Management Recommendations for Native Insect Pollinators in Texas

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Background Information

Pollination is a critical ecosystem service that helps to maintain the ecological integrity of native plant communities. The majority of flowering plant species require animal-mediated transportation of pollen grains among receptive flowers to facilitate pollination and produce viable seed. Potential pollinators include ants, bats, bees, beetles, butterflies, flies, hummingbirds, moths, and wasps.

Pollination and the formation of viable seed are critical for the perpetuation of native plant populations. In addition, the berries, nuts, pods and other fruit produced through pollination can serve as important food resources for a diverse array of animals including birds, insects, reptiles, and mammals. Because pollinators play such a significant role in plant reproduction as well as production of plant-based foods for other species, practices that benefit native pollinators should be a component of any wildlife management plan.

In Texas, as in most of the world, insects serve as the primary pollinators of the majority of native plants and are the most important pollinators of agricultural crops. As discussed below, some insect groups are more efficient and effective pollinators than others. These species are ideal focal targets to support overall native pollinator diversity. Implementation of practices to enhance pollinator habitat will also benefit a great number of species dependent upon diverse native plant communities.

Leafcutter bee. Michael Warriner.

Targeting Effective and Efficient Pollinators

Animal-pollinated plants generally entice potential pollinators through showy flowers that offer rewards in the form of nectar and pollen. Nectar, composed of sugars and other compounds, is an important energy source for many flower-visiting species. Some flower-visiting animals, such as butterflies, hummingbirds, and moths, visit flowers only to feed on sugar-rich nectar. Pollen represents a source of protein and fats for a smaller subset of flower-visitors. **Bees, while also feeding on nectar, are one of the few flower-visitors that purposefully forage for pollen, collecting and transporting it as a food source for their young.**

Native solitary bee carrying large amounts of pollen. USGS Bee Inventory and Monitoring Lab.

Bees rely upon pollen as a protein source for their developing larvae. Specialized pollen-collecting hairs or other pollen-carrying structures on their bodies enable adult female bees to gather and transport large amounts of pollen to their nest. Much of this gathered pollen will be consumed by their larvae, but bees are vigorous foragers and inadvertently drop or rub pollen off of their bodies as they move from flower to flower.

During a single day, a female bee may visit several hundred flowers, transferring pollen along the way. Additionally, bees have floral preferences and may concentrate their efforts during any given foraging trip on a certain species of flower in bloom. By focusing in on a single species or subset of species, female bees deliver the right pollen to the right flower. Compared to those animals that lack dedicated pollen-carrying structures or that don't forage specifically for pollen, bees are much more efficient and effective at transferring pollen among flowers.

Crafting a wildlife management plan that meets the needs of native bees is ideal for maintaining a robust population of native flowering plants on your property. At the same time, a wide variety of other pollinators will be supported by management activities that provide the food resources needed by bees.

Native vs. Non-Native Bees

Over 3,500 native bee species and roughly 30 non-native bee species have been recorded from North America north of Mexico. The European honey bee (*Apis mellifera*) is the most familiar and well-known non-native bee species in North America. Brought here in the early 1600s, honey bees now occur nearly continent-wide in the form of feral and managed colonies. The honey bee's status as a managed and easily transported insect has made this single bee species the most important pollinator of dozens of U.S. agricultural crops valued in the billions of dollars annually.

European honey bee. John Severns.

While certainly important from an agricultural perspective, honey bees are not a component of North America's native natural communities and could negatively impact those systems through competition for foraging resources, disease transmission to native bees, or other means. Beyond native pollinators, there is evidence that some cavity-nesting birds compete for nest sites with feral honey bee colonies, to their detriment. **Due to its non-native status and potential impacts on natural communities, the honey bee is more appropriately managed as a semi-free ranging agricultural animal and not as a component of native wildlife or within the context of a wildlife management plan.**

The number of native bee species in Texas vastly outnumbers non-native species. Texas's native bees display an incredible range of shapes, size, colors, and lifestyles. An accurate tally of the native bees that occur in Texas is not yet available but a conservative estimate suggests that over 700 native bee species occur here. **Native bees are generally the most efficient and effective pollinators of native plants and thus critical to the maintenance of Texas' natural communities.** In fact, many native plants can only be pollinated by native bees or other native pollinators. **Native bees are also very effective pollinators of many agricultural corps.** Several crops, including blueberries, melons, squashes, and tomatoes, are more effectively pollinated by native bees than the non-native honey bee. **The annual value of native bee pollination to U.S. agriculture is estimated to be $3 billion.**

Social and Solitary Native Bees

Many members of the general public are fearful of bees and other stinging insects. This fear is based on the defensive behavior some social insects display when their colonies are disturbed. Truly social insects live in cooperative groups composed of a queen and her daughter workers. Colonies of bald-faced hornets *(Dolichovespula maculata)*, European honey bees, paper wasps *(Polistes)*, and yellowjackets *(Vespula)* are well known for issuing contingents of workers to ward off perceived threats with venomous stings. **Social bees and wasps are most defensive at the nest site where they have much to protect (queen, eggs, larvae, stored food). While foraging among flowers for food, social bees and wasps are often oblivious to the presence of humans or simply fly away when disturbed.**

Southern plains bumble bee. Jessica Womack.

Social bees and wasps can be recognized by their mass aggregations and workers streaming to and from a single, defined nest site. Colonies of these species should be treated with respect. **Minimize traffic, mowing, or other vibration-creating activities close to the nest. Because of their benefit to native plant communities, social bee and wasp colonies should be conserved unless they cause direct damage by their nesting activity or constitute a stinging threat.** If a colony of social bees or wasps must be exterminated it is advisable to use the services of a licensed pest control operator. Some honey bee-keepers will provide removal services for this insect. For more information on honey bee removal see Texas Apiary Inspection Service: Bee Removal.

Only a very small number of native bees in Texas are social. The largest and most familiar are bumble bees *(Bombus)*. Their black and yellow bodies are easy to recognize as they buzz from flower to flower. Nine bumble bee species have been recorded from Texas. Bumble bee diversity is greatest in eastern Texas and declines westward across the state. While bee diversity overall tends to peak in arid regions, bumble bees in North America increase in diversity at higher latitudes and elevation.

Approximately 90% of bees native to Texas are solitary species. Unlike social bees, solitary bee females establish and provision nests on their own with no assistance from other individuals. There is no division of labor into queens, workers, or drones. Because nests are established by lone females, these bees will not attempt to defend their nest sites through aerial sting attacks. If a female solitary bee dies, then she could lose her entire reproductive effort because there is no colony to provision her young in her absence. Male bees do not collect pollen to provision young or otherwise assist in raising offspring.

Mason bee. Jessica Womack.

Even though they do possess stingers, female solitary bees tend to flee or hide when disturbed at the nest. The nest sites of native solitary bees can be approached without fear of defensive attack. Make sure you know the difference between social and solitary bee species in your area, though, to ensure safety. Always first observe nests of bees and wasps from some distance in the case they may be a social species. Stings from native solitary bees typically only occur if an individual bee is trapped in clothing or grasped in hand. Artificial nest structures for these bees can be placed next to areas of human activity.

Solitary bees tend to be less frequently observed than their social relatives. They may even be hard to identify as a "bee" given their wide range of shapes, sizes, and color patterns. Less well-known solitary bees such as large carpenter bees *(Xylocopa)*, leaf-cutter bees *(Megachile)*, mason bees *(Osmia)*, mining bees *(Andrena)*, squash bees *(Peponapis)*, sunflower bees *(Diadasia)*, and sweat bees *(Agapostemon)* are responsible for a substantial amount of pollination in agricultural and ecological systems.

Simple Needs

Nectar and pollen are the only food source for native bees. Most species benefit from sites with a diverse array of native herbaceous and woody plants which provide a succession of flowers from spring into early fall. While some native bees may be active as adults for only short periods of time (a few weeks to a month), bumble bees require a near continuous source of nectar and pollen from early spring, through summer, into fall to complete colony development. Additionally, different bee species have different active periods during the year. Some bees, like *Andrena* species, are primarily active in the spring. Others, like *Melissodes* species, are active in the summer or fall. A gap in floral availability could cause a site to lose its complement of pollinators which forage in that window. **Flowers across the growing season are needed to support the full complement of native pollinators.**

A secondary benefit of rich native plant diversity is increased availability of suitable egg-laying sites (host plants) for butterflies and moths. Host plant preferences vary greatly by species with some butterfly and moth species requiring very specific plants for egg-laying. The monarch butterfly *(Danaus plexippus)* and its well-documented dependence on milkweed *(Asclepias)* species is a classic example. Many other butterfly and moth species are far less specific and able to lay their eggs on a wide range of plant species. Consequently, increasing the number of native plants in an area can increase the number of butterfly and moth species that may be attracted to a site.

Great purple hairstreak. Cullen Hanks.

Along with nectar and pollen from flowers, native bees require suitable places to nest. Bees are considered central place-foragers, meaning that females conduct all of their collecting trips for food from one central point on the landscape, their nest site. The nesting habits of native bees can be broadly classified into three categories, ground-nesters (e.g., mining bees), tunnel nesters (e.g., mason bees), and cavity nesters (e.g., bumble bees).

Most native bees are ground-nesters, nesting in self-made burrows in bare soil. Tunnel nesters use holes left by wood-boring beetle larvae in standing dead trees or chew their own cavities into dead wood or pithy stems. A small percentage of bees (e.g., bumble bees), are social colony builders and nest in pre-existing underground cavities (rodent burrows), within clumps of grass thatch, or in other insulated above-ground cavities.

Identify and Protect What You Already Have

Once you are familiar with the basics of what native bees need, the next step is determining if those resources exist on your property. Survey your property to evaluate if it already contains diverse patches of flowering herbaceous plants or stands of flowering shrubs and trees. Observe these patches or stands at different times of day to see which plants are most heavily used by bees and other flower-visitors. **Patches of good-quality native flowering plants will be important sites to manage and protect within the framework of your property's wildlife management plan.**

Existing nest resources will be a little harder to recognize than patches of flowering plants, but general nesting habitats across a property can be roughly demarcated. Brush piles, downed wood, and standing dead trees represent potential natural nesting sites for tunnel nesting bees and bumble bees. Well-drained, sparsely vegetated patches of bare ground are preferred nesting habitat for many ground-nesting bees.

Sweat bee emerging from nest. Eric Jacob.

Ground-nesting bee activity can be difficult to observe because there is often little above-ground evidence of the nests. However, if you are patient, you can sometimes observe female bees perched just inside the entrance to their nest, preparing to depart for a foraging run, or flying low over the ground searching for their nest entrances or mates. Ground nest entrances may resemble small ant mounds, with small piles of excavated earth around the hole, or a cluster of holes in the ground. They can range in size from 1/8 to 1/2 inch in diameter, depending on the species. Bumble bees, on the other hand, do not dig their own nests but rather take up residence in abandoned rodent burrows or tussocks of grass in areas of thick herbaceous vegetation.

Refer to The Xerces Society for Invertebrate Conservation's Pollinator Habitat Assessment Form and Guide: Natural Areas and Rangelands to assess resources already present on your property, identify shortfalls, and potential management needs.

Adapt Current Management Practices

Management practices, such as grazing, haying, and prescribed burning can limit woody plant encroachment, suppress non-native plants, and enhance native herbaceous plant diversity. However, these practices should be implemented with the needs of native bees and other insect flower-visitors in mind as these practices have the potential to reduce or even completely eliminate floral resources, host plants, and nest sites. Certain management activities, if performed without care, can even harm pollinators and extirpate them from a site.

