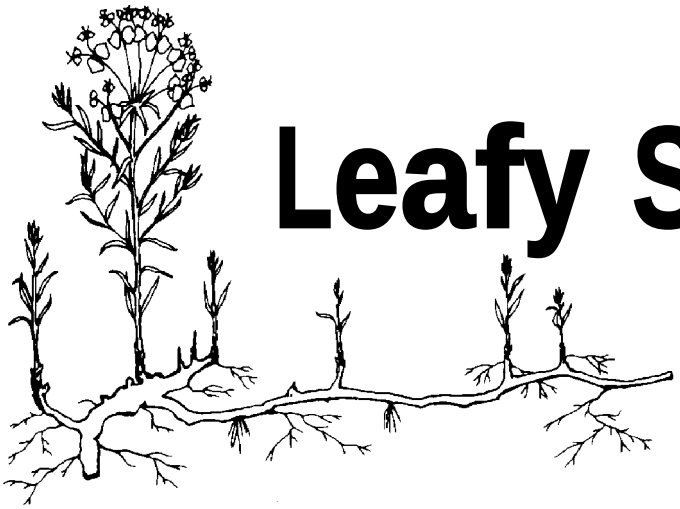

Leafy Spurge *News*

Agricultural Experiment Station
NDSU Extension Service
North Dakota State University, Fargo, ND 58105

Volume XXIII, Issue 1 January 2001

From the Editor's Desk

We are starting the new millennium with an interesting issue full of goodies. The big news is that Spurgefest II will be held, once again, at Medora in June 19-21. So Please put that date on your calendar!

We have only one item in the Letters to the Editor column this time so please send me more information you want to pass on. Our Honoree this time is Roald Lund who as Dean of the Experiment Station at NDSU was instrumental in getting the Leafy Spurge effort in North Dakota off the ground. Through his efforts we were able to get funding for leafy spurge research early on and get the momentum going. Once again I thank all my correspondents for sending material for this issue, for without your input there would not be one!

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Mark Your Calendar!

Spurgefest II is set for
June 19-21, 2001,
in Medora, N.D.!

Leafy Spurge Honoree
H. Roald Lund, Ph.D.

My earliest recall on Leafy Spurge comes from a visit by two men in a pickup containing bags of Calcium Chloride. They walked to an area on the northwest corner of our farmstead and sprinkled the salt on an area about the size of a 2 car garage. The spot was completely black for years. This was in 1950-1951 in Thordenskjold Township, Barnes County, ND.

The next most vivid recollection on Leafy Spurge is sitting under some cottonwood trees on the newly acquired Central Grasslands Livestock Research Station near Streeter, ND. The newly formed Ag Consultation Board and several members of the advisory committee and citizens were there on a tour. Kelly Miller was telling about his trip to Europe and especially the USDA-ARS research facility at Rome, Italy. Kelly said, "they don't have Leafy Spurge in Europe because of all the natural enemies present. He said simply and flatly "we should import those insects to kill the spurge naturally."

Easier said than done — said we in the Ag Administration. There was a lot of resistance to change that had to be overcome. We had an extensive research program on chemical weed control already in place, but as luck would have it, the scientists in both the ND Agricultural Experiment Station and the USDA-ARS were young and curious about alternative methods of weed control.

We had excellent relationships with a scientist in Canada who had been at the Rome Research Center. Kelly Miller, Jack Dahl, Russell Lorenz, Don Anderson, and myself were encouraged and joined in the pursuit of biological control of Leafy Spurge — "The scourge of the Prairies" as said by Don Howe, Hettinger, ND.

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H. Roald Lund was born in Fargo, ND on May 15, 1933 to Haakon and Ruby Lund. His mother was a college graduate from Valley City Normal School and daughter of a pioneer blacksmith, P. G. Davidson. Haakon was a successful farmer in Traill County near Hillsboro, ND. Ruby and Haakon eventually had 6 children and farmed at Christine, and finally at Nome, ND. Roald graduated from Nome High School and went to the North Dakota Agricultural College at Fargo, ND to study in Agronomy and Agricultural Education in 1951. He went on to complete a Masters Degree in Agronomy in 1958, now NDSU, and studied to be a plant breeder working in the Agronomy Dept for Dr. Rueben Heermann, the USDA-ARS Durum wheat breeder. After a short time tour of duty in the US Army, Roald and his wife, Janet, returned to Fargo and was hired as an assistant Agronomist by T. E. Stoa, Agronomy dept. chairman. He was assigned to the Hard Red Spring wheat and oat breeding projects with Dr. Glenn S. Smith as principle agronomist.

Dr. J. F. Carter became chairman of Agronomy in 1960-1961 and encouraged Roald to pursue a Doctorate at Purdue University where he studied the endosperm genetics of corn and in 1965 returned to NDSU as Assoc. Agronomist and Assoc. Professor of Agronomy assigned to corn breeding and the teaching of Dr. Carter's Introduction to Agronomy Freshman class which had about 90 students each quarter of the year and met at 7:30 Tues and Thurs morning for lecture. Roald introduced a concept of self-teaching using modern teaching aids, which allowed the students to schedule their instruction at times convenient for them — called "Auto-Tutorial" and is widely used in many classes at NDSU today.

It didn't take Dean Arlon G. Hazen long to recognize that he wanted this young professor in his office — so in 1969 Roald became Assistant Director of the NDAES, and Assistant Dean of Agriculture. Roald became Dean and Director in 1979-1980.

