New England Plant Conservation Program

Bouteloua curtipendula (Michaux) Torrey
Sideoats Grama

Conservation and Research Plan
for New England

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SUMMARY

Bouteloua curtipendula (Michaux) Torrey, commonly known as sideoats grama, is a mid-size, warm-season, perennial grass (Poaceae) common in the prairies of the Great Plains in central North America and relatively rare, but widespread, east and west of the Great Plains. Like other members of the genus, its short, pendent spikes usually hang down to one side of the flowering stalk and make it a very distinctive grass. The taxon found in the Great Plains and eastern United States — *B. curtipendula* variety *curtipendula* — is rhizomatous, in contrast to two other varieties found in the Southwest United States and Mexico, which are cespitose or stoloniferous.

Bouteloua curtipendula is well-adapted to the prairie environment. Its C_4 photosynthetic pathway supports energy efficiency in hot, sunny, and droughty growing conditions. Its rhizomatous nature allows it to withstand grazing pressure from large ungulates. When deep-rooted in prairie soils, it is tolerant of fire. It is wind-pollinated and reproduces both vegetatively and sexually. Although it prefers deep loess deposits of the middle Great Plains, it grows in a variety of fertile, upland soil types at the southern edge of its range in Texas. In the eastern United States, where the species becomes much more restricted, it occurs in natural openings in the forest, including small prairies, oak barrens, limestone barrens and glades, trap rock glades, and shale talus. Rarely is it found in acidic soils.

In New England, *Bouteloua curtipendula* is a Division 2 taxon in *Flora Conservanda*, i.e., a regionally rare species, but it is common elsewhere in its range. It is known from only seven western Connecticut occurrences, including four extant, one extirpated, and two historical. The extant occurrences are associated with dry, marble outcrop sites and trap rock glades, and the three historical occurrences include two rivershore and one marble outcrop sites. In the heart of its range, habitat destruction through over-grazing or conversion of prairie to agriculture has greatly diminished the species' abundance, although it is not considered a rare species in the Great Plains. In New England, known threats to the species include river impoundment, woody plant competition (shading), and invasive species; potential threats include inbreeding depression, development, and quarrying. The conservation objections for *Bouteloua curtipendula* in New England are to maintain four occurrences containing at least 450 clumps that annually produce 675 flowering stems. Conservation actions include regular surveys, habitat management, land acquisition/protection, landowner education, dedicated searches for historical occurrences, and *de novo* surveys. Actions of lesser importance are research projects on the species' relationship to ant populations, seed banking and plant propagation, and plant augmentation and/or reintroductions.

PREFACE

This document is an excerpt of a New England Plant Conservation Program (NEPCoP) Conservation and Research Plan. Because they contain sensitive information, full plans are made available to conservation organizations, government agencies and individuals with responsibility for rare plant conservation. This excerpt contains general information on the species biology, ecology, and distribution of rare plant species in New England.

NEPCoP is a voluntary association of private organizations and government agencies in each of the six states of New England, interested in working together to protect from extirpation, and promote the recovery of the endangered flora of the region.

In 1996, NEPCoP published "*Flora Conservanda*: New England," which listed the plants in need of conservation in the region. NEPCoP regional plant Conservation Plans recommend actions that should lead to the conservation of Flora Conservanda species. These recommendations derive from a voluntary collaboration of planning partners, and their implementation is contingent on the commitment of federal, state, local, and private conservation organizations.

NEPCoP Conservation Plans do not necessarily represent the official position or approval of all state task forces or NEPCoP member organizations; they do, however, represent a consensus of NEPCoP's Regional Advisory Council. NEPCoP Conservation Plans are subject to modification as dictated by new findings, changes in species status, and the accomplishment of conservation actions.

Completion of the NEPCoP Conservation and Research Plans was made possible by generous funding from an anonymous source, and data were provided by state Natural Heritage Programs. NEPCoP gratefully acknowledges the permission and cooperation of many private and public landowners who granted access to their land for plant monitoring and data collection. If you require additional information on the distribution of this rare plant species in your town, please contact your state's Natural Heritage Program.

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I. BACKGROUND

INTRODUCTION

Bouteloua curtipendula, otherwise known as sideoats grama, is a characteristic upland grass (Poaceae) of the prairies of the Great Plains of the interior United States and Canada (Griffiths 1912, Hitchcock 1971, Wipff 2003). Its prominence in Texas elevated the species to the state grass of Texas (Texas State Senate 1971). East of the Mississippi River, the species becomes increasingly rare towards the eastern seaboard (NatureServe Explorer 2003). In New England, it is an extremely rare species, having been known from only a few occurrences in western Connecticut (Graves et al. 1910, Seymour 1989, Angelo and Boufford 1998) and as a waif in Maine (Haines and Vining 1998). As a rare species in New England, or Division 2 taxon in *Flora Conservanda* (Brumback and Mehrhoff, et al. 1996), it is of regional conservation concern.

This plan addresses the concern for the conservation of the species in New England by first providing background information on its physical characteristics, taxonomy, biology, ecology, distribution, threats, and status throughout its range. The Background section also contains detailed status information on historical and extant occurrences in New England and measures that have been taken to date towards the species' protection. This report then provides a plan for the conservation of *Bouteloua curtipendula* in New England that includes specific population objectives, conservation actions, and a prioritized implementation table for the conservation of each occurrence in New England. Two other conservation plans being published by the New England Wild Flower Society are similar to this one in that they address the conservation of two other prairie grasses—*Sporobolus compositus* var. *compositus* and *Sporobolus heterolepis*—that are rare in New England (Engstrom, 2004a, Engstrom, 2004b).

There are three varieties of *Bouteloua curtipendula*, but only *Bouteloua curtipendula* var. *curtipendula* occurs in New England and throughout the eastern United States, including most of the Great Plains (Gould and Kapadia 1964, Wipff 2003). Unless noted otherwise, in this plan *Bouteloua curtipendula* will refer to the nominative variety.

Bouteloua curtipendula is a mid-size (to 80 cm), perennial grass that reproduces sexually and vegetatively via rhizomes (Wipff 2003). Its short, pendent spikes — usually hanging down to one side of the flowering stalk — make it a very striking grass. Ten species, plus the three *Bouteloua curtipendula* varieties, form a taxonomic complex whose center of distribution is in the southwestern United States and Texas. It is a C_4 grass, well adapted to the intense solar radiation, high temperatures, and droughts characteristic of the Great Plains. The species also is adapted to ungulate grazing and fire, two ecological processes closely associated with the prairies.

While found in a variety of upland soils in Texas, *Bouteloua curtipendula* most frequently grows in drier landscape positions on deep, fertile, loess soils of the middle

Great Plains. In the moist eastern United States, where prairie habitat is scarce or non-existent, the species grows most frequently in limestone glades or other exceedingly rocky habitats at low elevations. It can occur in sandy soils, yet rarely occurs in truly acidic substrate.

While the species is still common in the Great Plains, the widespread loss of prairie habitat, primarily to agriculture, has undoubtedly led to a massive decline in its abundance. In New England, at least one local extirpation has been caused by a river impoundment, and the species is potentially threatened by quarrying, competition from woody plants (shading), invasives, and inbreeding depression. Conservation measures of the species in New England have been centered around gathering field data, seed banking, and propagation.

There are four extant, two historical, and one extirpated occurrences in New England, all in Connecticut. The extant occurrences are associated with marble and trap rock glades; the historical and extirpated occurrences are associated with rivershore and limestone habitats. Currently, there are two occurrences with 200 or more clumps, and two occurrences with less than 35 clumps.

DESCRIPTION

Bouteloua curtipendula var. *curtipendula* (the variety in New England) is a rhizomatous, perennial grass with flowering culms ranging from 8-80 cm tall (Gould and Kapadia 1964, Wipff 2003). Flowering culms are solitary or in small clumps. Its distinctive flower head contains numerous (40-70), short-branched spikes that hang down mostly on one side along a 13-30-cm length of the top end of the stem. In New England, the thin flowering stems are often strongly arching and can blend into the herbaceous groundcover (Engstrom, personal observation). Running 1-3 cm in length, each pendulous branch contains 3-7 spikelets and extends a few mm beyond the base of the upper-most spikelet. Unlike many grasses, when the spikelets drop from the stem, they drop as a group with the entire branch. Spikelets are pressed close to one another and range from 5.5–8 mm in length, excluding awns. They contain one bisexual, fertile floret and one or two rudimentary sterile florets. The upper glumes equal the spikelet length, while the lower glumes are one- half or more the length of the upper glumes. While the lowest lemma is mucronate, the upper infertile lemmas have 1-3 awns, the center-most of the second lemma up to six mm long. The paleas are acute and unawned. Unlike many grasses, when in flower, the anthers are showy, being relatively large (1.5-3.5 mm) and usually red or red-orange. Also adding color are the often-purplish glumes and lemmas. The seed (caryopsis) of *Bouteloua curtipendula* is elliptical, about 4.5 mm long by 1.5 mm wide (Griffiths 1912).

The blades of *Bouteloua curtipendula* var. *curtipendula* are flat, bluish green, 3-7 mm wide, and up to 30 cm long (Gould and Kapadia 1964). In the field, the bluish-green leaf color noted at two New England populations separated the species from the yellow-green and somewhat shiny leaves of the otherwise similar *Schizachyrium scoparium* with

which it grows (Engstrom, personal observation). Another vegetative character distinguishing the two species is the round leaf sheaths of *Bouteloua curtipendula* versus the strongly flattened, keeled sheaths of *Schizachyrium scoparium* (William Moorhead III, Consulting Botanist, personal communication). This variety of *Bouteloua curtipendula* produces long and stout rhizomes. In a study of underground parts of grasses in the tallgrass prairie of eastern Nebraska, Weaver (1958) found that *Bouteloua curtipendula* has slightly coarser (1 mm in diameter) roots than other prominent prairie grasses. They can spread out 30-45 cm from the plant in the surface soil layer and can reach depths of 1.4-1.7 m.

TAXONOMIC RELATIONSHIPS, HISTORY, AND SYNONYMY

Bouteloua curtipendula (Michaux) Torrey is a member of the grass family (Poaceae) native to North America (Gould 1979, Wipff 2003). Within the grass family — one of the largest in the world for number of species — *Bouteloua* now falls within the subfamily Chloridoideae (Barkworth el al. 2003). In North America north of Mexico, this subfamily is almost entirely composed of a single large tribe, the Cynodonteae. *Bouteloua*, along with *Eragrostis*, *Sporobolus*, and *Muhlenbergia*, are some of the more diverse genera in the Cynodonteae. *Bouteloua* is a New World genus of about 40 species that has Mexico as its center of distribution (Wipff 2003). About half of these species occur north of Mexico. *Bouteloua curtipendula* is a member of the subgenus *Bouteloua*. In this subgenus, panicle branches fall off as a single unit, in contrast to the other subgenus (Chondrosum) where spikelets fall off individually (above the glumes).

The type specimen of *Bouteloua curtipendula* was collected by André Michaux in Illinois and was described as *Chloris curtipendula* in the 1803 publication *Flora Boreali-Americana* (Hitchcock 1971). In the first half of the 19th century, there were many names applied to the species, variously including it in the genera *Atheropogon*, *Dineba*, *Cynosurus*, *Aristida*, *Eutriana*, *Cynodon*, *Andropogon*, and *Heterostegon*. Two synonyms encountered during the research for this conservation plan are *Bouteloua racemosa* Schribn. *ex* Vasey and *Atheropogon apludoides* Muhl., the latter referring to the earliest collection in Connecticut (Oakes 1841). John Torrey applied the current name in 1848, after which the understanding of the taxon appears relatively stable. The genus name *Bouteloua* is named after Spanish brothers Claudio and Esteban Boutelou. Claudio was a professor of agriculture in Madrid (Hitchcock 1971). The specific epithet *curtipendula* refers the short and hanging spikelets (Fernald 1950).

