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INVASION DYNAMICS AND BIOLOGICAL CONTROL PROSPECTS FOR SERICEA LESPEDEZA IN KANSAS

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ABSTRACT—Sericea lespedeza [*Lespedeza cuneata* (Dum.-Cours.) G. Don], an exotic, drought-hardy perennial legume was first introduced into the United States from Japan. It was planted from the 1930s through the 1950s as a forage crop, for healing erosion scars on farmlands, establishing cover on mine spoils, and as cover for wildlife. The species range was unintentionally increased in the 1980s when seeds harvested from infested rangelands were planted on Conservation Reserve Program (CRP) acres. Sericea lespedeza has spread to extensive areas of native prairie and other lands not under cultivation in the more humid regions of the Great Plains in Texas, Oklahoma, Nebraska, Kansas, and eastward into Missouri and Iowa in the past decade. Left uncontrolled, the plants may dominate native grasslands. Hectares infested with sericea lespedeza in Kansas increased from 3,200 in 1988 to 187,492 in 2001, and it now occurs in 72 of the 105 counties. Seeds are disbursed primarily by wildlife and humans. Herbicides are available but expensive and often ineffective in long-term control. A potential biological control is the lespedeza webworm (*Tetralopha scortealis* Lederer, Family Pyralidae), a defoliating moth, larva that reduced seed production 98% in infested plants. Lespedeza webworms were successfully transplanted

into a sericea lespedeza population not previously infested. Severe drought in 2001 reduced lespedeza webworm numbers by 87% to 100% in sites sampled in eastern Kansas.

KEY WORDS: *Lespedeza cuneata*, sericea lespedeza, Chinese bush clover, *Tetralopha scortealis*, lespedeza webworm, biological control, invasive plant

Introduction

This study addresses both the migratory patterns of sericea lespedeza [*Lespedeza cuneata* (Dum.-Cours.) G. Don] in Kansas and evaluates the potential of the lespedeza webworm *(Tetralopha scortealis* Lederer) as a biological control of the plant. Sericea lespedeza, or Chinese bush clover, is an introduced perennial legume native to eastern Asia (Fig. 1). Since the late 1980s sericea lespedeza has rapidly expanded its range in Kansas. The plant is also found throughout Missouri, much of Oklahoma, eastern Texas, and is currently expanding into eastern Nebraska and western Iowa (Ohlenbusch et al. 2001). Its migration into the native grasslands of Kansas has been cause for much concern because it threatens to change the vegetation composition and productivity of the prairie ecosystem.

The history of the plant's migration into and through the area is lengthy and follows several pathways. It was first planted in the United States in 1896 by the North Carolina Agriculture Experiment Station (Heath et al. 1985). Little study or use of sericea lespedeza was conducted until 1924, when the US Department of Agriculture (USDA) secured seed from Japan and planted it at the Arlington Experiment Farm in Virginia (Ohlenbusch et al. 2001). At the time its perceived value for erosion control, hay, wildlife cover and food, and seed production was generally accepted. Sericea lespedeza was used on highway rights-of-way, dams, and waterways to stabilize soil (Hoveland et al. 1971). In the 1930s it was planted on strip-mined land in southeast Kansas and Missouri. It was also introduced into Missouri and other southern states, including Oklahoma during the 1930s, when it was planted on roadsides and used for forage. Additional plantings for wildlife habitat in Kansas occurred around state and federal reservoirs from the 1940s through the 1970s (Ohlenbusch et al. 2001). The most recent advances of the plant occurred while establishing native grasses on Conservation Reserve Program (CRP) acres (Scott 2000), a provision of the 1985 Farm Bill. Seed harvested from rangeland and used in CRP plantings often contained sericea lespedeza, which accelerated its spread