When applying any management practice to a property it is critical to avoid treating an entire area in one season. A site that is burned, grazed, or hayed in its entirety in the dormant season will virtually eliminate those native bees that are overwintering in dry stalks, stems, and twigs. Some pollinators, such as some species of butterflies, beetles, and flies overwinter in leaf litter and may be severely impacted by prescribed burns during the winter. Implementing these same practices to an entire site during the growing season will remove nearly all flowers (nectar and pollen resources), potential nest sites, and host plants of butterflies and moths. If the surrounding area does not support populations of these bees and butterflies, disrupting the entire site at one time could cause you to lose pollinator species diversity.

As a general rule, only treat up to 30% of a site at a time. For example: if you have a 12-acre, flower-rich hay meadow, only cut four acres in a single year and rotate through the remaining acreage over the following years. Untreated areas of the property will provide much needed food and nest sites and also serve as critical refugia for species to recolonize the managed portion as it recovers the following year.

Non-native grass monoculture (left) versus flower-rich, good quality bee habitat (right). Michael Warriner.

The prescriptions below are general guidelines to maintain areas with existing native insect pollinator habitat on your property. If you are actively restoring a property to a more natural state, you may find the need to conduct management outside of the time periods suggested below.

- Prescribed burns should be conducted from fall into early spring. Avoid burns during the growing season. Allow sufficient time for recovery between burns (burn cycle will vary by ecoregion) for thatch to accumulate and enable insect populations in burned sections to recover.
- Cattle grazing should be designed to protect and enhance areas containing nectar and pollen resources. Grazing intensity may be low to high depending upon the goals of your management plan. Low intensity grazing tends to promote selective consumption of grasses and the more palatable forbs, while high intensity grazing leads to uniform consumption of plant matter across the landscape. Low intensity, short duration grazing from fall into early spring may have the least impacts on native bee resources. High intensity, short duration grazing may be needed in restoration efforts to increase seed germination or control non-native grasses. Avoid grazing with goats or sheep as these feed more heavily on important nectar and pollen-bearing wildflowers.
- Haying should be restricted to fall through early spring to maximize availability of flowering plants for native bees. Avoid haying too low, as bumble bees often nest in ground-level accumulations of thatch. Instead, maintain a minimum cutting height of six to eight inches. If haying must be conducted during the growing season, leave blocks or strips uncut to retain some stands of flowers and nest sites. Avoid the application of chemical fertilizers, as these can increase the growth of non-native grasses and weeds to the detriment of annual and perennial wildflowers.
- Tilling or deep disking in areas that host aggregations of ground-nesting bees should be avoided. Tilling and disking also may promote the invasion or germination of non-native plants.

Try to vary the techniques applied to each site as much as possible. Reliance upon a single practice year after year can lead to a shift to a more homogeneous plant community. Applying a range of practices will result in a more diverse and healthy landscape.

A number of steps can be taken to further secure nesting habitat resources on your property.

- Allow dead trees to stand (so long as they do not pose a risk to property or people) and protect shrubs and herbaceous plants with pithy or hollow stems (e.g., cane fruits, sumac, elderberry), as these provide nesting habitat for tunnel-nesting native bees.
- Retain dead or dying branches whenever it is safe and practical. Wood-boring beetle larvae often fill dead trees and branches with narrow tunnels into which tunnel-nesting bees will establish nests. Additionally, bumble bees may choose to nest in wood piles.
- Retain rotting logs where some bee species may burrow tunnels in which to nest.
- Protect sloped or well-drained ground sites where plants are sparse and direct access to soil is available. These are the areas where ground-nesting bees may dig nests. Turning the soil destroys all ground nests that are present at that depth and hinders the emergence of bees that are nesting deeper in the ground.
- Protect grassy thickets, or other areas of dense, low cover from mowing or other disturbance. These are the sites where bumble bees might find the nest cavities they need, as well as annual and perennial wildflowers that can provide important food resources.

Augmenting Resources: Forage

A survey of your property over the course of a growing season may reveal deficits in available native flowering plants and/or nesting sites. There are steps you can take to augment these resources. Increasing the diversity of native flowering plants on your property is probably one of the more rewarding strategies. Increasing native plant diversity will also provide additional host plant resources for butterflies and moths.

Augmenting floral diversity with plants native to Texas is your best choice. Native plant species have coevolved with native bees over time, and they are also better adapted to the state's climate. For a list of native plants attractive to native bees, see the Ecoregional Plant Lists (Appendix A). These plants will also support scores of other native flower-visitors including beetles, butterflies, flies, hummingbirds, and wasps.

Incorporate native annual and perennial herbaceous plants as well as flowering shrubs and trees where possible to provide a succession of blooms from early spring, through summer, and into fall. Robust sources of nectar and pollen during these three periods will meet the needs of a wide range of native bees and other flower-visitors. A good starting point is ensuring that you have at least three plant species flowering in each of two or three seasons (dependent upon whether you are in a dry or wet area of Texas). Once that minimum is met you can then work to further increase native plant diversity over time. You can also start with a more species-rich seed mix if you desire.

Exactly how you increase native plant diversity at your site will depend upon the current condition of the area you wish to manage. Properties with low floral diversity may benefit from over-seeding with a native seed mix including forbs geared to native pollinator needs. If over-seeding a site, emphasize seeds from local sources. Obtaining an as-local-as-possible seed mix is not only helpful for establishment success but also aids in the protection of existing local plant gene pools. Within the ecologically and environmentally diverse state of Texas, local seed may mean seeds sourced from the same ecoregion as the target planting site.

American bumble bee. Michael Warriner.

Areas heavily invaded by non-native plants may require relatively intensive efforts, especially with regards to site preparation and weed control, to convert your property to a more native pollinator-friendly state. Conversely, your property may be in relatively good shape and simply require adjustments to management practices to increase and perpetuate resources already found on-site.

If the expense of restoring an entire site through re-seeding is too great, smaller "native pollinator plots" can be installed across a property and seeded with a high-quality native plant species mix. Such plots can be fenced to protect herbaceous and woody flowering plants from surrounding management practices, harmful invasive animals (e.g., feral hogs), or grazing herbivores.

Augmenting Resources: Nest Sites

The second piece of the puzzle in conserving native bee populations is increasing available nesting habitat. The specific conditions required by most ground-nesting solitary bees are not well known. Some species nest in the ground at the base of plants and others prefer smooth packed bare ground. Different species of native ground-nesting bees prefer different soil conditions, although research suggests that many ground nesting bees prefer sandy, loamy sand or sandy loam soils. Landowners can create conditions suitable to a variety of species by maximizing undisturbed areas of semi-bare ground.

In contrast to ground-nesting bees, other species such as many carpenter bees, leafcutter bees, and mason bees nest in cavities in dead wood or the pithy stems of herbaceous plants. Creating piles of dead woody vegetation from brush clearing can provide suitable nesting habitat for several native bees and a number of other wildlife species. If you lack standing dead trees, girdling select trees is another option for creating dead wood habitat for native bees, woodpeckers, and other species. Remember to consider the tree's proximity to areas of human activity, roads, and structures, before girdling it.

Ground-nesting solitary bee emerging from nest. Michael Warriner.

Pesticide Use

Pesticides are detrimental to a healthy community of native insect pollinators. Insecticides may not only kill insect pollinators, but sub-lethal doses can affect their foraging and nesting behaviors. In general, while pesticide labels may list hazards to honey bees, potential dangers to native bees are often not listed. For example, many native bees are much smaller in size than honey bees and are negatively affected at lower doses. Also, honey bee colonies may be covered or moved from a field, whereas native bees will continue to forage and nest in sprayed areas. Lastly, because most native bees are solitary, there is the potential for larger ramifications of a single mortality event. If a worker honey bee or bumble bee dies, then the colony can continue. If a solitary bee dies, then her entire reproductive output is lost. For these and other reasons, the use of pesticides in areas managed for native insect pollinators should be avoided. Drift from pesticides applied on lands with alternate uses should also be minimized. See Managing Pesticides to Protect Bees (Xerces Society for Invertebrate Conservation) for more information.

Learn More

The Xerces Society for Invertebrate Conservation has led efforts to conserve and manage native bees and other pollinators. They have produced a wealth of information that is available online (Bring Back the Pollinators) and in print (Attracting Native Pollinators: Protecting North America's Bees and Butterflies, Storey Publishing and Gardening for Butterflies: How You Can Attract and Protect Beautiful, Beneficial Insects, Timber Press). In cooperation with The Xerces Society, the Natural Resources Conservation Service has expanded their technical guidance on pollinator management and offer cost-share programs to assist landowners in management of their lands. With the 2008 and 2014 Farm Bills, Congress recognized that pollinators are a crucial part of healthy agricultural and natural landscapes. The Farm Bill authorized the U.S. Department of Agriculture (USDA) to undertake a broad range of incentive-based conservation programs on agricultural land. For more information on federal cost-share programs available to defray expense of improving lands for pollinators, see the USDA publication Using the 2014 Farm Bill Programs for Pollinator Conservation.

Agricultural Tax Appraisal Based on Wildlife Management Recommended Practices for Native Insect Pollinators in Texas

The protocols detailed below are general recommendations geared towards supporting populations of native bees and other native insect pollinators. These protocols were partially adapted from content developed by the U.S. Department of Agriculture's Natural Resources Conservation Service (NRCS) and The Xerces Society for Invertebrate Conservation. Accessing more information available from both organizations will provide more detailed guidance on implementation of pollinator-friendly activities on your property. Private landowners should also consult with local resource experts (e.g., TPWD or NRCS staff) for more site-specific information before crafting a wildlife management plan.

Species Targeted for Management

If you are developing a plan that includes native insect pollinator management, check the box for "Insects" on your Texas Parks and Wildlife Department (TPWD) Wildlife Management Plan for Agricultural Tax Valuation (PWD-885) form. You could broadly target "native bees." Managing for native bees has positive, spill-over

effects for other flower-visiting animal species as well. You could also add other broad target groups such as "butterflies" or "moths."

Since there are hundreds of native bee species in Texas (~700+), and detailed distributions are not known for most of these species, the best approach is to list major groups of native bees at the functional (e.g., solitary ground-nesting) and/or family level (e.g., *Andrenidae*). Most localities in the state typically host some member(s) of a given native bee family.

Targets for Management: Native Bee Functional Groups and Families

- Solitary ground-nesting bees
  - *Andrenidae*: Mining Bees
  - *Halictidae*: Sweat Bees
  - *Colletidae*: Plasterer and Masked Bees
  - *Apidae*: Digger Bees
- Solitary tunnel-nesting bees
  - *Colletidae*: Plasterer and Masked Bees
  - *Megachilidae*: Leaf-cutter and Mason Bees
  - *Apidae*: Carpenter Bees
- Social cavity-nesting bees
  - *Apidae*: Bumble Bees

If you are interested in butterflies as well, checklists of butterfly species known from individual Texas counties can be viewed at: www.butterfliesandmoths.org/checklists. With a county-specific list of butterflies, you can research individual species life history, preferred larval host plant(s), and habitat associations to target species that may occur on your property.

Several native bees, butterflies, and moths have been designated by TPWD as Species of Greatest Conservation Need (SGCN) in the agency's Texas Conservation Action Plan (Appendix B). Many of these SGCN are highly restricted and found in only a few counties. We know little about the actual distribution of most of these insects as formal survey work has been limited. As a result, some species may have more extensive distributions than are currently known. If one or more of these species occur in your county and you wish to manage potential habitat for them, then check the box for "Identified species of concern" and list species known from your county(ies).

