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# Lone star tick abundance, fire, and bison grazing in tallgrass prairie

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## Abstract

**Lone star ticks (*Amblyomma americanum* L.) were collected by drag samples of 1 km transects on 12 watersheds at Konza Prairie Research Natural Area near Manhattan, Kans., during summer 1995–1996. Watersheds were treated to 2 experimental treatments: 3 burn intervals (1-year, 4-year, and 20-year) and 2 grazing treatments (grazed by bison (*Bos bison* L.) or ungrazed). The objectives were to determine whether fire interval, time since most recent burn, and the presence of large ungulate grazers would cause changes in lone star tick abundance in tallgrass prairie in central Kansas. Watersheds burned at 1-year intervals had fewer larvae and adults than watersheds burned at 4-year or 20-year intervals. Watersheds burned during the year of sampling had fewer ticks than watersheds burned one or more years in the past. For watersheds burned 1 or more years in the past there was no effect from time since burn. The presence of bison did not affect tick abundance. Spring burning is an effective method to reduce tick populations in tallgrass prairie during the year of the burn.**

**Key Words: *Amblyomma americanum*, Ixodidae, habitat, integrated pest management.**

## Resumen

**En los veranos de 1995-1996 se colectaron garrapatas "Lonestar" ( Amblyomma americanum L.) mediante muestreos de arrastre en transectos de 1 km de largo en 12 cuencas hidrológicas en el Area Natural de Investigación de la Pradera Konza, cerca de Manhattan, Kans.  Las cuencas fueron tratadas con 2 tratamientos experimentales: 3 intervalos de quema (1 año, 4 años y 20 años) y 2 tratamientos de pastoreo [apacentado por búfalo (Bos bison L.) y sin apacentamiento].  Los objetivos fueron determinar si el intervalo entre quemas, tiempo desde la quema más reciente y la presencia grandes ungulados causaría cambios en la abundancia de garrapatas "Lonestar" en las praderas de zacates altos de la región central de Kansas. Las cuencas quemadas a intervalos de 1 año tuvieron menos larvas y adultos que las cuencas quemadas a intervalos de 4 y 20 años.  Las cuencas quemadas durante el año de muestreo tenian menos garrapatas que aquellas quemadas uno o mas años antes. No hubo diferencia entre cuencas quemadas un año o más antes del muestreo. La presencia de búfalo no afecto la abundancia de garrapatas. Durante el año de la quema, la quema de primavera es un método efectivo para reducir las poblaciones de garrapatas en las praderas de zacates altos.**

Ticks are obligate blood feeding parasites of vertebrates that can reach sufficiently high densities to impair growth and productivity of large wild and domestic ungulates. They are also vectors of bacterial, rickettsial and viral human, livestock, and wildlife diseases. Drummond (1987) estimated annual tick associated losses to the United States cattle industry from lone star ticks (*Amblyomma americanum* L.) at $82 million. Efforts to control these losses involve diet supplementation with minerals, choice of resistant cattle breeds, application of acaricides (Steelman 1976) and fire. Although burning is currently practiced in the central Great Plains primarily to improve forage quality for cattle, ectoparasite control is a potential secondary benefit and should be considered part of integrated pest management programs (Davidson et al. 1994).

The effects of fire on hard tick populations has been examined in woodland habitats for lone star ticks (Hoch et al. 1972, Davidson et al. 1994), deer ticks (*Ixodes dammini* Spielman, Clifford, Piesman, and Corwin: Mather et al. 1993), and winter ticks (*Dermacentor albipictus* Packard: Drew et al. 1985). Effects of fire have also been examined in mesquite (*Prosopis glandulosa* Torr.) grassland for gulf coast ticks (*Amblyomma maculatum* Koch: Scifres et al. 1988), and in a variety of habitats in Oklahoma for lone star ticks (Hair and Bowman 1986).

Hosts are also an essential habitat component for all stages of hard ticks. Large ungulates such as cattle (*Bos taurus*), bison (*Bos bison* L.), and white-tailed deer (*Odocoileus virginianus* Zimmerman) may serve as suitable hosts. Removal of deer where they are the primary host for adult hard ticks may reduce tick numbers after 2

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years (Bloemer et al. 1986, Presley and Hair 1988, Wilson et al. 1988).

