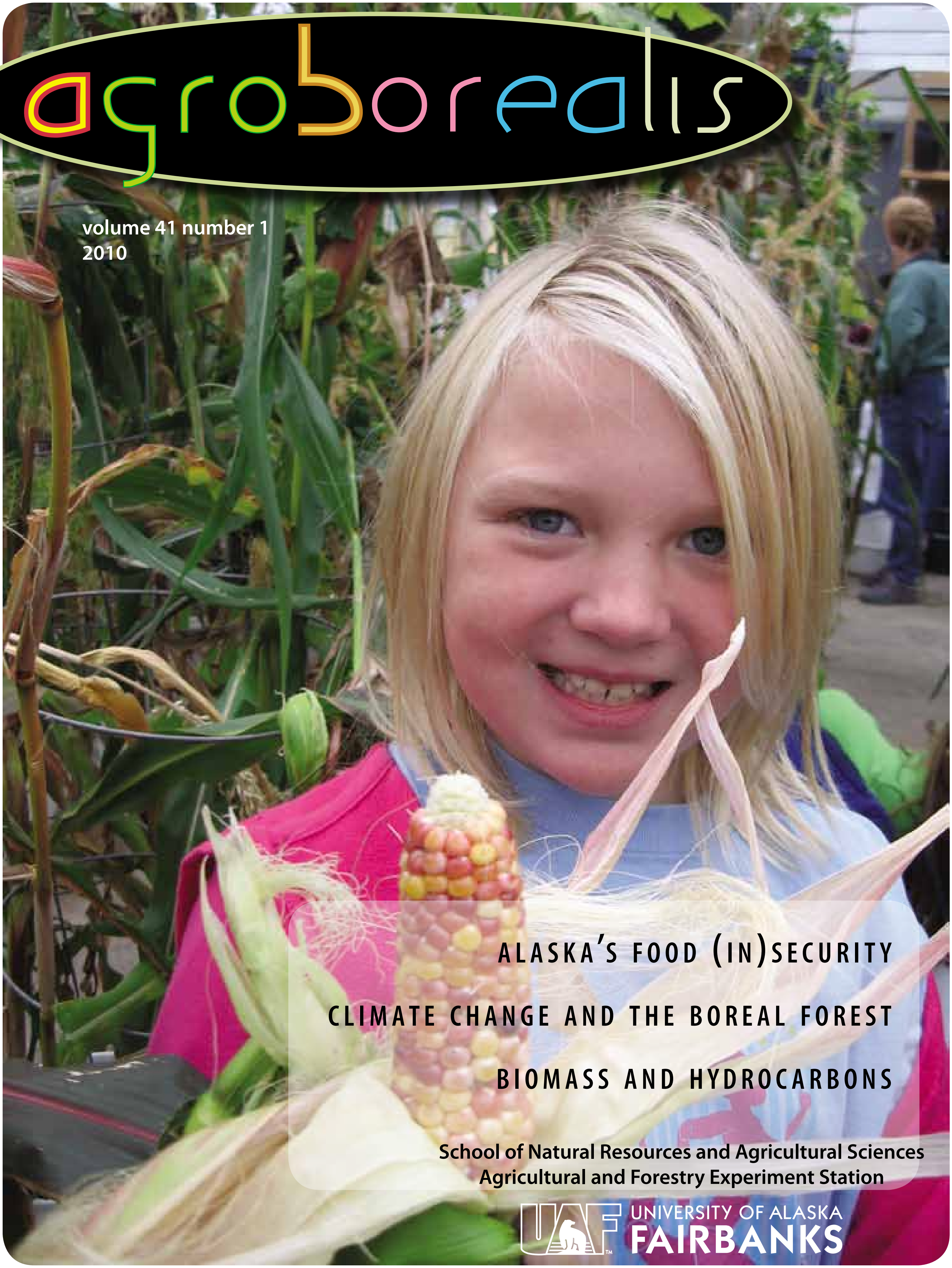

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2010

ALASKA'S FOOD (IN)SECURITY

CLIMATE CHANGE AND THE BOREAL FOREST

BIOMASS AND HYDROCARBONS

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

UAF UNIVERSITY OF ALASKA FAIRBANKS

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About the cover:

Savannah Moore, age 8 and a pupil at Kincaid Elementary School in Anchorage, in the school greenhouse where a multicolored popcorn variety was bred and developed by Glenn Oliver's students. School programs like this teach children about biology, genetics, food systems, and business management.

About this panel:

Elementary school teacher Glenn Oliver showing the multicolored kernels on an ear of corn; the variety ranges from pastels to deep shades of yellow, red, and purple.

See story on p. 23.

—PHOTOS BY GLENN OLIVER

Eggs dyed with birch bark dye, one of dozens of activities and experiments in the OneTree program.

Beer brewing with Alaska barley.

Brianne Frame with her 4-H reindeer in August 2010.

Alder and salmon biomass gasified and set afire.

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NEWS & PUBLICATIONS

New books and other publications at SNRAS!

Math in a Cultural Context has released five new titles in the Lessons Learned from Yup'ik Eskimo Elders series: ***Akaguagaankaa, The Story of a Giant: Yugpak Quliraq***, a storyknifing story by Al'aq Mary M. George; ***Kayak Design: Scientific Method and Statistical Analysis***, by Jerry Lipka, Carrie Jones, Nicolle Gilsdorf, Karen Remick, and Anthony Rickard; ***Kukugyarpak***, told by Annie Blue; ***The Raven Story and the Boulders: Akagyugnarli***, by Annie Blue; and ***Ellalluquuyuk, Slave Girl***, told by Annie Blue.

More on peony growing, cutting, and storing for market has been published in "***Peony Research 2009***," AFES Miscellaneous Publication 2010-02, by Patricia S. Holloway, Shannon Pearce, and Janice Hanscom.

"***Growing Small Grains in Your Garden***," a guide to small-scale grain selection, cultivation, processing, and storage in Alaska, was released as AFES Circular 135, by Bob Van Veldhuizen.

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SINCERELY, DEAN CAROL E. LEWIS
AND THE SNRAS FACULTY AND STAFF

AMSA: the future of arctic marine shipping

Key players in the realm of arctic marine shipping gathered in Fairbanks in October 2009 to examine ways to implement the seventeen recommendations of the Arctic Council's Arctic Marine Shipping Assessment that was released in April 2009. The Arctic Council is an intergovernmental forum that promotes cooperation, coordination, and interaction among the countries with territory in the Arctic. The Council also involves arctic indigenous communities and other arctic inhabitants on common arctic issues, in particular issues of sustainable development and environmental protection in the Arctic. Member states of the Arctic Council are Canada, Denmark (including Greenland and the Faroe Islands), Finland, Iceland, Norway, the Russian Federation, Sweden, and the United States of America. Permanent participants include the Aleut International Association, the Arctic Athabaskan Council, Gwich'in Council International, the Inuit Circumpolar Council, the Saami Council, and Russian Arctic Indigenous Peoples of the North.

The Arctic Marine Shipping Assessment was a major project of the Council's, undertaken by the Protection of the Environment working group, and was commissioned in 2004. When complete, the 200-page, multifaceted, interdisciplinary report was approved by the eight arctic states. The report includes scenarios as far into the future as 2050. "The word that applies is complexity," said Lawson Brigham, the chair of AMSA, a lead author of the AMSA report, and a UAF distinguished professor of geography and arctic policy. The seventeen recommendations highlight marine safety, protecting people and the environment, and infrastructure. Among the other considerations were marine geography, climate change, whaling, and governance. The next step was to find suitable ways to implement the recommendations, so the AMSA group convened an arctic policy workshop to do just this.

Participants in the workshop created a twenty-four-page report that was published by the University of the Arctic Institute for Applied Circumpolar Policy (IACP), titled *Considering a Roadmap Forward: The Arctic Marine Shipping Assessment.* More than seventy people came from the US, the United Kingdom, Norway, Denmark, Canada, China, and Japan. The international group of scientists, policymakers, shipping executives, indigenous community representatives, military leaders, and government officials met at UAF, hosted by Chancellor Brian Rogers and the UA Geography Program. The IACP partners are the University of the Arctic, the University of Alaska Fairbanks, and Dartmouth College. IACP is co-directed by UAGP Director/SNRAS Associate Dean and Vice Chancellor for Students Mike Sfraga and US Ambassador Kenneth Yalowits, Dartmouth College. This was the second Arctic policy workshop under IACP, the initial gathering being held at Dartmouth in December 2008.

"This is a subject that touches all citizens of the north," said UAF Chancellor Rogers in the opening session of the AMSA workshop. "The Arctic is a place of challenges and opportunities where people have lived and thrived for ages. We need to discover a roadmap forward."

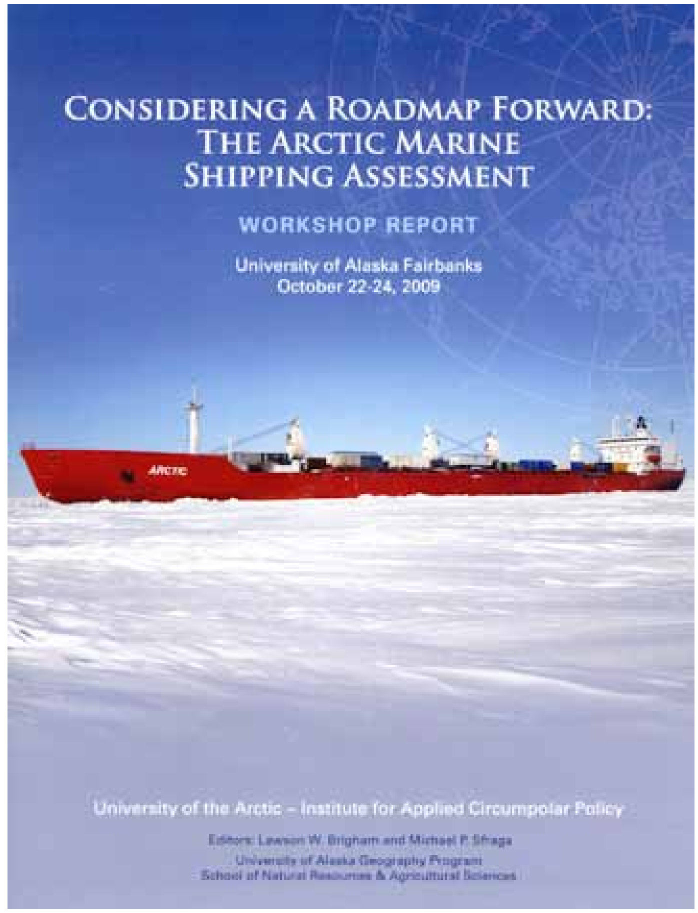
Mead Treadwell, at the time chair of the US Arctic Research Commission, said the AMSA report brought together the eight arctic nations to conduct the study and then negotiate and approve the AMSA report. "We asked how do we do it right," he said. "We looked at what shipping is in the Arctic today as well as what it can be." AMSA focused on Arctic marine safety and marine environmental protection issues consistent with the mandates of the Arctic Council.

Denise Michels, mayor of Nome, said marine traffic is very important to her city. "We're doing our best to accommodate all this traffic," she said. In 1990 Nome had thirty-four port calls and in 2008 there were 234, including four cruise ships. Michels said she sees maritime activity as Nome's next economic focus. "We're trying to be very proactive," she said. "These policies and recommendations in AMSA affect us immediately and they need to be implemented for all of us who live in Arctic Alaska."

The workshop participants broke into three groups based on the three AMSA recommendation themes: Enhancing Arctic Marine Safety, Protecting Arctic People and the Environment, and Building the Arctic Marine Infrastructure. The groups were charged with: identifying primary stakeholders and actors who should be involved; developing roadmaps for each recommendation (what actions are required); identifying key issues for each AMSA recommendation; naming sources of potential funding: and, establishing a timeline where possible.

"Nearly every remote region of the Arctic Ocean has been crossed by surface ships in summer," said Brigham, workshop co-chair. "The Arctic ministers decided with all this marine traffic today and greater marine access due to the retreat of Arctic sea ice, the Arctic states needed to conduct a comprehensive assessment and develop a strategy to protect the maritime Arctic, its people and the environment." After holding more than a dozen major workshops and fourteen town hall meetings in indigenous communities, the report was drafted from information acquired from more than 200 experts. "This topic goes well beyond climate change. It is about arctic natural resource development, the linkages of the Arctic to the global economy, the interplay of marine uses, and governance issues throughout the Arctic Ocean. Overall, AMSA is a message of the arctic states to the world with a framework to address the many complex challenges of protecting Arctic people and the environment in an era of expanding uses of the Arctic Ocean."

A series of informative presentations were also part of the workshop agenda. Scott Rupp, UAF professor and leader of the Scenarios Network for Alaska Planning program, UAGP/SNRAS, provided an overview of arctic climate modeling. Bernard Coakley, a UAF professor of geology, noted the many challenges faced by conducting marine geophysical research in the Arctic Ocean. One of the co-leaders of AMSA from Transport Canada and a working group chair in Fairbanks, Victor Santos-Pedro, gave a key update on the Arctic initiatives at the International Maritime Organization in London, the UN body that develops codes and regulations for the international maritime community. From Lloyd's



Register in London, a ship classification society, Des Upcraft provided important perspectives on regulating shipbuilding and marine operations on a global basis.

Brigham said research opportunities for UAF and the entire circumpolar north abound. A sample of critical topics for research includes: rates of Arctic sea ice change and future coverage; arctic marine navigation seasons; the economics of arctic natural resource development; marine ecosystem responses to arctic sea ice retreat; socio-economic responses to global climate change; the potential impacts of ship emissions and noise; establishment of an arctic observing network; enhanced hydrography and charting; and, the effectiveness of spill response technologies in cold regions.

The workshop brought an international group of experts to explore in depth the way forward for AMSA, Brigham said. "We held rich discussions and the working groups focused appropriately on AMSA's key outcomes, the seventeen recommendations, identifying necessary actions and key issues. The discussions were successful due in part to having the right mix of actors and stakeholders in each of the working groups."

Workshop co-chair Mike Sfraga said the decision to host and lead the discussion on AMSA was strategic in nature: "UAF is perfectly positioned to facilitate policy-related discussions related to the Arctic and Alaska specifically. With Chancellor Roger's support, we will expand our efforts in this area and create additional opportunities to explore critical policy issues that will impact Alaska far into the future."

The workshop report can be found on the website www.snap.uaf.edu/downloads/arctic-marine-shipping-assessment. The key components are the Roadmaps and Actions, and Key Issues, for each of the AMSA recommendations. Many of the roadmaps and actions will require funding by public-private partnerships. Receiving much attention at the workshop was the need for a mandatory polar code of navigation that is being developed by the IMO. Lengthy discussions were held regarding the importance, sensitivity and complexity of conducting surveys of indigenous marine use. These surveys are very necessary so that multiple use strategies in Arctic waterways can be developed. Also discussed was the need for enhanced research, including mitigation measures, on the impacts on marine mammals, and other migratory fauna, of increased Arctic marine operations.

One working group, led by David Jackson of the Canadian Coast Guard, focused on the requirements for a host of marine infrastructure issues such as ports, communications, aids to navigation, charts, places of refuge, environmental observations, marine traffic systems, and more. The participants agreed that the elements of this marine infrastructure are critical to the enhancement of marine safety and environmental protection in the Arctic Ocean.

The Fairbanks workshop report highlights three funding issues that received significant attention by the participants. There was general agreement that indigenous marine use surveys should be conducted, not in a unified circumpolar effort, but on regional and local scales. Public appropriations from national and regional arctic governments are key since such surveys relate to subsistence living, environmental protection, and multiple use management. Private funding may be important at the local, community level for detailed surveys and studies. The lack of marine infrastructure in most of the Arctic Ocean requires broad awareness of the issues and sustained commitment to funding. Government-industry partnerships and large investments will be required to provide an adequate safety net for marine operations and environmental protection. Public funding of an international arctic observing network should be a top priority of the arctic states but this will require substantial planning and fiscal collaboration. Liability and compensation issues from potential arctic marine disasters received attention at the workshop. Effective oil spill liability trust funds were deemed critical and the participants agreed they could be based on regional or bilateral agreements. The summer 2010 Gulf of Mexico spill places additional emphasis on liability and compensation issues for any future arctic marine operations.

Brigham and Mike Sfraga summarized the highest-priority arctic policy issues related AMSA in the workshop report. Among the many issues of future arctic marine use, these six stand out from the experts' discussions during the October 2009 workshop:

- A mandatory IMO Polar Code;
- Full tracking and monitoring of arctic commercial ships;
- An arctic search and rescue agreement (an initiative is underway);
- Surveys of indigenous marine use;
- A circumpolar response capacity agreement among the arctic states;
- Implementation of an arctic observing network to support science and marine operations.

Future arctic policy workshops, seminars, and conferences under the UAGP arctic policy initiative are planned. The AMSA workshop was a good start toward fulfilling Chancellor Roger's vision for America's Arctic University.

The icebreaker MV Tor Viking II, *docked in Gävle, Sweden. The ship is registered in Sweden and owned by Trans Viking Icebreaking & Offshore AS, Kristiansand, Norway. Icebreakers, necessary in the Arctic, serve as merchant and scientific vessels. Ship performance, environmental conditions, and ice navigation capabilities of successful operations in the Arctic Ocean are factors to be examined in marine shipping in the north. Photo taken by Kalle Mattson, February 18, 2010. From Wikimedia, used under the GNU Free Documentation License, Version 1.2 or later.*

Changing the forest and the trees—Is it climate?

By Glenn Patrick Juday

With each passing year, more and more people around the world have heard that the Arctic and far north of the planet are in a period of major climate change. Much of the public awareness about high latitude climate change involves coastal regions, where glaciers, sea ice, and projections of declining polar bear populations offer visible, often dramatic events and images that make memorable stories. But less-noticed events in the boreal forest of interior Alaska represent another sign, and also a cause, of climate change.

The boreal forest has long been the most intact of all the Earth's forest regions. Even though about half of the area of forest globally has been used or changed so that it no longer has tree cover, the boreal forest still occupies nearly the same extent now that it did at the beginning of human civilization. But now climate change has begun to affect the boreal more than any other forest region, and Alaska has been affected as early and as much or more than any other part of the boreal region.

National leaders, Alaska resource managers, and rural residents are interested in learning what has caused the change in climate and how Alaska forests are changing as a result. They are concerned about what future changes are possible. And increasingly, after years of study by many investigators, there are some answers.

Warming up to the boreal forest

The two great surface features of the far north, boreal land cover and Arctic Ocean ice cover, are not just passive objects acted upon by climate change, they are also a significant factor in Earth's climate balance because of their surface reflectivity. At scales that range from our clothing options to whole sections of the planet, dark surfaces absorb light energy and release some as heat, and light-colored surfaces reflect light and keep surfaces cooler. It is widely understood that changing the Arctic Ocean from a white, snow- and ice-covered surface to dark, open ocean water would warm the planet considerably. But less appreciated is the fact that the entire planet would be about 2°C colder if it weren't for the presence of the dark, rough-textured, conifer trees that grow across vast expanses of the northern part of the globe.

Drought-injured birch trees at Rosa-Keystone Dunes Research Natural Area in the Shaw Creek region of the Tanana Valley State Forest northeast of Delta Junction, Alaska, June 24, 2010. The near-record hot and dry weather of July 2009 so stressed trees across lowland central Alaska that root dieback occurred. As a result, in 2010 foliage mass is abnormally low (you can see through the canopy), and leaves are small, injured, and yellowish even in early to mid-summer. This is the second such stress episode in the past decade, and considerable tree death is likely if such weather conditions persist. Photo by G. Juday.

The boreal forest also plays a major climate-regulating role by influencing the level of greenhouse gases in Earth's atmosphere. Trees in general are very effective in storing the carbon dioxide they take up from the atmosphere to build their tissues in the form of the wood in their trunks and stems. In addition, and in the boreal forest in particular, cold soils and waterlogged acid soils make up a vast reservoir of plant litter representing carbon that has been taken out of the atmosphere and which is generally not subject to decay and re-release.

The amount of stored carbon of the far northern forest and tundra vegetation and soils is roughly equivalent to the carbon dioxide in the atmosphere today. But this stored carbon is only out of circulation to the extent that fires, warm temperature decay, and drying of wetlands do not move it back into the atmosphere. Warmer temperatures could mean less storage, and thus more greenhouse gases in the atmosphere, which cause more warming—a classic positive feedback. Given this potential of the boreal forest to amplify and reinforce an initial warming, the recent history of the factors in Earth's climate system that cause warming are an important signal of future change.

Changes in Earth's temperature regime, warmer or colder, can be particularly disruptive in the far north because they are usually greater compared with lower latitudes. In fact, the Arctic and Subarctic regions in general, and Alaska in particular, have experienced some of the greatest amounts of warming on Earth over the last few decades. Since the 1950s, mean annual temperatures in Alaska have increased by 2 to 3°C and in winter by up to 4°C. The greatest amount of warming has occurred over land areas and less over sea surfaces. (For further information see the Alaska Climate Research Center: http://climate.gi.alaska.edu/)

Of course, in the distant past temperatures have been far warmer than now on the top of the planet. What's different today is that human societies and users are invested in the resources and environments that are familiar to us. Climate change puts most of our anticipated future uses into question. And if climate change is of great enough magnitude it may quickly take some natural resource options off the table. Eventually the forests of the north will adjust to a new climate, as happened in the distant past. As forests adjust to a new climate, new opportunities for human uses will be created. The challenge for society is that the problems of climate change effects on forests often occur quickly (fires, insect outbreaks), while new opportunities usually take at least the amount of time necessary for a new generation of trees to grow to maturity. Boreal Alaska trees are in their prime when they are a century old, and even for several decades after. But a little over a century ago people were not planning and preparing for climate change, and there were no cities where Anchorage and Fairbanks exist today. This means it's really not too early to start planning and preparing for an altered climate of the future.

Fortunately for our ability to understand and anticipate likely changes, most of the variability in Earth's temperature and related climatic features is accounted for by four factors—solar variability, changes in coupled ocean and atmospheric circulation, volcanic activity, and finally changes in the levels of greenhouse gases and other human-caused compounds in the atmosphere. These main climate-forcing processes are responsible for a variety of influences, some of them decisive, on the condition of the forests of Alaska and the far north.

Cycling with the Sun

From the time of ancient Chinese astronomers, people have recorded spots on the Sun. These dark "spots" are actually huge convective storms of intense magnetism on the surface of the Sun, most of which are so large they could easily swallow the Earth. One of the first uses of the newly invented optical telescope in the early 1600s was to carefully map and count the visible spots on the Sun's surface. The long-term increase and then disappearance of these sunspots were eventually found to follow a roughly eleven-year pattern, which is now called the solar cycle. The first one that was systematically counted was named Cycle 1. Currently Cycle 24 is just underway. In addition to the eleven-year changes from maximum to minimum sunspot numbers there have been systematic changes in the highest sunspot counts at the maximum, and even in the occurrence of the cycles themselves. A multi-decade period of low or no sunspots is called a grand minimum.