One approach for targeting certain SGCN is to determine whether they have very narrow preferences for certain plant species. If an associated plant species has been documented as naturally occurring in your county, but the SGCN has not, that SGCN may occur in your county but has yet to be formally documented. For example, the Manfreda giant skipper (*Stallingsia maculosus*) represents just such a species. This butterfly has been documented from 14 counties in southern Texas and its larvae only feed on members of the plant genus *Manfreda*. The genus *Manfreda* has been documented from over 20 counties. The Manfreda giant skipper may occur in these additional counties where *Manfreda* species have been documented.

The species targeted in your plan is at your discretion. A plan could consist of a mix of species, incorporating subsets of focal butterflies, native bees, and other flower-visitors. The plan could also include approaches for both common and rare species.

Wildlife Management Activities

I. Habitat Control

Management practices, such as grazing, haying, and prescribed burning, should be implemented with native insect pollinator needs in mind as these techniques have the potential to reduce or entirely eliminate food (flower patches, host plants), nest sites, and the pollinator insects (adult or immature) that live in vegetation or litter. **Habitat control methods which disturb the site should not be applied to an entire location within a given year. Rather, only treat up to 30% of a given site annually.** The untreated sections of the property will continue to provide foraging and nesting opportunities as well as a "safe zones" from which insect populations can recolonize burned, grazed, or hayed sections of the property as vegetation there recovers.

a. Grazing Management

Grazing management, which may include deferment, is the planned manipulation of livestock numbers and grazing intensities to increase food, cover, or improve structure in the habitat of selected pollinator species. Grazing management plans include: (a) an assessment of the kind and class of livestock grazed, (b) determination and adjustment of stocking rates, (c) implementation of a grazing system that provides planned periodic rest for pastures by controlling grazing intensity and duration, and/or (d) excluding livestock from sensitive areas to prevent trampling, allow for vegetative recovery or eliminate competition between cattle and pollinators for food and cover (e.g. cows may eat pollinator host plants or remove nesting habitat). Fencing can also be used to enhance or protect sensitive areas designated in a plan. Activities should be reviewed annually.

Livestock grazing alters the structure, diversity, and growth pattern of vegetation, which affects the associated insect community. Grazing during a time when flowers are already scarce may result in insufficient forage for native insect pollinators, and high intensity grazing can cause local loss of floral diversity. Grazing when butterfly larvae are active on host plants can result in larval mortality, and if species of concern are present, grazing should be avoided during their life cycle.

For native bees and other native insect pollinators, cattle grazing plans should be flexible and closely monitored and designed to protect or enhance areas containing nectar, pollen, and host plant resources. Grazing intensity may be low or high depending upon the goals of your management plan. Low intensity grazing from fall into early spring may have the least impacts on available resources. High intensity, short duration grazing may be called for in restoration efforts to increase seed germination or control of non-native grasses. Careful planning and monitoring are necessary to avoid overgrazing and to meet grazing plan objectives. In general, one should avoid grazing with goats or sheep as they feed more heavily on nectar and pollen-bearing herbaceous plants.

Refer to TPWD ecoregion-specific habitat control recommendations (Agricultural Tax Appraisal Based on Wildlife Management) and NRCS Conservation Practice Standard for Prescribed Grazing (Code 528) to prepare a grazing proposal for your plan.

Key Points for Grazing and Native Insect Pollinators:

- Assess if grazing is compatible with the specific needs of target native insect pollinator species on site, including targeted butterfly species.
- Grazing should only be applied to 30% or less of a site in a given year.
- Landowners should work with a range specialist (e.g. NRCS or TPWD field staff) to develop a grazing plan suited to their site and objectives. Site needs will vary with local ecological characteristics and land use history.
- Landowners should regularly monitor site conditions in grazed areas and practice adaptive management in response to changes in site condition.
- Prevent grazing during periods when flowers are already scarce (mid-summer) to maintain forage for native insect pollinators, especially bumble bees.
- Avoid grazing when butterfly eggs, larvae, and pupae of species of concern are on host plants.
- At severely overgrazed sites, livestock should be excluded for long enough to allow vegetation to regain a diversity and abundance of herbaceous plant species.
- Maintain populations of native herbaceous plants by applying grazing regimes that allow plants to flower, set, and shed seed. This often requires resting the pasture regularly.

b. Prescribed Burning

Prescribed fire can play an important role in the long-term maintenance of native insect pollinator habitat, but it can have negative effects on populations in the short term unless the needs of pollinators are considered in project design. **Prescribed burns should be conducted from fall into early spring, when pollinators are not active, and only applied to 30% or less of a site. Avoid burns during the growing season.** Allow sufficient time between burns for thatch to accumulate and enable insect populations in burned sections to recover. Plans should indicate a minimum percent of acreage and general burning cycle.

Refer to TPWD ecoregion-specific habitat control recommendations (Agricultural Tax Appraisal Based on Wildlife Management) for area and intensity levels and NRCS Conservation Practice Standard for Prescribed Burning (Code 338) to prepare a prescribed burning proposal for your plan.

Key Points for Prescribed Burning and Native Insect Pollinators:

- Burning prior to or just after green-up encourages grass species by removing thatch and enriching the soil. In combination with grazing, it can encourage grass consumption. Without grazing, it supports grass dominance.
- Conduct prescribed burns in a manner that protects native insect pollinator communities. Fires that are too frequent, widespread, or intense can reduce or eliminate native insect populations.
- Prescribed burns should only be applied to 30% or less of a site in a given year.
- Unburned areas will offer food resources and nest sites for insects and other animals to recolonize burned sites as vegetation recovers.
- A program of rotational burning where small sections are burned every few years will maximize re-colonization potential for resident pollinators.
- Longer periods between burns, if compatible with other management goals, will allow for the development of deep thatch preferred by bumble bees for nest sites.

c. Range Enhancement (Re-seeding)

Landowners who want to take an active role in increasing populations of native insect pollinators can increase available foraging habitat that provides sources of nectar and pollen throughout spring, summer, and fall. Native plant species and selected methods for establishment should be applicable to your specific ecoregion.

Seeding mixtures that provide maximum native plant diversity are recommended. Some periodic vegetation control may be needed in sites converted to native plant communities to assist in the establishment of desirable native plant species. This practice must be a part of an overall habitat management plan and designed to re-establish native habitats within a specified time frame.

Plant diversity is a critical factor in the design of native insect pollinator range enhancement areas. A succession of flowers should be available throughout the entire growing season (spring into early fall). Researchers have found that when eight or more plant species with different flowering times are grouped together at a single site, they tend to attract a significantly greater diversity of flower-visitors.

Under this guideline, areas of Texas with higher amounts of annual precipitation (See Appendix C; East Texas, Lower Valley, North Central, South Central, and Upper Coast) should include a minimum of at least three native plant species flowering in each of three blooming periods (spring, summer, and fall) in native pollinator enhancement sites. More arid areas of Texas may be unable to fulfill this nine species total and/or three species in bloom across spring, summer, and early fall. **Drier regions of the state (see Appendix C; Edwards Plateau, High Plains, Low Rolling Plains, Southern, and Trans-Pecos) may use a target of at least three plant species blooming in each of two blooming periods.**

Most open plant community types in Texas, like grasslands and savannas, contain one or more native bunchgrasses. These non-sod forming grasses often serve as host plants for butterflies, especially rare grassland-dependent skippers, and potential nesting sites for bumble bees. The inclusion of bunchgrasses may help sites to better resist invasion by non-native plants. Bunchgrasses are also essential to produce conditions suitable for prescribed burning.

Although an important component, bunchgrasses should not be allowed to dominate range enhancement sites. Seeding rates of native bunchgrasses should be less than seeding rates of forbs. Planting in the fall, rather than spring, will also favor forb development over grasses. **In dry regions of Texas (see Appendix C; Edwards Plateau, High Plains, Low Rolling Plains, Southern, and Trans-Pecos), flowering herbaceous annual and perennial plant species should make up at least 50% of a seed mix, as measured by seeds per square foot. Native grasses should account for no more than 50% of the mix. Regions of Texas with more rainfall (See Appendix C; East Texas, Lower Valley, North Central, South Central, and Upper Coast) should increase the percentage of flowering herbaceous annual and perennial plant species to 60%-75% with native grasses comprising the remainder (25%-40%) of the seed mix.**

Flowering shrubs could also comprise a component of a pollinator habitat planting. Native plants and seed should be procured from local eco-type providers when available. Local eco-type refers to seed and plant stock harvested from a local source. Plants selected from local sources will generally establish and grow well as they are already adapted to local climatic conditions.

Early planning for range enhancement should include a survey of existing native flowering plants. Native plants already present may reduce the need for some species within a seed mix. Your property may have ample flowering plant resources in the summer but may lack species flowering early or late in the season. With that information, your native seed mix could be better tailored to your property's specific needs.

Range enhancement should annually affect a minimum of 10% of the total area designated in the plan to receive credit, or a minimum of 10 acres annually, whichever is smaller. Refer to TPWD ecoregion-specific habitat control guidelines and guidelines for native grassland restoration projects (Agricultural Tax

Texas kidneywood is attractive to a large number of flower-visitors. Michael Warriner.

Appraisal Based on Wildlife Management) as well as NRCS Conservation Practice Standard for Range Planting (Code 550) to prepare a range enhancement proposal for your plan.

Key Points for Range Enhancement and Native Insect Pollinators:

- Plant diversity is a critical factor in the design of native pollinator range enhancement areas.
- At least three different native flowering plants within each of three blooming periods are recommended (spring, summer, early fall) in high rainfall regions of Texas. In drier regions of the state, landowners can use a target of three native flowering plants within each of two blooming periods.
- Ensure that range enhancements, especially in drier regions of the state, includes native plants that bloom during dry summer months when nectar and pollen may be scarce.
- Range enhancements for native pollinators should include at least one native bunchgrass adapted to the site.
- Where available and economical, native plants and seed should be procured from local eco-type providers.
- Conduct a survey of existing native flowering plant diversity on your property to identify potential seasonal shortfalls and better inform development of a site specific seed mix for enhancement.

d. Brush Management

Woody plant encroachment, which frequently occurs in the absence of regular disturbance, may reduce the area of open habitat that supports native bees and other native insect pollinators. Selective removal of target woody plant species can increase native flowering herbaceous plants, grasses, and preferred shrubs, thereby enhancing native pollinator habitat. **Brush management is a likely precursor to preparing a site for range enhancements or installation of native pollinator plots.** Depending upon the density and duration of brush cover, brush management alone may even release native seed banks and lead to establishment of acceptable pollinator habitat.

Brush management planning must consider soil types, slope angle and direction, soil loss and erosion factors, and subsequent planning to control re-invasion. This management practice includes retention of standing dead trees to provide nesting opportunities for cavity-nesting native bee species.

Native re-seeding efforts in areas cleared of brush should follow recommendations for range enhancement or native pollinator plots. Planting of native flowering shrubs and trees can also serve to enhance nectar and pollen resources for native pollinators. **Dense plantings of flowering trees and shrubs should be avoided as canopy cover can suppress growth of herbaceous plants.** Instead, small groups of flowering shrubs and/or trees scattered across open habitat are preferred.

Some sites may require repeated management to maintain open conditions conducive to native insect pollinators and the plants they depend on. Additional brush control in sites experiencing woody plant encroachment, and hosting native insect pollinator resources (nectar, pollen, host plants), should be conducted outside of the flowering season (i.e., during fall and winter) to limit impact on pollinator populations.