There are three varieties of *Bouteloua curtipendula*: *B. curtipendula* var. *curtipendula*, *B. curtipendula* var. *caespitosa* Gould & Kapadia, and *B. curtipendula* var. *tenuis* Gould & Kapadia (Gould and Kapadia 1964, Wipff 2003). Ranging from southwestern United States south to central Mexico and South America, *B. curtipendula* var. *caespitosa* overlaps with the nominative only in Texas, New Mexico, northeastern Arizona, and southeastern Utah. It is differentiated from the nominative by its cespitose growth form and high chromosome numbers. *B. curtipendula* var. *tenuis* is endemic to Mexico and differs from the other varieties in its stoloniferous growth habit.

Bouteloua curtipendula var. *curtipendula* shows morphological variation, especially in the southwest reaches of its range. There, it displays what appears to be introgressive hybridization with *B. curtipendula* var. *caespitosa*, *B. uniflora*, and *B. warnockii* (Gould and Kapadia 1964).

There are an additional 10 taxa in the *Bouteloua curtipendula* complex beyond the three varieties of *Bouteloua curtipendula* itself (Gould and Kapadia 1964). Of these 10, only *Bouteloua uniflora* var. *uniflora* and *Bouteloua warnockii* overlap with the range of *Bouteloua curtipendula* var. *curtipendula* in Texas.

"Sideoats grama" (or "side-oats grama") is the common name almost universally used as far back as 1912 (Griffiths 1912), with exceptions being "tall grama-grass" (Fernald 1950) and "side-oats grama-grass" (Gleason and Cronquist 1991). Some 19th century common names include "racemed Bouteloua" (Britton and Brown 1896), and "muskít-grass" (Gray 1867), the latter being an obvious precursor to "mesquite-grass" (Fernald 1950).

The chromosome count of *B. curtipendula* var. *curtipendula* is 2n=40, 41-60 (Wipff 2003).

SPECIES BIOLOGY

Bouteloua curtipendula is a warm-season, perennial grass with rhizomatous (*B. curtipendula* var. *curtipendula*), stoloniferous (*B. curtipendula* var. *tenuis*), and cespitose (*B. curtipendula* var. *caespitosa*) growth habits (Gould 1979, Wipff 2003). The rhizomatous type (*B. curtipendula* var. *curtipendula*) is typical for plants in the center, northern, and eastern portion of the species' range. Reproduction of the variety in our area is both vegetative (through rhizomes) and sexual.

As with most grasses, wind is the presumed means of pollination. While the nominative variety of *Bouteloua curtipendula* is normally cross-pollinated, apomixis does occur in *Bouteloua curtipendula* var. *caespitosa* (Harlan 1949, Gould and Kapadia 1964). Reported flowering dates in the literature range from mid-July through late September in Illinois (Mohlenbrock 2001), to June through November in Texas (Gould 1975). In New England, flowering dates range from July 24 to September 16, while fruiting dates range from August 6 to October 26 (data from various sources, as cited in the *Status of All New England Occurrences* section). At the time of one October 26 survey, half of the fruit had dispersed (Moorhead, personal communication).

Since *Bouteloua curtipendula* is an important range grass, there is a lot of information published on seeds and propagation. The species is variously described as having poor seeding habits (Griffiths 1912) to producing a "fair amount of seed if rather low viability" (United States Department of Agriculture 1937). Recent observers of one Connecticut occurrence (CT .005 [Woodbury]) have questioned the viability of seed

produced by plants in a trap rock glade (Moorhead, personal communication; Engstrom, personal observation). Numerous germination rates have been published and are summarized in Chadwick (2003). Rates range widely based on different treatments, seed sources, and seed dormancy lengths. Moist cold stratification is beneficial for the germination (Rock 1981), though only slightly so in Wisconsin trials (Greene and Curtis 1950). Very small amounts of seed have been collected from three occurrences in Connecticut and seed banked (New England Wild Flower Society, unpublished data). In one trial, three out of ten seeds germinated with a fresh, cold treatment with no sand cover, although only one seedling survived to maturity and was placed in the rare plant garden at Garden-in-the-Woods. Horticultural literature notes that the species can be directly seeded in the fall (late October in Wisconsin) or in the spring (June) (Rock 1981). Or, it can be grown in the greenhouse with either fall or spring seedings, potted, then outplanted. The species blooms the first year (Rock 1981). Since *Bouteloua curtipendula* is rhizomatous, it can be easily propagated through division. Division stock could then be used for augmentations or reintroductions, should they be necessary. While local seed sources would be necessary to retain genetic composition of local populations, *Bouteloua curtipendula* seed is commercially available (Natural Resources Conservation Service 1996). A web search revealed numerous sources for plants and seed. The Prairie Nursery in Westfield, Wisconsin, reports 8000 seeds/ounce in their catalogue.

An important natural mechanism for seed dispersal is believed to have been via the fur of bison and elk (Laughlin 2003). This is based on the experimental work on the adherence of *Bouteloua curtipendula* seeds to large mammals, ranging from rabbit to bison in size. The seeds of *Bouteloua curtipendula* are light enough to be moved by wind, especially over snow, but are probably not borne by the wind except in extreme conditions. Given their size and weight, seed could also possibly be dispersed via ants. One recent observation of the species in a trap rock glade in Connecticut (Moorhead, personal communication) suggested that the mounds that ants produce might favor *Bouteloua curtipendula* over the other grasses present. Whether this would be the result of better germination or rhizomatous expansion sites for the *Bouteloua curtipendula* is unclear.

Bouteloua curtipendula responds well to herbivory. As a rhizomatous variety, *B. curtipendula* var. *curtipendula* in particular is well-adapted to grazing pressure. In the Cross Timbers of northern Texas, the species increased in abundance or stayed the same under grazing pressure in many pastures studied, while most of the larger tallgrass prairie species showed heavy declines (Dyksterhuis 1948). Its habit of carrying the bulk of its foliage within several centimeters of the ground, as well as its vigorous rhizomatous nature, were believed to be the factors responsible for its persistence. It produces high-quality forage for livestock (as it presumably did for native ungulates prior to European settlement), and is has been used in regrassing abandoned farm lands (Harlan 1949, Leithead et al. 1971). Where it is rare, however, its preference by herbivores might work against the species. In a recent survey of *Bouteloua curtipendula* in a trap rock glade in Connecticut, Moorhead (personal communication) noted that four of the seven fruiting culms produced that year had been bitten off.

As with all the species in the genus, *Bouteloua curtipendula* is a C_4 photosynthesizer (Gould 1979). The Kranz Syndrome leaf anatomy, in combination with this chemical pathway, allows C_4 plants to more efficiently utilize carbon dioxide. C_4 grasses are adapted to hotter, drier, sunnier conditions than counterpart C_3 species.

Bouteloua curtipendula is intolerant of shade. All references cited note the species as occurring in open habitats, from prairies to small glades with forests. Its heavy sunshine requirement is also suggested by its being a C_4 species.

HABITAT/ ECOLOGY

While the species occurs in a variety of habitats throughout its range, *Bouteloua curtipendula* is foremost a prairie species of the Great Plains of North America (Sims and Risser 2000, Wipff 2003). Within this broad swath of central North America, the species is most frequent in the mixed-grass prairie. This central zone of the prairie is ecotonal between the more mesic tallgrass prairie to the east and drier shortgrass prairie to the west. In this zone, from east to west, the average annual precipitation changes from 100 cm/year in the tallgrass prairie, to 30 cm/year in the shortgrass prairie, with the mixed-grass prairie averaging 50 cm/year (Sims and Risser 2000). The mixed-grass prairie has an unstable boundary that shifts over time due to climate fluctuations, as well as land use practices (Sims and Risser 2000).

In Kuchler's (1964) map of potential natural vegetation of the United States *Bouteloua curtipendula* is included in a variety of plant associations of the Great Plains. It is a dominant in the Bluestem-Grama Prairie (*Andropogon-Bouteloua*) plant association of central-west Kansas and adjacent Nebraska, Colorado, and Oklahoma, and is mentioned as a component (but not dominant) species in 10 other plant associations of the Great Plains and adjacent regions.

The Great Plains occupy the physiographic region of low relief east of the Rocky Mountains and west of the Mississippi River. North of the Missouri River, till, outwash, lake bottom sediments, and loess deposits associated with late Wisconsinan glaciation are the parent materials of the flat and rolling plains landscape. South of the Missouri River soils are derived from alluvial fan and plain deposits, or non-transported material (Brouillet and Whetstone 1993). Mollisols are the soils largely associated with the tallgrass and mixed grass prairies, although alfisols become prevalent at the southern end of the prairies in Texas (Steila 1993). Soils of both of these soil great orders are generally fertile. The natural vegetation of these prairies is largely free of woody plants and dominated by grasses (Sims and Risser 2000).

Throughout its range, which covers much of the eastern half of the United States, *Bouteloua curtipendula* occurs in a variety of edaphic conditions and in a wide elevation range. Even in the Great Plains, the center of its distribution, the species can be found in a variety of soils and associations. *Bouteloua curtipendula* grows at elevations from near

sea level in Texas and Connecticut, to 2500 m in the northwestern United States (Gould 1979). The soils in which the species grows also vary widely, although good drainage (dry, or rarely mesic) and relatively high soil fertility are common features (Leithead et al. 1971). Soils can range from very shallow (10 cm or less), basic (pH 8.0), humus-rich soils over limestone in Wisconsin dry prairies (Curtis 1959), to well-developed, fine sandy loam soils with clayey subsoils and a pH averaging 6.6 in the Western Cross Timbers region of Texas (Dyksterhuis 1948). Mollisols are the prominent soil order found in the more northerly prairies supporting *Bouteloua curtipendula* (Sims and Risser 2000). These highly fertile soils develop in loess deposits. They are characterized by a deep topsoil supporting an abundance of biological activity, both from plants and animals. Nowhere in the literature is there reference to this species growing in wet soils. In the eastern portion of its range, it is considered a species almost always found on calcareous or circumneutral substrates. This association with limestone was emphasized in Missouri (Steyermark 1934, Yatskievych 1999), and is apparent after reviewing the species' habitats in states to the east described in Appendix 4. A few possible exceptions to its association with calcareous soils are found in southern Michigan where its occurrence in oak barrens appears to place it in acidic, probably sandy, soils (Michigan Natural Features Inventory 2004), and at one site in northern Illinois where it grows in water-lain sand and gravel (Fell 1956). In the southern portion of its range in Texas, however, the species appears to grow in a variety of soil types, some of which appear to be acidic based on regional bedrock types (Plant Resources Center 2003).

Primary ecological processes associated with prairie vegetation include grazing, drought, and fire (Sims and Risser 2000). Adaptations of many grasses to these processes include proportionally large underground parts; early-spring structural development (when moisture is most available); closing stomata and curling leaves during drought; C_4 photosynthetic pathway that contributes to efficient use of water; seeds that can germinate in relatively dry soils; and basal meristems. Compared to forested or other terrestrial ecosystems, grasslands have a large proportion of materials and energy flowing through grazing pathways. This is especially true in the prairies, where ungulates such as bison were an important part of the ecological equation.