This decadal-scale to century-scale solar (sunspot) variability is associated with, and is partly responsible for, variation in the Earth's surface temperatures. What has been learned only recently is that sunspots themselves reduce the amount of energy emitted by the sun (solar irradiance). However, the occurrence of sunspots is more than compensated for by the simultaneous development of bright regions on the Sun called faculae, which increase solar irradiance. The net result is that more energy is directed toward the Earth during times that can be characterized by greater sunspot activity. As the time between successive solar cycles decreases and solar activity (reflected by sunspot number) increases, the Earth's temperature increases. Exactly how much influence solar variability has on global temperatures is debated. Although a few climatologists argue that solar variability accounts for a significant part of recent global warming and cooling, the consensus of the scientific community is that solar variability has been responsible for only a minority share of Earth's temperature increase over the past century.

In general, the direct change in solar irradiance between the solar sunspot maximum and minimum is too modest

Low sun angle at midnight, looking north across Birch Lake along the Richardson Highway in northern Alaska, June 24, 2010. Unique characteristics of the far north, such as long summer day length, permafrost, and limited numbers of species, and specific characteristics of boreal Alaska such as a semi-arid climate and unique genetic diversity from glacial refugia, require specialized and local knowledge to evaluate the effects of climate warming. Photo taken by Glenn Juday.

to directly produce all of the change in Earth surface temperatures that occurs during the course of the solar cycle. However, if some mechanism, such as increased admission of energy through the atmosphere, amplifies the slight energy boost of a solar maximum then a notable temperature effect of solar variability is plausible. In one study, the upward trend of total solar irradiance as measured by the ACRIM satellite is estimated to have contributed between 10 and 30 percent of the global surface temperature increase during the period 1980–2002.

In the longer term context, for the past century the general trend of solar variability has been toward a temperature-increasing influence. According to indirect (proxy) measurements or reconstructions of past solar activity based on isotope changes in the atmosphere during solar maxima, the sun has been much more active in the last sixty years than at any time over the last several millennia. Sunspot numbers averaged about 29 (s.d. 16) at solar maximum over the last 8,000 years. But the average number of sunspots at solar maximum since 1940 has been 75, which is over 2.5 standard deviations above the long-term average. The highest solar sunspot count of the past century occurred in 1957, which ironically was the International Geophysical Year that saw the first international scientific campaign to measure such phenomena.

It's clearly not the only factor, but there is an intriguing coincidence between solar activity, high latitude temperatures, and forest effects. At the time of the strong 1957 solar maximum, Alaska and other high latitude northern hemisphere locations experienced a very warm summer, and the most severe drought of the twentieth century. In 1957 Alaska experienced the greatest area burned (2.02 million ha) for the following half-century, exceeded only in 2004. The warm and dry weather conditions in Alaska in 1957–58 produced a distinctive marker ring series across most tree species and site types because of reduced ring width caused by warm temperature-induced drought stress. The warm weather in 1957 and 1958 also stimulated one of the largest white spruce cone crops (seeds released in 1958) of the previous several decades. In the boreal forest of Alaska most of the white spruce between twenty-five to sixty-five years old encountered today actually date from the 1958 cone crop. Similarly, solar peaks of the 1980s and 1990s were generally associated with high summer temperatures in interior Alaska, increased wildland fire, and high drought stress in trees. Solar minima generally were also associated in time with cooler temperatures, better tree growth on dry sites, and low total area burned.

Solar Cycle 23 appears to have ended in December 2008, but a prolonged lull in solar activity (August 2008 was first month in the previous century with no sunspots at all) made defining the end of Cycle 23 somewhat challenging. The solar maximum for Cycle 24 is now forecast to occur in 2013 and reach only a modest maximum sunspot number compared to recent decades. As long as this weak solar activity persists, the Earth, and especially the far north, is likely to experience a weaker warming influence than occurred in the solar cycles typical of the past century. It is conceivable that a grand minimum could occur in the future, which would represent a long-term cooling influence. The last series of grand minima coincided with the Little Ice Age, an irregular period that caused a series of global cooling issues for humans and the ecosystems that support them. But solar activity is not the only process causing temperature variability. And even the strongest cooling influence of solar variability can be counteracted or overcome by other factors affecting Earth's temperature.

Author (Glenn Juday) with Japanese exchange student Miho Morimoto from Hokkaido University in northern Japan, Quartz Lake vicinity, near Delta Junction, Alaska, July 2010. Cores extracted from the drill-like corer provide a record of the tree's growth performance based on ring-width and the physical and chemical properties of the wood. This tree is about a century old, and registers increasingly unfavorable climate conditions in recent decades. Photo by David Klein.

The ocean and atmosphere: keeping in circulation

The Earth is so much hotter near the equator than in the polar regions that air and water are set in motion, in the form of weather and ocean current systems, to even out the temperature imbalance. The chronic movement of air masses in weather systems along the same routes drags along the surface of the ocean and eventually steers the major ocean currents along well-defined pathways. Because of the rotation of the Earth, warm rising air masses spin around a predominant weather pattern.

General atmospheric circulation, including the path of the storm systems, in both Northern and Southern hemispheres takes the form of ring-like modes or patterns of variability that circle around the poles. These modes oscillate between high "index" and low "index" conditions. High "index" conditions of air mass motion are marked by below-average barometric pressure over the polar cap regions, above-normal pressure in mid-latitudes, and by enhanced westerly air motion in the subpolar (55 degrees latitude) regions. Low "index" conditions have the opposite departures from mean conditions. A name is typically applied for the location of the oscillation. In the US, the north polar oscillation is often referred to as the Arctic Oscillation (AO), whereas in Europe the phenomenon or its extension over the North Atlantic Ocean is usually called the North Atlantic Oscillation (NAO). The fluctuations in the modes of ocean and atmospheric circulation occur on time scales ranging from a week to decades.

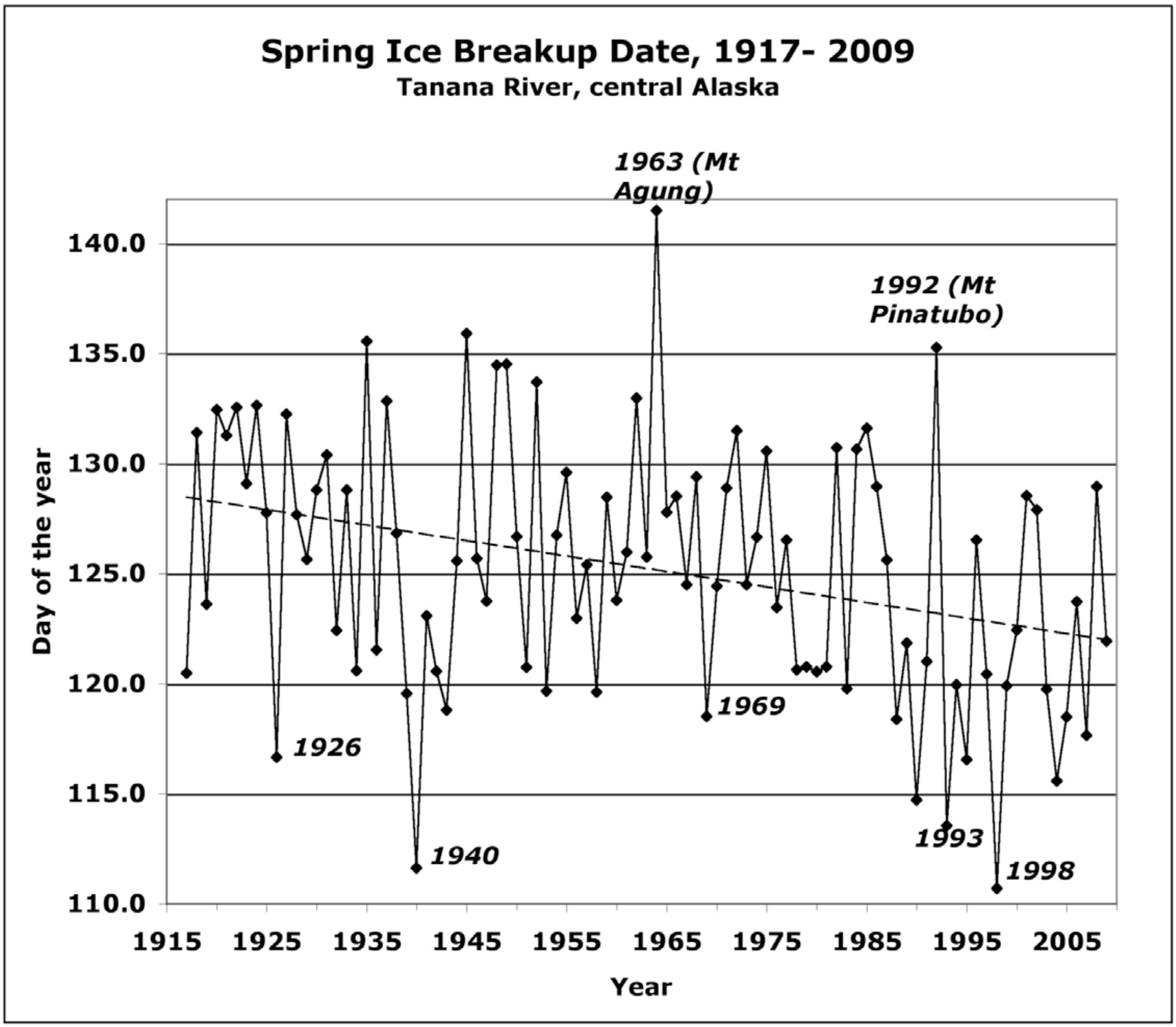
The vast Pacific Ocean Basin south of Alaska is one of the dominant surface features of the Earth, and the two alternate modes of Pacific Ocean and atmosphere circulation variability have an influence on much of the planet's weather. "El Niño" (Actually El Niño/Southern Oscillation or ENSO) refers to a persistent Pacific Ocean circulation pattern in which the tropical trade winds weaken and become warmer, and warm water replaces cold upwelling water in the eastern equatorial Pacific. Nearly all of Alaska is distinctly warmer for the six to eighteen months of a typical ENSO, because the location and movement of prevailing weather systems more effectively scoop up air from latitudes near Hawaii and direct it north to Alaska.

The opposite mode of an ENSO is a "La Niña" event. During the La Niña pattern, the trade winds become stronger, and cold, nutrient-rich water upwells along much of the eastern tropical Pacific Ocean. Alaska is colder than average during "La Niña" conditions because a persistent high-pressure system northeast of Alaska allows cold polar air to flow from the northeast to the southwest over much of the state. La Niñas tend to closely follow El Niños in the ocean/climate cycles. Circulations that do not match the extreme patterns of El Niño or La Niña are termed "Niño neutral" and represent a majority of years.

Of the oscillation modes, boreal Alaska is most strongly affected by the ENSO, but with a definite influence of the AO detectable. Essentially, as one moves farther south in the state (closer to the Pacific Ocean) there is an increasing ENSO signal, and as one moves from the center of the state toward the Arctic coast there is an increasing AO signal.

Although the year-to-year change in the total area burned in Alaska that is explained by the El Niño condition is relatively small (~16%), many of the largest forest fire years in Alaska are strong El Niño years. Growth of most trees on moisture-limited sites in interior Alaska is directly tied to the alternating ENSO conditions in the same way that weather and climate changes are produced by solar variability. In the Interior, highest rates of growth occur during the cool/moist ENSO regime (La Niña), and lowest rates of growth during the ENSO period (El Niño) that produces hot/dry conditions. Trees in the cooler, moister parts of western Alaska, which is influenced by the Bering Sea, grow most in warm years and

Figure 1. Time of spring ice breakup on the Tanana River at Nenana, Alaska. Years with high values represent late spring breakup (cold) and years with low values represent early breakup (warm). The highlighted years are single-year anomalies associated with short-term volcanic cooling (1963, 1992—above the line), or strong El Niño warming (1926, 1940, 1969, 1993, 1998—below the line) influences. The overall trend of the data, indicated by a least squares regression fit (dashed line), is downward toward earlier breakups, consistent with a long-term warming trend. Most other natural systems in Alaska with a long-term record show the same general trend.



least in the cool years. Because these patterns are so strongly expressed in the trees, climate reconstruction can be developed from tree-rings for the period before instrument-based measurements of temperature. The reconstructions show that reversals of the Pacific climate state from the "warm" North American phase to the "cold" North American phase have occurred throughout the last four centuries on the scale of every few decades, although the size and location of the area affected varied somewhat.

The strongest El Niño measured up to that time occurred in 1983, but was then surpassed by the 1997–98 El Niño. The exceptionally strong El Niño of the late 1990s was in turn followed by an exceptionally strong and prolonged La Niña. These events produced pronounced effects on Alaska weather and forest conditions. The earliest spring breakup of river ice in the 90-year series on the Tanana River took place in 1998 under the influence of the record strong El Niño (Figure 1). The strong 1999–2002 La Niña cool period provided relief from warm season drought stress, and represented the most climatically favorable period for tree ring growth of upland white spruce since before the 1976–77 climate regime shift. In fact, this series of years with cool weather may even have prevented tree death from cumulative effects of heat and drought on some particularly sensitive sites.

During the last few decades of the twentieth century, "warm" ENSO conditions with respect to the influence on Alaska weather were frequent, strong, and persistent. A return to the alternate, cooler mode of influence occurred from 1999–2002, followed by more record warmth. Certainly the extended cool weather of 2008 in coastal Alaska was consistent with the strong cold mode of atmosphere/ocean circulation. But at the same time that this cold Pacific influence was happening, the Arctic Ocean was setting records for minimum ice extent. What, then, is the outlook for the ocean/atmosphere contributor to climate variability and forest conditions?

ENSO is essentially a large-scale mechanism for dissipation of excess heat in the Pacific Basin. The warming influence of increasing greenhouse gas concentrations continues to retain more energy in the Earth climate system. If there is more heat retained in the climate system, then there is more heat to transfer, and stronger and more prolonged El Niño events (followed by strong La Niña events), in contrast to "Niño neutral" years, would logically follow. So, by this logic, decadal-scale variability of ENSO, AO, and NAO is likely to be superimposed on a longer-term century-scale warming.

Still, the uptake, storage, and movement of heat around the planet by the world ocean is not fully understood yet, especially as it relates to events that happen or shift between alternate modes so infrequently that modern science has not yet been in existence long enough to observe them. Abrupt changes from mode shifts appear to be more likely, and there is a real potential for climate surprises from this form of variability.

Blowing your top: volcanic effects

Volcanic eruptions that are rich in sulfur aerosol compounds and powerful enough to inject material into the upper atmosphere (a small minority of all eruptions) cause a brief one- to three-year global cooling influence. The sulfur aerosols cool the Earth's surface by causing the atmosphere to reflect more solar radiation, including reflection back into space before it can enter the Earth climate system. The cooling can be strong, but is short-term.

Following this particular kind of eruption, the new volcanic aerosol components of the upper atmosphere absorb some solar radiant energy as well as some of the extra, reflected energy from the Earth's surface. As a result of these gains in radiant energy, the stratosphere is gradually heated, while the atmosphere near the surface experiences a more immediate cooling. When the eruption is in the tropics, this slower, upper atmospheric heating is greater near the equator than in the high latitudes, producing a stronger heat imbalance from the equator to the polar regions, especially in winter. During the Northern Hemisphere winter this enhanced temperature/energy gradient strengthens the jet stream, producing winter warming of Northern Hemisphere continents by heat transport from the south following the quicker post-eruption cooling of the atmosphere near the Earth's surface.

The short, acute cooling influences of major volcanic eruptions during the warm-season have left distinctive patterns in Alaska and global tree-ring series. These patterns, which vary by region, are still being studied. One of the most distinctive and informative volcanic events in Alaska is indicated by the tree ring formed in 1783, the year of a particularly sulfate-rich eruption at the Laki volcanic field in Iceland. The first generation of Alaska tree-ring investigators noticed some unusual properties of the 1783 ring and suggested a connection to a cold temperature anomaly. A successive generation of investigators took up the challenge and made a tentative connection between volcanic eruption, global-scale cooling, and tree-ring growth. A recent synthesis with access to sophisticated geophysical, climatic, and tree-ring data provides an example of the profound effects volcanic events can produce.

Long-term tree ring records indicate that 1783 was the coldest summer in over 400 years in northwestern Alaska. European explorers in coastal northwest Alaska reported famine and population decrease of Alaska native people sometime between 1779 and 1791. Early and contemporary anthropological studies indicate possible famine in nearby areas at around the same time. Inuit oral history describes extreme cold in summer causing famine and death a few centuries ago in northwest Alaska. The oral history and tree ring evidence indicate that in much of northern Alaska,

Spruce grouse in an area burned by the 1983 Rosie Creek Fire in the Experimental Forest unit of Bonanza Creek Long Term Ecological Research site, southwest of Fairbanks, Alaska, October 2009. Major changes in the Alaska boreal forest of the past few decades, such as large areas of fire and insect-killed trees and the regeneration of new forest, confront wildlife species with challenges and opportunities that in turn shape the forest and provide ecosystem services for people in a constantly shifting scene. Photo by David Spencer.

summer in 1783 was terminated by snow and freezing conditions in late June, which persisted until the next year.

One of the major volcanic cooling events of the twentieth century was the Mount Pinatubo eruption of June 1991 in the Philippines. The Mount Pinatubo eruption reduced global mean air temperatures by mid-1992 up to 0.5°C at the surface and 0.6°C in the troposphere. Effects persisted for several months and were followed by above-average warmth in 1993 as would be expected from a tropical eruption. In Alaska the 1992 cooling effect was severe. The 1992 snow-free season in central Alaska was from May 20 to September 12, the shortest of the century. The early snowfall clumped on deciduous trees in fully leafed-out condition, and weighted the trees so heavily that many bent or snapped. Even white spruce that survived were severely weakened from stem breakage and became infestation centers for engraver beetles (Ips) that killed many trees. The strong early growth season warming in boreal Alaska in 1993 produced very favorable conditions for a spruce budworm outbreak that year.

Enhanced levels of volcanic activity in the second half of the twentieth century, according to well calibrated and verified climate models, have contributed a net cooling effect that masked the magnitude of other warming influences, including greenhouse gases. If volcanic activity falls back to a lower level, the next several decades would experience an additional warming influence (less cooling) compared to the previous several decades. Volcanic activity capable of causing a one- to three-year cooling effect on Earth is highly irregular and not currently predictable. A strong eruption is a low probability but would be a high forest-impact event in Alaska over the next decades, while a lack of eruptions would allow greater climate influence of the other forcing influences.

Below: Budworm damage to a white spruce seedling, Chena Ridge Road area southwest of Fairbanks, June 2006. Spruce budworm outbreaks in central Alaska occur after summers with optimum distribution of high temperature anomalies at critical stages in the insect's life cycle. Populations of budworm at the outbreak level were not known in central Alaska until extreme warmth of the post-1976 period, when a sudden climate regime shift produced suitable temperatures. Sustained outbreak level populations of budworm kill large amounts of white spruce in Canada. Photo by Paul Renchen.

It's a gas: greenhouse gas sources and sinks

Greenhouse gases absorb some of the energy escaping from the Earth's surface and atmosphere and re-radiate it back down to the near-surface. They act in a way similar to a blanket—they don't add heat themselves, but slow the escape of heat energy that is already present. As a result, one characteristic of a greenhouse-caused warming is that cold temperature increases (winter temperatures, daily low temperatures) are stronger and often steadier than increases in the upper range of temperatures. Several features of recent Alaska warming, including disproportionate winter warming and nighttime warming, are completely consistent with a predominantly radiative forcing—greenhouse gas type of warming.

In the last several decades the Earth has warmed beyond the level associated with the combination of long-term solar influence, volcanic influence, and periodic ocean-atmosphere circulation changes. There is no big mystery as to why. While there is a need for even greater precision, and there are always a few surprises in any process of scientific study, no unknown factor is required to explain surplus warming of recent decades. The extra warming matches well with standard calculations of the warming influence of increased concentrations of greenhouse gases in the atmosphere. Aside from water vapor, the two most important greenhouse gases are carbon dioxide and methane. The increase in atmospheric greenhouse gases has been directly measured for about half a century, and even the annual increases are accurately measured.

Increasing greenhouse gas concentrations in the atmosphere come about both directly and indirectly. Direct causes include human additions of these gases to the atmosphere from fossil fuel combustion, newly invented industrial compounds that produce a greenhouse effect, cement production, and petroleum production. Geologic carbon dioxide is also naturally vented from volcanoes. Indirect causes increasing greenhouse gases are mainly destruction of vegetation that decreases plant uptake and storage of carbon dioxide, allowing more to stay in the atmosphere, and human alteration of the methane production and uptake.

The annual net movement of carbon from atmospheric carbon dioxide into plant carbon is called the terrestrial carbon sink, and a similar sink exists in the oceans. The terrestrial sink stores an amount of carbon equivalent to 15 to 30 percent of annual global emissions from fossil fuel combustion and industrial activities. In other words, without the uptake and storage of carbon dioxide by land vegetation, the increase of greenhouse gases would be happening even more rapidly and reach higher levels.

From 1981 to 1999, different forest regions of the world contributed the major influence on the terrestrial carbon sink, both positively and negatively. Biomass carbon gains (removal of carbon from the atmosphere) occurred in the Eurasian boreal and temperate regions and in North American temperate forests. This terrestrial carbon uptake was a result of new forests growing on sites that previously had been cleared and were now rebuilding carbon storage. By contrast, losses of stored carbon to the atmosphere and less uptake of carbon in tree growth occurred in some parts of the Canadian boreal forest and in the Alaska boreal forests. In those areas reduced carbon uptake was a response to accelerated disturbance by wildland fire and insects, which increased tree death, and also from hotter and drier conditions less favorable for tree growth. Increased forest disturbances such as fire and insect-caused tree death can also promote speeded up decomposition (by soil warming) of carbon in stored in soils, and its release as greenhouse gases.

Finally, current human use and management of the boreal forest have been affected by the carbon balance as well. Tree harvest and the manufacture of wood products that are kept from decomposition on a long-term basis can represent a net movement of carbon from the atmosphere into storage. However, this effect is almost always overcome by forest management systems of repeated short cycles of tree growth and cutting that often accompanies commercial forest management. Under such multiple short rotations, less carbon stays in storage (in both wood and soil organic matter) than in a forest growing undisturbed for the equivalent time.

