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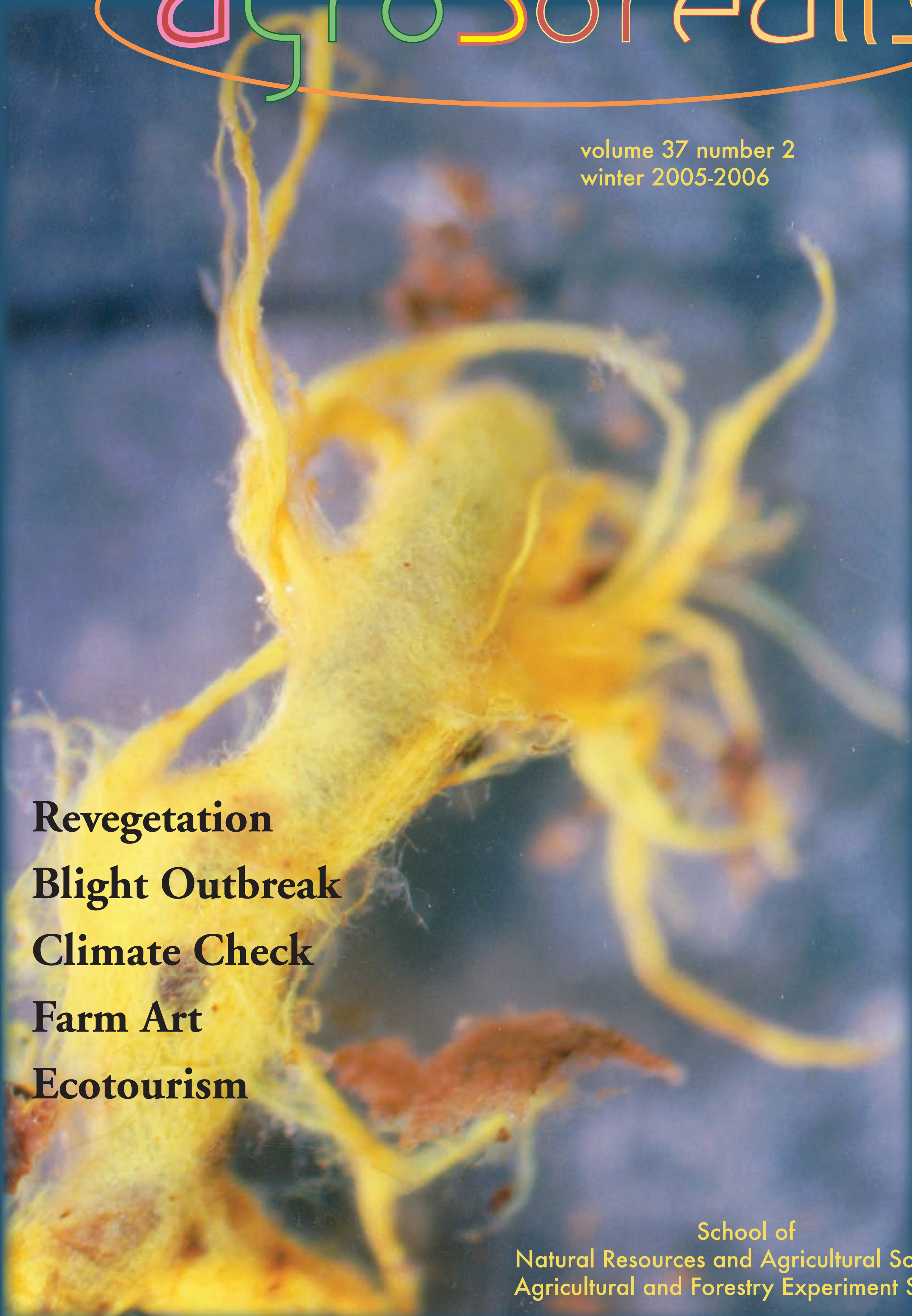

Revegetation

Blight Outbreak

Climate Check

Farm Art

Ecotourism

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

University of Alaska Fairbanks

contents:

Alaska's potatoes are now protected by an interagency diagnostic and alert network. See story on page 22.
—PHOTO BY DOREEN FITZGERALD

Visitor center at Kennecott Mill Town in Wrangell-St. Elias National Park. See story on page 25.
—PHOTO BY STEVE TAYLOR

About the cover:
Mycorrhizae and root tip. This colorful specimen is typical of very late succession; the photographer found it only at Exit Glacier above the most recent glaciations. The yellow hyphae of the fungal symbiote shown here create a sheath around the outside of the root tip. See story on page 14.
—PHOTO BY DOT HELM

Right: bench at the Georgeson Botanical Garden, by Jamie Smith. See story on page 20.

letter from the dean and the associate director:

Dean Carol E. Lewis

Associate Director G. Allen Mitchell

Although work at our School and the Experiment Station primarily focuses on issues related to circumpolar climes, in this issue we report on a study conducted in Chile, where graduate student Scott Harris carried out the first market research of community-based ecotourism in the Valdivian temperate forest ecoregion. Our work is often aimed at solving practical problems, but here we also showcase our basic research as Professor of Forestry Glenn Juday assesses the accuracy of a climate-change assessment made twenty-four years ago by researchers who predicted how events in warmer climes might affect Alaska and its circumpolar neighbors—they were right.

Our work in the Arctic and subarctic is traditional, and its immediate effects are in these regions. For post-mining revegetation, Dot Helm, retiring professor of vegetation ecology, pioneered the use of natural colonizers and woody transplants integrated with seeding. Her research, in partnership with Usibelli Coal Mine in interior Alaska, resulted in a sustainable landscape in an open-pit mine. In the short term, our researchers and our partners are immediate responders, as was the case when two people teamed to avert what could have been a disastrous infestation of late blight in the 2005 potato crop: Roseannn Leiner, assistant professor of horticulture and Cooperative Extension horticulture specialist, and Lori Winton, research scientist with USDA Agricultural Research Service.

As the research arm of the School of Natural Resources and Agricultural Sciences, the Agricultural and Forestry Experiment Station is one of five research institutes at the UAF that seek answers to questions that are relevant to international, national, and state communities. These institutes form the core of research at the University of Alaska. They work singly, with each other, with schools and colleges that are a part of the statewide system of campuses, and with non-university partners. They address both single-discipline and multidisciplinary challenges that affect the lives of people in the Arctic and subarctic. Their research also extends beyond these regions, because our lives are affected by events worldwide—we increasingly interact with other cultures and governments, and are increasingly affected by the condition of Earth's atmospheric, oceanic, and land systems.

We hope you enjoy this issue of *Agroborealis* and appreciate the diversity of thought and interest our faculty, staff, and students bring to the University of Alaska Fairbanks—the research university of the Arctic.

Carol E. Lewis
Dean and Director

G. Allen Mitchell
Associate Director

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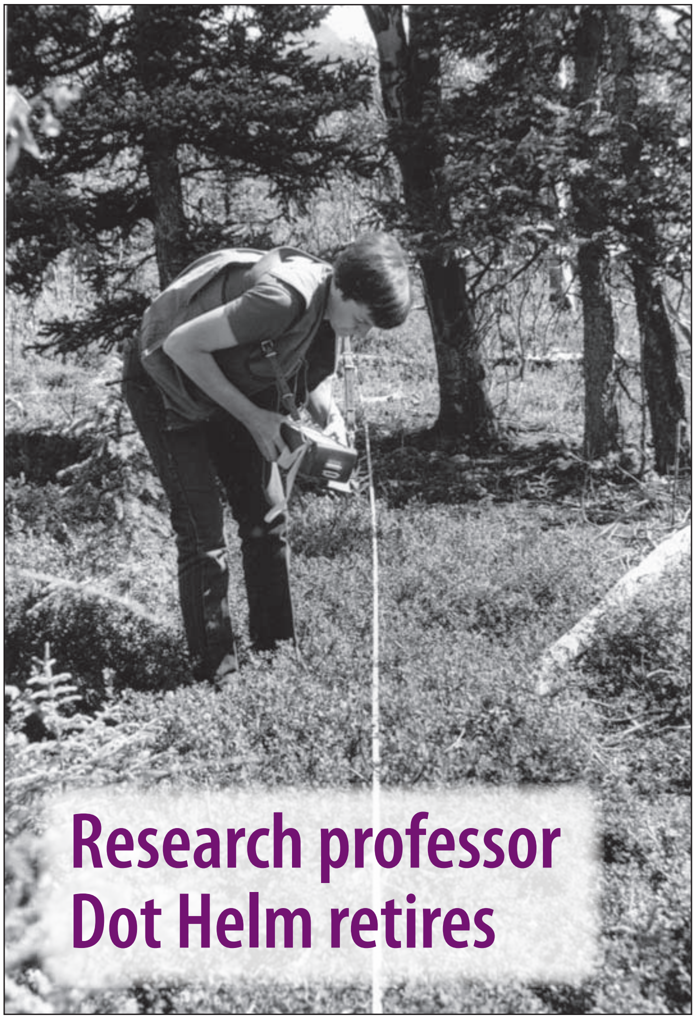
Research professor Dot Helm retires



Dot Helm uses a data recorder (circa 1990) to record plant cover along a transect during a pre-mining vegetation inventory, an activity she's spent a lot of time doing over the years.
—AFES FILE PHOTO

Although Dot Helm, SNRAS research professor of vegetation ecology, retired from those duties in June 2005, she noted during the preparation of these articles that she seems to be busier than ever. She has a twenty-year history of work on revegetation in Alaska.

"My main research focuses on ecology of disturbed lands, both natural (predominantly glacial, floodplain, and burned systems) and anthropogenic, predominantly mining," She said. "In this work, we try to understand the natural processes and mimic those during revegetation. Much of my current research focuses on mycorrhizae—the symbioses among plant roots and certain fungi in which the fungi help the plant absorb nutrients and moisture from the soil, and the plant provides the fungi with an energy source." Helm also works on matching plant materials and growth media on mined sites to achieve desired post-mining land-use goals.

"One of the things I've enjoyed most about my work is working with the mining industry on applied issues," she said. "As a result of my research being funded almost entirely by contracts and grants—from companies as well as local, state, and federal agencies—it's satisfying to see research actually being used. It has also been enjoyable working with the resource people at Kenai Fjords National Park."

For the Plant, Animal, and Soil Sciences Department at SNRAS, Helm taught NRM 493, Ecology and Management of Disturbed Lands. Her course, with many guest lecturers, covered floodplains, soil formation, soil survey and mapping, vegetation succession on deglaciated lands, introduction to mycorrhizae, biogeochemistry and volcanoes, range and wildlife, mining regulations, and reclamation of lands after coal mining and placer mining.

"Anyone who has seen glacial moraines and placer mine tailings has been struck by the similarities," Helm said. "This led to the obvious approach of trying to understand natural successional processes and mimicking them for mined land revegetation. This was a significant reason behind studying some of the natural chronosequences, as well as mycorrhizae."

Helm holds a bachelor of science degree from the University of Delaware (1969); master of science degrees from the University of Michigan (1970) and Colorado State University (1977), and a PhD from Colorado State (1981).

"I came to Alaska in 1980 after finding a job through an announcement at a national professional meeting," She said. "As a graduate student, I had worked part of my way through school assisting with pre-mining vegetation inventories. This experience was really helpful with my initial work on the proposed Susitna Hydroelectric Project. I began assisting Usibelli Coal Mine in 1985 with their pre-mining inventories and assessing long-term succession on their sites. Eventually I helped with revegetation trials on new mine sites, as well as monitoring of current succession. I had projects there almost every year until I retired. That experience expanded into helping the proposed Wishbone Hill Coal Project and Nolan Creek placer mine with similar inventories, revegetation trials, and monitoring.

What I'm looking forward to in retirement is seeing some local trails without snow. During the past twenty-five years, my fieldwork precluded having much free time in the summer. I also want to help local trail groups with trail maintenance and building, something I've missed since switching careers thirty years ago. I also want to work on some personal goals, and I plan to still help with some revegetation."

—Doreen Fitzgerald

Selected Refereed Publications

Helm, D.J., and B.R. Mead. 2004. Reproducibility of vegetation cover estimates in southcentral Alaska forests. *Journal of Vegetation Science* 14:33–40.

Helm, D.J., Allen, E.B. & Trappe, J.M. 1999. Plant growth and mycorrhiza formation by transplants on deglaciated land near Exit Glacier, Alaska. *Mycorrhiza* 8: 297–304.

Helm, D.J., and W.B. Collins. 1997. Vegetation succession and disturbance on boreal forest floodplain, Susitna River, Alaska. *Canadian Field-Naturalist* 111:553–566.

Collins, W.B., and D.J. Helm. 1997. Moose (*Alces alces*) habitat relative to riparian succession in the boreal forest, Susitna River, Alaska. *Canadian Field-Naturalist* 111:567–574.

continued on page 15

Usibelli Coal Mine:

A case history of change in revegetation success criteria and monitoring

by Dot Helm

Naturally exposed seams of subituminous coal, such as those pictured above a few miles from Two Bull Ridge, made Healy's coal readily accessible for steamwheelers and the Alaska Railroad.
—PHOTO BY CHRIS AREND, COURTESY USIBELLI COAL MINE

Note: This article was adapted from one originally prepared for Northern Latitudes Mining Reclamation Workshop, June 4-6, 2003. Fairbanks, Alaska: Helm, D.J. 2003. Evolution of revegetation success criteria and monitoring for Usibelli Coal Mine, Alaska.

Introduction

Revegetation was originally viewed as the application of seed and fertilizer to quickly establish green cover on disturbed lands, which essentially meant seeding grasses. But in Alaska and elsewhere, concepts of revegetation success have changed as we've learned from several decades of experience with long-term succession and the interactions among natural colonization and amendments (e.g., seed and fertilizer) applied by operators.

Initial mined land revegetation in Alaska was performed in early 1970s by Usibelli Coal Mine, Inc. (UCM), before reclamation was required by law. They used visual monitoring—on the ground, from the air, and with permanent point photographs—to monitor their progress and create a historical record. Revegetation was, and still is, considered an important part of their company goals.

In 1977, the Surface Mining Control and Reclamation Act, which required bond-release standards and quantification of vegetation success, was implemented in the United States. Alaska accepted responsibility for its own regulations and implemented the Alaska Surface Coal Mining Control and Reclamation Act in 1983, which must be as effective as the federal law. At this time vegetation ecologists began using quantitative vegetation sampling techniques to estimate cover, diversity, and woody species density in a traditional, stratified random sampling design, and revegetation still focused on grasses.

As we learned more about successional patterns, we realized that although the fibrous root network of grasses was still needed for short-term surface erosion control on slopes, establishing long-term plant communities requires an emphasis on woody plants. Both natural colonizers and woody transplants form the core of desirable post-mining plant communities, where the surrounding native vegetation of the boreal forest is predominantly woody. In the late 1980s and 1990s, the focus of revegetation efforts shifted to emphasize the initiation of a successional sequence that integrates seeding and woody transplants with natural colonization to establish wildlife habitat.

In 2002, we began exploring use of systematic grids to periodically monitor the rapid expansion of shrub communities and the resultant change in strata. The current availability of global positioning system (GPS) and geographic information systems (GIS) are very useful for long-term monitoring. Long-term goals now concentrate on woody plants, the predominant components of long-term communities and the

Reclaimed area near treeline in Gold Run Pass. The area was seeded and fertilized in the late 1970s, but is dominated by many native shrub species almost thirty years later. In 1985, it had twenty-seven plant species.
—PHOTO BY DOT HELM

surrounding vegetation, while short-term goals emphasize grasses and other herbaceous species that establish quickly for short-term surface erosion control.

Revegetation Objectives

On most mined lands, the goals of revegetation are primarily to limit erosion and meet water quality standards that minimize off-site impacts. Secondary objectives are to establish cover for post-mining land use (wildlife habitat, park, shopping mall) that blends with surrounding land uses or is acceptable to neighbors (public wildlife habitat or private subdivisions). These goals are frequently quantified by standards for ground cover, diversity, density of woody plants, and sometimes plant productivity. The mine operator may have other specific goals, especially if the company wants to maintain a corporate image (or be a good neighbor) whether it is near a subdivision or a national park.

Although not required to do so, UCM began revegetation in the early 1970s, when revegetation in Alaska was its infancy. Usibelli is a family-owned mine where many employees live in the surrounding area, and the company's revegetation effort is part of its corporate image.

One lesson learned from monitoring and successional studies at UCM and other places is that the operator's revegetation effort is actually only a small part of the larger picture of successful revegetation. Revegetation planning begins with the pre-mining assessments and mine planning. Three general sources of material exist: (1) existing natural resources such as soils and plants present pre-mining, (2) amendments applied by operator, and (3) natural inputs from the environment over time. Ideally, operators need to understand what's there and what might be added, so they can provide missing elements or facilitate establishment of natural vegetation.

Use of on-site resources should be considered when developing objectives to increase the feasibility or reduce costs of certain treatments. Understanding how these materials work and what successional changes occur over time may make seemingly complex goals relatively simple. Remember that some plant species require shade and certain soil conditions, so in many cases, it is not realistic to aim for immediately reestablishing the vegetation that existed before mining.

Revegetation Requirements

When the Alaska Surface Coal Mining Control & Reclamation Act was implemented in Alaska, permit applications required pre-mining assessments for vegetation, soils, wildlife, surface and subsurface hydrology, meteorological data, and cultural resources. Vegetation inventories included cover by all plant species, diversity, and woody species density within each vegetation type mapped. Cover estimates had to meet certain precision limits for total vascular plant cover within a vegetation type. On some mine sites where moose habitat was a priority, current annual growth estimates of browse species were needed.

The law also requires a reclamation plan that includes revegetation and bond-release standards. An operator has to post a bond sufficient to reclaim the mine site should the operator walk away at any point in time. The bond is released in three stages: when the land is backfilled and regraded, when seeded, and when vegetation meets certain bond-release criteria after ten years in low rainfall regions (five years in moister regions). The standards for final release can be based on native vegetation, historical data, or test plots.

At one time, if bond-release standards were based on native vegetation, then a reference area (frequently fenced to exclude grazing or browsing) was sometimes established, although this technique was never used by UCM. When the mined area was considered for bond release, the revegetation was compared with the reference area. The idea was to adjust cover for annual variability owing to drought or moisture conditions, which is particularly important for arid sites where moist years may result in unusual growth. Using a reference area assumed that the goal was to reestablish existing vegetation. However, vegetation on the reference plot might be at a much later stage of succession (mature forest) than the revegetated area, so it might not be a suitable standard.