Brush management practices should annually affect a minimum of 10% of the total area designated in the plan to qualify, or a minimum of 10 acres annually, whichever is smaller. Refer to TPWD ecoregion-specific habitat control recommendations (Agricultural Tax Appraisal Based on Wildlife Management) and NRCS Conservation Practice Standard for Brush Management (Code 314) to prepare a brush management proposal for your plan.

Key Points for Brush Management and Native Insect Pollinators:

- Woody plant encroachment can reduce the availability of flowering herbaceous plants and grasses needed by pollinating insects.
- Removal of woody, encroaching plants is often a precursor to range enhancement and re-seeding with native flowering herbaceous plants and native bunchgrasses, although depending upon density and duration of brush cover, native range may rebound after brush management alone.
- Brush management can involve retention of dead snags and should be conducted outside of the flowering season.

Mechanical brush management is an alternative to prescribed fire as a means of removing woody vegetation when fire is a not a feasible tool.

e. Riparian Management and Enhancement

Riparian areas can host a number of herbaceous and woody plant species visited by native insect pollinators. These areas can include seeps, springs, streamside zones, swales, and wet meadows. They may require annual and seasonal protection from mismanagement, such as that caused by livestock trampling. Riparian management and enhancement can include providing livestock with alternate watering sites, deferring livestock grazing in pastures with riparian areas during critical periods of the year, total exclusion of livestock from pastures with riparian areas, and fencing riparian areas to exclude or provide short duration grazing by livestock. Establishing site-suitable flowering annual and perennial native herbaceous plants, shrubs, and/or trees along streams or spring margins can provide foraging opportunities for native insect pollinators and reduce erosion. These plantings should include a mix of native plants that provide a succession of flowers from spring, summer, into early fall. **A minimum of one Riparian Management and Enhancement project must be implemented and maintained every 10 years to qualify.**

Potential Riparian Management and Enhancement projects might include:

- Fencing
  - Complete fencing of riparian areas
  - Partial fencing of riparian areas
- Deferment from livestock grazing
  - Complete deferment
  - Partial deferment.

Ground-nesting solitary bee. Jessica Womack.

- Establishment of vegetation for native insect pollinators
    - Flowering annual and perennial native herbaceous plants, shrubs, and/or trees

Refer to NRCS Conservation Practice Standard for Riparian Herbaceous Cover (Code 390) and Riparian Forest Buffer (Code 391) to prepare a specific riparian management and enhancement proposal for your plan.

f. Habitat Protection for Species of Concern

Planned protection and management of a property to provide habitat for native insect pollinator species of concern may include protection of nesting sites or patches of host plants, managing plant diversity to increase available nectar and pollen sources, and/or control of non-native, invasive species. As previously discussed, several native insect pollinators are SGCN and represent potential targets for this action (Appendix B). However, most of these species have restricted distributions and opportunities for most landowners will be limited. If targeting one or more these species, research their specific needs and actions you would need to take to manage for potential or occupied habitat on your property. More detailed information on these species can be obtained from TPWD's Nongame and Rare Species Program.

The monarch butterfly is a species of concern that has a wide distribution across Texas and which is an appropriate management target for many landowners. This butterfly has very specific host plant requirements for egg-laying and larval development. Monarchs only lay their eggs on milkweed species. Spring and fall migrating adult monarchs also require ample sources of nectar from flowering plants to fuel their migrations. Adult monarchs are less specific than their larvae and will forage for nectar from a wide range of native plant species.

On lands targeted for management and/or restoration of monarch habitat, the following actions should be considered:

- Ensure that native annual and perennial herbaceous flowering plants are available, diverse, and abundant to serve as nectar sources for adult butterflies. Some sites may benefit from range enhancement and/or dedicated native pollinator plots. Refer to the NRCS's Monarch Butterfly Resources for more guidance.
- Ensure that native milkweed species (preferred by female monarchs for egg laying) are available for monarch caterpillars. If milkweed is not present on the landscape, implement range enhancement efforts such as prescribed grazing, prescribed fire, brush clearing, or invasive plant species removal that can promote growth of

Monarch caterpillar. Derek Ramsey.

native milkweeds. Ideally, management activities will occur mid-summer or in the dormant season. Avoid scheduling management activities March-May or September-November.

- A planting program for milkweeds appropriate for your ecoregion of Texas may augment or replace activities that promote the growth of milkweed from the existing seed bank. Increasing milkweed availability could be incorporated into range enhancement re-seeding efforts or through planting native pollinator plots with milkweed. See TPWD's Texas Milkweed Identification Guide to learn more about species that are native to your region of the state. See the Xerces Society of Invertebrate Conservation's Milkweed Seed Finder to source ecoregionally appropriate seed and Milkweed: A Conservation Practitioner's Guide for tips on establishment.

The American bumble bee (*Bombus pensylvanicus*) is a species that has experienced declines across much of its North American range, though Texas populations appear to be relatively stable. This bee species has the potential to occur in most counties in the state and is a good target for management. This bee is easy to identify and practices that benefit the American bumble bee also benefit a wide range of native insect pollinators.

Many other potential SGCN could represent targets for management. Research on their potential distribution and habitat requirements is all that is required to determine if your property potentially supports habitat for these species. **A minimum of one project must be implemented every five years to qualify.**

Refer to NRCS Conservation Practice Standard for Restoration and Management of Rare or Declining Habitats (Code 643) to prepare a habitat for protection for species of concern proposal for your plan.

American bumble bee. Jessica Womack.

g. Prescribed Control of Native, Exotic, and Feral Species

Maintain the population density of native wildlife, particularly white-tailed deer (*Odocoileus virginianus*) at or below the carrying capacity of the habitat to prevent overuse of desirable native plant species and to enhance habitat for native insect pollinators. Populations of exotic and feral animals should be strictly controlled to minimize negative impact on native species and habitats. This should incorporate harvest and vegetative monitoring over time to assess control intensity and impact on habitat to meet plan objectives. Remove or control non-native, invasive vegetation impacting native habitats and native insect pollinator populations. Convert non-native grasses, such as areas of bermudagrass (*Cynodon dactylon*), bufflegrass (*Cenchrus ciliaris*), and King Ranch bluestem (*Bothriochloa ischaemum* var. *songarica*) to native vegetation. **The removal or control of non-native vegetation must affect a minimum of 10% of the area designated in the plan to qualify, or 10 acres annually, whichever is smaller.**

II. Erosion Control

Erosion control efforts can be applied to benefit native insect pollinators primarily through inclusion of pollinator-friendly seed mixes in re-vegetation efforts.

a. Streamside, Pond, and Wetland Re-vegetation
Re-vegetate areas along creeks, ponds, streams, and wetlands to reduce erosion and sedimentation, stabilize stream banks, improve plant diversity, and improve the wildlife value of these sensitive areas. This practice can include the construction of permanent or temporary fences to exclude, limit, or seasonally graze livestock in order to prevent erosion, the use of native hay to slow and spread water runoff in areas where native vegetation has been recently reestablished (seeds in the hay aid in re-vegetation), establishment of vegetative buffer areas or filter strips along water courses or other runoff areas, establishment of 3:1 upland buffer to lake basin/wetland acreage in diverse native grass/legume/forb mixture to prevent sedimentation, the installation of rip-rap, dredge spoil, or other barrier material along erodible embankments to prevent erosion and protect wildlife habitat, and the establishment of stream crossings to provide permanent low water crossings in order to reduce or prevent erosion. **Development of seed mixes for re-vegetation projects should be tailored to native insect pollinator needs and include species that provide a succession of blooms from spring, summer, into early fall. Refer to TPWD ecoregion-specific erosion control recommendations (Agricultural Tax Appraisal Based on Wildlife Management) for area and intensity levels and NRCS Conservation Practice Standard for Riparian Herbaceous Cover (Code 390), Riparian Forest Buffer (Code 391), and Stream Habitat Improvement and Management (Code 395) to prepare a streamside, pond, and wetland re-vegetation proposal for your plan.**

III. Predator Control

a. Feral Hog Control: Feral hogs can damage floral resources, host plants, and nesting habitat important to native insect pollinators. Eradication of feral hogs can be employed to maintain native plant communities and pollinator habitat. Exclusion of hogs from these areas using fencing is a viable alternative, if eradication is not feasible. For information on feral hog control, see Control Techniques for Feral Hogs (Texas AgriLife).

IV. Providing Supplemental Food

a. Grazing Management: This is identical to Grazing Management in Activity 1.a. above. Refer to Grazing Management in Activity 1.a. for information to prepare a specific grazing proposal for the plan under this activity.

b. Prescribed Burning: This is identical to Prescribed Burning in Activity 1.b. above. Refer to Prescribed Burning in Activity 1.b. for information to prepare a specific prescribed burning proposal for the plan under this activity.

c. Range Enhancement (Range Re-Seeding): This is identical to Range Enhancement (Re-seeding) in Activity 1.c. above. Refer to Range Enhancement (Re-seeding) in Activity 1.c. for information to prepare a specific range enhancement proposal for the plan under this activity.

d. Native Pollinator Plots
Good quality, locally-adapted native flowering plant seed can be expensive and make range enhancement cost-prohibitive when re-seeding over a large area. An alternative option for landowners still wanting

to provide diverse, high-quality nectar, pollen, and host plant resources is the establishment of native pollinator plots. **These areas would consist of designated plots on a property that are seeded with a native seed mix containing a high percentage of herbaceous flowering plants along with a smaller native bunchgrass component.** These mixes should follow the general recommendations for Range Enhancement but would be applied at a smaller scale. A percentage of the plot could also be planted with smaller native flowering trees and shrubs, in areas that are compatible with site management plans.

Leafcutter bee. Nick Mirro.

Establishment of a native pollinator plot roughly follows NRCS recommendations for development of CP42 Pollinator Habitat (consult with your local NRCS agent on the detailed specifications of this conservation practice). Generally, larger planted areas result in greater potential benefit to native insect pollinators. **An area considered for a pollinator plot should have a minimum size of ½ acre although contiguous plots of two acres or more provide greater benefits.** Planting in blocks is preferred as this will minimize edge around the plot and reduce invasion from surrounding, unwanted vegetation and accidental exposure to pesticides. If block planting is not possible, strips can be planted but each strip must be a minimum of 20 feet wide. Strip planting may be more conducive for linear corridors along streams, roads, or hedgerows.

Seeding mixes should consist of a minimum of nine native herbaceous flowering plants with at least three species blooming in each season (spring, summer, and early fall) in high rainfall areas of Texas (See Appendix C; East Texas, Lower Valley, North Central, South Central, and Upper Coast). Drier regions of the state (see Appendix C; Edwards Plateau, High Plains, Low Rolling Plains, Southern, and Trans-Pecos) may use a target of at least three plant species blooming in each of two blooming periods. Annual and perennial flowering herbaceous native plants (and shrub component if included) should make up at least 50%-75% of the seed mix with native, non-sod bunchgrass comprising the remainder of the mix. A portion (no more than 20%) of the native seed mix can be represented by flowering shrubs attractive to native insect pollinators. A native seed mix containing a higher number of species should be considered when feasible as additional plant species will potentially increase diversity of native insect pollinators.

Eastern carpenter bee. Jessica Womack.

