UNIVERSITY OF ALASKA FAIRBANKS

Special Program Review

UAF Farms and Large Animal Care

1/9/2015

Committee Members:
Nettie La Belle-Hamer, Associate Vice Chancellor for Research (Chair)
John Blake, Associate Vice Chancellor for Research and UAF Attending Veterinarian
Kelly Drew, Professor, IAB Biomedical and Health Sciences
Jennifer Harris, Executive Officer, School of Fisheries and Ocean Sciences
Ruth Prato, Instructor of Accounting, School of Management
Arleigh Reynolds, Associate Dean, Veterinary Medicine
Milan Shipka, Professor of Animal Science, Chair; UAF Institutional Animal Care and Use Committee
Steve Sparrow, Interim Dean, School of Natural Resources and Extension and Interim Director, Agricultural and Forestry Experiment Station
Cameron Wohlford, Senior Project Manager

Assisting the Committee:
Sylvan Robb, Sr. Program Analyst, Office of Management & Budget
Carla Willetto, Associate Veterinarian, Animal Resources Center

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Abstract

UAF has been engaged in agricultural teaching and research since its inception in 1917 as the Alaska Agricultural College and School of Mines. The College site was selected in part to enable co-location with the Fairbanks federal agriculture experiment station established in 1906. Both the Fairbanks Experiment Station and the Matanuska Experiment Farm were transferred to the college in 1931. Over the years, UAF animal research broadened such that today UAF operates several facilities for agricultural and animal research. This committee was charged by Chancellor Rogers to perform a special program review of the four main facilities to consider whether there are additional possibilities for achieving savings. It is this committee's assumption that the mission of UAF will be best served if large animal research and education continues at some level. We are therefore seeking creative solutions to the strategic use of the reduced funding available for underwriting this enterprise.

Definitions

Inventory maps for each of the facilities involved in this report have been provided by Facility Services and are available on the special review Web site (http://www.uaf.edu/finserv/omb/uaf-program-reviews/).

LARS	Robert G. White Large Animal Research Station comprised of herds of reindeer, caribou, and muskoxen located off Yankovich Road in Fairbanks, Alaska.
BRAF	Biological Reserve Animal Facility located on UAF North Campus (north of the ski trails) focuses on naturalistic housing of research animals and has periodically been used as a quarantine facility.
FEF	Fairbanks Experiment Farm comprised of the agricultural reindeer facilities, Georgeson Botanical Garden, and the field between West Tanana Drive, the Parks Highway, and Geist Road, the T-Field, and several buildings on the north side of West Tanana Drive.
IOHF*	Irving 1 Animal Facility will be decommissioned and repurposed in February 2015. All indoor components of this animal facility have been relocated to BiRD. The outdoor pens and runs at the north end of the Irving 1 facility are to be demolished in summer 2015 but a location for their replacement has not yet been determined.
MEF	Matanuska Experiment Farm comprised of greenhouses, agricultural fields and forest lands, small herd of cattle, fully equipped soil and plant analysis laboratory, two classrooms with distance delivery capability, located near Palmer, Alaska.
DJFRS	Delta Junction Field Research Site comprised of agricultural fields and forest lands located near Delta Junction, Alaska.

* Irving I and the BiRD animal facilities are not part of this review. However, since the relocation of the outdoor pens and runs from Irving 1 is discussed and since LARS, BRAF, and FEF are listed as possible relocation sites, this facility is discussed in this report.

Bottom Line Up Front

- Under the assumption that UAF wants to continue large-animal related research and educational activities, this committee found no actions that would at once preserve our capacity and realize significant cost savings for the next fiscal year. Instead, we found ways to potentially increase revenue or decrease operating costs over a longer time frame.
- UAF should invest in LARS for the future as it is our most advanced large animal care facility. It is used in research, outreach, and education, including our new professional veterinary medicine program.
- UAF Animal Facilities should be managed to provide services and access for multiple researchers and programs. Our animal care program is centralized but management of many of our facilities continues to be decentralized and independent. No permanent UAF animal facility should be managed by an individual Principal Investigator (PI). If scientifically justified, IACUC procedures allow for establishment of temporary project-specific satellite facilities. However, these are terminated at the end of the project. We propose that UAF animal facilities be placed under the Animal Resource Center (ARC) to provide a common centralized management system. In ARC animal welfare trumps PI needs, ensuring compliance with animal care laws and access to animals for use in research and education for multiple PIs.
- Maintenance of the animal herds and colonies for research and education requires financial support similar in concept to maintaining buildings, even during periods of lower usage. To this end, university owned or maintained animals will require Fund 1 support for their basic long-term care to ensure the ethical treatment of the animals and compliance with federal law. However, the recharge rates for research services specific to projects that are allowable charges on grants and contracts should be examined to establish a standardized methodology for both rate calculation and application.
- Public Private Partnerships (P3) should be explored for using the farmlands as revenue generators. This could be applied to FEF, MEF, and/or DJFRS.
- Sales of farm-related products should be explored for possible increases in current revenue streams. Concerns about competition with local vendors could be addressed by a strategic P3.
- Efforts to increase revenue generation through outreach and education programs should be explored at all facilities.
- Researchers across UAF disciplines should be made aware of the facilities' potential and encouraged to use them, especially non-traditional users of such facilities. The intent is to more fully exploit the assets as long as the new activities do not interfere with the existing animal research or basic animal care.

Recommendations Summarized by Facility

1. LARS is the most expensive and the least expendable of the large animal facilities at UAF. It is used for research and education by both faculty and students. Basic veterinary services are not charged to the researchers due to need to remain in compliance with animal care laws. There are recharge rates for use of specific protocols by faculty. There is currently large animal research occurring at LARS and faculty continue to submit proposals to funding agencies based on the capacity there. The Veterinary Medicine program will be dependent on the facility to meet curricular and research obligations. There are additional needs of the Veterinary Medicine program that could be met through expansion of LARS specifically to support the curriculum.
    a. Recommendation: continue with basic veterinary care as Fund 1 support through the VCR budget to ensure compliance with federal and state laws, proper care of the animals, and broad access to the animals for the faculty.
    b. Recommendation: an assessment needs to be done to determine optimal species availability and animal numbers. Given the changing programmatic interests at UAF, the herd size and species availability may need adjustment.
    c. Recommendation: continue operating LARS for both research and teaching, but reexamine the recharge rates. Recharge rates should reflect the actual cost to maintain the animals inclusive of all non-project specific costs with the knowledge that animals will need to be subsidized when not supported by a project. We suggest looking at other similar facilities at other universities as comparison and focusing on costs that are project specific.
    d. Recommendation: pursue removing LARS from the UAF radiation license even though it will limit future research using radioactive isotopes. Many of the experiments that previously used radioactive isotopes are no longer actively pursued by current faculty or can be done with stable (non-radioactive) isotopes. This may take some time, but will allow animals on LARS to be used for food production research and meat sales.

2. BRAF is inactive currently, but incurs very little expense as the naturalistic facility for research animals.

    Recommendation: no change in the status of this facility but do recommend that the IACUC specify what is required to make existing components usable for animal housing and what components, if any, should be condemned.

3. IOHF has been used for a wide variety of species in projects that require access to either combined indoor-outdoor runs or outdoor housing with adjacency to the animal facility service areas and utilities. Historically, these runs and holding areas have been used for basic biological, biomedical, and behavioral research involving sheep, reindeer, mink,

ducks, geese, various passerines, rodents, fox, and bears. More importantly, proper sanitation of the facility requires direct access to utilities such as water, electrical, and sewage. There are plans to remove the existing outdoor holding area as part of the BOR approved West Ridge Deferred Maintenance Plan. The facility needs to be rebuilt with one that meets requirements for proper animal care. The optimal location requires further consideration.

Recommendation: Go forward with existing plans to relocate the outdoor holding areas with an open design that is sufficiently flexible to accommodate different projects and different users. There is not a consensus in the committee on the issue of where to build this, but there is a consensus that we need to build it. If we leave the new build until grant funding drives specific need for modifications, there is a danger the facility will be built with too narrow a scope. That would drive up future costs and mitigate the usefulness of doing the build now. Additionally, without the facility in place, there is a minuscule chance of receiving a grant that requires this capability even on the premise that it would be constructed if the grant were received. The build is estimated to cost $650k and take one year to complete. It is currently budgeted in the Deferred Maintenance Plan and should move forward.

4. FEF and MEF have both animal and crop farming capacity, both in the agricultural realm. The animals cannot be moved to LARS without losing the food production aspect of their use to research until LARS is removed from the Nuclear Regulatory Commission (NRC) radiation license. However, once that is done the herd could be moved.
    a. Recommendation: the reindeer at FEF could be moved to either MEF or LARS, depending on cost and access analysis. This would allow the FEF to become animal-free and cut down on those duplicated expenses. There are many hurdles to moving this herd, but it is currently viewed as a possibility.
        i. The current state of MEF is not adequate to house the reindeer. An investment of University funds would be required to improve the facility so it could accommodate reindeer. However, given the facility's prime location, there is substantial revenue generating tourism potential.
        ii. The Reindeer Industry Act of 1937 limits ownership of reindeer in Alaska to Alaska natives only. There is an exception for non-native ownership of reindeer originating in Canada. UAF reindeer are held under permit granted by the Bureau of Indian Affairs.
        iii. The animal care is funded mostly out of Hatch funds and the required one-to-one matching fund 1 for Hatch. The support for the basic care needs to be moved to ARC from SNRE/AFES. The research dollars should stay where the research is conducted, including the ICR.
        iv. LARS cannot house animals intended for human food production until this facility is removed from our radiation license as it negates the possibility of meat sales or research into meat quality and marketability.

v. The PI for the Reindeer Research Program manages the herd at the FEF and also works with the reindeer herders in Northwest Alaska. The Reindeer herders, including some Alaska Native herders, were contacted by the PI and told the Program was being cut. Although somewhat misguided, it did raise some voices in defense of the program. Some of the herders who spoke out were agreeable to the idea of soliciting more state support. If properly coordinated, this may be a strategic help for UAF.

b. Recommendation: a herd size analysis needs to be done for the animals at both FEF and MEF. It is suspected that the herds are not of the optimal size for the current uses. It may save costs to cull the herd appropriately if the herd size is determined to be larger than required. Given the small number of cattle at MEF it is unlikely that herd reduction would be the outcome of the analysis, but this is difficult to tell without further study.

c. Recommendation: explore a public private partnership arrangement to generate revenue for the FEF.

d. Recommendation: continue to use the lands to grow food for the herds and explore additional agricultural research and extension opportunities related to climate change and food security. These lands are not being fully exploited currently.