Biological control of Leafy Spurge was one of the early taskforces that led to today's successful efforts. Dr. Don Anderson, Associate Director of Research, was instrumental in the formation of many task forces that brought the resources from the new staff, facilities, and research funds, both state and federal to focus on the solution to the problem. This approach to problem solving was very effective and this cross discipline approach is widely in use at NDSU today.

Roald retired from Ag Administration in 1994 and returned to the Plant Science Dept. as a teacher of Plant Science 202, and researcher in potatoes. He retired from employment at NDSU on Dec. 31, 1999 and he and his wife, Janet , reside at their home on Pelican Lake at 23174 Pelican-Bass Lane, Pelican Rapids, MN, 56572. *hrlund@means.net*. Roald says he and Janet, are very fortunate, by having had a wonderful and rewarding career in public service at NDSU.

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Web Page

The TEAM Leafy Spurge web site at http://www.team.ars.usda.gov/ has received a major facelift. USDA-ARS ecologist Gerry Anderson, co-principal investigator of the area-wide program, said the revised web site provides "a wealth of information for people interested in integrated pest management strategies for leafy spurge." "The new site is extremely comprehensive, and we wíll keep working to make it even better," he said. The site includes summaries of TEAM Leafy Spurge projects, an extensive listing of contacts, a photo library of leafy spurge biocontrol agents, an archive of papers presented at leafy spurge symposiums, a frequently asked questions page, biographies of program participants, PDFs of TEAM's informational brochures, and more. Most of the web site's content, Anderson said, is entirely new. All told, the site currently consists of more than 268 web pages (equivalent to about 400 pages of printed text), 2,256 total files in 55 folders, and nearly 700 megabytes of images. The web site also features links that can be used to e-mail questions and comments to TEAM Leafy Spurge personnel and other leafy spurge specialists. In addition, starting this month, the web site features an online registration form for Spurgefest II, scheduled for June 19-21, 2001, in Medora, N.D. The registration form can be found at www.team.ars.usda.gov/spurgefest2/register.html

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Rumors

Leafy spurge flea beetles don't start rumors, but can be the subject of gossip and hearsay. This past summer, rumors about a flea beetle population crash in North Dakota resulted in the cancellation of field day events, restricted access to healthy and harvestable flea beetle populations, and agency officials contemplating reduced funding for future leafy spurge biocontrol efforts. Unfortunately, the rumor was "just plain wrong," says Gerry Anderson, an ecologist at the USDA-ARS Northern Plains Agricultural Research Laboratory in Sidney, Montana, and co-principal investigator of the TEAM Leafy Spurge area-wide program. "Flat out, there was no big, widespread flea beetle population crash this summer," Anderson said. ""The rumor gave the impression that flea beetles weren't doing well, and that's too bad because they're doing great. In fact, there were more flea beetles at more sites this summer than ever before, and we can expect to see even more in the future." Anderson says he thinks he knows how the rumors started. "We saw some interesting thing this year some incredible things, really and yes, we saw some populations decline in specific, localized areas," Anderson said. "But, and this cannot be over-emphasized, the declines we saw resulted from massive reductions in spurge. The flea beetles were gone, but so was the spurge."

Entomologist Bob Richard, director of the USDA-APHIS Biological Control of Weeds Laboratory in Bozeman, Montana, said the site-specific population declines were classic examples of flea beetles in action. "The flea beetles are doing exactly what they're supposed to do," Richard said. "When all the spurge is gone, they'll be gone too; they either move to find more spurge or die." Unfortunately, the "facts got all mixed up," Anderson said, causing some unnecessary concern about the general well being of flea beetles. But, on a positive note, the rumor stressed an extremely important aspect of biocontrol. "The lesson from this summer, and it's a really important one, is that flea beetles cannot be taken for granted," Anderson said. "Never assume that flea beetles will just be there. It's not like it used to be ten or even five years ago; we now have some incredible flea beetle numbers spread across a wide geographic area, and we can expect to see more site-specific spurge reductions and flea beetle population declines. People need to be prepared."

TEAM Leafy Spurge offers the following tips to prevent site-specific population declines from causing problems for your leafy spurge biocontrol program.

- Don't miss your opportunity to harvest! "Not utilizing good sites is the most common problem we see," says USDA-APHIS PPQ officer Dave Hirsch, who has conducted field day events for more than a decade. If you can collect several thousand flea beetles from a site, begin harvesting and use the flea beetles to start new release sites. The lesson: Don't delay.
- Don't depend on one site. You may have a favorite site, but don't expect it to produce big numbers forever, it can only last so long. As witnessed this summer, spurge infestations can decline rapidly when flea beetles populations reach high numbers, and a population that looks GREAT this year may be gone next year. The lesson: Start new sites every year to protect future harvesting opportunities.
- Where? "We saw many areas this summer where flea beetles had nearly eliminated the spurge and moved to new areas," Hirsch said. These new areas can be surprisingly long distances from the original site, he added, and can provide "unbelievable flea beetle numbers." The lesson: if flea beetles don't show up where (and when) expected, keep checking and scout surrounding areas.
- When? Although there are average dates to go by, emergence is site-specific and can vary by as much as two weeks. The lesson: If flea beetles don't show up when (and where) expected, keep checking and scout surrounding areas.
- Monitor your sites. When spurge infestations begin showing signs of rapid thinning due to flea beetle activity, be prepared, the flea beetle population could explode and take out the spurge in a single season. "We're now at a point where extremely rapid decreases in spurge infestations and subsequent flea beetle population declines will be more common," Richard said. The lesson: Monitor your sites and harvest accordingly to prevent the loss of populations that could be used to start new sites.
- Develop more partnerships! Private landowners have established thousands of new sites the past few years, but public agencies continue to provide most of the access to land and flea beetles for field day/distribution activities. Landowners who obtain beetles at field day events need to understand that they are getting "seeds" that need to be planted, managed and shared. "Developing partnerships and working together to help maintain the resource is absolutely crucial," Hirsch said. "We need more landowners like Leon Rummel of Gladstone and Ken Quam of Tolna that provide their neighbors with access to flea beetles." The lesson: Share your flea beetles! The bottom line, Richard said, is planning. "It really shouldn't be surprising that flea beetles will take out a patch of spurge then move on the greener pastures because that's what they're supposed to do," Richard said. "Managing your flea beetles is the key. If you monitor your sites and move your flea beetles around to start new sites, you shouldn't have any problems when flea beetles wipe out a site." TEAM Leafy Spurge is a five-year research and demonstration project funded and led by the USDA-ARS in partnership with the USDA-Animal & Plant

