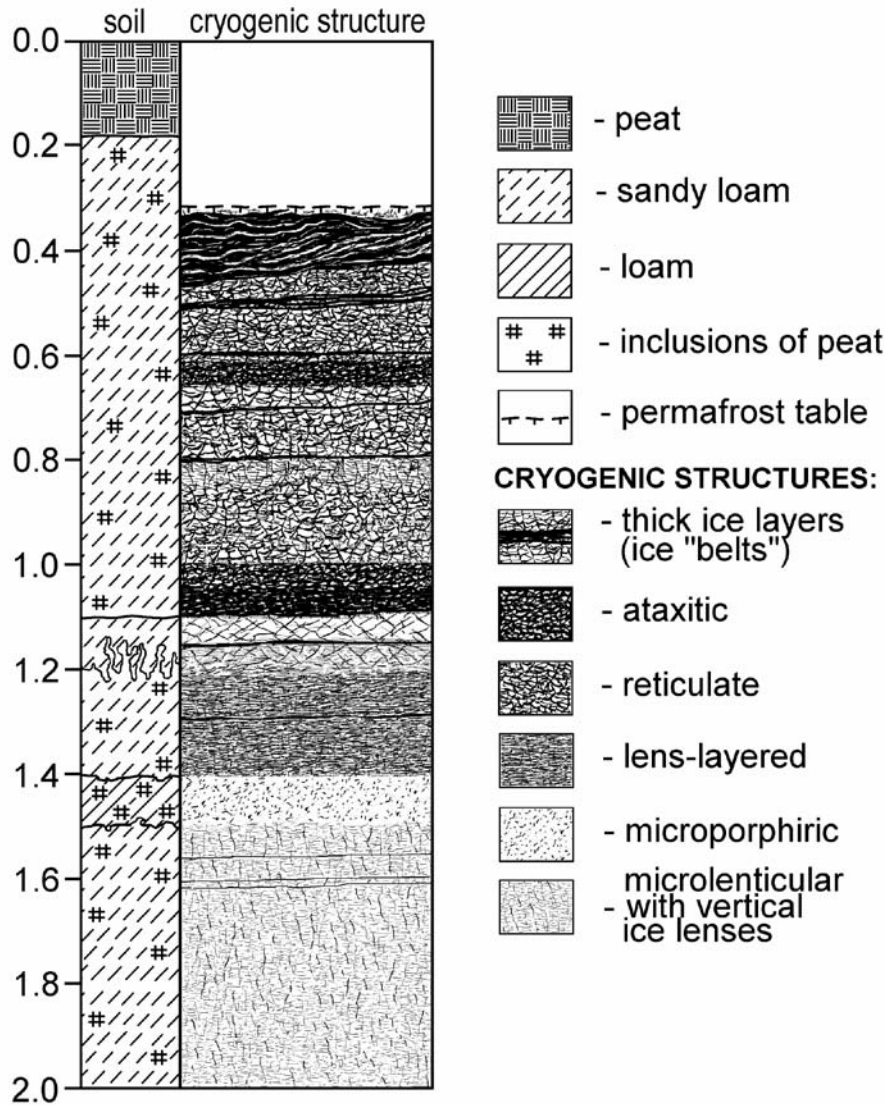
Based on first year's measurements, the average ice content of the soils measured to two meters depth is 55 percent ice, with a carbon content of 45 kilogram per cubic meter. The study revealed that ice wedges are the main type of massive ground ice and are extensive at the coast; 15 to 20 percent of the coastal sediments consisted of wedge ice, which is characteristic for most studied exposures, although wedge ice content varied widely in different sections, ranging from 1 to 45 percent. The upper part of an ice wedge is usually located no deeper than 10 to 20 centimeters beneath the permafrost table; in many cases the ice wedges cross all the strata exposed at the coastal bluffs and penetrate beneath sea level.

The highest wedge-ice content was found at relatively high bluffs that had a very dense polygonal net at the surface. At such sites the ice wedges were 3 to 3.5 meters wide, and the distance between them ranged from 5 to 7 meters.

The geocryologist team led by Shur found out that the formation of ice wedges has been accompanied by the lifting of material from lower layers along the ice-wedge, formation of vertically striped coarse-texture soils dominated by sand and gravel along ice wedges, and redistribution of this material in the active layer.

The growth of ice wedges has considerably modified the stratigraphy of the polygons along the ice wedge walls by pushing towards the surface mineral horizons and peat layers found deeper in the center of the polygons. This can

Figure 2. Cryogenic profile and stratigraphy of the exposed bluff at Site BSC-21.



have implications for recycling of old organic matter and the carbon pool found in the active layer, such as the mixing of organic matter of differing quality near the eroding surface.

Many ice wedges have been affected by underground thermo-erosion that results in bodies of massive thermokarst cave ice enclosed in the ice wedges. Formation of ice wedges leads to deformation of previously formed cryogenic structure and the development of vertically oriented cryogenic structures. Usually, the lowest ice wedge content was found for low accumulative surfaces such as coastal marshes, river deltas, and drained lake basins. These surfaces are characterized by large wedge polygons (up to 40 meters) and narrow wedges that are usually less than one-half meter wide.

At most of the sites, the ice content of organic and mineral sediments is very high. In most mineral horizons or layers, the main cryostructures of silty sediments are netlike (reticulate) and suspended (ataxitic). For sediments with ataxitic cryostructure, the volumetric content of visible ice

can be up to 80 percent. At many boreholes and exposures, numerous ice lenses and layers ten to twenty centimeters thick were found. An example of the cryogenic profile of the exposure is shown in Figure 1.

The active layers along the bluffs are five to forty centimeters deeper than those of tundra soils found one to five meters inland. In the tundra soils of bluffs that are more than three meters high, organic matter is churned down to more than three meters deep, compared to the Arctic Foothills, where the frost-churned soil organic matter is generally 1.2 meters deep.

In the sampled areas is a two- to five-centimeter organic horizon that overlies an organic-rich mineral horizon of eolian origin that is 15–20 centimeters thick. This A or Bw horizon overlies a buried organic horizon, suggesting the active thaw lake sequences. Below this buried horizon there is a mixed organic and mineral horizon created by cryoturbation, which is the mixing of soil layers due to repeated freeze-thaw processes and a major soil-forming process in arctic regions. Organic materials were frost-churned into the underlying gleyed horizons. Some of the cryoturbated organic matter sampled at two to three meters depth is of late Pleistocene age with C-14 dates older than 20,000 years.

Soil Organic Carbon (SOC) study

Overall results indicate that SOC along coastline of northern Alaska was greatly affected by types of soil and land cover, which

may further affect the bioavailability and transformation of dissolved organic carbon. During this research, Fugen Dou developed methodology to analyze the size fractionation of organic matter in soils, permafrost, and shallow water sediments. Dou is also working on the spatial variation of soil organic carbon along the coastline using GIS and geostatistic techniques to map SOC from Point Barrow to the Canadian border; the total mapped coastline is over 1,800 kilometers.

The soil organic carbon (SOC) content varied significantly with coastline types and ecosystems. In tundra bluffs near Barrow, SOC stores generally were greater than those in delta around the Colville River area.

Results of soil size fractionation show that most of the SOC present occurred in particulate organic carbon, which is consistent with other studies. Unlike temperate or tropical soils, particulate organic carbon was not distributed in a consistent pattern at different depths across all the sites where these observations were made.

Duo also analyzed the amount of dissolved organic carbon, which ranged from 0.30 to 0.52 percent of the total organic carbon. Although this is a small percentage of total SOC, soil dissolved organic carbon plays an important role in carbon transformation and mobilization.