5. DJRS is primarily crop lands and forest lands.
    a. Recommendation: explore a P3 arrangement to create what would essentially be a tenant farm for the Delta Junction agricultural lands not used for research.
    b. Recommendation: continue to use the lands to grow food for the herds and explore additional agricultural research opportunities related to climate change and food security. These lands are not being fully exploited currently.

Details of the Facilities

LARS

Purpose: LARS serves excellence in research and education in high-latitude biology

Unique capabilities of the current facility:

- Provides a unique facility for research and education that focuses on muskoxen, caribou, and reindeer
- Provides the expertise for maintaining colonies of these large animals
- Coordinates educational opportunities
- Conducts community outreach in support of the UAF mission

Research projects involve UAF graduate and undergraduate students, UAF faculty, research associates, visiting scientists, and interns. Research emphasis includes studies on:

- comparative nutritional and reproductive physiology
- endocrine and physiological controls
- behavior and energetics
- genetics and disease
- Pasture and grazing management

Other considerations:

Because we have LARS, we have the ability to conduct basic research with arctic ungulates including muskoxen and reindeer. This facility also provides significant community good will and tourist interest through tours and qiviut production and sales. Undergraduate and graduate teaching and research opportunities in large animal restraint, examination, and treatment techniques at UAF can only be taught using the facilities and equipment currently present at LARS. To accommodate changing program directions, particularly for Veterinary Medicine, animal populations may need some manipulation to include 10 of each of the more common domestic large and mid-size animals, such as 10 cows, 10 sheep, and five horses.

Without LARS we would lose not only our ability to do nutritional or reproductive research on muskoxen and reindeer, but the public outreach and community goodwill provided by this facility would be lost as well.

BRAF

Purpose: The Biological Reserve Animal Facility is a multi-use, multi-user facility to provide for naturalistic housing of a wide variety of species. The BRAF allows us to study animals in a minimally controlled environment under conditions as close to a natural setting as we can achieve while still allowing for access and monitoring of the animal subject. This is unlike our traditional animal research facilities that are designed to control for all factors that might influence the outcome of a research project.

Description:
The Biological Reserve Animal Facility is an AWA registered facility. The BRAF is a fenced area of approximately 7.5 acres within the 140 acre Biological Reserve located in the UAF North Campus.

This is a relatively old facility with minimal infrastructure, no utilities except electrical and internet to the bear monitoring cabin, and poor soils for construction. Its primary use is to provide for a quiet, undisturbed area where project specific naturalistic housing can be set up and maintained. Over the past 30 years we have used the BRAF for naturalistic housing for voles, snowshoe hare, Arctic fox, sheep, porcupines, black bears, ravens, various passerines, and wood frogs. We have also utilized animal pens for research and quarantine activities for horses, reindeer and muskoxen. Given the facilities isolation, it does offer a very quiet area to house animals while maintaining proximity to campus veterinary services and dedicated animal research procedure areas.

Given the multi-user orientation the BRAF is subdivided into areas:

1) The most complex activity in BRAF is the monitoring of black bears during hibernation. Black Bear hibernation monitoring has been conducted off and on for 20 years with significant upgrades being done in the past 10 years. This area consists of hibernation dens equipped to fully monitor physiological parameters up to four bears each winter. This includes but is not limited to oxygen consumption, CO2 production, sleep patterns, electroencephalogram, electrocardiogram, muscle movement, eye movement, and body temperature. An adjacent heated cabin with electrical and high speed internet is used as a monitoring station. This facility is for hibernating bears only and cannot be used to maintain awake, active bears.
2) A multi-purpose open sided hut (commonly called the Hare Hut) is available for some species. It is open faced but covered in wire mesh to prevent wildlife from getting in and to offer a secondary barrier should animals inside escape their primary enclosure. This is an open and very flexible structure that we have use for naturalistic housing of hares, porcupines, and various birds.
3) The west end of the BRAF is a 3.2 acre pasture with a wing fence and roofed shelter for feeding. Has been used for ungulate housing and research.
4) Arctic Ground squirrel hibernaculum has not been used successfully in over 20 years and is currently unusable.
5) Sheep shed row is used as cold storage for caging and equipment from other animal facilities. Sheep housing is a need for the Veterinary Medicine program and we should consider returning this area to animal holding.
6) Five holding pens for short term holding of ungulates are present near an ungulate handling facility. All are aged and in disrepair with noticeable frost jacking of posts. Runway to west pasture is also in disrepair.
7) Rest of facility is black spruce forest.

FEF

Purpose: Provides site for research (especially in agricultural, forestry, ecological, and other research, especially applicable to the Central Tanana Valley and surrounding areas), teaching (both local and distance), and outreach in agriculture, forestry and other natural resource issues.

Unique capabilities of the current facility:

- Has land farmed longer that any anywhere else in Interior Alaska (important for long-term monitoring, such as impacts of climate change on agriculture and forestry).
- Soils ideally suited for research on crops adapted to Interior Alaska (research done anywhere else in Alaska would not be applicable to Interior Alaska farming).

- Location at edge of UAF main campus provides unique, easy, and quick access for UAF researchers and instructors. Allows classes to do field trips within time frame of class period.
- Ideally suited for small-plot, intensive research on agronomic and horticultural crops.
- Longest continuous weather data in Alaska.
- Home to only university operated research reindeer herd in North America that is capable of meat quality and marketing studies, providing unique opportunities for herd health and production research. The university does NOT own the reindeer herd.
- Home of the Georgeson Botanical Garden, the only subarctic botanical garden in North America and one of the most visited locales in the Fairbanks area. It was ranked 19th among 50 Most Stunning University Gardens and Arboretums in the World (http://www.bestmastersprograms.org/most-stunning-university-arboretums-and-gardens/).
- Only tree-ring laboratory in Alaska, one of few fully equipped tree-ring preparation laboratories in U.S.
- Home to four outdoor kilns used by art classes for firing pottery. Only outdoor, university owned kilns in Alaska.

Other considerations:

Elimination of the FEF would eliminate the possibility of:

- Study of climate change effects on agriculture going forward by use of the longest maintained weather data in a single agricultural location in Alaska.
- Severely limit small plot studies of grains and oil seed crops applicable to interior Alaska. (see Aurora magazine, 2009, volume 1, issue 2) and severely limit breeding of new crops.
- Potentially elimination Georgeson Botanical Garden, one of the most visited sites in Fairbanks and source of UAF outreach aimed at all ages.
- Limit forestry research including tree ring research and forest regeneration studies,
- Limit access of UAF art students to modern, unique kilns for various ceramic firing techniques.
- Open fields needed for various kinds of research needing close proximity to campus (e.g. some atmospheric research, long-term songbird nesting monitoring).
- Loss of controlled environment facility for studying plant physiology.
- Loss of public goodwill/support for UAF would likely ensue should FEF be eliminated or the activities there significantly curtailed. We saw this some years ago with a proposal to place a Walmart store on the FEF fields.

Removing the animals from FEF would potentially limit herd management teaching, research, and outreach for NRM animal science classes if the animals are not as accessible. Moving them to LARS rather than MEF for this reason would be preferable. The pre-veterinary medicine programs

and veterinary medicine programs will already be using LARS as their main facility, so it will have minimal impact on these programs.

The FEF animal facility could support large-scale controlled reproduction and nutritional studies if easier access were granted to collaborating scientists. Animals from FEF could also serve as 'feeders' for LARS small herds used in hands-on practice for Veterinary Medical students, allowing fresh animals to the existing LARS herds and rest period for heavily used animals. Movement of animals between the facilities could only occur if the concerns regarding radiation contamination are satisfied. Further, as animals from FEF went to slaughter, students could follow the slaughter process through the USDA inspected slaughter facilities at North Pole or Delta Junction. As such, animals from this facility would also be used for Veterinary Medical students to learn about slaughtering techniques and practices important in the study of meat inspection.

Without this facility large-scale reindeer research would have to be done at LARS with an increase in animal numbers there. Slaughter practices would have to be moved elsewhere.

MEF

Purpose: Provides a site for research, especially in agricultural, forestry, and ecological research, especially applicable to the Mat-Su Valley and surrounding areas, support teaching (both local and distance), and engage in outreach in agriculture, forestry, youth and community development as well as other natural resource issues of importance to Alaskans.

Unique features:

- Only major UAF satellite campus located in close proximity to 65% of Alaska's population (also faster growing population).
- Location provides unique opportunities for exposure of large number of K-12 students to programs such as 4H, FFA, One-Tree.
- Has land farmed longer that any anywhere else in Southcentral Alaska (important for long-term monitoring, such as impacts of climate change on agriculture and forestry).
- Soils ideally suited for research on crops adapted to Southcentral Alaska (research done anywhere else in Alaska would not be applicable to Southcentral Alaska farming, which is home to the highest per acre value agriculture in Alaska).
- Longest continuous weather data in Southcentral Alaska.
- Contiguous green space between Matanuska Experiment Farm, Alaska state parks, Mat-Su Borough lands, and Mat-Su College forested lands provide easy access to a total of 3,000 acres of green space for recreation and for outdoor recreation research and teaching.
- Classroom facilities for UAF classes and outreach, especially for Mat-Su Valley and Anchorage area students, including cutting edge video conferencing technology allowing connection to all of Alaska.

