Abstract

By nature, invasive exotic species are difficult to control. The more management tools that are available to weed managers, the greater the chance that a particular noxious weed will successfully be controlled. Arapahoe County has made the decision to explore the use of beneficial insects to complement herbicide applications and mechanical controls. Insects for leafy spurge have been released in locations throughout the County to help provide some control. Three different *Apthona* flea beetle species have been released as well as *Oberea erythrocephala,* a stem and root-boring beetle. To date the *Aphthona* flea beetles have proven to be the most effective for leafy spurge control and results on the effectiveness of *Oberea erythrocephala* are still inconclusive.

Introduction

Leafy spurge is a non-native plant originally from Europe that will invade riparian areas, rangelands, pastures, and waste areas. The main reason it is successful at invading these sites is its massive underground root system. It can grow to depths of 30 feet and can sprout new plants from root fragments as small as ½ inch long. Plants will vary in height from 1 to 3 feet and are pale green in color. All parts of the plant contain a white, milky latex sap that can inhibit the movement of some herbicides into the root system and is poisonous to both humans and animals.

For the past five years Arapahoe County has been implementing biological controls on both public and private lands as a means of noxious weed control. In general biological controls, or beneficial insects, have proven largely to be successful. However, a few sites have shown very little results. Even if there are some failures, what is learned provides important knowledge when determining future release sites for the project.

The primary release site for Arapahoe County's biological control program is Cherry Creek State Park. In June of 1999 approximately 50,000 flea beetles imported from North Dakota were released in the Park. Releases were kept large in two different locations for the purpose of starting an insectary so insects could continually be collected from those sites and released elsewhere in the County. In June of 2000, an additional 40,000 flea beetles were released in areas surrounding the initial release sites to increase the area of the existing population. During the summer of 2001 the population was large enough to begin collection and redistribution of insects, with approximately 1,700,000 collected from the site since that time. This report will get into more detail of what is happening with the release site, site details and the future of the project.

Controlling Leafy Spurge

Leafy spurge is one of the most problematic noxious weeds that exist within Arapahoe County. It is estimated that this weed infests over 5000 acres in the western portion of the County alone. In many instances, the cost of controlling spurge through chemical or mechanical means is economically too prohibitive on a large scale so it becomes necessary to explore alternative methods of weed control to do more while helping to lower the overall cost. There are several methods that have proven successful in other areas of the country as well here in Colorado and those are the use of sheep, goats, plant pathogens, beneficial insects, and competitive grasses. All are capable weed management tools and could be successfully incorporated into any weed management plan. For Arapahoe County's needs and interests however, the use of insects has been chosen.

Above: Leafy spurge in full bloom

The use of beneficial insects as a weed management tool on a large-scale basis was chosen for several reasons. The first reason is to eventually provide a low-cost weed management tool to residents of the County. Second, insects require less time and resources in a large-scale setting than sheep or goats. Finally, they can be used in conjunction with mechanical, cultural and chemical control methods to achieve greater control of leafy spurge. As great as their benefits sound, they cannot be viewed as a sole cure-all for leafy spurge control, just a tool that can be used in a more comprehensive weed control program. Beneficial insects can also fail to do the job they are intended to do and although there are documented failures in trying to establish insects, the reasons for failure can be identified which is useful when determining future release sites. Although there is a downside, the success rate and level of control that has been documented from numerous sites is very encouraging.

Above: *Aphthona lacertosa* on a dead leafy spurge stem.

In almost all cases, bio-controls are collected from a noxious weed's country of origin. In the case of leafy spurge those countries would be European and Asian countries such as Austria, Hungary, the Czech Republic, Italy, Ukraine and Russia (Geltman 1998). There are several types of insects that feed on spurge in its native environment, ranging from different species of moths, flea beetles and weevils. All of them feed on the plant in some fashion, which in turn depletes the root reserve of the plant. This then allows it to become susceptible to diseases or other forms of stress, which keeps it from becoming a problem plant. When an insect is selected

for possible release in the United States, it is extensively tested by the United States Department of Agriculture (USDA) to be certain that they feed and complete their life cycle only on the weed specie they were intended for. An important concern for any purposely released insect as we don't want to release something that will become as much of a pest as the plant it was intended to control. After testing, it was found that the *Aphthona* species of flea beetles are host specific to leafy spurge and the risk of it becoming a pest is extremely low.