Active suppression of forest fires can sustain more carbon in storage, at least on a short or medium-term basis, than would otherwise be the case. Replacing forests with almost any other land cover reduces carbon dioxide uptake and storage, and reforesting bare land increases net uptake and storage. Overall this suggests that northern ecosystem management could be a significant contributor to future management of the carbon cycle.

On the record: climate trends in Alaska

Instrument-measured weather data in central Alaska start in 1904 with what became the Weather Service's University Experiment Station (UES). Continuous records at the UES station were begun in 1906 and continued as a function of the USDA Agricultural Experiment Station, which subsequently became the University of Alaska Agricultural and Forestry Experiment Station in the 1930s. Early Fairbanks weather data also come from downtown locations and the airstrip at Weeks Field. Since 1948, weather data have been collected at a "First Order" National Weather Service station at Fairbanks International Airport. Some urban heat island effect is present in the first order Fairbanks record, but it can be controlled by reference to long-term overlap with stations in rural Alaska, most of which also begin in the 1942–1950 period. A reconstructed record is possible from 1917 in Anchorage, 1921 at Denali National Park and Talkeetna in inland Southcentral Alaska.

These available longer term temperature records tell a consistent story. Across most of Alaska the greatest magnitude of the warming seasonally has been in the winter, but temperatures during the ecologically important spring and summer have increased as well. In central Alaska locations including Fairbanks, autumn temperatures have actually decreased slightly in recent decades. The reason for autumn cooling is not completely clear, but it is related to differences in the number of strong storms that pull warmth northward between the early and later period of the record.

In the highly continental climate region of central Alaska the mean of daily high temperatures during the warm-season increased only very slightly during the twentieth century, but the mean of daily low temperatures increased by more than 3°C. One result is a considerable increase in growing season length in central Alaska, which while still highly variable, now averages 120 days at many stations. The concentration

Table 1. List of five atmosphere-ocean general circulation models (GCMs) that were used to generate climate scenarios of the twenty-first century for the *Arctic Climate Impact Assessment*.

GCM acronym	Lead development institution
1. CGCM2	Canadian Centre for Climate Modelling and Analysis (Canada)
2. CSM_1.4	National Center for Atmospheric Research (USA)
3. ECHAM4/ OPYC3	Max Planck Institute for Meterology (Germany)
4. GFDL-R30_c	Geophysical Fluid Dynamics Laboratory (USA)
5. HadCM3	Hadley Centre for Climatic Prediction and Research (UK)

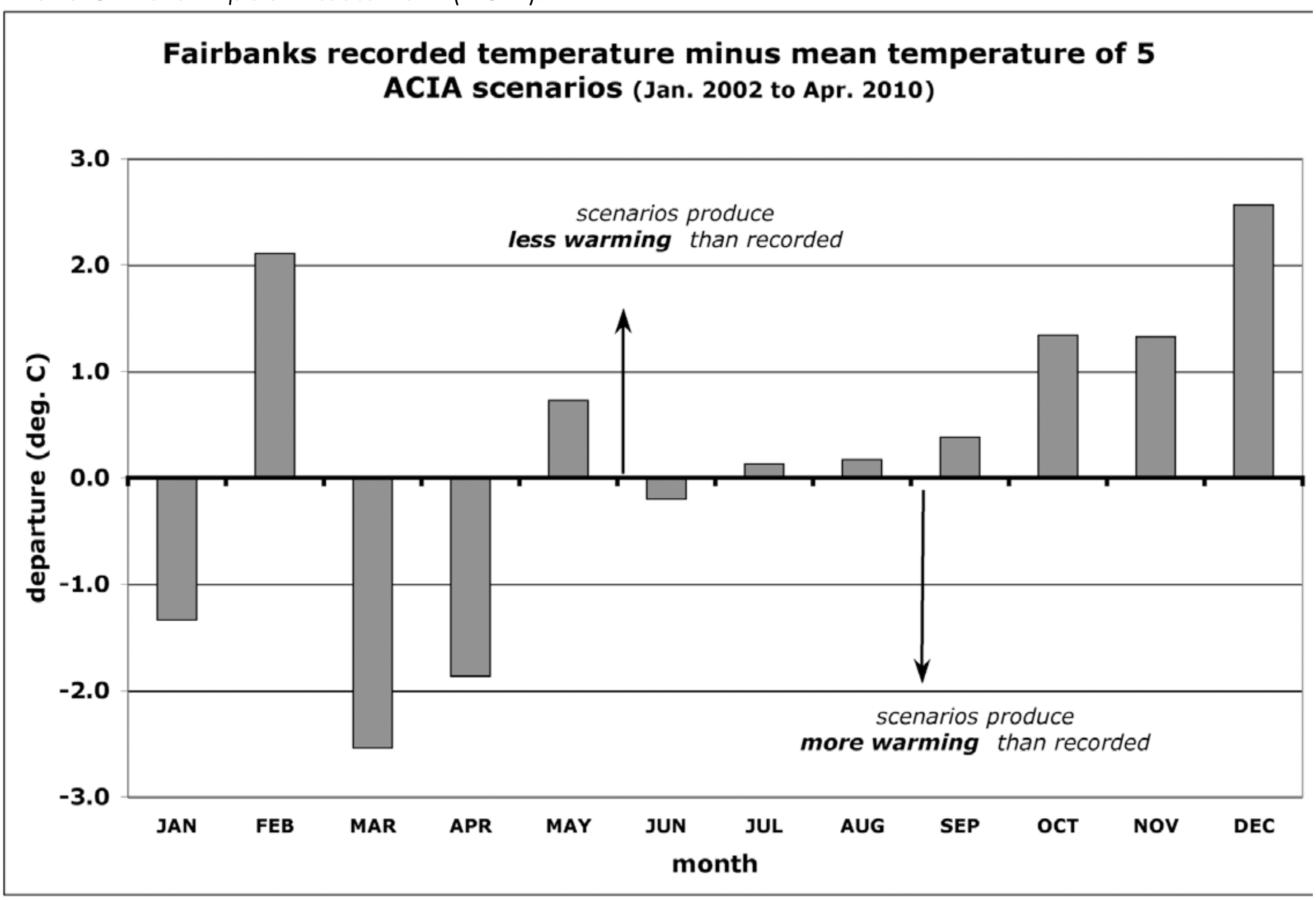
See: Kattsov, V.M., and Kallen, E. 2005. Future Climate Change: Modeling and Scenarios for the Arctic, Chapter 4, pp 99-150, In: *Arctic Climate Impact Assessment.* Arctic Council. Cambridge University Press. ISBN 978-0-521-86509-8.

of warming in the daily temperature minima is consistent with a process operating to dampen heat loss (greenhouse gases) rather than amplify energy input (e.g. increased solar luminosity).

Records of direct precipitation over the last 50 to 100 years do not show the same strong trend as temperature. In some Alaska regions precipitation increased (along portions of the southern coast), but the North Slope, Interior Alaska, and the Kenai Peninsula did not experience noticeable increase in precipitation. Across much of central and Interior Alaska, annual total precipitation is quite low. Precipitation in the 100-year Fairbanks climate record is about 280 mm/year. White spruce trees do not naturally occur in North America when annual precipitation is lower than the Fairbanks average.

Some of these Alaska climatic trends are synergistic in their effects. For example, as temperatures increased, snowmelt occurred earlier in the spring, which ended the

Figure 2. Comparison of Global Climate Circulation Model scenario-generated temperatures for the grid cell containing Fairbanks, Alaska compared to temperatures actually recorded during the 100-month period from January 2002 through April 2010. Overall, the scenarios generated realistic temperatures compared to the record, with a slight tendency for recorded data to be warmer (0.23 degrees C) than projected by the scenarios. Comparison is with the mean of the five climate scenarios used in the *Arctic Climate Impact Assessment* (ACIA).



period of snowpack accumulation and lengthened the period of evaporation of liquid moisture. As a result, despite steady levels of precipitation, plants experienced greater evapotranspiration demand under this type of climate change. Given the marginal supply of effective moisture for tree growth across much of lowland central Alaska, the result has been very strong, sustained, and widespread moisture stress in most of the Alaska boreal forest.

Summing it all up: how good are scenarios?

Scientists construct quantitative interactive models of the climate system based on the known factors that affect climate. Although there is always room for improvement, and what is unknown is obviously not in these models, still they can be useful tools of analysis. Strictly speaking, climate scenario models can't be used for prediction, for the simple reason that the outcomes are affected more by assumptions—such as what will world fossil fuel use be in 10, 20, or 30 years?—than by precision of available estimates of the main variables. Just change the assumptions about the future in the scenario, and you get a different outcome. However, the models can be used to calculate reasonably well a climate outcome that would occur if the controlling variables were to actually follow a defined path of change from the present (and, of course, if all the major controlling factors are set correctly). These scenarios of change are really stories of plausible outcomes *if* change were to follow a defined script. If the assumptions in the script are plausible, then the outcomes are plausible too.

Current mathematical representations of the Earth's climate are also limited in their spatial resolution. The number of calculations that must be done to represent the weather at a particular place on the surface of the planet is very large. The whole planet must be represented to make the model interactive, and the scenarios must go through a "spin-up" phase to see that they produce realistic output compared to recorded data. Finally, Global Circulation Models (GCMs) calculate results for many years into the future. The amount of time needed for the task could become too great to get done in a reasonable time period.

The main way to keep the number of calculations low enough even to be feasible is to reduce the number of blocks or grid cells that represent the surface of the Earth. Even so, the largest, fastest supercomputers churn away for days and weeks to produce the answers for the whole planet. As a result, the product or output that the current generation of GCM scenarios produces is a crude representation of averaged and homogenized large blocks of the Earth's surface, not the subtle and diverse place we actually live in. On the other hand such models do represent reasonably well global-scale changes, such as the change of seasons, the climate of the recent past as they go through their spin-up operation, and even the cooling effects of a volcanic eruption such as Mt. Pinatubo. But it is well understood that as you examine smaller intervals of time and more and more restricted parts of the Earth, scenarios are more likely to depart from the actual course of events. Are the GCMs reliable in their calculations about likely futures, especially at the local level rather than the entire globe? There is a good test case available.

One of the major synthesis studies and analyses of scenarios for a specific region of the Earth (rather than a more generalized global analysis) was the *Arctic Climate Impact Assessment* (ACIA). The ACIA Scientific Document was released in 2005. It used mid-range projections of human population increase, fossil fuel use, land cover change, etc. Special computer runs of five leading GCMs were spun up for the period 1900 to 2001, and then the scenario projections for 2001 to the year 2099 were used as a basis of analysis. A large team of authors was asked to assess what the Arctic region would be like if climate were to change over the next century in the way the scenarios calculated. The ACIA was an analysis based on the specified assumptions, not strictly a prediction, but we can now compare the first decade of GCM climate scenario output in ACIA to actual recorded data to see how realistic the scenarios were.

Figure 2 shows the recorded monthly temperature averages for Fairbanks during the period January 2002 (date at which ACIA analysis began) through April 2010 versus the mean temperature of the five ACIA-designated scenarios (for the full report see: www.acia.uaf.edu/pages/scientific.html). Overall, the combined five-scenario mean annual temperature was only 0.23 degrees C below the recorded mean temperature at Fairbanks during the period. The scenarios produced temperatures notably close to those recorded at Fairbanks during the summer months, especially June through September. The scenarios generally produced less than the recorded warming in the first part of winter, and greater than recorded warming in the second part of winter (Figure 2).

What does this comparison of the scenarios with the record tell us? At the least, even when focusing on a single grid cell for only a few years, we can see that effects that were examined in the ACIA analysis were realistic in the near term. Overall the scenarios were a reasonably good representation of what happened, or even a bit conservative in projecting temperature increases. So, the case on behalf of the effects that were projected for the future in the ACIA analysis appears to be strengthened.

Is global warming real?

Yes, the Earth has been warming. The far north, and Alaska in particular, have been on the leading edge of the evolving change in the climate system. Forests in Alaska are both subjects and actors in the processes of change. The explanation for the vast majority of change in the climate can be found in the four main influences that affect temperatures in the short and medium term: solar variability, ocean-atmosphere circulation, certain volcanic eruptions, and changes in greenhouse gases in the atmosphere. There are very important questions about the rate at which heat storage and release from the oceans affect the rate of atmosphere warming and the possible cooling effect if cloud cover were to increase, but in general no large amount of Earth's temperature variability remains to be explained by an unknown factor.

In any process of scientific study, standard procedure is to reduce the number of variables that may affect the outcome, ideally down to one that is tested as the most likely cause. The results obtained from this way of conducting investigations allow the highest confidence that the explanation offered actually caused the result. However, this technique of doing good investigations should not be confused with the way something as complex as the Earth's climate system actually functions. In reality, the various influences on temperature are not in competition with one another. Explaining temperature changes is not a case of either/or, such as solar variability versus greenhouse gases, but rather both/and. All the factors that influence temperatures—how warm or cold the Earth is at a given time—all happen at the same time to produce the result.

One useful way to think of it is that increasing greenhouse gases—the effect that people have control over—will make the Earth climate system warmer than it otherwise would have been. Unless there is a strong net cooling direction to the other three temperature-affecting influences, the Earth as a whole will warm as atmospheric greenhouse gases increase. In a few cases, the altered way that the global climate system operates at an overall warmer level will result in a net cooling in restricted geographic locations. That is no surprise, and has happened many times before.

Natural cycles and irregular years of extra warmth or cold are likely to continue in the future as they have in the past. But if strong increases of greenhouse gases in the atmosphere continue, the Earth climate system will retain more heat, causing an upward trend in temperatures, other factors remaing roughly equal. In fact, the climate system has not fully adjusted yet to the recent increases in greenhouse gases, so decades of warming influence are ahead of us. If solar sunspots do not cease, and cooling volcanic eruptions occur at long-term numbers, then the upward warming influence of greenhouse gases, superimposed on underlying cycles and events caused by other temperature –affecting factors, would produce a pattern of stairstep increases in average temperatures. Cool years would still occur, but would just not be as cold as previously. Warm years would be more frequent, more sustained, and occasionally more severe.

Humans are intensely social creatures, and it is sometimes a struggle for us to separate political/civic values from established empirical fact and scientific uncertainty. All of these realms of knowledge are legitimate parts of the climate change issue. But each element should be respected for what it is. The fact that temperatures have increased, and greenhouse gas increases are nearly certain to increase temperatures further (given likely assumptions about the future), are not reasons either to adopt unwise public policy measures or to avoid adopting needed public policies.

We happen to live in a changing world and to have recently assembled the capability to understand the likely near-term direction of climate change under specified circumstances. As hard as it was to gain that understanding, the real challenge ahead is to gain the wisdom to deal with it in the most constructive way.

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OneTree in Alaska

reflecting the heart of communities from woods to classroom

Nancy Tarnai

Above: sign at the Week in the Woods. Photo by Rachel Kaplan. Below: budburst experiment as a demonstration in a teacher workshop. Photo by Nancy Tarnai.

With the cutting of a single birch tree in July 2009 a new community outreach and research project named OneTree was launched in the Tanana Valley. Since then the tree has branched out to school children, teachers, graduate students, foresters, artists, craftsman, and carvers.

The UAF Forest Products Program is coordinating this collaboration that explores art and science through connections to a single tree. OneTree is based on a project by the same name that got its start in 1998, when one large oak was felled in the National Trust estate of Tatton Park in Cheshire, England. OneTree aims to show the unique value of woodlands by demonstrating the volume and quality of work that can be made from one tree. By focusing on a common goal—full utilization of a single tree—OneTree unleashes the breadth of creativity in its participants.

The prototype was developed in Fairbanks in cooperation with Week in the Woods, a family camp offered in the Tanana Valley State Forest. Elders, students, wood turners, birch bark artists, biologists, loggers, millers, and community members interested in working in new ways with trees and each other attended the camp. Possibilities include making tar, weaving a birch bark basket, riving green wood, or documenting a tree for different types of studies.

On July 6, 2009, OneTree and Week in the Woods participants harvested a birch tree near the campsite. The tree was divided into portions for three different groups, including Week in the Woods campers, OneTree artisans, and teachers who were allocated materials for their classrooms.

"The sky's the limit on what happens and it depends on who steps forward to participate," said OneTree coordinator Jan Dawe, an adjunct forestry professor at

UAF's School of Natural Resources and Agricultural Sciences, at the outset of the program. "Whether you're intrigued by the biology of birch trees or wonder how climate shift may be affecting the forest, whether you want to follow an inspiration to paint or write a poem while sitting under a tree or around the campfire, whether you make museum-quality pieces or are just getting started on woodworking or birch bark projects, OneTree wants you."

Since Dawe issued that call over a year ago, hundreds of people have responded, young and old, artistic or scientific, or both—all have been touched by the OneTree pull.

"It's not just arts and crafts," Dawe said. "It's a way for people to think about our forest resources." Assistant Professor Valerie Barber, director of the UAF Wood Utilization Research program, examined the properties of the original birch in great detail. She and Dawe documented every part of the tree that was distributed to volunteers and prepared a map showing where each piece went.

Forestry Professor Glenn Juday conducted tree ring analysis of sixteen birch trees in the area where the original tree was cut and found that six trees in the healthy stand pre-dated the Civil War.

Seeds have been exchanged, with researchers and students experimenting with how trees grow in different areas of the state. "Different genotypes of the same species will be brought together and grown in the same location; it's the basis of a common garden," Dawe said.

"Whenever a OneTree project is done its power is its ability to reflect a community's distinct focus," Dawe said. "The English OneTree project reflects that country's amazing woodworking tradition and the high standard of design exhibited by England's artisans and craftspeople. At North House Craft School in Minnesota, the OneTree project reflects the school's tremendous dedication to teaching and preserving the folk art traditions of their region. What they've accomplished in ten years is astonishing. For us in interior Alaska it seemed that OneTree could reflect the vitality that lies at this community's core. It seemed to be something that could be expressed by bringing artisans, Native culture-bearers, and the university and agency folks into K-12 classrooms."

Sarah Gray, left, a student at Randy Smith Middle School in Fairbanks, showing Jan Dawe her budburst sketch and records. Photo by Nancy Tarnai.

The idea is to build integrated curricula that start with the biology of the plant and then extend that knowledge through art and science projects. This year, more than twenty-five K-12 teachers in Fairbanks are using OneTree projects; fourteen are doing dormancy/release from dormancy experiments by trying to force branches of living trees on their school grounds to leaf out at various times of the winter, seeing how the response of the branches changes over time. In Talkeetna, six classrooms in one school are doing the same kind of study. Young students are learning to closely observe, take notes, and draw. "They'll know male catkins from female and all the stages of winter buds swelling through bud burst," Dawe said. Other activities in the schools have included nature printing, twig art, silk scarf and egg dyeing with birch bark dyes.

The Fairbanks North Star Borough School District art teachers grabbed onto the OneTree project with great gusto, holding an exhibit of their work during the month of August at the Morris Thompson Cultural and Visitors' Center. Once the art teachers determine age-appropriate uses for OneTree projects using wood, twigs, bark, and pollen, they will begin incorporating them into classrooms across the district.

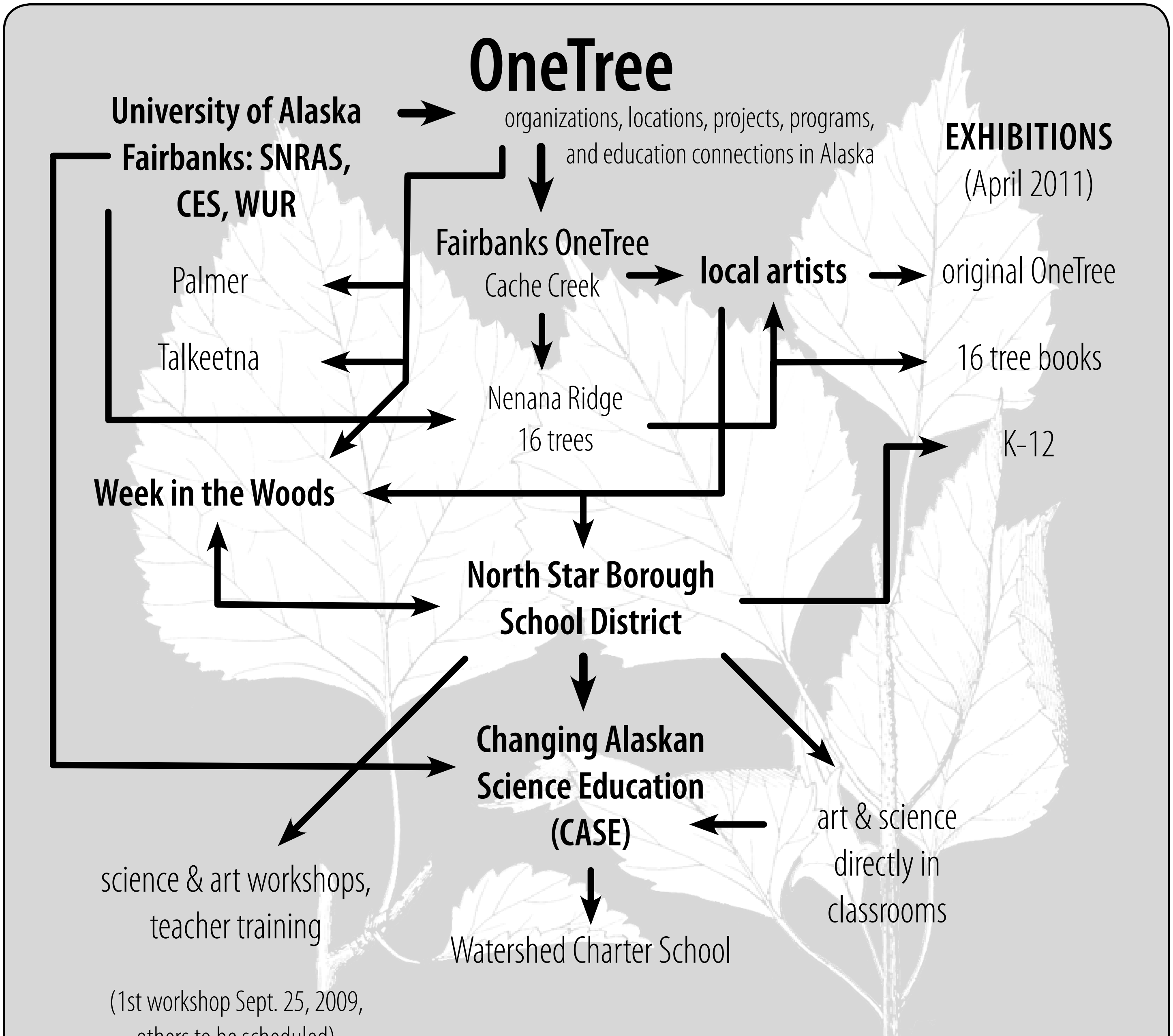
Dawe has conducted numerous workshops for teachers, explaining and demonstrating OneTree. At a November 2009 session, enthusiastic teachers experimented with twig and leaf prints in Dawe's garage. Elementary Art Specialist DeAnn Moore said, "We're surrounded by trees here and it's important to incorporate that into the curriculum. It keeps children active and engaged in the arts, plus the sciences."