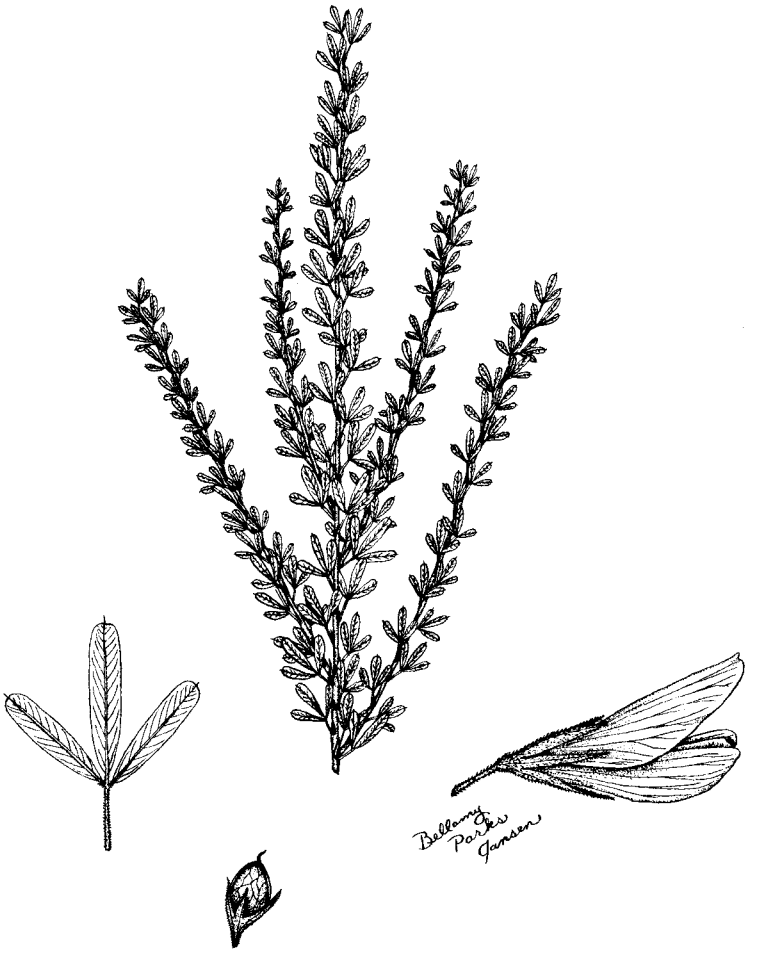

Figure 1. Sericea lespedeza (*Lespedeza cuneata* G. Don). Source: Illustration by Bellamy Parks Jansen. Reprinted from *Common Legumes of the Great Plains: An Illustrated Guide* by James Stubbendieck and Elverne C. Conard by permission of the University of Nebraska Press. Copyright © 1989 by the University of Nebraska Press.

into former crop fields. However, it was not widely recognized as a problem plant at that time nor had it been designated a noxious weed.

Currently, the species appears to be moving from Kansas into southeastern Nebraska (Ohlenbusch et al. 2001). In Kansas, sericea lespedeza has migrated beyond its perceived area of adaptation, that is, it has expanded into areas with less than 750 mm of annual precipitation (Heath et al. 1985)

and is now well established throughout Kansas. Because of this rapid expansion, the State of Kansas designated sericea lespedeza a statewide noxious weed in 2000, the only state that has made such a designation (Scott 2000).

The significance of this migration through the Great Plains could be enormous. The plant's aggressive nature enables it to reduce grass production in native tallgrass prairie by as much as 92% (Eddy and Moore 1998). This, combined with its ability to reduce the number of grass species in an infested area by 66% and native forb species by 70%, drastically changes the ecology of the grassland. Preliminary studies indicated a reduction in the abundance and species richness of insects in dense stands of sericea lespedeza (Eddy and Moore 1998). This, in turn, could reduce the number of native birds that are attracted to the area. If sericea lespedeza continues its invasion into the Great Plains, the diversity of the grassland biota will decline.

The economic implication to cattle producers is substantial, resulting in a reduction of grass forage and subsequent grazing income. Although sericea lespedeza may provide forage, it is high in tannins and is not palatable to cattle. Additionally, tannins bind with protein in the plant, reducing its digestibility (Donnelly and Anthony 1970; Cope and Burns 1971) and cattle do not gain weight as well when they consume sericea lespedeza. An option for cattle producers, and the one most often taken, is to attempt control by chemical methods. Spot treatment with herbicides during the early stages of an infestation can be successful in retarding rate of spread. Field-ground applications have the disadvantage of inadequate coverage on rough or rocky sites. Broadcast aerial applications are expensive and provide limited penetration of the chemical through dense vegetative cover. Herbicides also destroy native legumes and other broad-leaved plants valuable to the health of the grassland ecosystem.