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Health Inspection Service. Its goal is providing landowners and land managers with proven leafy spurge control techniques based on IPM strategies. TEAM participants include the National Park Service, U.S. Geological Service, U.S. Forest Service, Bureau of Land Management, Bureau of Reclamation, Bureau of Indian Affairs, land grant universities (including Montana State University, North Dakota State University, South Dakota State University and the University of Wyoming), cooperative Extension Services, county weed supervisors, and private ranchers and landowners. For additional information on TEAM Leafy Spurge, leafy spurge biocontrol or Integrated Pest Management, see the TEAM Leafy Spurge web site at http://www.team.ars.usda.gov

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of anticipation we're seeing for Spurgefest II, we're expecting a big turnout," he said. "We'll be set up to handle about 300 people, and I'd advise anyone who is interested to register as soon as possible." Additional information about the event can be found on the TEAM Leafy Spurge website at www.team.ars.usda.gov/spurgefest2.html, and an electronic registration form can be found at www.team.ars.usda.gov/spurgefest2/register.html.Mail-in registration forms are available by calling Theodore Roosevelt National Park at 701/623-4466 or writing to TRNP/Spurgefest II, Box 7, Medora ND 58645. Additional information about the event, as well as a mail-in order form, will be published in the next issue (April) of The Leafy Spurge News.

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Letters To The Editor

Dear Leafy Spurge News,

I feel that I have been able to eradicate it from 7½ acres with the exception of the viable seeds, almost entirely by persistence and a variety of experiments with a number of methods. In May 1994 I discovered several patches of leafy spurge in a remote area of our home place. Indications are that, in 1985 or 1986, hay that had been donated from Montana to feed the starving deer had been placed in any spot accessible by 4-wheel drive or snowmobile. Later conclusions from observations established that the only spread from the initial site was by seed propulsion and rhizome extension. The only evidence of spread by deer is along the down-hill trails where seedlings are still emerging below the trail.

Initial spray of 7½ acres of blooming spurge, done by Custom Spray of Spokane in conjunction with Steven County Weed Board plus an extremely dry 4 months with a combination of Tordon and Krenite, except for the two test plots of (5) 100sq.ft. areas 4' x 25', achieved what we thought to be a complete control. It did achieve what I estimated to be an 85% reduction overall. However we were to learn the facts of leafy spurge!

In another set of experiments I used black plastic 14' x 40 feet sealed with dirt and left 1 year covered a solid patch of full blooming Spurge, ½ of which I tilled in and the ½ just covered did not have any regrowth for 2 years. Two rains of ¾ in and two seedlings came up, which were promptly sprayed and killed. Just rototilling resulted with at least 85% kill and allowed me to plant a crop of winter wheat and winter rye. My conclusion, a grain crop could be planted and by rogueing the field with Scythe or any acceptable broad leaf herbicide, successfully harvested. Only seedlings and an occasional rhizome extension would be there at harvest. and they would not contaminate the crop. I really wished that I could have experimented more with different concentrations. 6½ oz per gallon of Roundup may well have been too strong for a good kill. Perhaps my 4 oz Hydep + 2 oz Tordon too is too strong ; but it has worked for me and my 7½ acre patch required just one 4 gallon back pack to treat every single spurge that I could find.

I have picture documentation and a lot of conclusions from the various trials. I have run out of source for further experiments. One back pack of chemicals now individually hits every emergent leafy spurge plant, that I, with a spotter, am able to identify. I now make four trips per year to prevent maturation of seeds, which I conclude would require me to embark on another 8 year project. Leafy Spurge can be eradicated chemically. Patience is the key, perhaps persistence is the more appropriate word. New stands are readily controlled. Old stands will take longer.

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New Products

TEAM Leafy Spurge will be supplementing its popular "Biological Control of Leafy Spurge" handbook with several new informational products that will be available later this year. First off, a new CD will feature a variety of information about biological control. Included will be a PowerPoint presentation, an electronic version of the "Biological Control of Leafy Spurge" manual, a photo gallery and additional resources. The new CD, which will be available in March or April, will serve as the foundation for a series of similar products. "The CD will be a great product," said Gerry Anderson, co-principal investigator of the TEAM Leafy Spurge project. "It has something for everyone, and we expect to see a big demand for it." Anderson said he's most excited about the fully narrated PowerPoint presentation. "It's a fantastic tool for weed managers and Extension agents," he said. "It's easy to use, and provides a wealth of information about using biological control." The photo gallery will feature photos about various aspects of biological control, including biocontrol agents, before-and-after biocontrol photos, using biocontrol agents, etc. The additional resources section will feature ready-to-print posters that can be used at field day events and similar activities, a comprehensive list of contacts, and a selected bibliography for additional information on various aspects of leafy spurge management.