Based on its distribution, *Bouteloua curtipendula* var. *curtipendula* is relatively drought-tolerant, although its exclusion from arid regions (like the Chihuahuan Desert) suggests it is not a real xerophyte. *Bouteloua curtipendula* var. *caespitosa* is the xerophytic form of the species. The drought-tolerance of *Bouteloua curtipendula* var. *curtipendula* has been noted in several studies. Weaver (1958) describes *Bouteloua curtipendula* as a very drought-resistant species, noting that the roots of the species go down as far as 1.4-1.7 m. In his study of prairie vegetation response to severe droughts in tallgrass prairie of eastern Nebraska, Robertson (1939) found that while *Bouteloua curtipendula* showed a net increase in abundance (8.6%) immediately post-drought, the species was one of the more unstable of the perennial grasses, i.e. it lost significant numbers of stems in some plots while at the same time gaining significant stems in others. Except for *Sporobolus compositus, S. cryptandrus*, and *Agropyron smithii*, all the other perennial prairie grasses showed marked declines. In contrast, annual grass and forb populations burgeoned after the drought. A greenhouse study of prairie grass

seedlings ranked *Bouteloua curtipendula* seedlings fifth among 14 in drought resistance (Mueller and Weaver 1942). Species typical of the shortgrass prairie were more drought-tolerant than *Bouteloua curtipendula*, and species typical of the tallgrass prairie were less tolerant.

Fire is an important natural disturbance in North American grasslands (Collins 1990). Drought, high temperatures, and strong winds, in combination with highly flammable fine fuels, produce ideal conditions for fire. Fire is generally acknowledged to stimulate short-term productivity of grasses in central North American grasslands, especially the tallgrass prairie (Glenn-Lewin et al. 1990). The effect disappears after one or occasionally two years, unless burned again. Additionally, fire is advantageous in maintaining grasslands by reducing or eliminating woody plant competition. In the literature reviewed in Glenn-Lewin et al. (1990), *Bouteloua curtipendula*, along with most C_4 grasses of the tallgrass prairie, showed an increase in flowering stem production following spring burns. In two studies, *Bouteloua curtipendula* showed a 60-600% increase in flower stem production. The species showed varied flowering response to fire in different habitats within sites. For example, in Minnesota, the driest areas showed the greatest flower stem stimulation, while in Wisconsin, the slightly more mesic (dry-mesic) areas showed greater stimulation. Also, a late-spring versus early-spring burn showed twice the flowering stem production in Wisconsin. The authors concluded, however, that there are many methodological problems with the fire studies, and that year-to-year variation due to weather can sometimes produce more variation in production than fire. In other literature, *Bouteloua curtipendula* showed no significant difference in productivity (flowering stems and aboveground mass) in replicate burned versus unburned plots in a tallgrass prairie in Kansas (Hurlbert 1988). In these experimental plots, *Bouteloua curtipendula* was a minor component of the prairie grass mix. Another tallgrass prairie study shows that *Bouteloua curtipendula* decreases with burning (Wright 1974).

There is a wealth of information on the species' habitat outside of the northeastern United States. Detailed in Appendix 4, this information not only shows the species occupying prairie habitat of the Great Plains, but also restricted glades and barrens throughout much of the predominantly forested eastern United States. A great many of the habitats in the eastern states are related to limestone bedrock formations. All of the habitats have in common open, or sparsely shaded, conditions.

In the northeastern United States, *Bouteloua curtipendula* is rare and restricted to distinctive habitats. In southeastern Pennsylvania, it occurs in grasslands and stunted woodlands associated with the State-Line Serpentine Barrens in Chester and Lancaster counties (Dann 1988, The Nature Conservancy 2004). In these areas, the *Bouteloua curtipendula* grows with other prairie grasses, such as *Sorghastrum nutans, Aristida purpurascens*, and *Sporobolus heterolepis* (also rare), as well as the serpentine endemic *Aster depauperatus*. In the Ridge and Valley physiographic region of central Pennsylvania, *Bouteloua curtipendula* is the dominant grass in remnant "xeric limestone prairies", as described by Laughlin and Uhl (2003). These prairies, which may be

equivalent to glades elsewhere in the Northeast, occur in extremely shallow limestone soils on south-southwestern slopes.

In New York, *Bouteloua curtipendula* is known primarily from the Hudson and Housatonic Valleys, and less commonly from Long Island and the limestone-rich counties of western New York (New York Natural Heritage Program, unpublished data; New York State Museum unpublished herbarium label data). In the Hudson Valley, it occurs in calcareous redcedar barrens, on dry banks along the river, on limestone rocks, on dry shaly slopes, on dry till and calcareous conglomerate river bluffs, and also in weedy, highly-disturbed sandy or gravelly habitat associated with sand pits, power lines, and industrial development. In Columbia County, also within the Hudson Valley, *Bouteloua curtipendula* was abundant on the shale talus of a few hills, but largely absent elsewhere in the county (McVaugh 1958). On these unstable, excessively-drained, largely unforested shale slopes, *Bouteloua curtipendula* grew with dry woods species, as well as with other prairie species, such as *Sorghastrum nutans, Elymus canadensis,* and *Solidago rigida*, and several native annuals. At a calcareous (marble) redcedar barrens site in Dutchess County, *Bouteloua curtipendula* occurs as a dominant or important species in two small (1.5-2 ha) areas on steep, west-facing slopes with other important herbs such as *Schizachyrium* scoparium, *Carex eburnea, Aster patens*, *Minuartia michauxii, Solidago nemoralis, Antennaria plantaginifolia*, and *Centaurea maculosa* (Edinger 2003). Rare species more typical of prairie and dry, open habitats further west that also occur at this site are *Asclepias viridiflora, Draba reptans, Aristida purpurascens, Sporobolus compositus* var. *compositus* and *Linum sulcatum*. In western New York (Jefferson County), *Bouteloua curtipendula* is currently known from an alvar grassland and associated moist, transition pavement barrens. There, it grows in shallow soil on nearly level limestone outcrops, which are typically flooded in the spring and droughty in the late summer/fall (Reschke 1990). Associated species in the alvar include *Sporobolus neglectus*, *Panicum flexile*, *Sporobolus heterolepis*, *Solidago ptarmicoides*, *Allium schoenoprasum* var. *sibiricum*, and *Deschampsia cespitosa*.

At the northeast extreme of its range in Connecticut, *Bouteloua curtipendula* occurs rarely in both limestone and trap rock glades. It historically occurred also in sandy riverbanks or near river fields (Connecticut Geological and Natural History Survey [CTGNHS], unpublished data). The limestone glades, classified as *Schizachyrium scoparium – Bouteloua curtipendula* medium-tall grassland by CTGNHS or *Juniperus virginiana* / *Schizachyrium scoparium – Bouteloua curtipendula* Wooded Herbaceous Vegetation by The Nature Conservancy (CTGNHS, unpublished data), are small openings (less than 0.1 hectare) associated with marble outcrops. These glades are very dry sites found on knoll summits and on very steep southwest-facing slopes. Associated species at one of these limestone glades include *Schizachyrium scoparium*, *Helianthus divaricatus, Solidago ptarmicoides, Carex eburnea*, *Oryzopsis racemosa*, *Pycnanthemum* sp., and *Gentiana quinquefolia* (Engstrom, personal observation). The surrounding forest is a mix of *Fraxinus americana*, *Quercus rubra*, *Quercus alba, Carya glabra*, *Juniperus virginiana, Pinus strobus, Tilia americana,* and *Ostrya virginiana*. At another limestone site, *Asplenium platyneuron*, *Pellaea atropurpurea*, and *Asclepias verticillata* are

herbaceous associates, and *Juniperus virginiana*, *Juglans nigra*, and *Celtis occidentalis* are woody associates (CTGNHS, unpublished data).

The two trap rock glades where *Bouteloua curtipendula* occurs in Connecticut are located on the brows of small cliffs with west and southeast exposures. These trap rock glades, otherwise known as subacidic rocky summit/outcrops, cedar glades, or *Juniperus virginiana* / *Danthonia spicata* community (CTGNHS, unpublished data), are very small (circa 100 meter^2) openings associated with gently sloping basalt outcrops. The *Bouteloua curtipendula* grows in very shallow, stony, humus-rich soil over the trap rock, with herbs indicative of more acidic sites (*Danthonia spicata*, *Polygonum tenue*, *Trichostema dichotomum*, and *Viola fimbriatula*) and at the same time herbs indicative of circumneutral or subacidic substrates (*Aquilegia canadensis*, *Asplenium platyneuron*, *Elymus trachycaulus*, and *Potentilla arguta*) (Moorhead, personal communication; Engstrom, personal observation). The forest surrounding these glades is similar in composition to that of the limestone glades, although no *Juglans nigra* or *Celtis occidentalis* occur at these sites. Elevations of the Connecticut sites range from 15 m or less, to 411 m.

THREATS TO TAXON

In the heart of its range in the prairie states, habitat destruction through conversion to agriculture was, and probably still is, the biggest threat to *Bouteloua curtipendula*. On the ecosystem level, the prairies have undergone a massive decline. As much as two-thirds of the 370 million hectares of all original prairie in the Great Plains are estimated to have been lost since European settlement less than two centuries ago (Sims and Risser 2000). Essentially all of the tallgrass prairie has disappeared, with most states and provinces reporting greater than 99% loss. Less mixed-grass prairie has been lost; state or provincial estimates of decline range from 99.9% in Manitoba to 30% in Texas. Likewise, major declines of the shortgrass prairie have occurred, from 80% or more in Texas and Saskatchewan, to 20% in Wyoming.

In addition to habitat lost directly to agriculture, shifts in ecosystem processes have damaged prairie habitat (Sims and Risser 2000). Whereas once there were millions of bison (*Bison bison*) grazing intensively for short-periods over unfenced millions of hectares, now fenced-in cattle are likely to overgraze parcels of only hundreds of hectares. Overgrazing leads to major shifts in species composition with non-native species often invading. There has also been a massive decline in the prairie dog (*Cynomys ludovicianus*), a species whose foraging and burrowing habits had a major impact in prairie ecology, both directly and indirectly. Prairie fragmentation, as well as changing cultural habits, has lead to the decline of fire in the prairie. This has lead to woody plant encroachment and subsequent decline of prairie species.

Outside the Great Plains, both habitat destruction and habitat change threaten *Bouteloua curtipendula* populations, and in some cases have led to extirpations. In Connecticut, one and possibly two, *Bouteloua curtipendula* occurrences along rivers have disappeared. Impoundment of the river was the documented cause of one extirpation,

and likely the cause of the species' disappearance at another site. Details for this are provided in the section following the Status of New England Occurrences. Other habitat destruction mechanisms that potentially threaten populations in Connecticut and New York include mining (for sand or aggregate) and development, both commercial and industrial (New York Natural Heritage Program and CTGNHS unpublished data). Competition — through shading — by encroaching woody plants, both native and invasive, is believed to have led to the demise of several New York occurrences and is believed to be a threat at several Connecticut occurrences. Competition from invasive herbs is another potential threat in New England. Though not presently a problem, recreation activities (ATV and hiker traffic) are noted as potential threats to at least two Connecticut occurrences.

Another potential threat to the genetic integrity of the native Connecticut populations is the potential cross-breeding of wild, native plants with plants grown from commercial seed mixes. This is noted as a real possibility at one *Bouteloua curtipendula* occurrence (CT .004 [Brookfield]) where a limited access highway comes very close to the native population (Moorhead, personal communication). The potential for a cross might come if the highway right-of-way was planted with a wildflower seed mix containing *Bouteloua curtipendula*.

In Pennsylvania, population numbers in the few scattered occurrences have declined by 48% during the 20th century due to habitat losses from agriculture, development, and woody plant encroachment (Laughlin 2003). Loss of theorized natural dispersal agents — bison and elk — would also lead to the species decline. These large mammals were extirpated from Pennsylvania in the first half of the 19th century (Matthiessen 1964).