To determine which fraction of dissolved organic carbon plays a more important role, ultra-filtration was used to isolate high-molecular-weight dissolved organic carbon. Preliminary results show that the high-molecular-weight fraction decomposed quickly, which is consistent with observations of marine dissolved organic carbon.

Along with quantifying the quality and quantity of soil dissolved organic carbon, some factors of soil pretreatment and soil leaching reagents were evaluated. Compared to fresh soils, oven-dried and freeze-dried soils released more dissolved organic carbon, indicating that soil drying processes damage soil particles and/or soil microbial biomass and enhance dissolved organic carbon yield. Furthermore, seawater decreased dissolved organic carbon release compared to distilled water, likely because the sea salts in seawater enhanced the aggregation and precipitation of the carbon.

Gas flux measurement

On land, carbon is stored in soils and living plants, and cold soils are effective in storing undecomposed or partially decomposed organic matter. Warming at high latitudes could increase decomposition rates, leading to a change in the dynamics of soil carbon cycling and the release of more carbon dioxide into the atmosphere.

After a section of coastline erodes, the newly exposed ice wedges melt and the soil drains, lowering the water table and increasing the depth of the active layer. Carbon rich peat soils extend deep into the permafrost. As these soils melt, the organic material becomes available to decomposers that can metabolize the carbon into methane (CH_4) and carbon dioxide (CO_2), which are released into the ocean and atmosphere. Trapped gases are also released upon thaw of permafrost.

For this research, all soil samples from frozen soil horizons and permafrost layers were collected in the field and shipped frozen to the Palmer Research Lab of the SNRAS Research and Extension Center. During thawing, the samples were stored in sealed respirometer chambers connected to an infrared cell to measure the methane and carbon dioxide gas released.

According to preliminary results, when eroding coastline thaws, the amount of trace gases released relates well with water content of soil horizons and the ice content of permafrost horizons. As the volume of water or ice in soil or permafrost horizons reaches 80 percent or higher, soil methane content increased, while carbon dioxide content decreased.

“We found that the relative release rate of both gases depends on several factors,” said Michaelson. “Gas release from thawed samples varied with soil texture and water content, and with organic carbon content and quality.”

At specific sites, such as the Colville River delta sediments, where soil texture and organic carbon were evenly distributed and of similar quality at similar depth, high correlations were observed for these soil factors. As volumetric water content increased from 45 to 96 percent, the average carbon dioxide release decreased by about 87 percent. For methane, as the soil crossed the saturation threshold of 80 percent water or ice content, the average release increased sharply, by about 1,279 percent.

“Although the amount of trace gases released by eroding soils is small relative to terrestrial carbon respiration, they have high concentrations of organic carbon and are transferring significant amounts of soil carbon to the coastal waters,” Michaelson said.

The significance of these releases can be determined as erosion rates become better known. “We’re trying to assess the amounts of gasses that are evolving from the more active gas-producing soil layers (soil surface active layers) versus the evolution of trapped gasses from the melting of the permafrost layers,” Michaelson said.

Upper permafrost layers can contain higher amounts of trapped methane. With large proportions of eroding soil being permafrost (approximately half within a one-meter exposure), increased erosion rates could result in increasingly significant methane effluxes.

As organic carbon undergoes the transfer from the terrestrial to near-shore, conditions such as temperature, moisture, and aeration change significantly, and it remains uncertain what percentage of methane might be oxidized within the more aerobic, thawed soil environment as the peat becomes exposed within the high-energy beach environment.

Working with Ping and Michaelson, wetland biogeochemist Sabine Fiedler joined the research team in 2005 to study dissolved methane and carbon dioxide concentrations in the aquatic system along the coastal zone. Based on her preliminary results, all samples were supersaturated, which demonstrates that dissolved carbon dioxide and methane within arctic aquatic systems can be a prominent part of carbon budgets. Fiedler works at the Institute of Soil Science and Land Evaluation, University of Hohenheim, Germany.

International cooperation and educational opportunities

The collaborative and international aspects of the research are illustrated by the 2005 international team, which consisted of: UAF researchers Ping, Michaelson, and graduate student Lynn of SNRAS/AFES; Shur and graduate student Prothap Kodeal (civil and environmental engineering), Dou, Kanevskiy (formerly of the Russian Earth Cryosphere Institute); Jorgenson of ABR; Fiedler, a visiting scientist from Germany; visiting scientist Vladimir Tumskey, a permafrost expert from Moscow State University, Moscow, Russia; and Jerry Brown, president of the International Permafrost Association (IPA), who participated in measuring the coastal line retreat at



Sampling the active layer at Prudhoe Bay: Lorene Lynn taking the sample, Eugen Dou writing notes.
 —PHOTO BY MIKHAIL KANEVSKIY

Elson Lagoon near Barrow through on-site measurement and remote sensing. The IPA, representing 26 member countries, coordinates the International Polar Year permafrost program and maintains contact with other IPY activities. Organization goals are to: develop an international network of permanent permafrost observatories; establish a sustainable data system, and develop the next generation of permafrost researchers.

Another investigator, Laodong Guo, formerly a research faculty member of IARC and now at the Stennis Marine Research Institute of the Southern Mississippi University, studies the geochemistry of the soil and permafrost samples and relates it to the origin of dissolved organic carbons in arctic rivers.

“This research has provided a rare opportunity to train graduate and undergraduate students in arctic tundra ecology, permafrost landscape, and field techniques,” Ping said.

In 2006, permafrost, massive ground ice, and soil cryogenic structures were studied. The research team worked together to establish patterns in the relationship between terrain units, soil, and ground ice. Shur, Fortier, and Kanevskiy were joined by Eva Stephani, an undergraduate student from the Université Laval Québec.

David Weindorf, a soil scientist at Tarleton University in Texas used his participation as an opportunity to expand his curriculum, and he found soils along the coastal delta that have not been included in the US soil classification system. Beatrice Haggard, an undergraduate student from his department, participated in every phase of the fieldwork, gaining valuable research experience.

“Our fieldwork, and the participation of my graduate student and others, was made possible by the efficient logistical support provided through VECO, NSF, and the Barrow Arctic Science Consortium,” Ping said. The consortium is a nonprofit organization that encourages research and educational activities pertaining to Alaska’s North Slope and the adjacent portions of the Arctic Ocean. Organized in 1995, it provides a means for local organizations and other interested persons to work together to support arctic science. The Barrow-based organizations are the North Slope Borough, the Ukpeagvik Iñupiat Corporation, and Ilisagvik College (the local center for post-secondary education). A cooperative agreement between the NSF Office of Polar Programs funds BASC activities. Logistics in 2006 included provision of rental vehicles, helicopters, and lodging at Toolik

Lake Field Research Station, Prudhoe Bay, Kaktovik, and Helmerick's Camp.

The project also has collaborated with the Arctic Coastal Dynamics program in developing a circumarctic coastal database.

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Sandbags shore up the bluff at the Flaxman Island site of an abandoned Dew Line facility that is east of Deadhorse, between Deadhorse and Barter Island.