- Only soil and forage testing laboratory in Alaska with capability for routine analysis of various soil components, and available on a fee basis to the public agencies, private firms, and individuals.
- Will provide site for veterinary medicine teaching about domestic livestock production.
- Infrastructure in place (with some upgrades) to increase livestock production and large animal herd health research (including readily available forage, year-round liquid water).
- Four modern greenhouses (approximately 4500 total square feet) available for various kinds of agricultural and biological research (three of the greenhouses can be heated and used year-round).
- Processing/storage facilities are in place and open for local entrepreneurs, helping new agricultural industries get off the ground.
- Co-location of research and extension faculty and staff allows unique opportunity to integrate research and outreach.

Other considerations:
Elimination of the Matanuska Farm and/or the cattle seed stock would eliminate the possibility of:

- Access to agricultural and natural resource learning opportunities for much of Alaska's urban population.
- Long term monitoring studies of climate change effects on agricultural production in Southcentral Alaska.
- Contiguous green space used by the public and by public schools in the region.
- Recruitment of students to UAF who prefer not to move to Fairbanks.
- Potential source cattle herd for Veterinary Medicine program, including research and herd health education.
- Forage testing and soil testing in Alaska available on a per sample fee basis to public agencies and to individuals.
- Incubator facilities for growth in peony, rhodiola, other vegetable crops (now using coolers and other facilities for staging such crops for optimum marketing).
- Removal of the only co-location of CES outreach team with teaching and research capabilities,
- Lose of capability of holistic land and livestock grazing management by elimination of hundreds of acres of established pasture or by elimination of foundation cattle herd (holistic animal/plant/soils management is the future of sustainable agriculture in Alaska and other areas of the USA and of the Circumpolar region; Note that initial studies are currently modeling animal influence on plant species and soil conditions are underway at LARS)
- Loss of public visibility and support for UAF in Southcentral Alaska. An example was the public outcry seen with a recent proposal to restrict access through the MEF to public trails.

This facility is too far from Fairbanks to act as the main facility to provide equipment and animals for teaching large animal restraint, examination and treatment techniques but it could act as a feeder source of animals for LARS. In this way sustainable herds of cattle, sheep, and goats could be maintained rather inexpensively in Palmer and then shipped as needed to LARS, keeping the number maintained at LARS to only that needed at the moment for teaching and research purposes. This station is also the only facility we have where large scale controlled nutritional and reproductive studies can be performed on traditional livestock species.

Another opportunity could be available for week long or extended weekend wet labs using animals at the MEF should the facilities be improved there to provide short term dormitory facilities for the Veterinary Medical students, something that is currently in the planning stage. Further, given that the MEF is located in such close proximity to 65% of Alaska population, the animals and facilities naturally lend themselves to recruitment for the Veterinary Medical program and recruitment for other animal related programs in general.

Without this facility we would lose our source of cattle for teaching in the veterinary medicine program and for research purposes. This would be very hard to re-attain the minimum herd size required to meet the needs of teaching, research, and outreach. The reasons for this are that large mammals have longer gestation periods and fewer offspring. Additionally, purchasing large mammals for research is not really feasible.

DJFRS

Purpose: Provide a site for research, especially in agricultural, forestry, and ecological research applicable to the Upper Tanana Valley and surrounding areas (the region with largest acreage under managed agriculture in Alaska). The facility is managed under Fairbanks Experiment Farm.

DJFRS consists of agricultural fields and forest, both currently used in research efforts. No animals are located there. It is low cost to operate and the research there includes agronomy, soil, and forestry research. DJFRS is used as staging for ecological research in the area. We do not recommend selling the land, or even some of the land. UAF could lease land, but market inquiry for leased land in Delta resulted in estimate of only $20 to $50 per acre annually, thus revenue would be minimal. Most strategic plan would be to explore potential options for leasing or share cropping to grow hay for LARS, perhaps in a P3, and to sell to public buyers.

Unique capabilities of the current facility:

- Soils and climate typical of those in the region and thus only site suited for research on crops adapted to Delta Junction region, which has majority of Alaska's farmed land.
- Only research farm in Alaska set-up to study long-term irrigation effects on agronomic crops.
- Provides "home-base" for ecological scientists studying fire, climate change, vegetation, and related activities in Upper Tanana Valley region
- Location of longest tillage study (20 years) anywhere in subarctic region.

- Lowest cost agricultural research facility in Alaska.

Other considerations:

Elimination of the Delta Junction Field Research Site would:

- Eliminate large plot cereal grain and oil seed research under conditions in which crops are being produced in Upper Tanana Valley Alaska.
- Eliminate irrigation research in the driest agricultural region of Alaska with application for Yukon Territory, Canada.
- Base for numerous UAF research studies in the Upper Tanana Valley area.
- Loss of visibility and public support for UAF in Delta Junction area. Famers in the area visit the research plots often and rely on much of the research done there in developing their own crop management practices.

This facility permits large scale research into crop growth, sustainability, and potential marketability in our sub-arctic climate. This information is important for veterinary students who may be making recommendations to Alaskan farmers on forage and concentrate sources for their animals. This site is not labor intensive. Development and testing of new crop varieties suited for our climate requires a facility of this size.

Without this facility we would lose our ability to test the feasibility of new crop strains for commercial agricultural use in our climate.

Financial Analysis

Below is an overview showing the FY14 Unrestricted expenses and revenues for the facilities. This includes 103010 and Fund 14 (match) costs for LARS, FEF, MEF, and DJFRS. BRAF incurs almost no expenses to operate and none were included here. Note also that the figures below do not include recharge center activity for veterinary services provided by the Animal Resources Center.

Annual Unrestricted Financial Overview		
Personal Services Costs	$	708,431
Travel	$	1,466
Services	$	214,657
Commodities	$	172,531
Match commitment - partial (USDA capacity funds)	$	350,431
Total Expenditures:	**$**	**1,447,517**
Admission, gift and qiviut sales	$	106,000
Admission, gifts & plant sales, straw, haylage, livestock & meat sales	$	131,966
Total External Revenue:	**$**	**237,966**

Financial notations and recommendations:

- As with most programs, personal and staff benefits cost represent the largest category of total expenses
- The financial data does not include Veterinary Medicine tuition receipts of approximately $350K per academic year beginning FY16
- The figures presented:
    - exclude faculty salaries
    - include caretaker and technician salaries
- UAF will reduce the facilities operations costs at FEF with the new heat & power plant
- Timelines to increase grant research opportunities must be articulated by program management
- Philanthropic giving and external funding opportunities are available and must be explored

Chart of current research and academic activities occurring on the facilities are contained in Appendix A.

Appendix A: Research Use of Farms and Large Animals

This is a compilation of many of the publications and classes that rely on UAF's large animal facilities for research capacity. While we realize this is not a complete list, it is representative of the depth and breadth of the impact these facilities have on the UAF research enterprise.

Research at and Use of Facilities in Past Five Years

Facility	Classes Using	Research Projects	Publications
Biological Reserve Animal Facility		5 projects	9 journal articles
Delta Junction Field Research Site		11 projects	29 journal articles, 1 AFES publication
Fairbanks Experimental Farm		27 projects	42 journal articles, 4 book chapters, 9 AFES publications, 1 CES publication, 15 other publications, 9 thesis & dissertation, 3 conference papers
Large Animal Research Station	9 current classes + 5 new Veterinary Medicine Classes	22 projects	25 publications
Matanuska Experiment Farm		27 projects	21 journal articles, 1 book chapter

Biological Reserve Animal Facility

Research Projects Requiring Facility

Barnes: Preliminary MRI scan and live tissue sampling from black bears; Hibernation genomics and physiology in bears; The Significance of Prehibernation Status for First-year Reproductive Success in Male Arctic Ground Squirrels; Wood Frog freeze tolerance under natural conditions

Kielland: Geophagy in snowshoe hares

Publications Based on Research Conducted at Facility

Fedorov, V. B., Goropashnaya, A. V., Stewart, N. C., Toien, O., Chang, C., Wang, H., et al. (2014). Comparative functional genomics of adaptation to muscular disuse in hibernating mammals. *Mol Ecol*, *23*(22), 5524–5537.

Fedorov, V. B., Goropashnaya, A. V., Toien, O., Stewart, N. C., Chang, C., Wang, H., et al. (2011). Modulation of gene expression in heart and liver of hibernating black bears (Ursus americanus). *BMC Genomics*, *12*, 171.

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Coltrane, J. A., & Barboza, P. S. (2010). Winter as a nutritional bottleneck for North American porcupines (Erethizon dorsatum). *J Comp Physiol B*, *180*, 905–918.

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Zhao, S., Chao, C., Goropashnaya, A. V., Stewart, N. C., Xu, Y., Toien, O., et al. (2010). Genomic analysis of expressed sequence tags in American black bear Ursus americanus. *BMC Genomics*, *11*(201).

Delta Junction Field Research Site

Research Projects Requiring Facility

Small grains research (barley, oats, and wheat)
Soil fertility/fertilizer Research
Oil-seed crops (mainly canola)
Entomology research (grasshopper research, agricultural insect pest biology)
Bio-energy crop research
Hybrid poplar research
Weed and herbicide research
Willow and brush control research
Larix sibirica (Siberian larch) plantation
Weather data collection

Remote sensing (use of reflectors for satellite calibration)
Grad students:
Megan Lene (M.S., dropped out): Phosphorus and potassium fertilizer rates for Alaska crops.