Because populations are small, inbreeding depression, genetic drift, and stochastic events (such as disease or weather) are other potential threats to the species' viability in the region. While no genetic studies have been done on *Bouteloua curtipendula*, genetic studies and theory suggest that selection may work against self pollinated individuals and homozygotes derived from selfing in small populations of outcrossing species (Neel et al. 2001).

DISTRIBUTION AND STATUS

General Status

With a rank of G5, *Bouteloua curtipendula* is a species considered secure on a global scale (NatureServe Explorer 2003). The distribution of *Bouteloua curtipendula* var. *curtipendula*, which is the variety of interest in this plan, basically mirrors that of the Great Plains, i.e. the central third of North America (north of Mexico), from southern Manitoba and Saskatchewan south to the Texas-Mexico border (Wipff 2003). The ranges of the other two varieties of *Bouteloua curtipendula* combined extend from the southwestern United States south through Mexico and into South America (Gould 1979).

Since it includes all varieties, the detailed distribution of *Bouteloua curtipendula* shown in *Flora of North America North of Mexico* (Wipff 2003) and utilized in this description must be adjusted by distributional information provided in the variety-specific maps shown in Gould and Kapadia (1964) and Gould (1979).

The northern edge of the *Bouteloua curtipendula* var. *curtipendula* primary range extends from southeastern Saskatchewan east across southern Manitoba, then southeast through the middle of Minnesota and Wisconsin to northern Illinois. From northern Illinois, its primary range extends south through western Illinois, then cuts southwest across southeastern Missouri. Thus, it is absent from the Mississippi lowlands natural division in Missouri (Yatskievych 1999). Continuing south, in Arkansas it occurs mostly in the northern counties, and in Oklahoma and Texas it occurs throughout, excepting the eastern-most counties.

The southern edge of the primary boundary of the taxon stops short of the international boundary at Texas for the most part, excepting at least one record of it in Coahuila, Mexico (Gould and Kapadia 1964 addenda, Gould 1979). *Bouteloua curtipendula* var. *curtipendula* becomes less common in west Texas, where *B. curtipendula* var. *caespitosa* is the prevalent variety. The primary western boundary of the taxon's range includes much of New Mexico, excepting the southwest portion of the state, into northeastern Arizona, southeastern Utah (Cronquist et al. 1977) and eastern Colorado. North of Utah, the taxon occurs primarily east of the Rocky Mountains, including eastern Colorado, Wyoming and Montana.

Outside of this primary range, *Bouteloua curtipendula* var. *curtipendula* occurs irregularly in all the far western states, as well as British Columbia and Alberta. Likewise, in the states east of the Mississippi River it has a much spottier distribution, even though it is recorded in most of the eastern states. Excluding Maine and Hawaii, where the taxon is considered introduced, *Bouteloua curtipendula* var. *curtipendula* is recorded from 41 states, the District of Columbia, five Canadian provinces, and one Mexican state (Table 1). These 41 states include Florida, where it occurs in at least two rare limestone glades (Gholson, unpublished data). One of these Gadsden County records with a voucher specimen is considered non-native in the Atlas of Florida Vascular Plants (Institute for Systematic Botany 2002). However, the species' presence in such appropriate, and natural, habitat for the species would indicate that it is indeed native. South Carolina, where the species establishment from an introduction has been questioned (Radford et al. 1968), is also included in the list of 41 states. The taxon has never been documented in seven states: Vermont, New Hampshire, Massachusetts, Rhode Island, Delaware, North Carolina, and Alaska.

Table 1. Occurrence and status of *Bouteloua curtipendula* in the United States and Canada based on information from Natural Heritage Programs.

OCCURS & LISTED (AS S1, S2, OR T &E)	OCCURS & NOT LISTED (AS S1, S2, OR T & E)	OCCURRENCE REPORTED OR UNVERIFIED	HISTORIC (LIKELY EXTIRPATED)
Connecticut (S1, E): 4 extant, 2 historical, and 1 extirpated	Florida (S1?): 2 occurrences in one county (Gholson, unpublished data)	Alabama (SR)	District of Columbia (SH)
Georgia (S2)	Illinois (S3S4): 54 counties (Mohlenbrock 2001)	Alberta (SR): (Wipff 2003)	
Louisiana (S1): at least 4 counties (Northeast Louisiana State University Herbarium 1996)	Iowa (S4)	Arizona (SR)	
Manitoba (S2)	Kentucky (S3?): 15 extant occurrences	Arkansas (SR)	
Maryland (S2)	Mississippi (S3S4)	British Columbia (SR) (Wipff 2003)	
Michigan (S1S2,T): Michigan Natural Features Inventory (2004)	Saskatchewan (S3)	California (SR)	
New Jersey (S1, E)	Virginia (SR): more than 5 occurrences (Tom Rawinski, personal communication)	Colorado (SR)	
New York (S1, E): 19 occurrences including 7 extant, 4 historical, 2 extirpated, 4 possibly extirpated, and 2 unknown (New York Natural Heritage Program, unpublished data)	West Virginia (S3): 3 adjacent counties (Strausbaugh and Core 1977)	Idaho (SR)	
Ontario (S2): 6 counties (Oldham 1999)	Wyoming (S3): at least 41 occurrences (Rocky Mountain Herbarium 1998)	Indiana (SR)	
Pennsylvania (S2)		Kansas (SR)	
		Minnesota (SR)	
		Missouri (SR)	
		Montana (SR)	
		Nebraska (SR)	
		Nevada (SR)	
		New Mexico (SR)	
		North Dakota (SR)	
		Ohio (SR)	
		Oklahoma (SR)	
		Oregon (SR)	

Table 1. Occurrence and status of *Bouteloua curtipendula* in the United States and Canada based on information from Natural Heritage Programs.			
OCCURS & LISTED (AS S1, S2, OR T &E)	**OCCURS & NOT LISTED (AS S1, S2, OR T & E)**	**OCCURRENCE REPORTED OR UNVERIFIED**	**HISTORIC (LIKELY EXTIRPATED)**
		South Carolina (SR): introduction not established (Radford et al. 1968)	
		South Dakota (SR)	
		Tennessee (SR): at least 12 counties (University of Tennessee Herbarium 2004)	
		Texas (SR)	
		Utah (SR)	
		Washington (SR)	
		Wisconsin (SR)	

The species is rare in the northern-most portion of its range, including Canada (Ontario, Manitoba, and Saskatchewan) and the northeastern states, and in the southeastern United States (Wipff 2003 and Table 1). It is uncommon, or at least shows a very spotty distribution, in the more interior states east of the Mississippi River. The center of its distribution appears to be Kansas and Nebraska. While recorded in all of the western states, i.e. west of, or including, the Rocky Mountains, the distribution map indicates it occurs rarely over that vast terrain, except in New Mexico. Though dated, the rarity of the species in the Pacific Northwest region is evidenced by a lack of records from Idaho, Oregon, and Washington (Hitchcock and Cronquist 1973). Likewise, in the Intermountain West (the Great Basin and adjacent lands) *Bouteloua curtipendula* var. *curtipendula* is recorded as occurring in northeastern Arizona and southeastern Utah (Cronquist et al. 1977).

What this table does not illustrate is the extreme decline the species has undergone in the prairie states. In these states, which are biogeographically central to the species, the landscape has essentially been converted to agricultural fields. As described in the preceding Threats section, perhaps as much as two-thirds of the all the prairies (tallgrass, mixed-grass, and shortgrass) in the Great Plains have disappeared (Sims and Risser 2000). While *Bouteloua curtipendula* in the Great Plains states is generally not threatened, it has undeniably undergone a huge population decline.

In states east of the Mississippi River where the species is not considered rare or uncommon, loss of its favored prairie, savannah, barren, and glade habitats has undoubtedly resulted in huge declines in the species' abundance. Precipitous declines (90-99%) have been documented in the following ecosystems where the species occurs: dry sand and blacksoil prairies in Michigan, oak barrens in Michigan, prairies in Indiana

and Ohio, oak savanna throughout the Midwest, bluegrass savanna-woodland and prairies in Kentucky, limestone redcedar (*Juniperus virginiana*) glades in Tennessee, and Black Belt prairie in Alabama and Mississippi (Noss et al. 1995).

Status of All New England Occurrences — Current and Historical

Bouteloua curtipendula, known as a native plant in New England only from Connecticut, has been categorized as a Division 2 taxon in *Flora Conservanda*, i.e., a taxon rare in the New England region (Brumback and Mehrhoff, et al. 1996). Two 1902 specimens at the Gray Herbarium from North Berwick, York County, Maine, with "wool-waste" as label data (Arthur Haines, Herbarium Recovery Project, unpublished data) are considered introduced, or non-native, hence not further documented in this conservation plan. In a New England Botanical Club report on plant distribution, *Bouteloua curtipendula* is listed as occurring in Massachusetts (Bean et al. 1946). While no Massachusetts specimens have been found in researching this plan, a specimen from this state should be sought after, especially since the list in the New England Botanical Club report was purportedly based on documented specimens. It should also be noted that three New York occurrences (two extant and one historical) lie within 30 km of four Connecticut occurrences (three extant and one historical), and that all of these occurrences, plus three other Connecticut occurrences more distant, are in the Housatonic River watershed.

In 2003, independent botanist/ecologist Tom Rawinski (personal communication) observed many individuals of *Bouteloua curtipendula* on the grounds of the EcoTarium in Worcester, Massachusetts, in an area seeded to warm-season grasses. Because the planting of such grasses is becoming increasingly popular, the origin of newly discovered populations must be held in question. One supplier of *Bouteloua curtipendula* seed, Calvin Ernst, admitted to Rawinski that his stock originated from the McAlisterville cedar glade in Pennsylvania. A web search shows *Bouteloua curtipendula* is readily available from a number of commercial sources.

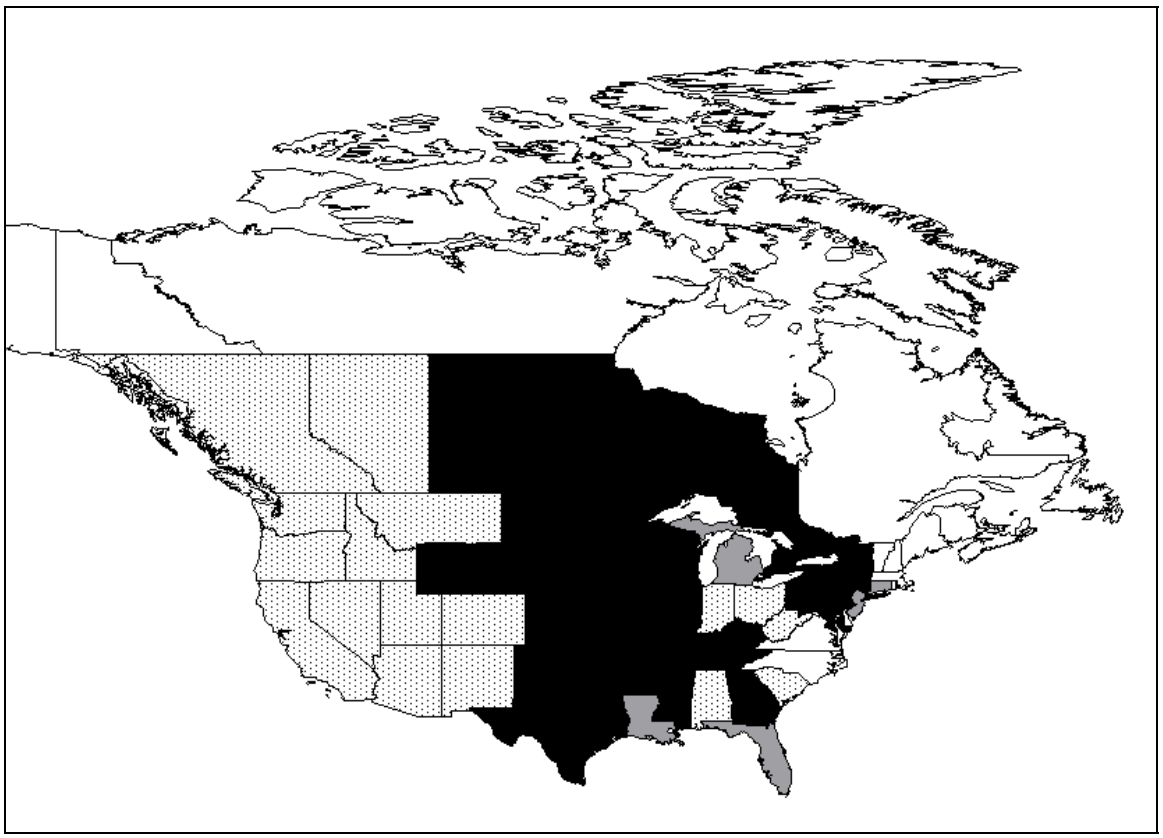

Figure 1. Occurrences of *Bouteloua curtipendula* in North America. States or provinces shaded in gray have one to five (or an unspecified number of) current occurrences of the taxon. Areas shaded in black have more than five confirmed occurrences. Areas with stippling are ranked "SR" (status "reported" but not necessarily verified). See Appendix for explanation of state ranks.