—PHOTO BY GARY MICHAELSON

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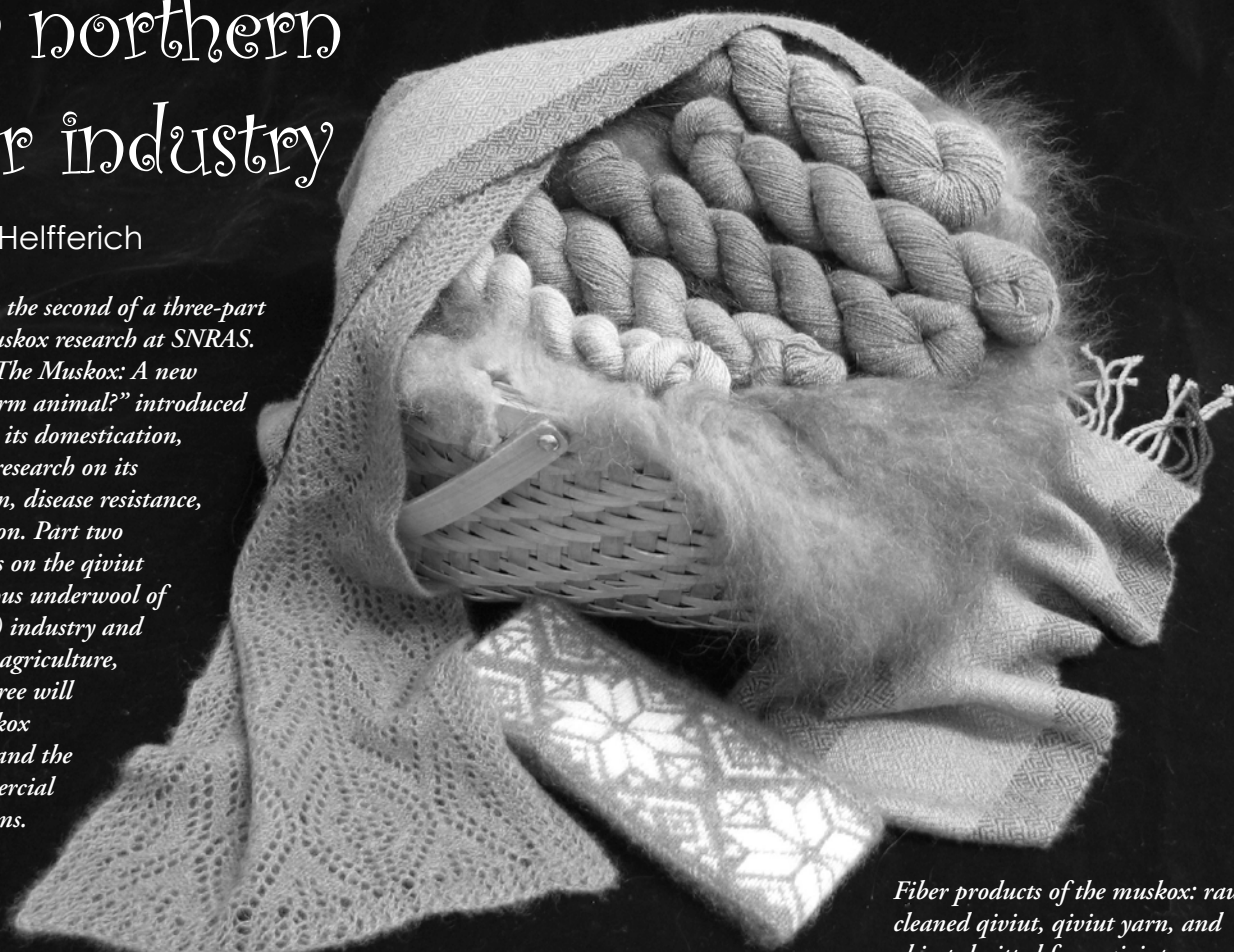
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The Muskox: wooly and warm in a northern fiber industry

Deirdre Helfferich

Note: this is the second of a three-part series on muskox research at SNRAS. Part one, "The Muskox: A new northern farm animal?" introduced the animal, its domestication, and recent research on its reproduction, disease resistance, and nutrition. Part two concentrates on the qiviut (the luxurious underwool of the muskox) industry and sustainable agriculture, and part three will review muskox husbandry and the three commercial muskox farms.



Fiber products of the muskox: raw cleaned qiviut, qiviut yarn, and objects knitted from qiviut.

—PHOTO BY SANDY GARBOWSKI

When I was a child, my parents would, in summertime, frequently take me to visit what I knew as the Muskox Farm on Yankovich Road, north of the University of Alaska Fairbanks campus. This farm became the Robert G. White Large Animal Research Station (LARS). I loved to watch these big, longhaired relatives of sheep and goats—from a safe distance, that is—and would importune my parents to drive by the farm on the way home in the hope that I might get a glimpse of the animals. Forty years later, small children still delight in the great hairy beasts that roam the fields of the station, and now visitors can go on guided tours of the animal enclosures there from June to September to learn more about the natural history

of the caribou, muskoxen, and reindeer kept on the grounds. Researchers at the Institute of Arctic Biology and the School of Natural Resources and Agricultural Sciences have delved into the biology and behavior of muskoxen, discovering many things about the reproduction, nutrition, and husbandry of these animals.

Sustainable agriculture and muskox

Muskoxen, although undomesticated, are at the forefront of the movement toward sustainable northern agriculture. Human beings have long used animals and plants originally native to equatorial and Mediterranean climes, adapting them to more extreme environments

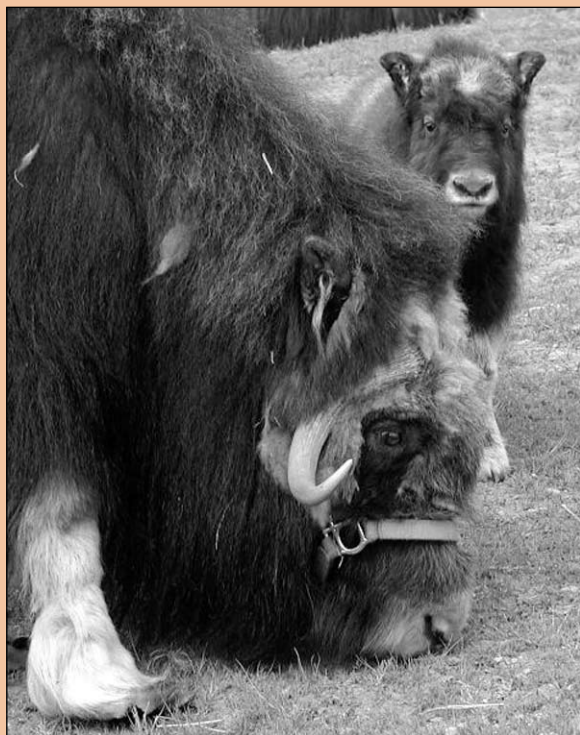
as they moved outward from these areas into Asia, the Americas, and the polar regions. For many animals that evolved in tropical and temperate zones (sheep, cattle, goats, horses), the move to subarctic and arctic climes has been difficult, and has required special housing and other accommodations, adding to the expense of their husbandry. Alaska has depended on subsistence and transport of food from lower latitudes to maintain its population, and has never been agriculturally self-sufficient. In modern times, it has simply been easier and less expensive to ship food and other agricultural goods from lower latitudes than to support the development of local agriculture that is independent of the industry elsewhere. However, the hidden costs of expending the energy

Sustainable agriculture policy in North America

In 1988 Congress established the Sustainable Agriculture Research and Education program, or SARE, part of the Cooperative State Research, Education, and Extension Service, to promote and research ecologically sound agricultural practices. One program goal is to help farmers and ranchers increase their profits while lessening the environmental impact of their agriculture, and to strengthen communities. The program provides information to researchers, educators, farmers, and consumers, and offers competitive grants for sustainable agriculture research and education.