Publications Based on Research Conducted at Facility

Journal Articles

Pantoja, Alberto, Derek S. Sikes, Aaron M. Hagerty, Susan Y. Emmert, and Silvia I. Rondon. "Ground beetle (Coleoptera: Carabidae) assemblages in the Conservation Reserve Program crop rotation systems in interior Alaska." *Journal of the Entomological Society of British Columbia* 110 (2014): 6-18.

Sparrow, S.D., Zhang, M., masiak, d.t. , and Van Veldhuizen, R.. 2014. Harvest and Nitrogen Management of Three Perennial Grasses as Biomass Feedstock in Subarctic Alaska. *Arctic* 67 (3): 388-395.

Fielding, Dennis J., Ellen Trainor, and Mingchu Zhang. "Diet influences rates of carbon and nitrogen mineralization from decomposing grasshopper frass and cadavers." *Biology and fertility of soils* 49, no. 5 (2013): 537-544

Fielding, Dennis J., Linda S. Defoliart, and Aaron M. Hagerty. "Effects of Carbaryl-Bran Bait on Trap Catch and Seed Predation by Ground Beetles (Coleoptera: Carabidae)." *Journal of economic entomology* 106, no. 2 (2013): 669-674.

Seefeldt, S. S., R. A. Boydston, P. N. KAspari, M. Zhang, E. Carr, J. Smeenk, and D. L. Barnes, 2013. Aminopyralid residue impacts on potatoes and weeds. American Journal of Potato Research, 90:239-244.

Zhao, A. Zhang, M. & He, Z. (2013). Spectroscopic characteristics and biodegradability of cold and hot water-extractable soil organic matter under different land uses in subarctic Alaska. Communications in Soil Science and Plant Analysis, 44, 3030-3048. Fbks & Delta.

Fielding, D.J., Conn, J.S. 2012. Feeding preference for and impact on an invasive weed (Crepis tectorum L.) by a native, generalist insect herbivore, Melanoplus borealis (Orthoptera: Acrididae). Annals of the Entomological Society of America. 104(6):1303-1308.

Fielding, D.J., E. Trainor and Mingchu Zhang. 2012. Diet influences rates of carbon and nitrogen mineralization from decomposing grasshopper frass and cadavers. Biology and Fertility of Soils. 49: 537-544
Pantoja, Alberto, Richard Ranft, Dennis Fielding, Aaron Hagerty, and Susan Emmert. "Effects of Soil Depths on Nymphal Eclosion of Melanoplus sanguinipes (Fabricius)." *Open Entomology Journal* 6 (2012): 49-52.

Pike, K. S., G. Graf, R. G. Foottit, H. E. L. Maw, C. von Dohlen, J. Harpel, A. Pantoja, S. Emmert, and A. M. Hagerty. "Eriosomatine aphids (Hemiptera: Aphididae: Eriosomatinae) associated with

moss and roots of conifer and willow in forests of the Pacific Northwest of North America." *The Canadian Entomologist* 144, no. 04 (2012): 555-576

Zhao, Aiqin, Mingchu Zhang, 2012. Size fraction of soil water soluble organic C and N under different land uses in Alaska. Soil Sci. 177:683-694. Fbks, Delta and Palmer

Zhao, Aiqin, Mingchu Zhang, 2012. Spectroscopic characteristics and biodegradability of soil cold and hot water extractable organic matter under different land uses in Alaska. Comm. Soil Sce. And Plant Anal. 44:3030-3048 Fbks, Delta and Palmer

Conn, J.S., Werdin Pfisterer, N.R., Beattie, K.A. 2011. Development of the Alaska agricultural weed flora 1981-2004: a case for prevention. Weed Research. 51(1):63-70.

Fielding, D. and Mingchu Zhang, 2011. Populations of the northern Grasshopper, Melanoplus borealis (Orthoptera: Acrididae), in Alaska are Rarely Food Limited. Environ. Entomol.40 (3): 541-548.
Fielding, Dennis J. "Oviposition site selection by the grasshoppers Melanoplus borealis and M. sanguinipes (Orthoptera: Acrididae)." *Journal of Orthoptera Research* 20, no. 1 (2011): 75-80
Fielding, Dennis J., and Jeffery S. Conn. "Feeding preference for and impact on an invasive weed (Crepis tectorum) by a native, generalist insect herbivore, Melanoplus borealis (Orthoptera: Acrididae)." *Annals of the Entomological Society of America* 104, no. 6 (2011): 1303-1308.

Fielding, Dennis J. "Assessment of grasshopper abundance in cereal crops using pan traps." *International Journal of Pest Management* 57, no. 3 (2011): 239-247.

Zhang, Mingchu, S. D. Sparrow, R. Van Veldhuizen, and d. t. masiak. 2011. Soil quality under different land uses in a subarctic environment in Alaska. Journal of Land Use Science 1-13.

Zhang, Mingchu, and Dennis J. Fielding. "Populations of the Northern Grasshopper, Melanoplus borealis (Orthoptera: Acrididae), in Alaska Are Rarely Food Limited." *Environmental entomology* 40, no. 3 (2011): 541-548.

Fielding, Dennis J., and Linda S. Defoliart. "Embryonic developmental rates of northern grasshoppers (Orthoptera: Acrididae): implications for climate change and habitat management." *Environmental entomology* 39, no. 5 (2010): 1643-1651.

Pantoja, Alberto, Joseph Munyaneza, James Crosslin, Aaron Hagerty, Susan Emmert, Keith Pike, Juan Alvarez, and Andrew Jensen. "Leafhopper and aphids associated with potato in Alaska: species composition, seasonal abundance, and potential virus vectors." In *Bioforsk Fokus*, vol. 5, no. 5, p. 36. 2010.

Ranft, R.D., S. S. Seefeldt, M. Zhang and D.L. Barnes. 2010. Development of a soil bioassay for triclopyr residues and comparison with a laboratory extraction. Weed Technology, 24:538-543.

Zhang, M, S. D. Sparrow, A. Pantoja, And P.J. Bechtel. 2010. Crop nutrient recovery from three land applied fish byproducts. pp 87-103. In: P. J. Bechtel (ed), A Sustainable Future: Fish Processing and Byproducts. Fbks & Delta

Hagerty, Aaron M., Alberto Pantoja, and Susan Y. Emmert. "Lady beetles (Coleoptera: Coccinellidae: Coccinellini) associated with Alaskan agricultural crops." *Journal of the Entomological Society of British Columbia* 106 (2009): 39-45.

Hagerty, Aaron M., Alberto Pantoja, and Susan Emmert. "First record of diamondback moth (Lepidoptera: Plutellidae) from interior Alaska." *Western North American Naturalist* 68, no. 2 (2008): 249-250.

Seefeldt, S. S., J. S. Conn, M. Zhang, P. N. Kaspari. 2009. Vegetation changes in Conservation Reserve Program lands in interior Alaska. Agrictulre, Ecosystems, and Environment, 135: 119-126. Delta

Sparrow, S.D. and d. masiak. 2008. Second harvest timing and cut height of forage crops in Central Alaska. *Agronomy Journal* 100: 1615-1621.

Seefeldt, S. S., R.A. Boydston, and P. N. Kaspari. Clopyralid and dicamba residue impacts on potatoes and weeds. American Journal of Potato Research, (in press). Fbks and Delta

Zhang, M., S. S. Malhi. 2010. Perspectives of canola/oilseed rape as a bioenergy crop, Biofuel 1 (4): 621-630 Fbks and Delta

AFES Publications:
R. Garber-Slaght, G. Holdmann, S.D. Sparrow, and d. t. masiak. 2009. Opportunities for Woody Biomass Fuel Crops in Interior Alaska. Alaska Agricultural and Forestry Experiment Station Mics. Pub 09-09. University of Alaska Fairbanks, Fairbanks, Alaska.

Fairbanks Experiment Farm

Research Projects Requiring Facility

Reindeer (reindeer, carcass yield and meat and quality)
Small grains (mostly barley, wheat, oats)
Oil-seed crops (canola, sunflowers)
Soil Fertility (inorganic fertilizer research, research on organic fertilizers, e.g. compost, fish wastes)
Peony research (flower shelf-life, plant nutrition, pest management)
Research at GBG (Vegetable and ornamental crop adaptability trials, propagation and preservation of endangered plant species)
Bio-energy crops (mostly willows, poplar, grasses)
Fruit Tree and Berry Crop Trials
Vegetable Crop Trials (help here Meriam, as well with other work you have done or are doing)
Controlled environment agriculture research (at the CEAL facility), especially work on LED lights for growing plants

High tunnel and season extension research
Forage grasses and haylage trials
Long-term ecological monitoring of birch trees (T-Field), part of Generation One-Tree, a citizen science project.
Long-term weather/climate data collection (among oldest continuous data sets in AK).
Tree-ring analysis (Tree-Ring laboratory is located at Farm)

GI

Winter-time atmospheric boundary layer turbulence and dynamics
Climatological Research
Permafrost Research
Remote sensing (use of reflectors for satellite calibration)

IAB

Poplar province plantation at T-Field

INE

Mineral sample processing for teaching and research (laboratory in "The Barn").