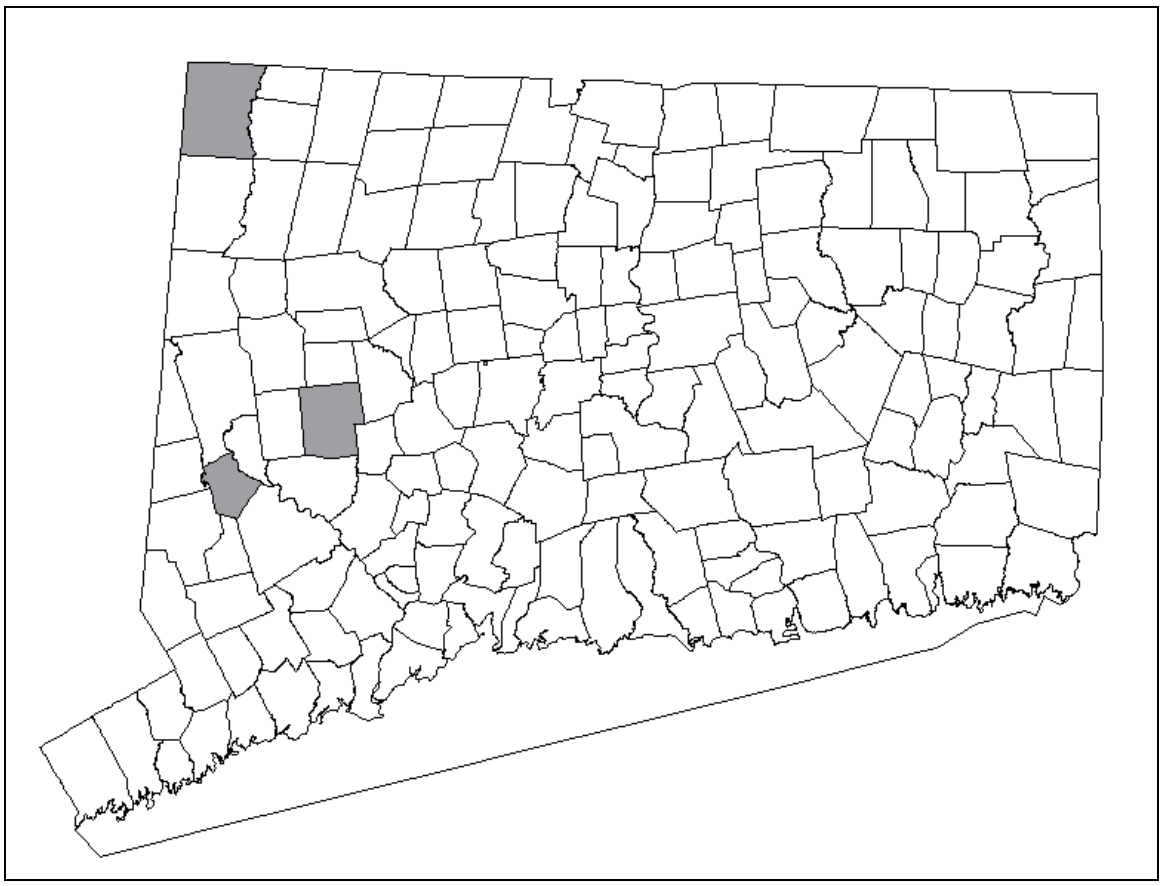

Figure 2. Extant occurrences of *Bouteloua curtipendula* in New England. Town boundaries for Connecticut (the only New England state in which the taxon occurs) are shown. Towns shaded in gray have one to five extant occurrences of the taxon.

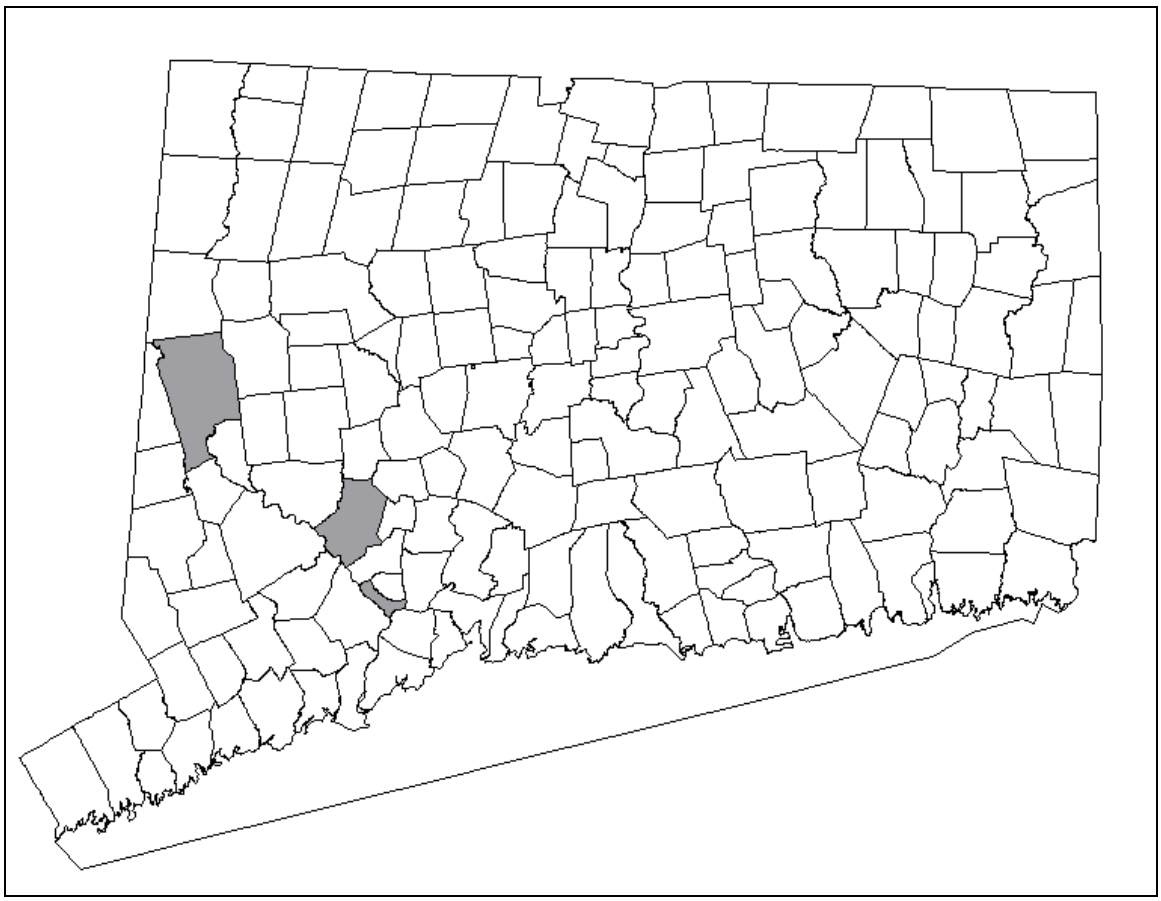

Figure 3. Historic occurrences of *Bouteloua curtipendula* in New England. Towns shaded in gray have one to five historic records of the taxon.

Table 2. New England Occurrence Records for *Bouteloua curtipendula.* Shaded occurrences are considered extant.			
State	**EO #**	**County**	**Town**
CT	**.001**	**Litchfield**	**Salisbury**
CT	.002	Litchfield	New Milford
CT	.003	New Haven	Oxford
CT	**.004**	**Fairfield**	**Brookfield**
CT	**.005**	**Litchfield**	**Woodbury**
CT	**.006**	**Litchfield**	**Woodbury**
CT	.007	New Haven	Derby

II. CONSERVATION

CONSERVATION OBJECTIVES FOR THE TAXON IN NEW ENGLAND

The primary conservation objective for *Bouteloua curtipendula* in New England is to maintain four occurrences of the species distributed throughout its historical range in the western part of Connecticut. These four will include all extant occurrences: two on marble and two on trap rock. The goal for the total *Bouteloua curtipendula* population in New England is to have 450 clumps with a total annual production of 675 flowering stems. The total of 450 clumps will include two occurrences with 200 clumps, plus occurrences with 30 and 20 clumps. Population size is expressed in terms of clumps because the species is rhizomatous; hence, precise genet figures are unobtainable. The rationale for conserving four occurrences is based on being able to maintain all extant occurrences. The population numbers are based on high count figures (or reasonable estimate in case of CT .001 [Salisbury]) for all four extant occurrences. The goal of producing 675 flowering stems annually equals 150% of the number of clumps based on a rough average of known stem production at Connecticut occurrences. Another conservation objective is to have at least three of the four occurrences protected, via conservation easement or land acquisition, within the next twenty years. Additionally, it is recommended that a strong effort be made to relocate historical occurrences, or discover new occurrences through *de novo* surveys.

III. LITERATURE CITED

Angelo, R. and D. E. Boufford. 1998. Atlas of the flora of New England: Poaceae. *Rhodora* 100: 101-233.

Bakowsky, W. O. and M. J. Oldham. 1998. Significant prairie and savannah vegetation in northwestern Ontario. Unpublished report. Ontario Natural Heritage Information Centre, Ministry of Natural Resources, Peterborough, Ontario, Canada.

Barkworth, M. E., K. M. Capels, S. Long, and M. B. Piep (Editors). 2003. *Flora of North America North of Mexico Volume 25: Magnoliophyta: Commelinidae (in part): Poaceae, part 2*. Oxford University Press, New York, New York, USA.

Barkworth, M. E., K. M. Capels, and L. A. Vorobik (Editors). 2000. *Manual of Grasses for North America North of Mexico*. Utah State University, Logan, Utah, USA. Available (in progress) at http://www.herbarium.usu.edu/webmanual/default.htm (Accessed: February 11, 2003).

Baskin, J. M. and C. C. Baskin. 2000. Vegetation of limestone and dolomite glades in the Ozarks and midwest regions of the United States. *Annals of the Missouri Botanical Garden* 87: 286-294.