Biological control may offer a cost-effective method for controlling invasive plants. Klamath weed (*Hypericum perforatum* L.), a rangeland pest in the northwestern United States, was nearly eradicated by two species of leaf beetles (*Chrysolina quadrigemina* Suffrian and *C. hyperici* Forster, Family Chrysomelidae) in the 1950s (Pfadt 1985). Blossey et al. (2001) reported that purple loosestrife (*Lythrum salicaria* L.) was severely defoliated by *Galerulcella calmariensis* L. and *G. pusilla* Duft, both Family Chrysomelidae. The moth *Cactoblastus cactorum* Begroth, Family Pyralidae, found in association with South American *Opuntia* spp. successfully controlled *Opuntia stricta* Haworth, a North American exotic that had infested rangeland in Australia (Pemberton 1996). An example of success-

ful biological control in Kansas is the decline in acres infested by musk thistle (*Carduus nutans* L.) following the introduction of the musk thistle seed head weevil (*Rhinocyllus conicus* Froelich, Family Curculionidae) (Scott 2001a).

Heath (et al. 1985) reported damage to sericea lespedeza plants in April and May by the three-cornered alfalfa hopper, (*Spissistilus festinus* Say, Family Membracidae), and by the grasshopper (*Schistocerca americana* Drury, Family Locustidae), that reduced seed production by defoliation in late summer. Buntin and Wiseman (1990) reported that low tannin sericea lespedeza did not alter significantly the growth and development of two generalist insects, (*Heliothis zea* Bodie and *Spodoptera frugiperda* J.E. Smith Family Noctuidae). Buntin (1991) studied defoliators on low tannin sericea lespedeza in Georgia and found that the grasshopper (*Plathypena scabra* F., Family Locustidae), caused extensive exfoliation of the species.

The earliest known report of damage to sericea lespedeza by the lespedeza webworm in Virginia, North Carolina, and Georgia was described by Poos and Hetrick (1945). They also noted feeding damage on Korean lespedeza (*Lespedeza stipulacea* Maxim.) and common lespedeza [*Lespedeza striata* (Thunb.) Hook & Arn.]. Allyson (1977) indicated lespedeza webworms fed on *Tephrosia* spp. in addition to species of *Lespedeza*. Lespedeza webworms were found along with two other lespedeza defoliators, the grasshopper (*Schistocerca americana* Drury, Family Locustidae) and armyworm (*Pseuladaletia unipuncta* Haworth, Family Noctuidae) (Heath et al. 1973).

The first feeding damage on sericea lespedeza by lespedeza webworms in Kansas was observed by James Duncan, noxious weed supervisor for Chautauqua County, in 1998. He noticed a 1.2 ha field with numerous sericea lespedeza stems wrapped in a matrix of silk threads. The encased foliage had been eaten by larval lespedeza webworms.

This study was designed to document the expansion of sericea lespedeza in Kansas from 1986 through 2001 and assesses the effect of the lespedeza webworm on the growth and reproduction of the plant.

Methods

Migration Pattern

The estimated area infested with sericea lespedeza in the 105 Kansas counties has been reported annually from 1988 through 2000 (except 1990 and 1992) by county noxious weed supervisors to the Kansas Department of

Agriculture. Occurrence of the species in Kansas counties until 1986 was obtained from herbarium records in the Kansas State University Herbarium in Manhattan and in the R. L. McGregor Herbarium of the University of Kansas in Lawrence. Progression of the invasion in Kansas was noted in terms of annual increases in reported hectares into counties not previously infested, annual increases in hectares in counties with existing populations, and the rate of expansion. Physical and biological mechanisms of dispersal of the species were observed and recorded.

Effect of Lespedeza Webworms

Seven study sites were selected from 22 lespedeza webworm populations in eastern Kansas in August 1999. Sites were selected from field surveys with the assistance of personnel from the Kansas State Cooperative Extension Service and from USDA's Natural Resources Conservation Service. Site selection was based on representative spatial positions of the webworm populations over the region, vegetation composition of the sericea lespedeza–infested area, density of the webworms, and the size of the area infested with webworms. Study sites were established in Chase, Chautauqua, Cowley, Greenwood, Lyon, Nemaha, and Osage Counties.

