Reducing Invasion by Targeting Vulnerable Life-stages: Effects of Fire on Survivorship of *Lespedeza cuneata*

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Abstract: The ecological impact of invasive species has continued to rise in recent decades despite increased awareness and mitigation efforts. One approach to controlling the impact of invaders may be to target vulnerable life-stages. In this study, *Lespedeza cuneata* seeds were sown into intact prairie plots that were assigned to different burning times to ascertain the effects of burning on different plant life stages. Preliminary data suggest that late season burns (September) resulted in the lowest survivorship ($\bar{x}$ = 29%) at the end of the first growing season versus an early season burn (April, $\bar{x}$ = 88%). Although these data suggest that late-season burning is more effective than early season burning, quantification of over-winter survivorship will be necessary to assess the full impact of these treatments on *L. cuneata* establishment.

Introduction: The impact of invasive species on natural ecosystems has continued to rise despite an increase in awareness and mitigation efforts over the past several decades [1]. Any invader has the potential to disrupt an ecosystem whether by displacing or decreasing the diversity of native species or by altering existing ecological processes. These detrimental effects can alter productivity, as well as the stability of the ecosystem by disrupting nutrient cycles, hydrological cycles, or specific organisms responsible for critical processes [2, 3]. Management of invasive plant species is difficult because different species often display unique characteristics that contribute to successful invasion. However, there are certain demographic features that all species have in common— survival, growth rate, and fecundity. Ramula et al. (2008) [4] found that perturbation to any single demographic has very little effect on population growth rate (λ) while simultaneous perturbations in two of the demographics, specifically survival and growth rate, would most likely result in a decline in λ. Consequently, the most effective and cost-efficient control strategy would likely employ a perturbation that adversely affects two or more demographic stages. Because perturbations naturally occur in many systems, such disturbances may have only modest effects on native species while greatly reducing invasive success by focusing on specific, vulnerable life stages; however, there are relatively few studies that examine how natural disturbance regimes influence key life stages of invasive species.

Lespedeza cuneata ([Dum.-Cours.] G. Don) is an herbaceous, long-lived perennial legume introduced as a forage crop to the United States in 1896 from Eastern Asia [5]. Since then, its spread has been galvanized throughout the Eastern United States partly from low palatability in its woody mature form, its usage as an erosion deterrent on roadsides and in strip mines, and as a pasture crop [6]. The spread of *L. cuneata* into the Great Plains has had a profound impact on native grasslands by reducing native grassland diversity.

Over the past decade, land managers have attempted to control the spread of *L. cuneata* using various methods including herbicide treatments, grazing, and fire. Traditional herbicide treatment is largely ineffectual against *L. cuneata* because, although mature plants are eliminated by the herbicides, high propagule production of up to 6000 seeds per plant per year creates an extensive seed bank from which new plants will germinate [7]. Grazing by large herbivores is also ineffective as even an 80% leaf loss has no effect on λ[8].

Prairie ecosystems are dominated by perennial grasses that are well adapted to prairie fires. However, traditional burning has had a relatively weak effect on existing *L. cuneata* stands in previous studies. This is not surprising given that mature *L. cuneata* have extensive root systems and buds below the soil surface that are likely protected from fire. Young plants that have not allocated sufficient resources below-ground may be more vulnerable to fire than to herbivory [8]. However, there is very little data available on fire-induced mortality at different life stages for *L. cuneata*. It is possible that burning *L. cuneata* at a vulnerable life stage may prevent its invasion.

Methods: The effect of fire on immature *L. cuneata* seedlings was tested by manipulating the timing of fires in order to assess the effect on seedlings at different life stages. The experiment was conducted at University of Kansas's NESA field station. Ninety 1m x 1m plots were established in a grid with 0.5m between plots. There were nine different treatment combinations that were each replicated ten times. The treatments were as follows: *L cuneata* seed was added to plots that were either unburned or burned once at different times during the growing season (April, May, June, July, September of year 1 or April of year 2). In addition, there were No Seed/No Burn control and no Seed/April Burn control treatments. Seeds were hand collected from a population adjacent to the

study site. For seed addition plots, seeds were sown at a rate of 4000 seeds/ m^2. All seeds were sown in March of year 1. The burns were made with a propane torch within each 1 m^2 plot to simulate the effects of a natural prairie fire. Based on the literature, a typical prairie fire reaches 240-411° C. The burns were monitored by temperature strips responsive to 27° temperature intervals between 93 and 426°C.

The plots were surveyed until an initial germination time was ascertained. Every 20 days, 4 plants per plot were randomly selected and marked to quantify survivorship while all other *L. cuneata* plants in the plot were removed. Shoot mass and length of the removed plants were measured to determine plant size at each interval. Midway between the 20 day intervals, any additional *L. cuneata* seedlings were removed to maintain discrete temporal differences among cohorts. At the end of the first growing season after the September burn, all plots were surveyed to determine the survivorship of marked *L. cuneata* seedlings under different burning regimes.

Results/Discussion: A census was taken at the end of the first growing season to determine survivorship through the first growing season. The mean survivorship was calculated for each burn treatment. The April burn treatment had the highest survivorship (88%) while the September burn treatment had the lowest (29%; Figure 1). There was a negative trend in survivorship as the season progressed, however this may be an artifact due to a reduction in the time available to assess re-sprouting. Although unlikely, it is possible that some individuals may re-sprout in the following spring. These results suggest that early season burns do not lead to decreased recruitment compared to unburned plots presumably because fire-induced seedling mortality is offset by increased germination rates. Differences in recruitment and survivorship cannot be assessed until over-winter survivorship is quantified.

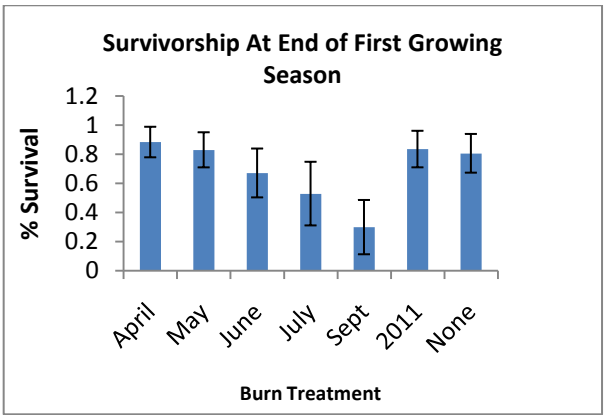

Fig 1. Survivorship of *L. cuneata* seedings at the end of first growing season.

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