Congress defines sustainable agriculture as “an integrated system of plant and animal production practices having a site-specific application that will, over the long term:

1. satisfy human food and fiber needs;
2. enhance environmental quality and the natural resource base upon which the agricultural economy depends;
3. make the most efficient use of nonrenewable resources and on-farm resources and integrate, where appropriate, natural biological cycles and controls;
4. sustain the economic viability of farm operations; and enhance the quality of life for farmers and society as a whole.”¹




Mother and baby at LARS.

—PHOTO BY JAN E. ROWELL



The map shows the distribution of wild muskoxen. The dark gray shows the “original” distribution of muskoxen (at the beginning of the nineteenth century, after their decimation by hunting and other factors). The black shows the areas where muskoxen have been reintroduced with success in the twentieth century. A small population has also been introduced successfully on the Taimyr Peninsula in Siberia (arrow, landmass not shown on map).

—  MAP COURTESY WIKIMEDIA USER MASAE, 2007; MODIFIED BY D. HELFFERICH

The Canadian government also is supporting sustainable development, which “integrates environmental, economic, and social interests in a way that allows today’s needs to be met without compromising the ability of future generations to meet theirs.” Similar to the description above, in Canada the government has outlined four key points defining sustainable agriculture:

- [It] protects the natural resource base; prevents the degradation of soil, water, and air quality; and conserves biodiversity
- contributes to the economic and social well-being of all Canadians
- ensures a safe and high-quality supply of agricultural products
- safeguards the livelihood and well-being of agricultural and agri-food businesses, workers and their families.”²

Thus, a sustainable agriculture would depend on native plants and animals where feasible, locally developed and grown food and other agricultural products, and locally manufactured value-added goods.

1. “What is Sustainable Agriculture?” from the SARE program website, accessed 5/10/07 at www.uaf.edu/coop-ext/SARE/sustainable.html.

2. Agriculture and Agri-Food Canada, “Sustainable Development Strategy. Sustainable Agriculture: Our Path Forward.” From the introduction, accessed 6/6/07 at www4.agr.gc.ca/AAFC-AAC/display-afficher.do?id=1175533355176&lang=e

to raise food and agricultural goods in one place and ship them thousands of miles to where they are consumed are becoming untenable socially, environmentally, and politically, and have given rise to concerns for the long-term sustainability of our agricultural practices. The groundswell of the sustainability movement in this country and worldwide has resulted in changes over the last two decades in the national and state policies of the United States and Canada (see sidebar, opposite).

The sustainable agriculture concept fits with John J. Teal, Jr.'s guiding philosophy that indigenous animals and plants for each major biogeographical zone should be selected for domestication, rather than attempting to adapt creatures from one area (such as the Mediterranean ancestor of the sheep) to the rest of the world. Teal worked to put his philosophy into action, raising muskoxen for their qiviut. Others soon followed his example, some successfully and some not. Today there are at least three commercial farms in North America that raise muskoxen, concentrating on the production of qiviut. Qiviut is a valuable fiber, and has been marketed and popularized as a luxury fiber in part by the work of the Oomingmak Musk Ox Producers' Cooperative, centered in Anchorage, Alaska, which uses qiviut in a cottage fiber industry.

Attempts to domesticate the muskox began as early as 1899 (primarily with an eye toward its meat), although the possibility was discussed in scholarly journals before this.¹ Muskoxen disappeared from Siberia and Alaska by the mid-1800s, reduced to only a few hundred animals in Canada and Greenland by 1917, at which point an international agreement to protect them was reached.² In the early 1930s an attempt to reintroduce them to their old range was made, and Greenlandic muskoxen were brought to Nunivak Island. They thrived, and further reintroductions elsewhere helped to speed their spread in Alaska, Siberia, northern Quebec in Canada, and Norway. However, it was not until Teal's efforts in 1954 that a rigorous domestication process began.

Muskoxen, being already elegantly adapted to extreme northern temperatures, forage, and other conditions, are site-specific to Alaska and other parts of the polar north. They produce extremely valuable fiber and meat, and are already part of a small, but important, northern fiber industry—making them a potentially suitable livestock animal for a sustainable world.

In 1969, muskoxen were recognized for their agricultural value in Alaska by Secretary of the Interior Walter J. Hickel, when he banned hunting of muskoxen on Nunivak Island National Wildlife Refuge, saying, "The muskox is not a game animal and should continue to be developed for domestic purposes.... To permit such a hunt would be contrary to the intentions of the conservation-minded people who worked so hard in the 1930s to import the first of these gentle animals to this country from Greenland. The muskox is a rare animal and one which, through careful breeding and domestication, offers an excellent means of developing new industry in the Arctic." As governor, Hickel had vetoed a bill the year before, approved by the Alaska State Legislature, that would have allowed big game hunts of the animal.³

Wild muskoxen on Banks Island, Canada.

—PHOTO BY JAN E. ROWELL

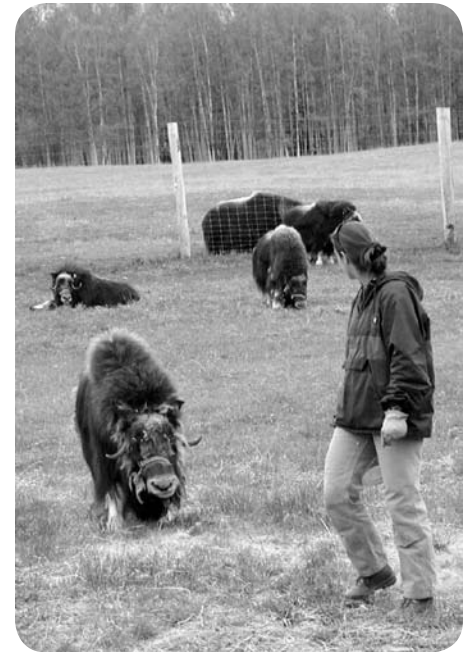


Above: muskox calf, about three weeks old.

—PHOTO BY CHRIS TERZI

Below: Renee in the LARS fields with muskox, bringing in a cow for combing.

—PHOTO BY JAN E. ROWELL



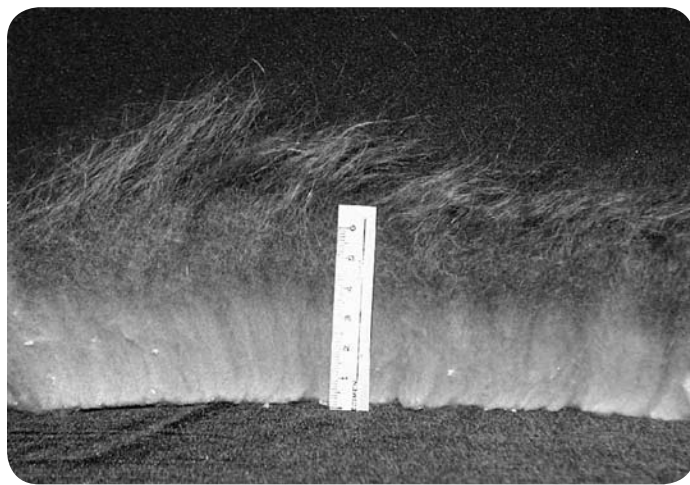
Qiviut and muskox skirts

The shaggy muskox is perhaps best known for its long pelt, and in particular for its fine underwool, or qiviut. The fibers of this insulating underlayer are long (about 8 to 13 cm depending on where on the animal they grow) and fine, averaging around 17-18 microns for wild muskoxen, with females and young animals having slightly finer hairs. Qiviut is thus classed as a superfine fiber. In comparison, sheep's wool usually ranges from 17 microns for the finest merino wool to 40 microns for coarse wool. Qiviut does not shrink in hot water, and is smooth in comparison to sheep's wool. This means that it does not felt. Articles of clothing made with qiviut may be cleaned by handwashing gently in warm water.

