Tanglehead in Southern Texas: A Native Grass with an Invasive Behavior

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Tanglehead in Southern Texas: A Native Grass with an Invasive Behavior

By David B. Wester, Fred C. Bryant, Aaron D. Tjelmeland, Joshua L. Grace, Scott L. Mitchell, John T. Edwards, Fidel Hernández, Robert K. Lyons, Megan K. Clayton, Sandra Rideout-Hanzak, Richard V. Machen, and J. Alfonso Ortega-S.

On the Ground

- Tanglehead is a native bunchgrass with a pan-tropical distribution. Historically, tanglehead was common but not abundant in southern Texas and was considered a decreaser whose presence indicated good range condition.
- Beginning in the late 1990s, the Texas Coastal Sand Plain ecoregion witnessed dramatic increases in the abundance and distribution of tanglehead: thousands of acres of former grasslands were replaced by dense monotypic stands of tanglehead, reducing habitat quality for livestock and wildlife.
- Our research has focused on understanding factors related to tanglehead's expansion, its effects on habitat quality, and management practices that can improve range condition and habitat quality.

Keywords: grazing management, habitat quality, invasive grasses, native grasses, prescribed fire, rangeland improvement.

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Tanglehead (*Heteropogon contortus*), a perennial warm-season bunchgrass with a pan-tropical distribution,[1] is mentioned in many vegetation descriptions of southern Texas from ~20 to 50 years ago,[2,3] but also is absent in other accounts.[4,5] Tanglehead is common on Loamy Sand and Sandy Loam Ecological Sites where soils typically are deep loamy fine sands or fine sands. One of the few papers that provides quantitative data is Johnston's[6] account of past and present grasslands in southern Texas and northeastern Mexico in which he indicated that tanglehead was commonly encountered but not abundant (33% frequency with trace amounts of cover) in non-grazed settings and less frequent (2%) in grazed settings. This observation of the relationship between tanglehead abundance and livestock grazing is important and is supported by a similar finding in mesquite grasslands in Arizona where tanglehead showed a "marked increase in abundance during the first years of protection from grazing."[7]

Tanglehead has increased both in abundance and distribution throughout thousands of acres in the Coastal Sand Plain ecoregion of southern Texas (Fig. 1) over the past ~30 years. Its dramatic increase in abundance has come at the expense of other native species: what once were both rich and diverse plant communities (Fig. 2) have now become dense and largely monotypic stands of tanglehead (Fig. 3). And yet tanglehead is considered a native species throughout the region of southern Texas where its populations have expanded so quickly and extensively in many areas. For example, beginning in 1999 we monitored plant species composition along 22 permanent transects established in native grasslands on a private ranch in Kleberg County, Texas. In 1999 tanglehead species composition was only 1.4% but it increased to 2.7% (2002), 8.1% (2009),[8] and 7.7% (2016) over the ensuing 17 years. Composition of other native species decreased from 56% to 37% during the same time period. Tanglehead has taken over other kinds of plant communities as well. Data we have collected in one of our experimental pastures in Duval County, Texas, exemplify what has happened on thousands of acres throughout the Coastal Sand Plain of Texas. In a former Conservation Reserve Program pasture, the area occupied by tanglehead increased from 5.3 acres (2009) to 7.5 acres (2011) to 16.1 acres (2013)—overall, an increase of over 200%. The 114% increase between 2011 and 2013 occurred during the driest 18 months on record and