Although one can't expect to establish in a decade a black spruce (*Picea mariana*) community on permafrost, or match the status of fifty-year-old poplar (*Populus balsamifera*) forest, revegetation practices can initiate the successional processes that will eventually achieve the desired goals. Many forest understory species may require shade, organic soils, microorganisms, and other features that may not be achievable in the first ten years. But species can be planted that will facilitate the plant community development along those lines.

Vegetation different from the original type may be more desirable for post-mining bond release. For instance, if moose habitat is desired, black spruce forests, which have relatively low values for moose, may be replaced with a mosaic of willows and mixed paper birch-white spruce forest. Today we try

View from Two Bull Ridge Mine above Hoseanna Creek toward Poker Flats. The road visible is the main road to the mine. To the rear of the plain below can be seen regular rows of shrub plantings; early in reclamation efforts the Department of Natural Resources asked that vegetation be planted in orchard-like rows. Later UCM was requested to plant in clusters along low-lying ground where moisture could gather and the vegetation could spread in more natural progression.
—PHOTO BY CHRIS AREND, COURTESY USIBELLI COAL MINE

to understand the successional processes and use revegetation strategies to initiate succession that will produce the desired vegetation. Bond-release standards are established that approximate what vegetation might be expected in ten years.

In some cases, older vegetation communities might be an appropriate standard, but in others, the vegetation present before mining may not be the most desirable for the post-mining land use. For instance, if human settlement has resulted in fire suppression, a mosaic of various vegetation stages may have matured into more uniform, older vegetation with lower wildlife values for some charismatic megafauna, such as moose. Before settlement, a more diverse vegetation structure may have supported a larger diversity of wildlife species. In this case, the desired vegetation would be a mosaic more characteristic of early successional stages. Hence it would be inappropriate to compare it to the older, possibly less desirable vegetation.

Some mines may have historical data that can be used for standards, especially if revegetation was started before it was required. Most mines will establish revegetation test plots before opening a new mine to select growth media and plant species suitable for the site conditions and post-mining land use.

Usibelli Coal Mine Case History

At the UCM, the original objective was to achieve green vegetative cover quickly using a seed mix of over twenty commercially available species. This approach was typical for revegetation in the 1970s, since green grass was desired and little was known about Alaska revegetation at the time. In fact, a Canadian consultant was used. In these early efforts, some woody transplants were used on some sites with varying success.

During the 1980s, after enactment of the Alaska Surface Coal Mining Control & Reclamation Act was implemented, UCM began inventorying vegetation before mining and evaluating existing revegetation on the Poker Flats and Gold Run Pass mines to establish technical standards for bond release. Shrub transplants were added back into their planting strategy. Today the main focus of UCM revegetation is the establishment of woody species and their diversity; grasses are used primarily for short-term surface erosion control, catchment of organics and seeds, and initial soil buildup of organic material in soil profile. The emphasis of bond-release standards has changed to reflect this.

Usibelli Succession

A 1989 succession study looked at various ages of sites, including the original reclamation of 1972 and unreclaimed sites from earlier operators. Different slopes, aspects, and substrates planted at different times were evaluated for cover by different plant species. As a result, UCM began to better understand which plant species in their seed mixes were most successful under what conditions. The seed mix was reduced from the original twenty or more species to about eight to twelve. Some of these species were intended for very short-term cover, like the first year, while others were intended for slightly longer term ground protection or particular niches. Most grass species began losing vigor in the second year after the last fertilization, and some became negligible shortly after that.

Grasses typically require higher nutrient levels than woody species. Only three or four species (Arctared red fescue [*Festuca rubra*], Manchar brome [*Bromus inermis*], common meadow foxtail [*Alopecuris pratensis*]*, and some other fescues [*Festuca* spp.]) provided much cover after year four. As these grasses died, the resulting litter mat helped catch seeds and organics and contributed to soil development. While some

* Common meadow foxtail, a potential forage grass, should not be confused with foxtail barley (*Hordeum jubatum*), a weed in many areas that can be harmful to wildlife because of its awns.

colonization began within the first five years, after the litter mat thinned more and more local plants, especially woody species, began colonizing around years six or seven.

Bond-Release Standard History

Initial bond-release standards established in the mid-1980s at UCM were based on measurements of existing revegetation that was six or seven years old. Cover, diversity, and woody density standards applied to the entire site that would be proposed for bond release.

With monitoring, however, we began to realize that most of the seeded species do not survive, and even the hardier herbaceous species died back unless fertilized. This created a perceived dilemma, because the diversity standards depended heavily on the grass cover, which would probably die off by year ten, yet in that time period, the woody plants frequently did not provide much ground cover. However, once woody plants are established, they will live, reproduce, and help establish plant communities by providing shade and leaf fall.

In essence, the way standards were implemented appeared to force operators to encourage grass growth, which monitoring suggested was not a good idea. However, it was also observed that along with the transplanted woody plants, native colonizers established themselves, then spread in revegetated areas. This had the desirable effect of creating a patchwork of vegetation types.

In the late 1990s, these observations resulted in a reinterpretation of revegetation success requirements. An overall ground cover standard is still required, but the diversity and density standards are only applied to a subset of the site, where woody plants are emphasized. Diversity is based only on the woody density (not overall cover), and the woody area could be delineated any time up to the request. This accommodated the slower cover production by woody plants, which on these sites live much longer than grass without fertilization.

Now the operators could focus on establishing woody plants that would grow, establish more cover, reproduce (for some woody species), and facilitate establishment of woody plant communities. The regulators did place a cap on the number of stems that could be counted per acre so that alder thickets (*Alnus* spp.) in a small portion of the site would not provide most of the stems for the entire site.

As it turns out, the cap is low enough that any time woody plants are visible on standard aerial photos, there are more than allowed to be counted. The mine is not penalized for the additional stems, but they can not count them toward their density. This makes delineation of acceptable woody areas fairly simple. Lines can be drawn around shrub communities on aerial photos with knowledge that they have at least as many stems as allowed. This is a minimal estimate of the area that meets the density and diversity requirements of a "woody" area. A more realistic estimate also would include nearby areas. This approach enables mine company personnel, rather than a vegetation consultant, to delineate the pertinent areas.

Monitoring Techniques

Another issue with the original monitoring was that it used "stratified random sampling"—random sampling units in "homogeneous" areas—like the pre-mining inventories. These homogeneous areas changed rapidly over time, especially in early succession. Strata were used initially to learn what was in these different vegetation types and to parallel the pre-mining sampling.

For years, some large-scale inventory and monitoring programs, like that of the US Forest Service, have used systematic grid designs rather than stratified random sampling. Statisticians seem to be encouraging the systematic designs, especially for long-term monitoring, on the basis that the arbitrary strata boundaries were biased by ecologists' perceptions of processes, which change as we learn more. Systematic designs also include "edge" or ecotone areas, where greater diversity occurs, but which were usually along boundaries in stratified random sampling, causing them to be ignored frequently. A side benefit of systematic grids is that company personnel can probably relocate systematic points more readily with consumer-grade GPS units—even if they have never before been to a point. For the 2002 monitoring, we established a systematic grid with points spaced about 250 meters apart in the Gold Run Pass area. Based on preliminary results, we may need a slightly denser grid to have adequate sampling. But overall, it seems far more efficient and effective than the random stratification used before.

Conclusion

Over thirty years of revegetation history at Usibelli has suggested that grasses are needed for initial surface erosion control, debris catchment, and adding organic matter to soil. They facilitate soil development that generally does not occur as rapidly with slower growing native species. On the Poker Flats and Gold Run Pass sites, seeded grass species die, the litter decomposes from years three to seven, and natural colonization becomes significant at around years five to seven. In conjunction with a better understanding of how succession on revegetated sites works and a broader definition of bond-release criteria, the interpretation of these criteria have been modified over the years to better reflect current thoughts on revegetation success, including emphasis on woody communities.

Acknowledgements

I thank Usibelli Coal Mine for financial and logistical support for these studies, plus the opportunity for many studies on their sites since 1985. People that have been directly responsible for input to these studies include Larry Jackson, Alan Renshaw, Mitch Usibelli, and Steve Denton. Numerous people over the years have provided input regarding old site locations and their history as well as general observations on what is happening with both the native and revegetated sites.

Reclamation flight spraying seeds and fertilizer; photo taken at Poker Flats August 14, 2004. The Nenana River and Healy area are in the distance. Usibelli uses canola in its seed mix as a marker: when the plants bloom, their bright yellow flowers help identify areas that are well seeded and those that need supplemental seeding. The company hires teams of college students in the summer to manually broadcast seed in patchy spots.
—PHOTO BY FRED WALLIS, COURTESY USIBELLI COAL MINE

Seed and "topsoil":

to use or not to use?

by Dot Helm

Note: This article was adapted from a presentation by the same name at Northern Latitudes Mining Reclamation Workshop, October 1-3, 2001, at Whitehorse, Yukon, Canada.

Two issues almost always arise in reclamation projects: what plant materials, if any, to use and what growth media to use? Examples of plant materials include seed, both commercial and locally collected, cuttings, or seedlings. Growth media are the materials spread on the surface of the prepared site: topsoils, overburdens, "waste" materials, or mixes. During the last twenty years, I have observed the use of various treatments, plant materials, and growth media, either at existing revegetation sites, during new revegetation, or in planned studies. Some observations are synthesized here.

The selection of both plant materials and growth media have economic and regulatory considerations as well as the usual biologic aspects. That is, some things work biologically, but might be expensive, and some things might be legally required. Seeding or use of other plant materials is (1) an expense, (2) a method of erosion control, (3) a method of controlling undesirable plant species, (4) a method of establishing desirable species, (5) a public relations benefit, or (6) a potential method of impeding natural colonization if not done correctly. Like all tools, seeding requires appropriate use—the right species and seeding rates for existing conditions and the desired post-mining land uses. Several studies including abandoned and active Alaska coal mines demonstrate the advantages and disadvantages of seeding. Not seeding, or using other erosion control techniques, may be even more expensive if the soils erode.

Related to growth media is the fact that many regulations suggest or require the use of surface soil. It frequently has many beneficial biological and organic characteristics: seeds, rhizomes, and soil microorganisms, although fine-grained (loams or finer) materials typical of surface soils are more likely to erode than coarse sands and gravels typical of sub-surface materials. There are situations when surface material is not be the most appropriate media, depending on overburden characteristics, plant materials, and objectives. Using surface materials can be initially expensive, but when appropriate could save thousands of dollars in the long term; if inappropriate, it could be an unnecessary expense that provides no benefit.

Revegetation generally aims to limit soil erosion to natural levels, while maintaining the water quality of nearby streams (minimizing off-site impacts). Other considerations are desired plant community diversity; achieving a specific ground cover level; providing suitable vegetation for post-mining land uses; or establishing plant communities or appearances compatible with neighbors as diverse as public wildlife habitat or private subdivisions. A mining company may also have some specific signature appearances it wants to achieve. Some of these goals are more suitable for active mines, and others more applicable to abandoned mined sites.

When developing objectives, consideration of available on-site resources increases feasibility and can reduce the cost of certain treatments. For instance, when reclaiming lands under an Abandoned Mine Lands (AML) program, plant and soil or overburden materials may be available in areas to be regraded; active mines may be able to salvage materials as new areas are cleared. Understanding how these materials interact with the successional changes in vegetation and soils that occur over time is important to project success and may make complex goals relatively easy to achieve.

Approaches

Revegetation can range from "do nothing" to an attempt to reestablish plant communities immediately following the disturbance activity, which in many cases is an unrealistic goal. Some approaches are more suitable for AML environments and some for active mines. The do-nothing approach has resulted in both relatively barren and heavily vegetated AML sites. An AML Trust Fund is funded by fees from active coal mines and is managed by a federal agency. The funds are used by state agencies to reclaim the barren AML sites, especially those with safety hazards. In some cases, succession has changed the sites to blend with surrounding native vegetation and made old mine sites difficult to detect. In almost all cases, natural successional processes will cause changes in what was planted, but the type and rate of successional change will depend on treatments and site conditions.

Usable plant materials may be local, native, or introduced. By local I usually mean plant materials collected in the general project area (seeds, stem cuttings, or transplants); native refers to species native to the region that may not be found in the project's immediate vicinity; introduced species include those not native to project region, and frequently include "weedy" species such as dandelions (*Taraxacum officinale*).

The terms undesirable and desirable refer to how the species relates to the project objectives. For instance, if moose browse or a woody plant community is desired, then tall fireweed (*Epilobium angustifolium*) could be undesirable because dense stands could shade out the woody plants. But it is a native species, probably local near many mine sites. If the revegetation objective is to establish a meadow of magenta flowers, then tall fireweed could be desirable; if a meadow of many colored flowers is the objective, fireweed's ability to out-compete other flowers would make it less desirable.

One simple, traditional revegetation method is to regrade with the most abundant or convenient growth media material and seed with a mix of commercial herbaceous species. This has the short-term benefit of establishing ground cover quickly, assuming the species planted were matched with appropriate growth media. It has the disadvantage of possibly bringing introduced species to the site and incorporating them in the gene pool. If no plant materials are brought in, as in the do-nothing approach, this risk is avoided, but the site may erode before plant cover or a physical protective cover is established. Note that plant cover can only enhance the engineering design; it cannot hold poorly designed slopes in place.

In recent years, more emphasis has been placed on using native, even local, plant materials and using topsoil where appropriate to assist revegetation.

Soapberry (Shepherdia canadensis) *and other natives colonizing seeded grass area at the Usibelli Coal Mine.*
—PHOTO BY DOT HELM

Seeding

Combining the use of seed, plants, and appropriate growth media can facilitate revegetation. Seeds and plants can reduce surface erosion caused by wind and water. Seeding can also foster establishment of other plant species by reducing wind flow near the surface, providing a catchment for other seeds, and maintaining soil friabilty. If plants fail to establish quickly, silty areas may develop salt crusts that will inhibit colonization by many species. The concern about introduction of non-local and non-native plant materials into an area and their subsequent propagation or entrance into the gene pool should be balanced against potential damages to downstream neighbors if ground cover is not established rapidly enough.

In most places I've observed in Alaska, seeded species (both introduced and native) usually die out or at least lose vigor within five to ten years and frequently less for most grasses. In the case of heavy grass seeding, litter cover (vertical projection of plant material on the ground) that protects the soil surface from erosion and weed establishment may build up in the short term, but can also reduce the extent of natural colonizers. However, I have also seen unseeded areas where no vascular plants (plants with stems and leaves, not mosses) had become established after five years, and the area eroded.

Some Alaska cases

The following examples from abandoned and active coal mines and placer mines illustrate effects of seeding and different growth media.

At **Gold Run Pass** on Poker Flats, near Healy, sites were seeded in the late 1970s. When first sampled in 1985, one site had substantial grass and litter cover with only four percent bare ground, and none of the few colonizers were along any of the transects. Nine years later (1994), colonizers provided eleven percent cover. In 1985 another site had only eight percent cover, but had twenty-seven species, including white spruce (*Picea glauca*), blueberry (*Vaccinium uliginosum*), resin birch (*Betula glandulosa*), and paper birch (*Betula papyrifera*).

By 1994 one-fourth of this area was covered woody species. Although this second site developed woody communities faster than the site with heavy grass and litter cover, the litter on the grass site has been reduced over time, and extensive woody colonization has occurred.

An abandoned placer mine near **Mile 101 Steese Highway**, northeast of Fairbanks, was reclaimed in 1993 by creating channels and regrading the site (Nelson et al., 1995a, b). Some trials used seeding and woody cuttings, but most areas were left for natural colonization. Unseeded control plots near the seeded plots were first colonized mostly by species not present in adjacent native vegetation. Outside the seeded and control plots, natural colonization occurred at first primarily from buried debris, but by the fourth growing season significant willow growth was present. However, by year four, some unseeded areas still had no vascular plant growth. While most willow colonization occurred outside the seeded area, not seeding didn't guarantee colonization, and some unseeded places were colonized by less desirable species, such as dandelions.

In the **Lower Knob Creek** areas near Sutton in southcentral Alaska, abandoned coal mines are being reclaimed by the Alaska Department of Natural Resources. Sites were regraded and covered with overburden materials. Some areas were left unseeded and others were lightly seeded with herbaceous species. After five years, in an unseeded area densities averaged 7.4 balsam poplar (*Populus balsamifera*) seedlings per square meter (overall vegetation cover was near 3 percent), but this was next to a forest; farther from the forest edge, the average was 1.9 seedlings per square meter in the seeded areas (average cover near 60 percent). Because some portions of the seeded areas were inadvertently striped by uneven application of seed and (or) fertilizer, the amount of seeded cover varied substantially across the area. In these striped areas, no significant relationship was found between density of woody colonizers and cover of other species (usually the herbaceous seeded species). However, there were many unseeded or low-cover areas with few colonizers and many heavy-cover areas that had many colonizers. Seedlings in the seeded area were generally larger than those of the unseeded area, probably because of the fertilizer application. Almost all areas had greater densities of woody seedlings than will survive to maturity.

Areas in **Upper Knob Creek** were seeded with commercial grass seed, and most have less native colonization than those in Lower Knob Creek. The amount of grass cover, however, depended on the growth media. Alder (*Alnus sinuata*) is becoming a major colonizer on several sites after five years, and it seems that in areas where treatments include seeding and fertilization, alder becomes a major player.

As another example of variable colonization in the Knob Creek area, a regraded site was left unseeded, and a systematic grid of two-by-four-meter cells was monitored for colonization. After five years, it averaged about two woody seedlings per square meter, although some cells had as many as eight. One end of the site was colonized largely by less desirable herbaceous species, the other end by balsam poplar, and the middle by paper birch. Where the herbaceous species were, fewer woody colonizers existed. This end also happened to be near some woody species, while the poplar colonizers at the other end were near a poplar forest. Birch, which have much heavier seeds than poplar, were believed to have regenerated from seeds and catkins that rolled down a hill. We could not conclude whether these colonization patterns resulted from interactions among the major species or whether they were a function of what was growing nearby.