"We're very excited about the CD," Anderson said. "By combining various products, we were able to stretch our dollars further and come up with a product that satisfies a wide range of needs." Also in the works are herbicide and multi-species grazing manuals to complement the popular biocontrol manual. "We've had a lot of requests for manuals on herbicides and grazing, and we've got the best of the best helping work on them," Anderson said. "There's no one with more expertise on herbicides than Rod Lym, and the same goes for Tim Faller and Kevin Sedivec on grazing." The manuals will ultimately be packaged on a CD with PowerPoint presentations, photo galleries and additional resources. Anderson said TEAM Leafy Spurge will then have a comprehensive series of CDs that "covers all aspects of leafy spurge management." Also slated for release this year is a revision of the award-winning "Purge Spurge" CD database. Anderson said the goal is simple. "People need good information to win the war on leafy spurge and other noxious invasive weeds, and we're trying to provide the tools they need," he said. "Information is absolutely the key." Release dates for the new products will be featured on the TEAM Leafy Spurge website at www.team.ars.usda.gov. For additional information, e-mail teamls@sidney.ars.usda.gov

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Spurgefest

It's back by popular demand — Spurgefest is returning to Medora! TEAM Leafy Spurge is pleased to announce that Spurgefest II, a follow-up to the popular Spurgefest '99, is set for June 19-20-21 in Medora, N.D. "We're really excited," said Chad Prosser, TEAM Leafy Spurge program manager. "Spurgefest '99 was a big success, and Spurgefest II is going to be even bigger and better." The three-day event will feature a TEAM Leafy Spurge symposium, tours of TLS research and demonstration sites, a hands-on flea beetle collection demonstration, a flea beetle distribution and more. The format will be similar to Spurgefest '99, but with more emphasis on field tours. "People are telling us they want more opportunities to see the management strategies we're researching and demonstrating," Prosser said. "That's exactly what we'll be providing at Spurgefest II." Gerry Anderson, co-principal investigator of the TLS program, says people will be pleased with the tours. "Our demonstration sites look great," Anderson said. "People who've seen the sites in previous years will be impressed with the multi-species grazing, grazing-biocontrol, herbicide and herbicide-biocontrol demonstrations."

Following is a summary of the three-day event:

- June 18 — Pre-registration, 5-8 p.m., Medora Community Center.
- Day 1/June 19 — Team Leafy Spurge Symposium, 8 a.m., Medora Community Hall. TEAM Leafy Spurge program participants will present their findings and be available to answer questions. Fee: $15 (includes snacks and catered noon lunch). Registration runs from 7 a.m. to 7 p.m. at the Medora Community Center.
- Day 2/June 20 — Tours of TEAM Leafy Spurge research and demonstration sites, departure at 8:30 a.m. from Tjaden Terrace/Burning Hills Amphitheater parking lot. Fee: $15 (includes bus tour, snacks and BBQ lunch). Registration runs from 7-9:30 a.m. at Tjaden Terrace.
- Day 3/June 21 — Hands-on flea beetle collection demonstration, flea beetle distribution, speakers and Pitchfork Fondue luncheon. Buses depart for flea beetle collections at 8:30 a.m. from Tjaden Plaza/ Burning Hills Amphitheater parking lot. Fee: $20 (includes Pitchfork fondue). Registration starts at 7 a.m. at Tjaden Terrace. NOTE: People interested in the Pitchfork Fondue on must register no later than the morning of June 21! Also, there is no fee for transportation to or participation in the flea beetle collection demonstration. Anderson encouraged interested individuals to register as soon as possible. "Based on the success of Spurgefest '99 and the level

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Believe It or Not

What makes leafy spurge different from most other plants? Apparently not much (so long as you overlook the latex, root buds, and a few other things that annoy cows and people) according to Dr. Dave Horvath with the USDA-ARS Plant Science Research unit in Fargo. Recently his lab undertook an experiment designed to understand how similar leafy spurge is to *Arabidopsis thaliana*. Leafy spurge is a perennial weed in the "*Euphorbia*" family, while *Arabidopsis* is a simple annual weed in the "mustard" family. Because of its simplicity, *Arabidopsis* is being used as a model to study how plants grow and respond to their environment. Think of it as kind of the fruit fly of the plant kingdom. Because it has been chosen as a model plant, a large amount of money and time has been spent on gathering information on the genetics and physiology of this small weed. In fact, it is very likely that the entire genome of this plant will be sequenced by the end of the summer. Because there are a lot of tools and tricks that have been developed to study growth and development in *Arabidopsis*, we thought it might be helpful to see if we could use some of them to help us understanding how the growth of leafy spurge root buds is controlled.

One of the more useful techniques that has been developed is known as micro-array technology. Micro-arrays are made by spotting a very small amount of a specific gene on a microscope slide. Because the spots are so small, one can easily place over 20,000 different genes on a single slide (note there are probably only 20,000 to 30,000 different genes in most plants). Once such slides (or "chips" as they are commonly called) are made, one can use them to study what is happening in the plant during a specific change in growth or after exposure to stress. For a more detailed explanation of how micro-arrays help us look at what genes are turned on and off, see the article by Dr. Wun Chao in this issue of Leafy Spurge News.