A measure of control of sericea lespedeza is the percentage reduction of seed production. Five criteria were used to determine the effect of lespedeza webworms on seed production of infested plants when compared to adjacent plants not infested with lespedeza webworms. The criteria were: number of infested and uninfested stems per square meter, percentage of stem length encased in web, number of flowers per stem, and number of seeds per stem. Twenty 1-m^2 quadrats were placed randomly in sericea lespedeza populations infested with lespedeza webworms at each of the seven sites. Similar quadrats were located in sericea lespedeza populations without lespedeza webworm infestations within 5 m of the randomly located quadrats. Sampling occurred in August and September of 1999, 2000, and 2001.

Spatial and density changes of webworms were monitored at the seven sites from August 1999 to August 2001. Number of lespedeza webworm–infested stems per square meter was based on 20 randomly placed quadrats in each of the sites. Dispersal distances and directions from the 1999 lespedeza webworm baseline population perimeters were measured during August in 2000 and 2001.

To test if expansion of lespedeza webworm population could be accelerated, we introduced them into four areas in Kansas with stands of sericea

lespedeza. Transfer of lespedeza webworms into populations of sericea lespedeza not infested with webworms was initiated in August 1998. Twenty sericea lespedeza stems infested with lespedeza webworms were transplanted into sericea lespedeza populations in each of four counties (Chautauqua, Greenwood, Lyon, and Osage). Individual infested stems were tied to sericea lespedeza plants on sites free of lespedeza webworms and were monitored through August and September 1998. The survival and dispersal of the transplanted lespedeza webworms was noted in July 1999, and the progress of an established population was followed through 2000 and 2001.

Observations of incidences of dispersal of sericea lespedeza seeds on the seven study sites were made from September to November in 1999 and 2000. Feeding, web-spinning behavior, cocoon construction by the larvae, and the response of the lespedeza webworm to weather events were recorded during the study.

Results

Migration Pattern

Reported hectares infested with sericea lespedeza in Kansas since 1988 have steadily increased (Fig. 2). The estimate of 3,200 infested hectares in 1988 increased to 187,492 hectares by 2000. Herbarium records showed that the species was collected from 28 counties in eastern Kansas prior to 1986. Sericea lespedeza was reported in 36 counties in 1995, 49 counties in 1997, 54 counties in 1998, 62 counties in 1999, 69 counties in 2000, and 74 in 2001 (Scott 2001b). The nearly three-fold increase in the number of counties infested with sericea lespedeza during the period from 1986 through 2001 occurred at the rate of approximately 14,000 ha per year. During the late 1980s and the early 1990s, reporting of sericea lespedeza hectares was often delayed because the plant was not recognized immediately by agency resource managers, nor later by most landowners. A substantial portion of the apparent increase in sericea lespedeza in Kansas during this period was because of new discoveries as well as invasions.

Recent expansion of the range of sericea lespedeza in Kansas is to the northwest. Prior to 1999 there were no reports of the species in the western agricultural district of Kansas (Fig. 3). A further indication of westward expansion was the three-fold increase in the number of counties first reporting hectares infested with sericea lespedeza in the north-central and south-central agricultural districts from 1997 to 2001.

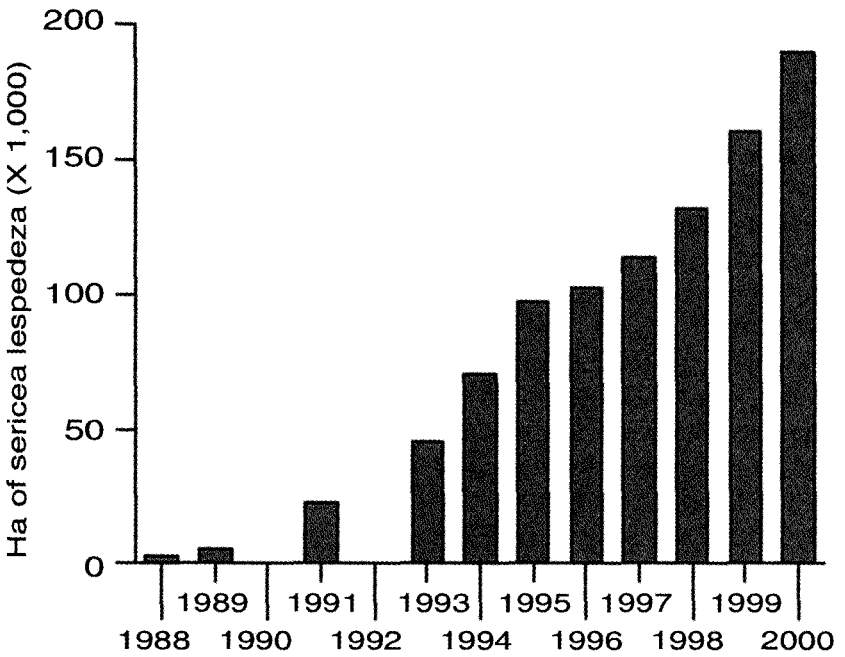

Figure 2. Sericea lespedeza–infested hectares reported in Kansas from 1988 through 2000.