Bean, R. C., C. H. Knowlton, A. F. Hill. 1946. Ninth report of the committee on plant distribution. Preliminary lists of New England plants – XXXIV. *Rhodora* 48: 15-25.

Britton, N. L. and A. Brown. 1896. *An Illustrated Flora of the Northern United States, Canada, and the British Possessions*. Charles Scribner's Sons, New York, New York, USA.

Brouillet, L. and R. D. Whetstone. 1993. Climate and physiography. Pages 15-46 in Flora of North America Committee (Editors), *Flora of North America North of Mexico Volume 1: Introduction*. Oxford University Press, New York, New York, USA.

Brumback W. E., L. J. Mehrhoff, R. W. Enser, S. C. Gawler, R. G. Popp, P. Somers, D. D. Sperduto, W. D. Countryman, and C. B. Hellquist. 1996. *Flora Conservanda*: New England. The New England Plant Conservation Program (NEPCoP) list of plants in need of conservation. *Rhodora* 98: 233-361.

Carr, L. G. 1944. A new species of *Houstonia* from the cedar barrens of Lee County, Virginia. *Rhodora* 46: 306-310.

Chadwick, A. C. 2003. *Bouteloua curtipendula.* In Fire Effects Information System [web application]. United States Department of Agriculture, Forest Service, Rocky

Mountain Research Station, Fire Sciences Laboratory. Available at http://www.fs.fed.us/database/feis/ (Accessed: February 12, 2004).

Collins, S. L. 1990. Introduction: fire as a natural disturbance in tallgrass prairie. Pages 3-7 in S. L. Collins and L. L. Wallace (Editors), *Fire in North American Tallgrass Prairies.* University of Oklahoma Press, Norman, Oklahoma, USA.

Cronquist, A., A. H. Holmgren, N. H. Holmgren, J. L. Reveal, and P. K. Holmgren. 1977. *Intermountain Flora, Volume Six*. Columbia University Press, New York, New York, USA.

Curtis, J. T. 1959. *The Vegetation of Wisconsin*. University of Wisconsin Press, Madison, Wisconsin, USA.

Dann, K. T. 1988. *Traces on the Appalachians: A Natural History of Serpentine in Eastern North America*. Rutgers University Press, New Brunswick, New Jersey, USA.

DeSelm, H. R. 1989. The barrens of Tennessee. *Journal of the Tennessee Academy of Science* 64: 89-95.

Dore, W. G. and J. McNeill. 1980. *Grasses of Ontario*. Biosystematics Research Institute, Research Branch, Agriculture Canada. Monograph 26, Ottawa, Ontario, Canada.

Dyksterhuis, E. J. 1948. The vegetation of the Western Cross Timbers. *Ecological Monographs* 18: 325-376.

Edinger, G. J. 2003. Assessment and classification of the Red Cedar Communities at Nellie Hill, Dutchess County, NY. New York Natural Heritage Program, Albany, New York, USA.

Engstrom, B. 2004a. *Sporobolus compositus* (Poiret) Merrill var. *compositus* (Tall Dropseed) Conservation and Research Plan for New England. New England Wild Flower Society, Framingham, Massachusetts, USA.

Engstrom, B. 2004b. *Sporobolus heterolepis* (A. Gray) A. Gray (Prairie Dropseed) Conservation and Research Plan for New England. New England Wild Flower Society, Framingham, Massachusetts, USA.

Fassett, N. C. 1951. *Grasses of Wisconsin*. University of Wisconsin Press, Madison, Wisconsin, USA.

Fell, E. W. 1956. Notes on a new hybrid *Carex*. *Rhodora* 58: 318-320.

Fernald, M. L. 1950. *Gray's Manual of Botany*. Eighth Edition. American Book Company, New York, New York, USA.

Fitzgerald, H. 2002. *Establishing Conservation Priorities on Connecticut's Trap Rock Ridges: A Site Conservation Plan*. M. Sc. Thesis, School of Natural Resources, University of Vermont, Burlington, Vermont, USA.

Florida Natural Areas Inventory. 1990. Guide to the Natural Communities of Florida. Florida Natural Areas Inventory and Department of Natural Resources, Tallahassee, Florida, USA.

Georgia Natural Heritage Program. 2003. Plants of special concern list on website. Available at http://georgiawildlife.dnr.state.ga.us/content/specialconcernplants.asp (Accessed: February 21, 2003).

Gleason, H. A. and A. Cronquist. 1991. *Manual of Vascular Plants of Northeastern United States and Adjacent Canada*. Second Edition. The New York Botanical Garden, Bronx, New York, USA.

Glenn-Lewin, D. C., L. A. Johnson, and T. W. Jurik. 1990. Fire in central North American grasslands: vegetative reproduction, seed germination, and seedling establishment. Pages 28-45 in S. L. Collins and L. L. Wallace (Editors), *Fire in North American Tallgrass Prairies.* University of Oklahoma Press, Norman, Oklahoma, USA.

Gould, F. W. 1975. *Grasses of Texas*. Texas A and M University Press, College Station, Texas, USA.

Gould, F. W. 1979. The genus *Bouteloua* (Poaceae). *Annals of the Missouri Botanical Garden* 66: 348-416.

Gould, F. W. and Z. J. Kapadia. 1964. Biosystematic studies in the *Bouteloua curtipendula* complex II. Taxonomy. *Brittonia* 16: 182-207.

Graves, C. B., E. H. Eames, C. H. Bissell, L. Andrews, E. B. Harger, and C. A. Weatherby. 1910. *Catalogue of the Flowering Plants and Ferns of Connecticut*. Connecticut State Geological and Natural History Survey Bulletin No. 14, Hartford, Connecticut, USA.

Gray, A. 1867. *Manual of the Botany of the Northern United States*. Fifth Edition, Eighth Issue. Ivison, Blakeman and Company, New York, New York, USA.

Great Plains Flora Association. 1986. *Flora of the Great Plains*. University Press of Kansas, Lawrence, Kansas, USA.

Greene, H. C. and Curtis, J. T. 1950. Germination studies of Wisconsin prairie plants. *American Midland Naturalist* 43: 186-194.

Griffiths, D. 1912. The grama grasses: *Bouteloua* and related genera. *Contributions from the National Herbarium* 14: i-viii, 343-428.

Haines, A. and T. F. Vining. 1998. *Flora of Maine*. F. V. Thomas Company, Bar Harbor, Maine, USA.

Harlan, J. R. 1949. Apomixis in side-oats grama. *American Journal of Botany* 36: 495-499.

Hitchcock, A. S. 1971. *Manual of the Grasses of the United States*. Second Edition, revised by Agnes Chase (unabridged reprint of the 1950 U.S. Government Printing Office publication). Two Volumes. Dover Publications, New York, USA.

Hitchcock, C. L. and A. Cronquist. 1973. *Flora of the Pacific Northwest*. University of Washington Press, Seattle, Washington, USA.

Hurlbert, L. C. 1988. Causes of fire effects in tallgrass prairie. *Ecology* 69: 46-58.

Index Herbariorum. 2003. Part I: the Herbaria of the World, Eighth Edition [web application]. New York Botanical Garden, Bronx, New York. Available at http://www.nybg.org/bsci/ih/ih.html (Accessed: April 15, 2003)

Institute for Systematic Botany. 2002. Atlas of Florida Vascular Plants [web application]. University of South Florida, Tampa, Florida. Available at http://www.plantatlas.usf.edu/main.asp?plantID=151 (Accessed: February 4, 2004).

Jones, C. H. 1944. Studies in Ohio floristics –III. Vegetation of Ohio prairies. *Bulletin of the Torrey Botanical Club* 71: 536-548.

Keys, J. E., and C. A. Carpenter, S. Hooks, F. Koenig, W. H. McNab, W. Russell, and M. L. Smith. 1995. Ecological units of the Eastern United States - first approximation (map and booklet of map unit tables). U. S. Department of Agriculture, Forest Service, Atlanta, Georgia, USA.

Kuchler, A. W. 1964. Manual to accompany the map of potential vegetation of the conterminous United State. Special Publication No. 36. American Geographical Society. New York, New York, USA.

Laughlin, D. C. 2003. Geographic distribution and dispersal mechanisms of *Bouteloua curtipendula* in the Appalachian Mountains. *The American Midland Naturalist* 149: 268-281.

Laughlin, D. C. and C. F. Uhl. 2003. The xeric limestone prairies of Pennsylvania. *Castanea* 68: 300-316.

Leithead, H. L., L. L. Yarlett, and T. N. Shiflet. 1971. 100 native forage grasses in 11 southern states. Agricultural Handbook No. 389. Soil Conservation Service, U. S. Department of Agriculture, Washington, D.C., USA.

Matthiessen, P. 1964. *Wildlife in America*. Viking Press, New York, New York, USA.

McVaughn, R. 1958. Flora of Columbia County area, New York. New York State Museum and Science Service Bulletin Number 360, University of the State of New York, Albany, New York, USA.

Mehrhoff, L. 1997. Thoughts on the biogeography of grassland plants in New England. Pages 15-24 in P. D. Vickery and P. W. Dunwiddie (Editors), *Grasslands of Northeastern North America*. Massachusetts Audubon Society, Lincoln, Massachusetts, USA.

Michigan Natural Features Inventory. 2004. Rare plant reference guide [web application]. Michigan State University Extension, Lansing, Michigan. Available at http://web4.msue.msu.edu/mnfi/data/rareplants/cfm?species=bouteloua=curtipendula (Accessed: February 5, 2004).

Mohlenbrock, R. H. 2001. *The Illustrated Flora of Illinois: Grasses Panicum to Danthonia*. Southern Illinois University Press, Carbondale and Edwardsville, Illinois, USA.

Mueller, I. M. and J. E. Weaver. 1942. Relative drought resistance of seedlings of dominant prairie grasses. *Ecology* 23: 387-398.

Natural Resources Conservation Service. 1996. List of sources of perennial grass seed. Available at http://plant-materials.nrcs.usda.gov/pubs/ndpmcarsedundlst.pdf (Accessed: February 12, 2003)

NatureServe Explorer: An online encyclopedia of life [web application]. 2003. Version 1.8. Arlington, Virginia, USA: NatureServe. Available at http://www.natureserve.org/explorer (Accessed: January 21, 2004).

Neel, M. C., J. Ross-Ibarra, and N. C. Ellstrand. 2001. Implications of mating patterns for conservation of the endangered plant *Eriogonum ovalifolium* var. *vineum* (Polygonaceae). *American Journal of Botany* 88:1214-1222.

Northeast Louisiana State University Herbarium. 1996. Louisiana Grasses [web application]. In conjunction with Texas A & M University Bioinformatics Working Group. Available at http://www.csdt.tamu.edu/FLORA/cgi/lagrasses_map_page?gen=bouteloua&spec=curtipendula (Accessed: February 4, 2004).

Noss, R. F., E. T. LaRoe III, and J. M. Scott. 1995. Endangered ecosystems of the United States: a preliminary assessment of loss and degradation. Biological Report 28. U. S. Department of Interior, National Biological Service, Washington, D. C., USA.

Oakes, W. 1841. Some notes on rare plants of New England. *Hovey's Magazine of Horticulture* 7: 178-186.

Oldham, M. J. 1999. Natural Heritage Resources of Ontario: Rare Vascular Plants. Natural Heritage Information Centre, Ontario Ministry of Natural Resources, Peterborough. Available as pdf file from http://www.mnr.gov.on.ca/MNR/nhic/species/rarevascular.pdf (Accessed: February 10, 2003).