We do not yet have enough genes cloned from leafy spurge to make a leafy spurge chip. Consequently, we wanted to see if we could use *Arabidopsis* chips to study growth and development of leafy spurge. It was hoped that, since leafy spurge and *Arabidopsis* are both plants, the genes they contain would be similar enough that some of the cDNAs from the leafy spurge genes would find their *Arabidopsis* counterpart on the chip. Consequently, Dr. Horvath traveled to Michigan State University where they routinely do micro-array experiments with *Arabidopsis* chips. To test the system, Dr. Horvath compared young growing leaves of leafy spurge plants to mature leaves (both of which are much easier to collect than growing vs. non-growing root buds) and looked to see if we could use the *Arabidopsis* genes on the chip to see specific differences in these two samples. The experiment was a surprising success. Leafy spurge cDNAs stuck to over 80% of the *Arabidopsis* genes. It was clear that we could see some genes that were turned on in the young leaves and off in the old ones (and visa-versa) on the *Arabidopsis* chips. Although there are probably four to eight thousand genes that are too different to detect, it looks like there is enough similarity between *Arabidopsis* and leafy spurge to use this powerful tool to study gene expression in leafy spurge and possibly other weeds and crops as well. Use of this technique will undoubtedly lead to the identification of genes involved in stress responses and growth and development. Once such genes are identified, we can begin to study how they are turned on and off. If we can learn this, we should be able to find ways to turn these genes on or off and develop new ways to control the growth of leafy spurge. Perhaps we will someday be able to cause the root buds to grow in late fall or prevent their growth in the spring or turn off the genes that help protect spurge from drought, cold, insects and disease.

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Micro-array: A New Technology in the Quest to Vanquish Leafy Spurge

A new wave in (weed) science has emerged. This wave is propelled by advanced molecular techniques. With these techniques, we may be able to understand the biology of weeds better than any of us could have imagined even 3 years ago. In last issue of Leafy Spurge News, you were introduced to me, Dr. Wun Chao, a new USDA-ARS research plant molecular geneticist in the Plant Sciences Research (PSR) unit in Fargo. You were also introduced to some terms like "cDNA library" and "expressed sequence tags or ESTs" used by myself and others who do research in genomics (the efforts to map and sequence all genes and to unravel their function). cDNA libraries and ESTs are the basic tools for our genomics project on leafy spurge. For practical reason of time and money, we are not planning to sequence the entire genome of leafy spurge. However, we plan to examine the expression of genes that control the growth and development (dormancy) of leafy spurge root buds. The technique we will use is called the micro-array technology. This is the first time that this new and powerful technique has been applied to develop new knowledge in weed science.

Why is it important to study the expression of genes? Genes and their products (proteins and enzymes) regulate physiological processes like bud dormancy and growth. The expression of genes is influenced by developmental factors like stage of growth and age and environmental factors like temperature, light, biological control agents, etc. Environmental factors can turn the expression of genes, like "dormancy genes", on and off. By looking at how many particular genes are turned on or off in a given environment or during a particular stage of development, such as when root buds become dormant, we can begin to understand what the plant is doing to make these changes. In time and with some luck, this understanding should lead to improved methods of weed control.

Until recently, a technique called Northern analysis has been used to examine gene expression in leafy spurge. This method studies one gene at a time. In contrast, micro-array technology can now be used to study the expression of hundreds to thousands of genes among different samples at the same time. To do this, thousands of individual genes (ESTs) are spotted on a small microscope slide. With the technology today, one can spot up to 36,000 genes per slide. DNA copies (cDNAs) made from all the expressed genes of a given sample are tagged with a special fluorescent label. These cDNAs will find and stick to the gene they come from. Two samples (say from dormant and growing root buds) can be compared by labeling one cDNA sample (say from dormant buds) with a red tag and the other cDNA sample (say from growing buds) with a yellow tag. The two tagged cDNA samples are mixed and applied to the slide. Since the cDNAs stick to the gene they came from quantitatively, the difference in gene expression between dormant and growing buds is distinguished by the intensity of red verses yellow fluorescence at the same spot. For example, if a particular gene is turned on more in dormant buds (red tag) than growing buds (yellow tag), the spot on the slide will be more red than yellow. Therefore, using the micro-array technique, one can not only analyze the same set of genes under many different developmental and environmental conditions but also can examine the expression of genes from the whole genome at the same time. Recently, we found that micro-array technology can be expanded to study the gene expression of leafy spurge using an *Arabidopsis* micro-array slide (see Horvath's article in this issue for details).

So what is the limitation of this method? It requires many ESTs. In other words, we need as many sequenced independently expressed genes as possible. At present, Dr. Jim Anderson in our group has sequenced about 500 genes (cDNAs) from the leafy spurge cDNA library. Many more are needed. We plan to make our first slide when the number of independent clones reaches 1000. At that time, we will begin to decipher genes that are responsible for root bud dormancy and growth.