Site selection for native bee plots should consider existing non-native, invasive plant pressures and available methods of weed control. Site preparation and plant establishment should be accomplished according to the appropriate NRCS conservation practice and specifications (consult your local NRCS agent or TPWD biologist for more information). Either broadcast seeding (spreading seed over an area by hand or hand-held spreader) or mechanical seeding using a no-till drill calibrated to native seeds can be employed to plant seed, depending on the plot's size and topography. Application rates may differ among species planted. Preparing the seedbed is crucial. Where broadcast seeding is used, the soil surface should be disturbed by raking or very shallow disking to promote good seed to soil contact. Raking the soil following broadcast seeding or using a roller or cultipacker to press seed into soil (when practical) will aid with this as well.

Juniper hairstreak. Cullen Hanks.

No-till drills which have been calibrated for native seeds can be used to sow seeds directly into existing vegetation that is either dead-standing or growing at a height of eight inches or less. However, stubble should be cut low or raked off if possible as it may clog coulters. Areas covered by dense vegetation can be prepared for no-till seeding by applying a biodegradable, broad-spectrum herbicide in the spring, and repeating applications to any new growth for the duration of a growing season at minimum. Sites should be planted immediately following the final spray. Herbicides are allowable during site preparation (prior to planting) to eliminate unwanted plant species that compete with desirable nectar and pollen producing plants. Insecticides should not be used in the planting area.

The planted area must be regularly inspected for invasive and/or noxious plants or other plants that may compromise the purpose of this enhancement. Herbicides may be spot-sprayed to remove broad-leaf weeds, and grass-selective herbicides may be applied to larger areas to eliminate persistent, unwanted grasses. Similarly, the entire site should be high mowed in the first year post-planting to cut back persisting annual or biennial weeds before they go to flower. Use of insecticides should be avoided at all costs.

In general, mowing is inadequate for management of native insect pollinator habitat in the long term, except to remove annual non-native plants during establishment (i.e., high-mowing before they flower) or to facilitate a prescribed burn or light disking. Mowing alone smothers desirable annual and perennial flowering plants with clippings and may increase undesirable grass species.

Appropriate management activities for native pollinator plots include light disking, prescribed burning, or herbicide applications. Periodic maintenance will be required within the plot to ensure that grass litter does not suppress annual and perennial herbaceous flowering plants. Undesirable species should be controlled using the least damaging method, for example, spot-spraying with herbicide or physical removal.

Management activities that might impact flowering plants within the native pollinator plot should not be conducted until after the bloom period has concluded to avoid disrupting nectar, pollen, and host plant resources. **Plants should also be afforded time to set and shed seed to further establish planted species within the plot.**

Native pollinator plots should be protected from grazing animals and fenced where needed to buffer these sites from adjacent management activities. **Management activities should be applied to no more than 30% of an individual plot during a given year, except during the first year post-planting.**

Native pollinator plots should annually affect a minimum of 1% of the total area designated in the plan to receive credit, or a minimum of one acre annually, whichever is greater.

Refer to NRCS Conservation Practice Standard for Conservation Cover (Code 327) and the Xerces Society for Invertebrate Conservation Establishing Pollinator Meadows from Seed to prepare a native pollinator plot proposal for your plan.

V. Providing Supplemental Shelter

Most native solitary bee species in the U.S. excavate nests underground. Nests consist of narrow tunnels leading to small chambers (the brood cells) six to 36 inches or more under the surface. Bee eggs and larvae develop inside these brood cells. In order to build these nests, ground-nesting bees need direct access to the soil surface, often on sloped or well-drained sites. Bumble bees nest either in pre-existing underground cavities or above ground in deep thatch on the soil surface. The remainder of our native bees are solitary dead wood-nesters that build their nests inside hollow tunnels. These tunnels may occur in the soft pithy centers of some twigs and stems, cavities left behind by wood-boring beetle larvae or are excavated by the bees themselves in dead wood. Some native solitary bees also make use of cavities in soft, above-ground rotting logs, and stumps. The following practices may be employed to further increase nesting opportunities for native bees.

a. Brush Piles and Slash Retention

The planned placement and/or retention of brush piles can provide nesting opportunities for native solitary bee species and bumble bees. This practice also includes slash retention, or leaving dead brush on the ground where it was cut or uprooted. **A minimum of 1% of the designated area must be treated annually to qualify.** Note that there are many opportunities to create brush piles after brush management activities.

b. Woody plant/shrub establishment

When appropriate, include shrubs or herbaceous plants with hollow or pithy stems that can provide nesting habitat for tunnel-nesting bees. Plants with stems that bees utilize include box elder (*Acer negundo*), sunflower (*Helianthus*), sumac (*Rhus*), wildrose (*Rosa*), elderberry (*Sambucus*), raspberry and blackberry (*Rubus*), cup plant (*Silphium perfoliatum*), snowberry (*Symphoricarpos*), ironweed (*Vernonia*), and yucca (*Yucca*). **A minimum of 1% of the designated area must be treated annually to qualify.**

Leafcutter bee. Jessica Womack.

c. Natural Cavity/Snag Development

Retain and create snags for native cavity-nesting solitary bees. Wood-boring beetle larvae often fill dead trees and branches with narrow tunnels into which tunnel-nesting bees establish nests. Undesirable trees can be girdled or individually treated with herbicide and left standing. **A minimum of five snags per acre, on 5% of the acreage, must be created/retained annually to qualify.**

VI. Census

If you are managing your property with the goal of enhancing resources for native bees and other flower-visitors, one way to gauge success is to conduct annual censuses or surveys. Such efforts, conducted over several seasons, can provide insight as to whether your management is enhancing and/or supporting populations of these insects.

The most challenging aspect of a survey will be identifying what you see. Bee identification, especially to species level, can be challenging even for the most experienced entomologists. A good rule of thumb to remember is that bees, for the most part, tend to be hairy, full-bodied insects (there are exception, though). For bees, hair is an effective structure for trapping and transporting pollen back to the nest. See The Xerces Society's Citizen-scientist Bee Monitoring Guide and Streamlined Bee Monitoring Protocol for Assessing Pollinator Habitat for an introduction on identifying and differentiating major bee groups. Additional resources for pollinator identification can be found in Appendix D.

You can keep things simple by just concentrating on major groups of bees and other flower-visitors or surveying only for target species. Plan on bringing a digital camera/smart phone with you to

Sweat bee. Katja Schulz.

photograph the insects you observe for later examination back at home. If you are really ambitious, you could start a reference collection by collecting voucher specimens of bees and other insects. For this see The Very Handy Manual: How to Catch and Identify Bees and Manage a Collection. Caution should be exercised by those with known allergic reactions to bee stings. It is worth noting that solitary bees rarely sting unless provoked (i.e., smashed or squashed), so passive observation is unlikely to trigger an attack.

a. Incidental Observations

Although incidental observations provide less data than systematic, regular census efforts, they can yield valuable data. For this activity, you can conduct a timed flower-visitor walk that could be incorporated into other routine activities you conduct on your property. Observations can be made on any group of flower-visitor including bees (native and non-native), beetles, butterflies, hummingbirds, moths, and wasps. With this activity, allot a fixed amount of time to wander across portions of your property. This method has the advantage of allowing you to target flower-rich areas for observation as they shift over the seasons.

Warm, sunny days with light wind are optimal conditions for flower-visitor walks. **At a minimum, walks should be conducted in spring (March-May), summer (June-August), and fall (September-October) with at least one walk per season.** Walks should be traversed at a steady pace with periodic stops to observe flowers for visiting insects. Restrict observations to six feet in front and six feet to either side. Approach flowers slowly so as not to disturb feeding insects.

Watch where your shadow falls as a shadow cast over a patch of flowers may drive insects away. You will be looking for insects that are actively working flowers (hovering in front of, crawling over, and/or crawling into flowers). Do not record flower-visitors that just fly through your observation area. During your

Southern plains bumble bee. Jessica Womack.

survey, note which plants are in flower and which plant species are most heavily used by flower-visitors. These represent nectar and pollen resources to perpetuate and protect on your property.

Recording Data

To evaluate how your management activities are influencing native insect pollinator populations, record the data collected during flower-visitor walks. Technology and online resources allow for enhanced data storage and can aid in identification. The Texas Nature Tracker and Nongame and Rare Species Programs at TPWD use the online citizen-science portal, iNaturalist to compile data on nongame species of interest from naturalists across the state.

You can use iNaturalist to record your own observations, get help with identifications, collaborate with others, and access the observational data collected by other iNaturalist users. A smart phone iNaturalist app (Android/iPhone) is available and enables users to capture images of species and upload them for identification. Digital images can also be uploaded to iNaturalist directly through the website as well. Use of iNaturalist is free and only requires signing up and establishing a user profile.

Once you have an account, you can record flower-visitors during your surveys using a smart phone and the iNaturalist app. Your observations will be mapped and cataloged in your list of observations. Different privacy levels (viewable by the public to completely private) can be applied to your mapped observations.

The advantage of uploading your observations to iNaturalist is that it is composed of a community of amateur and professional naturalists who interact to identity species. Also, your data is recorded and organized in iNaturalist and can be downloaded to different file formats. Users can establish projects and "places" in iNaturalist to further consolidate data. If you choose, you could establish a dedicated place for your property alone or contribute data to an existing iNaturalist project. **TPWD has established the project, Bees and Wasps of Texas as a data repository for private landowners conducting flower-visitor surveys and managing their lands for these species.**

Brown-belted bumble bee. Jessica Womack.

Other resources available include Bumble Bee Watch (Xerces Society for Invertebrate Conservation), an interactive map of bumble bee observations collected by citizen scientists. Users submit pictures with accompanying date and location information and fill out a key to make a preliminary identification of the bumble bee to species. The data point is added to a map, and the preliminary identification is either confirmed or corrected by an expert. This tool can be used to compare the user's data with that of other citizen scientists and has resulted in very useful data on the range of declining bumble bee species.

b. Census and Monitoring of Nongame Wildlife Species

Regular, periodic counts of nongame wildlife species can be used to inform management timing, determine especially valuable plant species or habitat features, and increase knowledge of the local, regional, or state status of specific pollinators, such as bumble bees or other species of conservation need. This practice could also include developing checklists for the property of pollinators on site, high-value plant species, or high-value habitat features.