The above observations are examples of areas where different results were obtained through seeding or not seeding. I have seen no case where seeding precluded long-term colonization. Indeed, some levels of seeded cover may facilitate colonization. In other cases, heavy cover appears to slow colonization in the short term, while providing important soil protection. Some unseeded areas have negligible cover after five years.

Growth media

Selection of growth media (overburden, surface horizons, or mixes) depends on availability, plant materials, and post-reclamation objectives. Some species have optimum soil condition requirements, particularly pH, and these should be matched with available materials. Although AML situations frequently do not have available significant surface horizons, some materials may be salvaged if existing vegetation must be cleared to allow for regrading steep slopes.

Many of the early commercial grass cultivars, such as Manchar smooth brome (*Bromus inermis*) had agricultural origins and grew best on sites with pH values near 6 to 7. Many of the most common woody species planted for browse also need soil pH values near neutral. In southcentral Alaska under native vegetation, mature surface horizons frequently have pH values near 5 or lower, so using native soils was useful only with certain plant species. Now available are commercial grass species, such as Norcoast Bering hairgrass (*Deschampsia beringensis*) and Nortran tufted hairgrass (*Deschampsia caespitosa*), that are more tolerant of lower soil pH values and are suitable for topsoiled areas.

An early study comparing plant growth on loess (topsoil) versus sandstone (overburden) near **Healy** had similar values for cover of seeded species and perennial vascular plant cover through three years of monitoring, although the sandstone had slightly less in year one. Species tolerant of lower pH values, such as Arctared red fescue (*Festuca rubra*), initially provided more cover (86–95 percent) on the loess (pH 5) compared with sandstone (pH 7, 64 percent cover) but this difference decreased over time. In contrast, Manchar brome, which does better on soils with higher pH, was not observed on the loess plots, but initially provided 20 percent cover on the sandstone. Brome is a taller plant than red fescue with a deeper root system, which resulted in more roots at the 10 to 20 cm depth in the third year. In this case, sandstone was the better choice for achieving a more diverse plant community.

In another study near the same area, on **Two Bull Ridge** on the other side of the valley, fires had thawed the permafrost several decades ago and surface soils there were very different.

Multiple woody and herbaceous species as well as mushrooms colonizing seeded area near Thompson Pup in the Brooks Range (left) and Poker Flats near Healy (right). This demonstrates the amount of natural colonization that can occur even in conjunction with active grass growth.
—PHOTOS BY DOT HELM

Also, the sandstone tested there was from near the surface so it had already weathered somewhat, and its pH was similar to that of the surface soils. In this case, most grass species did better on the sandstone for the first two years, were similar in year three, and after that were better on surface materials. After ten years, growth of grasses is minor on both treatments, but colonization by alder is more robust on the sandstone plots.

Considering the biological aspects of topsoil, the mycorrhizal fungi of some soils may not be appropriate for some plant materials. Mycorrhizae are symbioses of plant roots and certain fungi where the fungi help the plant absorb nutrients and moisture from the soil while the plant provides the fungus with an energy source (carbon) (See p. 14). The appropriate fungi may be related to plant species, soil environment, and age of roots, but some may be more general. In an active mine environment, the fungi may be supplied by using fresh topsoil. In an AML situation, local soils could be used to inoculate seedlings at the time of planting, or transplants of seedlings or saplings from the surrounding environment would have the soils and accompanying fungi already present. In brief, mycorrhizal fungi are important for revegetation, but matching soils, plant species, and fungi is necessary.

A study conducted near **Jonesville** in the Sutton area evaluated sources of inoculum from two different successional stages in the surrounding vegetation for their effect on growth of poplar and alder (Helm and Carling, 1993). After two years, the inoculum from a mature forest was better than that from a younger site. In this case, both soils could have provided benefits to a revegetation effort. In a followup study near **Healy**, two growth media were selected to inoculate alder seedlings. One came from a site with mature paper birch and an understory of alder; the other came from a black spruce (*Picea mariana*) site, which was not expected to have the appropriate inoculum. In this case, the inoculum from the paper birch site provided some benefits, but that from the black spruce site did not.

In AML work at **North Jones** near Sutton, the state has been able to recover some soil and plant materials while regrading areas. Since this was done, the seeded growth there has been better than on other areas where treatments were the same, except for the recovered soil. However, the grubbed (topsoiled) site was on a slightly more gentle slope, which could have contributed to the result.

Integration of plant materials and growth media selection

Wishbone Coal Project was a proposed coal mine located on the **Matanuska Valley Moose Range** near Palmer, Alaska. The post-mining land use was to be moose habitat, particularly browse. Since the site had sufficient surface soils useful for reclamation, the company decided to use topsoil, which had a pH near 5. Most of the species used for moose browse at the time (feltleaf willow and balsam poplar) were generally started in soils with pH values near 7. This appeared to be a mismatch between growth media and plant species. Also, bluejoint reedgrass (*Calamagrostis canadensis*) is frequently an aggressive colonizer after disturbance and was expected to interfere with woody regeneration. Here is another potential drawback of live topsoil—the presence of less desirable species when trying to achieve a specific revegetation goal.

A study in this area used four growth media and seven woody species to determine what combinations would work in this environment (Helm, 1992, 1994, 1998). Three growth media included soils from beneath a paper birch and white spruce community, upland meadow dominated by bluejoint reedgrass, and lowland meadow that had diverse plant species. A fourth type, glacial till, was used to simulate overburden in the area. Surface materials were bulldozed off all plots, temporarily stockpiled at the side, then respread within a day's time. This simulated a mining disturbance, but not transportation or stockpiling of the material. This trial also included an unseeded control plot and plots seeded with a mix of commercial grass species at low and medium rates to evaluate the benefits of using aggressive revegetation techniques compared with natural colonization. Because the topsoils were beneath successional plant species, mostly paper birch, it was believed that native colonization may be adequate for ground cover. However, the Alaska Department of Fish and Game (ADF&G) had indicated that they wanted to see as much browse after mining as before. The agencies and the mine company agreed that some of this could be achieved through succession, otherwise the planting density might be greater than would appear in a natural stand of willows.

The four growth media (three soils and glacial till) were selected for their pH values, availability, land potential as source of seed, rhizomes, and mycorrhizal fungi for desired woody plant species (Helm, 1994). The three soils had pH values near 5. Based on drill cores, the pH of the glacial till should have been near 7, but when the plots were installed, the bulldozers did not get below the contact zone, so the pH was lower than anticipated, near 6.

The seven woody species included balsam poplar and feltleaf willow (*Salix alaxensis*), both of which could be rooted easily in a sand bed and usually started in soils with pH near neutral; barclay willow (*Salix barclayi*) and Bebb willow (*Salix bebbiana*), which are both moose browse species but generally grow on the lower pH soils of upland sites; alder (*Alnus tenuifolia*) selected for hare habitat and nitrogen-fixing capabilities; paper birch selected for moose browse (it was the most common tree species present); and white spruce selected for thermal and hiding cover for moose. The three willow species and poplar were planted from rooted cuttings; seedlings were used for the other three species.

Many changes occurred over the ten years the plots were monitored. But after ten years, the seeded plots were almost indistinguishable from the control plots: almost no seeded grasses could be observed, and plots were heavily colonized by tall fireweed and bluejoint reedgrass. However, this colonization did not occur rapidly enough to achieve the desired ground cover. Most woody plants grew enough that the overstory closed within five to seven years, creating a shady forest-type environment. Colonizers here were the more desirable woody species as well as herbaceous species that are likely found in the forest understory—white spruce (*Picea glauca*), paper birch, bunchberry (*Cornus canadensis*), and oakfern (*Gymnocarpium dryopteris*). On a nearby separate grass study site, grasses also have largely disappeared and planted trees are several meters tall. Species did not do as well on the overburden site, but that was not disturbed as it might be under a normal mining regime. However, topsoils apparently were better in this case, and the intensive revegetation technique (using rooted cuttings and seedlings) was more successful for project objectives.

The question at the time of the study was what species could be established on which growth media. Moose densities were known to be high in the area, so most plots were fenced to preserve the study. The upland meadow plot was left unfenced, since we thought that would be overrun by bluejoint anyway. What we found after a number of years was that although all the woody species could survive and grow well in the fenced plots, the feltleaf willow and balsam poplar (proposed main browse plants) did not grow well under the browsing conditions on the low-pH soil. The barclay willow tolerated the browsing; after twelve years, it is hedged but still reasonably vigorous. Bluejoint is losing vigor. Although the soil originally appeared to be a mismatch for the goal of creating moose browse, it was found that all the plant species could grow in the low-pH soils, but only the species that usually grew in those soils could also withstand browsing. The point of this study is that it is critical to understand the interactions among the growth media, plant species, and other ecological conditions.

Conclusion

In any revegetation project, care must be taken to match the plant species, growth media, and project objectives. Seeding and use of other plant materials almost always reduces erosion, but sometimes appears to slow natural colonization in the short term. In areas where I have worked, however, very few seeded species have survived in any abundance, and natural colonization almost always takes place on seeded areas. The type and rate of colonization depends on original treatments and surrounding plants. Not seeding is no guarantee that colonization will occur, and it presents a short-term liability for erosion.

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What are Mycorrhizae?

text and photos by Dot Helm

Mycorrhizae (*myco+rhizae* = "fungus-roots") (pronounced like Mike O'Rhizee) are symbioses between plant roots and specialized fungi that help the plant absorb nutrients and moisture from the soil and provide an energy source (carbon) for the fungus. There are two main types, and they are distinguished by whether the threads that make up the mycelium (hyphae) are external to root cells (**ecto**mycorrhizae, EcM) or internal to root cells (**endo**mycorrhizae). Ectomycorrhizae are by far the most common mycorrhizae on woody plants that we've studied, a trend that seems characteristic of northern latitudes. EcM have a Hartig net between root cells and a sheath enveloping the root tip (Fig. 1), and external hyphae (Figs. 2-3, cover photo) that allow the fungus to access much larger volumes of soil than that available to the plant roots alone (Read 1992; Smith and Read 1997). Endomycorrhizae have hyphae internal to root cells and have several subdivisions including arbuscular, ericoid, arbutoid, and other types.

The combination of specific fungi and plant roots form characteristic morphotypes—several of the more photogenic ones are illustrated in Figs. 2-4 and on the cover, but some can be very difficult to detect even with 40x dissecting microscope. Some morphotypes may look similar, but may be distinguished by the sheath patterns, revealed in plan view by carefully peeling the fungal sheath off the root and flattening it before viewing under compound microscope. Formal descriptions consist of characteristics described in *Concise Description of North American Mycorrhizae*. (Goodman et al., 1986)

Ectomycorrhizae are quite diverse. Some fungi seem to associate with many plant genera; some plant species associate only with certain fungal species. Some EcM fungi are more common in mineral soils, some in organic soils; some on young trees, others on older trees. In other words, EcM relationships in the soil and vegetation can be complex. Our goal of understanding these relationships is why we have looked at EcM on many naturally disturbed sites (deglaciated areas, especially Exit Glacier) and at anthropogenic disturbances (mined sites) in several areas.

For revegetation, EcM can colonize by use of fresh topsoil, or soils can be used to inoculate individual woody seedlings at time of planting or in a greenhouse. But care must to taken to use appropriate soils for inoculum, considering the plant species and the site where it is being transplanted. Hence, if we are to successfully restore disturbed sites, we must not only initiate a successional trajectory with plant species, but also provide appropriate mycorrhiza fungi for the plants.

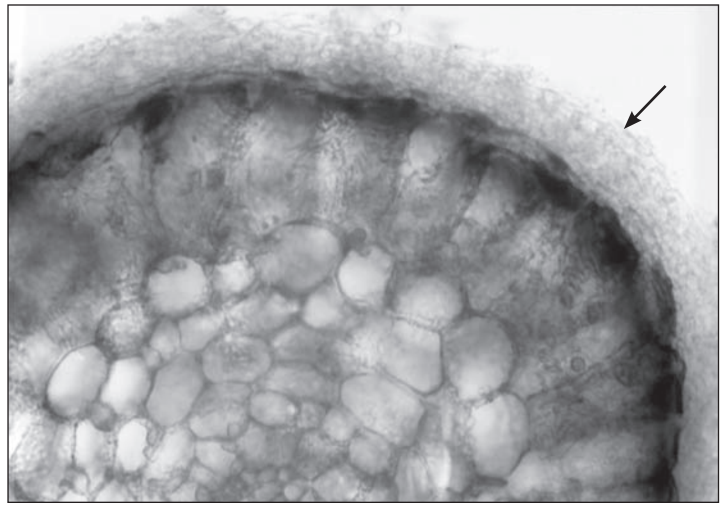

Figure 1. Cross-section of mycorrhizal root showing the sheath (arrow) around the outside of the root and the Hartig net between the root cells (visible in the photograph as dark irregular lines crossing over and around the cells). As shown in other pictures, the sheath may be well developed or poorly developed. The Hartig net may only occur between outer cells in some morphotypes or go most of the way to the center in

Figure 2. Some morphotypes may have twisty roots, be light colored, and have lots of emanating hyphae.

Figure 3. Other morphotypes may be black with emanating hyphae and have relatively straight root tips.

Figure 4. Some morphotypes may have felty or smooth sheaths without extensive emanating hyphae.

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http://www.dnr.state.ak.us/mlw/mining/coal/index.htm

Abandoned Mined Land program in Alaska:

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Mycorrhizae:
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Assessing Climate Change: Did We Get it Right?

by Glenn Patrick Juday

Introduction

Fairbanks, Alaska, January 1981. The midwinter days are only about four hours long, and there is no particular warmth in the sun that will struggle a few degrees above the horizon near noon. As another workday begins, across the town curtains remain closed in residences because the inside lights would illuminate the household to the dark world outside. But groggy residents sitting down to breakfast hear a succession of strange sounds. There are muffled thumps and whooshing sounds, gurgles and splats. It's oddly familiar, but a bit distant in the memory of the residents too. People begin to flip on exterior lights and peek out to investigate what's happening in the dead of the subarctic winter.

It's a thaw. And not just a weak, barely above freezing thaw, but a well-above freezing spell that sets in and stays. First the snow accumulated in tree crowns sags, then falls to the ground with a thump. Then the branches of spruce trees spring back, uncompressed, flinging through the air with a whooshing sound. Then a drip line develops along the edge of roofs. Finally, snow and ice are falling and gurgling everywhere. It's a thaw. Only it's not spring. Snow and ice are returning to liquid form at the time of year with the lowest mean daily temperatures. What's happening?

Air from the mid-Pacific is rushing down the slopes of the north side of the Alaska Range, scouring out the normally stagnant pools of cold that develop on the floor of the Tanana Valley, and bathing the far north in extravagant warmth. This year, the mean monthly temperature in Fairbanks for January ends up 30.0° F (16.7° C) above normal—one of the warmest if not the warmest above-normal for any weather station in the history of North America. The immediate cause of this temperature increase is a circulation-driven chinook (a southerly, downslope mountain wind), not direct greenhouse warming. But, after reports and hypotheses that the planet might warm as the result of carbon dioxide produced by humans accumulating as a greenhouse gas in the atmosphere, and that the warming would appear first in the Arctic—people wondered—is this spectacularly unusual warmth a signal of things to come?

The Conference

April 1982, Fairbanks. A group of Alaska scientists and academicians led by the UAF Agricultural and Forestry Experiment Station (AFES) convene a national conference on The Potential Effects of Carbon Dioxide-Induced Climate Changes in Alaska. The Alaska Humanities Forum provides crucial financial support.

Although climate change research and assessment in 2006 is a minor industry at regional, national, and international levels, in 1982 there were few sources of support for an effort to pull together scholars across disciplines and look seriously at what the climate change issue would mean for society. Today it's hard to even catalog the notices of the meetings, workshops, task forces, and presentations.

In 1984, AFES published proceedings of the conference (McBeath et al. 1984), which contained papers from national experts and Alaska investigators and scholars. These academicians in the natural sciences, social sciences, resource management, and the humanities were in the best position to examine the past record of climate change, risks, vulnerabilities, and opportunities from climate change, and especially the potential effects of future climate change.

But a crucial question even today is whether academicians collectively are any good at assessing the climate change future. The 1982 Alaska conference was one of the first regional meetings with this ambition in the climate change field. Considering the twenty-four years of events that followed, what can we say now compared to then? In other words, "Did we get it right?"

What follows are highlighted quotes from individual chapters in the 1982 conference proceedings, followed by an updated 2006 consensus in the literature. It is beyond the scope of this article to cite all of the conference papers and all of their major assertions, forecasts, or projections. But the papers that have been cited offer a good cross-section of the subjects covered and some statements that represent a good test of whether the view of the future offered back then was accurate or useful. The work of climate change assessment is now stretching out into a multigenerational effort, and a retrospective such as this one may be helpful for those who need to listen, ponder, and decide in the future.

The Chapters

Atmospheric and Oceanographic Measurement Needed for Establishment of A Data Base (Charles Keeling)

1982 Conference Quote: "The plotted values [of carbon dioxide at the Mauna Loa Observatory–ed.] range from 312 parts per million at the beginning of the record to about 340 parts per million at present."

2006 Update: Atmospheric carbon dioxide concentration in early 2006 was nearly 380 parts per million (http://www.cmdl.noaa.gov/ccgg/iadv/). A half-century ago, when observations were first made at Mauna Loa in 1958, the year-to-year increase was about 1 part per million. Over the last decade the average annual increase was about 1.8 parts per million, with a most recent annual increase of about 2.2 parts per million.

Possible Effects of a Global Warming on Arctic Sea Ice, Precipitation, and Carbon Balance (Will Kellog)

1982 Conference Quote: In describing the results of a climate model "It can be seen that by the year 2000 the average global surface temperature could be warmer than at any time in the past 1000 years or more, …"

2006 Update: The model results are supported by actual events. The Intergovernmental Panel on Climate Change concluded that "the rate and magnitude of global or hemispheric surface 20th century warming is likely to have been the largest of the millennium, with the 1990s and 1998 likely to have been the warmest decade and year" (IPCC 2001). The year 2005 had the highest global surface temperature in more than a century of instrumental data in the Goddard Institute for Space Studies (GISS) annual analysis, but the small amount by which it exceeded 1998 is within the margin of error (http://data.giss.nasa.gov/gistemp/2005/).