Above: *Aphthona flava*. Photo courtesy of the USDA ARS Sidney.

There are four species of flea beetles that are established in insectaries in Arapahoe County. Those species are *Aphthona nigriscutis*, *Aphthona lacertosa*, *Aphthona czwalinae*, and *Apthona flava*. Although they are all flea beetles, each has its own specific characteristics that distinguish it from each other. *A. nigriscutis* is copper in color and favors dry sites with southern facing slopes. It establishes quickly and is highly effective against spurge. *Aphthona lacertosa* and *Aphthona czwalinae* are both black in color and it is very difficult to distinguish the two without a microscope. They are typically found together in the field and both favor moist sites. *A. lacertosa* establishes very quickly, does significant damage to spurge plants and is more versatile then any of the other species. *A. czwalinae* will have some effect except it has been found that its population will decrease as other populations of flea beetles increase over time. *Apthona flava* is the largest of the flea beetle species and is gold in color. It is not very well established in County insectaries but is widely spread throughout the Coal Creek drainage and surrounding areas because of previous releases done by Colorado State University. Although it will establish, it does not significantly impact leafy spurge.

Above: *Aphthona lacertosa*. Photo courtesy of the USDA ARS Sidney.

The condition of the site where any of these flea beetle species are released is important to their survival. Soil type, moisture, available sunlight and the density of the spurge all play a part in the success of a flea beetle release. All of these species do best in sandy loam to clay loam soil types because these soil types allow the formation of fine roots near the soil surface, which is favorable habitat for the larvae (Mundal and Carlson 1999). Soils that are high in clay or sand are not favorable and those sites often fail or only have moderate success. Water at a site can also hinder survival. The site location needs to be well drained and free of spring flooding or any standing water. Direct sunlight is favorable and most species do best on southern facing slopes that receive direct sunlight (Mundal and Carlson 1999). This is also important to flea beetle collection because the adults come to the tops of the plants during the middle portion of the day when the sunlight is most intense. When the adults make their way to the top of the plant they can be

Above: *Oberea erythrocephala*, stem and root boring beetle. Photo courtesy of the USDA ARS Sidney.

collected by a sweep net. Plant density also has an effect, extremely dense stands can inhibit the activities of the adults so moderately dense stands are more favorable for establishment. As populations increase, they will begin to move into dense stands. Even with all of these restrictions, flea beetles are adapted to a wide range of environmental conditions so they are not as fragile as they may seem.

Besides the *Apthona* species of flea beetles there is another insect that Arapahoe County has recently released for leafy spurge control, a stem and root boring beetle named *Oberea erythrocephala,* or commonly known as a longhorn beetle. Although the effectiveness of this insect is still to be proven, the advantage of this insect is that soil type is not a limiting factor for successful establishment like it is for flea beetles. The reason for this is that instead of the adult female depositing eggs on the soil surface, the female will girdle the stem and lay an egg directly into the stem of the plant. The egg will then hatch and the larvae will burrow down into the root crown where it will feed until emerging as an adult the following year. Limiting factors for this insect are available water, they do best in locations near open water such as lakes or streams, and ability to rapidly increase its population. A female will lay an average of 60 eggs over its life cycle compared to the 250 eggs a female flea beetle will lay (Hansen 1995). Even with these characteristics, there is the possibility for it to be an effective weed control tool in areas where flea beetles do not do well or where it is not environmentally feasible to apply herbicides. Releases of this insect were made in July of 2002 so it will be at least two more seasons before any noticeable impacts are seen at the release sites.