This study reports the numbers of adult, nymphal, and larval lone star ticks collected by drag-cloth along 1-km transects as a function of grazing regime (bison grazing, no grazing), frequency of spring fire (1-year, 4-year, 20-year), and time since most recent fire at the Konza Prairie Research Natural Area. The initial hypotheses were that areas with large ungulate grazers would harbor more ticks than ungrazed areas, that more frequently burned sites would produce fewer ticks than less frequently burned sites, and that time since most recent fire would predict tick densities.

## Study Area

The Konza Prairie Research Natural Area (Konza), in the Flint Hills of Kansas, is a 3,487 ha ranch owned by the Nature Conservancy and managed by the Division of Biology at Kansas State University. The Flint hills constitute the largest remaining area of tall-grass prairie left in the world. The vegetation is dominated by warm-season perennial grasses including big-bluestem (*Andropogon gerardii* Vitman), little bluestem (*Schizachyrium scoparium* Michx.), and Indian grass (*Sorgastrum nutans* L.) on the uplands, and forests of bur oak (*Quercus macrocarpa* Michx.), Chinkapin oak (*Q muehlenbergii* Engelm.), hackberry (*Celtis occidentalis* L.), and eastern red cedar (*Juniperus virginiana* L.). The prairie is gently rolling with thin soils overlying cherty limestone. Tallgrass prairie remains in the Flint Hills because the soils are too thin for row-crop agriculture. Today the primary land use in the Flint Hills is livestock production, primarily beef cattle. In 1987 a herd of bison was established on part of Konza. The primary research goal at Konza is to identify the effects of disturbance (fire and large ungulate grazing) on the biological communities and ecosystem function in tallgrass prairie. Approximately 1,100 ha have been fenced to contain the herd of about 240 bison year round. Except for short periods when the bison are excluded from watersheds to allow rodent trapping, and when they are rounded up for veterinary examinations in the fall, the bison are free to move around the enclosure. The remaining area has not been grazed since before Konza was established in 1981. Deer populations appear to be high throughout Konza, but their numbers have not been determined.

The second experimental treatment at Konza is burning. Konza has been divided into a series of watersheds, each subjected to a prescribed burn interval. The intervals considered in this study were 1-year, 4-year, and 20-year burn. Because Konza was established 17 years ago, there have been no planned burns on the 20-year watersheds; the term refers to intended interval. In addition to the prescribed fire program, there have also been wildfires. Two of the 20-year watersheds had wildfires, 1 in 1992, the other in 1996 (Table 1). All watersheds used in this study were burned during March or April.

## Methods

Study sites, consisting of 1 km long transects were established in 14 watersheds at Konza (Table 1). Two replicate watersheds were selected for 1-year, 4-year, and 20-year burn intervals in grazed watersheds, and the same in ungrazed watersheds except 20-year ungrazed. There was not a replicate watershed for the 20-year interval without grazing. Two additional watersheds were sampled, a 2-year ungrazed watershed during 1995, the year it was burned (included as a 1-year site), and a 4-year grazed site in 1996. At each study site, during summer 1994, 1-km transects were marked with 1.2-cm diameter by 1.3-m steel conduit driven into the ground at 100-m intervals. In each watershed, transects were laid out so that approximately equal lengths were on uplands, slopes, and lowland areas. Each transect was sampled monthly during June, July, and August 1995 and 1996. A random number table was used to establish the order that transects were sampled each month.

Transects were sampled during afternoons throughout the month. Sampling was not done during rain, when the grass was wet, or when wind speed was too great to keep the drag cloth in the grass (greater than about 20 kph). Sampling consisted of dragging a 1-m wide by 1.2-m long flannel cloth hemmed at each end and attached to wooden dowels to keep the cloth spread as it was dragged over the grass (Bram 1978). The forward dowel had a rope attached to allow dragging. The cloth was examined for ticks after every 25 to 30 m. It gener-