1982 Conference Quote: "In summary, then, what we can say about the Arctic Ocean ice pack is that theory (models) tells us that the Arctic Ocean will become ice-free in summer with a relatively modest [5 degrees C, ed.] warming, one that could occur very early in the next century, …"

2006 Update: This projection is well supported by events. During the period 1979–2004 Arctic Ocean sea ice extent at the end of the melt season (September) declined by 7.7 percent per decade (Stroeve et al. 2005). In September 2005, sea ice in the Arctic reached a record minimum exceeding the pervious record of 2002 (Serreze et al. 2003), more than 14 percent lower than the 1978–2000 mean. In the past, a low ice year would be followed by a rebound to near-normal conditions, but the three years since 2002 have been consistently low-ice years.

1982 Conference Quote: "… if the tundra and taiga grow [increase in net growth, ed.] due to the increased temperature and longer growing season, this will take CO_2 out of the atmosphere and incorporate it into additional biomass. If, on the other hand, the material in the surface is dried out and oxidizes or decays, this will add CO_2 to the atmosphere. The result of the first would be a negative net feedback, and the result of the second would be would be a positive feedback that would accelerate the buildup of CO_2 and the consequent warming."

2006 Update: Results since 1982 largely support a decrease in Alaska boreal forest growth, contributing to a large positive feedback to warming. Ground-based studies of tree growth across the boreal region of Alaska find that, surprisingly, summer warming causes a strong decrease in above-ground tree growth (and thus carbon uptake) in all the major tree species on several, but not all, site types (Juday et al. 2005). Studies based on satellite remote sensing find that net surface photosynthesis actually decreased across most of the North American boreal forest during the period 1982-2003, with a particularly strong decrease in Alaska. Most of the North American tundra grew more during the same period (Goetz et al. 2005). The Alaska tundra largely has become greener during since then. During the twentieth century, growing season length in central Alaska increased by at least fifty percent.

Temperature Trends in the Alaska Climate Record; Problems, Update, Prospects (Glenn Juday)

1982 Conference Quote: "…calendar year 1981 had the highest or second-highest mean annual temperature (MAT) in the record. Winter temperatures across much of the state have been especially high since the winter of 1976-77."

2006 Update: Fairbanks MAT has been high since 1977, but has not quite surpassed the 1981 value. The abrupt increase in temperatures in much of western North America that occurred from 1976 to 1977 and which largely has been sustained since, is now widely recognized. The 1977 climate change was so pervasive and powerful that it has been given the name "regime shift." (Ebbesmeyer et al. 1984, Miller et al. 1994).

1982 Conference Quote: "[Fairbanks] Summer temperatures have been warming but the trend may have passed its peak in 1980-81."

2006 Update: Fairbanks warm season temperatures have continued to increase, and even cool intervals such as those in 1984-85, 1992, and 2000-2003 were not as cold as earlier in the century. Mean temperature of the 2004 warm season set a record in the 102-year series.

1982 Conference Quote: "…an apparent correlation exists between the solar cycle and Alaska temperature trends. … The hypothesis would then predict that the true direction of Alaska MAT trend would be downward to the mid-80s, and that MAT would peak again in the early 90s. … If, as expected, CO_2 effect begins to overwhelm the natural range of climate variability between now and the end of the century, Alaska would experience a stairstep increase in temperatures, the peaks of which would reach unprecedented highs. A weak cycle peak in the early 1990s might delay the setting of new records until the expected temperature peak of the 2000-2010 decade. … The 1980s to early ’90s will be an interesting, and potentially important time to be observing Alaska’s weather.”

2006 Update: The tendency of Alaska MAT to follow a nine- to thirteen-year solar cycle was not as well defined in the last decades of the twentieth century compared to earlier decades, although temperatures did in fact decrease in the mid-1980s and increase in the early 1990s. Future trends could clarify whether the sustained high values since the early 1980s represent the end of strong decade-like cycles, or a stairstep increase of a strong warming trend superimposed on continuing cycling behavior.

Potential Impact of a Warmer Climate on Permafrost in Alaska (Tom Osterkamp)

1982 Conference Quote: “It is clear that a warming of +3°C in Alaska would cause widespread thawing of permafrost in the discontinuous zone and substantial changes in the continuous zone. … The degree of impact would hinge on the exact magnitude of the temperature change and the time scale over which it occurs. While these factors cannot be predicted accurately, the present evidence suggests that warming is likely to begin soon.”

2006 Update: The temperature of permafrost near the ground surface in different long-term records in northern regions, especially between 55° and 65° North, show a significant warming trend during the last thirty years. In Alaska the recent climate warming has brought soil temperatures very close to 0°C or thawing, and at some sites long-term permafrost thawing has started (Osterkamp et al., 2000; Osterkamp and Romanovsky 1999).

Observed and Predicted Effects of Climate Change on Wolverine Glacier, Southern Alaska (L.R. Mayo and D.C. Trabant)

1982 Conference Quote: “A small but hydrologically significant shift in climate occurred during the study period of 1967-1981 in the glacier-clad mountains of southern Alaska. Air-temperature and glacier snow-and-ice balance measurements taken continuously show that air temperature increased abruptly in 1976 and was accompanied by substantial glacier growth.”

2006 Update: Changes in the amount of ice in Wolverine Glacier are mainly the result of changes in moisture brought into the region by the averaged wintertime air circulation. Many other Alaska glaciers respond to summer temperatures. Using 1965 as the reference level, the cumulative change in Wolverine glacier by 2004 was equivalent to the loss of 15 m of water over the area of the glacier (http://ak.water.usgs.gov/glaciology/all_bmg/3glacier_balance.htm). From the mid-1950s to the mid-1990s, 67 measured Alaska glaciers lost 0.52 meters per year in thickness. The estimated loss in volume of all Alaska glaciers during that time is 52 cubic kilometers per year (water equivalent), equal to a rise in world sea level of 0.14 mm/year. (Arendt et al. 2002).

Some Aspects of Vegetation and Temperature Relationship in the Alaskan Taiga (L.A. Viereck and K. Van Cleve)

1982 Conference Quote: “Higher average summer temperature with little of no change in precipitation would be expected to increase the frequency of naturally occurring wildfires in interior Alaska.”

2006 Update: The record high summer temperature of 2004 across most of Alaska was accompanied by a prolonged dry spell, and extreme warmth and drying occurred in the summer of 2005 also. The most extensive forest fires in the fifty-six-year Alaska record occurred in 2004, and 2005 was third highest in the series. The fires in those two years in Alaska and Yukon Territory burned an area equivalent to the nation of Ireland. Perhaps as much as one-fourth of all forest in the northeast quarter of Alaska burned in 2004 and 2005.

The Impact of Increased Air Temperature on Tundra Plant Communities (F.S. Chapin)

1982 Conference Quote: “An increasing air temperature is likely to exert its most important effects through changes in length of growing season rather than through direct temperature effects. … The greatest unknown in the picture of increased carbon dioxide is water availability…water stress will lead to reduced photosynthesis and respiration.”

2006 Update: In Alaska north slope locations where temperature increases have been accompanied by drying, tundra has become a net source of stored carbon moving into the atmosphere (Oechel et al. 1993, 2000). Where arctic climates have become warmer and wetter, tundra has been responsible for a net uptake of carbon from the atmosphere (Chapin et al. 2000). Across the Arctic moisture changes that have accompanied temperature increases have been regionally variable and so the carbon loss or gain of tundra has been variable, and net sum of the changes have not amounted to a major loss or gain of carbon to date (McGuire et al. In press).

Sea Ice, Carbon Dioxide, and Climate (Gunter Weller)

1982 Conference Quote: “…processes of antarctic sea ice … are complicated by various feedback mechanisms, and carbon dioxide mechanisms are difficult to quantify against a noisy background…”

2006 Update: For the period 1973-2002 there is either no trend in antarctic sea ice coverage (Pielke et al. 2004), or a slight overall increase. While the Antarctic Peninsula has continued to warm, the Antarctic continent has not warmed over the past two to three decades (Thompson and Solomon 2002).

Carbon Dioxide: Scientific Puzzle, Political Dilemma (George Woodwell)

1982 Conference Quote: “…solutions to this problem are closely related to solutions to other major environmental and economic issues. The carbon dioxide problem is part of the global problem with the management of resources of energy. Steps that result in reducing the total amount of fossil fuels burned … contribute as well to amelioration of … other problems."

2006 Update: Fossil fuels have remained the predominant portion of the mix of energy resources in Alaska, the U.S., and the world. Carbon dioxide releases are accelerating. Some progress has been made on individual environmental quality goals, such as new awareness, data, and policies for maintaining biodiversity resources, but the consequences of the use of fossil fuels and the greenhouse gasses they release have become more detectable, numerous, and challenging.

Overview

In retrospect, most of the positive assertions that the scientists felt they were able to make at the 1982 conference were close to the course of actual events twenty-four years later. Some directions of change, such as overall carbon storage or release, are still not clear because they result from a huge number of individual changes in soils and organisms that are still occurring. And some events and changes caused by high temperatures that are of great interest and importance in managing resources and the environment, such as forest fires and large-scale tree death from insect outbreaks, were not a focus of attention. But, in a subject matter that is prone to controversy and intense debate about appropriate public policy measures, the scientists and other academicians who gathered twenty-four years ago can be seen as a generally reliable source of information when judged by the most demanding and inflexible standard of all—reality.

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Harvesting Art

by Jamie Smith

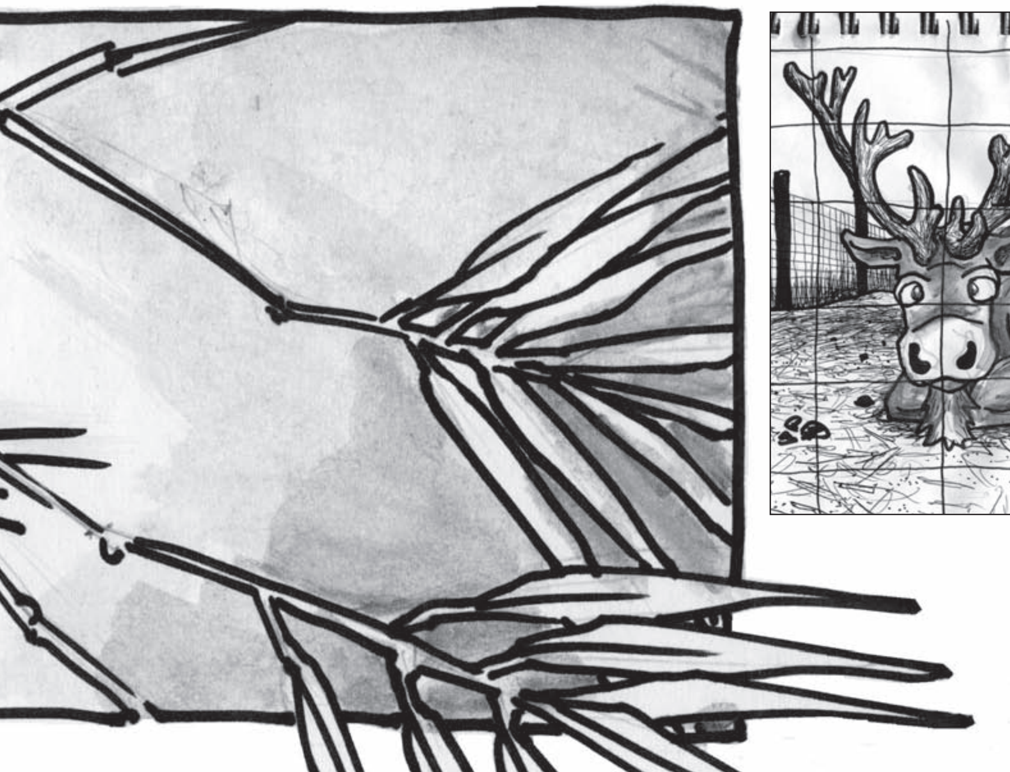
Smith is a adjunct instructor at UAF who teaches drawing and sequential art. He and his students often use the Fairbanks Experiment Farm and other SNRAS/AFES facilities. Some of his drawings are featured here.

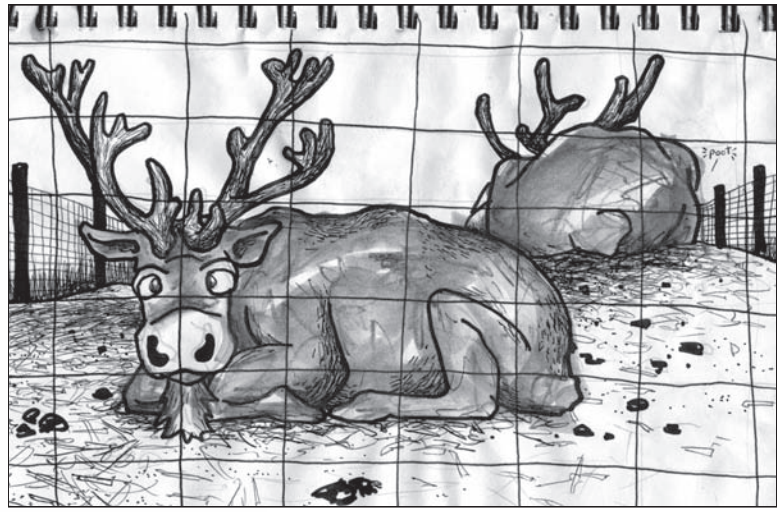
After introducing the fundamentals of drawing such as perspective and composition, and some demonstration of basic techniques, it's time to move out of the classroom setting. Taking classes on field trips is perhaps one of the best methods of teaching, by giving students a chance to apply newly acquired skills of observation and interpretation to the natural world. Immersion in different environments is an experience that can help stimulate creativity while also focusing instruction on specific assignments (like, for example, the use of value and line).

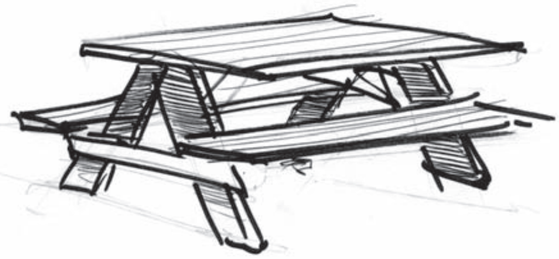
While field sketching, one interacts with surroundings in a more meaningful and immediate way, and, more often than not, this results in works with which the artist has a sense of real connection and intimacy. It also underscores a valuable habit of bettering one's abilities through constant practice by doodling everywhere you go!

Some of my favorite resources to explore are right here on the UAF campus; the symphony hall, theatre, library, Wood Center, musk ox farm (the Large Animal Research Station), and even the bowling alley are all places to expose students to a wide variety of settings, each with its own particular demands and underlying artistic merit, but by far the most rewarding trips are to the experiment farm's greenhouses and gardens.

Plant forms in particular are deceptively simple to study; confronted with what at first is an overwhelmingly complex subject matter, one must set about identifying patterns and reducing them, simplifying shapes into recogniz-







able forms, while retaining the gestural quality of a living thing. This is representational art, in that one is really "re-presenting" in a drawing what one sees.

In this way the artist is like a gardener—patiently arranging and rearranging elements, picking, pruning, and transplanting until the work is realized, and can be harvested from the sketchbook. Indeed, art is a wonderful opportunity to visually stop and smell the flowers—to take the time and really look at things most of us get too busy to appreciate and enjoy simply for their own sake. While I'm flogging a metaphor to death, it is still apt: field sketching in these environments also encourages the cross-pollination of a student's interests among the different disciplines available at the university—some of the best work I have seen has come not from "artists" but science majors.

This collection of quick little sketches, all done while lecturing at the elbows of students during recent field trips, serve not only as examples of the lessons taught as a teacher, but just as important, mementos of a shared experience that grows back again every season and each semester.

Clockwise from opposite: barn at the Fairbanks Experiment Farm; bamboo in greenhouse; reindeer at the Fairbanks Experiment Farm; picnic table at the Georgeson Botanical Garden; plant in greenhouse; flowers at a fence on the Fairbanks Experiment Farm.

Blight outbreak tests new Western Plant Diagnostic Network

by Doreen Fitzgerald

Late blight shriveling the tips of potato leaves.
—PHOTO BY ROSEANN LEINER

On August 9, 2005, in perfect flying weather, one pilot looked down on a Matanuska Valley farm and noticed something odd—brown circular patterns in a potato field. The pilot notified the potato grower, who on the next day brought a sample of the affected plants to Roseann Leiner. Leiner is a horticulture specialist with the Cooperative Extension Service (CES) and SNRAS assistant professor of horticulture.

Lori Winton, a research scientist with the USDA Agricultural Research Service based at UAF, happened to be at the Palmer Research and Extension Center working on a plant disease called white mold. Together Leiner and Winton examined the potato plant sample under a microscope and identified late blight, a fast-spreading potato disease caused by a water mold, a fungus-like microorganism named *Phytophthora infestans.* The disease can also affect tomato, eggplant, and hot pepper plants, although eggplant, and peppers are not commercial crops in Alaska. The Alaska potato crop, (8,850 tons in 2004) has a $2 million value to producers.

What happened next was part of an organized plan put in place as part of the U.S. homeland security effort. A National Plant Diagnostic Network has been formed, with Alaska participating in the regional Western Plant Diagnostic Network. Its purpose is to provide a pathway for identifying and responding to plant diseases in the most efficient manner possible. As part of this effort, "First Detector Training" was held in 2004 in Anchorage and in Fairbanks, primarily for extension service agents.

After examining the sample in the lab, within two hours Leiner had notified Fred Sorenson of CES, looked at the field, and sent six samples to a plant pathologist at the Oregon State University diagnostic lab that is part of the disease confirmation system.

Sorensen, who leads the diagnostic network in Alaska, is CES resource agent and coordinator for Water Quality and Integrated Pest Management. By 2 PM that afternoon Leiner sent three microscopic images to the Oregon lab and got a preliminary confirmation that the distinctive spores of late blight were indeed there in abundance.

The plant diagnostic network provides a predetermined pathway for notification and sample identification. "If the network hadn't been there, I would have had to decide if I send a sample and where to send it," Leiner said. "The diagnosis was quick, growers got the information they needed, and although some commercial fields and home gardens were affected, the network performed as we hoped it would."