The question that is often asked is how does control of leafy spurge by flea beetles compare to control with herbicides since herbicides are looked at as the benchmark for weed control. This question is difficult to answer because there are many different factors that play into the success or failure of a weed control effort. Timing, weather, soil conditions, human error, wind, and other environmental factors can all play a part and are all variables that should be considered. Given this premise, studies have shown that flea beetles can provide control at rates equal to or higher than the best available herbicides. The added advantage is that flea beetles provide long-term control while herbicides will need to be applied annually to maintain control. However, when environmental conditions are not favorable for flea beetles, the level of control they provide is not very good so it would be necessary to use another method of weed control in those areas. Now that we have this knowledge, we can use this to develop a more specialized integrated weed management plan for large infestations of leafy spurge that span over different environmental conditions. The result would then be minimal overall cost and less resources used because you are using the different weed control tools in areas where they are best suited.

Above: *Aphthona nigriscutis* flea beetle. Photo courtesy of the USDA ARS Sidney.

Cherry Creek State Park Release Site:

The Cherry Creek State Park release site is an experiment in the effectiveness of large-scale releases on the density of leafy spurge. Common practice for flea beetle releases had been to do a release of 100 to 500 insects at a time. Only recently have numbers increased to a standard of 2000 flea beetles per release. By releasing such large numbers, it was hoped that in addition to controlling the spurge, a suitable insectary could be established in a short amount of time so insects could then be redistributed elsewhere in the County. The one draw back to large-scale releases is a total failure of the population due to poor site conditions, flooding or an extremely cold winter. Fortunately none of those happened and the insects over-wintered nicely.

This site is located in the northeast portion of the park and consists of approximately 20 acres of fairly dense leafy spurge. It is an open site that slopes slightly to the southeast. The soil type is predominantly clay and moisture levels are typical for this region. In 1993 the State of Colorado released approximately 100 *Apthona nigriscutis*. The condition of the site as it was found in June of 1999 is pictured to the right. The sign in the middle depicts where the original insects were released. As you can see, there is a 10-foot diameter area where the insects are affecting the spurge. Initial sweeps of the area, before new insects were released, yielded approximately 100-150 flea beetles. Following the sweeps, a 50/50 mix of *A. nigriscutis* and *A. lacertosa* totaling about 30,000 insects were released just to the east of the state release area. An additional 20,000 *A. lacertosa* were released in two other spots within the vicinity.