Observations of incidences of dispersal of sericea lespedeza seeds by animals recorded during the study were: 11 in bird droppings, 42 in cattle droppings, 27 in white-tailed deer (*Odocoileus virginiana* Zimmerman) pellet groups, and 81 in seed-bearing stems carried by cotton rats (*Sigmidon hispidus* Say and Ord). Other observed instances of dispersal were 20 in mud on agricultural equipment, 9 on running boards or grilles of pickups, and 2 in runoff following rainfall. Vermeire et al. (2001) noted that sericea lespedeza seed was dispersed into native and domestic grasslands, shrublands, and woodlands. Additional sericea lespedeza populations were established by intentional and accidental plantings by landowners and state and federal agencies from 1930 to the late 1980s (Ohlenbusch et al. 2001).

Effect of Lespedeza Webworm

The effectiveness of the lespedeza webworm in reducing seed production of sericea lespedeza was evaluated (Table 1). Mean number of infested stems ranged from 1 stem per quadrat (Chautauqua County) to 30 stems per quadrat (Greenwood County). An average of 66% of the foliage of infested

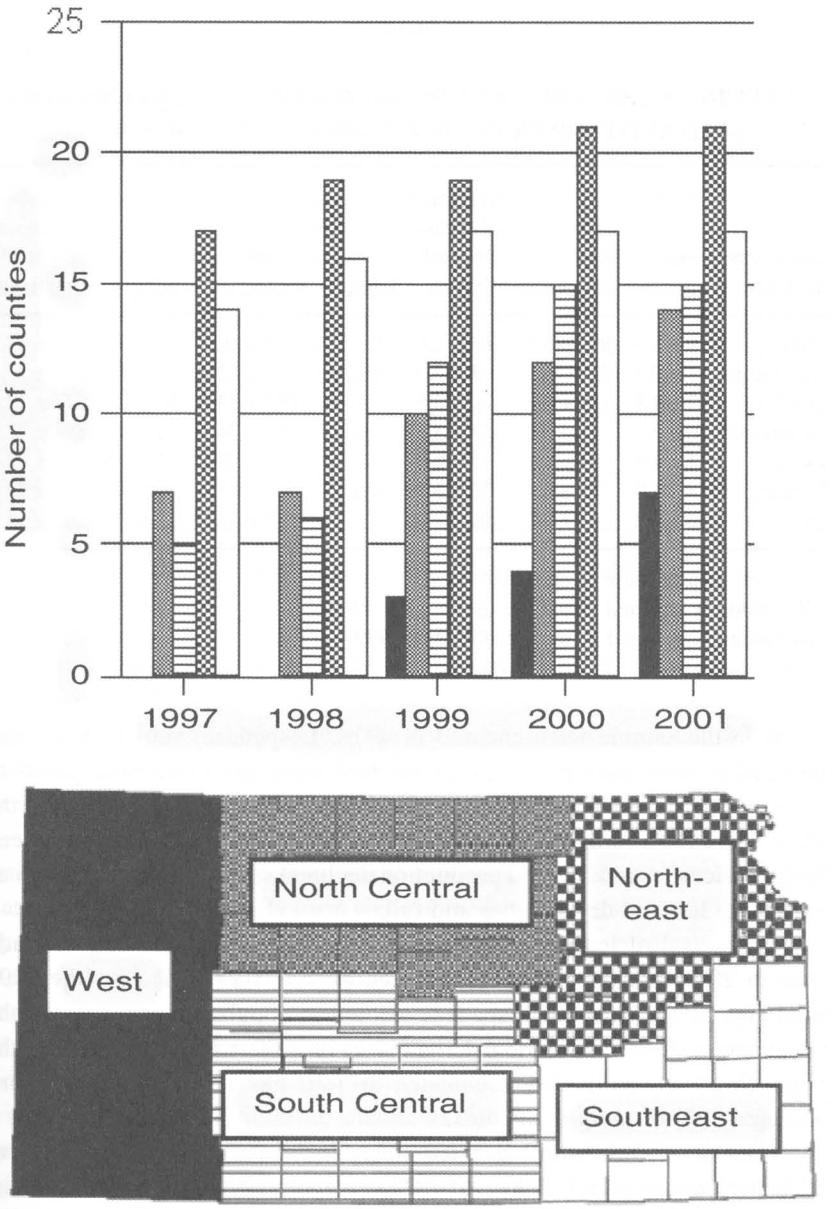

Figure 3. Number of counties in each Kansas agriculture district reporting reporting sericea lespedeza from 1997 through 2001.

TABLE 1

EFFECTS OF THE LESPEDEZA WEBWORM ON SERICEA LESPEDEZA SEED AND FLOWER PRODUCTION (0 ± SE PER QUADRAT)

Study sites by county	No. of stems/m^2 [a]		Percentage of stems[a] Encased in web	No. of flowers/stem[b]		No. of seeds/stem[c]	
	Infested	Uninfested		Infested	Uninfested	Infested	Uninfested
Chase	9 ± 1.0	97 ± 10.9	65 ± 2.6	11 ± 1.0	621 ± 19.2	8 ± 1.2	580 ± 47.5
Chautauqua	1 ± 0.1	102 ± 11.9	55 ± 3.0	18 ± 4.0	361 ± 13.2	4 ± 0.7	392 ± 27.4
Cowley	17 ± 1.8	118 ± 6.9	70 ± 3.5	14 ± 1.8	1003 ± 33.2	10 ± 1.0	977 ± 22.0
Greenwood	30 ± 3.3	64 ± 5.0	75 ± 3.6	10 ± 1.4	978 ± 24.9	2 ± 0.4	894 ± 22.5
Lyon	11 ± 1.5	98 ± 9.1	65 ± 3.0	11 ± 1.3	615 ± 18.5	5 ± 0.8	606 ± 22.0
Nemaha	8 ± 1.0	85 ± 4.3	70 ± 3.7	9 ± 1.3	554 ± 15.4	5 ± 0.9	507 ± 12.7