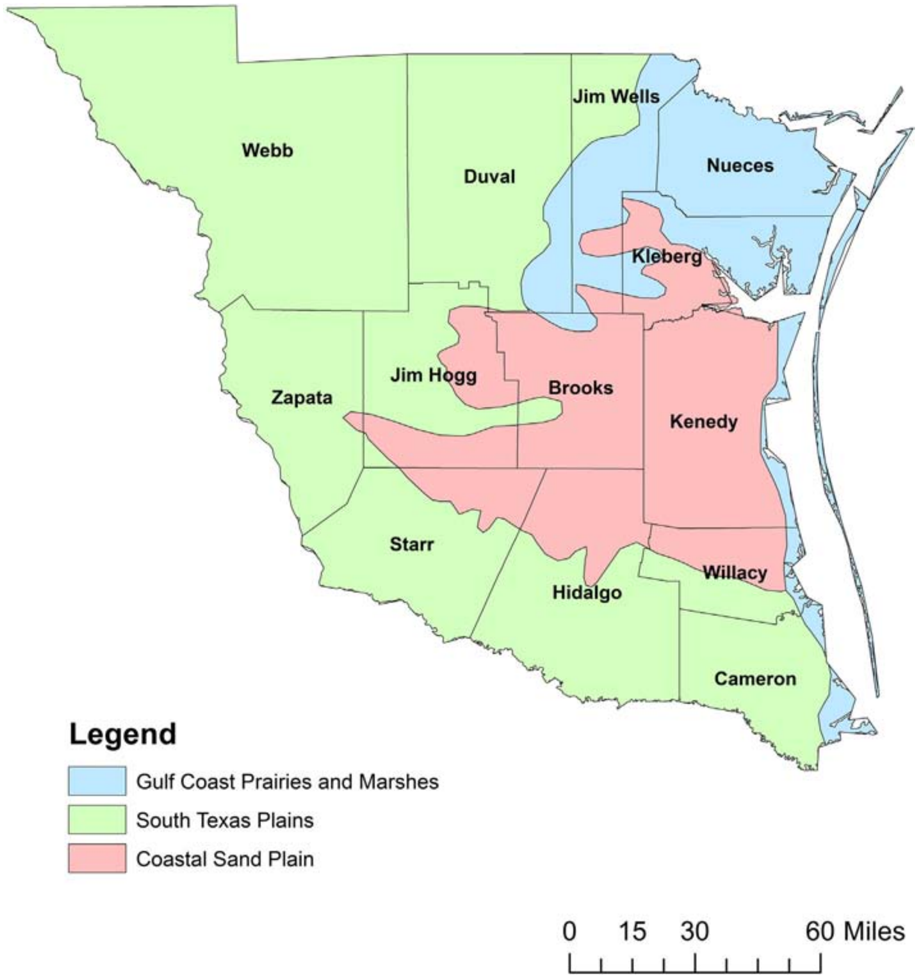

Figure 1. A map of southern Texas showing the location and size of the Coastal Sand Plain (map adapted and used with permission from Plant Resources Center, University of Texas at Austin).

Figure 2. A native plant community in the Coastal Sand Plain, Texas. Photo courtesy of Eric Grahmann.

Figure 3. A tanglehead-dominated plant community in the Coastal Sand Plain, Texas. Photo courtesy of Fidel Hernández.

represented encroachment into Kleberg bluestem (*Dichanthium annulatum*) and Kleingrass (*Panicum coloratum*), 2 exotic species that are generally resistant to such invasion.

Vegetation dynamics typically represent responses to changes in land-use patterns as well as climate, and it is likely that these factors are related to tanglehead's expansion as well. Johnston's[6] data indicating that tanglehead was less common in grazed settings are consistent with the hypothesis that recent increases may be related to livestock reduction or removal from many ranches in southern Texas whose management focus has shifted to wildlife enterprises. For example, from the 1980s through 2002, cattle numbers in Jim Hogg County, Texas ranged from 54,605 (1987) to 47,192 (1992). Since then, cattle numbers have decreased by ~50% to 20,712 (2007), 24,733 (2012), and 27,000 (2017).[9]

Rainfall patterns also have been implicated in vegetation dynamics. Neilson's[10] classic study of black grama (*Bouteloua eriopoda*) seedling dynamics in southwestern New Mexico showed that "seedling years" could be associated with changes in seasonal rainfall patterns involving summer-wet (or dry) and winter-wet (or dry) cycles. Rainfall records from Hebbronville (Jim Hogg County, Texas) from 1995 through 2010 suggest that summer (July–September) rainfall amounts exceeded long-term averages in the early 2000s when spring (April–June) rainfall was below long-term averages (Fig. 4). Although tanglehead can begin flowering as early as April, peak flowering typically occurs between July and September; the flowering period itself typically lasts about 2 weeks, with seed production lasting another 2 to 3 weeks after which seeds are dispersed. Tanglehead seeds typically undergo a post-harvest ripening period apparently caused by both endogenous and exogenous inhibitors that can limit seed germination.[11] Both mechanisms weaken over a 12-month period following seed maturation, after which seed germination can be high.[11] Despite high seed production, however, tanglehead does not form a persistent seed bank.[12] It is reasonable, therefore, to suggest that periods of abundant rainfall that coincide with flower production in one year and with release from dormancy of dispersed seeds the following year—which were observed, for example, in the early 2000s in Hebbronville, Texas—might be implicated in tanglehead's recent increases. These observations suggest that