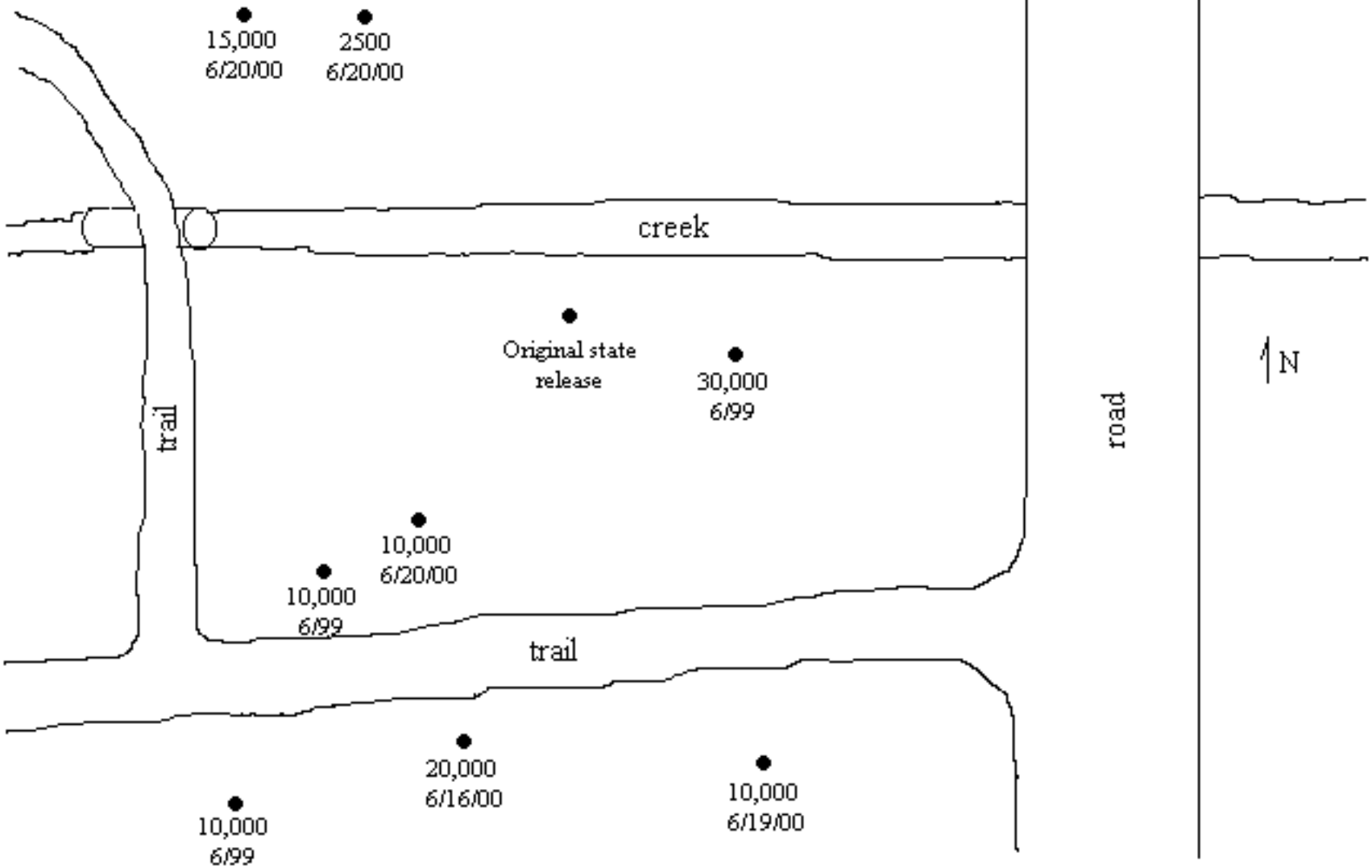
Above: Condition of the release site where *Oberea erythrocephala,* or longhorn beetle, was released in July of 2002.

Over-wintering loses were a major concern. Fortunately the winter of 1999 into 2000 was fairly mild with low temperatures never dipping below 0 degrees Fahrenheit. The site was inspected in the middle of May of 2000 to look for signs of insect activity. Spurge density around the original state release site decreased, increasing the size of the impact area to roughly 1000 sq. ft. Sweeps around this area yielded a large amount of *A. nigriscutis* as well as a large amount *A. lacertosa*. In June of 2000, 40,000 more insects were released in areas away from the previous year's releases. Summer of 2001 is when we really started to see results. Large areas of spurge around the previous year's

release sites had been wiped out and almost all of the other areas of the site were showing signs of feeding or had adults actively feeding on plants. Before and after photos are depicted on the following pages. The pictures show all the typical signs that we would expect to see for an area where a release is made, reduced stand density, delayed emergence, wilting or other signs of drought stress, and emergence of desirable grasses. Seeing this kind of result signified that we could begin collection and redistribution efforts. An estimated 1.5 million insects were collected and redistributed to several Arapahoe County landowners, Cherry Creek State Park, Cherry Creek Ecological Park, 17-Mile House, City and County of Denver, City of Ft. Collins, Adams County, Gilpin County, Douglas County, and Larimer County. Even though there is a chance that we could have a cold winter, a typical Colorado winter is suitable for flea beetles.