Plant Resources Center. 2003. Flora of Texas Database [web application]. University of Texas, Austin. Available at http://129.116.69.198:427/fmpro?-db=fltexdbonline.fp5&-format=results%5fii.html (Accessed: February 8, 2004).

Pullen Herbarium. 2002. Herbarium specimen database [web application]. Thomas Pullen Herbarium, University of Mississippi, University, Mississippi, USA. Available at http:// www.herbarium.olemiss.edu/searchmissnew.php (Accessed: February 7, 2004).

Quarterman, E. 1989. Structure and dynamics of the limestone cedar glade communities in Tennessee. *Journal of the Tennessee Academy of Science* 64: 155-158.

Radford, A. E., H. E. Ahles, and C. R. Bell. 1968. *Manual of the Vascular Flora of the Carolinas*. University of North Carolina Press, Chapel Hill, North Carolina, USA.

Reschke, C. 1990. *Ecological Communities of New York State*. New York Natural Heritage Program, New York State Department of Environmental Conservation, Latham, New York, USA.

Robertson, J. H. 1939. A quantitative study of true-prairie vegetation after three years of extreme drought. *Ecological Monographs* 9: 431-492.

Rock, H. W. 1981. *Prairie Propagation Handbook*. Sixth Edition. Wehr Nature Center, Hales Corners, Wisconsin, USA.

Rocky Mountain Herbarium. 1998. Atlas of the vascular flora of Wyoming. University of Wyoming, Laramie, Wyoming, USA. Available at http://www.esb.utexas.edu/tchumley/ wyomap/atlas.htm (Accessed: February 3, 2004).

Rodgers, J. 1985. Bedrock Geologic Map of Connecticut. Connecticut Geological and Natural History Survey, Department of Environmental Protection, Hartford, Connecticut, USA. 42x54" color map, scale 1: 125,000.

Rosburg, T. R. and D. C. Glenn-Lewin. 1996. Species composition and environmental characteristics in the loess hills of western Iowa (USA). *Natural Areas Journal* 16: 313-334.

Seymour, F. C. 1989. *The Flora of New England*. Second Edition, Third Printing with Supplement. Phytologia Memoirs V. Privately printed.

Sims, P. L. and P. G. Risser. 2000. Grasslands. Pages 323-356 in Barbour, M. G. and Billings, W. D. (Editors), *North American Terrestrial Vegetation*. Second Edition. Cambridge University Press, Cambridge, UK.

Steila, D. 1993. Soils. Pages 47-54 in Flora of North America Committee (Editors), *Flora of North America North of Mexico Volume 1: Introduction*. Oxford University Press, New York, New York, USA.

Steyermark, J. A. 1934. Some features of the flora of the Ozark region in Missouri. *Rhodora* 36: 214-233.

Strausbaugh, P. D. and E. L. Core. 1977. *Flora of West Virginia.* Second Edition. Seneca Books Inc., Morgantown, West Virginia, USA.

Texas State Senate. 1971. Senate Concurrent Resolution No. 31: Official state grass, [web application]. Available at http://www.geobop.com/world/na/us/tx/resolution.htm (Accessed: February 12, 2004).

The Nature Conservancy [web application]. 2001. Ecoregions of the United States of America (map). The Nature Conservancy, Arlington, Virginia, USA. Available at http://gis.tnc.org/data/MapbookWebsite/map_large.php?map_id=27andimage=LARGE (Accessed: February 11, 2003).

The Nature Conservancy [web application]. 2004. New Texas serpentine barren preserve. Available at http://nature.org/wherewework/northamerica/states/pennsylvannia/preserves/art9593.html (Accessed: March 8, 2004).

Transeau, E. N. 1935. The prairie peninsula. *Ecology* 16: 423-437.

United States Department of Agriculture. 1937. Range Plant Handbook. USDA Forest Service, Washington D. C., USA.

University of Tennessee Herbarium. 2001. Database of Tennessee Vascular Plants [web application]. University of Tennessee, Knoxville, Tennessee, USA. Available at http://tenn.bio.utk.edu/vascular/database/vascular-maps.asp?categoryID=monocots&familyID=Poaceae (Accessed February 4, 2004).

Waterfall, U. T. 1948. Distributional notes and some minor forms from Oklahoma. *Rhodora* 50: 91-98.

Waterfall, U. T. 1949. Some results of a summer's botanizing in Oklahoma. *Rhodora* 51: 18-28.

Weaver, J. E. 1958. Summary and interpretation of underground development in natural grassland communities. *Ecological Monographs* 28: 55-78.

Weaver, J. E. and T. J. Fitzpatrick. 1934. The prairie. *Ecological Monographs* 4: 109-295.

Wipff, J. K. 2003. *Bouteloua* Lag. Pages 250-269 in Barkworth, M. E., K. M. Capels, S. Long, and M. B. Piep (Editors), *Flora of North America North of Mexico Volume 25: Magnoliophyta: Commelinidae (in part): Poaceae, part 2*. Oxford University Press, New York, New York, USA.

Wisconsin Plant Ecology Laboratory. 2003. Wisconsin Plant Ecology Laboratory data [web application], Prairie description. University of Wisconsin, Madison, Wisconsin, USA. Available at http://www.botany.wisc.edu/wisflora/curtis.html1#Prairie (Accessed: February 21, 2003).

Wright, H. A. 1974. Effect of fire on southern mixed prairie grasses. *Journal of Range Management* 27: 417-419.

Yatskievych, G. 1999. *Steyermark's Flora of Missouri, Volume 1*. Missouri Department of Conservation, Jefferson City, Missouri, USA.

IV. APPENDICES

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1. **Abbreviations for Herbaria (Index Herbariorum 2003)**

2. **Habitat Descriptions Outside Northeastern United States**

3. **An Explanation of Conservation Ranks Used by The Nature Conservancy and NatureServe**

1. Abbreviations for Herbaria (Index Herbariorum 2003)

CONN = Torrey Herbarium at University of Connecticut, Storrs, Connecticut

GH = Gray Herbarium at Harvard University, Cambridge, Massachusetts

MISS = Pullen Herbarium, University of Mississippi, University, Mississippi

NEBC = New England Botanical Club at Harvard University, Cambridge, Massachusetts

NCBS = Connecticut Botanical Society at Yale University, New Haven, Connecticut

NY = New York Botanical Garden, New York, New York

VT = Pringle Herbarium at the University of Vermont, Burlington, Vermont

YU = Yale University, New Haven, Connecticut

2. Habitat Descriptions Outside Northeastern United States

The following descriptions excerpted from floras in the central and western portion of the species' range give an indication of the variety habitats the species can be found in:

- "Open grassland and woodland openings; often dominant or co-dominant, increasingly used in native-grass mixtures" (Great Plains Flora Association 1986: 1227, referring to the Great Plains region)

- "Dry grassy, shrubby and open woodland hillsides, mesas and canyons at low elevations" (Cronquist et al. 1977: 440, referring to the intermountain region [Great Basin and adjacent country] in western United States)

- "Prairies; dry hills....rather common on the bluffs bordering the Mississippi" (Mohlenbrock 2001: 306, referring to Illinois)

- "Glades, upland prairies, savannas, and rocky openings of mesic to dry upland forests, almost always on calcareous substrates; also roadsides and railroads" (Yatskievych 1999: 676, referring to Missouri)

- "...in open grasslands, woods borders and road right-of-ways, generally in the better soils and on little disturbed sites" (Gould 1975: 338, referring to Texas)

- "A characteristic plant of high prairies..." (Fassett 1951: 68, referring to Wisconsin)

In the mixed-grass prairie of west-central Kansas *Bouteloua curtipendula* is a dominant in the more mesic sites, along with *Andropogon gerardii*, *Sporobolus compositus*, and *Pascopyrum smithii*, while it is of secondary importance in the drier landscape positions (Sims and Risser 2000). In central Oklahoma mixed grass prairie, the species is prevalent, along with *Schizachyrium scoparium*, *Andropogon chrysocomus* (= *A. hallii*), *A. saccharioides* (=*Bothriochloa* sp.), *Agropyron smithii*, and *Sporobolus asper* (=*S. compositus*). In their major study of the tallgrass, or true prairie, of eastern Nebraska, western Iowa, and adjacent states, Weaver and Fitzpatrick (1934) noted *Bouteloua curtipendula* as a minor component of both the *Stipa spartea* and *Andropogon furcatus* (= *A. gerardi*) consociations, the former occupying dry slopes and ridges of the central and northern portions of the true prairie, and the latter prominent on moist slopes and well-drained lowlands.

In Texas, where the species reaches its southern extent, *Bouteloua curtipendula* var. *curtipendula* shows a wide ecological amplitude in terms of soil types, yet appears constrained in distribution by climate-related factors. Based on label data from 66 specimens of this variety found in the Flora of Texas Database (Plant Resources Center 2003), the species is notably absent from the arid lands of the Chihuahuan Desert ecoregion (The Nature Conservancy 2001) of the western panhandle. Specimens are also

very sparse from the humid Upper West Gulf Coastal Plain, Piney Woods, and Gulf Coast Prairies and Marshes ecoregions of eastern Texas. Based on specimens, the species is well distributed throughout the Southern Shortgrass Prairie, Crosstimbers and Southern Tallgrass Prairie, and Edwards Plateau ecoregions. With open, upland conditions being common factors, the species spans the spectrum of soil textures and reactions. Divided by ecoregions, the habitats listed below are all based on herbarium label data of Texas specimens. Counties are in parentheses.

Southern Shortgrass Prairie
prairie area (Lipscomb)
limestone outcrop (Hutchinson)
sandy prairie (Cochran)
caliche slope (Castro)
tight soil (Andrews)
mesquite savannah (Howard)

Edwards Plateau
open rocky slopes (Crockett)
sterile gravelly or rocky soil (Uvalde)
soils here derived from granite (Gillespie)
brown clayey soil (Bandera)
sandstone hills range site, stony fine sandy loam soil

Crosstimbers and Southern Tallgrass Prairie
Austin chalk (Williamson)
dry gravelly prairies on steep sandstone slopes (Wise)
hillslope blackland prairie (Fannin)
native blackland prairie (Hunt)

In the Western Crosstimbers region of north-central Texas (west of Dallas), *Bouteloua curtipendula* averaged 27% cover in vegetation plots used in describing this unique savannah vegetation (Dyksterhuis 1948). This vegetation/physiographic region is mapped as a portion of the mixed-grass prairie in a recent grasslands map (Sims and Risser 2000), yet it, along with the Blackland Prairie, is treated uniquely as the Crosstimbers and Southern Tallgrass Prairie ecoregion by The Nature Conservancy (2001). It is a region of rolling tablelands with sandstone-derived sandy loam (and gravelly in places) over clay soils supporting a grass-dominated herb layer and a sparse, small tree canopy of *Quercus stellata* and *Q. marilandica*. More important grasses (yet all with less than 10% cover) include *Buchloe dactyloides, Aristida* spp., and *Bouteloua hirsuta*. Annual forbs account for 18.8% of the groundcover.

In the limestone plateau region of south-central Oklahoma known as the Arbuckle Mountains, *Bouteloua curtipendula* occurs on the drier portions of north slopes while typical tallgrass prairie grasses occupy the lower slopes (Waterfall 1948). Xeric grassland species (*Bouteloua hirsuta, B. rigidiseta,* and *Triodia* spp.) dominate the south slopes in this region. To the west in the more arid Oklahoma panhandle (Cimarron

County), *Bouteloua curtipendula* is of secondary importance in the Mesa de Maya phytogeographic region (Waterfall 1949). Here the species grows at nearly 1525 m elevation in *Hilaria jamesii – Bouteloua gracilis* dominated grasslands in the valleys among the basalt-capped sandstone mesas. Pinyon-juniper woodlands occupy the mesa slopes.