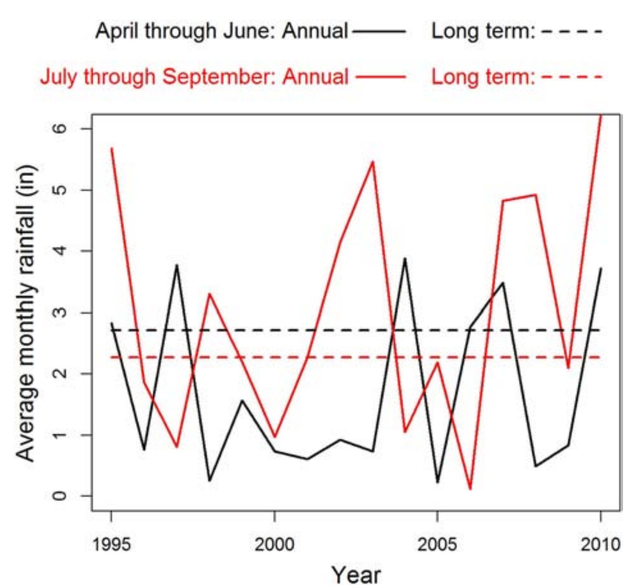

Figure 4. Average monthly rainfall from 1995 through 2010 in late spring (April through June; solid black line) and in summer (July through September; solid red line); long-term monthly averages are corresponding dashed lines (Hebbronville, Texas, National Oceanic and Atmospheric Administration).

reproductive ecology should be considered when developing tanglehead management and control strategies.

Two common range management practices throughout the Texas Sand Plain region include discing and prescribed burning. Many landowners who incorporate hunting leases into their wildlife enterprise (e.g., for northern bobwhite [*Colinus virginianus*]) use winter discing to stimulate forb emergence the following spring and summer. Discing also is used to break up dense stands of tanglehead; this practice, however, causes considerable soil disturbance and may bring buried tanglehead seeds to the surface where successful emergence is more likely. Prescribed burning is an integral component of habitat management in southern Texas where it is often used for brush suppression; its effects on tanglehead, however, have not been thoroughly documented.

Impacts of Tanglehead on Ecological Communities

There is an urgency and interest on the part of land managers to manage the spread of tanglehead. This interest is warranted because of the potential negative impacts that monotypic stands of this species may have on the native plant and animal communities. Invasive grasses often produce negative, cascading effects on biotic communities, with the diversity and abundance of native plants, insects, and wildlife decreasing as cover of the invasive plant increases. Increasing cover of tanglehead appears to result in similar community effects. For example, species richness of native grasses decreased as tanglehead cover increased along a gradient from 0% to 80%, and native grass cover decreased 8% to 10% for every 10% increase in tanglehead cover.[13] In a detailed pin-frame study of the effects of tanglehead on the canopy architecture of the herbaceous communities it occupies,[14] we have extended these results by showing that although tanglehead generally reduces canopy cover of other native species in its immediate neighborhood, these effects are not always linear and they vary seasonally as well as annually. Nevertheless, it is true that increasing cover of tanglehead results in fewer forb and native-grass species as well as less bare ground. Such compositional and structural changes in the plant community can have negative impacts on important wildlife species, especially grassland birds such as northern bobwhite.[13] Bare ground, forb species richness, and grass species richness are important components of this species' habitat. Consequently, increases in tanglehead cover would reduce the amount of bobwhite habitat and thus bobwhite density. Our ongoing research suggests that this phenomenon indeed happens, with bobwhites avoiding points when tanglehead cover is greater than 20% and bobwhite density decreasing when tanglehead cover exceeds 30% to 40% in pastures. This latter observation of decreasing bobwhite density is stronger with increased tanglehead aggregation (J. Edwards, 2017). Given the ecological and economic importance of this game bird, managing the spread and cover of tanglehead is of utmost importance to many land managers in southern Texas.