**Table 1. Grazing and burning treatments of watersheds at Konza Prairie Research Natural Area, Kansas. A map showing the locations of watersheds at Konza can be found on the World Wide Web at Http://climate.konza.ksu.edu/images/wshd.gif.**

| Watershed | Grazing treatment | Burn interval | Date of last burn | Size |
|---|---|---|---|---|
| | | | | (ha) |
| K1A | None | 1 year | 1996 | 100 |
| K1B | None | 1 year | 1996 | 100 |
| 2C | None | 2 year | 1995 | 23 |
| K4A | None | 4 years | 1993 | 55 |
| K4B | None | 4 years | 1996 | 76 |
| K20A1 | None | 20 years | 1980 | 90 |
| N1A | Bison | 1 year | 1996 | 100 |
| N1B | Bison | 1 year | 1996 | 123 |
| N4A | Bison | 4 years | 1994 | 106 |
| N4B | Bison | 4 years | 1991 | 56 |
| N4C | Bison | 4 years | 1994 | 82 |
| N20A | Bison | 20 years | 1992 | 77 |
| N20B | Bison | 20 years | 1996 | 82 |

ally took about 2 hours to run a transect. All ticks found were collected in vials that were marked with collector name, date, watershed, and transect interval. Counts, species, and stage identifications were made later in the laboratory under a microscope. Adult ticks were identified by reference to APHIS (1976). Larvae and nymphs followed Clifford et al. (1961).

Carbon dioxide traps (Bram 1978) were tested on 28–29 June 1996, to see if they would be more efficient than drags to collect ticks. Nine traps were placed at 20 m intervals in a 3 × 3 grid in watershed N20A, which had the highest collection rate. The traps were set on 1 $m^2$ plots where the grass was clipped and removed, between 1500 and 1700 hours. They were checked at 2200, 0600, 1200 and 1700 hours.

Adults, nymphs, and larvae of lone star ticks collected on drags were tabulated by month to identify seasonal activity patterns. Adults, nymphs, and larvae were summed for the 3 months each year to quantify tick numbers for each watershed. Each treatment was replicated 4 times, 2 watersheds (or transects) each for 2 years. Because the data were not normally distributed and did not have equivalent variances, treatments were compared using non-parametric statistics using the Procedure NPAR1WAY in SAS version 6.11 (SAS Inst. 1993). The 2 sample tests (Grazed vs. Ungrazed) of grazing treatment were analyzed using the Wilcoxon rank sum test (Model: Grazing treatment = tick number for each stage), and 3 sample tests (1-year, 4-year, 20-year) on burn interval were analyzed using Kruskal Wallace analysis of variance (Model: burn interval = tick number for each stage). To test whether there was an effect of time since most recent burn on larval tick numbers the transformed (see below) number of ticks in watersheds was regressed on the log of time since the most recent fire. The number of ticks was transformed using a $\log_{10}$ transformation of the number of larvae + 1 (because 0 values cannot be log transformed). Because a large number of observations contained 0 ticks during the year of the burn, the number of ticks at watersheds the year of the burn was tested with the number of ticks at watersheds 1 or more years after burning with the Wilcoxon rank sum test, as above. The transformed number of ticks in watersheds burned 1 or more years in the past was then regressed against the log of number of years since burning.

## Results

Tick numbers were generally low along transects. Even on transects with large numbers of larvae the ticks were highly aggregated within few intervals so that most intervals collected no ticks. The $CO_2$ traps caught one adult lone star tick. Because the effort for this technique was great and the results poor, this method was abandoned.

Adults, larvae, and nymphs of lone star ticks were most abundant. The only other species collected, *Dermacentor variabilis* Say, the American dog tick, was rare, and is not considered in this report. Because both species are common in the Flint Hills, vouchers have not been sent to archive collections. Specimens are preserved in alcohol at Kansas State University.

The temporal patterns of adults, larvae, and nymphs over all watersheds are presented in Figure 1. Adults were most common early in the season, and probably reached peak numbers in spring before sampling began. Nymphs were also most abundant early in the summer, and like adults, they remained present throughout the sampling period. Larvae did not appear until July, and reached their peak in early August 1995 and late July 1996. Larvae remained abundant into August, but few were collected by September.