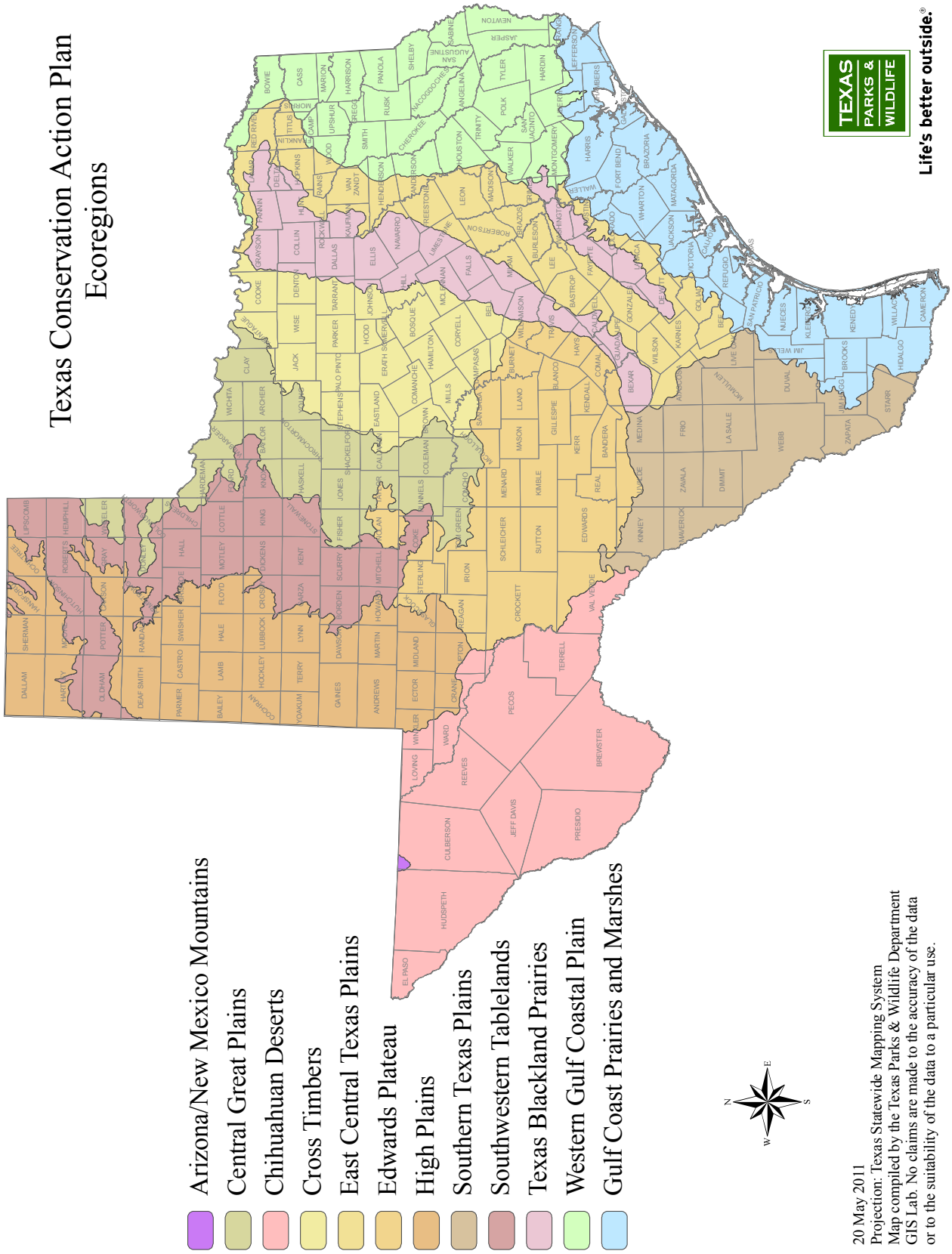
Bee Monitoring Protocol

The Xerces Society for Invertebrate Conservation has developed detailed protocols for implementing a bee monitoring effort (Citizen-scientist Bee Monitoring Guide and Streamlined Bee Monitoring Protocol for Assessing Pollinator Habitat). These standardized protocol are simple and easy to follow, concentrating only on very broad bee groups. Landowners interested in a systematic, yearly assessment of bee populations on their lands should apply this methodology. Download copies of these protocols for full details. **Two separate survey efforts applying either methodology should be conducted per year.**

Monarch Butterfly Monitoring Methods

Several dedicated survey efforts exist for monitoring monarch butterfly populations and include tagging of fall-migrating monarchs (Monarch Watch), monitoring egg-laying and larvae in the spring (Monarch Larval Monitoring Project), and reporting sightings of both spring- and fall-migrating monarchs (Journey North). **If monarchs are a focus, a minimum of two of these activities should be completed on an annual basis.**

Appendix A. Ecoregional Plant Lists for Texas



Central Great Plains, High Plains, and Southwestern Tablelands Native Plant List

Species	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
Creek plum (*Prunus rivularis*)												
Chickasaw plum (*Prunus angustifolia*)												
Gyp blue-curls (*Phacelia integrifolia*)												
Pink evening primrose (*Oenothera speciosa*)												
Plains greasebush (*Glossopetalon planitierum*)												
Giant spiderwort (*Tradescantia gigantea*)												
Texas redbud (*Cercis canadensis* var. *texensis*)												
Littleleaf sumac (*Rhus microphylla*)												
Fragrant gaillardia (*Gaillardia suavis*)												
Oklahoma plum (*Prunus gracilis*)												
Texas sage (*Salvia texana*)												
Amelia's sand-verbena (*Abronia ameliae*)												
Texas vervain (*Verbena halei*)												
Mountain peppergrass (Lepidium montanum)												
Huisache daisy (*Amblyolepis setigera*)												
Texas verbena (*Verbena halei*)												
Winecup (*Callirhoe involucrata*)												
Purple sand verbena (*Abronia angustifolia*)												
Zizotes milkweed (*Asclepias oenotheroides*)												
Spider milkweed (*Ascelpias asperula*)												
Annual pricklepoppy (*Argemone polyanthemos*)												
Four-nerve daisy (*Tetraneuris scaposa*)												
Hartweg's sundrops (Calylophus hartwegii)												
Chocolate daisy (*Berlandiera lyrata*)												
Blackfoot daisy (*Melampodium leucanthum*)												
Prairie penstemon (*Penstemon cobaea*)												
Berlandier's sundrops (*Calylophus berlandieri* ssp. *pinifolius*)												
Fragrant sumac (*Rhus aromatica*)												
Golden tickseed (*Coreopsis tinctoria*)												
Indigo bush (*Amorpha fruticosa*)												
Lanceleaf coreopsis (*Coreopsis lanceolata*)												
Roughleaf dogwood (*Cornus drummondii*)												

Central Great Plains, High Plains, and Southwestern Tablelands Native Plant List

Species	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
Chokecherry (*Prunus virginiana*)												
Fendler's penstemon (*Penstemon fendleri*)												
Prickly pear (*Opuntia engelmannii* var. *engelmannii*)												
Missouri evening-primrose (*Oenothera macrocarpa*)												
Spotted beebalm (*Monarda punctata*)												
Texas thistle (*Cirsium texanum*)												
Butterfly milkweed (Asclepias tuberosa)												
American basket-flower (*Centaurea americana*)												
Common prickly pear (*Opuntia macrorhiza*)												
Mountain pink (*Centaurium beyrichii*)												
Narrow-leaf coneflower (*Echinacea angustifolia*)												
Purple horsemint (*Monarda citriodora*)												
Firewheel (*Gaillardia pulchella*)												
Mexican hat (*Ratibida columnifera*)												
Smooth sumac (*Rhus glabra*)												
Partridge pea (*Chamaecrista fasciculata* var. *fasciculata*)												
Yellow plainsman (*Hymenopappus flavescens*)												
Pink plains penstemon (*Penstemon ambiguus*)												
Rocky mountain zinnia (*Zinnia grandiflora*)												
Leadplant (*Amorpha canescens*)												
Prairie spiderwort (*Tradescantia occidentalis*)												
Broad-leaf milkweed (*Asclepias latifolia*)												
Bush morning-glory (*Ipomoea leptophylla*)												
Buttonbush (*Cephalanthus occidentalis*)												
Sand milkweed (*Asclepias arenaria*)												
Showy milkweed (*Asclepias speciosa*)												
Englemann's milkweed (*Asclepias engelmanniana*)												
Gray goldenrod (*Solidago nemoralis*)												
Green milkweed (*Asclepias viridiflora*)												
Illinois bundleflower (*Desmanthus illinoensis*)												
Prairie acacia (*Acacia angustissima*)												
Prairie sunflower (*Helianthus petiolaris*)												

Central Great Plains, High Plains, and Southwestern Tablelands Native Plant List

Species	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
Plains milkweed (*Asclepias pumila*)												
Gray-golden aster (*Heterotheca canescens*)												
Leavenworth's eryngo (*Eryngium leavenworthii*)												
Black prairie clover (*Dalea frutescens*)												
Common sunflower (*Helianthus annuus*)												
Baldwin's ironweed (*Vernonia baldwinii*)												
Camphorweed (Heterotheca subaxillaris)												
Dotted blazing star (*Liatris punctata*)												
Broom snakeweed (*Gutierrezia sarothrae*)												
Maximilian sunflower (*Helianthus maximiliani*)												
Big blue sage (*Salvia azurea*)												
Canada goldenrod (*Solidago canadensis*)												
Tall goldenrod (*Solidago altissima*)												

Chihuahuan Deserts Native Plant List

Species	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
Cenizo (*Leucophyllum frutescens*)	■	■	■	■	■	■	■	■	■	■	■	■
Huisache (*Acacia farnesiana*)	■	■	■									
Texas mountain laurel (*Sophora secudiflora*)		■	■									
Big Bend bluebonnet (*Lupinus havardii*)		■	■	■								
Guajillo (*Acacia berlanderi*)		■	■	■								
Mexican redbud (*Cercis canadensis* var. *mexicana*)		■	■	■								
Bottle evening-primrose (*Oenothera primiveris*)		■	■	■	■							
Scrambled eggs (*Corydalis aurea*)		■	■	■	■	■	■	■	■			
Woolly paperflower (*Psilotrophe tagetina*)		■	■	■	■	■	■	■	■	■		
Perfumeballs (*Gaillardia suavis*)			■	■								
Blue curls (*Phacelia congesta*)			■	■	■							
Littleleaf sumac (*Rhus microphylla*)			■	■	■							
Texas bluebonnet (*Lupinus texensis*)			■	■	■							
Texas sage (*Salvia texana*)			■	■	■							
Winecup (*Callirhoe involucrata*)			■	■	■							
Blackbrush acacia (*Acacia rigidula*)			■	■	■	■						
Huisache daisy (*Amblyolepsis setigera*)			■	■	■	■						
Mexican buckeye (*Ungnadia speciosa*)			■	■	■	■						
Mexican prickly poppy (*Argemone mexicana*)			■	■	■	■						
Short-fruit evening-primrose (*Oenothera brachycarpa*)			■	■	■	■						
Fragrant mimosa (*Mimosa borealis*)			■	■	■	■	■					
Creosote bush (*Larrea tridentata*)			■	■	■	■	■	■	■			
Four-nerve daisy (*Tetraneuris scaposa*)			■	■	■	■	■	■	■	■		
Brownfoot (*Acourtia wrightii*)			■	■	■	■	■	■	■	■	■	
Desert marigold (*Baileya multiradiata*)			■	■	■	■	■	■	■	■	■	
Western primrose (*Calylophus hartwegii*)			■	■	■	■	■	■	■	■	■	
Whitebrush (*Aloysia gratissima*)			■	■	■	■	■	■	■	■	■	
Black willow (*Salix nigra*)				■	■							
Fragrant sumac (*Rhus aromatica*)				■	■	■						
Golden prairie clover (*Dalea aurea*)				■	■	■						