On the first day, Leiner met with potato growers, Bill Campbell of the Department of Natural Resources Division of Agriculture, and Peter Bierman, the CES district agent. Campbell and Bierman helped to contact other potato growers to let them know the disease was in the valley. At the same time, SNRAS/CES horticulturist Jeff Smeenk took a list of chemical management tools to the state Department of Environmental Conservation and found out which ones were currently approved for use in the state, which allowed growers who wanted to apply fungicides to do so the same day. Once plants are infected there is no cure, and plants must be pulled up and buried to stop the disease from spreading.

"We don't know the source of this outbreak," said Leiner. "It doesn't take much, if conditions are right. At the end of the growing season, we have the moisture and full canopy, leaves covering the ground on a large potato plant. These conditions favor the development of the disease, much more than when plants are small, with more air circulation."

Late blight is common in the Pacific Northwest, with its cool, wet climate. Potatoes may be exposed to the disease during the growing season from inoculum produced on infected cull piles, volunteer potato plants, or the disease may originate from infected seed pieces. Also, tomato transplants in home gardens may be infected with late blight if imported from other Western states. Under the right conditions (see sidebar) spores from infected plants can be carried for miles in moist air, such as during thunderstorms or misty days. The disease is spread when the spores land on healthy plants, under favorable conditions for infection.

Last summer's event started with infection seen in four commercial potato fields. By state fair time, infected samples were found on potatoes and tomatoes in home gardens, in both the Mat-Su Valley and Anchorage, probably blown in from potato fields.

Because the disease requires a living cell to survive, in fields it is killed by a hard frost. It won't spread from plants buried in soil that freezes, but can survive in soil or on stored tubers that don't freeze.

Leiner said that seed potatoes have been tested for the disease, and warned against growing potatoes from tubers purchased to eat, from a grocery store. "Plant certified seed potatoes, not eating potatoes," she said, emphasizing that the disease does not affect people and grocery store potatoes are perfectly safe to eat. Because 2005 was a blight year, growers were advised not to save potatoes for seed, even though perhaps 99 percent of the tubers would be disease free. The occurrence of late blight is worldwide, and potato producing states in the U.S. experience periodic outbreaks.

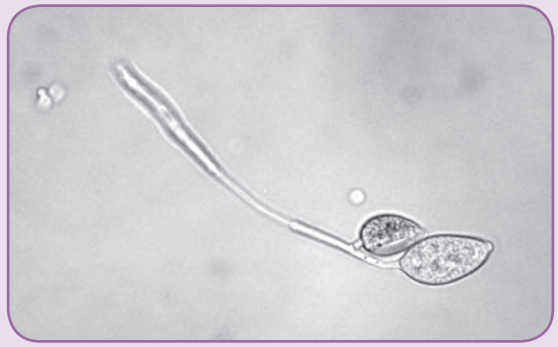
Cooperating agencies in the Alaska Plant Diagnostic Network are CES, the UAF Agricultural and Forestry Experiment Station (AFES), the Alaska Division of Agriculture, and from the U.S. Department of Agriculture, the Agricultural Research Service and the Animal and Plant Health Inspection Service.

"All of us worked very hard to put this system in place," said AFES Director Carol Lewis. "I really appreciate the essential input and quick reaction from the folks involved."

Helping the grower community to avoid a disaster were horticulturists Leiner and Smeenk; Allen Mitchell, AFES associate director; Winton and Joe Kuhl, research scientists with USDA ARS; CES agent Bierman; and Campbell, who contributed valuable interaction and communication with growers.

"Although individual growers have experienced losses, we now know that we can respond to invasive disease infestations, and we know that our immediate response team can minimize those losses," Lewis said. "Part of our mission is to respond to the immediate needs of our clients, and this new system is an excellent example of the importance of partnerships for services the university can provide."

A closer look at late blight



Phytophthora infestans *sporangia seen through a microscope at 400x magnification.*
—PHOTO BY LORI WINTON

Late blight was the cause of the Irish potato famine, which began in September 1845. Leaves on potato plants suddenly turned black and curled, then rotted. At the time it seemed mysterious, brought on by a fog that had wafted across the fields of Ireland. The organism (*Phytophthora infestans*) that actually caused it had been transported in the holds of ships traveling from North America to England, then carried by winds from southern England to the countryside around Dublin. The blight spread throughout the fields, spores infected plants, multiplied, and were carried by cool breezes to surrounding plants. Under ideal moist conditions, a single infected potato plant could infect thousands more in just a few days. When potato tubers were dug up they looked edible, but within days shriveled and rotted. Past potato crop failures in Ireland had been regional and short-lived, but the crop failures due to late blight were nationwide and three of the next four years were potato crop disasters. During the resulting famine, Ireland lost nearly three million people, roughly one-third to starvation, two-thirds to emigration.

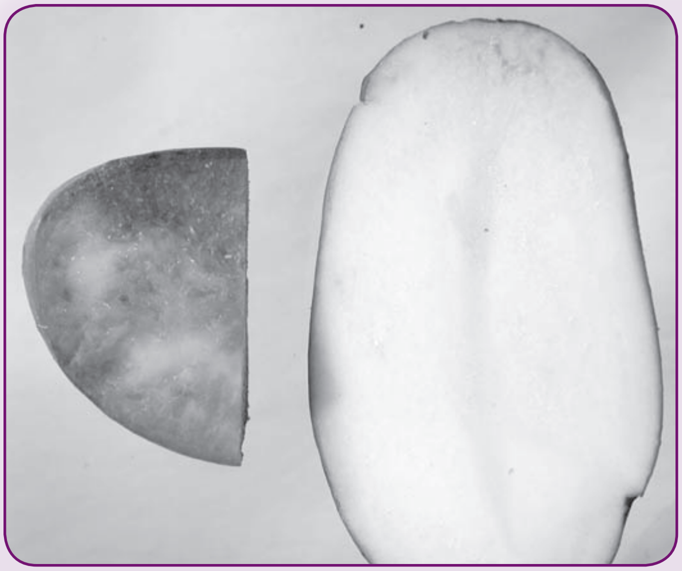
Late Blight in Alaska

Although Alaska potato fields are relatively free of late blight, there have been outbreaks of the disease three times in the past eleven years. The disease may originate from infected seed, or plants may be exposed during the growing season from inoculum produced on infected cull piles or volunteer potato plants from tubers that didn't feeze over winter. Tomato plants in home gardens also can be infected.

Under the right conditions spores from infected plants can be carried for miles in moist air, infecting healthy plants and spreading the blight. Currently, no labeled chemicals will kill the late blight fungal strains that have recently been found once they become established in a plant. Because of this, growers need to foster prevention practices, including cultural and chemical management practices that reduce the potential for occurrence, spread, and losses from late blight.

Potato Late Blight Disease Cycle

The pathogen overwinters as mycelium in infected potato tubers. Mycelium is the vegetative system of fungi that is



Two potatoes cut in half, interiors toward the viewer. The one on the left is afflicted with late blight; the other is healthy.
—photo by Roseann Leiner

made of microscopic filaments (mycelial hyphae) that become visible when these filaments join into a thick network outside the tissues that have been attacked by phytopathogenic fungi. The mycelium will spread up the new sprouts, particularly in the cortical tissue. Reaching the aerial part of plants, the mycelim produces sporangiophores that emerge through stomata (microscopic pores) on stems and leaves.

Sporangia produced on the sporangiophores can become airborne or rain dispersed, and after landing on wet potato leaves or stems, they can germinate and cause new infections. Mycelium emerging from this infection site will penetrate new tissue, leading to the formation of lesions. New sporangiophores protruding through stomata appear as white fungal growth on the underside of leaves with lesions. These sporangiophores will produce more sporangia that can likewise be spread by wind and rain.

Sporangia can also be dispersed to the soil or tubers at the soil surface, where they infect directly or through the formation of zoospores that can move in water and penetrate the tubers through lenticels or wounds. At relatively low humidity (below 80 percent) sporangia lose their viability in three to six hours. They can germinate only when free moisture or dew is present on leaves. The fungus will sporulate most abundantly at humidities near 100 percent. At harvest time tubers can be contaminated and consequently infected by sporangia on the soil surface or plant tissue. Infected tubers may be in the ground as volunteer potatoes, in cull piles, or planted as seed. The infection of tubers may not be apparent at harvest but it will develop in storage.

Precautions for Growers

Because early detection and treatment are important for controlling the disease, learn to recognize late blight plant and tuber symptions.

Understand conditions favoring development and avoid them if possible. Late blight is most likely to develop during periods of high humidity combined with temperatures between 55° to 80° F. Even in the absence of rainfall, sprinkler irrigation provides ideal conditions. Cool, rainy weather, high relative humidity, and heavy dew formation favor infection, disease progress, and spore production.

Field selection and carefully managed irrigation practices can help reduce periods that favor the disease. Plant potatoes in fields with good water infiltration and drainage characteristics. Modify irrigation as necessary to avoid water ponding or overapplication of water. Avoid planting in field areas where plants cannot be adequately protected with fungicide, or are at a higher risk of infection.

Eliminate sources of inoculum, which are first likely to be infected plants in cull piles, infected volunteer potato plants, and infected seed tubers. Infected potato and tomato plants in home gardens, greenhouses, and nurseries are other sources. Home gardeners should remove and bury vines if they see a wet brown rot that spreads quickly to other green leaves. Disposal of cull and unusable material from commercial potatoes is recommended and in some places required (freezing, chopping, feeding to livestock, composting, and burial).

Potato fields directly downwind from fields that had late blight the previous season may be at a higher risk because of the potential for spores to move from infected volunteers.

Purchase only certified seed from a seed operation you know. When late blight occurs in a region, seed tubers are not necessarily infected, but there is an increased risk. Examine field inspection records and shipping point inspection reports for information about the seed lots considered for purchase.

Excessive nitrogen applications promote heavy vine growth, extending the period during which relative humidity within the canopy remains above 90 percent, a level favoring spore production and leaf infection. Manage nitrogen for optimum plant growth and yields, without stimulating excessive vine growth.

Grow less susceptible varieties. In Idaho, for example, all commercial potato varieties grown there are considered susceptible to late blight, but some varieties are more so.

Information Resources

UAF Cooperative Extension Service has publications available at local extension offices and the CES website: uaf.edu/coop-ext

For more on late blight, visit the website: lateblight.org/

Information on late blight from Oregon State University Extension: http://plant-disease.ippc.orst.edu/disease.cfm?RecordID=890

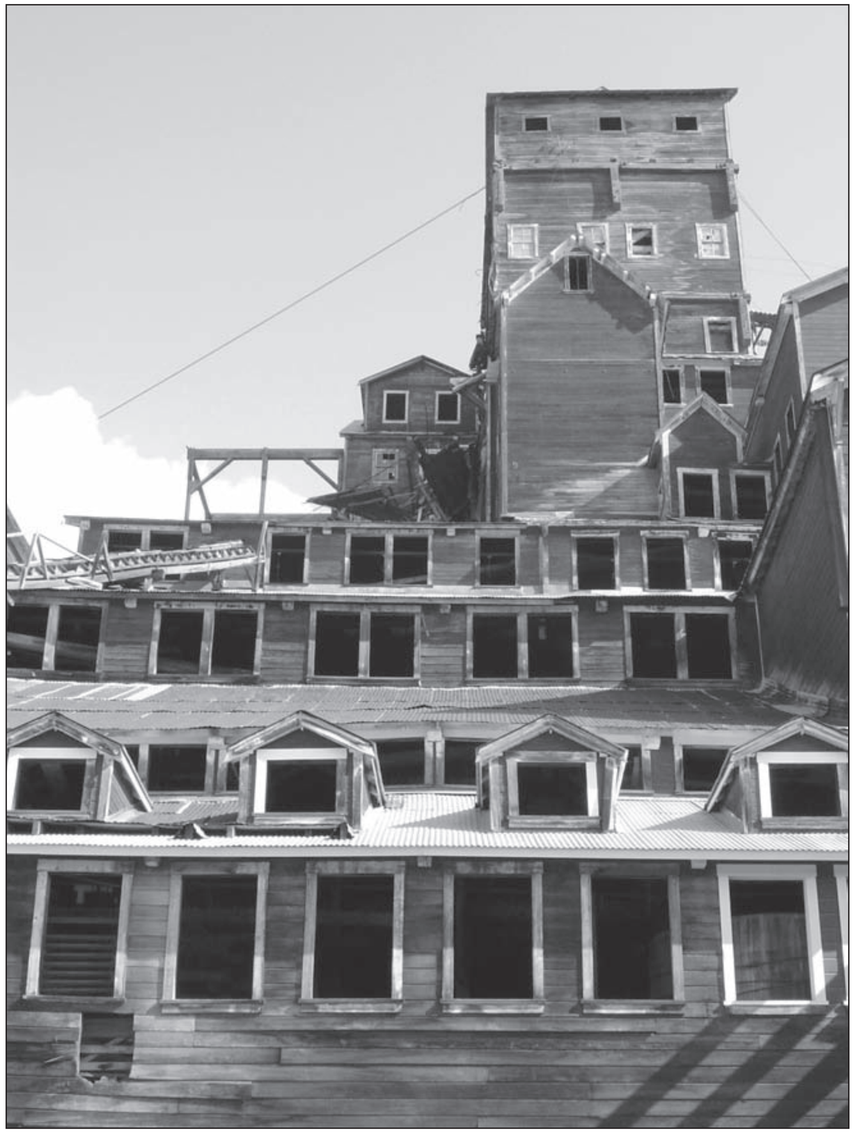
Western Plant Diagnostic Network website: www.wpdn.org/

Fred Sorensen can be reached at the Anchorage CES office at 907.786.6300 or by e-mail at dffes@uaa.alaska.edu.

Kennecott Mill Town

Visitors and the park experience

Note: the spelling is Kennecott *for the mill town, but* Kennicott *for the valley, river, and glacier.*



A view of the mill building windows.
—PHOTO BY STEVE TAYLOR

When public lands are developed for visitors, how do managers know how much, or how little, to provide for the public? Something as simple as signage, or as developed as ranger-guided tours, may be appropriate. For his master's thesis, graduate student Stephen Taylor set out to gain specific information about what people who visit the Kennecott mill town area want. His thesis, "Visitor Preferences for Interpretation in the Kennecott Mill Town, Wrangell-St. Elias National Park," from which much of this article is taken, was recently published as Bulletin 113 by the School of Natural Resources and Agricultural Sciences, Agricultural and Forestry Experiment Station. Taylor's work was supervised by Peter Fix, SNRAS assistant professor of outdoor recreation.

In the Wrangell-St. Elias Park and Preserve, near the village of McCarthy (population approximately forty-two year-round residents), the historic mining town of Kennecott draws tourists to the Kennicott Valley every summer. The valley, with one of the richest deposits of copper ore ever found in North America, is in the Wrangell Mountains at the eastern edge of the Copper River Basin, which is bounded by the Talkeetna Mountains on the west, the Alaska Range to the north, the Wrangell-St Elias Range on the east, and the Chugach Range to the south.

The National Park Service (NPS) purchased many of the Kennecott mill town buildings in 1998 and has since been stabilizing and rehabilitating them. Taylor and Fix conducted a study in summer 2004 for NPS park managers that will assist them in developing a support facilities plan for the valley. Their study, which used a visitor survey, was designed to assess which experiences tourists found to be significant, and to determine how those experiences contributed to their preferences for particular management options.

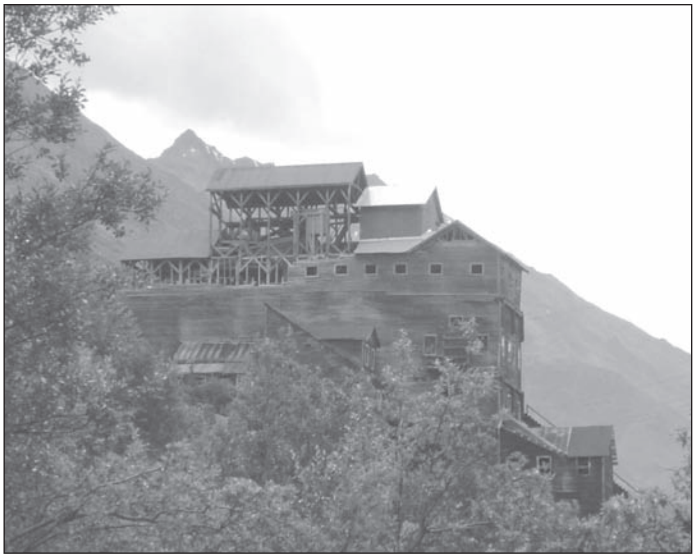
Visitor study

Park visitation may increase in the coming years due to an increase in the visibility and accessibility of the Kennicott Valley. Public awareness of the valley has increased with the addition of the Wrangell-St. Elias park visitor center on the Richardson Highway in Copper Center. Access within the Kennicott Valley is gradually becoming less difficult and therefore more enticing to a broader range of park visitors. Only a few years ago, summer access to McCarthy and Kennecott was limited to a handcart strung across the river, or by airplane. The park was the province of "backcountry" visitors. Today a footbridge spans the river, allowing for a less daring entrance to the park.

Park managers are developing a support facilities plan for the Kennicott Valley. Because very little information exists on frontcountry users in the park, the managers wanted to know visitor preferences and expectations, but past visitor studies have focused on backcountry uses of park resources.

Baseline information on frontcountry visitors can help park managers understand how management actions will affect park users. Park managers posed four specific questions they felt would help address their concerns:

- What are the significant visitor experiences?
- How can the significant visitor experiences inform us



Side view of the old mill building looking toward the mountains behind McCarthy.
—PHOTO BY STEVE TAYLOR

about what types of interpretation to provide (waysides, audio, publications, etc.)?

- What do visitors think is the significance of Kennecott?
- How do people get information about Kennecott before their arrival?

Past experience has led park managers to believe that visitors differ in several ways. For instance, evening visitors are thought to be seeking a more primitive and unimproved setting than daytime visitors. Managers believe that demographics and preferences differ based on the time of the season visitors come to the park. For example, it is thought that Alaskan visitors and Kennicott Valley residents seek the "ghost town" feel and will dominate in the spring and fall seasons, while the summer will bring more nonresidents who want to see a more developed mill town.

These four questions and the hypothesis that visitor preferences would vary with their motivations guided the study design. Taylor and Fix designed an onsite survey to address these questions, deciding to query the visitors' significant experiences by gauging what motivated them to come to the park. Study participants numbered 233, a survey response rate of 66.4 percent.