The Watershed Charter School has been exuberantly participating in OneTree. "The biggest attraction to the OneTree project is the opportunity to combine art with science," said Watershed second-grade teacher Moira O'Malley. "There is more of an awareness of nature when kids get to feel it, smell it, collect it, and use it in art projects. The idea of OneTree fits in nicely with our Watershed School philosophy, which emphasizes combining science lessons with outdoor explorations and studies directly connected to our community. We are fortunate to have birch trees in the boreal forest next to our school."

OneTree has helped O'Malley's students understand budburst, female and male catkins, and pollen shed. "The knowledge they have gleaned from their birch branch observations has been apparent on our hikes when they get excited about finding catkins or budburst on other trees and they know the correct terminology," O'Malley said.

As well as collecting data from birch branches, O'Malley's students have made paper with birch leaf imprints, leaf prints, and nature wreaths. This year they are making Christmas ornaments with the small birch slices they sanded last year.

In 2010 Dawe was invited to join Changing Alaskan Science Education, or CASE (principal investigators Drs. Richard Boone, Laura Carsten Conner, and Kevin Winker). CASE works by pairing a graduate student Fellow with a K-12 teacher mentor, with the aim of bringing inquiry science into the classroom. CASE Fellow Zach Meyers has joined the OneTree team, and is leading investigations in three classrooms at the Watershed School. There, students are comparing progeny from last year's Nenana Ridge 'onetrees' and studying how seedlings respond to Fairbanks' lengthening growing season (three vs. four vs. five months long).



*birch leaf image (*Betula neoalaskana*) adapted from* **Alaska Trees and Shrubs***, by L.A. Viereck and E.L. Little, Jr.*

Dawe and Meyers are joined by Jesse Hensel, whose MFA in wood sculpture, teaching experience, and familiarity with interior Alaska enable him to help K-12 students extend their science investigations into related art activities, with everything from papermaking to charcoal production on the agenda.

Eventually Dawe and Barber hope to expand OneTree across the state. Barber will be working with homeschoolers in the Palmer area, and a new OneTree was launched recently in Talkeetna. More than twenty teachers from Fairbanks and Talkeetna recently began a series of nine teacher training workshops with OneTree.

Originally OneTree was a project funded through the USDA National Institute of Food and Agriculture Wood Utilization Program (UAF is a part of this); there are fourteen schools throughout the country in the program. The purpose of the Alaska Wood Utilization Program is to conduct research, outreach, and education to further the forest products industry in Alaska and to educate the population about some of Alaska's natural resources. Barber is also part time UAF Cooperative Extension and OneTree fits in nicely with its community outreach and education goals. "OneTree is a great community project that builds awareness of Alaska's tree species and some of the products (non-timber as well as timber) and projects that can be developed," Barber said. A hand-crank dowel maker was purchased by the program and knitting needles are being produced with the eventual hope of raising money to foster and continue the OneTree projects. New funding sources are needed to continue and grow the program.

More OneTree art exhibits by artists, teachers, and students are planned for spring 2011 in Fairbanks. Mixed-media artist Margo Klass is working with teacher Chris Pastro at Randy Smith Middle School to create sixteen books made of and about birch. Those creations will be on display in the spring.

"It's gone totally beyond our expectations," Dawe said. "The students are excited and interested; we couldn't be happier with how this initial project has worked out."

Hensel called OneTree a bridge. "It's hit off a lot of dominoes," he said. "It taps into the needs and aesthetic desires of Fairbanks. The excitement and curiosity are contagious. People are catching on to OneTree. It is growing and spreading in ways we didn't originally intend. That's the mark of a great project."

Links:

Alaska OneTree: www.onetreealaska.org

UK OneTree (the original OneTree): www.fellsidewood.co.uk/onetree/

CASE: www.uaf.edu/cnsm/gk12project/

Jesse Hensel's website: www.jessehensel.com

The Watershed School: www.thewatershedschool.com/

A Week in the Woods: http://weekinthewoods.org/

From left to right: Tom Malone, Jingjing Liang (SNRAS); with Gerry Engle, David Nesheim, and their field crew (Afognak Native Corporation Forestry Department).

Observing the trees: Forest Dynamics and Management

There are few forest management tools available to land owners and resource managers in the northern forests of Alaska compared to other parts of the country. Providing the people of Alaska with scientifically accurate information by monitoring the growth and change of the northern forests is the major purpose of the UAF Program of Forest Dynamics and Management.

The program's principal investigator is Dr. Jingjing Liang, assistant professor of forest management at SNRAS and a forester certified through the Society of American Foresters. Although the program commenced in 2007, its predecessor, the UAF Forest Growth and Yield Program (originally directed by Dr. E.C. Packee, professor emeritus in forest management), had been active since 1983. In addition to charting the growth and health of forests, the Forest Dynamics and Management program identifies forest characteristics and regeneration properties, and provides land managers and owners with information to assist decision-making. The newest projects are to establish a permanent sample plot system on Afognak Island, and to develop forest growth models to assist decision making for the Afognak Native Corporation. Researchers with the program include Dr. Liang, staff member Thomas Malone, two graduate students, and several summer field assistants.

There are many projects included in the program, with the largest establishing and monitoring fixed-sized permanent sample plots located throughout the northern

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Alaska's food (in)security

Deirdre Helfferich and Nancy Tarnai

In the 2006 election in Alaska, only one statewide candidate highlighted food security as an issue of importance on his campaign website. Since then, the issue of food security has filtered into the awareness of Alaskans everywhere—just as it has nationally. In Alaska, this was spurred by the food and heating oil crisis in the Bush in the winter of 2008–2009. The tribulations of being at the very end of the supply chain came home to villages like Emmonak that year, and made international news. Now, local food production is on everybody's mind, from Governor Sean Parnell, who recently signed a bill establishing a Farm-to-School program, to the schoolchildren creating gardens on school property.

The importance of in-state and local food production is not just in the vital arena of eating: the ecological impact of modern industrial agriculture, and particularly in the long-distance costs of shipping food and production supplies to the northernmost state (both externalized monetary costs and those to the environment), is an area of increasing concern to policymakers, researchers, and to the general public. Because there are few or no local suppliers, Alaska farmers must import fertilizer, seed, equipment, glazing, even compost.

> Agriculture and food consumption are important drivers of environmental pressures, especially habitat change, water use, and excessive nutrient runoff. Existing production practices are heavily dependent on fossil fuels and freshwater supplies. Worldwide, agricultural production accounts for 70 percent of the global freshwater production and 38 percent of the total land use.
>
> Along with its ecological impact, agriculture requires substantial energy inputs…[it] uses energy directly as fuel or electricity to operate equipment, heat or cool buildings, and provide lighting on the farm and indirectly in the fertilizers and chemicals produced off the farm. (*CSA News*, "Local Food Systems: Advantages and challenges of growing, buying, and selling locally," by James Giese, August 2010, v. 55 n. 8, p. 4, www.crops.org/publications/csa-news)

The concept of "food miles" is one familiar to Alaskans; while for the Lower 48 the average distance traveled by one's bag of groceries is in the realm of 1,500 miles, the trip to Alaska is often more than twice or three times that.

Many discussions in the news or by public figures describe Alaska as having "only three days' worth of food on store shelves," or "importing 95 percent of its food." Yet, as Carol Lewis, dean of SNRAS and director of the Agricultural & Forestry Experiment Station (AFES), wrote in an opinion piece for the SNRAS Science & News blog, "the truth is we don't really know exactly what that figure is. [We are] conducting a statewide survey to pin that number down. We want to clarify what is being produced in state and who and where the producers are." This basic question, of how much food and what type Alaskans produce, is important to answer if we are to resolve the many nutrition-related and food security issues the state must address.

A preliminary survey of food production in the Fairbanks area is being conducted by SNRAS student Charles Caster for his senior thesis project. Dr. Joshua Greenberg, associate professor of resource economics, will expand this to a statewide survey. Likewise, UAF researchers David Fazzino, Phil Loring (now with the Alaska Center for Climate Assessment & Policy), and Rachel Garcia, a SNRAS graduate student, are researching food production and systems in Alaska. Other surveys or studies on wild game and subsistence foods harvest by the Alaska Department of Natural Resources shed further light on the source, quantity, and type of food produced and consumed (see "The Security of the Red Meat Supply in Alaska," p. 36.). Studies of the effects of climate change on Alaska agriculture and subsistence are also underway. Complementary efforts like these will serve to determine what the food situation actually is: where the state is vulnerable and what its food strengths are. Until this is done, the state's civil servants cannot make fully informed public policy or regulations.

Signs that food issues are coming to the forefront are everywhere in the 49th state. These include the establishment of Slow Food chapters, the rising popularity of community supported agriculture (CSAs) and subscription agriculture in Alaska, the newly founded Alaska Food Policy Council, the growing number of community greenhouses and gardens, the rising attendance each year at the annual Sustainable Agriculture Research & Education Conference and Organic Growers School, community food and health organizations such as the Sitka Local Foods Network, the increase in farmers' markets, educational efforts incorporating agriculture. Here is how a few aspects of the burgeoning food movement are expressing themselves.

Alaska Food Policy Council

Food policy councils are groups that examine how food systems in their purview operate and then make policy recommendations for improving those systems. From Wikipedia:

> …the area of public policy concerning the production, distribution, and consumption of food. It consists of the setting of goals for food production,

processing, marketing, availability, access, utilization and consumption, as well as the processes for achieving these goals. … Food policy comprises the mechanisms by which food-related matters are addressed or administered by governments, by international bodies or networks, or by any public institution or private organization. As a subfield of public policy, food policy covers the entire food chain, from natural resources to production, processing, marketing and retailing, as well as food hygiene, consumption, and nutrition.

The first food policy council in the United States was organized thirty years ago; now there are more than a hundred councils in North America. According to the Food Security Coalition (www.foodsecurity.org),

> "Food policy councils have been successful at educating officials and the public, shaping public policy, improving coordination between existing programs, and starting new programs. Examples include mapping and publicizing local food resources; creating new transit routes to connect underserved areas with full-service grocery stores; persuading government agencies to purchase from local farmers; and organizing community gardens and farmers' markets.… Since they bring together a cross-disciplinary group of stakeholders, Food Policy Councils can help to bridge this gap and identify ways to address interconnected issues and improve the food system."

The Alaska Food Policy Council (http://alaskafoodpolicy.blogspot.com) held its initial meeting in Anchorage in May 2010. Attending the event were representatives from state agencies, food banks, rural villages, educational institutions, agricultural associations, Native groups, rural and urban communities, restaurants, health and nutrition agencies, resellers of food, and many other aspects of Alaska's food system. The meeting focused on three objectives: to develop a clear understanding of the role and activities of a food policy council, to identify food system issues and priorities in the state, and to choose an organizational structure. This was a tall order for the eighty-some attendees, with the first two items largely accomplished but the last still underway. The work started at this meeting is continuing: committees were formed that address governance and communications; education and regulation; food security, hunger, social justice, and health; indigenous traditional and cultural foods; production; and the supply chain: processing, distribution/transportation, infrastructure, development, and planning. The council has also created a working mission statement:

> The Alaska Food Policy Council works to strengthen Alaska's food systems to spur local economic development, increase food security, and improve nutrition and health. The council serves as a resource for information on local and state food systems, and works to identify and propose policy and environmental changes that can improve the production, processing, distribution, health, security and safety of our food.

The council is preparing a document on food systems and the role of food policy in Alaska, and is working on its organizational structure. Committee representatives met on November 4, 2010 to consolidate data about current resources and needs pertaining to food in the state of Alaska, and to lay the groundwork for preparing a strategic plan for the council, and, eventually, for policy recommendations concerning the state's food system.

Slow Food

The Slow Food movement has two chapters in Alaska: Slow Food Anchorage and Slow Food Southeast Alaska (based in Juneau). Slow Food is an organized, international movement that started in Italy in protest of the declining quality and increasing tastelessness of modern food. From the Slow Food USA mission statement:

> Slow Food USA seeks to create dramatic and lasting change in the food system. We reconnect Americans with the people, traditions, plants, animals, fertile soils and waters that produce our food. We work to inspire a transformation in food policy, production practices and market forces so that they ensure equity, sustainability and pleasure in the food we eat.

Elizabeth Dubovsky, president, describes the Slow Food group in Juneau:

> Slow Food Southeast Alaska was started about a year ago by a small group of volunteers who all love and appreciate good, healthy, homemade food. Our official membership is currently over two dozen people, with an e-mail list of close to eighty people throughout southeast Alaska. We also have a Facebook page where we have roughly 220 fans (Slow Food Southeast Alaska).
>
> At our monthly meetings we focus on a different food theme and invite members of the local community to share their knowledge about "slow food," for example, a demonstration on how to make different jams and jellies, or someone coming in to talk about mushroom hunting around southeast Alaska. The goal of these themed meetings is to help connect local consumers with the local, wild foods that we are surrounded with here in southeast Alaska. There's so much wild food available outside our back door and oftentimes we either don't know that it's there or we don't have the knowledge we need to safely and effectively harvest and prepare it.
>
> Other projects that our members hope to pursue over the coming months:

Slow Dinners - Partner with local restaurants to feature local, seasonal foods on their menus.

Community Kitchens - Help connect local cooks/bakers with DEC-certified local community kitchens so that they might be able to cook/bake in a more commercial setting and perhaps pursue their dream to sell food products to local businesses and buyers.

Terra Madre - One of our members has been selected to attend Slow Food's bi-annual Terra Madre conference in Torino, Italy. She will go to the Terra Madre event to represent Slow Food in Alaska and the things that make Alaska cuisine so unique. After her return we hope to do an event where she can share her stories and what she learned from other representatives attending and participating in this unique food conference and celebration.

Community food & health

Traditional and country foods are another important area of food security, for, when talking about food security, it is important to remember that it is not just the quantity of food available that is important, but also the specific foods and their quality. David Fazzino, assistant professor of anthropology at UAF, defines food security as access at all times to sufficient, safe, and nutritious food, including preferred and culturally-appropriate foods. Nutrition-related disease, such as obesity or diabetes, is increasing in Alaska as well as the rest of the nation. Lack of clean fresh water, or poor water sanitation systems, can taint the entire food supply and affect the ability of people to provide their own, safe foods. Communities are increasingly recognizing the connection between good, fresh food and good health. Villages as far-flung as Igiugig and Sitka, Emmonak and Juneau are forming food networks, health consortiums, community gardens or markets—with the express purpose of improving health by encouraging people to eat fresh, local, or traditional foods and to become more physically active in activities like gardening. Alaskans are becoming aware of the interaction of economics, culture, food, water, and health, and village councils, boroughs, and city governments around the state are working to improve the situation.

Many of these community food efforts are part of a larger health and sustainability organization, particularly in southeast and southcentral Alaska. Examples include:

• Sustainable Girdwood: Dedicated to transitioning Girdwood, Alaska, from a consumerist community into a sustainable one, the group is working to establish sustainable energy and sustainable food production infrastructure in the area. *www.sustainablegirdwood.com*

• Sustainable Homer: Dedicated to being a resource for information and programs that can help people make a difference, this group hosts speakers on a variety of topics from peak oil to permaculture and collaborates on forums concerning such topics as energy, conservation, and local foods. *www.sustainablehomer.org/local_food.htm*

• Sustainable Juneau: With the Juneau Commission on Sustainability this group has organized the Juneau Farmers Market, community garden work parties, and other events. www.sustainablejuneau.blogspot.com, *http://juneau.org/sustainability/Sustainability_Commission.php*

• Kenai Resilience: their mission is to gather and celebrate local skills, knowledge and resources toward cultivating a more sustainable community, working on issues such as climate change, scarcity of fossil fuels, and food security. www.alaskafarmlife.com/kenairesilience/wordpress/

• Sitka Local Foods Network: This network is promotes the growing, harvesting and eating of local foods. Initiatives include the Sitka Farmers Market, the Sitka Community Greenhouse and Education Center, expanding local community and family gardens, promoting the responsible and sustainable use of traditional foods, and providing educational opportunities, technical expertise and encouragement to Sitkans wishing to grow their own food. *http://sitkalocalfoodsnetwork.org*

Sometimes these are communities in the abstract, such as a business or institution: for example, the University of Alaska has had an active wellness campaign for the last few years, part of which involves encouraging employees to join a CSA or food subscription service. Anchorage and Kodiak have begun a Veggies at Work program (www.veggiesatwork.org):

> "Veggies at Work" is a program designed to bring fresh, local, nutritious food to those in need. Started in 2006 by Marion Owens in Kodiak, [the program] works with businesses to grow produce to provide fresh options to local food pantries. By gardening in container gardens or raised beds right outside of the business, this program not only provides fresh vegetables to those in need, but it also reduces stress in the workplace, provides landscaping for businesses, and brings awareness of environmental and social issues.

The Cooperative Extension Service and Balance Alaska are expanding the program in Anchorage.

CSAs and subscription agriculture

Both community supported and subscription agriculture enable a farmer to share the burden of the season's up-front costs with customers. In community supported agriculture, customers buy shares of the season's harvest in advance, thus providing the farmer with the capital to purchase seed, fertilizer, or other supplies needed for that season. CSA farms typically build close relationships with their shareholders, educating them about agriculture and food preparation, and often encouraging their members to garden themselves, save seed, and try new foods. Members share in the harvest but also in the vagaries of growing food: if the farmer has a bad season, the members' food dollars will not go as far; likewise, in a good season, the members will benefit from larger shares for the same dollar amount. Members usually pick up their shares at the farm or at a designated pick-up spot, where they interact with other members and with their farmer. Special events, such as farm open houses and member picnics, help to acquaint members with their farm, with fresh food, and with each other. In this way, CSAs help to develop a community around locally grown food. The number of CSAs has been increasing steadily in Alaska over the last decade. There are now approximately twenty-five CSAs in Alaska (not counting school garden CSAs). CSAs operate locally, so shipping distances are drastically reduced, and build community based on both geography and common interest.

Subscription agriculture also assists the farmer in paying for up-front costs, but does not lay as much emphasis on community-building. Boxes of food may be delivered to a given pickup spot, or mailed to far-flung communities or mailboxes. The largest subscription farm operating in Alaska is actually not even in the state: Full Circle Farm is based in Washington, and purchases food from several farms on the West Coast. (Thus, almost all food in a Full Circle Farm subscription is shipped to Alaskans 1,500 miles or more, at minimum, and, because it is air shipped to keep it fresh, has a high carbon footprint, even though the food is certified organically grown. The advantage of a subscription farm is the convenience: a consistent amount of food is delivered to the workplace, pickup spot, or mailbox of the subscriber (usually the size of a subscription's produce boxes do not depend on the season, since the source farm can draw on other farms to fill the boxes), and the subscriber can make a choice about what food they want in that week's box, cancel their subscription at any time, or pick it up again on a seasonal basis.

Glacier Valley Farm, in Palmer, Alaska, functions as a sort of hybrid between these two main types: it offers subscriptions throughout the state and provides produce boxes year-round, relying on farm sources outside Alaska during the winter months, and it functions as a CSA for members in Palmer and Anchorage during the summer.

While subscription services can be beneficial to Alaskans seeking fresh or organic food year-round, they can be deleterious to the state's agriculture: the meteoric rise in memberships with Alaska CSAs over the last several years began to hit a wall in 2009, and many local farmers attribute this to confusion on the part of their customers about whether Full Circle was providing locally grown food. Full Circle, which has been actively expanding its market in Alaska for the last few years, uses language on its website and produce boxes such as "community supported agriculture," "local agriculture," "sustainable," and similar phrasing.

A 2008 post by Kim Sollien on the *Anchorage Daily News* blog AK Root Cellar addressed the issue of the value of locally grown food to Alaska's economy: "The local carrot vs. the global organic carrot." (http://community.adn.com/node/118880) In 2009, Anne-Corinne Kell of Spring Creek Farm in Palmer wrote a Compass opinion for the *Anchorage Daily News* on the confounding of community supported agriculture with subscription agriculture, as exemplified by Full Circle's influence in Alaska (www.adn.com/2009/03/17/726667/its-important-to-truly-support.html). She wrote, "I was struck…while attending the 2009 Potato and Veggie Grower's Conference in Palmer that fully half of the consumers on a panel defining themselves as "Community Supported Agriculture supporters" were actually buying their produce from Washington State's Full Circle Farms." Customers were not the only ones confused: an award-winning article that appeared in Alaska Newspapers, Inc. about Full Circle Farms' delivery program to Bush villages also failed to distinguish between agriculture that is community supported and the benefits to a community that fresh produce can provide—even when shipped long-distance. This type of confusion about agriculture in Alaska has proven to be an obstacle to establishing food security here: when even self-identified supporters, publicizers, and reporters on local agriculture have trouble recognizing it, it can be difficult for local growers to receive the support they need to thrive.

School gardens/farm-to-school programs

Agricultural education is a key component to true support for farming in Alaska. On May 4, 2010, Alaska Agriculture Day, Governor Sean Parnell signed the Farm-to-School Act into law. Bill sponsor Representative Carl Gatto described in a press release how the act will function:

> The Farm-to-School Act is similar to programs proposed in several other states. Its intent is to strengthen links between state agriculture and state food procurement in schools, expand local markets, improve nutrition, and even benefit the environment. … The program will, in order of priority:
>
> - Identify and develop policies and procedure, including proposed uniform procurement procedures, to implement and evaluate the program;
> - Assist food producers, distributors, and brokers to market Alaska grown food to schools by informing them of opportunities and requirements;
> - Assist schools in connecting with local producers by informing them of sources, availability and benefits of Alaska grown foods;
> - Indentify and recommend ways to increase predictability of sales and adequacy of supply;
> - Make available publications allowing students to see the benefits of preparing and consuming locally-grown food;
> - Support efforts to advance other farm-to-school extensions such as school gardens or farms and farm visits; and
> - Seek additional funds to leverage state expenditures.
>
> …HB 70 also gives schools the authorization to create a school garden or even a farm. In doing so they must allow students representing student organizations the opportunity to be involved in the

garden or farm operation. Schools may teach both organic and traditional farming methods.