Cross Timbers Native Plant List

Species	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
Creek plum (*Prunus rivularis*)												
Mexican plum (*Prunus mexicana*)												
Chickasaw plum (*Prunus angustifolia*)												
Pink evening primrose (*Oenothera speciosa*)												
Giant spiderwort (*Tradescantia gigantea*)												
Green hawthorn (*Crataegus viridis*)												
New Jersey tea (*Ceanothus americanus*)												
Sandyland bluebonnet (*Lupinus subcarnosus*)												
Texas redbud (*Cercis canadensis* var. *texensis*)												
Blue curls (*Phacelia congesta*)												
Fragrant gaillardia (*Gaillardia suavis*)												
Oklahoma plum (*Prunus gracilis*)												
Possumhaw (*Ilex decidua*)												
Texas bluebonnet (*Lupinus texensis*)												
Texas sage (*Salvia texana*)												
Wild hyacinth (*Camassia scilloides*)												
Huisache daisy (*Amblyolepis setigera*)												
Lyreleaf sage (*Salvia lyrata*)												
Mexican buckeye (*Ungnadia speciosa*)												
Texas verbena (*Verbena halei*)												
Winecup (*Callirhoe involucrata*)												
Ohio spiderwort (*Tradescantia ohiensis*)												
Zizotes milkweed (*Asclepias oenotheroides*)												
Spider milkweed (*Ascelpias asperula*)												
Engelmann's sage (*Salvia engelmannii*)												
Prairie penstemon (*Penstemon cobaea*)												
Berlandier's sundrops (*Calylophus berlandieri* ssp. *pinifolius*)												
Fragrant sumac (*Rhus aromatica*)												
Golden tickseed (*Coreopsis tinctoria*)												
Indigo bush (*Amorpha fruticosa*)												
Lanceleaf coreopsis (*Coreopsis lanceolata*)												
Roughleaf dogwood (*Cornus drummondii*)												

Cross Timbers Native Plant List

Species	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
White Barbara's-buttons (*Marshallia caespitosa*)												
Chokecherry (*Prunus virginiana*)												
Prickly pear (*Opuntia engelmannii* var. *engelmannii*)												
Rose gentian (*Sabatia campestris*)												
Green milkweed (*Asclepias viridis*)												
Missouri evening-primrose (*Oenothera macrocarpa*)												
Spotted beebalm (*Monarda punctata*)												
Standing winecup (*Callirhoe digitata*)												
Texas thistle (*Cirsium texanum*)												
Desert willow (*Chilopsis linearis*)												
Mealy blue sage (*Salvia farinacea*)												
American basket-flower (*Centaurea americana*)												
Cockspur hawthorn (*Crataegus crus -galli*)												
Common prickly pear (*Opuntia macrorhiza*)												
Narrow-leaf coneflower (*Echinacea angustifolia*)												
Purple horsemint (*Monarda citriodora*)												
Firewheel (*Gaillardia pulchella*)												
Mexican hat (*Ratibida columnifera*)												
Rattlesnake master (*Eryngium yuccifolium*)												
Smooth sumac (*Rhus glabra*)												
Partridge pea (*Chamaecrista fasciculata* var. *fasciculata*)												
Halberdleaf hibiscus (*Hibiscus laevis*)												
Texas kidneywood (*Eysenhardtia texana*)												
Leadplant (*Amorpha canescens*)												
Prairie spiderwort (*Tradescantia occidentalis*)												
Buttonbush (*Cephalanthus occidentalis*)												
Green milkweed (*Asclepias viridiflora*)												
Illinois bundleflower (*Desmanthus illinoensis*)												
Prairie sunflower (*Helianthus petiolaris*)												
Wooly ironweed (*Vernonia lindheimeri*)												
Black-eyed susan (*Rudbeckia hirta*)												
Gray-golden aster (*Heterotheca canescens*)												
Compass plant (*Silphium laciniatum*)												
Black prairie clover (*Dalea frutescens*)												

Cross Timbers Native Plant List

Species	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
Common sunflower (*Helianthus annuus*)												
Camphorweed (Heterotheca subaxillaris)												
Narrow-leaf gayfeather (*Liatris mucronata*)												
Pink-scale gayfeather (*Liatris elegans*)												
Frostweed (*Verbesina virginica*)												
Hairy sunflower (*Helianthus hirsutus*)												
Maximilian sunflower (*Helianthus maximiliani*)												
Big blue sage (*Salvia azurea*)												
White boneset (*Eupatorium serotinum*)												

East Central Texas Plains Native Plant List

Species	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
Creek plum (*Prunus rivularis*)												
Mexican plum (*Prunus mexicana*)												
Chickasaw plum (*Prunus angustifolia*)												
Pink evening primrose (*Oenothera speciosa*)												
Green hawthorn (*Crataegus viridis*)												
New Jersey tea (*Ceanothus americanus*)												
Eastern redbud (*Cercis canadensis* var. *canadensis*)												
Giant spiderwort (*Tradescantia gigantea*)												
Sandyland bluebonnet (*Lupinus subcarnosus*)												
Texas redbud (*Cercis canadensis* var. *texensis*)												
Oklahoma plum (*Prunus gracilis*)												
Possumhaw (*Ilex decidua*)												
Texas bluebonnet (*Lupinus texensis*)												
Wild hyacinth (*Camassia scilloides*)												
Black cherry (*Prunus serotina*)												
Lyreleaf sage (*Salvia lyrata*)												
Winecup (*Callirhoe involucrata*)												
Ohio spiderwort (*Tradescantia ohiensis*)												
Zizotes milkweed (*Asclepias oenotheroides*)												
Spicebush (*Lindera benzoin*)												
Prairie penstemon (*Penstemon cobaea*)												
Berlandier's sundrops (*Calylophus berlandieri* ssp. *pinifolius*)												
Fragrant sumac (*Rhus aromatica*)												
Indigo bush (*Amorpha fruticosa*)												
Golden tickseed (*Coreopsis tinctoria*)												
Roughleaf dogwood (*Cornus drummondii*)												
White Barbara's-buttons (*Marshallia caespitosa*)												
Chokecherry (*Prunus virginiana*)												
Clasping coneflower (*Dracopis amplexicaulis*)												
Prickly pear (*Opuntia engelmannii* var. *engelmannii*)												
Rose gentian (*Sabatia campestris*)												
Green milkweek (*Asclepias viridis*)												
Texas thistle (*Cirsium texanum*)												
Antelopehorns (*Asclepias asperula*)												
Mealy blue sage (*Salvia farinacea*)												

East Central Texas Plains Native Plant List

Species	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
American basket-flower (*Centaurea americana*)												
Cockspur hawthorn (*Crataegus crus -galli*)												
Common prickly pear (*Opuntia macrorhiza*)												
Pale purple coneflower (*Echinacea pallida*)												
Purple horsemint (*Monarda citriodora*)												
Firewheel (*Gaillardia pulchella*)												
Mexican hat (*Ratibida columnifera*)												
Rattlesnake master (*Eryngium yuccifolium*)												
Smooth sumac (*Rhus glabra*)												
Partridge pea (*Chamaecrista fasciculata* var. *fasciculata*)												
White prairie clover (*Dalea candida*)												
Whorled milkweed (*Asclepias verticillata*)												
Halberdleaf hibiscus (*Hibiscus laevis*)												
Compact prairie clover (*Dalea compacta*)												
Prairie spiderwort (*Tradescantia occidentalis*)												
Roundhead prairie clover (*Dalea multiflora*)												
Buttonbush (*Cephalanthus occidentalis*)												
Green milkweed (*Asclepias viridiflora*)												
Wooly ironweed (*Vernonia lindheimeri*)												
Black-eyed susan (*Rudbeckia hirta*)												
Common sunflower (*Helianthus annuus*)												
Narrow-leaf gayfeather (*Liatris mucronata*)												
Pink-scale gayfeather (*Liatris elegans*)												
Frostweed (*Verbesina virginica*)												
Hairy sunflower (*Helianthus hirsutus*)												
Maximilian sunflower (*Helianthus maximiliani*)												
Prairie blazing star (*Liatris pycnostachya*)												
Big blue sage (*Salvia azurea*)												
White boneset (*Eupatorium serotinum*)												
Swamp sunflower (*Helianthus angustifolius*)												

Edwards Plateau Native Plant List

Species	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
Creek plum (*Prunus rivularis*)												
Texas mountain laurel (*Sophora secudiflora*)												
Guajillo (*Acacia berlanderi*)												
Mexican plum (*Prunus mexicana*)												
Mexican redbud (*Cercis canadensis* var. *mexicana*)												
Texas almond (*Prunus minutiflora*)												
Escarpment black cherry (*Prunus serotina* var. *eximia*)												
Giant spiderwort (*Tradescantia gigantea*)												
Texas redbud (*Cercis canadensis* var. *texensis*)												
Blue curls (*Phacelia congesta*)												
Texas bluebonnet (*Lupinus texensis*)												
Texas sage (*Salvia texana*)												
White prickly poppy (*Argemone albiflora*)												
Mexican buckeye (*Ungnadia speciosa*)												
Texas verbena (*Verbena halei*)												
Winecup (*Callirhoe involucrata*)												
Emory's milkweed (*Asclepias emoryi*)												
Spider milkweed (*Asclepias asperula*)												
Blanco crabapple (*Malus ioensis* var. *texana*)												
Black willow (*Salix nigra*)												
Engelmann's sage (*Salvia engelmannii*)												
Prairie penstemon (*Penstemon cobaea*)												
Rusty blackhaw (*Viburnum rufidulum*)												
Fragrant sumac (*Rhus aromatica*)												
Golden prairie clover (*Dalea aurea*)												
Indigo bush (*Amorpha fruticosa*)												
Roughleaf dogwood (*Cornus drummondii*)												
White Barbara's-buttons (*Marshallia caespitosa*)												
Prickly pear (*Opuntia engelmannii* var. *engelmannii*)												
Green milkweek (*Asclepias viridis*)												
Missouri evening-primrose (*Oenothera macrocarpa*)												
Texas thistle (*Cirsium texanum*)												
Green antelopehorn (*Asclepias viridis*)												
Mealy blue sage (*Salvia farinacea*)												

Edwards Plateau Native Plant List

Species	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
Zizotes (*Asclepias oenotheroides*)												
American basket-flower (*Centaurea americana*)												
Cockspur hawthorn (*Crataegus crus -galli*)												
Common prickly pear (*Opuntia macrorhiza*)												
Narrow-leaf coneflower (*Echinacea angustifolia*)												
Purple horsemint (*Monarda citriodora*)												
Texas milkweed (*Asclepias texana*)												
Firewheel (*Gaillardia pulchella*)												
Mexican hat (*Ratibida columnifera*)												
Smooth sumac (*Rhus glabra*)												
Englemann's milkweed (*Asclepias engelmanniana*)												
Partridge pea (*Chamaecrista fasciculata* var. *fasciculata*)												
Texas kidneywood (*Eysenhardtia texana*)												
Compact prairie clover (*Dalea compacta*)												
White prairie clover (*Dalea multiflora*)												
Buttonbush (*Cephalanthus occidentalis*)												
Bluewood (*Condalia hookeri*)												
Green milkweed (*Asclepias viridiflora*)												
Wooly ironweed (*Vernonia lindheimeri*)												
Swamp milkweed (*Asclepias incarnata*)												
Gray golden-aster (*Heterotheca canescens*)												
Compass plant (*Silphium laciniatum*)												
Leavenworth's eryngo (*Eryngium leavenworthi*)												
Baldwin's ironweed (*Vernonia baldwinii*)												
Black prairie clover (*Dalea frutescens*)												
Common sunflower (*Helianthus annuus*)												
Dotted gayfeather (*Liatris punctata*)												
Julia's goldenrod (*Solidago juliae*)												
Narrow-leaf gayfeather (*Liatris mucronata*)												
Prairie goldenrod (*Solidago nemoralis*)												
Swamp milkweed (*Asclepias incarnata*)												
Western rough goldenrod (*Solidago radula*)												
Maximilian sunflower (*Helianthus maximiliani*)												

Edwards Plateau Native Plant List

Species	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
Big blue sage (*Salvia azurea*)												
Meadow aster (*Symphyotrichum pratense*)												
Texas aster (*Symphyotrichium drummondii* var. *texanum*)												