Experimental Management of Tanglehead

We have spent the past 20 years investigating tanglehead ecology and evaluating techniques to manage its abundance and spread. Our experimental evaluations have included single-management practices (e.g., herbicides or prescribed fire) as well as tandem-management practices (such as prescribed fire and herbicide, and prescribed fire and grazing). Our response variables of interest have included tanglehead plant mortality, seedling emergence and fate, and forage quality and its effects on livestock grazing behavior. Below we provide a summary of our research findings.

Single-management practices

We have conducted several experiments investigating methods of tanglehead control using single-management practices such as herbicides or prescribed fire. In one experiment, we applied 3 herbicides (glyphosate at 24 or 36 oz/ac; imazapyr at 48 or 96 oz/ac; or liquid hexazinone at 32 to 96 oz/ac) to replicated and randomized field plots and monitored average abundance of tanglehead 1 and 3 months following treatment; pre-treatment data were collected in all plots and non-treated plots were monitored over the same time period. Prior to treatment, tanglehead cover ranged from 23% to 38%; both glyphosate and imazapyr eliminated tanglehead from study plots 3 months post-treatment; cover in control plots increased from 15% to 33% during the same time period. This study was helpful in identifying chemicals capable for short-term control; however, both herbicides are non-selective and can be detrimental to desirable vegetation growing with tanglehead. Additionally, imazapyr has some soil activity which may prolong tanglehead control, but can limit new desirable plant establishment as well.

We also have investigated effects of prescribed fire on tanglehead regeneration and mortality. We quantified the common field observation that tanglehead regeneration can be prodigious following fire by monitoring seedling emergence in permanent quadrats for 4 months following a prescribed burn conducted in late February 2014 (Fig. 5). We recorded an average of 10 seedlings/ft^2 in the burned area within a week after the fire; in non-burned areas, however, seedling density was only 0.08 seedlings/ft^2. Within 2 weeks, tanglehead seedling density averaged over 25/ft^2 (with some quadrats containing 140 seedlings/ft^2) in the burned areas but declined thereafter. Monthly sampling in non-burned areas detected no seedlings until July; by 4 months following fire there were about 4 tanglehead seedlings/ft^2 in both burned and non-burned areas, suggesting that the flush of seedlings following the fire was temporary. We have recorded seedling flushes following late autumn fires which also declined post-burning but at a much slower rate: the ultimate fate of seedlings that emerge after burning depends on rainfall patterns following fire and so is difficult to predict. We also marked adult plants prior to burning, recorded their basal area as a measure of plant size, and monitored their survival for 4 months. Tanglehead mortality exceeded 65%, was not related to plant size, and did not change throughout the monitoring period.

We conducted a detailed study of the effects of prescribed fire on the size of tanglehead patches in 3 pastures on a ranch in Jim Hogg County, Texas, in areas of fine sandy loam and loamy sand soils. In February 2010 we used a Trimble ArcPad Unit to measure the size of over 500 tanglehead patches prior to a spring (conducted on 1 March) prescribed burn and then

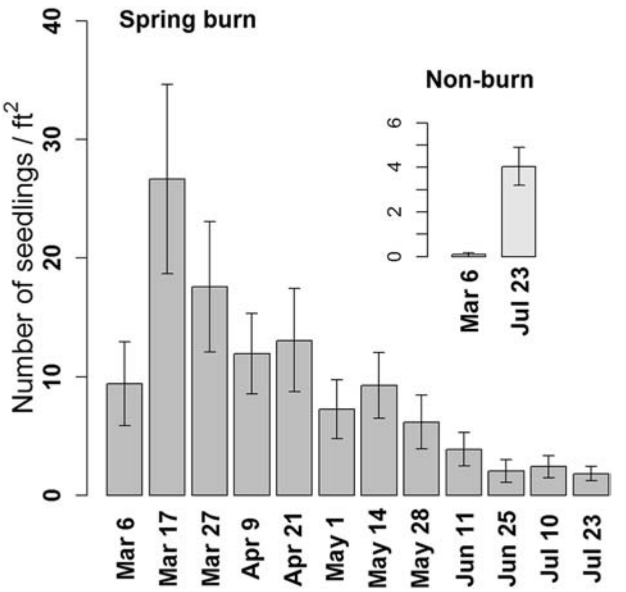

Figure 5. Mean tanglehead seedling density/ft^2 (± standard error) following prescribed fire in late February, Jim Hogg, County, Texas ($n=30$ for each sampling date); inset: seedling densities in non-burned areas ($n=25$ for each sampling date). Monthly sampling between March and July detected no seedlings in non-burned areas.