Osage	6 ± 0.8	63 ± 3.7	60 ± 2.9	6 ± 1.9	537 ± 15.0	5 ± 1.4	565 ± 14.8

[a] 20 1-m^2 quadrats/site (August 1999).
[b] 20 randomly selected stems/site (September 1999).
[c] 20 randomly selected stems/site (October 1999).

stems in the sample were encased in webs. Lespedeza webworm damage reduced average seed production from 644 seeds per uninfested plants to 5.7 seeds per infested plants on the seven study sites. Seed reduction on the plant can have a long-term impact on the number of seeds in the soil seed bank. Sericea lespedeza seed production declined severely in 2000 due to an extremely hot and dry summer and fall.

Dispersal of lespedeza webworms from the perimeters of five study sites in 2000 increased the infested area by 1.78 ha (33%) over the 1999 total area of 5.67 ha. The lespedeza webworm population perimeter at the Chautauqua site decreased to 0.45 ha (53%) in 2000, whereas the area of the Greenwood site remained unchanged at 1.30 ha. The 2001 populations declined 90% or more at all sites.

Density of webworm-infested stems increased in 2000 from 7% to 55% per square meter (mean of 26%) over the 1999 infestation levels. Density of infested stems per square meter declined from 87% in 2000 to 100% in 2001. The Lyon and Nemaha County sites lost their lespedeza webworm populations entirely (Table 2).

The 1998 transplants succeeded only at the Osage County site, where 32 infested stems occurred in 1999. Webworms dispersed northward 19 m from the introduction site. The number of infested second-year (2000)

TABLE 2

DENSITY CHANGES IN LESPEDEZA WEBWORM POPULATIONS, 1999 TO 2001

Study sites by county	Mean no. of stems/m^2 [a]			Density change (%)	
	1999	2000	2001	1999-2000	2000-2001
Chase	9 ± 1.0	10 ± 1.1	1 ± 0.3	+ 7	- 90
Chautauqua	1 ± 0.1	1 ± 0.3	0.1 ± 0.1	+ 13	- 89
Cowley	17 ± 1.8	21 ± 3.1	2 ± 0.5	+ 9	- 87
Greenwood	30 ± 3.2	45 ± 5.2	4 ± 1.0	+ 49	- 92
Lyon	11 ± 1.5	14 ± 1.7	0 ± 0	+ 25	- 100
Nemaha	8 ± 1.0	12 ± 1.4	0 ± 0	+ 55	- 100
Osage	6 ± 0.8	7 ± 1.1	1 ± 0.3	+ 24	- 88