The Farm-to-School Act is an important step in connecting schoolchildren to local food, and may complement other programs, such as Alaska Agriculture in the Classroom. Another example in the Fairbanks area, Calypso Farm & Ecology Center, has two interconnected school garden programs that have been going since 2003: the Schoolyard Garden Initiative (SGI) and Engaging Alaskan Teens in Gardening (EATinG). The goal of SGI is to create "a network of school gardens functioning as experiential learning environments for teachers and students during the school year and as food production gardens…during the summer months." Calypso staff act as consultants to school garden committees on garden design and creation, and on integrating gardening into existing curricula. The farm published a guide, *The Living Classroom Manual,* based on the use of school gardens to teach mathematics, science, and language arts in elementary school. The EATinG program employs teenagers to tend the school gardens during the summers and operate small CSAs and/or farmstands, thus providing "an innovative way to connect education, employment, food and community."

Other educational farms in the state include Turning Light Farm, in the Tanana Valley; Spring Creek Farm, on the campus of Alaska Pacific University; and the two AFES farms, the Matanuska Experiment Farm and the Fairbanks Experiment Farm. The Cooperative Extension Service, with its many agents, programs, and years of work with gardeners, cooks, and farmers, has supported agricultural education from its establishment, working with SNRAS and the Agricultural Research Service of the USDA.

At Kincaid Elementary School in Anchorage, teacher Glenn Oliver has been working with his extended learning students in second through sixth grade to teach them about plant biology, genetics, and breeding, by growing crops in a state-of-the art, insulated, solar-powered greenhouse sponsored and built by parents who were architects and contractors. Each summer the greenhouse is filled with popcorn, cucumbers, and tomatoes. The children grow vegetable starts and sunflowers that are sold in the spring to a nearby hardware store. "Snow can be halfway up the (outside) walls and our greenhouse is full of plants," Oliver said.

Oliver and his pupils developed a dwarf pink, red, and yellow popcorn variety. "You can't buy multi-colored dwarf popcorn anywhere but we have it," Oliver said. He has about 40,000 seeds in storage. As part of their studies the students pop and compare their corn with storebought brands. They measure and count the kernels. "It's just a blast," Oliver said. "The kids love it."

Oliver and his pupils will create a business plan to package their products, design a logo, and sell the corn. He believes that by working with agriculture students learn math, science, weather, life cycles of plants, and much more. "Many of these students have never grown food that they ate. They are able to take home food and share with their families. They are learning to become responsible for themselves."

Oliver asked SNRAS researchers to try growing the corn outdoors in Fairbanks' hotter and drier climate. Research Professional Jeff Werner and Professor Meriam Karlsson planted some seeds at the Fairbanks Experiment Farm in 2010. The corn grew well. "We are seeking a more uniform plant," Oliver said. "Eventually we want to plant fields of them."

"There's a big hole in education related to plants in particular," Oliver said. Werner echoed that sentiment, "This is integrating science, technology, English, and math into agriculture. Something as simple as growing popcorn has taught these young people genetics, DNA, plant breeding, and other opportunities," Werner said. "Integrating agriculture into the classroom should be an everyday event to help set a better table for Alaskans."

These are only a few of the arenas in which food activism has arisen in Alaska. New organizations, like the Alaska Community Agriculture Association (a farmers' group), the Alaska Diversified Livestock Association, the Alaska Farmers' Market Association, and the Alaskans Own Seafood community supported fishery, are supporting food producers in the state and getting the word out about what sustainable, local food production is and how it benefits Alaskans.

In 1982, the Alaska Agricultural Action Council, at the request of Gov. Jay Hammond, submitted the *First Report to the Legislature on the Development of a Plan for Alaskan Agricultural Development*. The Executive Summary listed "seven agricultural goals and long-range planning objectives" established by the Alaska State Legislature in 1981:

1. Promote self-sufficiency and decrease dependency on imported foods
2. Provide opportunities for Alaskans to produce their own food individually and collectively
3. Provide employment for Alaskans
4. Provide nutritional food products from local sources for Alaskans
5. Develop a self-supporting agriculture industry in Alaska
6. Encourage the export of surplus agricultural products
7. Ensure that agricultural development proceeds with sound environmental practices and energy efficiency

This was the first of several reports connected to the state's attempt to develop a large-scale agriculture industry with the Delta Agricultural Project and the Point MacKenzie Dairy Project. While the state's investment did result in more basic agricultural infrastructure and land in private ownership, twenty-nine years later Alaska still struggles to implement these basic goals. One important difference between then and now, however, is that in 1982, the project was large-scale and top-down, whereas now the self-sufficiency movement is small-scale, grassroots, and trickling upward from individual and local initiatives to regional and statewide initiatives. This change, reflecting a nationwide, even international shift in perspective on food production and distribution, may be the key to finally bringing food security to Alaska.

Leafhoppers and potatoes in Alaska

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Left: Balclutha puntata*, the most prevalent species of leafhopper found in the University of Alaska Museum of the North Insect Collection. Photo by Tom Murray.*

In Alaska, potato production accounts for 14 percent of total agricultural crop revenues and 60 percent of revenues from vegetables. All potatoes produced in Alaska are used for seed or fresh consumption within the state. However, Alaska is being considered as a potential seed potato production area for export. Due to its geographical isolation and climatic constrains, Alaska is relatively free of diseases and insect pests. Many potato diseases and insect pests common to North America have not been reported in Alaska. However, the biology of agricultural insect pests in the circumpolar region is lacking or poorly understood.

Diseases caused by phytoplasmas have become increasingly important in the Pacific Northwest, with recent outbreaks of potato purple top disease in Washington and Oregon causing severe yield losses and reduction in tuber quality in potato reported from 2005 to 2008. In the Columbia Basin, the potato purple top disease is associated with the Columbia Basin purple top phytoplasma vectored by the beet leafhopper, *Circulifer tenellus* Baker; while in other potato producing areas of the USA and in Mexico, purple top is associated with aster leafhoppers in the genus *Macrosteles*. Leafhopper is the common name used to refer to insect species under the Cicadellidae family. This family includes over 20,000 described species. Some of the species are considered vectors of plant diseases.

Despite the publication of a few agronomic and taxonomic studies, little is known about the taxonomic identity, population dynamics, distribution, ecology, and biology of leafhoppers affecting potatoes or other agricultural crops in Alaska. Potato plants showing symptoms of leafhopper-transmitted witches' broom have been reported in Alaska, but no reference is provided on the associated vectors.

A study from 1956 provided taxonomic keys and limited biological information on the leafhopper fauna of Canada and Alaska. Also, another study from 1997 provided a checklist of the leafhoppers of Yukon Territory of Canada, which included brief biological notes and their North American distributions. Of the 145 species reported in this study, fifty-four are known to be present in Alaska. No species were reported from potatoes in any of these studies, suggesting the need for further research on the insect fauna associated with potatoes in the state. The development of a seed potato industry in Alaska is dependent on the effective management of diseases and insect vectors. Information on taxonomic identity, biology, population dynamics, and geographical distribution of the insect pests is important in the development of integrated pest management programs. So, we undertook a study to rectify the lack of information on the leafhoppers associated with potato production in Alaska.

Leafhopper survey

Our approach was simple: we conducted surveys of areas likely to harbor leafhoppers, and drew upon specimen collections for identification. We took sweep net samples bi-weekly along potato field margins in the four major potato production areas of Alaska: Fairbanks, Delta Junction, Nenana, and Palmer. The sweep samples were collected from untreated potato plants in fields over two hectares. We placed the specimens in plastic bags, transported them to the laboratory, and sorted and preserved them in 80 percent ethanol. Initially, a series of specimens were identified by Chris Dietrich, (Center for Biodiversity, Illinois Natural History Survey, Champaign, Illinois). Subsequent identifications were made using the keys and comparison to the voucher collection.

Also, we examined the University of Alaska Museum of the North Insect Collection for leafhoppers. The museum is home to the Washburn Insect Collection, which was compiled by USDA entomologists J.C. Chamberlin, R.H. Washburn, and others during the 1940s and 1950s. This collection is considered the only large general insect collection maintained in the state of Alaska.

We also surveyed the leafhoppers with yellow adhesive cards placed along untreated potato field margins, with a density of eight cards per hectare on wooden stakes near Fairbanks, Delta Junction, and Palmer, Alaska. A total of 112 trap stations were deployed from May 13, 2004 to October 17, 2006. We placed the cards around field perimeters when the ground was sufficiently thawed or just before planting, and maintained them until the crop was harvested. Vegetation within 60–90 cm of the trap was trimmed regularly to a height of approximately three cm. The cards were replaced weekly. We counted the leafhoppers in situ on the cards, but problematic specimens were removed, washed in xylene, and examined under a stereoscope in 80 percent ethanol. Only adults were identified. The number of insects per trap per week was combined to calculate the mean number of insects per trap per fourteen-day period.

Species caught

A total of 53,145 specimens representing twelve species and eleven genera, were collected from May 13, 2004 to October 17, 2006 with sticky cards (Table 1). Not all species collected with sweep nets can be distinguished on the adhesive cards; therefore, the two species of *Draeculacephala* listed in Table 1 (*D. angulifera* and *D. borealis*) are presented as *Draeculacephala* spp. We identified a total of twenty species from the sweep net samples and adhesive cards.

The UAM collection contains 288 individuals representing thirty species in twenty-two genera. Eight genera are represented without species identification (Table 1). The most prevalent species in the UAM are *Balclutha punctata* and *Diplocolenus evansi* representing 28 percent and 17 percent respectively. Although not identified during the field study, the intermountain leafhopper, *Empoasca filamenta*, is present in Alaska, representing 7 percent of the UAM specimens. *E. filamenta* is considered the most important leafhopper species associated with potatoes in Idaho and a pest of potatoes in the Rocky Mountains and the Sierra Nevada.

Nine of the twenty species identified during the study were present in the UAM Insect Collection (Table 1); while eight species were collected with sweep nets but not detected in adhesive cards. All species collected represent new records for potato in Alaska. Eleven species (*C. xanthoneurus, D. snowi, D. ossia, E.

Table 1. *Percentage of Cicadellidae collected with adhesive cards (AC) and sweep nets (SN) from potato fields in Delta Junction, Fairbanks, Nenana, and Palmer, Alaska and those present at the University of Alaska Museum Insect Collection (UAM), Fairbanks, Alaska.*

Taxon	% collected on adhesive cards	% UAM
Balclutha sp.	0	<1
Balclutha impicta (Van Duzee)	0	4
Balclutha punctata (Fabricius) [1]	9	28
Cazenus xanthoneurus (Fieber) [1]	0*	0
Cicadula intermedia (Boheman)	0	<1
Cicadula melanogaster (Provancher)	0	2
Colladonus sp.	0	3
Colladonus flavocapitatus (Van Duzee)	0	<1
Colladonus torneellus (Zetterstedt)	0	<1
Davisonia snowi (Dorst) [1]	34	0
Deltocephalus nigriventer Sanders and DeLong	0	<1
Dikraneura ossia Beirne[1]	<1	0
Diplocolenus evansi (Ashmead)[1]	<1	17
Draeculacephala sp.[2]	<1	0
Draeculacephala angulifera (Walker)	0*	4
Draeculacephala borealis Hamilton	0*	<1
Elymana acrita DeLong	0	1
Empoasca sp.	0	1
Empoasca deluda DeLong [1]	0*	0
Empoasca filamenta DeLong	0	7
Evacanthus acuminatus (Fabricius)	0	7
Hecalus montanus (Ball) [1]	0*	0
Idiocerus sp.	0	<1
Idiocerus xanthiops Hamilton	0	<1
Limotettix corniculus (Marsh)[1]	3	0
Macrosteles sp.	0	2
Macrosteles binotatus (Sahlberg)	0	3
Macrosteles borealis (Dorst)	0*	2
Macrosteles fascifrons (Stål)[1]	27	7
Macrosteles laevis (Ribaut) [1]	0*	0
Oncopsis sp.	0	<1
Paluda gladiola (Ball)[1]	0*	2
Paraphlepsius apertus (Van Duzee) [1]	0*	0
Psammotettix confinis (Dahlbom)[1]	1	<1
Psammotettix latipex (DeLong and Davidson)	0	<1
Psammotettix striatus (L.)	0	<1
Scaphytopius sp.	0	<1
Scaphytopius acutus (Say)	<1	0
Sorhoanus flavovirens (Gillette and Baker)[1]	<1	0
Streptanus sp.[1]	<1	<1
Thamnotettix confinis Zetterstedt [1]	0*	0
Typhlocyba ariadne McAtee	0	2
Unidentified	24	0

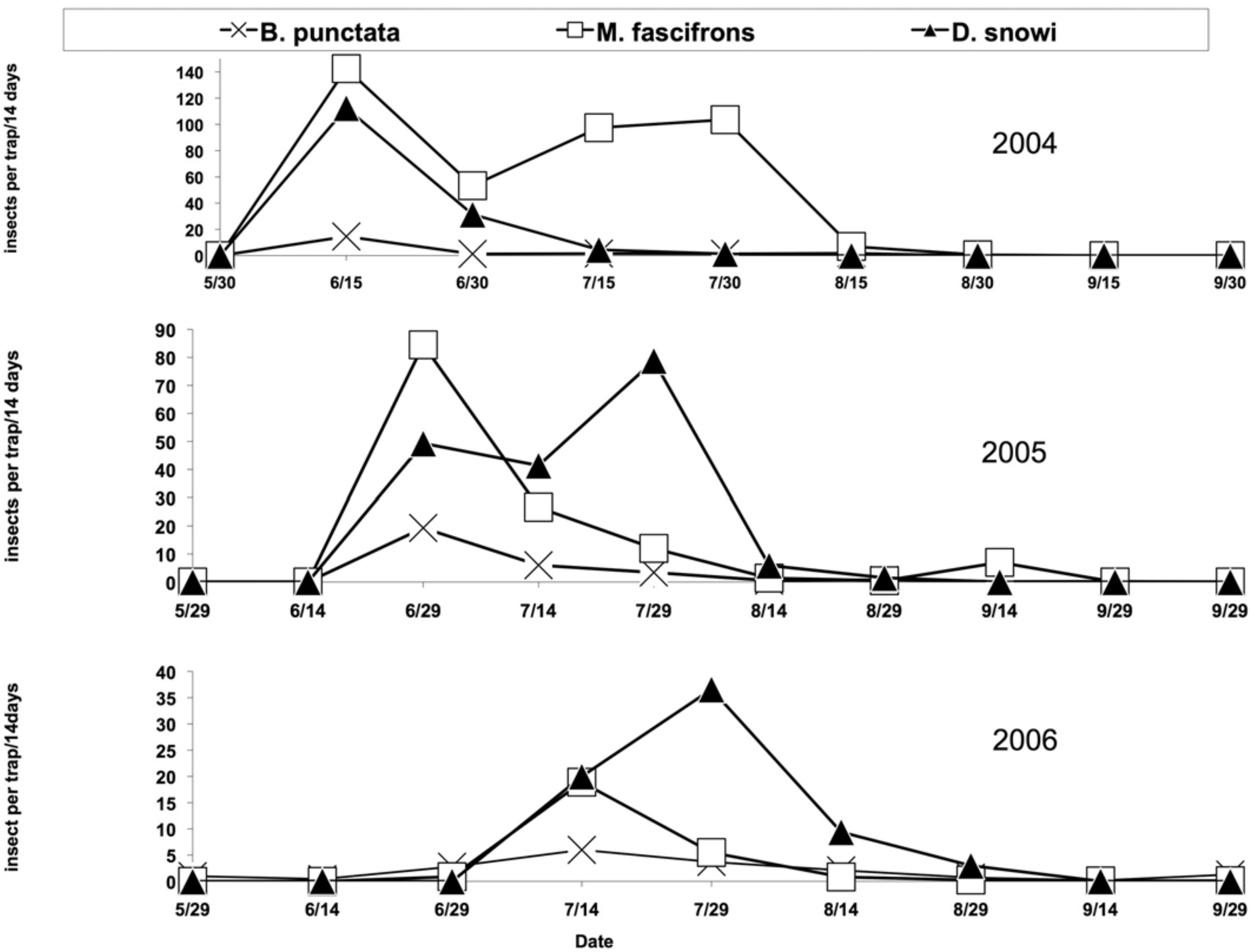
* = only collected with sweep net.
1. Species collected with sweep net and identifications confirmed by C. Dietrich.
2. Represent two species, *D. angulifera* and *D. borealis*, not distinguishable on adhesive cards.

deluda, H. montanus, L. corniculus, M. laevis, P. apertus, S. acutus, S. flavovirens, and *T. confinis*) represent new records for agricultural fields in Alaska. However, all species identified have been previously collected in the state. Most likely, this study represents the first report on these species from potatoes in Alaska as the species list compiled from the UAM Insect Collection has not been published and is not available from the UAM online database.

With the exception of *D. ossia*, which was absent from Palmer, all species were collected in all localities. Approximately 70 percent of the total number of specimens examined belonged to three species, *B. punctata, M. fascifrons*, and *D. snowi*. The relative density of the three most abundant species varied among locations (Table 1, Figs 1-3). *D. snowi* was common all three years at Delta Junction and Fairbanks and uncommon all three years at Palmer. *M. fascifrons* was fairly common most years and most sites, except Fairbanks in 2006. Differences in species composition among localities could be attributed to a number of factors. Climatic conditions vary greatly among major agricultural areas in the state. The climate in Palmer is moist and moderate due to maritime influences, whereas Fairbanks and Delta Junction are colder and drier due to continental influences. Cropping history could be another factor influencing species composition. In Alaska, commercial agriculture is a rather recent development with farms dating from the early 1930s in Palmer, the late 1940s in Fairbanks, and the 1950s in Delta Junction. The highest insect density observed during the trial was for the locality of Delta Junction during the year 2004 with 140 M. fascifrons per trap (june 15) during a fourteen-day period (Fig 1). This species was also the predominant species in the Palmer area (Fig 3).

Macrosteles fascifrons is known to feed and reproduce on cereals and grasses, crops common in the Palmer and Delta Junction area. This species, widely distributed in temperate regions of North America and in Eastern Siberia, is a vector of aster yellows phytoplasma in carrots and lettuce, purple-top phytoplasma in potato, and is associated with other diseases of vegetables and ornamental plants. The other abundant leafhopper collected in this study, *D. snowi*, was the predominant species in the Fairbanks area (Fig 2). The exception was the 2005 growing season where *M. fascifrons* outnumbered *D. snowi*. Although *D. snowi* has not been associated with plant diseases, little is known about its biology. This species has been associated with willows, *Salix* spp. which are common plants in

Figure 1. Mean number of *Balclutha punctata, Macrosteles fascifrons*, and *Davisonia snowi* per trap per 14-day sampling period collected with yellow adhesive cards near Delta Junction, Alaska, 2004, 2005, and 2006.



Alaska. Additional research is needed to better understand the presence of this species in potato fields in Alaska.

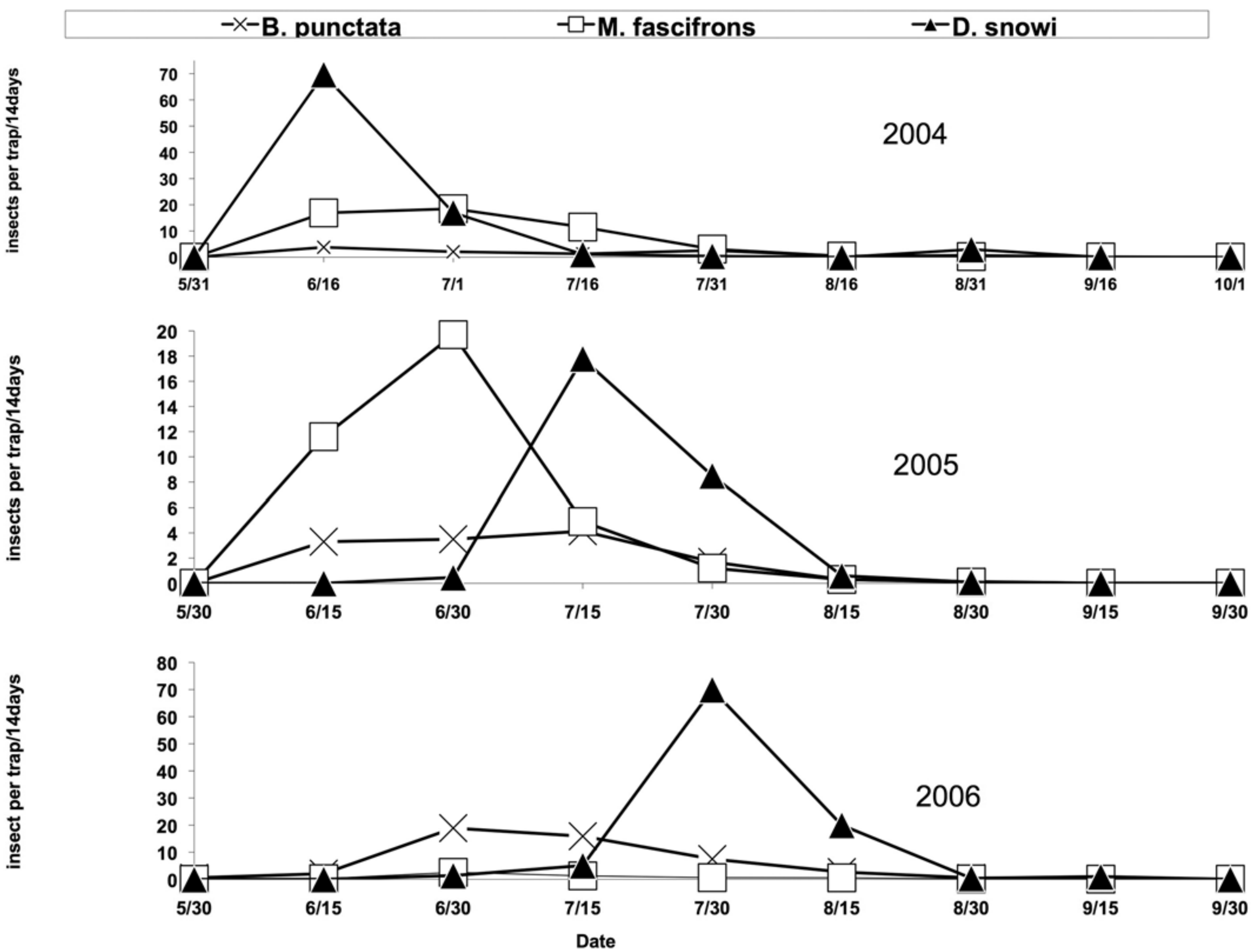
Similar to the Fairbanks area, *D. snowi* was the predominant species in the Delta Junction area during the 2005 and 2006 growing seasons (Fig 1), but not during 2004. Population densities of *D. snowi* in the Palmer area were consistently low every year (Fig 3). The differences between species, sites and years cannot be explained with current knowledge of leafhopper biology in the state.