Other (non-UAF)

Alaska Songbird Institute (long-term swallow nesting monitoring – important to determine climate change impacts on bird nesting behavior)
Wildlife Society (Kestrel nesting)

U.S.D.A. Agricultural Research Service (closed in 2012)

Weed and Herbicide Research (Seefeldt)
Long Term Weed Research (Conn)
Entomology Research (Grasshopper management, agricultural insect pest biology)
Soil Leaching Research (Seefeldt/Schnabel)

Graduate Students (recent past and present):

George Agiuar (MNRM&G, active): Effect of freezing on reindeer meat quality.
Tina Busbaum (M.S., completed degree): Pollination biology of bog blueberry.
Amanda Byrd (M.S., completed degree): Biomass production and carbon sequestration potential of poplar as a short-rotation bio-energy crop.
Erin Carr (M.S., active): Use of cover crops to depress weed seed germination.
Theodore Delaca (M.S., inactive?): Release of plant nutrients from organic amendments in soil.
Justin Hogrefe (MNRM&G, active): Climate change and agriculture.
Kimberly Maher (Ph.D., completed degree): Non-timber forest products in Interior Alaska.
Yosuke Okada (M.S., inactive?): LED spectral quality in relation to plant growth.
Rehanon Pampel (M.S., completed degree): Bumble bees in agricultural fields in Interior Alaska.
Watcharee Ruairuen (Ph.D., active): Evapotranspiration in Subarctic agricultural soils.
Nicole Swensen (M.S., completed degree): Soil temperature modeling for agriculture.
Ellen Trainor (M.S., completed degree): Grasshopper population dynamics.
Sean Willison (M.S., dropped out): Using sedges for wetland revegetation.
Susan Woods (Ph.D., active): Soil temperature and vegetable productivity.
Aiqin Zhao (Ph.D., completed degree): Mineralizable organic nitrogen in subarctic soils.
Karen Hill (M.S, completed degree): Breeding wheat for the subarctic. (Was M.S. student at WSU, did field research at Fairbanks Experiment Farm).

Senior thesis and other undergrad research
There have been lots. I won't list right now, but might want to later.

Support Activities:
Field equipment (boats, ATVs, chain saws, etc.) maintenance and storage for forestry researchers.
Reindeer work on Seward Pen (Greg can help out here)

Publications Based on Research Conducted at Facility

Note: This list includes papers for which a significant amount of the work occurred at the FEF.

Journal Articles

Beck, P.S.A.; Juday, G.P.; Alix, C.M.; Barber, V.A., Winslow, S.E.; Sousa, E.E.; Heiser, P.; Herriges, J.D.; Goetz, S.J. 2011 Changes in forest productivity across Alaska consistent with biome shift. Ecology Letters 14: 373-379. Doi: 10.1111/j.1461-0248.2011.01598.x

Cebrian, M. R., Kielland, K., and Finstad, G.L. 2008. Forage quality and reindeer productivity: multiplier effects amplified by climate change. *Arctic and Alpine Research* 40(1):48-54.

Christie, A., Finstad, G. 2009. Reindeer in The "Great Land": Alaska's Red Meat Industry. *Journal of Agricultural & Food Information*, 10:354-373.

Evans, A. L., Bey, R. F., Schoster, J. V., Gaarder, J. E., Finstad, G. L. 2008. Preliminary studies on the etiology of keratoconjunctivitis in reindeer (*Rangifer tarandus tarandus*) calves in Alaska. *Journal of Wildlife Diseases*. 44(4): 1051-1055.

Evans, A.**,** das Neves**,** C. G., Finstad**,** G.L. Beckmen**,** K., Skjerve**,** E., Nymo, I.H., **and** Tryland, M. 2012. Evidence of alphaherpesvirus infections in Alaskan caribou and reindeer. *Veterinary Research* 2012, 8:5

Fielding, Dennis J., Ellen Trainor, and Mingchu Zhang. "Diet influences rates of carbon and nitrogen mineralization from decomposing grasshopper frass and cadavers." *Biology and fertility of soils* 49, no. 5 (2013): 537-544

Fielding, Dennis J., Linda S. Defoliart, and Aaron M. Hagerty. "Effects of Carbaryl-Bran Bait on Trap Catch and Seed Predation by Ground Beetles (Coleoptera: Carabidae)." *Journal of economic entomology* 106, no. 2 (2013): 669-674.

Finstad, G., Bucki, C., Aguiar, G., Wiklund, E. and P. Bechtel. 2009. Alaskan Fish Byproducts as a Feed Ingredient for Reindeer. In: *A Sustainable Future: Fish Processing Byproducts*. Chapter. Book of Proceedings. Portland, Oregon. Feb. 2009.

Juday, Glenn, P. 2013. Monitoring Hectare-Scale Forest Reference Stands at Bonanza Creek Experimental Forest LTER. Pp 31-48 IN: Camp, A.E.; Irland, L.C.; Carroll, C.J.W. (eds.) Long-term Silvicultural & Ecolological Studeies: Results for Science and Management, Volume 2.Global

Institute for Sustainable Forestry Research Paper 013, Yale University School of Forest and Environmental Studies. 187 p.

Juday, Glenn, P.; Densmore, Roseann V.; Zasada, John C. 2013. White Spruce Regeneration Silviculture Techniques 25 years after Wildfire: the Rosie Creek Fire Tree Regeneration Installation. Pp 49-65 In: Camp, A.E.; Irland, L.C.; Carroll, C.J.W. (eds.) Long-term Silvicultural & Ecological Studies: Results for Science and Management, Volume 2. Global Environmental Studiess 187 p.

Juday, G.P. and C. Alix. 2012. Consistent negative temperature sensitivity and positive influence of precipitation on growth of floodplain Picea glauca in Interior Alaska. Canadian Journal of Forest Research 42:561-573.

Mayfield J. A. and G. J. Fochesatto. 2013: "The Layered Structure of the winter Atmospheric Boundary Layer in the Interior of Alaska". *J. Appl. Met. and Climatol.*, 52, 953-973.

Malingowski J., D. Atkinson, G. J. Fochesatto, J. Cherry and E. Stevens. 2014: "An Observational Study of Radiation Temperature Inversions in Fairbanks, Alaska". *Polar Science*, 8, 1, 24–39.

Pantoja, Alberto, Richard Ranft, Dennis Fielding, Aaron Hagerty, and Susan Emmert. "Effects of Soil Depths on Nymphal Eclosion of Melanoplus sanguinipes (Fabricius)." *Open Entomology Journal* 6 (2012): 49-52.

Pietsch, G., Finstad, G.L., Bevins, J., & Prichard, A.K. 1999. Antibiotic treatment and post-handling survival of reindeer calves in Alaska. Journal of Wildlife Diseases. 35(4):735-740.

Pike, K. S., G. Graf, R. G. Foottit, H. E. L. Maw, C. von Dohlen, J. Harpel, A. Pantoja, S. Emmert, and A. M. Hagerty. "Eriosomatine aphids (Hemiptera: Aphididae: Eriosomatinae) associated with moss and roots of conifer and willow in forests of the Pacific Northwest of North America." *The Canadian Entomologist* 144, no. 04 (2012): 555-576

Wiklund, E., G. L. Finstad, S. Worker and Bechtel, P.J. 2008. Effects of early castration on carcass composition, yield and quality characteristics of meat from young reindeer (*Rangifer tarandus tarandus*) bulls and steers. *Rangifer* 28: 1 – 8.

Wiklund, E., Finstad, G., Johansson, L., Aguiar, G., and Bechtel, P. J. 2008. Carcass composition and yield of Alaskan reindeer steers and effects of electrical stimulation applied during field slaughter on meat quality. *Meat Science*, 78, 185-193.

Wiklund, E., Finstad, G., Aguiar, G. & Bechtel. 2011. Short communication: Does carcass suspension technique influence reindeer (Rangifer tarandus tarandus) meat quality attributes? Animal Production Science, 51 (4) pp. ci-civ…

Wiklund, E; Farouk, M.; & Finstad, G. 2014. Venison: Meat from red deer (*Cervus elaphus*) and reindeer (*Rangifer tarandus tarandus*). *Animal* Frontiers 4(4) 55-61.

Zhang, Mingchu, 2012. Size fraction of soil water soluble organic C and N under different land uses in Alaska. Soil Sci. 177:683-694.

Zhao, Aiqin, Mingchu Zhang, 2012. Size fraction of soil water soluble organic C and N under different land uses in Alaska. Soil Sci. 177:683-694.

Zhao, Aiqin, Mingchu Zhang, 2012. Spectroscopic characteristics and biodegradability of soil cold and hot water extractable organic matter under different land uses in Alaska. Comm. Soil Sce. And Plant Anal. 44:3030-3048

Zhao, Aiqin, Mingchu Zhang, 2012. Spectroscopic characteristics and biodegradability of soil cold and hot water extractable organic matter under different land uses in Alaska. Comm. Soil Sce. And Plant Anal. 44:3030-3048

Conn, J.S., Werdin Pfisterer, N.R., Beattie, K.A. 2011.Development of the Alaska agricultural weed flora 1981-2004: a case for prevention. Weed Research. 51(1):63-70.

Fielding, Dennis J. "Oviposition site selection by the grasshoppers Melanoplus borealis and M. sanguinipes (Orthoptera: Acrididae)." *Journal of Orthoptera Research* 20, no. 1 (2011): 75-80

Fielding, Dennis J., and Jeffery S. Conn. "Feeding preference for and impact on an invasive weed (Crepis tectorum) by a native, generalist insect herbivore, Melanoplus borealis (Orthoptera: Acrididae)." *Annals of the Entomological Society of America* 104, no. 6 (2011): 1303-1308.

Fielding, Dennis J. "Assessment of grasshopper abundance in cereal crops using pan traps." *International Journal of Pest Management* 57, no. 3 (2011): 239-247.

Juday, G.P. 2011. The Biome Shift Now Occurring in the Boreal Region: Characteristics and a First Look at Knowledge Needs. Pp62-63 IN: Frontiers in Understanding Climate Change and Polar Ecosystems: Summary of a Workshop, Committee for the Workshop on Frontiers in Understanding Climate Change and Polar Ecosystems. National Research Council. 86pp ISBN: 0-309-21088-7. (http://www.nap.edu/catalog/13132html).