In the loess hills region of western Iowa, *Bouteloua curtipendula* is a component of most grassland communities and some woodland communities (Rosberg and Glenn-Lewin 1996). This region of rugged hills bordering the Missouri River is derived from the dissection of deep (20-60 m), Wisconsinan-aged loess deposits. Here the species is most frequent (15-20%) in the mid-grass community types, which occupy the drier summit, upper slope, and mid-slope positions, and is less frequent (5-10%) in the chronically disturbed bluff colluvium and the moister tallgrass communities occupying lower slopes. It was infrequent in the redcedar (*Juniperus virginiana*)woodland and woodland edge communities. *Schizachyrium scoparium*, *Andropogon gerardii*, *Muhlenbergia cuspidata*, *Lygodesmia juncea*, *Carex heliophilia*, and *Amorpha canescens* are the most frequent species associated with *Bouteloua curtipendula* in the grassland community types. In terms of plant biomass in the grasslands, *Bouteloua curtipendula* ranged from circa one percent in the tallgrass to 8.5% in the mid-grass community.

In his classic study of the vegetation of Wisconsin, Curtis (1959) found *Bouteloua curtipendula* to be a major dominant in xeric (dry and dry-mesic) prairies. In contrast, he did not include it as a prevalent species in either mesic or wet-mesic prairie types, and it was not present at all in wet prairies. Based on his sampling, *Bouteloua curtipendula* is one of the top ten indicator species for dry prairie. Other indicator species in this prairie type include *Schizachyrium scoparium*, *Anemone patens*, *Arenaria stricta*, *Artemesia caudata*, *Aster ptarmicoides*, *Aster sericeus*, *Panicum perlongum*, *Petalostemum purpureum*, and *Solidago nemoralis*. The xeric prairies, including dry and dry-mesic types, are found on predominantly steep, southwest-facing slopes with thin, organic-rich loess soils over limestone and other bedrock types. These sites have very calcareous soils with pH values rarely less than 8.0 and calcium values of 5000 ppm or greater the rule. This type of prairie, locally known as "goat prairie," is most frequently associated with the high bluffs found along the Mississippi, Wisconsin and lower Chippawa Rivers (Wisconsin Plant Ecology Laboratory 2003).

Further east, out of the prairie country, *Bouteloua curtipendula* becomes restricted to specialized habitats. In Ontario, it is found in dry limestone plains and what is described as a "natural prairie on a dry, gravelly limestone ridge among the oak woodland" in the southern portion of the province (Dore and McNeill 1980: 386). Here it is associated with *Andropogon gerardii*, *Schizachyrium scoparium*, *Sorghastrum nutans*, *Bromus kalmii*, *Panicum* sp., *Lespedeza* sp. and *Lechea* sp. The species is also found in prairie/savannah areas in the northwestern portion of Ontario (Bakowsky and Oldham 1998).

A Threatened species in Michigan (Michigan Natural Features Inventory 2004), *Bouteloua curtipendula* is a species of oak barrens/savanna and hillside prairie. In the

former, it is associated with a suite of species typical of sandy, acidic soils, such as *Quercus velutina*, *Comptonia peregrina*, *Gaultheria procumbens*, *Gaylussacia baccata*, *Quercus prinoides*, *Vaccinium angustifolium*, and others. In the latter, it is associated *Schizachyrium scoparium*, *Stipa spartea*, *Lupinus perennis*, and others.

In Ohio, at the east end of Transeau's (1935) "prairie peninsula," *Bouteloua curtipendula* is included as a subdominant in a list of prairie plants based on data collected from prairies throughout the state (Jones 1944). In West Virginia, it is known from shale barrens and limestone areas (Strausbaugh and Core 1977).

In the barrens of Tennessee, *Bouteloua curtipendula* can be a dominant species along with other tallgrass prairie species of the Great Plains, such as *Andropogon gerardii*, *Sorghastrum nutans*, *Sporobolus compositus* var. *compositus*, and *Schizachyrium scoparium* (DeSelm 1989). These barrens are characterized as xeric to mesic (and sometimes wet-mesic) grassy openings in woods that are maintained by a combination of periodic droughts, fire (ignited by lightning and by humans), and grazing (native ungulates presettlement and cattle). They occur on different substrates in the different physiographic regions: loess soils of Western Tennessee, loess soils shallow to cherty subsoil over limestone on the Western Highland Rim, clayey soils over limestone in the Central Basin and Ridge and Valley, shallow soils over limestone on the eastern skirt of the Plateau, and on shallow, sandy, rocky soils of the Plateau's undulating terrain. Related to these barrens are limestone cedar glades. Working in the Central Basin of Tennessee, Quarterman (1989) distinguishes glades from barrens, both of which are openings in woods, by defining glades as having less than 50% perennial grass cover and barrens as having greater than 50% perennial grass cover. She describes the glades community as having soils less than 20 cm deep, while the barrens as having greater than 20 cm of soil. She notes that the mid-tall prairie grasses, including *Bouteloua curtipendula*, occur where the soil is deeper, and hence is typical of barrens versus glades vegetation.

The affinity that *Bouteloua curtipendula* shows to limestone is found in other areas of the southeastern United States. For example, it occurs in cedar barrens, or glades, natural communities in Lee County, Virginia (Carr 1944). While technically in the Cumberland Plateau, this county in extreme western Virginia is located in an extension of the Great Valley physiographic region and contains significant Ordovician limestone deposits. Likewise, in northern Georgia the species is known from limestone glades and barrens (Georgia Natural Heritage Program 2003). A specimen at MISS (Duncan #13017) has label information describing its occurrence on shallow soil of cedar glades in Catoosa County, Mississippi (Pullen Herbarium 2002). Even in the Florida panhandle, the disjunct *Bouteloua curtipendula* from Gadsden County is associated with limestone (Angus Gholson, unpublished data). Here it occurs in the globally-imperiled (G1) "upland glade" natural community (Florida Natural Areas Inventory 1990). Found on crests or slopes of low hills, this community is characterized by small (less than 2 hectares) openings where pavement-like limestone outcrops occur. Dominant vascular plant species in this unique community include such species as *Schoenus nigricans*, *Hedyotis nigricans*, *Dichromena colorata*, and *Yucca flaccida*.

A very different habitat for *Bouteloua curtipendula* that occurs in the southeastern United States is the Black Belt. On the distribution map in the *Manual on the Web* (Barkworth et al. 2000, same map at much smaller scale used in the *Flora of North America* [Wipff 2003]), there is a string of county records that follow this landform stretching from west-central Mississippi to central Alabama. Low, hilly terrain with clay soils, and *Juniperus virginiana-Schizachyrium scoparium* sparse woodland alliance and *Quercus stellata-Quercus marilandica* forest association (potential vegetation types) characterize this landform (Keys et al. 1995).

3. An Explanation of Conservation Ranks Used by The Nature Conservancy and NatureServe

The conservation rank of an element known or assumed to exist within a jurisdiction is designated by a whole number from 1 to 5, preceded by a G (Global), N (National), or S (Subnational) as appropriate. The numbers have the following meaning:

1 = critically imperiled
2 = imperiled
3 = vulnerable to extirpation or extinction
4 = apparently secure
5 = demonstrably widespread, abundant, and secure.

G1, for example, indicates critical imperilment on a range-wide basis -- that is, a great risk of extinction. S1 indicates critical imperilment within a particular state, province, or other subnational jurisdiction -- i.e., a great risk of extirpation of the element from that subnation, regardless of its status elsewhere. Species known in an area only from historical records are ranked as either H (possibly extirpated/possibly extinct) or X (presumed extirpated/presumed extinct). Certain other codes, rank variants, and qualifiers are also allowed in order to add information about the element or indicate uncertainty.

Elements that are imperiled or vulnerable everywhere they occur will have a global rank of G1, G2, or G3 and equally high or higher national and subnational ranks (the lower the number, the "higher" the rank, and therefore the conservation priority). On the other hand, it is possible for an element to be rarer or more vulnerable in a given nation or subnation than it is range-wide. In that case, it might be ranked N1, N2, or N3, or S1, S2, or S3 even though its global rank is G4 or G5. The three levels of the ranking system give a more complete picture of the conservation status of a species or community than either a range-wide or local rank by itself. They also make it easier to set appropriate conservation priorities in different places and at different geographic levels. In an effort to balance global and local conservation concerns, global as well as national and subnational (provincial or state) ranks are used to select the elements that should receive priority for research and conservation in a jurisdiction.

Use of standard ranking criteria and definitions makes Natural Heritage ranks comparable across element groups; thus, G1 has the same basic meaning whether applied to a salamander, a moss, or a forest community. Standardization also makes ranks comparable across jurisdictions, which in turn allows scientists to use the national and subnational ranks assigned by local data centers to determine and refine or reaffirm global ranks.

Ranking is a qualitative process: it takes into account several factors, including total number, range, and condition of element occurrences, population size, range extent and area of occupancy, short- and long-term trends in the foregoing factors, threats, environmental specificity, and fragility. These factors function as guidelines rather than arithmetic rules, and the relative weight given to the factors may differ among taxa. In some states, the taxon may receive a rank of SR (where the element is reported but has not yet been reviewed locally) or SRF (where a false, erroneous report exists and persists in the literature). A rank of S? denotes an uncertain or inexact numeric rank for the taxon at the state level.

Within states, individual occurrences of a taxon are sometimes assigned element occurrence ranks. Element occurrence (EO) ranks, which are an average of four separate evaluations of quality (size and productivity), condition, viability, and defensibility, are included in site descriptions to provide a general indication of site quality. Ranks range from: A (excellent) to D (poor); a rank of E is provided for element occurrences that are extant, but for which information is inadequate to provide a qualitative score. An EO rank of H is provided for sites for which no observations have made for more than 20 years. An X rank is utilized for sites that are known to be extirpated. Not all EOs have received such ranks in all states, and ranks are not necessarily consistent among states as yet.

Sideoats Grama. Bouteloua curtipendula. 3 more photos VIEW GALLERY. View gallery.Â Sideoats Grama Bouteloua curtipendula is native to Texas and many other States, and has been named the State grass of Texas because in grows in all Texas regions. Positive. On Jul 21, 2006, princessnonie from New Caney, TX (Zone 8b) wrote Sideoats grama [Bouteloua curtipendula (Michx.) Torr.] is one of the most utilized species for grasslands restoration in northern Mexico. This grass has been widely used due to its great adaptability to a wide range of environmental conditions and due to its high forage quality [1]. In the past years, breeding programs have focused on selecting outstanding genotypes for restoration of degraded grasslands [2â€“5].Â The maximum entropy method is available in the MaxEnt software and has several advantages, i.e., it is possible to obtain a high level of certainty using limited records of presence [16]. Hence, it serves to determine the environmental niche of different genotypes, if their geographic distribution is known [17, 18]. Bouteloua curtipendula, commonly known as sideoats grama, is a perennial, short prairie grass that is native throughout the temperate and tropical Western Hemisphere, from Canada south to Argentina. The species epithet comes from Latin curtus "shortened" and pendulus "hanging". Sideoats grama is a warm-season grass. The culms (flowering stems) are 30â€“100 cm (12â€“39 in) tall, and have alternate leaves that are concentrated at the bottom of the culm. The leaves are light green to blue-green in color, and... The Scientific Name of Sideoats Grama is Bouteloua curtipendula. Sideoats Grama Physical Description. This is a clump-forming grass that will have its stems branch out at angles, making almost an upside-down cone shape. But it is not densely formed, allowing it to mingle with other nearby species.