There were no significant differences in the numbers of ticks on transects in grazed versus ungrazed watersheds (Table 2). In the Kruskal Wallis analysis of variance, numbers of larvae varied among burn treatments, as did adults, but not nymphs. The mean numbers of larvae and nymphs both were more than an order of magnitude greater at watersheds with 4 and 20

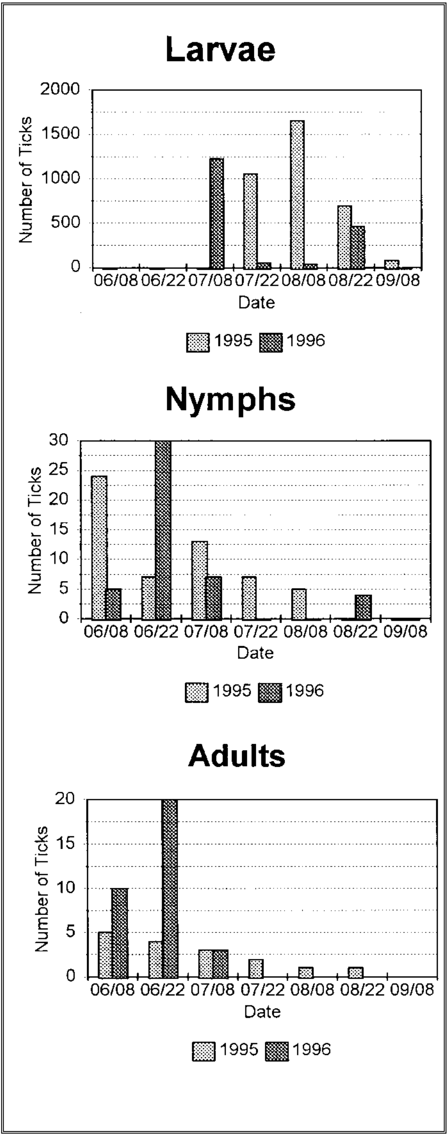


**Fig. 1. Monthly abundances of lone star tick adults, nymphs, and larvae at Konza Prairie Research Natural Area, Kans. during 1995 and 1996. Dates are 2-week midpoints from which data were summed.**

year burn intervals than at sites burned annually (Table 2). High variance in nymph numbers may have reduced the power of this test, which was nearly significant.

All stages of lone star ticks had significant regressions (larvae F = 12.8, df 1,22, P = 0.002, $R^2$ = 0.37; nymphs F = 9.0, df 1, 22, P = 0.007, $R^2$ = 0.29; adults F = 7.2, df 1, $2^2$, P = 0.014, $R^2$ = 0.25) of numbers collected at watersheds against time since burn (Fig. 2). The differences were attributed to the large number of low values (0s) in watersheds that were burned the same

Table 2. Numbers of larvae, nymphs, and adults collected during each year along 1 km transects at watersheds burned at 1 yr, 4 yr, and 20 yr intervals and at grazed and ungrazed watersheds at the Konza Prairie Research Natural Area, Kansas during 1995 and 1996.

| Treatment | n | Mean larvae | S.D. | Mean nymphs | S.D. | Mean Adults | S.D. |
|---|---|---|---|---|---|---|---|
| Fire Interval | | | | | | | |
| 1 year | 9 | 14.4 | 37.4 | 0.1 | 0.3 | 0.4 | 0.5 |
| 4 year | 9 | 298.7 | 448.0 | 5.4 | 6.3 | 2.4 | 2.3 |
| 20 year | 6 | 321.0 | 459.7 | 5.7 | 7.8 | 2.4 | 2.5 |
| $X^2$ / P | | 6.73 / 0.03 | | 4.99 / 0.08 | | 6.71 / 0.04 | |
| Grazing | | | | | | | |
| Grazed | 13 | 170.8 | 283.8 | 5.9 | 6.4 | 2.2 | 2.2 |
| Not grazed | 11 | 243.5 | 466.2 | 1.5 | 2.8 | 1.2 | 2.0 |
| Z / P | | 0.08 / 0.78 | | 2.23 / 0.14 | | 2.52 / 0.11 | |

year the samples were taken. The Wilcoxon rank sum test of numbers of ticks collected during the year of burning versus samples taken 1 or more years after burning was significant for larvae (Z = -3.2, P = 0.001), nymphs (Z = -2.81, P = 0.005), and adults (Z = -2.99, P = 0.003). When samples from watersheds burned during the sampling year were removed, the regressions were no longer significant for larvae (F = 0.001, df 1,11, P = 0.98), or nymphs (F = 1.06, df 1,11, P = 0.32), but adults (F = 6.16, df 1, 14, P = 0.03) were significant.