Muskox skin includes primary and secondary hair follicles. Primary follicles are associated with sweat and sebaceous glands, and produce the long, coarse guard hairs; secondary follicles produce the qiviut, which are not associated with sweat glands. Because of this, unlike wool, which has about twenty percent lanolin and oils, raw qiviut is a much dryer fiber, at about seven percent grease. Qiviut is shed, or molted, in the spring, from May to June. The secondary hair follicles from which this underwool grows are dormant in the winter, becoming active again in spring. The onset of the spring molt marks the beginning of the growth cycle. Muskoxen grow new qiviut throughout the summer and fall, with peak growth occurring during August and petering out by the end of November.⁴ In research done by Morgan A. Robertson for her master's thesis with the Institute of Arctic Biology, earliest-season qiviut growth was shown by cows who had given birth and the latest-season growth was shown by yearling calves.

The primary follicles are interspersed with secondary ones, in a pattern similar to those of domestic sheep, goats, bighorn sheep, wildebeests, impalas, and other such animals. However, according to a paper by University of Saskatchewan researchers Peter Flood, Margaret Stalker, and Jan Rowell (Rowell is now with SNRAS as a research associate in animal sciences):

The feature that clearly distinguishes the muskox from other wild ruminants examined to date is the extraordinarily high [secondary to primary follicle] ratio, averaging 37:1. In other wild species this ratio ranges from as low as 0.26:1 in Grant's gazelle (*Gazella granti*) to 7-8:1 in the kongoni.... Among domestic ruminants, it is only in the improved breeds of sheep that the [secondary to primary] ratio approaches that in the muskox, being 20:1 in the Merino. The more primitive mountain breeds have ratios between 3:1 and 5:1. However, domestic wool-producing sheep have an important characteristic not possessed by the muskox: their primary follicles produce fine fibres that are similar to wool.⁵



Fleece combed from a muskox, clearly showing the distinct layers of qiviut and intermediate hairs. The qiviut stands about 4 inches high, with intermediate hairs another 3-4 inches above that (the ruler is 6 inches).

—PHOTO BY JAN E. ROWELL

This means that all the follicles on a sheep produce the fine wooly fibers needed for the textile industry, and do not need to be separated from the coarse guard hairs as they do on a muskox. Thus, a sheep can simply be sheared of all its pelt, while a muskox must shed the undercoat, which then must be cleaned of rougher fibers to be useable.

The density of hair follicles on muskoxen is also very high, approximately 42 per square millimeter, which makes sense given the extreme temperatures that the animals must survive. Muskox hairs are of three main types: the downy qiviut, the long guard or skirt hairs, and the intermediate hairs (finer than skirt hairs and of variable diameter). The guard hairs are shed irregularly throughout the year, while the qiviut and intermediate hair comes out in great clumps and sheets during a concentrated period in the spring. The qiviut can be plucked or combed from the muskoxen in spring or gathered from shrubbery in the field.

Nutrition and hair growth

Adult muskoxen only produce about five to eight pounds of qiviut a year, about the same amount of fiber as an adult Merino sheep per shearing, even though they are significantly larger than sheep. Sheep have been bred for thousands of years to produce prodigious amounts of wool; a Peppin Merino ram can produce up to forty pounds of wool per year.

Factors controlling production of qiviut include secondary hair follicle density, which is very high in muskoxen, as stated above, and the effect of nutrition on the growth rates of the hairs themselves. Adjustments made to muskox feed to improve overall nutrition and qiviut production can have an effect. Wild muskoxen have slightly thicker hairs than farmed ones, and there is some indication that this may be due to better nutrition: in a good year animals in the wild have their natural diet available to them, whereas, because of the lack of knowledge about their needs, kept muskoxen may not necessarily get a fully nutritious or appropriate diet.

Muskoxen have extremely efficient digestion for ruminants, and cannot thrive on the high-protein diets that domestic horses and cattle require, for example. Early attempts to domesticate muskoxen were sometimes complicated by feed that was suitable for horses, such as clover and grain, but caused muskoxen intestinal distress and even led to death from malnutrition. Wild muskoxen eat a varied diet, changing according to season, of shrubs, grasses, and leafy plants, such as daisies, Labrador tea, crowberry, blueberry, horsetail, fireweed, sedges, mosses, young or dwarf birches, alders, or willows. Researchers at LARS have been improving the quality of their muskoxen fodder, with an eye toward maintaining the health of the animals and increasing qiviut production.

Morgan Robertson studied the effects of commercial rumen-protected methionine (an essential amino acid) supplements on qiviut production for her master's thesis. She conducted her experiments using the commercial methionine Smartamine M, discovering that it promoted qiviut growth, increasing yield and improving fiber length and strength. The study showed significant gains in raw qiviut harvested, about 11 percent for steers, 15 percent for lactating cows, and around 17 percent for calves. This translates to approximately a half pound to a pound more per year per adult muskox. In a 1999 interview with Doug Schneider for Arctic Science Journeys, Robertson explained:

“What we’re specifically interested in with these animals...is the role methionine plays in wool production. So they absorb methionine from their gut. It’s transferred to cystine in their body and cystine plays a major role in hair growth and skin growth.... We found that we did get improvements in wool yields, and we also found that we had differences in fiber properties. We got stronger fibers and we also got somewhat larger fibers, somewhat coarser fibers.”⁶

Robertson went into more detail in her thesis:

Methionine is considered the preferred dietary precursor for wool protein synthesis, increasing both fiber length and fiber diameter in sheep...Following absorption in the small intestine, methionine is converted to cystine in the body by transulfuration. Cystine is critical to wool synthesis because it provides disulfide bonds, or cross-linkages, that are required for fiber formation. Keratin, the primary component of wool and hair, is known to have a high concentration of cystine when compared to most other body proteins...Ruminal microorganisms can degrade dietary methionine, which constitutes a major limitation to the supply of methionine, and cystine, for wool growth. Protection of dietary methionine from microbial degradation can be achieved by a chemical protectant, and some cystine

and methionine containing proteins are naturally resistant to ruminal degradation (e.g., fish and blood meal). Commercially available rumen-protected methionine and fishmeal can positively influence protein deposition in members of the family Bovidae (e.g., cattle, sheep, goats) when the post-ruminal supply is limiting.... The ability of methionine supplements to improve wool production and body protein turnover in domestic ruminants suggests that such positive gains could be made in farmed muskoxen.⁷

Although the hairs of muskox fed methionine were slightly thicker (making them stronger), the fiber AFD was still finer than the 17-18 microns found on wild-harvested muskoxen and the qiviut was still soft and fine. So methionine supplementation may be a useful tactic for the muskox farmer.