2002 was not a good year for collection as approximately 200,000 insects were collected from the same site. Although collection was not as good, the site still showed signs of significant flea beetle damage and the area affected expanded to over a ½ mile from the original release points. Insects were re-distributed to Arapahoe County landowners, Cherry Creek State Park, Cherry Creek Ecological Park, Larimer County, and the City and County of Denver.

Cherry Creek Site Map



Cherry Creek Release Site View 1

Cherry Creek State Park Release Site

- **This site was started in June of 1999 with 20,000 flea beetles, *Aphthona nigriscutis* and *Aphthona lacertosa*.**
- **Herbicides were not used on this site.**

Aphthona lacertosa

Aphthona nigriscutis

ARAPAHOE COUNTY
COLORADO'S FIRST

Cherry Creek Release Site View 2

Cherry Creek State
Park Release Site

- **This site was started in June of 1999 with 20,000 flea beetles, a mix of *Aphthona nigriscutis* and *Aphthona lacertosa*.**
- **Herbicides were not used on this site.**

Aphthona lacertosa

Aphthona nigriscutis

ARAPAHOE COUNTY
COLORADO'S FIRST

Cherry Creek Release Site View 3

ARAPAHOE COUNTY
COLORADO'S FIRST

Cherry Creek Release Site View 4

Cherry Creek State
Park Release Site

- **This site was started in June of 1999 with 35,000 flea beetles, a mix of *Aphthona lacertosa* and *Aphthona nigriscutis*.**
- **Herbicides were not used on this site.**

Aphthona nigriscutis

Aphthona lacertosa

ARAPAHOE COUNTY
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Field Observations:

Above: *Aphthona lacertosa* adults feeding on mature leafy spurge plants. What looks like black specs are all flea beetles.

The Arapahoe County flea beetle program is now into its fifth season and during that time a lot of valuable information has been gained in regards to flea beetles. Out of the three species that have been released, the most versatile specie is the *A. lacertosa*. It will establish on most sites and will readily move to find other areas of leafy spurge once it is done feeding in an area. Also, it will increase its population much more quickly than the other species of flea beetles. Next, it has been learned that ants will adversely effect flea beetle populations. Not only do ants disrupt the adult activities but they will also eat the eggs that are laid on the soil surface. Consequently areas of leafy spurge that surround nests or are in areas with high ant populations will show no signs of flea beetle damage. We have also learned that Colorado's climate changes the flea beetle lifecycle somewhat. In colder climates adults will emerge in the middle part of June, however, we have found that adults will emerge as early as mid-May. It is assumed that this can be attributed to our milder winters and increased soil temperatures earlier in the year. The question we are most often asked, "is there a need to re-vegetate areas of leafy spurge once the flea beetles are done?" In most locations, native vegetation will begin to re-establish as the spurge is controlled. At the Cherry Creek Release Sites, blue grama, western wheatgrass, intermediate wheatgrass, needle and thread and smooth brome have all begun to re-establish themselves at this site. Leafy spurge growth in the release sights is something that we are beginning to more closely monitor throughout the season. Last year we noticed that control would be excellent in some areas until the adults would begin to die off. There would then be a sudden re-growth of spurge in August through September. Although the plants are stunted and show severe stress, we need to look at those plants more closely to determine whether or not they are still capable of setting seed. If so, how much and is this true for the other release sites. Finally, we have learned many things about collection and re-distribution. We have found that during the collection process, flea beetles are at the most risk when they are being sorted from other insects and debris. If the sorter is exposed to sunlight and there are a large number of insects in it, the quick build up of heat and humidity will kill them. In all observed instances there has been no evidence that any of the species have caused any damage to native or desirable vegetation, which should eliminate any concerns of that nature.