re-measured the size of each patch 5 months and 1 year post-burn. Fifty percent of all patches were less than 75 ft^2 in area prior to the burn; 75% of patches were less than 320 ft^2; and the largest patch was over 100,000 ft^2 in area. Average size of small patches (patches less than 75 ft^2) increased in both burned and non-burned areas between pre-burn and 1-year post-burn sampling periods; however, the rate of increase was higher in burned areas (50% increase in patch size) than in non-burned areas (17% increase in patch size). There were no significant changes in average patch size in either burned or non-burned areas for patches larger than 75 ft^2. These data reveal an interesting response of tanglehead to fire. Although individual adult plants suffer high fire-induced mortality, and although there are large flushes of seedlings following fire (whose fate is closely tied to post-burn rainfall), the effects of fire on the areal extent of a patch of tanglehead depend on the size of that patch: small patches increase in area following fire whereas larger patches do not, and this may be related to fuel load effects because: 1) fire temperature is a product of fine fuel load; 2) tanglehead generally produces higher biomass than associated native plants; and so 3) larger tanglehead patches generate regions of higher fire intensity.

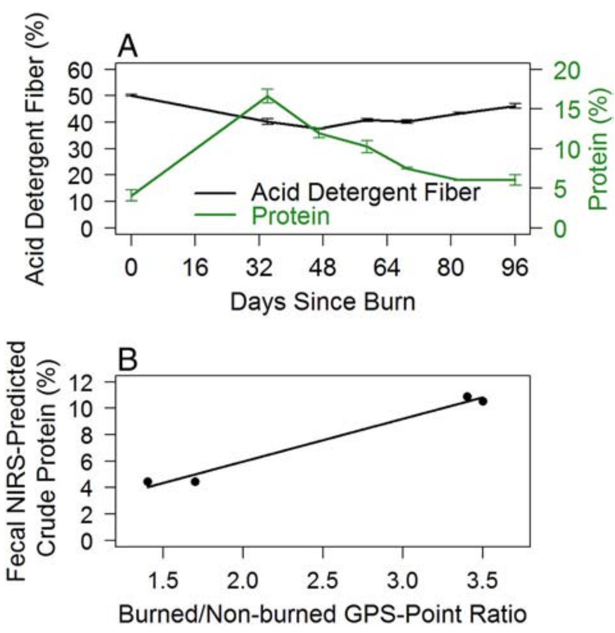

Figure 6. A, Mean crude protein (%) (± standard error) and acid detergent fiber (± standard error) (%) contents of tanglehead ($n=3$ for each sampling date) following prescribed fire in late February, Jim Hogg County, Texas. **B,** Fecal near infrared reflectance spectroscopy-predicted diet crude protein as a function of ratio of GPS points on cattle in burned versus non-burned, Jim Hogg County, Texas.

We investigated the effects of fire on tanglehead forage quality by measuring crude protein and acid detergent fiber contents of plants (Fig. 6A) that survived the February 2014 fire (discussed above). Tanglehead crude protein prior to fire averaged 4%; regrowth crude protein content increased to 16% 34 days post-fire and then decreased to 6% by 96 days after fire; the pasture was not grazed following burning. Plant fiber content was lower in early regrowth and increased with plant age. We might expect increased livestock use of regrowth tanglehead as a result of improved forage quality. In a follow-up experiment using cattle with GPS collars, we measured 52% herbage utilization in burned tanglehead stands compared with just 1.8% in non-burned tanglehead stands; increased used of burned tanglehead stands can extend for up to 6 months following fire. Because mature tanglehead typically has a low crude protein content, cattle will require protein supplementation for acceptable performance. However, regrowth during the first 60 days following fire may be adequate to support moderate animal gains (0.5–1 lb/day) as long as crude protein content exceeds 7% on a dry matter basis and there is adequate quantity of forage.