Qiviut production

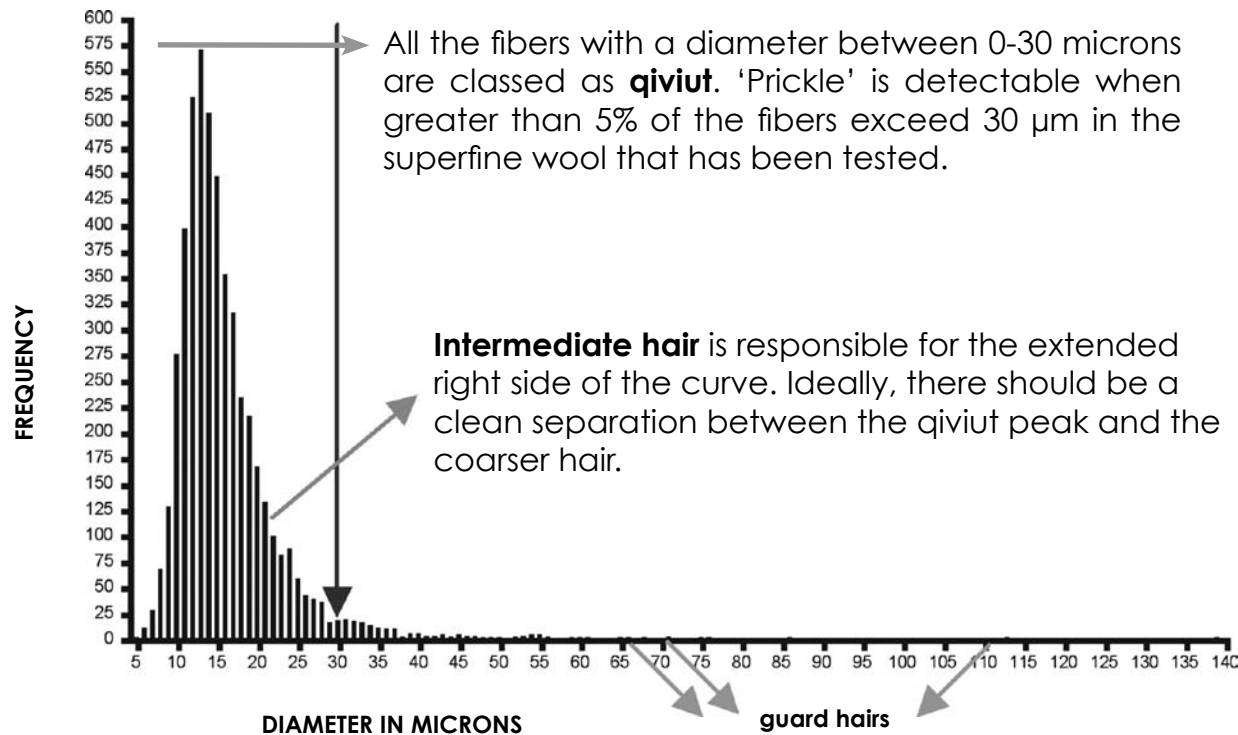
Most commercially available qiviut is removed from hides of wild muskoxen harvested for food. Qiviut combed from captive animals during shedding is still relatively rare. The down is “shed in a tightly synchronized moult each spring.”⁸ Shedding is first evident in yearlings and two-year-olds,

Muskox cow at LARS, her entire fleece on the floor before her after combing. This is about four pounds of raw qiviut.
—PHOTO BY JAN E. ROWELL



the Optical Fiber Diameter Analyser and Average Fiber Diameter

Average Fiber Diameter (AFD) is the single most important characteristic for determining commercial value and end product use of wool. The optical fiber diameter analyser generates a frequency histogram for each sample measured. The graph below characterizes combed raw qiviut from a captive adult cow at LARS.



FROM "QIVIUT: DEFINING QUALITY," POSTER BY J.E. ROWELL

who start to shed in late April (in the Fairbanks area, at the 65th parallel). Then comes the rest of the herd, with the newly-calved cows the last to start (mid-May to early June). Once they begin shedding, muskoxen will rub themselves against fences or other handy objects, leaving tufts of qiviut behind. This qiviut, however, is not likely to match the quality of combed qiviut.

Because muskoxen have a completely synchronized shedding period, Rowell said, it makes it "very easy to time and concentrate the combing" of the qiviut, which is convenient and economically advantageous for the farmer. Rowell has been studying muskoxen and their potential as an agricultural animal for much of her professional career, researching fiber characteristics, reproduction, behavior, population dynamics, as well as other aspects of muskox health and growth. She has worked to establish quality standards for muskox fiber and good management practices to improve the yield and quality of qiviut.

The characteristics of the raw fiber determine the quality and textile performance of the end product. Qiviut is valued for its softness, light weight, and warmth, and, as in any animal textile industry, the fiber must be harvested for both quality and yield. Many fiber characteristics can be measured mechanically, providing a consistent, accurate measurement that is helpful in maintaining good farm management practices. These are known as objective measures, and are valuable for consistently producing high-quality qiviut.

The average fiber diameter, or AFD, is "the single most important characteristic for determining commercial value and end product use" of an animal fiber.⁹ Generally speaking, the finer and longer the fiber, the more valuable (although, of course, fiber strength also plays a part in its utility and commercial value). Fiber diameter is measured using an optical fiber diameter analyser, which generates a frequency histogram for each sample

measured. The histogram (see illustration above) is a graph providing a visual indicator of the quality of the sample, based on the diameters of the hairs. Qiviut from farmed muskoxen has an AFD between 14-16.5 microns, according to research by Robertson, 2-3 microns lower than that measured from wild muskoxen. "This," writes Rowell, "is commercially significant," making qiviut one of the finest fibers harvested in the world. Fiber diameter varies not only with the type of hair, but also by the region of the muskox's body, as does the amount of intermediate fiber and the cleanliness of the qiviut. This means that with farmed muskoxen, the prime, clean qiviut can be selectively harvested—and associated processing costs to the farmer reduced.

Also, with captive animals, the farmer can potentially breed for fine AFD, supplement the diet for improved yield, and comb the qiviut for high quality. Qiviut coarsens with age, going from an average of 16.7 microns in yearlings to 17.9 in adults. "While this



Morgan Robertson combing a cow confined in the modified buffalo crush. Note the characteristic “spectacles” around the cow’s eyes and the evident thickness of the qiviut remaining in the animal’s coat along the spine.
—PHOTO BY JAN E. ROWELL

could be commercially significant,” says Rowell, “it is not as dramatic as the fiber coarsening that occurs in cashmere goats, where a 1.3 micron difference exists between the first and second fleece with a continued coarsening rate of about 0.5 microns a year.” In most animals producing superfine fibers, like cashmere goats, fiber coarsens with age until individuals cease to be commercially useful for the production of superfine fiber. In many species males produce coarser fibers than the females, to the point that only a portion of the herd, in some cases only the babies and the younger females, produce good quality fiber. “With muskoxen,” said Rowell, “you get equivalent quality between male and female, young and old.” The entire herd provides good qiviut, and the increase in coarseness with the age of the animal is minimal, making each member of the farmer’s herd a valuable fiber producer.

Because farmed qiviut is combed and not shaved, it contains very little guard hair. A muskox fleece, rather than being the entire pelt, is a single large sheet of qiviut that is carefully combed from the animal rather than being plucked in tufts. In the shedding

process, the qiviut loosens from the skin and begins to lift away from it, eventually falling away from the skirt, rubbed off by the animals or snagged by twigs and pulled out. At a certain stage in the molt, the undercoat will be a short but relatively uniform distance from the skin, and the comber can use a long-toothed hair pick to pull it gently away in a single sheet. The loosening process starts at the head and moves backward along the body, so they can be combed in a few sessions over a period of a week or two. Muskoxen will develop what look like large spectacles of underwool around their eyes when their fleeces are ready for combing. If the fleece is combed out too early, the hairs will tweak the skin as they pull out, irritating the muskox and coming out in small tufts.