Despite occurring in low number, several species collected are of potential economic importance. For example, *B. punctata* is associated with at least four phytoplasma groups in Alaska, but the ability to transmit the pathogens to potatoes has not been established. Up to twenty *B. punctata* per trap per fourteen-day sampling period were collected in the Delta Junction and Fairbanks areas (Figs 1, 2). The role of *Balclutha* spp. in phytoplasma transmission is still unclear and requires additional research. In Oregon and Washington *Balclutha* spp. were not found associated with the Columbia Basin purple top phytoplasma. However, the population density of this species is lower in Washington and Oregon than the densities observed in Alaska (Table 1, Figs 1-3). *Draeculacephala* spp. has the potential to be an agricultural pest in Alaska. Another species in this genus, *D. soluta* Gibson, has been reported to cause hopperburn to South American rice. Similar hopperburn damage caused by the potato leafhopper [*Empoasca fabae* (Harris)] is documented in potatoes in the midwest and northeast USA. In our field study, we collected two species in the genus *Draeculacephala*, *D. angulifera* and *D. borealis*. Another species, collected in low numbers but of possible economic importance is *S. acutus*. This species, collected from the three sites sampled with adhesive cards, is a known vector of x-disease phytoplasma in stone fruits. Another species of the same genus, *Scaphytopius irroratus* Van Duzee, is associated with aster yellows phytoplasmas in vegetable crops in Texas.

In all surveyed localities, cicadellid populations start to build in early June to early July, reaching a peak by mid-June to late July (Figs 1-3). Population densities peaked earlier in Fairbanks (Fig 2) than in Delta Junction (Fig 1) or Palmer (Fig 3). The exception was the 2006 growing season where all insect densities peaked in July for the localities of Fairbanks and Delta Junction. During 2006 *M. fascifrons* was collected soon after the cards were deployed in the field (Fig 3), suggesting that the species might overwinter in Alaska.

The number of leafhoppers per adhesive card in Alaska is lower as

Figure 2. Mean number of *Balclutha punctata*, *Macrosteles fascifrons*, and *Davisonia snowi* per trap per 14-day sampling period collected with yellow adhesive cards near Fairbanks, Alaska, 2004, 2005, and 2006.



compared to the Columbia Basin, where densities of up to 192 leafhoppers per trap were reported. In the Columbia Basin of Washington and Oregon, the beet leafhopper completes at least three generations per year. Our data suggests that depending on the year and location some leafhopper species can complete two generations per year in Alaska. Flight activity, as measured by mean number of leafhoppers per card, starts as early as May and by October no activity is detected at any of the Alaska locations, whereas leafhoppers were collected with adhesive cards in the Columbia Basin until late October.

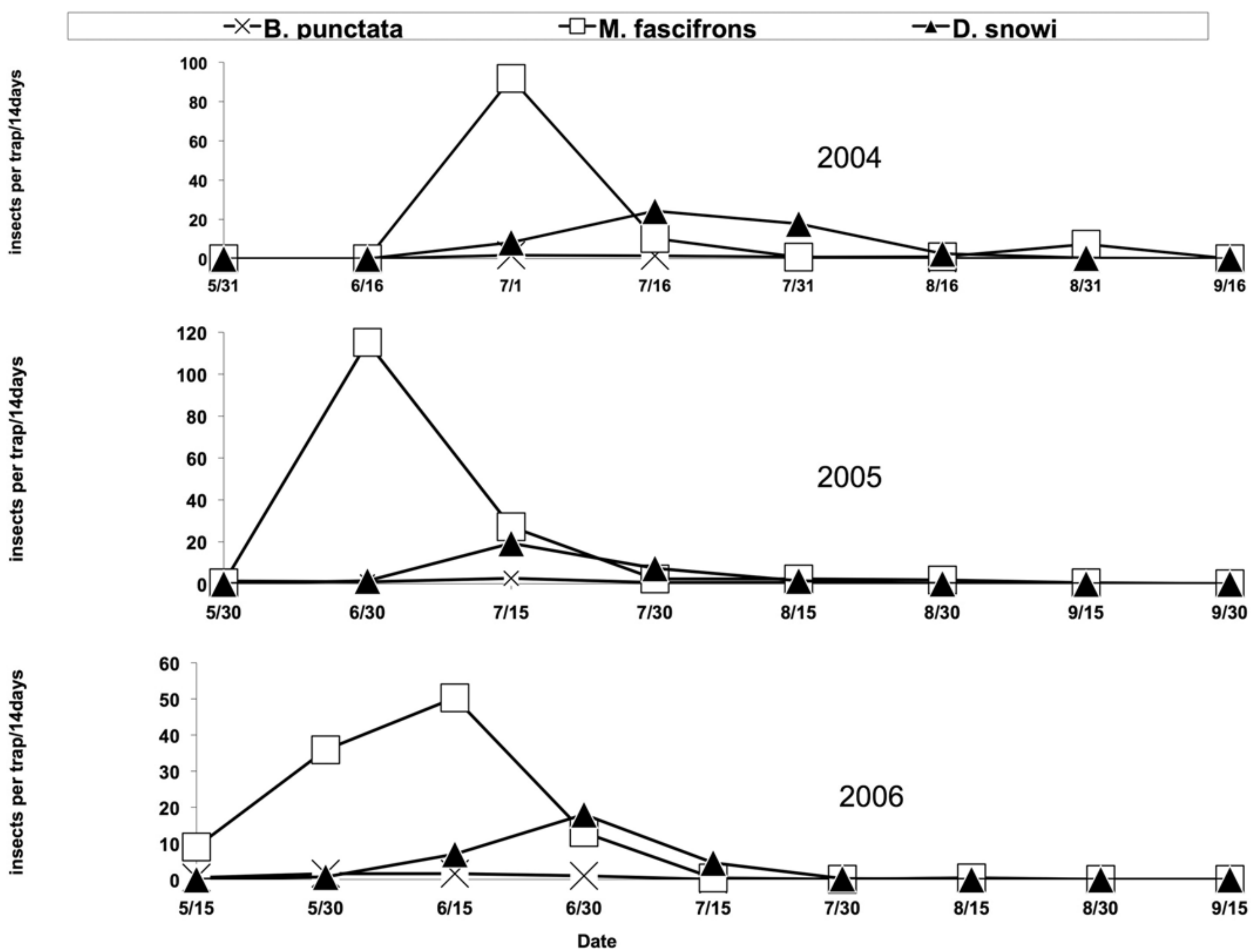
To our knowledge, this is the first long-term report on species composition and population dynamics of cicadellids associated with agricultural crops in Alaska since a 1949 report on leafhoppers in agricultural fields in the Fairbanks area. This is the first time cicadellids have been associated with potatoes in Alaska. Our research covers species composition, population dynamics, geographical distribution, and abundance of the cicadellids associated with potato production in Alaska. Information on the biology, development, alternate hosts, and overwintering strategies of the agriculturally important species is needed to develop effective integrated pest management (IPM) strategies.

This represents the first extensive study of this group of insects in agricultural fields in the state and provides information needed for the development of IPM for cicadellids in potatoes. The development of IPM strategies for Alaska is of particular interest since it is expected that insect populations and the potential for potato seed production in the state may increase with climate change. Future research should investigate the correlation between the leafhopper species present in Alaska with phytoplasma diseases in potato fields, alternate hosts of the common species, and overwintering habits of the economically important species.

Acknowledgements

We thank Alaska vegetable and/or potato growers Frank Borman, Lyle Brasier, John Pinckley, Ted Pyrah, Ben Vanderweele, Calypso Farm and Ecology Center, Ann's Greenhouse, and Sven Ebbesson for use of their farms; and Pat Holloway for access to the University of Alaska Fairbanks Georgeson Botanical Garden. Phil Kaspari, University of Alaska Extension agent, provided invaluable assistance in gaining access to producers' fields. Technical assistance in the field laboratory was provided by Bethany Sweet, Bob Torgerson, Candice Flint, Cary Curlee, James Malapanis, Nettie Jenkins, and Steve Lillard. Critical comments to an earlier draft of this

Figure 3. Mean number of *Balclutha punctata, Macrosteles fascifrons*, and *Davisonia snowi* per trap per 14-day sampling period collected with yellow adhesive cards near Palmer, Alaska, 2004, 2005, and 2006.



manuscript were provided by S. Rondon, Oregon State University, D. Fielding, and L. DeFoliart, USDA, ARS, and J. Pena and P. Stansly from the University of Florida.

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You are my Sunshine!

Anita Hartmann

Carol Lewis, dean of the School of Natural Resources and Agricultural Sciences (SNRAS) and I had been chatting at various UAF meetings last spring, so when she told me SNRAS was developing a new strain of barley, "Sunshine Barley,"[1] I immediately inquired how to acquire some of the grain for my own hobby. I come from a long line of home brewers: Grandpa kept his "rheumatiz' medicine" in a jug on the kitchen drain board; my parents made wines from the wild grapes and other fruits on our Wisconsin farm (which they inevitably bottled too soon and thus regularly blew their corks in the cistern where they were stored); my aunt perfected her own bathtub gin recipe that was a dead ringer for Beefeater gin and enlivened many a Chicago ladies' bridge party during the Depression; and I've been developing a blended red table wine made from local and wild grown fermentables such as rhubarb, chokecherries, cranberries, blueberries. I had given Carol a bottle of my 2009 recipe to evaluate, and her feedback contributed to improvements for the 2010 blend: "Rebel Red" took First Place at Tanana Valley State Fair 2010. So when she called to offer me some of the barley harvest I was thrilled to accept!

"See what you can do with it," Carol said as we loaded two sacks of new barley into my car. "I don't think you'll be able to brew much of anything with it, it's unmaltable. The protein's too high."

Wonderful! The scientist in me immediately formulated two testable hypotheses. Hypothesis 1: can the grain be malted? This is a critical question since malted barley is one of the four essential ingredients of beer.* Hypothesis 2: can the malted Sunshine Barley be brewed into a decent, drinkable beer? I consulted my bibles[2,3] for guidance and inspiration, and decided on parsimony: a simple lager from malted grain. As Leon Kania writes,[1] "Why in the Sam Hill would anyone want to make beer from grain…? …[Y]our malt may not measure up to the commercial product…personal pride and satisfaction are probably the main reasons anyone brews with grain malts" (p. 68). Regardless of the reasons, if a person wants to brew beer from grain malts, Kania's book provides recipes and instructions to get the beginner started, and I use several of his tricks for ease and convenience of the home brewer.

Pilot Study

Before undertaking a large-scale brewing, I wanted to determine how ripe the grain was and how long it would take to reach each stage of the malting process. Malting begins with sprouting the grain in much the same way you would for alfalfa sprouts for your salad. Starting with one tablespoon of grain added to eight ounces of room-temperature well water,[4] there were only ten "floaters," so the grain was fully mature and well dried. I left the grain in the water to soak for 48 hours, then drained it into my alfalfa sprouter for ease of daily rinsing and airing.

After 36 hours the barley had visible sprouts. Nibbling a few verified that the seeds were changing from a hard, rock-like consistency to a softer, more chewable form and tasted sweet. I employed an old-time malter's trick of peeling the husk off a few grains every day to check the growth of the shoots (acrospires): when the shoot inside the grain is about two-thirds the length of the grain it's considered to be at the stage where it will yield the optimum of malt sugar and the residual enzymes necessary for brewing beer. This step took an additional 36 hours.

The next step, of drying without toasting, can be a challenge since the temperature must be controlled. For this small pilot sample, I spread the sprouted grain on a


Hartmann winnowing the barley in her driveway.

screen in my oven set on "warm" and kept the door ajar. The goal is to dry the sprouted grain without toasting and caramelizing it into a darker, less fermentable malt. The pilot sample needed 24 hours in the oven to reach the pale malted barley goal. Now that I knew how long this grain required to reach each stage, I was ready for a bigger batch.

Full Brew Ahead

I weighed out five pounds of barley, soaked them, spread them out on the trays of a table-top food dehydrator (no heat) to sprout with the fan on, and rinsed daily. When the acrospires were at the proper length, I turned on the heat of the dehydrator to 1200F to dry the grain. Then I carried the dried and cooled grain outside to winnow in the breeze of a three-speed fan. Post-winnow weight was 4.3 pounds. A new "sinkers-and-floaters" test revealed a brewer's challenge: high percentage of only partially malted grains. Next, grist the grain in the mill with blades set to crack each grain into about 4-5 pieces.

Because the grain was only partially malted, I added one-half teaspoon of liquid alpha-amylase, which enyzmatically converts starches to simple fermentable sugars, to two gallons of well water, and step-mashed for 2.5 hours. (I drain the sweet wort for brewing beer and reserve the mash.5) I brewed what I like to drink with the mash extract: a European-style light lager pilsner. In addition to the mash extracted from the Sunshine Barley, this lager uses: unhopped malt, Cascade boiling hops, Willamette domestic finishing hops, a small amount of Irish moss, some yeast energized and lager yeast. Sunshine Barley has such a high amount of protein, it needs several hours for the protein sediment (trub) to settle before racking and pitching the yeast. The lager was fermented in a darkened keg at 55-60°F for seven days and then bottled. At bottling, the lager was a lovely gold, clear, with alcohol content 5.20 percent by weight.

Is it a decent, drinkable beer? Well, I think so, but then I brew what I like. For unbiased opinions I sent samples out for competitive judging. At the 2010 Tanana Valley State Fair the brew earned a Fair Theme Award ("Barn in the USA") and its overall drinkability was judged as "Good," earning 27 points. At a sanctioned competition of the American Homebrewers Association it was also judged "Good" with a final score of 22.5 points and the judging sheets offered some very helpful comments for improving on this first effort. I consider the experiment a success.

An Informal German Taste Test

The editor and her husband, a German national, took home a bottle of this Sunshine Barley brew, "Amber Waves of Grain," and had a little informal beer tasting. To both of us it tasted lemony and slightly sweet, rather like a well-filtered hefeweisen. To me, the beer had a scent reminiscent of apple cider. The beer, we agreed, was quite light with a hint of hops and would be a good summer beer for drinking in very hot weather.

Notes and references:

*Water, malted barley, hops, and yeast.

1. See "Sunshine barley ready to grow," Nancy Tarnai, SNRAS Science & News, January 28, 2009. On line at: http://snras.blogspot.com/2009/01/sunshine-barley-ready-to-grow.html.
2. Kania, L.W. (2000). *The Alaskan Bootlegger's Bible: Makin' beer, wine, liqueurs, and moonshine whiskey; an old Alaskan tells how it's done.* Wasilla, Alaska: Happy Mountain Publications.
3. Papazian, C. (1983). *The Complete Joy of Home Brewing,* 3rd ed. New York, New York: Harper-Collins Publishers. Described by the Associated Press as "the homebrewer's bible," we acquired it as a participant's gift my partner-in-crime received when he entered his English Bitters at the 2009 E.T. Barnette Home Brew Competition held at Silver Gulch Brewery in Fox, Alaska.
4. Water is an extremely important ingredient in beer making; consider the pure water claims of several commercial beers: "Hamms beer: from the land of sky blue waters" or "Coors beer: made from pure Rocky Mountain spring water" and so forth. Papazian's book contains good information on water qualities including a chart of the water used in famous brewing areas around the world.
5. Kania reports that bootlegging was so rampant during Prohibition in one northern city that the spent mash from illicit breweries clogged the sewage system! No need to throw out the spent mash from Sunshine Barley: it's great served as hot cereal with raisins & cream—so sweet it doesn't even need brown sugar. I also use a cup of the spent mash, instead of oatmeal, for making wonderful homemade bread.

Anita Hartmann has a PhD in neuroscience, and is currently Associate Dean, UAF College of Liberal Arts. She owns a small scale organic farm off Chena Hot Springs Road and makes moose sausages to go with the homebrew.

Reindeer market project makes history!

George Aguiar

Reindeer make a first-ever appearence in a fair showing in August 2009, Fairbanks, Alaska. Roscoe Beadles is holding the lead of his award-winning 4-H reindeer. Photo by Nancy Tarnai.

Seeking to educate 4-H and FFA students in reindeer husbandry, the UAF Reindeer Research Program launched a market reindeer pilot project in 2007. The undertaking, the first of its kind in the US, guided selected students through sixteen months of raising reindeer. The culmination of the project was for the participants to present their reindeer at the Tanana Valley State Fair livestock auction in Fairbanks, Alaska, in August 2009.

Collaborating with the Reindeer Research Program were the Bureau of Indian Affairs, the Kawerak Reindeer Herders Association, 4-H, FFA (Future Farmers of America), and UAF Risk Management.

Because reindeer had never officially been included in a livestock market project anywhere in the country, the first year of planning and preparation (2007) found the RRP establishing protocols for showmanship and judging, designed specifically for reindeer. An application and screening process for the 4-H and FFA students were developed along with a teaching curriculum for required training sessions in reindeer husbandry. By mid-September the training sessions were completed and the animals were distributed to the five chosen applicants and released to their facilities.

The students all had very different backgrounds and were introducing their reindeer to different environments. Pumba went to an eight-acre pasture where he cohabitated with an older reindeer steer. Adolf was housed in a 60 ft. x 60 ft. pen with his new herd consisting of ducks and a standard poodle. Chuck and Butch were off together to a pen of similar size with pigs and chickens in neighboring quarters. Winston's new peers were a horse, goats, and turkeys.

The candidates chose various methods of halter breaking their animals. One individual began his socialization with his reindeer by sleeping in the same barn with him for a week. Others tried sheer force, pulling on their animal's halter even when all fours were planted. Others fell somewhere in between. Success was ultimately achieved by both methods.

Students used their reindeer market project to write research papers for class and as subjects for oral presentations. Students gave injections, trimmed hooves, and some even had to cut and bandage broken antlers. In July 2009 a workshop was scheduled to evaluate whether the animals and their handlers were ready for the fair. Three of the five reindeer were approved to show at the fair. The two animals that were not approved bypassed the fair and went directly to slaughter and processing.

In August 2009 the pilot project was put to the test. Students and their animals were at the fair for ten days. Upon arrival the animals were weighed. Winston, Adolf, and Pumba weighed in at 204, 171, and 168 pounds respectively. Students were given a horse stall and a stall within the cattle barn for housing their animals throughout the fair. The reindeer and students attracted much attention from the public. Kids wanted to pet the reindeer. Cameras came out every time the reindeer made an appearance. The *Fairbanks Daily News-Miner* published a front page article about the reindeer market project and the students involved. Channel 11-TV spotlighted one of the students and her reindeer on the evening news. The animals and their owners adapted well to the other livestock, housing facilities, and publicity, and made an excellent impression both inside the show ring and out.

As the end of the fair approached the market livestock auction neared. Rabbits, chickens, turkeys, cows, pigs, sheep, goats, and reindeer were auctioned off to the highest bidders. The reindeer were part of a terminal project, meaning that they must be sent directly to slaughter after auction. The winning bids for each of the three reindeer were $7.25/lb., $5.25/ lb. and $5.75/lb. on the hoof or live weight. After the bidding, the students met with the buyers and expressed gratitude for their support and took pictures. They had fulfilled their part of the contract. A year-long commitment of raising a reindeer to market for slaughter was over. The young people and their reindeer had just made history.

As the first group of reindeer and

their owners neared the completion of their project, four new candidates had already been chosen to receive reindeer steers to raise for the 2010 Tanana Valley State Fair. The new students received four new calves selected for distribution: J.R., Zesty, Arnold, and Bo left the Reindeer Research Program herd at the Agricultural and Forestry Experiment Station to join their new owners.

The program gained national attention, and has served as inspiration and a model for a similar project in Kalamazoo, Michigan. Carol Borton, project leader for the 4-H club Tundra Busters and a livestock superintendent, provides 4-Hers with the opportunity to learn and practice reindeer husbandry. The program accepted fourteen students in its first year, having to turn away twenty more due to resource limitations. The main focus of the program is a showmanship competition at the end of the summer for the fair. Preparation for this event meant that the children worked intensively with the deer assigned to them. They help handle, halter break, and feed the reindeer. Next summer Borton would like to bring the 4-Hers to Alaska to see a reindeer handling on the Seward Peninsula and visit the Reindeer Research Program at the University of Alaska Fairbanks so they can experience the reindeer industry at first hand.

Modifications to the pilot project in Alaska were made to address some of the handling issues from the previous year. The calves would start training at younger ages. Halters were put on the reindeer at about two months of age and animals were handled weekly. The animals were also released to the candidates in mid-August rather than mid-September. Classes were modified slightly to emphasize subjects that would be relevant to the new crew of students and animals. Once again a variety of other livestock, including goats and horses, would be part of their new everyday existence until that August day in 2010 when both reindeer and owners loaded up and headed for the Tanana Valley State Fair to again be part of the livestock market project.

Security of the red meat supply in Alaska

Thomas F. Paragi, S. Craig Gerlach, and Alison M. Meadow

Food security is a key issue for Alaskans. We live at the end of a long food chain where most of our food is industrially produced and packaged, imported into the state, and then transported by air, truck, and/or barge to urban and rural communities. Most people are aware that the average piece of food travels 1,500 miles from producer to consumer in the US, but we calculated distances from 1,600 to 2,500 miles for vegetables coming to Anchorage or Fairbanks, with most suppliers far outside the state. You can increase these distances for food going to outlying communities. In-state commercial storage is almost nonexistent. Alaskans are vulnerable and food insecure because of the potential for disruptions in supply and the fact that our food system is controlled by big producers outside the state, the "big box stores" inside the state, and little local production.

Food prices in our remote state depend on a combination of transportation costs and relatively little competition between food retailers. Up to 12 percent of food cost in the US is due to transportation—this percentage will necessarily be higher given our longer food chain and high fuel cost in remote areas. Five supermarket chains account for 40 percent of food retail sales in the US. Of the nine supermarkets in Fairbanks, seven stores are owned by three of the top US supermarket chains. In 1977 it was estimated that 95 percent of food in Alaska is imported, despite our seemingly large number of avid gardeners, hunters, and fishers. This figure has been used by many sources since then but research to verify it only began recently.

Alaskans eat a variety of animal protein, including domestic livestock and wild game and fish. To understand how much red meat we import, in the summer of 2008 we assembled data from 2001-2006 about the relative proportions of red meat that are imported, that are produced within state, and that are harvested wild from the countryside. We attempted to capture the main components common to both urban and rural Alaska. Our individual research specialties focus on production of game meat from wild systems and factors that affect vulnerability of supply and nutritional quality in food systems of urban and rural Alaska. Moose, caribou, and deer composed 91 percent of game harvest by boned-out carcass weight. We did not estimate harvest of marine mammals by Alaska Natives, production of red meat for home use, or the domestic production or wild harvest of fowl. Although these latter sources may be important in some areas or for particular families, particularly the wild species in rural Alaska communities where the country food harvest is associated with culture, identity, and tradition, overall we believe they are presently minor components of total animal protein consumed statewide, excluding fish.