Tandem-Management Practices

In an effort to discover an effective technique for the control of tanglehead, we also have evaluated tandem-management approaches such as patch-burn grazing and prescribed fire plus herbicides. In one of our other studies, patch burning was initiated late winter (February or March) on two ranches experiencing tanglehead invasion to determine whether patch-burning could be used as a tool to place increased grazing pressure on tanglehead. Cattle fecal samples were collected during the study to monitor changes in nutrition using fecal near infrared reflectance spectroscopy analyses. Cattle were fitted with global positioning system (GPS) collars to monitor use of burned and non-burned areas every 3 weeks, three or four times throughout the growing season. During the month following burns, there were no differences in number of GPS-points/acre between burned or non-burned plots on either site. However, 1 to 3.5 months post-burn, burned areas had as much as two to six times more GPS points/ac (Fig. 7). Crude protein from fecal sampling was closely correlated to use

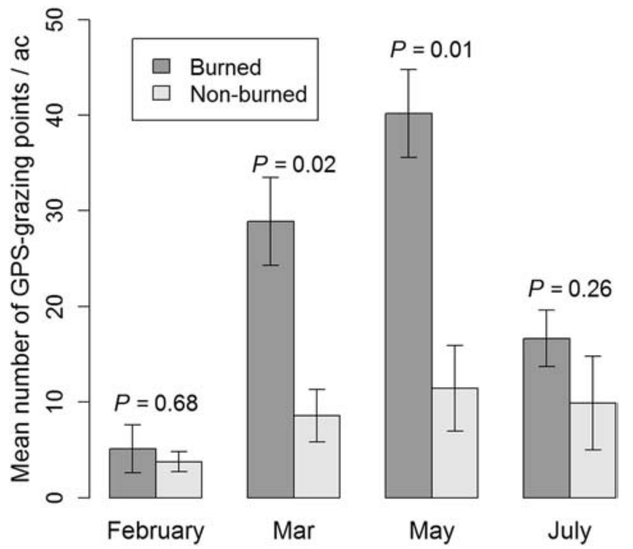

Figure 7. Mean number of GPS grazing points/ac (± standard error) on the Puesta del Sol Ranch (Jim Hogg County, Texas) in burned ($n = 4$) and non-burned ($n = 3$) areas.

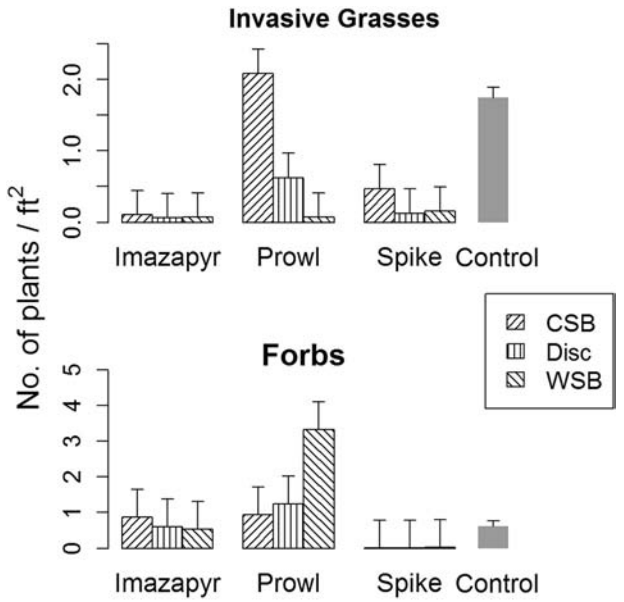

Figure 8. Mean density/ft^2 (+ standard error) of invasive grasses and forbs in experimental plots that were treated with a combination of cultural practices (cool season burn, CSB; discing; and WSB, warm season burn) and herbicide application (imazapyr, Prowl H_20 or Spike) 2.5 years post-treatment (Jim Hogg County, Texas).

of burned plots (Fig. 6B), demonstrating cattle preference for tanglehead during early growth stages. Although fire and grazing treatment combinations may have a limited period of effective use, they can be replicated throughout pastures to create plant community structure that may be more beneficial for wildlife and improve forage for livestock.