## Discussion

Ecological factors that are essential to the maintenance of grassland habitats such as fire, grazing, and periodic drought (Reichman 1987) affect important habitat features of ticks. Water stress is a major element governing tick survival and behavior (Hair et al. 1975, Kock 1984). Ticks in search of a host ascend vegetation when temperature and humidity conditions are appropriate, and in the presence of elevated $CO_2$, produced by a nearby vertebrate host, wave their front legs to catch the passing host (Hair and Bowman 1986). Vertebrate herbivores serve as hosts for tick populations. Fire and drought affect vegetation in ways that alter the microclimates that ticks need to maintain water and thermal balance (Sonenshine 1993). In addition, during certain seasons fire is expected to cause direct tick mortality (Schmidtmann 1994).

The overall number of ticks at Konza was low. With drag transect length of 1 km, which sampled 1,000 $m^2$, the mean number of lone star ticks on transects was 1.73 adults, 3.7 nymphs, and 207.2 larvae. In Cherokee Co., Okla., grasslands yielded 9 adults and 41 nymphs per comparable sampling area (Hair and Bowman 1986). In that same study they reported 87 to 182 adults and 406 to 3,119 nymphs 1,000 $m^{-2}$ in woodland habitats. They did not report larval numbers. The lone star tick is primarily a woodland species that reaches its greatest density in second-growth woodland habitats that are also favored by white-tailed deer (Semtner and Hair 1973, Sonenshine 1993). Similar habitat associations can be expected at Konza.

The fire treatments were associated with a significant reduction in tick numbers at Konza. Larvae and nymphs were more than 20 times as abundant on watersheds with 4- or 20-year burn intervals than on watersheds burned annually. Adult densities followed a similar pattern with approximately 5 times as great a density on 4- and 20-year burned watersheds. Although the effects of fire on ticks were profound during the year of a burn, after one or more years, the effect disappeared regardless of the burn interval.

Other studies have also documented the effects of fire on tick populations, but usually in woodland habitats or in small plots (Davidson et al. 1994). In Texas, summer populations of the Gulf-Coast tick in mesquite-bunchgrass habitat were reduced by fires that occurred in the previous fall or winter (Scifres et al. 1988). They reported that more than 75% of ticks were killed when the temperature in the fire-front was >330° C, and ≥ 60% of fine fuels were consumed. They believe survivors resulted from uneven burning which left refugia in patches of unburned mulch. They also conducted laboratory studies to derive temperature thresholds for mortality. Mortality was 100% if the temperature was >150° C for 15 sec, and mortality exceeded 90% when the temperature was 90–125° C for 30 sec.

Fire temperatures were measured at Konza at watersheds burned annually and at 4 year intervals (Gibson et al. 1990). Recorded temperatures at the ground varied from 19 to 399°C. Temperatures varied within treatments between headfire and backfire. Watersheds with long interburn periods burned hotter than those burned annually. Mean maximum temperatures at ground level during burns at Konza grassland sites varied from 107° to 213°C at upland sites, and from 177° to 199°C at lowland sites, which tended to have more fuel. They did not record how long temperatures remained at close to the maximum, but it generally takes > 30 sec for fuel on the tallgrass prairie sites at Konza to burn (J. Cully, personal observation, and D. Hartnett, Pers Comm). The absence of ticks from drags during the year of burning is evidence that fire temperature and duration is sufficient to kill nearly all of the ticks.

The presence of bison did not affect lone star tick numbers at Konza. Lone star ticks have a wide range of vertebrate host species and are found in abundance on white-tailed deer and cattle. Although it is reasonable to