[a] Samples were 20 1-m^2 quadrats/site (August), ($\bar{x}$ ± se per quadrat).

stems increased to 223, expanding the infestation an additional 54 m. Webworm-infested stems moved from the introduction site in all directions: 71% of the infested stems were to the northeast, 15% to the south, 8% to the east, and 6% to the west. Only eighteen infested stems were found scattered over the site on August 30, 2001.

Lespedeza webworms were observed forming webs and feeding on sericea lespedeza foliage from early July until late September each year. Larvae that did not actively form webs or feed constructed a "tent" or shelter by pulling one or more layers of leaves around themselves and securing them with silk threads. By September 30 larvae left the stems and formed earthen cocoons in the soil beneath the plant. The larvae assembled granules of soil into elliptical chambers and fixed them together with labial secretions resembling liquid silk. The soil-covered puparia (1.0 cm long, 0.75 cm wide) provided overwintering chambers for the pupae. Moths began to emerge in early summer, and they flew to host plants in the vicinity where eggs were laid on the foliage. Flight distance and direction appeared to be affected both by direction and velocity of the wind.

The decline of lespedeza webworm–infested stems in 2001, by 92% from 2000, may be attributed to low larvae and pupae survival during the extreme heat and dryness of August and September, followed by a long, unusually cold winter. From August 9 to September 4 temperatures reached or exceeded 38°C on 21 days and rainfall totaled 4 mm at the Greenwood

County site (normal average rainfall for that period exceeds 76 mm). The average winter temperatures were lower than those in the past 10 years (WMO/NOAA 2001). These extreme weather conditions arrested larval and pupal development, as noted by small last-instar larvae and shriveled pupal cases found under sericea lespedeza plants at the study areas. Weakened immature webworms were probably unable to survive the combination of extreme temperatures and dryness. Field surveys of the distribution of lespedeza webworms in Kansas and the absence of records of the occurrence of the species northward into Nebraska and Iowa indicate that Kansas is on the northern edge of the range of the species.

Poos and Hetrick (1945) state that the lespedeza webworm occurs only from Maryland to Florida. Kimball (1965) indicates the species is distributed from North Carolina to Florida. Since we have found no mention in the literature of the occurrence of the lespedeza webworm in the Great Plains, the species may have moved with sericea lespedeza as its range expanded westward. Possibly the lespedeza webworm existed on the native flora until the entry of the sericea lespedeza from introductions into the region. We found lespedeza webworms feeding on slender lespedeza [*Lespedeza virginica* (L.) Britt.], a native species primarily found in Kansas and Missouri, in four of the seven study areas and we also found feeding damage on leadplant (*Amorpha canescense* Pursh), a common legume on the study areas.

Conclusions

The migration of sericea lespedeza into the grasslands of the Great Plains threatens the biological and cultural vitality of the region. An introduced population of the plant existed here for nearly 50 years before it was recognized as an invasive species. Rapid expansion of its range and density during the last decade has led to it being listed as a Kansas noxious weed in 2000. It has expanded into areas with less than 750 mm of annual precipitation, previously regarded as outside its range of adaptation. The competitive ability of the plant threatens the integrity of the tallgrass prairie ecosystem and the economic viability of the ranching industry. Traditional approaches to invasive species control such as herbicides and cultural practices are limited in their effectiveness. This suggests that an effective biological control may be needed.

Lespedeza webworms eliminated sericea lespedeza seed production on infested stems. The level of control depended on the percentage of infested stems in the sericea lespedeza population. Lespedeza webworm

population numbers fluctuated annually, with some doubling in area and/or density, and others declining in area and density or all dying. Extremes in temperature and dry soils may be responsible for major population changes and reduced control benefits of the species. Moderate summer and fall temperatures and an increase in soil moisture would allow the lespedeza webworm to reestablish its earlier population levels. The webworm may be cyclic in its population fluctuations.