The study showed that not all respondents are in search of the same experiences at the mill town. Five groups of survey respondents were identified: the **Outdoor Enthusiast** (16 percent), the **Park Experience Visitor** (32 percent), the **History Buff** (22 percent), the **Generalist** (10 percent), and the **Tourist** (20 percent).

Each group was initially defined by their motivations for coming to the park and the activities in which they participated. Also examined was how the groups differed by travel characteristics, primary subject of interest in the Kennicott Valley, and demographics. The motivation domains were: nature, exercise, solititude, history, family, and companionship.

• **Outdoor Enthusiast**: These visitors were highly motivated to experience nature and solitude and to get exercise. They had high participation rates in outdoor activities such as hiking and backpacking. Most of this group were U.S. residents and traveled with their family and friends. Nature, exercise, and solitude were the three dominant motivations for this group. Learning scores were also quite high. These visitors are generally not primarily motivated by local history. Their interest in other aspects of the park is illustrated by their activities and interests. While most people in the four other groups rated history as their primary interest, only 14.8 percent of the Outdoor Enthusiasts did. This group also had the highest percentage of backpackers, hikers, mountaineers and climbers. There were very few foreigners in this group and their typical length of stay in the Kennicott Valley was two or three days. They tended to travel with family and friends, but also had the highest percentage traveling solo (18.2 percent). Finally, about one-quarter previously had visited the Kennicott Valley.

Outdoor Enthusiasts received information about the park from many sources. The NPS website (31.8 percent) was the most popular source, but word of mouth and the *Milepost* were also important. Half got their information from within Alaska. These visitors tended to be the same age as the other groups and nearly half (48.5 percent) had attained a bachelor's degree.

• **Park Experience**: These people had very high scores in all six motivational domains. Popular activities among this group were exploring the mill town, hiking, wildlife viewing, and biking. This group traveled more frequently as a family. A likely reason these visitors come to Kennicott Valley is because it is part of the National Park System. The two most prominent park attributes are the rugged mountainous wilderness and the historical mining activity that took place in the Kennicott Valley.

The Park Experience visitor, who represents about 30 percent of park guests, presumably visits to experience wilderness and historical aspects of the park. These visitors ranked at the top in all motivations, illustrating that multiple aspects of the park are quite important to them. Their participation rates were high: exploring the mill town (82.8 percent), hiking (76.6 percent), nature walks (57.8 percent), and wildlife viewing (53.1 percent). Also, biking was most popular among this group (17.2 percent).

History, geology, and wildlife were the top three interests, accounting for 90 percent of the group, again illustrating their diverse interests in the park. Thirty-three percent of the Park Experience nonresident visitors obtained their primary information from the Internet, with about two-thirds of them visiting the NPS website. Travel books and word of mouth made up a substantial portion of information sources for those not using the Internet. Approximately 67 percent of this group obtained information in Alaska before visiting the park. The visitor center in Copper Center was used as a source of information by about 10 percent of the Park Experience group.

About one-third were Alaska residents. The average age was 45, and 34 percent of the group had achieved a graduate

View of the Kennicott Glacier and creek mouth.
—PHOTO BY STEVE TAYLOR

degree. These visitors typically remained in the Kennicott Valley for two or three days and over 60 percent spent four or more hours in the mill town. The Park Experience visitors traveled with family and friends, and roughly 18 percent traveled with children.

• **History Buff**: This group was primarily motivated by the area's history, but also enjoyed exercise. Respondents were almost unanimous in stating that history was their primary interest. Participation in outdoor activities was comparatively low, but exploring the mill town was very popular. These visitors stayed a relatively short time in the Kennicott Valley, but spent comparatively more time in the mill town.

History Buffs are differentiated from the other groups by their high interest in Kennicott Valley history. This was their primary motivator, while solitude, exercise, and learning were not as important. Note that the learning score may be low because the survey's two learning items dealt with learning about nature and ecology, not history. History Buffs participated less in backpacking, hiking, wildlife viewing, and nature walks than the other groups. About 83 percent explored the mill town, a very popular activity among this group.

The Internet was not a popular information source for this group. Many nonresident History Buffs used word of mouth and travel books to get park information before their visit to Alaska. Sixty percent obtained information within Alaska before their arrival at the park. Twenty percent came from Alaska and an equal number came from foreign countries. They stayed only a short time in the Kennicott Valley (93 percent stayed three days or less), and over half stayed in the mill town between two and six hours. Roughly two-thirds were male, 39 percent had a graduate degree, and the group's average age was 50 years.

• **Generalist**: No one motivation was significantly more important than another, and all were fairly low when compared with the other groups. Camping and fishing were popular activities for this group, while exploring the mill town and interpretive programs were not popular. Primary subjects of interest were history and geology. Many of the nonresidents in this group did not obtain information before their arrival in Alaska.

In all six domains, a typical Generalist visitor was moderately motivated to visit the park, although no one domain stood out from the others in importance. These people were interested in sightseeing, wildlife viewing, fishing, camping, and nature walks. Exploring the mill town and attending interpretive programs were not high on their list, although they were interested in history (60 percent) and geology (25 percent). This group represented only about 10 percent of summer park visitors.

Just under 80 percent of these visitors obtained park information before arriving in Alaska, about half using guide books such as the *Milepost* and *Lonely Planet*. Once in Alaska, many Generalists obtained their information in Anchorage and Fairbanks.

These visitors were typically more likely to be male, less educated than the other groups, and averaged 42.67 years in age. Children were most common with this group, although children were present only about 20 percent of the time. The group was a mix of resident, nonresident, and nonresident foreign visitors.

• **Tourist**: While technically all visitor groups were tourists, people in this category appear to be a little less adventurous than the others and prefer a more structured visit. They were highly motivated by history, nature, and solitude; exercise, family, and companionship were of very low importance. Sightseeing, wildlife viewing, and hiking were other popular activities, but backpacking was very uncommon. Many reached the Kennicott Valley by plane or tour bus. About 75 percent were first-time visitors to the valley. About 20 percent of all visitors were identified as Tourists.

Of all five groups, the Tourist had the highest participation rates in interpretive programs (41.5 percent) and exploring the mill town (85.4 percent). Park history was very important: 41 percent listed exploring the mill town as their primary activity, and 70.6 percent rated history as the subject that they were interested in most.

Nearly half of these visitors traveled to the Kennicott Valley by plane or tour bus and most visited the Kennicott Valley less than three days, with much of that time spent in mill town. Although no data were collected on where visitors lodged while in the valley, many of these visitors probably stayed in the Kennicott Glacier Lodge (in the mill town), since most didn't backpack, but said they remained in the town for more than 17 hours. While nearly 25 percent of the other four visitor groups had been in the Kennicott Valley before, nearly all the Tourists were first time visitors.

Over 90 percent of the nonresident Tourists gathered information before coming to Alaska. They were the most frequent users of travel agents, tour companies, and websites other than the official NPS website. Several specified using the Kennicott Glacier Lodge website. The Tourist visitors used the official NPS website as their primary source of information 25 percent of the time.

Management options surveyed:

- Further stabilize the old mill town buildings,
- Provide opportunities to explore inside more mill town buildings,
- Provide opportunities to explore the outside of more mill town buildings,
- Add signs and exhibits explaining the historical significance of the mill town buildings,
- Provide a film explaining the historical significance of the Kennecott mill town, and
- Add an audio-guided tour explaining the significance of the Kennecott mill town.

During the summer season each day was divided into morning and afternoon time blocks, which were then randomly selected for sampling. During the selected time block, every third visitor to leave the mill town who was over age eighteen was asked to participate in the four-page on-site survey. The survey covered seven broad topics: demographics, sources of information about Kennecott, trip characteristics, participation in activities, importance and quality of available interpretation, trip motivations, and preferences for six management options. The survey asked respondents to rate six management options on a five-point scale ranging from "would strongly detract from experience" to "would strongly add to experience."

Survey results

Common themes within each group emerged when the motivations were analyzed in conjunction with activity participation, demographics, and travel characteristics.

Some differences in management preferences were detected between these groups. Most notably, the Outdoor Enthusiasts held a neutral opinion or were slightly against the six management options when compared with the Park Experience group. Of the six management options, the audio guided tour of the mill town had the least support from all visitor groups.

Season of visit (midsummer vs. late-summer) did not explain many differences in the visitors. Although some significant differences in activity participation were found, no differences were detected in preferences for management options between midsummer and late-summer visitors. Differences between resident and nonresident visitors were found on many trip characteristics, activities, demographics, and importance and quality of interpretation. However, when compared by residency, visitors differed on only one of the six management options. Alaska residents felt audio guided tours would, on average, slightly detract from their experience, while nonresidents felt, on average, the audio guided tours would slightly add to their experience in the mill town.

Sources and Further Reading

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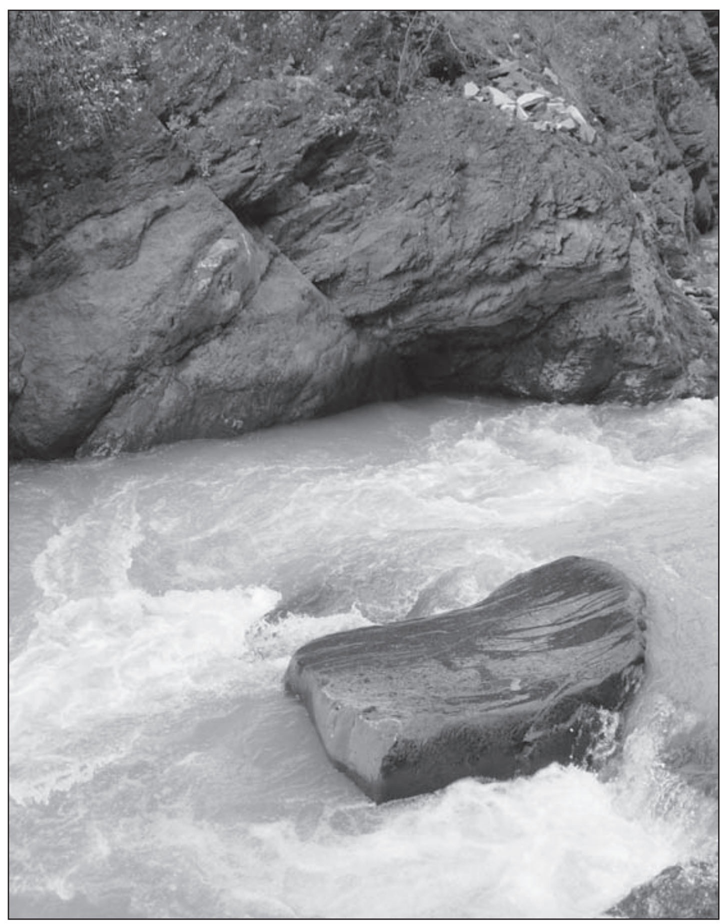
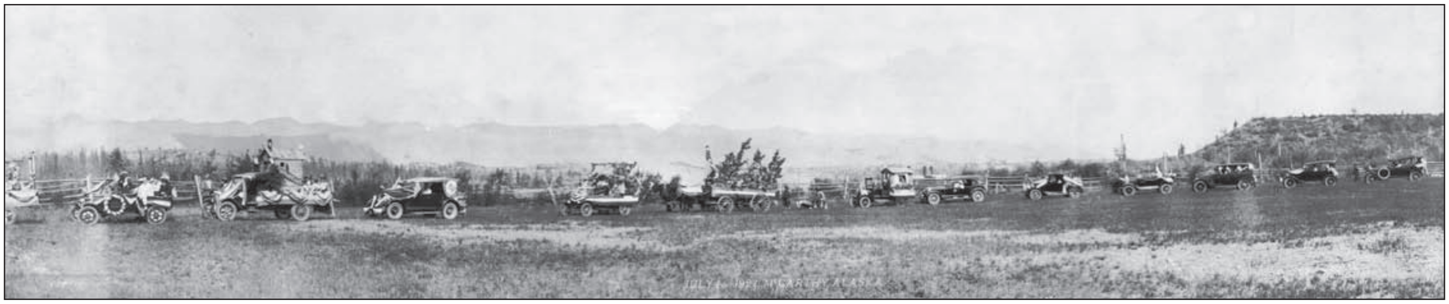


McCarthy Creek.
—PHOTO BY STEVE TAYLOR



Fourth of July parade, 1927, McCarthy, Alaska.
—PHOTO COURTESY ELMER E. RASMUSON LIBRARY ARCHIVES, CANDACE WAUGAMAN COLLECTION, ACCESSION NUMBER 2004-36-1

Some local history

Humans have lived in the Copper River Basin for at least the last millennium, and archaeological evidence points to occasional habitation through the last 8,000 years. The Ahtna people lived in the region and used copper for tools and trade. European exploration began in the 1780s, when the Russians traveled farther inland from their bases on the Kenai Peninsula and the Aleutians, looking for new sources of furs. Russian exploration in the area ended in the mid 1800s, after Ruf Serebrennikov and his party were killed by the Ahtna near the village of Batzulnetas in 1848. (Batzulnetas later became the focal point for an important legal case in Alaska subsistence fishing rights, *Katie John vs. United States of America*.)

In 1885, Lieutenant Henry T. Allen of the U.S. Army mapped the area, establishing good relations with the Copper River Ahtna and their Chief Nicolai, and naming the Chitina and Chitistone rivers (*chiti* is an Athabaskan word meaning "copper"). Other scientific parties came and explored the Wrangell Mountains, including army Lt. Frederick Schwatka and geologist Charles Willard Hayes of the U.S. Geological Survey (USGS). Their journals of their explorations of the headwaters of the White River, the Skolai Pass, and the upper Chitina drainage were serialized in the *New York Ledger* in 1892. These expeditions, along with the discovery of gold in the Klondike and other areas, made geologic and topographic study of Alaska an attractive prospect, and in response the USGS and the War Department increased the number of their surveys.

In 1899, Oscar Rohn of the War Department found chalcocite (copper sulfide, a very profitable but generally scarce copper ore) in the moraine of the Kennicott Glacier, named after explorer and naturalist Robert Kennicott. A year later prospectors Clarence Warner and "Tarantula Jack" Smith found more copper, silver, and trace gold deposits on Bonanza Ridge, northeast of the present townsite. These two prospectors' discovery became the Bonanza Mine, one of five extremely profitable mines supplying copper and silver to the Kennecott Copper Corporation.

Stephen Birch, a twenty-eight-year-old mining engineer from New York, sensed his opportunity and purchased Smith and Warner's extremely valuable yet remote claim. With the financial backing of J.P. Morgan and the Guggenheim family, Birch formed the Alaska Syndicate and the Kennecott Mines Company in 1906, which purchased the rest of the area claims. This company became the Kennecott Copper Corporation in 1915.

To get the ore out of the Kennicott Valley, the company built the Copper River Northwestern Railway (1908–1911), which was disparagingly nicknamed the "Can't Run and Never Will" line by skeptics. The line cost $23 million to build, including the famous "Million Dollar Bridge," over the Copper River, which was completed in 1910. The railway extended 196 miles from Kennecott to Cordova, where the Alaska Steamship Company transported ore to Tacoma, Washington, for smelting. In 1908 the Alaska Syndicate bought the steamship company specifically for this purpose.

The mill and town were company-owned and run, employing approximately 600 people at peak production and supporting the nearby town of Shushana Junction (later renamed McCarthy). More than 1,000 people lived in the area during the mine's heyday. It went into full operation in 1911 and continued until November 1938, when the town was abandoned by the company after the higher-grade ore was depleted and the price of copper fell.

The mine is historically important also because the world's first successful ammonia-leaching plant for concentrating lower-grade ore began operation there in 1916. The railroad hauled more than a billion tons of ore out of the Kennicott Valley, with a total value of about $200 million at the time—the equivalent of more than $1 billion in 1998 dollars. Mine profits helped the company fund other mining operations in South America and elsewhere (Kennecott is still one of the world's major minerals extraction companies.)

The corporation donated the railroad right of way to the government in 1941. Part of the route later became the Chitina-McCarthy Road, where railroad spikes still occasionally turn up in vehicle tires. The company sold off their Kennicott property and mineral rights in the 1950s and '60s. In 1978, Jimmy Carter declared the area a National Monument. The next year, the Wrangell-St. Elias monument became part of a World Heritage Site, and in 1980 the Wrangell-St. Elias National Park and Preserve was created, but the mill town was still held in private hands. In 1986 the town and mill buildings were declared a National Historic Landmark, and the Park Service bought some of these buildings in 1998.

—Deirdre Helfferich

(see resources for further reading on p. 28)

CENTENNIAL AT THE FARM

Photo taken at the Fairbanks Experiment Farm circa 1925, showing a luxuriant growth of sunflowers.
—photo courtesy Rasmuson Library Archives, Alaska and Polar Regions, Agricultural Experiment Station Collection, Accession #68-4-142

Publications and events

Centennial celebration: Saturday June 24, 2006

Planning has begun for a day-long community event at the Fairbanks Experiment Farm to celebrate the research facility's first 100 years. The community open house will allow guests to view displays and participate in activities related to the farm's history, present work, and future. A reunion of employees, students, and faculty at the farm, as well as farmers who worked with the station, is also in the works. An event for the university community is planned for the fall.

Farm workers, where are you?

We're collecting farm-related stories and photos for the centennial. If you ever worked at the Faribanks farm as a research, staff member, or student, or know who to locate someone who did, we'd like to hear from you. Please get in touch by e-mail, mail, or phone: AFES Publications, P.O. Box 757200, Fairbanks AK 99775-7200; 907.474.5042; fndlf2@uaf.edu.

Centennial publications!

In honor of this historic marker, the AFES Publications Office is producing four publications relating to the history of the farm and experiment station and agriculture in the Tanana Valley.

1. A special edition of *Agroborealis*, featuring articles about the farm's history along with current research. This will supplement the previous special history edition, *100 Years of Alaska Agriculture,* which is available on line, at www.uaf.edu/snras/afes/pubs/agro/

2. *"Throw All Experiments to the Winds": Practical Farming and the Fairbanks Agricultural Experiment Station, 1907-1915*, by Rochelle Lee Pigors. Senior Thesis Series 2006-01. This engaging history of the early years of the Fairbanks farm and the Alaska Agricultural Experiment Station is illustrated with maps and photographs.