The foregoing results suggested that cultural practices such as prescribed fire and herbicides can impact tanglehead-dominated plant communities. In 2012, we initiated experiments on 3 separate ranches in the Coastal Sand Plain to investigate longer-term responses of tanglehead to control measures that included discing in late May or prescribed fire (cool season burns in early March or warm season burns in mid-July) alone as well as each of these treatments combined with herbicide application (within 2 weeks following discing, 3 weeks following cool season burning, and 7 weeks following warm season burning). Imazapyr, Spike (tebuthiuron), or Prowl H_20 (pendimethalin) were applied at low (32, 24, and 24 oz/ac, respectively), medium (64, 32, and 32 oz/ac, respectively), or high (96, 48, and 48 oz/ac, respectively) rates. Treated plots were 25 x 160 ft in size; seedling emergence by species was monitored for 2.5 years following treatment. Invasive grass density (mostly tanglehead but also occasional buffelgrass [*Pennisetum ciliare*] and natal grass [*Melinis repens*]) was similar among experimental plots at the onset of the study. Two years post-treatment, we achieved the best tanglehead control when discing or burning were combined with herbicides—and these factors interacted in their effects on invasive grass density (Fig. 8). Invasive grass density was low in plots treated with imazapyr or Spike regardless of discing or burning; also, invasive grass density was low in plots that were disced or burned in the summer regardless of herbicide application. Prowl H_20, however, was effective only when combined with discing or summer burning. Forb densities 2 years post treatment were low in plots treated with Spike but otherwise were similar to forb density in the control plots.

In summary, single management practices (such as herbicide applications with glyphosate, imazapyr, or Spike) show promise for short-term tanglehead control. However, longer-term control can be achieved when these chemicals are used in combination with other practices such as warm-season prescribed fire. We also have shown that prescribed fire alone can be effective in killing adult plants as well as destroying seeds on plants and on the soil surface: these effects are important in reducing existing tanglehead populations and limiting future populations. Also, because the regrowth of burned tanglehead plants that survive fire is of higher forage quality than mature plants, livestock grazing can be used in conjunction with prescribed fire to manage dense stands of tanglehead.

Conclusions

Historical vegetation descriptions of southern Texas indicate that tanglehead was common but not abundant throughout the Coastal Sand Plain—and also that it was more common in non-grazed settings. Beginning in the late 1990s and extending throughout the early 2000s, tanglehead populations dramatically increased in southern Texas. Although the ultimate causes for this rapid expansion likely will never be fully understood, reasonable proximate causes may be related to changing land use (reduced livestock numbers) and rainfall patterns (wet summer months) that promote seedling establishment.

Management strategies to reduce tanglehead's dominance in former native grasslands are centered on basic principles of range management that recognize the interlinking connections between soils, plants, and animals. Our work indicates that effective management strategies for tanglehead 1) should capitalize on the fact that adult tanglehead plants are not tolerant of fire, and 2) can be applied within a regeneration niche[15] framework. A regeneration niche is the gap created when an individual plant dies and another takes its place, with no guarantee that the new individual will be of the same species. This concept of how community richness develops may be used in conjunction with tanglehead's susceptibility to prescribed fire and its increased palatability following burning to decrease the abundance of this invasive species. For example, autumn and winter burns can kill a large proportion of adult tanglehead plants and also will destroy seeds on existing plants as well as seeds on the soil surface: limiting seed input will have long-term consequences because tanglehead does not form persistent seedbanks. Plants not killed by fire have higher forage quality (lower fiber and higher crude protein) and are palatable to grazing animals: heavy stocking on regrowth tanglehead will weaken these plants. Herbicidal application on large scales is not economical, but because tanglehead populations can be effectively controlled with chemicals such as imazapyr and Spike when used in combination with cultural practices that target adult plants, it may be reasonable to incorporate chemical control on an as-needed basis to control tanglehead in localized areas. However, a combination of livestock grazing and prescribed fire—two of Leopold's fundamental tools of habitat management—likely will be more effective than herbicide application for longer-term management at the landscape scale.

Southern Texas supports a higher diversity of plant, butterfly, and vertebrate species than any other region in Texas. For example, the Lower Rio Grande Valley Wildlife Refuge, only 1/17th the size of Everglades National Park, has more combined species of amphibians, birds, mammals, plants, and reptiles.[5] At the heart of this hyper-diverse region[5] is the Coastal Sand Plain, the area where tanglehead populations have expanded so dramatically. Tanglehead reduces species richness in the communities it dominates and has impacts on community structure and function that have far-reaching consequences on habitat quality for livestock and wildlife alike, especially grassland birds such as northern bobwhite. Developing practical management strategies that are based on sound science will provide an opportunity to improve rangelands in *The Last Great Habitat*[5] in southern Texas.

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