Karlsson, M. and J. Werner. 2011. High tunnel covering materials for northern field production. Acta Horticulturae 893:1333-1339.

Wiklund, E., Finstad, G., Aguiar, G. & Bechtel. 2011. Short communication: Does carcass suspension technique influence reindeer (Rangifer tarandus tarandus) meat quality attributes? Animal Production Science, 51 (4) pp. ci-civ.

Wilmking, M.; Hallinger, M.; van Bogaert, R.; Kyncl, T.; Babst, F.; Hahne, W.; Juday, G.P; de Luis, M.; Novak, K.; Vollm, C.2012. Continuously missing outer rings in woody plants at their distributional margins. Dendrochronologia 54 p. doi: 10.1016/j.dendro.2011.10.001

Zhang, Mingchu, and Dennis J. Fielding. "Populations of the Northern Grasshopper, Melanoplus borealis (Orthoptera: Acrididae), in Alaska Are Rarely Food Limited." *Environmental entomology* 40, no. 3 (2011): 541-548

Conn, J.S., Werdin Pfisterer, N.R. 2010. Variation in seed viability and dormancy of 17 weed species after 24.7 years of burial: the concept of buried seed safe sites. Weed Science. 58(3):209-215.

Fielding, Dennis J., and Linda S. Defoliart. "Embryonic developmental rates of northern grasshoppers (Orthoptera: Acrididae): implications for climate change and habitat management." *Environmental entomology* 39, no. 5 (2010): 1643-1651.

McGuire, D.; Ruess, R.; Lloyd, A.H.; Yarie, J.; Clein, J.S.; Juday, G.P.2010 Vulnerability of White Spruce Tree Growth in Interior Alaska in Response to Climate Variability: Dendrochronological, Demographic, and Experimental Perspectives. Canadian Journal of Forest Research. 40: 1197-1209. Doi:10.1139/X09-206

Neely, H. L., Koenig, C.A. Miles, T.C. Koenig, and M. G. Karlsson. 2010. Diurnal fluctuation in tissue nitrate concentration of field-grown leafy greens at two latitudes. HortScience 45:1815-1818.

Pantoja, Alberto, Joseph Munyaneza, James Crosslin, Aaron Hagerty, Susan Emmert, Keith Pike, Juan Alvarez, and Andrew Jensen. "Leafhopper and aphids associated with potato in Alaska: species composition, seasonal abundance, and potential virus vectors." In *Bioforsk Fokus*, vol. 5, no. 5, p. 36. 2010.

Ranft, R. D., S. S. Seefeldt, M Zhang, and D.L. Barnes. 2010. Development of a soil bioassay for triclopyr residues and comparison with a laboratory extraction. Weed Technology 24: 538-543 Fbks & Delta

Hagerty, Aaron M., Alberto Pantoja, and Susan Y. Emmert. "Lady beetles (Coleoptera: Coccinellidae: Coccinellini) associated with Alaskan agricultural crops." *Journal of the Entomological Society of British Columbia* 106 (2009): 39-45.

Conn, J.S., Stockdale, C., Morgan, J. 2008. Characterizing pathways of invasive plant spread to Alaska: I. propagules from container-grown ornamentals. Journal of Invasive Plant Science and Management. 1:331-336.

Hagerty, Aaron M., Alberto Pantoja, and Susan Emmert. "First record of diamondback moth (Lepidoptera: Plutellidae) from interior Alaska." *Western North American Naturalist* 68, no. 2 (2008): 249-250.

Book Chapters:

Zhang, M. (2014). Distribution and Biodegradability of Water Soluble Organic Carbon and Nitrogen in Subarctic Soils Under Three Different Land Uses. In Applied Manure and Nutrient Chemistry for Sustainable Agriculture and Environment. Fbks, Delta & Palmer

Zhang M, He Z, Zhao A. 2011. Ultraviolet-visible absorption features of water extractable humic fractions of animal manure and relevant compost. pp 61–82, In: Z. He (ed.), *Environmental Chemistry of Animal Manure*. Nova Science Publishers, Inc. Hauppauge, New York, USA.

Zhang M, Sparrow SD, Pantoja A, Bechtel PJ. 2010. Crop nutrient recovery from three land applied fish byproducts. pp 87–103. In: P.J. Bechtel (ed), *A Sustainable Future: Fish Processing and Byproducts*

Barber, V.A.; Juday, G.P.; D'Arrigo, R.; Berg, E.; Buckley, B.; Huntington, H.; Jorgensen, T.; McGuire, D.; Osterkamp, T.; Riordan, B.; Whiting, A.; Wiles, G.; Wilmking, M. 2009. Chapter 9: A Synthesis of Recent Climate Warming Effects on Terrestrial Ecosystems of Alaska. Pp110-139. In: (Wagner, F.H. Ed.) Climate Warming in North America, Evidence and Environmental Effects. The University of Utah Press, 2009, 167 p. ISBN 978-0-87480-906-0

AFES Publications:

Karlsson, M. and J. Dawe. 2014. What are your implications of your research? AgroBorealis 44:46-47.

Holloway, P. S., Willison, S.M., and Sparrow, S.D. 2012. Germination of water sedge, *Carex aquatilis*, and cotton sedge, *Eriophorum angustifolium* from Arctic coastal wetlands, Prudhoe Bay, Alaska. Alaska Agricultural and Forestry Experiment Station Mics. Pub 2012-02. University of Alaska Fairbanks, Fairbanks, Alaska

Pampell, Rehanon, Alberto Pantoja, Derek Sikes, Patricia Holloway, and Charles Knight. "A guide to bumblebees of the Interior." *Agroborealis* 42, no. 1 (2011): 56-67.

Holloway, Patricia S.; Pearce, Shannon; Hanscom, Janice. 2010.
Peony Research 2009. AFES Miscellaneous Publication 2010-02.
Fairbanks, AK: UAF: 12 pp.

Pantoja, Alberto; Hagerty, Aaron M; Emmert, Susan Y; Munyaneza, Joseph E. 2010. "Leafhoppers and potatoes in Alaska." *Agroborealis* 41(1): 28–33.

Van Veldhuizen, Bob. February 2010. Growing Small Grains in Your Garden. AFES Circular 135. Fairbanks, AK: UAF: 24 pp.

Garber-Slaght, R. , G. Holdmann, S.D. Sparrow, and d. t. masiak. 2009. Opportunities for Woody Biomass Fuel Crops in Interior Alaska. Alaska Agricultural and Forestry Experiment Station Mics. Pub 09-09. University of Alaska Fairbanks, Fairbanks, Alaska.

Karlsson, M. 2009. Growing under the midnight sun. SNRAS/AFES Misc. Pub. No. MP 2009-06.

Karlsson, M. 2009. Growing fresh vegetables: midnight sun & the earth's warmth. SNRAS/AFES Misc. Pub. No. MP 2009-10

CES Publications:

Calhoun, K. and M. Karlsson. 2011. Growing apples in interior Alaska, suitable varieties for cold climates.
CES, UAF, HGA-00043.

Other:

Juday, Glenn; Dawe, Jan; Meyers, Zach; Morimoto, Miho; Allaby, Andrew; Grant, Tom. 2013. Boreal Alaska – Learning, Adaptation, Production (BAKLAP) Quarterly Report 2013 Quarter #1 (January 1, 2013- March 31, 2013). 70pp.

Juday, Glenn; Dawe, Jan; Meyers, Zach; Morimoto, Miho; Allaby, Andrew; Grant, Tom. 2013. Boreal Alaska – Learning, Adaptation, Production (BAKLAP) Quarterly Report 2013 Quarter #2 (April 1, 2013- June 30, 2013). 105pp.

Juday, Glenn; Dawe, Jan; Meyers, Zach; Grant,Tom; Jess, Ryan. 2013. Boreal Alaska – Learning, Adaptation, Production (BAKLAP) Quarterly Report 2012 Quarter #4 (October 1, 2012- December 31, 2012). 28pp.

Juday, Glenn; Dawe, Jan; Grant, Tom; 2012. Boreal Alaska – Learning, Adaptation, Production (BAKLAP) Quarterly Report 2012 Quarter #3 (July 1, 2012- December 31, 2012). 18pp.

Calhoun, K. and M. Karlsson. 2011. Fruit tree and berry crop trial program. Final report. Western Sustainable Agriculture Research and Education.

Karlsson, M. 2011. Alaska Berries III. Final report USDA-CSREES.

Karlsson, M. 2011. Alaska Berries III. Progress report USDA-CSREES.

Calhoun, K. and M. Karlsson. 2010. Fruit tree and berry crop trial program. Progress report. Western Sustainable Agriculture Research and Education.

Juday, Glenn P. 2010. Changing the Forest and the Trees – Is it climate? Agroborealis 41 (1):7-18
Zhang, M., S. S. Malhi. 2010. Perspectives of canola/oilseed rape as a bioenergy crop, Biofuel 1 (4): 621-630 Fbks and Delta

Zhang, M, Sparrow, S.D. Pontoja, A., Bechtel, P. J. 2010. Crop nutrient recovery from applied fish coproducts. pp. 87 – 103 IN: Bechtel, P.J. and Smiley, S (eds). A Sustainable Future: Fish Processing Byproducts. Alaska SeaGrant Publication number AK-SG-10-02. Fairbanks, Alaska.

Calhoun, K. and M. Karlsson. 2009. Fruit tree and berry crop trial program. Progress report. Western Sustainable Agriculture Research and Education.

Karlsson, M. 2009. Alaska Berries III. Progress report USDA-CSREES.

Karlsson, M. 2009. Alaska Berries III. Final report USDA-CSREES.

Karlsson, M. 2008. Alaska Berries III. Progress report USDA-CSREES.