3. *"Like a Tree to the Soil": A History of Farming in the Tanana Valley, 1903-1940,* by Josephine E. Papp and Josie A. Phillips. From Fairbanks' early beginnings the need to produce food locally inspired the many homesteaders whose names now are remembered in street and subdivision names: Ballaine, Grenach, McGrath, Yankovich, and many others. This well-illustrated book explores the histories of the farmers of Farmers Loop Road and other areas in the vicinity of Fairbanks, with chapters on the Tanana Valley Agriculture Association, dairy farmers, woodcutters, gardeners, town agriculturalists, teamsters and drovers, roadhouse proprietors, fur farmers, and others, and featuring appendices on homesteading, agricultural fairs and expositions, and local place names.

4. A booklet will be available at the centennial on June 24, with history tidbits, photographs, and sheets for the kids to color with line drawings of plants grown at the Georgeson Botanical Garden.

Come celebrate with us!

Mastering the philosophy of science: graduate student research

Graduate work at SNRAS covers many aspects of agriculture and natural resources management. Students can pursue doctoral studies in interdisciplinary Ph.D. programs with other UAF departments, developing a course of study that emphasizes multidisciplinary research in agriculture or land resources management. One such program is the doctorate in environmental studies. The University of Alaska Fairbanks is one of the key universities in the United States with expertise in environmental studies, focusing on the circumpolar north. Every year, about six or seven doctoral students are enrolled at SNRAS. The school also offers a master of science in natural resources management, and from twenty to thirty students are enrolled in the program each year. Research by graduate students has centered on biological and physical aspects of land management in Alaska in relation to land ownership, land use planning, economic analysis, and competing resource needs. Areas of emphasis have included forest management, land use planning, soil management, natural resource policy, parks and recreation management, horticulture, agronomy, and animal science.

Selected studies

The effect of agency culture on institutional performance: a comparative study of marine mammal co-management regimes in Alaska

Chanda Meek, PhD student (SNRAS and Resilience and Adaptation Program/Integrative Graduate Education and Research Traineeship)

MES, York University (Toronto, Ontario, Canada), 1999
BS, Western Washington University (Bellingham), 1996

Arctic coastal communities are part of a linked socio-ecological system consisting of the environment, the communities, and the social institutions developed to sustain the system. Co-management institutions able to link traditional knowledge and real-time observations of environmental change to local, regional, and national institutions charged with managing marine resources are theorized to be a source of system resilience in the face of rapid change. Many researchers have investigated the role of community self-organization in the success of co-management institutions, but few have studied federal agency capacities to engage in the same institutional processes. The proposed study examines to what extent agency culture affects federal agencies' capacities for successful co-management. The study compares two federal agencies, the U.S. Fish & Wildlife Service and the National Marine Fisheries Service, in their implementation of the Marine Mammal Protection Act of 1972. Despite being guided by the same federal policy, the agencies' implementation and active involvement in co-management has been different in terms of how they create collaborative agreements, for what purposes, and the structure of forums for interaction between staff and user communities; thus, these two agencies provide a unique basis for an examination of institutional performance in a time of rapid change in the Arctic. Co-management institutions developed for polar bears and walruses with the U.S. Fish & Wildlife Service will be compared to institutions developed for bowhead whales and beluga whales with the National Marine Fisheries Service to examine how the agencies differ in their approaches and the extent to which the differences affect performance of the institutions. The results will be analyzed through the theoretical lenses of institutional analysis and resilience.

Meek's thesis advisor is Gary Kofinas, assistant professor of resource policy and management.

Developing Fuel Models for the Anchorage Wildland-Urban Interface Using a Forest Inventory

Daniel L. Cheyette, MS, Natural Resources Management, 2005

BA, Rice University (Texas), 1991
JD, Lewis and Clark College (Oregon), 1996

Forests of the Anchorage wildland-urban interface were inventoried and a hierarchial classification of twenty forest types was created. The forest types were differentiated according to tree species, tree and basal area densities, and their degree of spruce bark beetle mortality. The inventory included the data necessary to parameterize the NEXUS—a fire behavior model that integrates algorithms for surface and crown fire initiation and spread. The inventory's twenty forest types consolidated into eight custom fuel models and canopy attribute sets that correspond to the cover types identified by the Anchorage Wildfire Partnership. Cheyette assessed the models using NEXUS and completed a sensitivity analysis that identified the most influential model parameters and the forest attributes that managers should prioritize in future mitigation efforts. Results indicate that needleleaf low-density forests pose the largest hazard due to large one-hour fuel loads and fuelbed depths, low crown-base heights and high crown-bulk densities. Stands infested by the spruce bark beetle also pose a serious hazard due to the ecological/physiological changes that promote the growth of *Calamagrostis canadensis* (bluejoint grass), a flash fuel that dries quickly and readily burns. The forest inventory, fire behavior predictions, and sensitivity analysis demonstrate that parts of Anchorage's wildland-urban interface are at risk under extreme weather and topographic conditions.

Cheyette's thesis advisor was Scott Rupp, professor of forest measurements and inventory.

Fire in Boreal Black Spruce (*Picea mariana* Mill.) Forests: Respiration, Temperature Sensitivity, and Bioavailability of Soil Organic Matter

Sarah Masco, MS, Natural Resources Management, 2005
BS, Western Washington University (Bellingham), 1998

Boreal forests store large quantities of carbon (C) and currently act as atmospheric C sinks; however, predicted increases in temperature and fire frequency may change the boreal forest from a net C sink to a net source. For nonpermafrost upland black spruce stands in interior Alaska, this study evaluates how organic soil carbon and nitrogen mineralization, and the bioavailability of carbon and nitrogen, respond to burning. Two years after an experimental wildfire, burned soils were warmer than control soils at all depths measured, and decay of common substrates was greater in the burned than in the control soils. Burned soils had higher concentrations of total carbon, lignin, nitrogen, and mineral nitrogen, and lower concentrations of dissolved organic carbon and soluble organic matter. However, apparent differences in organic matter quality did not correlate well with respiration metrics. In laboratory incubations, burned soils respired less than control soils, and this difference was entirely due to differences on the first day of the incubation. Mean Q10 values ranged from 2.1 to 2.5 and were greater in the burned soils than in the control soils.

Masco's thesis advisor was David Valentine, professor of forest soils.

Upland Boreal Forest Successional Pathways near Fairbanks, Alaska

Thomas Kurkowski, MS, Natural Resource Management, 2005
BS, University of Wisconsin (Stevens Point), 2002

Previous studies have suggested that post-fire forest succession in interior Alaska can occur in two different ways, by self-replacement or species-dominance relay. Self-replacement occurs when pre-fire dominant species immediately replace themselves as the canopy dominants after fire. Species-dominance relay occurs when, after simultaneously establishing themselves after fire, deciduous trees relinquish canopy dominance to conifer species as the stand ages. The relative importance of these different successional processes at landscape scales in interior Alaska is unknown. To test for the importance of these two trajectories, Kurkowski built a multinomial logistic regression model that explains the relationship between classified vegetation type and topographic variables. The relative occurrence of species-dominance relay was determined by comparing aged stands to known successional patterns. The model correctly predicted 78 percent of spruce distribution. That the majority of stands are not following the species-dominance relay pattern implies that most of the study area appears to be following a self-replacement trajectory, with only a small proportion of sites capable of supporting both deciduous and spruce species. These results have important implications for modeling forest succession in interior Alaska because of the importance of these dynamics in determining the fire regime, carbon storage, and global warming scenarios.

Kurkowski's thesis advisor is Scott Rupp, professor of forest measurements and inventory.

Motivations of Organizational Participation in a Voluntary Environmental Program: A Case Study Green Star, Anchorage, Alaska

Jean Doherty, Masters of Natural Resource Management student
BS, Rowan University (Glassboro, New Jersey), 2002

The Green Star logo may be displayed by Green Star members who have won the Green Star Award or the Green Star Air Quality Award. More information on the program and its members is available at the organization's website, www.greenstarinc.org.

Green Star is a voluntary environmental awards program in Anchorage, Alaska, that assists businesses and organizations in pollution prevention and waste reduction. Green Star was founded in 1990 as a cooperative effort between the City of Anchorage, Anchorage Chamber of Commerce, the Alaska Department of Environmental Conservation, and Alaska Center of the Environment in order to recognize businesses that hold themselves to higher environmental standards. In 1996, Green Star became an independent nonprofit organization. Currently, there are 273 Green Star member businesses. To study the motivations for participating in a voluntary environmental program and to identify the potential strengths and weakness of Green Star, a questionnaire was sent to all member organizations. Approximately 33 percent of the firms responded. "Reducing Environmental Impact" was most often cited as the number one reason for enrolling in the Green Star program—more often than cost reduction or improving environmental image in the business and public communities. Organizations also ranked their satisfaction with various aspects of the Green Star program and the potential barriers to earning a Green Star Award. Based on this preliminary analysis, the involvement of top management and the commitment of employees are key factors in the organizations' success in meeting the standards of Green Star. To explore this relationship further, four firms will be chosen for case studies and semi-structured interviews conducted with top management and select employees. Interviews will also be conducted with representatives of organizations that dropped out of the Green Star program due to dissatisfaction.

Doherty's thesis advisor is Gary Kofinas, assistant professor of resource policy and management.

The Potential of Lodgepole Pine in Alaska

Alina Cushing. MS, Natural Resource Management, 2005
BS, University of Arizona (Tucson), 1996
MAS, University of Mississippi (Oxford), 2001

The introduction of non-native trees should be informed by various perspectives. In the case of forestry in high-latitude regions, managers face the challenge of finding cold-hardy species adequately adapted to harsh climatic environments. Lodgepole pine (*Pinus contorta* Dougl. Ex. Loud.) has been introduced to three regions at or above its natural northern latitudinal extent: Alaska, Iceland, and northern Sweden. Analysis of interviews in each region revealed the structure of common arguments, including underlying assumptions and perceptions of the natural world. Results of a mail-out survey to the Alaska public indicate that a considerable number of people are concerned about the possibility that introducing non-native species will have negative effects on the native ecosystem. However, acceptance of non-native trees increased in the case of small-scale ornamental plantings and when economic benefit is demonstrated. Comparing twenty-year growth data of lodgepole pine in Alaska with native white spruce *(Picea glauca)*, lodgepole pine achieved greater height, diameter, and volume. The response of lodgepole pine in all three regions to scenarios of climate change was predicted using tree-ring analysis. Results indicate a negative response (reduced growth) in the Fairbanks area, a positive response (increased growth) in Delta and Glennallen, and a positive response at all but one Icelandic site and both Swedish sites. Overall, lodgepole pine appears relatively well-adapted to the present and modeled future environments of interior Alaska, Iceland, and northern Sweden.

Cushing's thesis advisor was Glenn Juday, professor of forest ecology.

Birch trunk, on the University of Alaska Fairbanks.
—PHOTO BY DEIRDRE HELFFERICH

Production and Quality of Spring Sap from Alaskan Birch (*Betula neoalaskana* Sargent) in Interior Alaska

Kimberley Anne Camille Maher, MS, Natural Resources Management, 2005
BS, Boston College (Massachusetts), 1998

Little is known about the specifics of spring sap production in Alaska birch *Betula neoalaskana* Sargent. With an emerging industry in Alaska based on the harvest of birch sap, additional information is needed. This thesis is an exploratory study that investigates the production of sap during the 2002 and 2003 spring seasons in the Fairbanks region and characterizes the dissolved solid components of the sap harvested in 2003. April 2002 and 2003 had strongly contrasting weather patterns that affected sap yields. In general, trees yielded more sap in the wet, cool spring of 2002 than the dry, warm spring of 2003. Larger diameter trees yielded more sap in both years, and this correlation was stronger during the dry, warm spring. Stand location on the hillside and indicator species were also related to sap yield. Carbohydrate content of birch sap is mostly glucose (44 percent) and fructose (40.3-54.6 percent); sucrose and galactose are also present. The relative concentration of carbohydrates varied throughout the sap season. Macronutrients (Ca, K, and Mg) and micronutrients (Mn, Fe, Al, Na, Zn and Cu) are present in the sap; their concentrations increase throughout the season.

Maher's thesis advisor was Glenn Juday, professor of forest ecology.

Using GIS-Based and Remotely Sensed Data for Early Winter Moose *(Alces alces gigas)* Survey Stratification

Karen Joanne Clyde (Clyde-Lien), MS, Natural Resources Management, 2005

BA, Ryerson University (Canada), 1993. Thesis published 2004.

Stratifying aerial survey areas is a key step for reducing variance in moose population estimates. In the Yukon and Alaska, use of fixed-area grids of early winter moose counts combined with the increasing availability of GIS and remotely sensed data provide the opportunity to develop standardized and repeatable habitat-based stratifications. Clyde used univariate comparisons, stepwise regression, and AIC modeling to describe moose distribution as a function of landscape level variables for an area in west central Yukon during 1998 and 1999. Results quantified early winter habitat use of upland shrub habitats and support previous observations for early winter moose habitat use in Alaska, Minnesota, and Montana. Number of patches, in association with areas of alpine and shrubs, were found to be highly influential for survey blocks where moose are expected to be present in high numbers. Overall, model performance based on relative abundance of moose was less predictive than for blocks where moose were present or absent. Spatial resolution of GIS and remotely sensed data used in this study (225 mk grid cells) provided sufficient spatial detail to generate correlations between moose presence and habitat for a first level stratification. This work contributes information for more efficient aerial survey work by defining areas likely to have high density of moose.

Clyde's thesis advisor was Dave Verbyla, professor of geographic information systems.

Moose browsing on willow.
—PHOTO BY CP MCROY, INSTITUTE OF MARINE SCIENCE, UAF

Aspen Coppice with Coarse Woody Debris: a Silvacultural System for Interior Alaska Moose Browse Production

Todd F. Nichols, MS, Natural Resources Management, 2005

BS, University of Alaska Fairbanks, 1995

Browse production and use by moose *(Alces alces gigas)* in interior Alaska was investigated in four- and two-year-old quaking aspen *(Populus tremuloides)* coppice stands following clear-felling without removal of the mature aspen stems. Moose winter browse utilization, as related to distance from cover, coarse woody debris (CWD), and browse species composition, was quantified. Aspen terminal leaders were sampled to relate current annual growth (CAG) dry biomass (g) to leader diameter (mm). Stem density, current annual browse production, and browse use were estimated.

Browse use was determined as 1) the proportion of aspen stems browsed (stand scale), proportion of browsed leaders per stem (stem scale), and 3) diameter-at-point-of-browsing (leader scale). Aspen sucker density ranged from 23,000-43,000 stems/ha. Terminal leader diameter was found to be a good estimator of individual stem CAG biomass. CWD did not impede moose utilization of stems. Browse use declined from mature stand edge to center (100m). Beyond 15 m from mature stand edge, browse use was low compared to that within 15 m of the stand edge. Clear-felling without removal of stems is a viable silvicultural method to re-initiate seral aspen in lieu of prescribed fire or mechanical treatments on south-facing hillsides.

Nichols' thesis advisor was Edmond C. Packee, professor of forest management.

—Abstracts compiled by Deirdre Helfferich

Ecotourism in Chile

by Scott Harris and Deirdre Helfferich

Research at SNRAS, while primarily focused on northern climes, sometimes crosses the globe to high-altitude areas in warmer lands. Masters degree graduate Scott Harris focused his thesis on Chilean ecotourism in the Valdivian temperate rainforests.

The Valdivian forest is one of the world's five great temperate rainforests, and the only one in South America. It is a dazzling example of biodiversity, containing over seventy percent of the woody plants found in Chile, including more than 122 species of vascular plants. According to the World Wildlife Fund, these forests include the monkey puzzle tree (*Araucaria araucana*), a tree existing since the time of dinosaurs, and the second oldest living organism on earth; and the alerce (*Fitzroya cupressoides*), a conifer that can live to 3,600 years old, measuring up to 16.5 feet in diameter and 198 feet in height. The forest is home to a unique assemblage of animal species, including the threatened Chilean guemal (*Hippocamelus bisulcus*), the small feline known as the kodkod (*Oncifelis guigna*), the world's smallest deer, the Southern pudu (*Pudu puda*), the Southern river otter (*Lutra provocax*), and the rufous-legged owl (*Strix rufipes*), a cousin of the Northern spotted owl (*Strix occidentailis caurina*) of the U.S. Pacific coast.*

The value of the Valdivian forest to tourism has not been fully explored. The World Wildlife Fund describes the situation:

> Land-use processes in Chile have resulted in severe forest fragmentation, with many of the remaining fragments in the hands of either small, rural farmers or large commercial forestry enterprises. The threats to the remaining forest are significant and include intensive logging and replacement of native forest with plantations of exotic species of pine and eucalyptus. Argentina is engaged in a big push to copy the Chilean free market model, and Chilean investors are quickly buying up large tracts of cheaper land in Argentina, including Valdivian forests, where they plan to install plantations.

Harris studied the ecotourism market in this region of southern Chile. The fundamental hypothesis of community-based ecotourism as a conservation strategy is that when people can benefit from activities that rely on intact natural environments, they will be more likely to act to preserve those environments because they can see that they have something to gain by preserving them. In the Valdivian forest ecoregion, communities and organizations are developing their ecotourism industry with the goals of conserving forest biodiversity and promoting community development. However, Harris said in his thesis, they are proceeding without a clear picture of the availability and preferences of the ecotourism market.

Harris decided to provide a profile of the target market for community-based ecotourism projects in this part of Chile. His study was the first market research of community-based ecotourism in the region. He posed two basic questions to create this profile: do the preferred activities and experiences of ecotourists in Chile match those that communities and organizations are developing in their projects? How do the travel motivations of these ecotourists, who prefer the activities and experiences associated with these projects, compare to the motivations outlined in the definition of ecotourism?