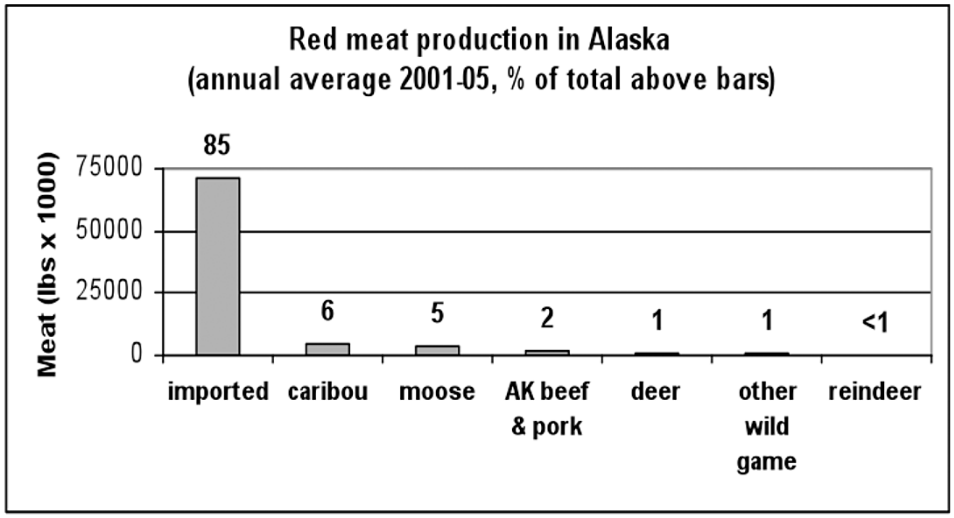
We found that an annual average of 85 percent of red meat from hoofed animals in Alaska was imported from outside sources during 2001-2006 (figure below). Rising fuel costs and increasing demand as a result of human population growth warrant consideration of how and where red meat will be produced and distributed in Alaska, now and in the future.

Many climate scientists forecast a warmer and drier scenario in the Interior with more frequent wildland fires. Such conditions will likely shift forest composition from spruce toward deciduous trees, or may even produce a biome shift from forest to a grassland savanna with scattered trees. In the long term, potential for livestock production in Alaska, especially in the Interior's boreal forest zone, may improve if adequate precipitation allows for local forage and grain production.

Wood bison indigenous to the boreal forest in North America were recently imported from Canada and are part of a restoration and conservation effort to reestablish a wild grazing system. At present the animals are in confinement following a disease quarantine (now completed) and pending decisions over when and where they will be released into the wild. It may be at least a decade after a reintroduction before small numbers of wood bison may be harvested. Plains bison indigenous to the central grasslands of North America currently exist as wild herds in parts of Alaska (primarily near Delta Junction and McGrath) and as domestic livestock on private lands (primarily near Delta Junction).

In the short term, commercial in-state livestock production might expand to serve local markets (especially on the road system) to reduce reliance on imported red meat. Ranching of elk and plains bison at low density may hold promise because of broader foraging ability (grazing and seasonal browsing), but fencing costs are a financial challenge. Some residents already raise goats and northern sheep breeds on predominantly native forage (including shrubs, such as willow) for home use, and this may also increase.

Wild game production occurs mostly on public lands and uses solar energy—meaning that game animals feed on plants that use the sun as energy. Unlike most agricultural crops,



wild forage does not require other energy inputs, such as fossil fuel. Moose habitat in the boreal forest generally benefits from fire disturbance or logging if willows or deciduous trees regenerate. However, game production is less reliable than livestock—animals are often dispersed relative to settlements, and there is limited control over production factors. Some production factors for wild ungulates on public lands can be value-laden, resulting in controversy; examples include harvest of females and calves, predator control to increase the survival of calves, and prescribed burns to improve browse production. Nearly one of every three moose currently harvested in Alaska comes from the Interior near population centers around Fairbanks and Delta Junction.

We expect it will remain difficult to engage the rural and urban public or government in serious discussions about agricultural policy until the price of food becomes a substantially larger (even prohibitive) proportion of annual income for Alaskans, or until major disruptions in transportation increase the frequency and magnitude of local and regional food shortages. More public discussions are being held on protection of lands suitable for food production, exploring means such as new zoning models, in response to population increase and potential loss of productive agricultural land because of residential or industrial development near urban centers.

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A version of this article was originally published as a post on the Alaska Farm Bureau website in August 2008. For more on agriculture in Alaska, see: http://dnr.alaska.gov/ag/ag_services.htm

Data sources:

Imported red meat (includes veal and lamb): courtesy of Jerardo Alberto, US Department of Agriculture, Washington, DC (calculations by Dr. Jennifer Schmidt, UAF)

Wild game harvest: Alaska Department of Fish and Game www.wildlifenews.alaska.gov/pubs/techpubs/mgt_rpts/harvest_summary.pdf

Alaska beef and pork production: Alaska Department of Natural Resources, Division of Agriculture

Alaska reindeer: US Department of Agriculture www.nass.usda.gov/Statistics_by_State/Alaska/Publications/Annual_Statistical_Bulletin/2006/akmilk06.pdf

Salmon and alder: Gasification of low value biomass in Alaska

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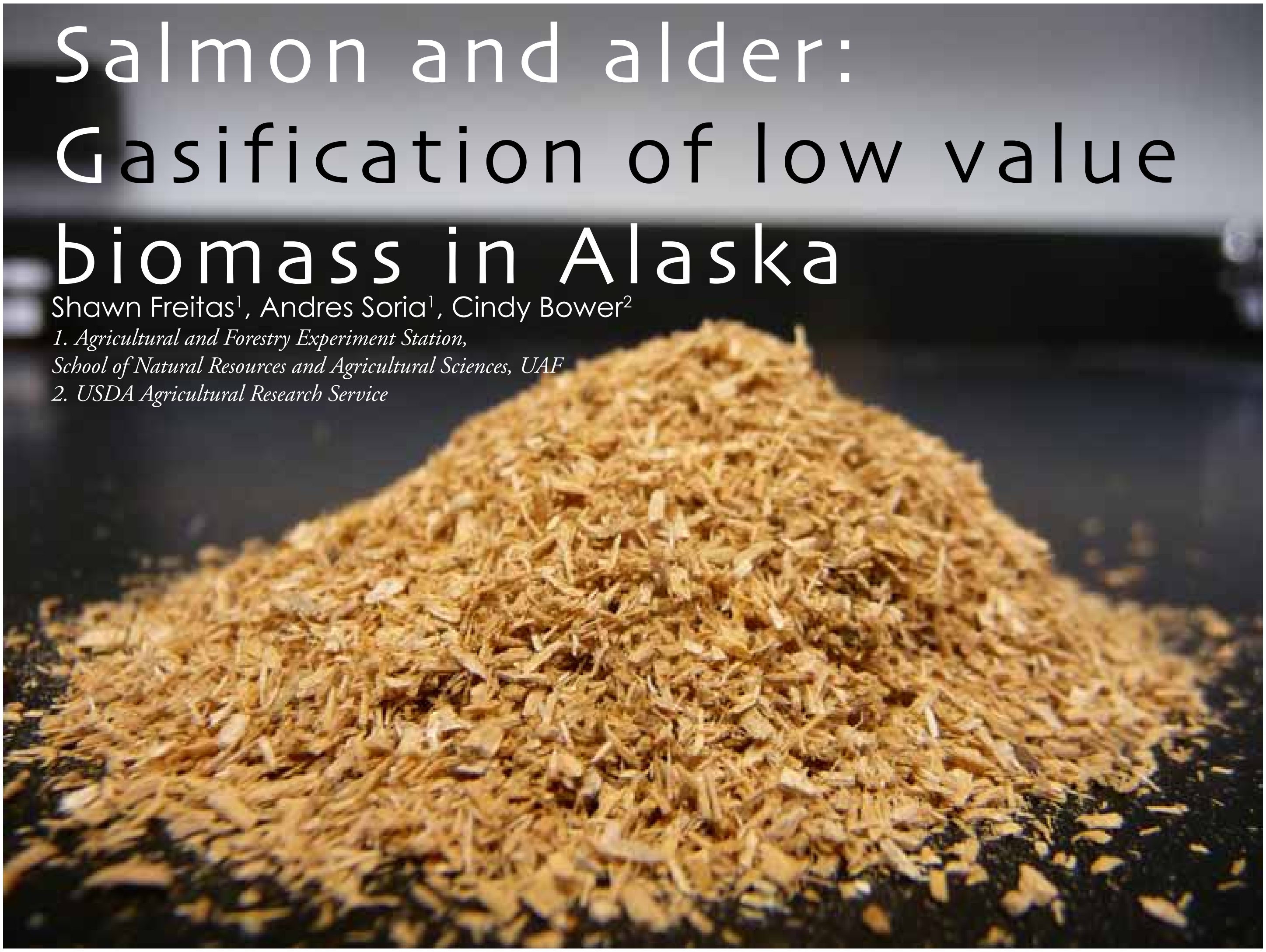

Figure 1. Alder sawdust.

Salmon processors are an integral part of Alaska's world-class seafood industry, employing an average of 20,000 people annually. Most of the processors are geographically located in remote areas near productive fishing sites and as a result the need for importing large amounts of resources and fuel into these areas is logistically challenging and costly. Over the past few years the rising cost of diesel and gasoline has caused a significant increase in the energy costs incurred by the land-based processors. As a result of the Magnuson-Stevens Act, processors could soon face increased costs in the disposal of their fish processing waste. One way of offsetting these costs is to take advantage of the available biomass that may be found in certain locations near on-shore processing facilities.

By combining fish waste and shrubs, we have made a first attempt at converting Alaska-specific biomass into a volatile hydrocarbon mixture that could offset fuel use in remote locations. Our research project was designed to maximize the value of waste streams and underutilized biomass resources in Alaska for production of a combustible gas that could be used to produce heat or possibly operate internal combustion engines. The biomass resources chosen as the feedstock for the experiments included salmon processing wastes (*oncorhynchus*) and small diameter, fast growing red alder (*Alnus rubra*). The project was geared in particular for use in fish processor facilities.

Figure 2. RBH Lab-modified GEK gasifier

We focused on small-diameter alder and fish processing wastes, using them to create a gasifier feedstock mixture. This mixture was gasified and the gasifier was optimized to function with the lightly processed, high moisture materials.

We chose to use a modified GEK downdraft gasifier to conduct the experiments. Modifications to the unit as received from the manufacturer were necessary to make it function with loose, mixed material and to optimize the system to work with high moisture biomass. Modifications included change in fan design, filter media, feed mechanism, air intake, exhaust gas cleanup, and motor control. All of these were done at the AFES Palmer Center for Sustainable Living, in the Renewable Based Hydrocarbons Laboratory (RBH Lab).

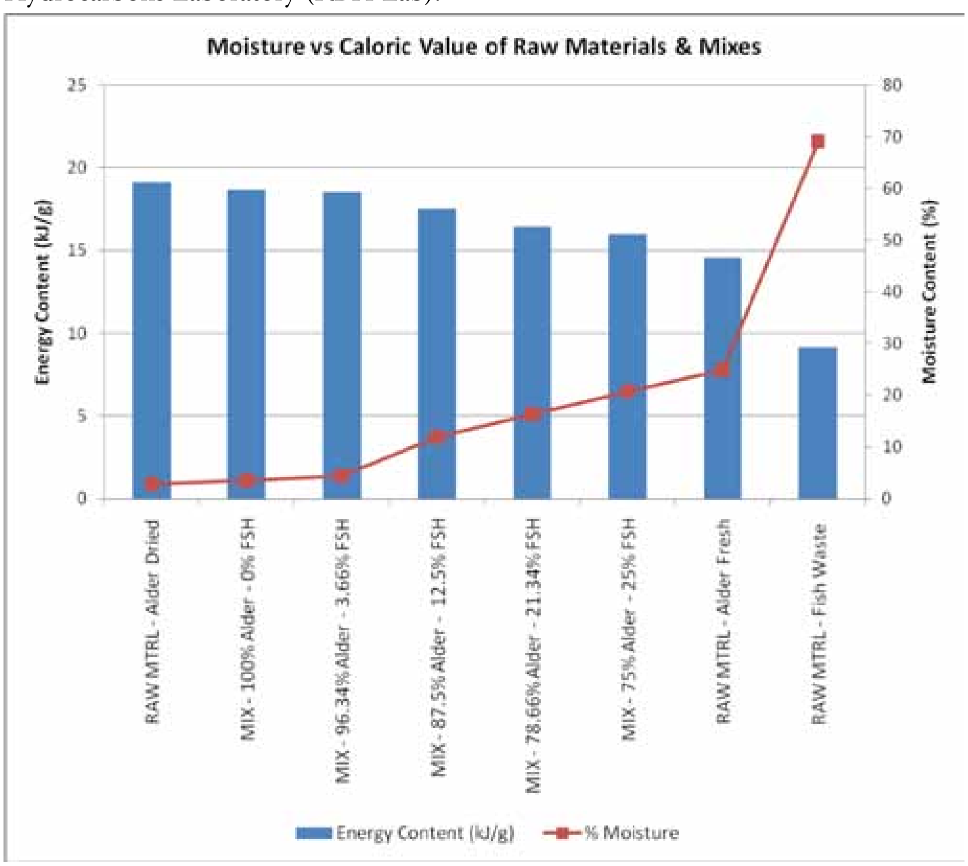

Table 1. Comparison of the moisture and energy content of the fuel mixes and raw materials

To evaluate the potential use of salmon wastes, which were received as a slurry with a moisture content as high as 70 percent, the salmon waste needed to be dried. The waste was mixed with a drier biomass, and used on a percent weight basis to produce a feedstock that reduced the overall moisture to a range that would gasify in the modified reactor (<30 percent). Fundamentally, creating a lower-moisture feedstock was driven by the same requirements that lead people to dry firewood. It is very difficult to burn wet wood and correspondingly high-moisture feedstock does not gasify well. When one attempts to burn wet wood, combustion often fails because the water content is so elevated that the heat that would have been generated in the flame is dissipated and absorbed by the water, quenching the reaction and stopping the process. Gasifying high-moisture biomass requires a significant energy input to the process, which drives down its overall efficiency. Because overall energy efficiency and optimization were important aspects of the project, we developed a series of mixtures of salmon waste and alder sawdust with acceptable ranges of moisture for gasification. The moisture content of these mixtures ranged from 4 percent for air-dried alder up to 22 percent for ¾ alder and ¼ fish mixtures.

We produced three-inch diameter pellets of mixed salmon and alder by loading an approximate volume of the mixture into a dedicated mold and pressing it at 5000psi to ensure desirable mechanical characteristics of the pellets as well as consistency in their form.

Pictures of the raw materials used and the pellets are shown in Figures 1, 3, and 4.

There is no previous literature on gasifying alder, or salmon and alder mixtures, so the work included the fundamental characterization of the biomass feedstocks, including elemental analysis as well as modeling the molecular progression of the thermochemical breakdown. Under idealized conditions and assuming a perfect conversion of the available biomass, one could expect to generate a great deal of energy from the chosen mixtures. However, in reality the energy values of the mixtures as shown by calorimetry are much lower, as there are no perfect conditions in the real world. This comparison, summarized in Figure 5, shows the room for improvement that could possibly be gained by optimizing reactors, feedstocks and conversion systems to approach ideal conditions, setting the stage for future work.

There is a great deal of potential for using gasification as a means to produce a combustible gas, but as Figure 5 shows, this relies heavily on the assumption that all reactions will go to completion and this is very difficult to achieve in practice. The gas composition will vary based upon the described thermochemical reactions and on the original biomass mixture (alder and salmon heads and viscera). Any change in species, from salmon to willows, will yield different gas characteristics.

The biomass mixture is controlled by the creation of the feedstock, but the thermochemical reactions are controlled by conditions in the gasifier. The gasification process is very dynamic, with constantly changing conditions based on temperature, amount of air (oxidant), gas flow rate, and moisture. In a small laboratory/pilot scale system, a minor change in these parameters can result in dramatic temperature changes.

Figure 3. Salmon head and viscera slurry.

Figure 4. Pellets formed from alder and salmon wastes.

We chose to conduct all experiments under equal conditions to minimize the error caused by the natural variability in the materials. Our gasifier was loaded with wood charcoal to produce a hot zone, where temperatures as high as 1000°C were achieved. As charcoal is consumed and combustion is allowed to continue the temperature will rise, but without the addition of new material the temperature will eventually drop until new material is added. This cycle is very consistent and temperatures under identical conditions were predictable, enabling us to use 800°C as a starting point to

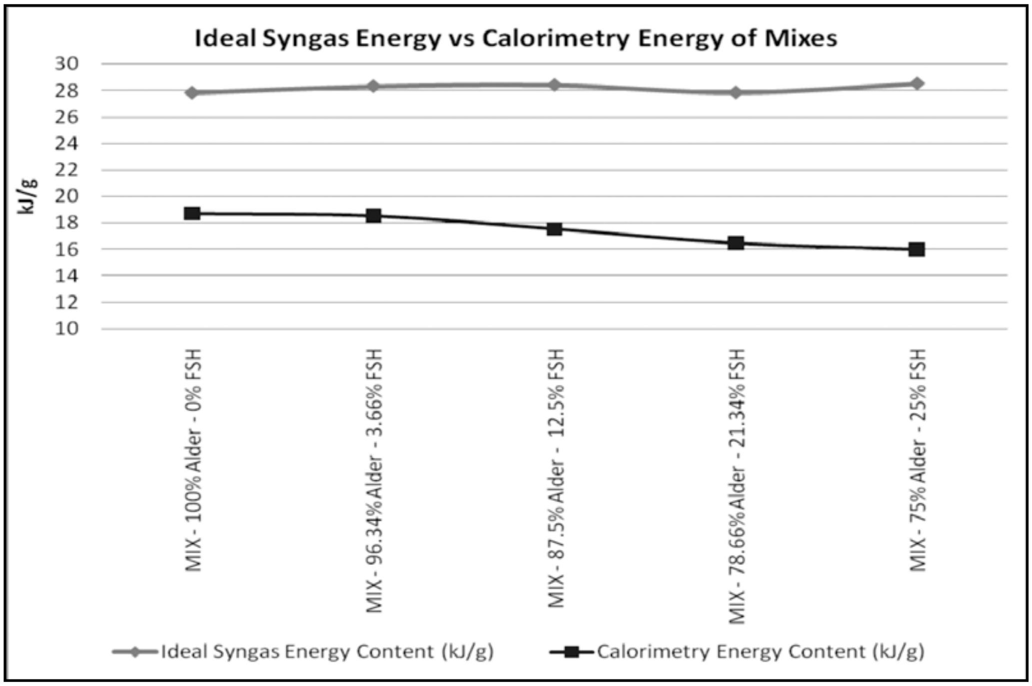

Figure 5. Comparison between the theoretical energy content of an ideal producer gas generated by the fuel mixtures and their energy content determined through calorimetry. Both energy contents reflect the energy generated by combustion.

begin our gasification experiments. As soon as the temperature dropped below this 800°C starting point (from a high of 1000°C), the experimental pellets were loaded into the gasifier unit. The amount of pellets gasified was limited to approximately 1.5Kg per run, resulting in a sustained gasification process of 15 to 20 minutes. A series of thermocouples were placed in the reactor to monitor the conditions during each run.

The temperature profiles for the gasification experiments in the "hot zone" as well as in the resulting flame are presented in Figure 6.

Typically, a high temperature "hot zone" region will create the conditions necessary to break down the biomass mixture in such a way that it will have a higher energy content, resulting in more combustible products being produced and a corresponding higher flame

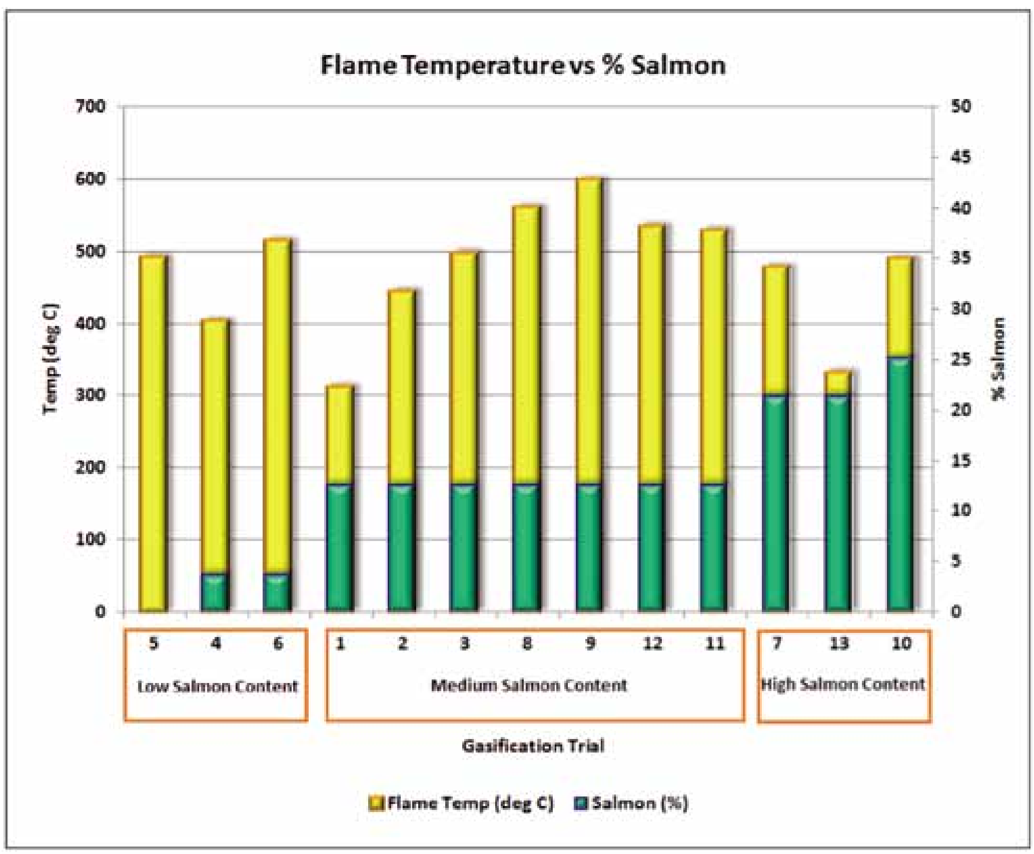

Figure 6. Comparison of the hot zone temperature and the % salmon present in the fuel pellets introduced into the gasifier.

Figure 8. Gasification of alder and salmon flame.

temperature. The relationship between the salmon percentage in the mixture and this hot zone region is generally as the percent of salmon increased the temperature of the hot zone increased, until the salmon percent exceeded around 21 percent, after which the temperature of the hot zone began to drop. This performance drop is attributed to the high moisture content of the mixtures and although a combustible gas was produced, increasing the salmon proportion above 21 percent yielded no measurable improvement in the practical energy harnessed by the system.