Karlsson, M. 2008. Alaska Berries III. Final report USDA-CSREES

Theses and dissertations

Watcharee Ruairuen 2014: Evapotranspiration in Subarctic agricultural soils.

George Agiuar 2013 : Effect of freezing on reindeer meat quality.

Nicole Swenson: 2013 -Modeling Changes in the Length of the Agricultural Growing Season in Interior Alaska

Erin Carr 2012: Use of cover crops to depress weed seed germination.

Sean Willison 2012: Using sedges for wetland revegetation.

Tina Buxbaum (M.S., completed degree): 2011 -Pollination Biology of the Bog Blueberry, Vaccinium Uliginosum L. in Interior Alaska

Mayfield, John A. "The micrometeorological effects of drainage flow in the winter atmospheric boundary layer". December 2011.

Rehanon Pampell: 2010, "Survey of bombus species (hymenoptera: apidae) near agricultural lands in interior Alaska."

Ellen Trainor 2010 Responses of soil nutrients and soil respiration to frass and cadaver deposition from grasshoppers (orthoptera: acrididae) in Alaskan agricultural soils.

Conference papers:

Fochesatto G. J. *"Goldstream valley drainage flow" Alaska Weather Symposium. Springtime 2012. Fairbanks, AK.*

Fochesatto G.J. and J. A. Mayfield, 2010. Structure and Dynamics of the High Latitude Stable Boundary Layer. Poster EGU2010-5589. Proceedings of the European Geosciences Society. Vienna, Austria.

Mayfield, John. "Synoptic Driven High Latitude Stable Boundary Layer States in the Interior Alaska". Conference paper, Alaska Weather Symposium Spring 2010. Fairbanks, AK.

Large Animal Research Station

Classes Using Facility

BIOL 271 Principles of Ecology
BIOL 371 Principles of Ecology
BIOL 441 Animal Behavior
BIOL 459 Wildlife Nutrition
BIOL 659 Wildlife Nutrition
WLF 101 Survey of Wildlife Science
WLF 222 Principles and Techniques of Wildlife Management
WLF 460 Wildlife Nutrition
WLF 660 Wildlife Nutrition

Course	Students since Fall 2011	SCH since Fall 2011	Tuition since Fall 2011*
BIOL 271 Principles of Ecology (this was renumbered to BIOL 371)	196	608	$137,476
BIOL 371 Principles of Ecology	126	204	$55,716
BIOL 441 Animal Behavior	40	120	$31,431
BIOL 459 Wildlife Nutrition	22	80	$21,288
BIOL 659 Wildlife Nutrition	3	0	
WLF 101 Survey of Wildlife Science	191	277	$51,588
WLF 222 Principles and Techniques of Wildlife Management	21	22	$5,091
WLF 460 Wildlife Nutrition	46	140	$36,722
WLF 660 Wildlife Nutrition	**0**	**0**	
Total	**645**	**1,401**	**$339,312**

- Assumes course enrollment has the same percentage of out-of-state students as UAF overall.

Research Projects Requiring Facility

Barboza: Hormone assessment in blood, hair and feces of captive caribou and reindeer; Fiber degrading microbes and enzymes in the rumen of muskoxen; Monitoring body stores in muskoxen; Outreach; Habitat influences on caribou Phase I

Blake: Muskox Husbandry; Development of a serological assay for Erysipelothrix rhusiopathiae in muskoxen; Rotational grazing of muskoxen - pilot study

Checkley: Validation of filter paper blood sampling for disease surveillance in muskoxen

Gilbert: Behavioral Observation Exercise at LARs for Students

Hauer: Muskoxen Husbandry SOP; Caribou Husbandry SOP

Jack: Reindeer Husbandry; Muskox Husbandry; Caribou Husbandry

Lewis: Comparative Study of Capture Techniques in Reindeer

Rowell: Timing of breeding and gestation length in muskoxen; Fetal development following timed conception; Testing the utility of electric fence for muskox containment; Efficacy of commercially available sheep CIDRs for estrous synchronization in farmed reindeer; Farmed muskox behavior as it relates to handling efficiency

Shipka: Genetic testing of muskoxen

Publications Based on Research Conducted at Facility

Colson, K.E.; Mager, K.H.; Hundertmark, K.J., Reindeer Introgression and the Population Genetics of Caribou in Southwestern Alaska, 2014, Journal of Heredity, 105, 585-596

Gustine, D.D.; Barboza, P.S.; Addison, J.; Shively, R.; Oliver, L., Isotopic nitrogen in fecal fiber as an indicator of winter diet in caribou and muskoxen, 2014, Rapid Communications in Mass Spectrometry, 28, 625-634

Thompson, D.P.; Barboza, P.S., Responses of caribou and reindeer (Rangifer tarandus) to acute food shortages in spring, 2013, Can. J. Zool., 610-618

Mager, K.H.; Colson, K.E.; Hundertmark, K.J., High genetic connectivity and introgression from domestic reindeer characterize northern Alaska caribou herds, 2013, Conservation Genetics, 14, 1111-1123

Cameron, R.D.; Griffith, B.; Parrett, L.S.; White, R.G., Efficacy of calf: cow ratios for estimating calf production of arctic caribou, 2013, Rangifer, 33, 27-34

Lauper, Murielle; Lechner, Isabel; Barboza, Perry S.; Collins, William B.; Hummel, Jurgen; Codron, Daryl; Clauss, Marcus, Rumination of different-sized particles in muskoxen (Ovibos moschatus) and moose (Alces alces) on grass and browse diets, and implications for rumination in different ruminant feeding types, 2013, Mammalian Biology, 78, 142-152

Williams, Cory T.; Barnes, Brian M.; Buck, C. Loren, Daily body temperature rhythms persist under the midnight sun but are absent during hibernation in free-living arctic ground squirrels, 2011, Biology Letters, Online

Klein, David R.; Shulski, Martha, The role of lichens, reindeer, and climate in ecosystem change on a Bering Sea island, 2011, Arctic, 64, 353-361

Finstad, Gregory L.; Kielland, Knut, Landscape Variation in the Diet and Productivity of Reindeer in Alaska Based on Stable Isotope Analyses, 2011, Arctic, Antarctic, and Alpine Research, 76, 543-554

Ashley, N.T.; Barboza, P.S.; Macbeth, B.J.; Janz, D.M.; Cattet, M.R.L.; Booth, R.K.; Wasser, S.K., Glucocorticosteroid concentrations in feces and hair of captive caribou and reindeer following

adrenocorticotropic hormone challenge, 2011, General and Comparative Endocrinology, 172, 382-391

Qi, M.; Wang, P.; O'Toole, N.; Barboza, P.S.; Ungerfeld, E.; Leigh, M.B.; Selinger, L.B.; Butler, G.; Tsang, A.; McAllister, T.A.; Forster, R.J., Snapshot of the Eukaryotic Gene Expression in Muskoxen Rumen—A Metatranscriptomic Approach, 2011, PLoS ONE, 6, e20521EP –

Gustine, D.D.; Barboza, P.S.; Lawler, J.P.; Arthur, S.M.; Shults, B.S.; Persons, K.; Adams, L.G., Characteristics of foraging sites and protein status in wintering muskoxen: insights from isotopes of nitrogen, 2011, Oikos, 120, 1546-1556

Clauss, Marcus; Lechner, Isabel; Barboza, Perry; Collins, William; Tervoort, Theo A.; Sudekum, Karl-Heinz; Codron, Daryl; Hummel, Jurgen, The effect of size and density on the mean retention time of particles in the reticulorumen of cattle (Bos primigenius f. taurus), muskoxen (Ovibos moschatus) and moose (Alces alces), 2011, British Journal of Nutrition, 105, 634-644
Sundset, M.A.; Barboza, P.S.; Green, T.K.; Folkow, L.P.; Blix, A.S.; Mathiesen, S.D., Microbial degradation of usnic acid in reindeer rumen, 2010, Naturwissenschaften, 97, 273-278

Gustine, David D.; Barboza, Perry S.; Lawler, James P., Dynamics of Body Protein and the Implications for Reproduction in Captive Muskoxen (Ovibos moschatus) during Winter, 2010, Physiological and Biochemcial Zoology, 83

Gustine, David D., Protein status of muskoxen and caribou in late winter, 2010, 251

Lechner, Isabel; Barboza, Perry; Collins, William; Gunther, Detlef; Hattendorf, Bodo; Hummel, Jurgen; Clauss, Marcus, No 'bypass' in adult ruminants: Passage of fluid ingested vs. fluid inserted into the rumen in fistulated muskoxen (Ovibos moschatus), reindeer (Rangifer tarandus) and moose (Alces alces), 2009, Comparative Biochemistry and Physiology, Part A, 154, 151-156

Gunn, A.; Russell, D.; White, R.; Kofinas, G.P., Facing a future of change: Wild migratory caribou and reindeer, 2009, Arctic, 4, iii-vi

Lokken, James A.; Finstad, Gregory L.; Dunlap, Kriya L.; Duffy, Lawrence K., Mercury in lichens and reindeer hair from Alaska: 2005-2007 pilot survey, 2009, Polar Record, 45, 368-374

Rattenbury, Kumi; Kielland, Knut; Finstad, Greg; Schneider, William, A reindeer herder's perspective on caribou, weather and socio-economic change on the Seward Peninsula, Alaska, 2009, Polar Research, 28, 71-88

Munn, Adam J.; Barboza, Perry S.; Dehn, Jon, Sensible Heat Loss from Muskoxen (Ovibos moschatus) Feeding in Winter: Small Calves Are Not at a Thermal Disadvantage Compared with Adult Cows, 2009, Physiological and Biochemical Zoology, 82, 455-467