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Bug Bombing:

Aerial Application of Flea Beetles for Leafy Spurge Managment

In the early part of the century, leafy spurge was introduced into the rugged Butte and Custer counties of Idaho as an ornamental. The undesirable nature of the plant was not recognized until the 1950's. Since that time, leafy spurge has spread across public and private lands, and now infests more than 8,000 acres in Butte and south Custer Counties. This includes remote mountainous areas as well as the banks of the irrigation system and natural waterways of the area. In addition to spreading in flowing water, on farm machinery, in harvested forage, and on the coats of wild and domestic herbivores, leafy spurge is a favored food of mourning doves, which can successfully transport the seed long distances in unpredictable directions.

It is conservatively estimated that $100,000 annually is expended in time and materials to suppress this plant in the Lost River watershed.

Working with public and private land managers in the area, it has been possible to assemble an informal area-wide plan to reduce the spread of leafy spurge. This integrated program includes mapping and monitoring of the problem, public education, landowner education, short and long term herbicide applications, law enforcement activity, development of insectiaries, the harvest and re-release of biological control agents and now bio-agent delivery to remote locations using a helicopter.

The Animal Plant Health Inspections Service (APHIS) released 300 *Aphthona nigriscutis* (flea beetles) in Lost River in 1988. This original release has been nurtured, harvested and redistributed in the drainage in accessible locations. It is now possible to economically harvest hundreds of thousands of these spurge-eating beetles in a few hours. In cooperation with the US Forest Service (USFS), Bureau of Land Management (BLM) and the weed departments of Butte and Custer counties, we have harvested and released thousands of *A. nigriscutis* in accessible areas.

In 1999, we discovered that Andrew Deutscher, Research Weed Specialist with the Rocky Mountain Research Station of the USFS funded with a grant from the Forest Health Protection Division of the USFS had successfully demonstrated that these flea beetles could be delivered and established by dropping them from a helicopter on remote and inaccessible locations. We mobilized our cooperators and with only $2,000 of Idaho Department of Agriculture Cost-Share Grant Funds we implemented a program in the Lost River Valley to deliver flea beetles to our inaccessible populations of leafy spurge

"Bug bombing" was wildly successful. We collected over 400,000 insects at a cost of about $0.0021 each. Two hundred and forty thousand of these were packaged in 120 specially designed "bug bombs". These bug bombs were placed in inaccessible locations using a helitack helicopter and their location recorded using GPS. In 2001, we will visit 10% of the sites to evaluate establishment. However, based on our experience with ground delivery in similar habitats, we expect to find better than 95% establishment.

The program appears to be cost effective. Our cost of a single "drop" was about $20. This included direct helicopter costs, helicopter ferry time and chase crews, the materials and labor to construct the "bombs", collection and "arming" the "bombs" with insects. The base cost of the seasonal lease for the helitack helicopter was absorbed by the Challis/Salmon National Forest. This compares favorably with ground crews that can deliver insects to 20 or less sites per day. If one assumes that in several years each drop will expand to a diameter of 1000 feet, this works out to a one-time "control" cost of $7.50 per acre, as compared to perennial or biennial herbicide treatments at $150-250 per acre, or permitting the spurge to "run wild".

Helitack crew huddling with land managers to work out detail of the "mission."

The helicopter hovers momentarily over the spurge patch, the "bomb" is dropped and the GPS reading recorded.

Within minutes the beetles are crawling out of the container looking for a meal.

There are also the subjects of timeliness and efficiency that are harder to quantify. *However, in our opinion, since the sites treated with the helicopter are so difficult and time-consuming to get to, none of them would have received treatment without using the helicopter.* Our partners who have other areas with access problems, such as the cliffs of the South Fork of the Snake River are considering the use of the "bug bomb" approach.

"Bug bombing" worked so well that it will be continued and extended to include "saturation bombing" of larger infestations. The "bombing" procedure also permits the mapping of remote spurge locations.

This program will be carried on in conjunction with the inventory, education and weed management programs of the Lost River Coordinated Weed Management Area.

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Cooperators

Butte County and Custer County Department of Noxious Weeds
Salmon District, Bureau of Land Management
Big Butte Resource Area, Idaho Falls District, Bureau of Land Management
Idaho Department of Agriculture
Idaho Department of Transportation
Big Lost Irrigation District
Butte County and Custer County Commissioners
US Animal Plant Health Inspection Service
Lost River Ranger District, USFS
Forest Health Protection, USFS
Rocky Mountain Experiment Station, USFS
Lost Rivers Coordinated Weed Management Area sponsored by the Butte Soil and Water Conservation District.

Biocontrol Manuals Available

There may still be snow on the ground, but it's not too soon to be thinking about leafy spurge. With that in mind, weed warriors are reminded that the TEAM Leafy Spurge "Biological Control of Leafy Spurge" handbook is available and ready to ship. Last year, TEAM Leafy Spurge distributed 15,000 of the manuals in a six-week period immediately prior to and during the leafy spurge flea beetle field season. "Once people saw how useful the manuals are, they became hot items, especially for people planning field day events," said Chad Prosser, TEAM Leafy Spurge program coordinator. "Things got a little hectic — we started shipping them out in late May, and were sending them out on a daily basis through mid-July."

This year, Prosser is encouraging weed agents and land managers to order manuals early and avoid "the sense of urgency we saw last year." "It's not a bad idea to get the manuals to people who will be using flea beetles in advance of the field season," Prosser said. "That way, they'll have plenty of time to think about their plan and ask questions if need be, and they'll be prepared when it's time to collect and release flea beetles."