Future of the Project

The Cherry Creek release site is a success in regards to leafy spurge control. It is anticipated that this success can be repeated in other areas where leafy spurge impacts lands in Arapahoe County as well as the State of Colorado since this weed does not stop at jurisdictional borders. In 2003 we plan to continue to make releases within Cherry Creek State Park, the Cherry Creek Watershed, Kiowa Creek, Box Elder Creek, Coal Creek, and Sand Creek as these are the areas within Arapahoe County that are the most effected. We will continue to supply other jurisdictions that request insects as well. Monitoring will continue on sites where releases were made in 2001 and 2002 to document either success or failure. Monitoring of the Cherry Creek release site is of particular interest to see how well control is maintained over the next few years. Finally, we will continue to look at new insects or other bio-control agents that are introduced by the USDA that potentially could be another useful weed control tool.

Below: Leafy spurge in the Cherry Creek Ecological Park. In 2001 approximately 200,000 flea beetles were released throughout this 75-acre park. Some positive results were already seen in 2002 and it is expected that results similar to Cherry Creek State Park will be seen in 2003.

References

- Anderson, G.L., Delfosse, E. S., Spencer, N. R., Prosser, C. W., and Richard, R. D. 2000. Biological Control of Leafy Spurge: An Emerging Success Story. *Proceedings of the X International Symposium on Biological Control of Weeds.* Montana State University, Bozeman, Montana. Pg 15-25.

- Bansund, Dean A., Leitch, Jay A., and Leistritz, F. Larry. 1996. Economic Analysis of Herbicide Control of Leafy Spurge (*Euphorbia esula* L.) in Rangeland. Agricultural Economics Report No. 342. Department of Agricultural Economics, North Dakota State University, Fargo.

- Bansund, Dean A., Leitch, Jay A., and Leistritz, F. Larry. 1997. Predicted Future Economic Impacts of Biological Control of Leafy Spurge in the Upper Midwest. Agriculture Economics Report No. 382. Department of Agricultural Economics, North Dakota State University, Fargo.

- Ferrell, Mark A. 1999. Imazapic activity on leafy spurge. Western Society of Weed Science, 2000 Research Progress Report. p. 6.

- Geltman, Dmitry V. 1998. Taxonomic notes on *Euphorbia esula* (Euphorbiaceae) with special reference to its occurrence in the east part of the Baltic region. Annales Botanici Fennici, Finnish Zoological and Botanical Publishing Board.

- Hansen, R. W. 1995. *Oberea erythrocephala:* Permit application information supplement. USDA-APHIS-PPQ-BATS.

- Leitch, Jay A., Leistritz, F. Larry, and Bangsund, Dean A. 1994. Economic Effect of Leafy Spurge in the Upper Great Plains, and Results. Agricultural Economics Report No. 316. Department of Agricultural Economics, North Dakota State University, Fargo.

- Lym, Rodney G., Messersmith, Calvin G., and Zollinger, Richard. 2000. Leafy Spurge Identification and Control. NDSU Extension Service W-765 (Revised). North Dakota State University, Fargo.

- Mundal, Donald A. and Carlson, Robert B. 1999. *Aphthona* flea beetle establishment determined by soil composition and root growth pattern. North Dakota State University, Entomology Department, Fargo.

- Mundal, Donald A., Olson, Denise L., and Carlson, Robert B. 2000. The effect of *Apthona spp.* flea beetle larval feeding on Leafy Spurge, *Euphorbia esula* L., Root Systems and Stem Density in North Dakota: 1986-96. North Dakota State University, Entomology Department, Fargo.

- Rees, N.E., Quimby, PC. Jr., and Coulson, JR. Finding biological control agents: federal agency research and procedures. Reprinted from: Biological Control of Weeds of the West.

- Rowe, M. L., Nissen, S. J., Masters, R. A., Lee, D. J., and Bowditch, B. M. 1995. Relatedness of North American and European leafy spurge based on DNA markers. 1995

Leafy Spurge Symposium. Fargo, North Dakota. July 25-27, 1995. p. 33.

- Sell, Randall S., Bangsund, Dean A., and Leistritz, F. Larry. 2000. Impediments to Controlling Leafy Spurge in the Northern Great Plains. Agricultural Economics Report No. 185. Department of Agricultural Economics, North Dakota State University, Fargo.