Muskoxen have to be acclimated to combing. At LARS, an adapted buffalo crush is used to gently but firmly hold the animal in place while being combed. Generally speaking, females, calves, and castrated males are amenable, but bulls tend to be more irritable or even dangerous, and at LARS, are sometimes sedated and given their annual hoof-trimming and veterinary checkup in one



Alastair Newton, a former LARS intern, combing an exceptionally fine fleece, demonstrating how the qiviut can be removed from the animal in a single sheet.
—PHOTO COURTESY LARS

go with their spring fleecing, to make the process easier and less traumatic for both the bull and the farmhands.

Combed qiviut contains intermediate hairs and a small amount of guard hair. Depending on the process used to clean it, farmed qiviut can give a de-haired yield of 80-88 percent, which is very good, especially in comparison to the shaven pelt, where 50 percent or more by weight is removed during dehairing. (Dehairing is the process of removing the skirt and other coarse hairs from the fleece.) The fleece can be graded and cleaned as it is combed. Cleaning at this stage is the removal of foreign matter. Matted, dirty qiviut and qiviut contaminated with vegetation can be easily pulled from the fleece. After the fleece or raw qiviut is combed and de-haired, it may be further cleaned.

The raw, cleaned qiviut is spun and then the yarn is washed. Natural qiviut is a soft grayish brown in color, but it takes dye well and can be found for sale in myriad colors. Bleaching weakens the fiber, however, so many spinners and knitters recommend using only the overdyed natural qiviut, which has darker, more subdued colors. Because the fibers are very smooth, qiviut yarn is slippery and hence better suited for knitting than weaving. It is usually spun into a fine, lace-weight yarn because it is so warm, and sometimes used in blends with silk or other fine fibers.



Tundra, a bull at LARS, shown in side and frontal views during the spring molt, illustrating the classic shaggy muskox look. This animal was not combed soon enough, so some of its qiviut will be lost as a result, and that recovered will be harder to clean.

—PHOTOS COURTESY LARS

The potential for a qiviut industry

A search on the Internet reveals many fiber artists who have explored qiviut's qualities, among them Donna Druchunas, author of *Arctic Lace*, a recent book that explores knitting with qiviut, and the knitters of Qiviut-Knit-Along, a community blog of knitters, spinners, and crocheters.

Qiviut yarn can be found in many specialty yarn shops now, but it is still expensive, ranging from \$60 to \$100 an ounce for 100 percent qiviut: a luxury fiber indeed! Raw qiviut, according to Robertson, can cost as much as \$330 to \$385 per kilogram (\$147 to \$171 per pound).¹⁰ The expense, fiber length, and insulative value of qiviut yarn lends itself to use as a lace-weight yarn, and most patterns and clothing made from it are fine and lacy. Companies such as the Oomingmak knitters' collective, the Jacques Cartier Clothier Qiviut Boutique, and others sell finished clothing made with these yarns and market them using such adjectives as "luxurious," "rare," an "indulgence," "exotic," and the like.

The engaging appearance of the animal, its symbolism as an animal of the high Arctic and of the last Ice Age, and qiviut's cachet as an exclusive and desirable fiber is important to the public demand for muskox products and to their monetary worth. The high value of qiviut means that there is economic incentive to raise muskoxen commercially, despite the challenges inherent in farming alternative, undomesticated livestock about which little is known.

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7. Maximizing Qiviut Growth in Muskoxen. Morgan A. Robertson. Master of science thesis, May 2000. University of Alaska Fairbanks Institute of Arctic Biology (Biology & Wildlife). p. 3.



8. Rowell, et al., p. 1670.

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10. Robertson, p. 20.

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Ontario Handweavers and Spinners, www.ohs.on.ca

2097 Gary Crescent, Burlington
ON L7R 1T1 Canada
888-OHS-1232 or 905-634-3234

The guild offers classes and certification, and publishes a quarterly magazine, *Fibre Focus*. In-depth studies, or certification theses, are available for loan to members by contacting Beth Whitney, OHS Librarian, at 100 Victoria Street, London, ON N6A 2B5 Canada.

Sustainable Agriculture Program, Cooperative Extension Service, University of Alaska Fairbanks. Copies of the program's newsletter, *Sustainable Agriculture for Alaska*, are on line at www.uaf.edu/coop-ext/SARE/newsletter.html.

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Hand spinning with qiviut

Carding raw muskox wool requires different techniques than those used for wool or cashmere; qiviut can be damaged if carded or spun as though it came from a sheep or goat. E. Marguerite Cornwall provides instructions on cleaning, carding, and spinning qiviut in her 1983 article, "Some Hints on Spinning Musk Ox Wool," recommending cotton carders "to align the musk ox wool and render a more uniform mass without too much mixing. It is the mixing which causes the fiber to wrap around the hooks and work into pills." Cornwall writes that qiviut "blends beautifully with fine wools, especially with high-count Merino, and with cashmere, silk, angora, camel down, etc.," but she recommends carding the qiviut separately first.¹

The LARS website includes these instructions for fiber preparation for spinning:

To de-hair the fiber before spinning, grasp a handful of fiber and pull out the long, coarse guard hairs.

Next, remove the intermediate fibers, those that are fine, but straighter than the underlying qiviut. The more intermediate fibers removed, the softer your spun yarn will be. The intermediate fibers can be saved and blended with other fibers or spun alone for a somewhat heavier, fuzzier yarn.

Any dandruff on the base of the fiber can be carefully snipped off with small, curved scissors. Carding is not required, however, if you choose to card the fiber, cotton cards are recommended. Care should be taken or the fiber will pill.²

1. Some Hints on Spinning Musk Ox Wool. E. Marguerite Cornwall. *Spin-Off Magazine*, March 1983.

2. Robert G. White Large Animal Research Station website, page on Qiviut. Accessed 5/31/07 on line at www.uaf.edu/lars/qiviut.html#Preparation.

Local Herbs!

adapted from Senior Thesis 2007-01, Producing Fresh Herbs for Fairbanks Restaurants, by Jacquelyn Denise Goss

full thesis available on line at www.uaf.edu/snras/afes/pubs/SeniorTheses/ST_07_01.pdf

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According to the latest US Department of Agriculture trade survey, Americans purchase roughly half of their fresh produce through food service venues. This means that for every 100 unprocessed apples a person eats, 50 will come from restaurants or fast-food eateries. Forty-eight of the apples will be obtained from a retail store or supermarket, while less than two apples will come directly from the grower. To an agricultural producer, this means that as many consumers can be reached through food service venues as through retail outlets.

While selling to retail outlets will secure large and steady accounts with limited delivery costs for farmers, most retail outlets are owned by a few multi-regional corporations. As members of these large corporations, retail stores operate with large purchasing power and volumes, allowing them to negotiate low prices in exclusive contracts with growers. Many retail corporations have ownership in the various stages of food production and distribution, including cargo vehicles and entire farms. For a small-scale farmer in Fairbanks where wages are considerably higher than the national average, it can be difficult, if not impossible, to sell in volumes and at prices demanded by retail stores.

Restaurants, on the other hand, have more freedom to reach agreements with local producers. Chefs are often willing to accept and pay a higher price for a premium quality product. The purchased volumes are also more consistent with the amounts available from most local farmers, and packaging for restaurants is less restrictive because specialized containers and barcodes are not necessary.

Another benefit of selling to restaurants is that many chefs are educated consumers when it comes to fresh produce and herbs. The chefs are familiar with how to use, prepare, and present produce in meals and dishes. Through a middleman who knows the products, a

farmer can introduce local consumers to new varieties and specialty crops. When consumers cook at home, they will start asking for locally grown ingredients at farmers markets and other outlets in order to recreate dishes available in restaurants. In addition to educating consumers, chefs can also communicate to producers marketing trends, consumer preferences, and customer requests without delays.