Compiled by Dave Hirsch (USDA-APHIS PPQ/Bismarck) and Dave Nelson (state entomologist, North Dakota Department of Agriculture), the manual features information gathered from years of hand-on experience. "It really is one of the best resources I've seen in regard to biocontrol," Prosser said. "If people follow the guidelines in the manual, they will definitely improve their chances of successfully integrating biological control into their leafy spurge management plans." The manuals have been revised slightly from last year with the addition of a biocontrol release form that can be pulled or copied from the manual and used to record various kinds of information about release sites. The forms helps ranchers and land managers keep track of information that could potentially be used to trouble-shoot release sites. "It's not a big thing and it doesn't take much effort to fill it out — it's really just a way to make a permanent record of your release sites," Prosser said. "It's the kind of thing that might help a weed manager or Extension agent determine why flea beetles are or aren't working." Prosser recommends taking a picture of the release site to complement the release site form. "That way, you'll have both written and photographic records," he said. "It'll give you a chronology of your biocontrol efforts." The manuals can be ordered via e-mail at TEAMLS@sidney.ars.usda.gov, by calling 406/433-2020 or by writing to TEAM Leafy Spurge, USDA-ARS NPARL, 1500 N. Central Ave, Sidney MT 59270. State or federal agencies interested in ordering large quantities of the manual should contact Prosser (cprosser@sidney.ars.usda.gov; 406/433-9403) or Steve Merritt (smerritt@sidney.ars.usda.gov; 406/433-9440). The manuals were funded in part by a grant from the National Biological Control Institute.

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Poster

The Response of Glutathione Reductase and Glutathione-S-Transferase to Environmentally- and Chemically-Induced Stress; Amelioration by Polyamines in Leafy Spurge *(Euphorbia Esula L.)*

Abstract. Research is underway to establish key processes in the growth and development of leafy spurge that may be amenable to new and innovative methods for controlling this invasive weed that will be effective, cheaper and more environmentally friendly than present methods. These methods could be applied in the event that future circumstances render present methods ineffective. Basic physiology, biochemistry and genetics are areas of active research within our unit. Control of enzyme systems involved in the plant's response to stress (imposed by biotic or abiotic means) are possible candidates. Glutathione (GSH), a major constituent of all plant cells, consists of three amino acids linked together (a tri-peptide) that aids in controlling the plant's response to foreign chemicals and other stress, and behaves in many instances as an antioxidant. Glutathione reductase (GR) and glutathione S-transferase (GST) are key enzymes that regulate the action of GSH. The objective of our research is to characterize GR and GST in leafy spurge, determine their responses after induced stress of various kinds and establish ways to regulate them to the disadvantage of leafy spurge. In this report we also show that diclofop-methyl (DM) can be applied to leafy spurge to induce symptoms very similar to natural senescence. GR activity from leaves of untreated leafy spurge plants are consistently higher and somewhat more variable than GST activity (using 2,4-dichloronitrobenzene as a substrate). Activities ranged from approximately 120 to 170 nmol of product/min/mg protein for GR and approximately 50 to 120 nmol of product/min/mg protein for GST. Daily activities were more linear for GST than for GR. The activity of GR and GST from plants sprayed with 5 mM of the senescence-inducing compound DM increased within a few hours to nearly maximum levels by 26 h, and leveled off by 42 h. Activities of GR and GST from leafy spurge leaves treated 42 hrs with 5mM DM ranged from 250 to 320 nmol of product/min/mg protein and 175 to 210 nmol of product/min/mg protein, respectively. Polyamines are also natural constituents of plants that have many functions, most of which are still speculative, but are actively being investigated worldwide. Leafy spurge plants pre-treated 0.5 to 1 h with 20 mM polyamines (putrescine, spermidine or spermine) showed less visual damage when sprayed with 5 mM DM compared to plants sprayed with 5 mM DM alone. GR and GST activities were at essentially control levels in plants pre-treated with any one of the three polyamines, and less severe visual damage occurred to the leaves of the polyamine-treated plants than to plants sprayed only with DM. The increases in GR and GST activities induced by DM are similar to those of leafy spurge plants stressed by drought or iron deficiency. The ability of these polyamines to counteract the DM-induced activity of GR and GST suggest that they may play an important role in amelioration of the effects of biotic and abiotic stressors. Research is currently underway to attempt to establish whether these polyamines are functioning as anti-senescent agents; perhaps as antioxidants. We are still in the early stages of learning how to control the action of GSH, polyamines and their related constituents. This research should lead us forward in efforts to eventually control growth and development of leafy spurge and other perennial weeds.

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Mark Your Calendar!

Spurgefest II is set for June 19-21, 2001, in Medora, N.D.!

1999 Leafy Spurge Symposium Participants Grouped by Subject Matter

BASIC

Responses of glutathione-S-transferase and glutathione reductase to environmentally and chemically-induced stresses; amelioration by polyamines in leafy spurge (*Euphorbia esula* L.).

David G. Davis, Harley R. Swanson, Kristi A. Biewer, James V. Anderson, and Donald R. Rusness, USDA/ARS, Fargo, North Dakota. (Poster)

AFLP analysis on individuals from leafy spurge populations characterized as resistant or susceptible to flea beetle bio-control agents. David P. Horvath, USDA, ARS, Fargo, North Dakota.

BIOLOGICAL CONTROL

Aphthona flea beetle establishment determined by soil composition and root growth pattern. Donald A. Mundal and Robert Carlson, North Dakota State University, Fargo, North Dakota.

Integration of *Aphthona* flea beetles and herbicides for leafy spurge control. Jeff A. Nelson, Rodney G. Lym, and Robert Carlson, North Dakota State University, Fargo, North Dakota.