Lechner, Isabel; Barboza, Perry; Collins, William; Gunther, Detlef; Hattendorf, Bodo; Hummel, Jurgen; Clauss, Marcus, No 'bypass' in adult ruminants: Passage of fluid ingested vs. fluid inserted

into the rumen in fistulated muskoxen (Ovibos moschatus), reindeer (Rangifer tarandus) and moose (Alces alces), 2009, Comparative Biochemistry and Physiology, Part A, 154, 151-156

Barboza, P.S.; Parker, K.L., Allocating protein to reproduction in arctic reindeer and caribou, 2008, Physiological and Biochemical Zoology, 81, 835-55

Cebrian, Merben R.; Kielland, Knut; Finstad, Greg, Forage Quality and Reindeer Productivity: Multiplier Effects Amplified by Climate Change, 2008, Arctic, Antarctic, and Alpine Research, 40, 48-54

Munn, A.J.; Barboza, P.S., Could a big gut be too costly for muskoxen (Ovibos moschatus) in their first winter?, 2008, Zoology, 111, 350-362

Matanuska Experiment Farm

Research Projects Requiring Facility

Val Barber: Forest Products Program; Wood Utilization Research; Stooling beds project: with Jeff Graham DOF

Mingchu Zhang: Agronomic Crop Variety Trials (barley, oat, wheat, canola, sunflower); Soil Fertility Phosphorus Rate and Placement Study on Barley; Fish/Cardboard Compost Research

Milan Shipka: Creation of educational videos for health considerations in cattle in Alaska

A) Body condition scoring
B) Proper technique in administration of vaccines and other health treatments
C) Well animal health checks

Andy Soria: Gasification of Salmon Processing Waste to Power Greenhouses in Alaska
Developing a Fast Assessment Method for Catalytically Upgrading Biomass Pyrolysis into Drop-in Fuels and Chemical Feedstocks; Carbon Hydrogen Nitrogen Elemental Analysis for Biomass and Biofuel Research

Chien-Lu Ping: Wetland Protection and Hydric Soils Monitoring in Volcanic Ash-Derived Soils in Alaska; Black Spruce Forest Soils in Boreal Regions of Alaska: Their Characterization, Organic Carbon Pool and Relationship to Forest Management; Rapid Carbon Assessment of Soils in Alaska

Norm Harris: Production of Livestock on Small Acreages in Alaska: Defining the Animal Unit and Effective Distribution of Grazing Activities; Spatially Modeling the Distribution of Beef Cattle and Reindeer on Ranges at High Latitudes in Alaska; Remote Sensing of White Sweet Clover (Melilotus alba) on the Matanuska River Floodplain; Revegetation of Disturbed

Areas in Alaska; The effect of forage variety and color of plastic wrap on haylage quality and quantity in Alaska; High Spatial Resolution Vegetation Mapping for Assessment of Wildlife Habitat; Calculating the Carrying Capacity of Moose Habitat on the Chugach National Forest, AK using Remote Sensing, Ground Surveys and Nutritional Analyses; Seasonal Movements, Diet Composition, and Plant Nutritional Quality of Unimak Island Caribou; Characterization and Delineation of Caribou Habitat on Unimak Island using Remote Sensing Techniques

Jeff Smeenk: Season Extension for High Latitude Market Garden Production; Collaborative Work on Virus Free Potato

Alberto Pontoya: Enhance the Quality and Characterize Germplasm and Crops Adapted to Alaska; Utilizing Fish Waste as Soil Amendment For Food Production

Bonnie Fuhrman: Blueberry Variety Evaluation (Grant)

Projects involved eight Masters-level graduate students. Six students were from UAA and two were from UAF. Six of the students completed their degrees.

Publications Based on Research Conducted at Facility

Journal Articles

Payyavula, R. S., Navarre, D. A., Kuhl, J., & Pantoja, A. (2013). Developmental effects on phenolic, flavonol, anthocyanin, and carotenoid metabolites and gene expression in potatoes. *Journal of agricultural and food chemistry*, *61*(30), 7357-7365.

Takeoka, Gary R., Lan Dao, Leslie Harden, Alberto Pantoja, and Joseph C. Kuhl. "Antioxidant activity, phenolic and anthocyanin contents of various rhubarb (Rheum spp.) varieties." *International Journal of Food Science & Technology* 48, no. 1 (2013): 172-178

Zhao, A. Zhang, M. & He, Z. (2013). Spectroscopic characteristics and biodegradability of cold and hot water-extractable soil organic matter under different land uses in subarctic Alaska. Communications in Soil Science and Plant Analysis, 44, 3030-3048. Fbks & Delta.

Payyavula, Raja S., Duroy A. Navarre, Joseph C. Kuhl, Alberto Pantoja, and Syamkumar S. Pillai. "Differential effects of environment on potato phenylpropanoid and carotenoid expression." *BMC plant biology* 12, no. 1 (2012): 39.

Pike, K. S., G. Graf, R. G. Foottit, H. E. L. Maw, C. von Dohlen, J. Harpel, A. Pantoja, S. Emmert, and A. M. Hagerty. "Eriosomatine aphids (Hemiptera: Aphididae: Eriosomatinae) associated with moss and roots of conifer and willow in forests of the Pacific Northwest of North America." *The Canadian Entomologist* 144, no. 04 (2012): 555-576

Zhao, Aiqin, Mingchu Zhang, 2012. Size fraction of soil water soluble organic C and N under different land uses in Alaska. Soil Sci. 177:683-694. Fbks, Delta and Palmer

Chiapella, Jorge O., Veronica L. DeBoer, Guillermo C. Amico, and Joseph C. Kuhl. "A morphological and molecular study in the Deschampsia cespitosa complex (Poaceae; Poeae; Airinae) in northern North America." *American journal of botany* 98, no. 8 (2011): 1366-1380

Pantoja, Alberto, Aaron M. Hagerty, Susan Y. Emmert, Joseph C. Kuhl, Keith Pike, Juan M. Alvarez, and Andrew Jensen. "Aphids (Hemiptera: Aphididae) associated with rhubarb (Rheum spp.) in the Matanuska Valley, Alaska: species composition, seasonal abundance, and potential virus vectors." *Journal of the Entomological Society of British Columbia* 107 (2010): 75-81.

Pantoja, Alberto, Joseph Munyaneza, James Crosslin, Aaron Hagerty, Susan Emmert, Keith Pike, Juan Alvarez, and Andrew Jensen. "Leafhopper and aphids associated with potato in Alaska: species composition, seasonal abundance, and potential virus vectors." In *Bioforsk Fokus*, vol. 5, no. 5, p. 36. 2010.

Pantoja, Alberto, Aaron M. Hagerty, and Susan Y. Emmert. "A seasonal survey of click beetles in two potato production areas of Interior Alaska." *American journal of potato research* 87, no. 6 (2010): 531-536.

Pantoja, Alberto, and Joseph C. Kuhl. "Morphologic variation in the USDA/ARS rhubarb germplasm collection." *Plant Genetic Resources* 8.01 (2010): 35-41

Pike, K. S., George Graf, R. G. Foottit, H. E. L. Maw, G. L. Miller, Judy Harpel, Alberto Pantoja, Aaron Hagerty, and Susan Emmert. "Molecular and biometric assessment of Myzodium mimulicola (Hemiptera: Aphididae), with new synonymy and host and distributional data." *The Canadian Entomologist* 142, no. 05 (2010): 448-457.

Robertson, N. L., and Brown, Kathryn. First Report of *Bean yellow mosaic virus* in Alaska from Clover (*Trifolium* spp.). Plant Dis. 94 (3): 372. 2010. Palmer

Seefeldt, S.S., W.B. Collins, J.C. Kuhl, and Marcus Clauss. 2010. White sweetclover and narrowleaf hawksbeard seed viability after passing through moose. Invasive Plant Science and Management, 3: 26-31.

Conn, J.S., Seefeldt, S.S. 2009. Invasive White Sweetclover (Melilotus officinalis) Control with Herbicides, Cutting and Flaming. Journal of Invasive Plant Science and Management. July 2009, vol 2: pp 270-277.

Hagerty, Aaron M., Alberto Pantoja, and Susan Y. Emmert. "Lady beetles (Coleoptera: Coccinellidae: Coccinellini) associated with Alaskan agricultural crops." *Journal of the Entomological Society of British Columbia* 106 (2009): 39-45

Kuhl, J. C., A. Pantoja, J. Smeenk, and W. Campbell. "Field and Greenhouse Performance of Potato Sprouts." *American Journal of Potato Research* 86, no. 2 (2009): 150.

Pantoja, Alberto, Aaron M. Hagerty, Susan Y. Emmert, and Joseph E. Munyaneza. "Leafhoppers (Homoptera: Cicadellidae) associated with potatoes in Alaska: species composition, seasonal abundance, and potential phytoplasma vectors." *American journal of potato research* 86, no. 1 (2009): 68-75.

Robertson, N. L., and Brown, K. L. Identification and Molecular Characterization of a Potyvirus Isolated from Native Larkspur (*Delphinium glaucum*) in Alaska. Plant Dis. 93(4): 428. 2009. Palmer

Kuhl, Joseph C., and Veronica L. DeBoer. "Genetic diversity of rhubarb cultivars." *Journal of the American Society for Horticultural Science* 133.4 (2008): 587-592.

Hagerty, Aaron M., Alberto Pantoja, and Susan Emmert. "First record of diamondback moth (Lepidoptera: Plutellidae) from interior Alaska." *Western North American Naturalist* 68, no. 2 (2008): 249-250.

Book Chapters:

Zhang, M. (2014). Distribution and Biodegradability of Water Soluble Organic Carbon and Nitrogen in Subarctic Soils Under Three Different Land Uses. In Applied Manure and Nutrient Chemistry for Sustainable Agriculture and Environment. Fbks, Delta & Palmer