For the restaurant chef, contracting directly with growers can mean a fresher product that hasn't been exposed to various warehouses and climate-controlled cargo carriers. Fresh herbs in particular suffer reduction in quality because of their relatively short shelf life and the volatility of essential oils that give herbs their aroma and pungency. As an example, basil at 15°C will remain fresh and acceptable to most chefs for about 12 days. Below 15°C, the aroma and flavor of the herb begin to decline. At 10°C, buyers will start to notice discolorations or lesions in the leaves after 8 to 9 days. At 7.5°C, basil will lose marketability after only 5 days. Basil is one of several crops native to hot climates that are especially susceptible to chilling injury. This can make travel and storage difficult, because most other herbs store well at the 1 to 4°C usually maintained in refrigerators, storage warehouses, and climate-controlled cargo vehicles. In Fairbanks, most fresh herbs brought in by wholesale distributors have traveled at least a week before arriving at the restaurant, sometimes as many as ten days. A ten-day trip for basil can be perilous and chefs often have to reject the product because it is no longer useable.

Unfortunately for farmers in Fairbanks, reaching the restaurant market involves making widespread deliveries and setting up separate accounts as there is no local distribution system. Because herbs are often used in small quantities, the cost of making multiple deliveries may be prohibitive. A farmer specializing in commercial herb production can, in the right setting, make a fine living by selling

Summer use of culinary fresh herbs by restaurants in the Fairbanks area.

Herb	Pounds/week*
Basil	22.5
Parsley	17.5
Cilantro	12.0
Mint	4.0
Rosemary	3.5
Thyme	3.0
Oregano	2.0
Sage	1.5
Dill	1.0
French tarragon	1.0
Total	68.0

* Based on estimates given by chefs in personal interviews.

fresh herbs exclusively to restaurants. However, in rural areas with few high-scale restaurants, the farmer will likely have to diversify accounts and crops to successfully produce for the restaurant market.

Fairbanks creates a unique situation for farmers and restaurants because of the distance to conventional large produce outlets. Chefs may be willing to pay a higher price for fresh cut herbs to compensate for the high farm wages in a spread-out Fairbanks community.

Here in Alaska, I found two produce buyer surveys. The Alaska Division of Agriculture contracted a survey through AADLAND Marketing Group to assess the awareness, expectations, and perceptions that Alaska consumers have in terms of Alaska-grown produce. Most consumers held the belief that Alaska-grown products were superior to imported produce and even to organic produce, possibly because of the pristine environment throughout most of Alaska. More specific to restaurants is a survey conducted by AFES to determine the demand for baby salad greens among Alaska restaurants. The study found most chefs serving the tourist industry to have a preference for Alaska-grown produce, but many wished that these products were available through their existing wholesale supplier.

All the restaurants purchasing from local sources seemed satisfied with the quality and variety of herbs offered. One restaurant stated a desire for French

39 tarragon, another for lemongrass and holy basil, and several wished that more tomatoes, baby squash, and other specialty vegetables were available. Seven chefs were willing to pay premium price for locally grown products. Three chefs were willing to pay up to \$2.00 more per pound for certain locally grown herbs, one chef stated a 25 percent higher price, while the remaining chefs would not indicate an exact premium price tag.

One farmer, who supplies vegetables rather than fresh herbs to restaurants, stated that the lack of organization among growers hinders the ability to set up restaurant accounts. Often growers can only supply a portion of a restaurant's needs, but multiple farmers carry costs for separate deliveries instead of collaborating and splitting expenses. Farmers also waste time soliciting restaurants that have already set up farmer accounts, while other restaurants remain untapped. An option is to consolidate and share accounts and deliveries among several farmers to reduce marketing and distribution costs for selling to restaurants.

Americans are becoming more sophisticated as new ethnic foods with unconventional herbs and spices enter the restaurant scene. This was apparent in my survey. Cilantro was an herb in high demand, with half of the requests originating from a restaurant that opened a few months ago. Local growers also listed cilantro as a top-selling herb. A survey in Kentucky cited 28 percent of chefs to be "very interested" in purchasing locally grown cilantro, with only basil, garlic, and chives having higher interest ratings (in the 30th percentile). A hundred years ago, when parsley and sage were the most used herbs in the kitchen, very few Americans would have known of cilantro. Basil, the most purchased herb of this study, gained popularity with the immigration of people from India, Thailand, and the Middle East. Mediterranean and Asian cuisines use fresh basil and are projected in the "Top Cuisines" of 2007. Examples of herbs gaining in popularity with use in ethnic cuisines are epazote, mint, lemongrass, and nonstandard types of basil, such as lime and thai basil.

Accounts with ethnic restaurants should not be overlooked. Although only two ethnic restaurants were surveyed, these

accounts were in the top five fresh herb purchasers. Historically, ethnic restaurants have seen lower volumes of guests but are gaining in popularity, and the cuisines require a wide range and large volumes of herbs. Bundled with other products such as fresh chilies, tomatoes, spinach, and squash, a restaurant serving a limited number of diners may still support a sufficiently large account for a grower. The Lemongrass Thai Cuisine restaurant is an example of an establishment purchasing cilantro, parsley, several varieties of basil, mint, cabbage, broccoli, and fresh eggs from local producers.

Delivery is essential; it must be on time and early in the day to accommodate the chef's busy schedule. Essential oils break down in the afternoon heat, so the best strategy is to pick the herbs early in the morning and deliver them to the restaurant promptly to reduce the time the herbs are spent in high temperatures. In fact, better freshness was the number one reason most chefs maintained accounts with local producers.

Chefs admitted to a willingness to pay premium for locally grown products, but not necessarily for organic products. Many chefs are willing to sacrifice time and money to purchase quality fresh herbs. All chefs expressed some degree of dismay with the quality of herbs making their way to Fairbanks after extended travel. There was a general preference among the majority of the respondents for Alaska Grown products. The poor quality of imported herbs along with a desire for locally grown foods have resulted in a demand for direct delivered fresh-cut herbs among chefs in Fairbanks restaurants. By educating chefs on new specialty items, a farmer can reach a large customer base for increased sales and foster long-term promotion and use of fresh herbs. Chefs also are able to provide feedback, information, and suggestions to the farmer for desired types, stage of harvest, packaging, and trends in using herbs.

Challenges and obstacles selling to restaurants are not, however, uncommon. Staffing and management of restaurant kitchens tend to continuously turn over and change. Because new management can be expected to plan and approach menus and food preparation differently, a farmer cannot be assured of an account from one growing season to another. Most restaurants in the Fairbanks area use and buy fresh herbs in quantities that may be too small to justify the cost and effort of order preparation and weekly delivery. One option is to diversify and offer a larger array of products such as tomatoes and other vegetables. Collaborating with other farmers is another alternative, to consolidate orders for more efficient distribution and lower costs. Still, Alaska Grown products will need to be priced at premium in order to recover the high production and labor costs of Alaska. On the other hand, if farmers are prepared to offer quality fresh herbs and produce along with good service and timely deliveries, the chefs in Fairbanks appear willing to pay top dollar for locally grown fresh herbs.

Close-up of locally grown basil.

—PHOTO BY MERIAM KARLSSON





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Karen Hills, a former student assistant at the Robert G. White Large Animal Research Station, carrying an armful of qiviut. See story on p. 29.

—PHOTO BY JAN E. ROWELL



Right: these dry dragonhead mint seedheads may represent a new crop for Alaska—one well suited for your birdfeeder. See story on p. 14.

—PHOTO BY BOB VANVELDHUISEN