Tourists, researchers, conservationists, communities, and the tourism industry do not have a common definition of ecotourism. It is often considered in the same context as nature, rural, and adventure tourism because all these take place in mostly natural environments. In an effort to establish a common definition, at least among researchers and the conservation and rural development communities, the International Ecotourism Society provided one of the earliest definitions in 1991:

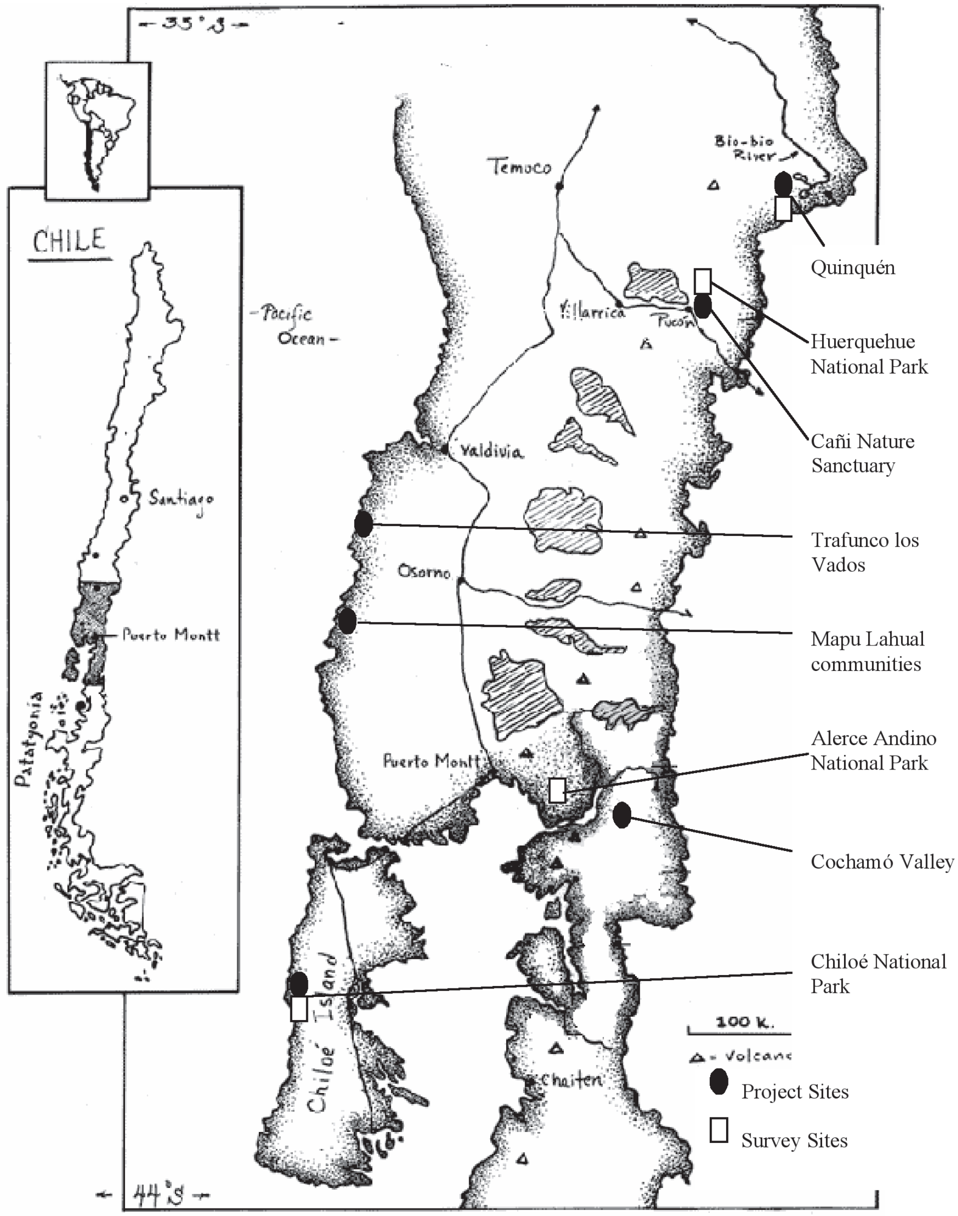
> Ecotourism is responsible travel to natural areas that conserves the environment and sustains the well being of local people (Epler-Wood 2002, p 9)

The International Union for Conservation of Nature and Natural Resources, now known as the World Conservation Union, further refined the definition in 1996 to address the involvement of local communities:

> Ecotourism is environmentally responsible travel and visitation to relatively undisturbed natural areas, in order to enjoy and appreciate nature (and any accompanying cultural features—both past and present) that promotes conservation, has low negative visitor impact, and provides for beneficially active socioeconomic involvement of local populations (Epler-Wood 2002, p 9)

Harris' primary research tool was a survey questionnaire presented to visitors at national parks and a campground in the study area. The survey was designed to identify visitor activity and experience preferences, spending levels and patterns, and motivations for their travels. His first question was

* www.panda.org/about_wwf/where_we_work/latin_america_and_caribbean/where/argentina/index.cfm?uProjectID=9L0803. Accessed January 12, 2006.



The study area, project, and survey sites. This map from Harris' thesis shows a portion of the Valdivian Temperate Forest ecoregion, which extends over much of southern Chile, from the Pacific Ocean to the west, and to the southern Andes Mountains to the east, from roughly 35° to 48° south latitude.
—MAP COURTESY SCOTT HARRIS

answered by comparing the available opportunities at developing ecotourism projects in the study area with the preferences identified in the survey. The second research question was answered by categorizing survey respondents based on how closely their travel motivations matched the motivations outlined in the above refined definition of ecotourism.

To design the questionnaire, Harris needed to understand the general, regional, and local contexts for community-based ecotourism development. The literature on ecotourism development provided the general context; the political context of forest conservation in Chile provided the regional context. Because a primary goal of all the community-based ecotourism projects in the study area is the conservation of native forest biodiversity, the political context is important, as it offers unique constraints and opportunities. Interpreting qualitative data collected at study area project sites (observations at operating and developing ecotourism projects, and interviews of funding organization leaders and community members) provided the local context. This local context identified the target market and defined the activities and experiences that will be available at project sites.

Typical survey respondents were in their early thirties and were university educated. They were traveling for approximately one and one-half weeks with one or more companions. They indicated strong preferences for visiting national parks, pristine natural areas, and for observing nature. Activity preferences leaned more towards day hikes and nature observation than higher intensity activities such as backpacking, water sports, or climbing.

The survey results showed that among national park and campground visitors there is a market for the type of experiences and activities that local ecotourism project sites are developing: trips in pristine landscapes, hostel or camping accommodations, simple means of disseminating trip planning information, and some flexibility with travel plans. Project proponents are also developing guided trips, especially horseback riding, but the interest in guided trips is small when compared to other activity preferences. However, guided trips may be a niche market. Fishing offers a good comparison. While the interest in fishing was lower than any other activity, the study area is famous for fishing, and lucrative fish guiding services exist there. Guides interviewed stated that guiding activity need not be intense to accrue financial benefits. On the other hand, the Cañi Sanctuary has not achieved financial self-sufficiency by focusing exclusively on guiding in the summer, so it is most likely that guided trips would only benefit a few individuals who had the marketing and guide skills to operate within a specialized market. The results also show that the preference for guided trips is not related to the expense of the trip, so lowering the price will not necessarily draw more clients.

Survey respondents were clustered into categories defined as **strong ecotourists, weak ecotourists,** and **general nature tourists**. **Strong ecotourists** have travel motivations that are characterized by the dual goals of ecotourism. They are interested in natural areas conservation and in traveling to areas where their travels will benefit local communities. They also believe that their travels can have a positive effect on both conservation and communities. Specific behaviors could include promoting the enterprise to others or making contributions to conservation or development organizations. **Weak ecotourists** have travel motivations characterized by the conservation goals of ecotourism, but less so by the community development goals. **General nature tourists** show the greatest variation in their travel motivations, and are not specifically motivated by conservation or community development. Harris explained that the cluster analysis used in his research hinges on the assumption that the motivations of strong ecotourists will translate into behaviors that will benefit conservation and communities.

The cluster analysis answers the question: if I have a hostel, or guided trip, which type of tourist would be most likely to show up? Most of the hostel visitors were characterized as general nature tourists; while most campers were identified as strong and weak ecotourists. While the overall preference for guided trips in this survey population is low, those who do prefer guided trips are mostly strong ecotourists. The majority of Chileans are classified as strong ecotourists; other South Americans, Europeans, Australians, and New Zealanders are typically general nature tourists. Strong ecotourists indicate the least flexibility in travel plans, while general nature tourists indicate the most flexibility for most trip planning variables.

Harris suggests two types of ecotourist projects likely to have a market in the study area. The first would be a hostel accommodation, mostly patronized by visitors from Europe, Australia, New Zealand, and other South American countries. The mean group size would be 2.5 persons and these visitors would spend more money than campers would. These visitors would obtain their trip planning information mostly by word of mouth, but would also use the Internet, the *Lonely Planet Chile and Easter Island* and other such travel guides, and local information. Most would be general nature tourists. These visitors would be more interested in guided trips than campers would.

The second project would be a campground, mainly patronized by both strong and weak ecotourists, and with a strong representation of Chileans. The mean group size would be 3.5 persons. The primary resource for trip planning would be by word of mouth. Campground visitors in general show little interest in guided trips. Most strong ecotourists who also preferred guided trips preferred to stay in hostels. However, the attributes of a particular project, such as a unique natural feature, or a reputation as an exceptional cultural experience could potentially draw more tourists regardless of general accommodation or activity preferences.

Scaled-response items that were not used as clustering variables serve as a good check on the validity of the cluster analysis. Strong ecotourists scored high on opinions about conservation and communities. This pattern fits the expectations for strong ecotourist attitudes.

Harris found a few surprising results: a noticable difference between operators' expectations and the market preferences for guided trips. Many proponents of ecotourism development believe offering guide services will be financially successful. However, his study revealed that the demand for guided trips may not meet expectations. Other surprises were the differences between the ecotourist profile defined by previous market studies and that found in Harris' study. It showed that the domestic ecotourism market was stronger than previous studies had indicated, that the tourists traveled in larger groups, and had a preference for camping. Previous market studies indicated that most ecotourists are foreigners, travel in couples, and prefer other accommodation types. Chileans show the strongest motivations for ecotourism. Chileans were the majority of survey respondents, and also represented the majority of park visitors. This high level of participation of Chileans in ecotourism suggests that project planners should not ignore the domestic market.

Wrote Harris in his thesis, "Conservation planners and community members see ecotourism development as an opportunity to provide seasonal financial benefits and to reduce activities that threaten biodiversity. Conservation planners don't expect anyone to get rich from ecotourism, but only small income opportunities are needed to benefit communities. Ecotourism can replace or reduce activities that threaten biodiversity, but replacement or reduction would most likely not be complete, nor would it involve everyone." However, many of the participants Harris interviewed believe that the negative effects of ecotourism are less than other economic alternatives.

In his thesis, Harris reviewed the political context for conserving native forest biodiversity in Chile: forestry and land tenure policy, indigenous rights issues, the country's neoliberal economic policies, and the role of government and private institutions. Chile has weak but growing political capacity and will for conserving native forest biodiversity, evident in the failed attempts to establish native forest management policy. Sustainably managing native forests has been a campaign issue of every post-Pinochet administration since 1990, but the policy of economic neoliberalism established by that military regime has consistently trumped forest policy reforms. Harris described this economic policy, seen as having resulted in "a modern Latin American success story":

"During the military regime of 1973 to 1989, economic measures were adopted that promoted privatization and foreign investment. Measures included abandoning many regulatory functions and liberalizing price structures and the labor market…. Export of Chile's natural resources is the primary driver of the country's success. In 1996, natural resources (primarily minerals, forest products, and salmon) [composed] 88 percent of Chilean exports."

Economic growth is still a higher priority than environmental protection in Chile, he added, despite the fact that pollution was an important issue during the transition from military dictatorship. "Years of neglect of the environment, particularly direct impacts on public health such as air and water pollution, are considered to be some of the reasons for Pinochet's loss of the plebiscite in 1989."

Still, the institution tasked with forest management (CONAF, or the National Forest Corporation), is underfunded and relatively low on the scale of Chilean government institutions, which results in an implementation gap between regulatory enforcement and what forest policy there is. However, since Pinochet, the capacity for environmental policy has improved. This began with rapid development of initiatives to address Chile's most significant environmental problems, the growth of protected regions (SNASPE, or the National System of State Protected Forested Areas), and the increase in democratic participatory measures in government.

Harris explained that ecotourism fits into this context because it is a private enterprise that poses no threat to Chile's economic development policies. Nonprofit organizations that promote community-based ecotourism development are making up for some of the institutional incapacities and shortages in labor and investment capital for community-based conservation and social development. Indigenous rights continue to strengthen in Chile, which, Harris wrote, "can only help to improve the ability of indigenous communities to participate in the national economy. The last forty years have seen turbulent land tenure changes, but through these changes many indigenous communities have remained intact and retained some of their lands."

The primary caveat for community-based ecotourism as a conservation strategy is that it assumes indigenous communities will continue to promote conservation. Says Harris: "While this is an area for further investigation, my qualitative data shows that the indigenous people I interviewed in my study area believe they have always practiced conservation and that they will continue to do so. However, my interviews were conducted within the context of ecotourism development. All the community members I interviewed knew that I was collaborating my research with organizations that were funding ecotourism development in their communities."

In the Valdivian temperate forest ecoregion, national park and camp visitors show strong preferences for hostels, camping, low-intensity nature-based activities, and pristine environments. All of these activities and experiences are being developed at ecotourism project sites in this region. Ecotourists obtain their trip planning information through simple means, such as word of mouth, that are within the marketing capabilities of ecotourism operators. Ecotourists who support the dual goals of ecotourism—biodiversity conservation and community development—fall into a tightly defined cluster, and the majority are Chilean.

Those involved with ecotourism development in this part of Chile have expectations that conform to the requirements for successful projects: namely that it takes a long time, should complement other conservation strategies, is site specific, and depends on committed project leadership.

Community-based ecotourism can complement the increasing, but currently weak, political capacity for native forest biodiversity conservation because it is an activity that has both institutional support and conforms to Chile's neoliberal economic development policy.

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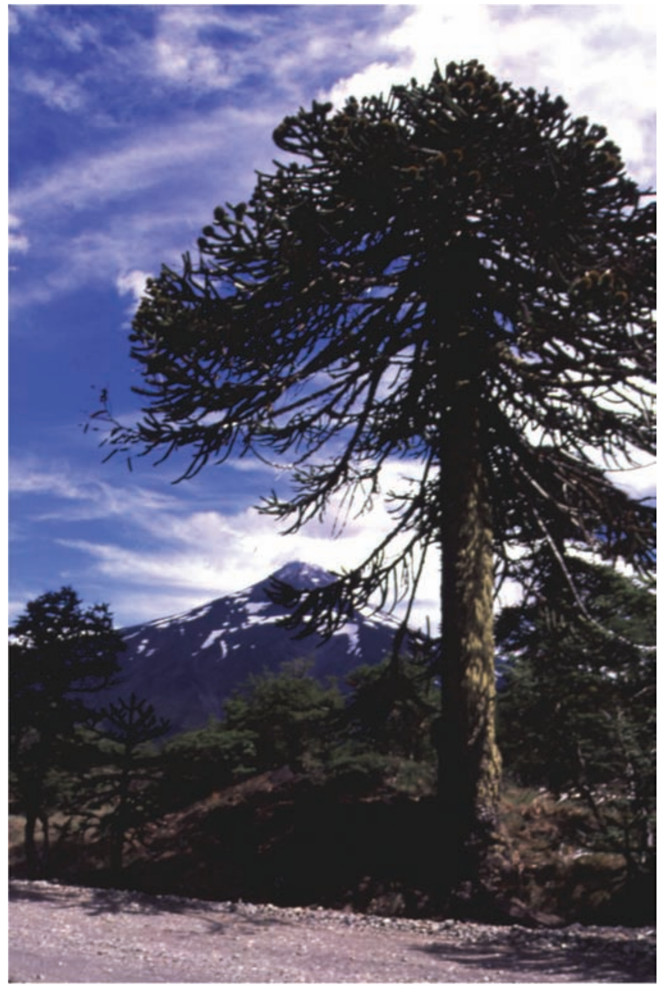
*Araucaria (*Araucaria arucana*), also known as the monkey puzzle tree, is the national tree of Chile. Between November and December female flowers start growing as spherical green cones formed by numerous coriaceous scales. Each cone releases between 120-200 seeds, called "piñones", which are 4-5 cm long and 1.5 cm wide. These seeds are an important part of the Pehuenche indigenous people's diet (*Pehuenche *means "people of Pehuén", the local name for this tree). The seeds have a high carbohydrate content and the collection, storage, trade, and preparation of meals from them is an important part of the traditional lives of the Pehuenche. The tree forms characteristic forests, and is valued for its uniqueness and natural beauty, providing important tourism and recreational opportunities. It is cultivated in gardens of Europe and America for its value as an ornamental or a botanical curio. Araucaria is also used to reconstruct climatic conditions by measuring the growth rings which may go back hundreds of years. Monkey puzzle wood has high mechanical resistance and moderate resistance to fungal decay, so it is used for beams in buildings, bridges, piers, roofs, furniture, boat structures, veneers, and plywood.*

Source: Global Trees Campaign, www.globaltrees.org/reso_tree.asp?id=24
—photo by Scott Harris



The beauty and biodiveristy of Chile's forest landscapes serve as incentives for ecotourists to visit.

—photo by Scott Harris

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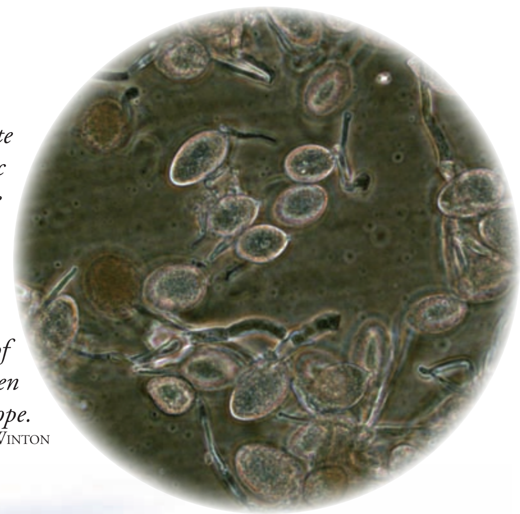

Left: Potato infected with late blight, showing characteristic wet brown rot, caused by the water mold Phytophthora infestans. *See story page 22.*
—PHOTO BY ROSEANN LEINER

Right: Sporangia of P. infestans *seen through a microscope.*
—PHOTO BY LORI WINTON

Below: Healthy potatoes growing in the field plots at AFES in Palmer Matanuska Valley.
—PHOTO BY ROSEANN LEINER