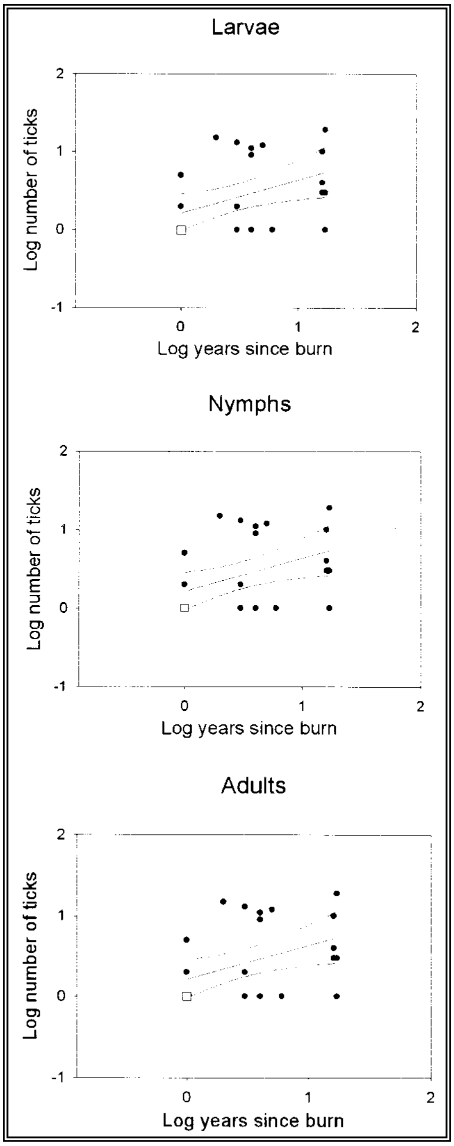


**Fig.2. Scatter plots and regression lines for numbers of larvae, nymphs, and adults, as a function of time since most recent burn at Konza Prairie Research Natural Area, Kans. The open squares represent points with 0 ticks collected during year 0 (the year of the burn), which include 9 observations (larvae), 8 observations (nymphs), and 6 observations (adults). Without those points, none of the regressions were significant.**

expect lone star ticks to also be abundant parasites of bison, I have been unable to find published accounts of this tick on bison. Lone star ticks have not been identified by handlers on the bison at Konza, nor on a herd at the Nature Conservancy's Tallgrass Prairie Preserve bison herd near Pawhuska, Okla. Gene Towne, manager of the Konza herd, presented me with an engorged lone star tick on 10 April 1998, that he found on a gravel road where bison had been congregated hours earlier. The only species of tick documented on bison are *Dermacentor andersoni* (Stiles) at the National Bison Range in Montana (Kohls and Kramis 1952) and at the Wichita National Game Preserve, Cache, Okla (Roudabush 1936). At Konza, bison are rounded up and given veterinary inspections in late fall, after most ticks in this area are no longer active. There is a small herd at Konza that I hope to be able to inspect this spring and summer to quantify tick parasitism. It is possible that the lack of effect of bison on lone star tick numbers is because lone star ticks do not parasitize bison. That possibility awaits further investigation.

Other studies have demonstrated reduced numbers of lone star ticks (Bloemer et al. 1986, Presley and Hair 1988), and deer ticks (Wilson et al. 1988) when white-tailed deer were excluded. Deer are present at Konza and appear to be abundant in the gallery hardwood forests that occur along valley bottoms, however, density estimates for deer are not available. Deer were frequently flushed in the grasslands while conducting tick drags, and may be more important than bison as lone star tick hosts at Konza. Deer were most often seen in the riparian forests or in field and grassland habitats in close proximity to forests. They were also observed in open prairie habitats, usually in association with patches of smooth sumac (*Rhus glabra* L.) or rough-leaved dogwood (*Cornus drummondii* C. A. Mey.). Sumac and dogwood were more abundant in the 4 and 20-year burned watersheds than in those burned annually. Quantitative data are not available on white-tailed deer distributions at Konza, but they appeared to be more abundant on watersheds with long than with short burn intervals. It is possible that it is primarily movement of deer from the wooded habitats into grasslands that reestablish tick populations following fire.

The Flint Hills in Kansas are at the periphery of the range of lone star ticks (Hair and Bowman 1986). Tick numbers in grassland habitats are low when compared to populations in woodland sites in Oklahoma, and similar high densities in the woodlands could be expected at Konza. This study demonstrated that annual burning is an effective method to reduce tick numbers in tallgrass prairie habitat. Where riparian forests occur at Konza, however, resident tick populations most likely will not be affected by burning, because grassland fire dies out when it encounters forested habitats during most years (personal observation).

Because cattle prefer to loaf in the shade within riparian areas, tick infestation rates on cattle may not be reduced even where annual burning has reduced tick populations in the grasslands. Where livestock production suffers because of lone star tick infestations, a burning regimen will probably be more effective if cattle are excluded from wooded riparian areas.

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