In this first attempt at gasifying two of Alaska's widely available and underutilized biomass resources, salmon processing waste and small-diameter alder, the study was successful in establishing mechanisms for gasifying these biomass streams up to 25 percent salmon using a downdraft gasifier. Interestingly, the low salmon waste mixtures with the lowest moisture content were not the ideal feedstocks for gasification. The experiments showed that high salmon mixtures, with up to 21 percent salmon, had the highest practical energy for the type of reactor used and that any increase in salmon content above this point resulted in a sharp decrease in performance. The gasification gases were combustible (Figure 8) and could assist shore-based salmon processors in the future by serving as a source of fuel for heating and for internal combustion engines.

Future work will focus on utilization of the gasification gases and will require better knowledge and understanding of their characteristics as well as the corresponding optimization practices related to the biomass that is available at the target locations.

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About the Renewable-Based Hydrocarbons Laboratory

Our modern high standard of living is a direct result of our ability to transform fossil fuel-based hydrocarbons (oil, gas, coal) into thousands of products, ranging from plastics, lubricants, solvents and fuels. Yet, fossil hydrocarbons will eventually run out. While alternative energy resources have a major role in diversifying our energy portfolio away from fossil resources, these alternatives (solar, wind, hydrogen, geothermal, hydropower, and nuclear energy) are able to produce electricity, but not hydrocarbons. Biomass is the only long-term, sustainable alternative to producing hydrocarbons that can displace fossil fuel-based resources.

The Renewable-Based Hydrocarbons Laboratory (RBH), a part of the Palmer Research and Extension Center, is a proof-of-concept laboratory dedicated to investigating novel and nascent technologies for transforming biomass into petroleum like hydrocarbons. The primary focus of RBH is to use thermochemical conversion techniques to transform forest, agricultural, protein, and waste biomass into combustible gases through gasification and liquid matrices using pyrolysis and liquefaction techniques. Research on the mechanisms of transformation, process optimization, and evaluation of different biomass feedstocks for conversion are helping pave the way for a new future that is more attuned to sustainability goals. Summer internship programs allow students to understand the state of technology better and to gain valuable practical experience in conversion methods that may play a significant role in our future energy and materials portfolio.

The proof of concept idea has extended to the RBH Lab itself, where, since July 2009, the facility has been generating its own electrical power and transportation fuel using the products of our reactions. The RBH Lab is complemented by the teaching/distance delivery center, instrumentation, and wood chemistry facilities at the Palmer Research and Extension Center.

Unlocking hydrocarbons from biomass

J. Andres Soria, PhD, assistant professor of wood chemistry

In the world of renewable energy, biomass is the sole source inherently capable of producing hydrocarbons, the raw material needed for fuel, the production of plastics, and making the variety of products that maintain the economy.

The development of alternative energy resources include solar, hydropower, geothermal, wind, hydrogen, and biofuels. Of this mix, solar, hydro, wind, geothermal (and in fuel cells, hydrogen) produce electrons. At the UAF Palmer Center for Sustainable Living, we are working to unlock hydrocarbons from Alaska biomass and exploring the repercussions that investing in thermochemical conversion research may have for a sustainable future for the state and the country at large.

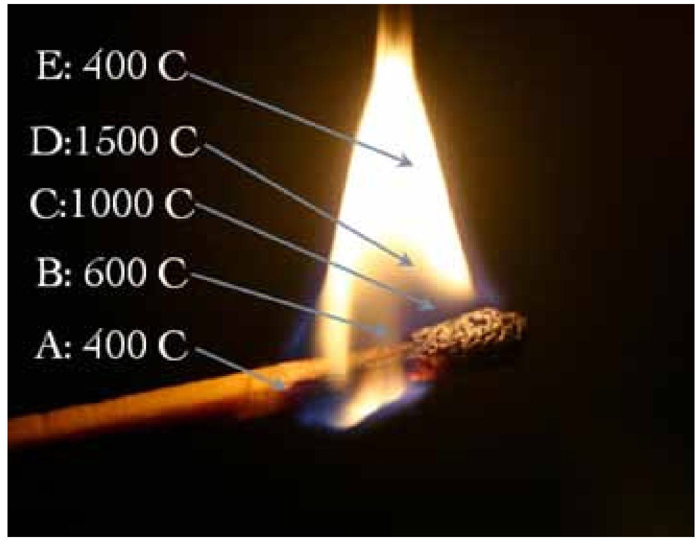

Figure 1. Stages of thermochemical conversion in a lit match.

Thermochemical Conversion Demystified

The complex process of adding heat (thermal) and chemicals as a means of breaking the raw materials of biomass down into hydrocarbons can be demonstrated by the simple act of burning a match.

The first stage of thermochemical conversion in the wood of the match occurs in the form of pyrolysis, the thermal breakdown of materials in the absence of oxygen. At a microscopic level, the wood is shielded from oxygen in the air by the flame itself. This superheated, anoxic (void of oxygen) zone causes the raw materials of wood to break down into bio-oils and gases. These bio-oils are complex hydrocarbon mixtures that range in chemical structures, but often contain five- or six-carbon aromatic rings, alongside phenolic structures from lignin and dehydration products from the sugars. Bio-oil itself can be considered a crude petroleum analog, a hydrocarbon rich black liquid substance that can be further refined and upgraded to yield fuels, bio-based plastics, resins, pharmaceutical and nutraceutical products. The key to the types of hydrocarbons we can produce has to do with the original makeup of the wood, the reaction conditions, and the upgrading option.

The differences between a hardwood and a softwood have deeper roots than just the permanence of leaves during fall and winter. From a chemical perspective, the types of phenolic compounds differ significantly, leading to the production of differing bio-oils. The same applies for interspecies analysis. As a result, we have a mechanism that evaluates the production of hydrocarbons on a species basis, yielding different ratios of compounds and in the process allowing for the understanding of the basic compositional analysis of that species. Discussion of the breakdown process for individual Alaska species under pyrolysis involves reaction pathways too complex to discuss here. Ultimately, one can obtain a series of end-products from pyrolysis that are stable enough to be contained, stored, and handled in the bio-oil. It is important to note that pyrolysis is an endothermic reaction, and just like the equipment that is being used in Palmer to study this process, the burning match zone is the representation of a zone where heat has to be introduced to maintain this chemical reaction. In the lab-scale reactors we have at Palmer, as well as larger industrial facilities, this is done by using external heaters, often electrical in nature, to provide enough energy input to sustain the process of bio-oil production.

The amount of heat determines the rate at which the original wood components break down into the bio-oil, the amount of product that is generated, and the extent of breakdown of the complex molecules into simpler hydrocarbon units. The higher the heat rate and temperatures, the more complete a breakdown and the faster the reaction time. Of course, we are bound by the laws of physics, and in line with thermodynamics, we must introduce energy into a system to cause the system to change. There is no free lunch. Introducing energy into a system has a cost, but in the match analogy, the pressing technical question is why the match flame does not die if at its core there is a process that robs energy from the fire? To understand the answer, one has to think of other liquid/gas interphases (i.e. boiling water to make steam), where materials tend to migrate and collect in different regions based on their inherent attributes.

The pyrolysis oils and gases that are released in zone A travel upward toward the bottom of the visible flame where they are further broken down, with extremely limited oxygen, into tars and lighter hydrocarbons. As the bio-oils break down into a volatile gas mixture, the flame expansion results in the compromise of the "invisible shield" that was holding oxygen out of the hot zone. It is in this area (Zone C and D in Figure 1) that we crack the hydrocarbons and release the most energy out of biomass. In this region, we are producing a gas that has enough energy, released through the flame, that it feeds the pyrolysis process with the necessary energy to sustain the reaction, until all the biomass is consumed. This process of breaking down the pyrolysis products into highly volatile hydrocarbons is called gasification. The products of gasification are the mixture of small size hydrocarbons, hydrogen, carbon dioxide, carbon monoxide, and water.

In Palmer, we have a downdraft and an updraft gasifier with which we are investigating the process using Alaska biomass. In larger scales, we produce alongside the combustible gas, a fraction of tars and char which are not visible in the burning match analogy. What we do get to witness in the match is the flame itself, which is the oxidative breakdown of these gasification products as part of the final thermochemical reaction. The processes of zones C, D, and E release energy, which we perceive visually as the flame and feel as heat. The heat itself follows convective movements, where it travels upward in a plume of air and radiates downward, supporting more pyrolysis, and the system continues until all the fuel (wood) is consumed.

The importance of understanding these systems, and how biomass breaks down under pyrolytic and oxidative pyrolysis (gasification) is key to unlocking the future role that biomass may play in producing fuels and products, especially those that require hydrocarbons as their feedstock. Economics will change, and if and when petroleum resources become so scarce that we must adopt an alternative, we will have only one choice among the renewable options to fill the gap. The sun, wind, water, tides, or heat from the earth will not be able to give us hydrocarbons; only biomass will. Alternatively, we could do nothing and wait a few million years for nature to replenish its coffers, but patience is not a trait we humans excel at.

Hydrocarbons are being produced at the Palmer Center for Sustainable Living from Alaska biomass in modest numbers, ranging from 100 to 300 hydrocarbon species from black spruce, alder, hemlock, yellow and red cedar, birch, Sitka spruce, and white spruce. As the work continues, we are learning more and more about the origin, uses, and ways to best unlock native biomass in order to provide a sustainable hydrocarbon feedstock for the future.

Carex spectabilis: *a sedge for landscaping and revegetation in Alaska*

Jay D. McKendrick

Establishing vegetation on barren ground is a challenge for some habitats in Alaska, especially wetlands and tundra. Usually, grasses have been the dominant plant used. This is probably because cultural practices of grasses are well understood and the seed is often readily available. In contrast the sedges are not usually cultivated for seed production. There is a growing desire to use indigenous sedge plants to revegetate ground in Alaska. How to accomplish this in the arctic tundra is often a question. Attempts to acquire the necessary seed supplies have usually met without success. That may be about to change.

In 1993, I was on St. Paul Island examining a site for revegetation.* During the survey, soil samples were collected and taken back to the soil laboratory in Palmer, Alaska, for testing. Contained within one sample was a rhizome of a sedge (*Carex*). The rhizome was planted in my yard in Palmer. It grew and developed into a handsome plant with promise as a landscape plant, owing to its clump growth form and arching seed stalks. It could be used as a perennial border plant around flower beds at homes and in urban landscapes in Alaska.

The plant was identified as *Carex spectabilis*. In addition to forming an attractive plant, it also produced seed abundantly in my yard. The seed proved viable and resulted in numerous seedlings around the mother plant. I took a clone of the plant to Idaho and planted it in my yard in Burley, Idaho. In that warmer climate, it also grew well and produced viable seed.

The species is close to two others, according to Hulten (1968). *C. spectabilis* is intermediate between *C. macrochaeta* and *C. podocarpa*. *C. macrochaeta* ranges along coastal regions and southward into the Pacific Northwest. *C. podocarpa* ranges through the Arctic and southward into the Pacific Northwest, and is more inland that *C. macrochaeta*. *C. spectabilis* is a coastal denizen and extends southward with *C. macrochaeta*, which may explain why it is easily grown in the Palmer and Idaho environs.

Because seed production is critical for acquiring indigenous plants for revegetation, and the fact that this plant appears easily cultivated and produces seed abundantly, it is a good candidate for revegetation of wetlands and tundra in Alaska. I have often contemplated the use of indigenous

Figure 1. Mature C. spectabilis *plant growing in Burley, Idaho. Note the seed stalks extend well above the leaves, which allows for easy harvest of seed.*

plants for landscaping, and *Carex spectabilis* appears to be one species with potential for revegetation and landscaping.

The next stage is to grow the plant for seed production. Seed has been supplied to a grower in the Matanuska Valley. We must await results of those plantings to determine how easily the seed can be produced commercially. When there is sufficient seed, field tests could be conducted to prove its capabilities for revegetation as well as a landscape specimen. However, within a few years Alaska may have a supply of an indigenous sedge for revegetation. Landscapers could have a source of plant material for shady, wet ground.

Figure 2. C. spectabilis *seedlings established naturally next to the mother plant.*

** Smith, Phillip D.J. and Jay D. McKendrick. 1993. Surface disturbance revegetation / rehabilitation plan M/V All Alaskan Project, St. Paul Island. DHI Consulting Engineers. Anchorage, Alaska. 19 pp.*

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See Hulten, E. 1968. *Flora of Alaska and Neighboring Territories.* Stanford University Press, Stanford, California. 1,008 pp.

Observing the trees, continued from page 22:

forests of Alaska from the south slope of the Brooks Range to Ninilchik on the Kenai Peninsula. Each of the more than 600 plots is periodically re-measured. At each plot trees and regeneration are measured, the site and soils are described, and pictures are taken. This data has been used to develop forest growth models, a forest vegetation simulator model, and to ground truth satellite imagery. "The big advantage is repeated measurements over time," said researcher Tom Malone. "This tracks the long-term changes that may occur in the forest."

Also, multi-species plantation experiments have been established to determine early growth rates and the best spacing for timber management. Other work includes: models of bark thickness and stem volume; estimation of stand woody biomass; and dynamics of tree diversity and its effect on forest productivity.

Projects completed include site index curves for birch, aspen, balsam poplar, and black spruce; a wood quality study; moose browsing effects on stand development; and development of a white spruce bark thickness model.

Dr. Liang recently developed and published the first geospatial models of population dynamics for the Alaska northern forests. This landmark research project enables accurate predictions on forest management outcomes for the region, and provides a useful baseline model to study the change of Alaska northern forests. Dr. Liang is currently investigating forest dynamics under climate change, and is seeking funding to construct regional and national geographic information systems of forest dynamics.

There are numerous forest management tools that will be developed in the future, including bark thickness and volume model development for the other tree species of the northern forests. A biomass research project will also be expanded.

Forestry research assistant Naomi O'Neal measuring trees in the winter, at the UAF Arboretum, at Permanent Sample Plot #448. O'Neal uses a tape measure to determine the diameter of the tree and a laser hypsometer to measure the tree's height. Photo by Tom Malone.

Agencies cooperating with the program include the US Forest Service, Bureau of Land Management, US Fish and Wildlife Service, National Park Service, the US Army and Air Force, the three Boroughs of interior and south-central Alaska (Fairbanks North Star Borough, Denali Borough, and the Matanuska-Susitna Borough), the State of Alaska departments of Forestry and Parks, numerous Native regional and village corporations, and the University of Alaska Land Management Office. The program is funded through grants and the Agricultural and Forestry Experiment Station.

Horace Drury

He faced the challenge of 'new problems in a new land'

Horace Drury, who served as the director of the Agricultural Experiment Station from 1967 to 1975, passed away Feb. 25, 2010 at the age of 94.

He was born in Columbus, Ohio, in 1915. A conservationist at heart, Drury wanted to see the fullest possible use made of trees that were cut down, game that was harvested, and of natural pastures. In his application to become director he wrote, "At some time in the foreseeable future people will begin coming to Alaska not to get rich and not just because they want more room, but because most of the potential farm land further south will be used up. At that time we will need to know what can be grown here and how to grow it, for it will be too late then to start learning."

He stated in 1967 that agriculture in Alaska was in a sorry state. "Many farmers are either on the very edge of bankruptcy or are being forced to continue pouring money from other sources into their farming operations with no end in sight. 'Successful' farmers are often found to be living on the depreciation of their equipment. Most government agents privately believe that the situation is hopeless and if it were not for political considerations, Alaska might well be abandoned to its fate."

Research and education were the keys to change, Drury believed. "We know right now that certain practices, in fact certain types of farming, are hopelessly uneconomical in view of current transportation costs," he wrote.

"Yet homesteaders are still sacrificing their personal resources…still being allowed to go heavily into debt to build up operations in which five pounds of feed are imported to grow one pound of relatively non-perishable produce such as meat or eggs. The mere fact that something will grow here does not mean that it should be grown here. This sort of thing can be minimized by education.

"We often do not know what it will cost to produce a given crop under Alaskan conditions or how much this cost might be reduced by new varieties or perhaps radically new practices. Often we do not know how much could be sold. Too often we rely on the results of studies performed in northern Wisconsin or Minnesota…(where) the growing season is longer and the day-night cycle is different.

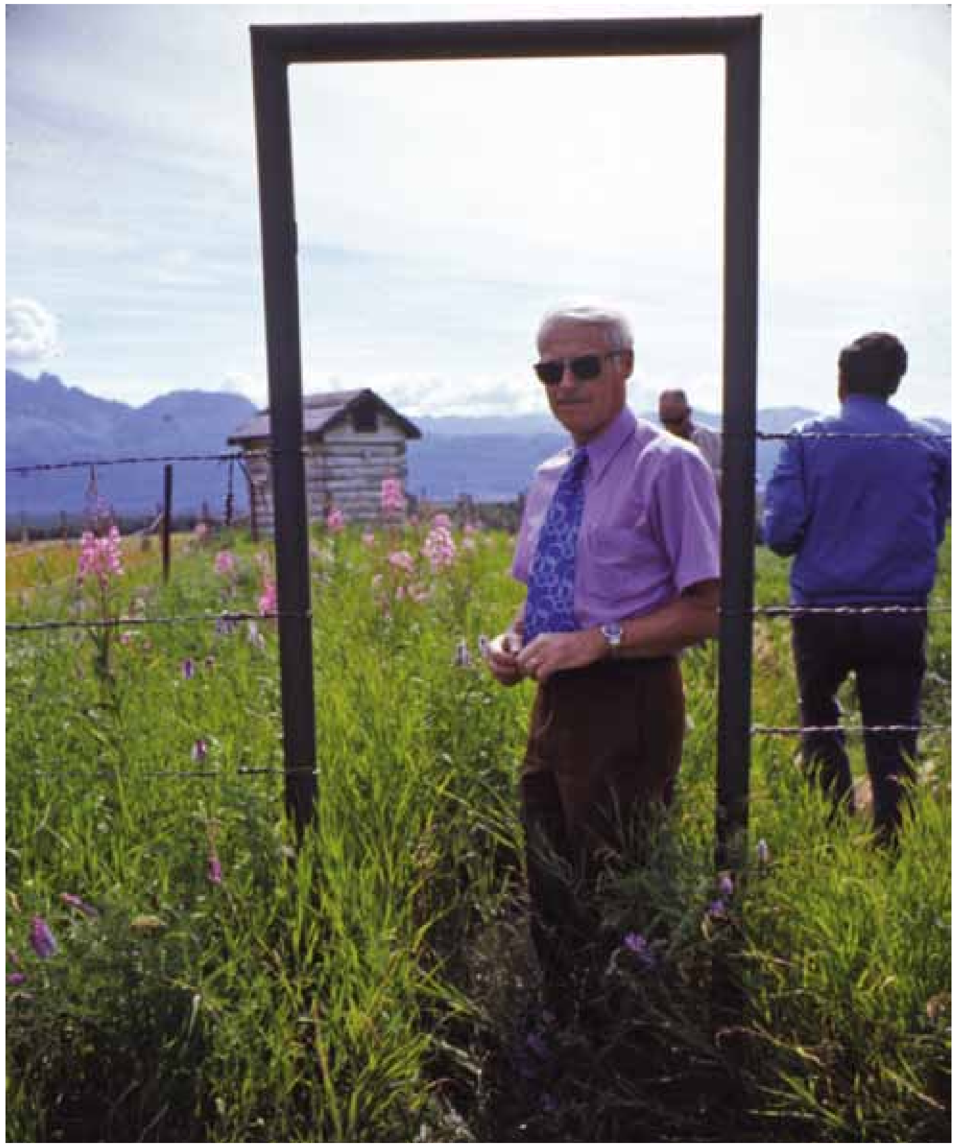
"…Problems can be solved by research. But this research must be carried out imaginatively and in Alaska. Currently, many people think that really effective research would cost more than it would be worth."

He wrote that his interest in growing things went beyond cultivated plants and domesticated animals. "I am a conservationist in the sense that I want to see the best possible use made of our natural resources."

Drury earned a bachelor of science in zoology at George Washington University, a master's in biology at Harvard University, and a doctorate in biology at Harvard. He said, "I have always been a compulsive teacher; perhaps I just find it difficult to keep my nose out of others' business. At any rate, I enjoy teaching." His background was animal physiology and biochemistry research.

Since the age of ten, Drury had dreamed of heading north, and he loved Alaska. "We like the vast, wild, beautiful landscapes, the climate (winter as well as summer) and the excitement of solving new problems in a new country."

He served in the Army Air Corps as an aviation physiologist from 1943 to 1946. He taught at Brooklyn College and Suffolk University. In the Air Force from 1951 to 1954, he became a major and was director of research the Arctic Aeromedical Research Laboratory in Seattle and at Ladd Air Force Base.



Horace Drury at the Matanuska Experiment Farm.

He was a private pilot, logging more than 7,500 hours in his plane. A music lover, he would often fly to music festivals in Alaska and Outside, and enjoyed looking down at farms as he flew over the land. The Drurys took over an overgrown abandoned homestead near North Pole and made it into a personal statement on the state of the art of agriculture in Alaska. His family wrote about the farm: "During the years that he managed his farm it consistently produced the highest grade, most cost effective and cleanest milk in the state…he was known to have the lowest bacterial count in its produced milk of all the farms in Alaska." He and his family built their home and all the farm buildings including a barn that was dubbed "the warmest barn in Alaska."

In 1984 Drury donated most of the homestead to UAF, with a portion used for development and the remainder as a nature conservancy. In addition to his scientific, musical, and flying talents, Drury was an inventor; he held a patent on a type of tire chain.

His family designated the Georgeson Botanical Garden as the recipient for memorial donations. "Dad truly loved the Georgeson Botanical Garden," his family wrote. Donations may be sent to the UAF Development Office, P.O. Box 757530, Fairbanks, Alaska, 99775 or visit www.uaf.edu/giving.

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Right: Recent publications at SNRAS. From left to right: Math in a Cultural Context's lastest math curriculum module, Kayak Design: Scientific Method and Statistical Analysis; *UA Geography's AMSA workshop report,* Consideraing a Roadmap Forward: The Arctic Marine Shipping Assessment*; and AFES Circular 135 from the Department of High Latitude Agriculture,* Growing Small Grains in Your Garden.

An amateur brewer tried using Sunshine Hulless Barley, the variety of barley released by the Agricultural & Forestry Experiment Station in 2009, with award-winning results. Photo by Anita Hartmann. See story on page 33.

A chicken tractor at Rosie Creek Farm, a certified organic farm that sells produce directly to restaurants, and to consumers through its community supported agriculture program. Small farms like this are part of a growing local food movement in Alaska. AFES photo by Nancy Tarnai. See story on page 23.