The lespedeza webworm is an efficient herbivore that can severely reduce the photosynthetic ability of the plant and consequently decrease the production of seed. The successful establishment of the Osage County population from lespedeza webworm larvae provided a biological strategy for increasing the frequency of the species over the range, thereby decreasing plant vigor and seed production, and slowing the dispersal of affected plants. The lespedeza webworm may prove to be an effective agent for biological control.

Acknowledgments

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References

Allyson, S. 1977. A study of some North American larvae of the genus Tetralopha Zeller (Lepidoptera: Pyralidae: Epipaschiinae). *Canadian Entomologist* 109:329-36.

Blossey, B., R. Cassagrande, L. Tewksbury, et al. 2001. Nontarget feeding of leaf-beetles introduced to control purple loosestrife (*Lythrum salicaria* L.). *Natural Areas Journal* 21:368-72.

Buntin, G.D. 1991. Effect of insect damage on the growth, yield, and quality of sericea lespedeza forage. *Journal of Economic Entomology* 4:277-83.

Buntin, G.D., and B.R. Wiseman. 1990. Growth and development of two polyphagous lepidopterans fed high and tannin sericea lespedeza. *Entomology Experimental Applications*, 55:69-78. New York and London: Kluwer Academic Publishers.

Cope, W.A., and J.C. Burns. 1971. Relationship between tannin levels and nutritive values of sericea lespedeza. *Crop Science* 11:231-33.

Donnelly, E.D., and W.B. Anthony. 1970. Effect of genotype and tannin on dry matter digestibility of sericea lespedeza. *Crop Science* 10:200-202.

Eddy, T.A., and C.M. Moore. 1998. Effects of sericea lespedeza [*Lespedeza cuneata* Dumont (G. Don)] invasion on oak savannas in Kansas. *Transactions Wisconsin Academy Science*, Arts and Letters, 86:57-62.

Heath, M.E., R.F. Barnes, and D.S. Metcalf. 1973. *Forages: The Science of Grassland Agriculture*. 3d ed. Ames: Iowa State University Press.

Heath, M.E., R.F. Barnes, and D.S. Metcalf. 1985. *Forages: The Science of Grassland Agriculture*, 131, 643. 4th ed. Ames: Iowa State University Press.

Hoveland, C.S., G.A. Buchanan, and E.D. Donnelly. 1971. Establishment of sericea lespedeza. *Weed Science* 19:21-24

Kimball, C.P. 1965. *The Lepidoptera of Florida*, 363. Gainesville, FL: Division of Plant Industry, State of Florida Department of Agriculture.

Ohlenbusch, P.D., T. Bidwell, W.H. Fick, W. Scott, S. Clubine, M. Coffin, G. Kilgore, J. Davidson, and J. Mayo. 2001. Sericea lespedeza: history, characteristics, and identification. Kansas State University Agricultural Experiment Station and Cooperative Extension Service. MF-2408.

Pemberton, R.W. 1996. The potential of biological control for the suppression of invasive weeds of southern environments. *Castanea*. 6:313-19.

Pfadt, R.E. 1985. *Fundamentals of Applied Entomology*, 168. New York: Macmillan.

Poos, F.W., and L.A. Hetrick. 1945. A new insect pest of lespedeza. *Journal Economic Entomology* 38:312-15.

Scott, W.T. 2000. Kansas noxious weed law and sericea lespedeza. Symposium, Sericea Lespedeza and the future of invasive species. Kansas State University Research and Extension. Manhattan, KS.

Scott, W.T. 2001a. Musk thistle reported acres. Unpublished data. Kansas Department of Agriculture, Topeka, KS.

Scott, W.T. 2001b. Sericea lespedeza reported acreage. Unpublished data. Kansas Department of Agriculture, Topeka, KS.

Stubbendieck, J., and E. C. Conard. 1989. *Common Legumes of the Great Plains: An Illustrated Guide*. Lincoln: University of Nebraska Press.

Vermeire, L.T., T.G. Bidwell, and J. Stritzke. 2001. Ecology and management of sericea lespedeza. Publication No. F-2874. Oklahoma Cooperative Extension Service, Stillwater, OK.

World Meteorological Organization/National Oceanographic and Atmospheric Administration (WMO/NOAA). 2001. Global Historical Climatology Network. Retrieved 11 March 2002, <http://www.earthinfo.com>.