Know thine enemy — understanding weed management through biological research. James V. Anderson, David G. Davis, Michael E. Foley, and David P. Horvath, USDA, ARS, Fargo, North Dakota.

Sex ratio effects on fecundity and fertility of a leafy spurge flea beetle *A. lacertosa*. Denise Olson and Don Mundal, North Dakota State University, Fargo, North Dakota.

CHEMICAL

Imazapic for leafy spurge control. Denise Markle and Rodney G. Lym, North Dakota State University, Fargo, North Dakota.

Wyoming's research on leafy spurge. Mark A. Ferrell, Extension Pesticide Coordinator, University of Wyoming, Laramie, Wyoming.

ECOLOGY

Above ground effects of flea beetle releases on leafy spurge infested rangeland. Don Kirby, North Dakota State University, Fargo, North Dakota.

Effects of prescribed burning and herbicide treatments on leafy spurge (*Euphorbia esula* L.)

Chadley W. Prosser, USDA, ARS, Sidney, Montana and Kevin K. Sedivec and William T. Barker, Animal and Range Sciences Department, North Dakota State University, Fargo, North Dakota.

Impacts of leafy spurge on local and landscape patterns of plant species diversity in Theodore Roosevelt National Park. Dan R. Cogan, U.S. Bureau of Reclamation, Denver, Colorado and Jack L. Butler, Central Missouri State University, Warrensburg, Missouri.

Seed study of a leafy spurge infestation. John Sterling, Don Kirby, and Rodney G. Lym, North Dakota State University, Fargo, North Dakota.

ECONOMICS

Economic analysis of sheep grazing of leafy spurge: preliminary results. Larry Leistritz, Randy Sell, and Dean Bangsund, North Dakota State University, Fargo, North Dakota.

Leafy spurge (*Euphorbia esula* L. EPHES) perceptions by ranchers and land managers. Randy Sell, Research Scientist, North Dakota State University, Fargo, North Dakota.

GRAZING

Comparison of companion grazing and single species grazing on leafy spurge infested rangeland.

Jack D. Dahl and Timothy C. Faller, Hettinger Research Extension Center, Hettinger, North Dakota, Kevin K. Sedivec and Jerrold Dodd, Animal and Range Sciences Department, North Dakota State University, Fargo, North Dakota; and James Karn and Don Stecher, Northern Great Plains Agricultural Research Center, Mandan, North Dakota.

Sheep grazing with flea beetles to manage leafy spurge. K. G. Beck, L. J. Lamming, H. D. Fraleigh, and J. R. Sebastian, Colorado State University, Fort Collins, Colorado.

Removing the constraints of sheep as an alternative integrated pest management tool.

Timothy C. Faller and Jack D. Dahl, Hettinger Research Extension Center, Hettinger, North Dakota.

Progress update on toxic compounds in leafy spurge for ruminants. Fathi Halaweish and Scott Kronberg, South Dakota State University, Brookings, South Dakota.

TECHNOLOGY

Change detection of leafy spurge (*Euphorbia esula*) infestations using aerial photography and geographic information systems. G. L. Anderson and C. W. Prosser, USDA, ARS, Sidney, Montana and S. Hager and B. Foster, USDI, Medora, North Dakota.

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Dieter Schroeder Retires From Switzerland's CABI Bioscience Centre

More than fifty years of service to the biological control community came to an end this September when long-time member of the biological control community, Dr. Dieter Schroeder, retired. Nearly all of Schroeder's tenure was spent at CABI Bioscience Centre Switzerland (formerly European Station of the Commonwealth Institute of Biological Control - IIBC). He spent the last four years as Centre Director, a period especially noteworthy at the center due to the construction of an extension to the Centre building increasing the available space by 50%.

Dr. Matthew Cock, formerly IIBC Deputy Director of Operations and CABI Bioscience Weed Biological Control Programme Leader, takes over as Centre Director of the Switzerland Centre in Delemont, with its active and committed staff and strong research program.

Dieter got his PhD in 1962 from Gottingen, West Germany on the pine shoot moth. In 1969 he joined Helmut Zwolfer in his work on biological control of invasive weeds, including leafy spurge, thistles, and St. Johnwort, and took over the Delemont Weed Section in 1973, when Helmut Zwolfer left. In the late 1970's he worked in close cooperation with Canada's Peter Harris, concentrating his work primarily on knapweeds and leafy spurge. During the course of the last twenty years biological weed control has developed into a major component of Switzerland Centre's work in Delemont with six research scientists and a varying number of Diploma and PhD students.

Quite early on Dieter established close cooperation with the USDA-ARS and the CSIRO European Weed Biocontrol Laboratories, and initiated with Paul Dunn annual meetings of the three groups to exchange information and to avoid duplication of work. Supported by Peter Harris, Dieter put much effort on encouraging Canadian and U.S. scientists and sponsors to join forces and form consortia to enhance support and progress in biological control of invasive weeds. There are now several such consortia coordinating the biological control program against different weed targets.

His contribution to weed biological control was recognized publicly by professional colleagues last year when Dieter, along with Peter Harris and Lloyd Andres, was an honoree of the Tenth International Symposium on Weed Biological Control in Bozeman, Montana.

Dieter will be remembered by those who worked with him for this enthusiasm, strong opinions, and certainly his humor and many jokes and stories. We all wish Dieter a long and fulfilling retirement, which judging by his plans will be no less busy than this career.