Gulf Coast Prairies and Marshes Native Plant List

Species	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
Mexican plum (*Prunus mexicana*)												
Chickasaw plum (*Prunus angustifolia*)												
Pink evening primrose (*Oenothera speciosa*)												
Giant spiderwort (*Tradescantia gigantea*)												
Green hawthorn (*Crataegus viridis*)												
New Jersey tea (*Ceanothus americanus*)												
Oklahoma plum (*Prunus gracilis*)												
Possumhaw (*Ilex decidua*)												
Black cherry (*Prunus serotina*)												
Gulf Coast penstemon (*Penstemon tenuis*)												
Lyreleaf sage (*Salvia lyrata*)												
Mexican pricklypoppy (*Argemone mexicana*)												
Winecup (*Callirhoe involucrata*)												
Ohio spiderwort (*Tradescantia ohiensis*)												
Texas lignum-vitae (*Guajacum angustifolium*)												
Zizotes milkweed (*Asclepias oenotheroides*)												
Salt heliotrope (*Heliotropium curassavicum*)												
Spicebush (*Lindera benzoin*)												
Prairie penstemon (*Penstemon cobaea*)												
Berlandier's sundrops (*Calylophus berlandieri* ssp. *pinifolius*)												
Fragrant sumac (*Rhus aromatica*)												
Indigo bush (*Amorpha fruticosa*)												
Plains coreopsis (*Coreopsis tinctoria*)												
Roughleaf dogwood (*Cornus drummondii*)												
White Barbara's-buttons (*Marshallia caespitosa*)												
Clasping coneflower (*Dracopis amplexicaulis*)												
Prickly pear (*Opuntia engelmannii* var. *engelmannii*)												
Rose gentian (*Sabatia campestris*)												
Green milkweed (*Asclepias viridis*)												
Lindheimer's hoarypea (*Tephrosia lindheimeri*)												
Longleaf milkweed (*Asclepias longifolia*)												
Shore milkweed (*Asclepias perennis*)												
Slim milkweed (*Asclepias linearis*)												
American basket-flower (*Centaurea americana*)												
Common prickly pear (*Opuntia macrorhiza*)												

Gulf Coast Prairies and Marshes Native Plant List

Species	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
Dwarf palmetto (*Sabal minor*)												
Purple horsemint (*Monarda citriodora*)												
Firewheel (*Gaillardia pulchella*)												
Rattlesnake master (*Eryngium yuccifolium*)												
Tenaza (*Havardia pallens*)												
Texas thistle (*Cirsium texanum*)												
Partridge pea (*Chamaecrista fasciculata* var. *fasciculata*)												
Mexican hat (*Ratibida columnifera*)												
Halberdleaf hibiscus (*Hibiscus laevis*)												
Slim milkweed (*Asclepias linearis*)												
Zexmenia (*Wedelia texana*)												
Green milkweek (*Asclepias viridiflora*)												
Wooly ironweed (*Vernonia lindheimeri*)												
Black-eyed susan (*Rudbeckia hirta*)												
Sand palafox (*Palafoxia hookeriana*)												
Compass plant (*Silphium laciniatum*)												
Common sunflower (*Helianthus annuus*)												
Narrow-leaf gayfeather (*Liatris mucronata*)												
Pink-scale gayfeather (*Liatris elegans*)												
Prairie blazing star (*Liatris pycnostachya*)												
Maximilian sunflower (*Helianthus maximiliani*)												
Silverleaf sunflower (*Helianthus argophyllus*)												
Big blue sage (*Salvia azurea*)												
Frostweed (*Verbesina virginica*)												
White boneset (*Eupatorium serotinum*)												
Swamp sunflower (*Helianthus angustifolius*)												

Southern Texas Plains Native Plant List

Species	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
Pink evening primrose (*Oenothera speciosa*)												
Berlandier's fiddlewood (*Citharexylum berlandieri*)												
Texas lignum-vitae (Guajacum angustifolium)												
West Indian milkberry (*Chiococca alba*)												
Cenizo (*Leucophyllum frutescens*)												
New Jersey tea (*Ceanothus americanus*)												
Sandyland bluebonnet (*Lupinus subcarnosus*)												
Oklahoma plum (*Prunus gracilis*)												
Rayless gaillardia (*Gaillardia suavis*)												
Rio Grande stickpea (*Calliandra conferta*)												
Texas bluebonnet (*Lupinus texensis*)												
Texas sage (*Salvia texana*)												
Mexican pricklypoppy (*Argemone mexicana*)												
Winecup (*Callirhoe involucrata*)												
Texas lignum-vitae (*Guajacum angustifolium*)												
Emory's milkweed (*Asclepias emoryi*)												
Zizotes milkweed (*Asclepias oenotheroides*)												
Hartweg's sundrops (*Calylophus hartwegii*)												
Salt heliotrope (*Heliotropium curassavicum*)												
Whitebrush (*Aloysia gratissima*)												
Prairie penstemon (*Penstemon cobaea*)												
Berlandier's sundrops (Calylophus berlandieri ssp. pinifolius)												
Fragrant sumac (*Rhus aromatica*)												
Plains coreopsis (*Coreopsis tinctoria*)												
Clasping coneflower (*Dracopis amplexicaulis*)												
Prickly pear (*Opuntia engelmannii* var. *engelmannii*)												
Rose gentian (*Sabatia campestris*)												
Retama (*Parkinsonia aculeata*)												
Spotted beebalm (*Monarda punctata*)												
Gregg's tubetongue (*Justicia pilosella*)												
Lindheimer's hoarypea (*Tephrosia lindheimeri*)												
American basket-flower (*Centaurea americana*)												
Common prickly pear (*Opuntia macrorhiza*)												
Purple horsemint (*Monarda citriodora*)												

Southern Texas Plains Native Plant List

Species	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
Firewheel (*Gaillardia pulchella*)												
Tenaza (*Havardia pallens*)												
Texas thistle (*Cirsium texanum*)												
Partridge pea (*Chamaecrista fasciculata* var. *fasciculata*)												
Texas kidneywood (*Eysenhardtia texana*)												
Texas mimosa (Mimosa texana)												
Mexican hat (*Ratibida columnifera*)												
Zexmenia (*Wedelia texana*)												
Wooly ironweed (*Vernonia lindheimeri*)												
Black-eyed susan (*Rudbeckia hirta*)												
Sand palafox (*Palafoxia hookeriana*)												
Common sunflower (*Helianthus annuus*)												
Dotted gayfeather (*Liatris punctata*)												
Pink-scale gayfeather (*Liatris elegans*)												
Maximilian sunflower (*Helianthus maximiliani*)												
Big blue sage (*Salvia azurea*)												
Frostweed (*Verbesina virginica*)												
White boneset (*Eupatorium serotinum*)												

Texas Blackland Prairies Native Plant List

Species	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
Creek plum (*Prunus rivularis*)												
Mexican plum (*Prunus mexicana*)												
Pink evening primrose (*Oenothera speciosa*)												
Eastern redbud (*Cercis canadensis* var. *canadensis*)												
Giant spiderwort (*Tradescantia gigantea*)												
Green hawthorn (*Crataegus viridis*)												
New Jersey tea (*Ceanothus americanus*)												
Sandyland bluebonnet (*Lupinus subcarnosus*)												
Texas redbud (*Cercis canadensis* var. *texensis*)												
Fragrant gaillardia (*Gaillardia suavis*)												
Longbract wild indigo (*Baptisia bracteata* var. *leucophaea*)												
Oklahoma plum (*Prunus gracilis*)												
Possumhaw (*Ilex decidua*)												
Texas bluebonnet (*Lupinus texensis*)												
Texas sage (*Salvia texana*)												
Wild hyacinth (*Camassia scilloides*)												
Black cherry (*Prunus serotina*)												
Texas verbena (*Verbena halei*)												
Winecup (*Callirhoe involucrata*)												
Ohio spiderwort (*Tradescantia ohiensis*)												
Spider milkweed (*Asclepias asperula*)												
Zizotes milkweed (*Asclepias oenotheroides*)												
Spicebush (*Lindera benzoin*)												
Engelmann's sage (*Salvia engelmannii*)												
Prairie penstemon (*Penstemon cobaea*)												
Berlandier's sundrops (*Calylophus berlandieri* ssp. *pinifolius*)												
Fragrant sumac (*Rhus aromatica*)												
Golden tickseed (*Coreopsis tinctoria*)												
Indigo bush (*Amorpha fruticosa*)												
Lanceleaf coreopsis (*Coreopsis lanceolata*)												
Roughleaf dogwood (*Cornus drummondii*)												
White Barbara's-buttons (*Marshallia caespitosa*)												
Rose gentian (*Sabatia campestris*)												
Prickly pear (*Opuntia engelmannii* var. *engelmannii*)												
Green milkweed (*Asclepias viridis*)												

Texas Blackland Prairies Native Plant List

Species	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
Missouri evening-primrose (*Oenothera macrocarpa*)												
Spotted beebalm (*Monarda punctata*)												
Texas thistle (*Cirsium texanum*)												
Butterfly milkweed (*Asclepias tuberosa*)												
Purple coneflower (*Echinacea purpurea*)												
Mealy blue sage (*Salvia farinacea*)												
American basket-flower (*Centaurea americana*)												
Cockspur hawthorn (*Crataegus crus -galli*)												
Common prickly pear (*Opuntia macrorhiza*)												
Narrow-leaf coneflower (*Echinacea angustifolia*)												
Purple horsemint (*Monarda citriodora*)												
Firewheel (*Gaillardia pulchella*)												
Mexican hat (*Ratibida columnifera*)												
Smooth sumac (*Rhus glabra*)												
Partridge pea (*Chamaecrista fasciculata* var. *fasciculata*)												
Halberdleaf hibiscus (*Hibiscus laevis*)												
Compact prairie clover (*Dalea compacta*)												
Prairie spiderwort (*Tradescantia occidentalis*)												
Buttonbush (*Cephalanthus occidentalis*)												
Green milkweed (*Asclepias viridiflora*)												
Illinois bundleflower (*Desmanthus illinoensis*)												
Wooly ironweed (*Vernonia lindheimeri*)												
Black-eyed susan (*Rudbeckia hirta*)												
Compass plant (*Silphium laciniatum*)												
Black prairie clover (*Dalea frutescens*)												
Common sunflower (*Helianthus annuus*)												
Narrow-leaf gayfeather (*Liatris mucronata*)												
Pink-scale gayfeather (*Liatris elegans*)												
Prairie blazing star (*Liatris pycnostachya*)												
Hairy sunflower (*Helianthus hirsutus*)												
Maximilian sunflower (*Helianthus maximiliani*)												
Big blue sage (*Salvia azurea*)												
Meadow aster (*Symphyotrichum pratense*)												
White boneset (*Eupatorium serotinum*)												

Western Gulf Coastal Plain Native Plant List

Species	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
Creek plum (*Prunus rivularis*)												
Mexican plum (*Prunus mexicana*)												
Chickasaw plum (*Prunus angustifolia*)												
Pink evening primrose (*Oenothera speciosa*)												
Giant spiderwort (*Tradescantia gigantea*)												
Green hawthorn (*Crataegus viridis*)												
Hog plum (*Prunus umbellata*)												
New Jersey tea (*Ceanothus americanus*)												
Texas redbud (*Cercis canadensis* var. *texensis*)												
Oklahoma plum (*Prunus gracilis*)												
Parsley hawthorn (*Crataegus marshallii*)												
Possumhaw (*Ilex decidua*)												
Wild azalea (*Rhododendron canescens*)												
Black cherry (*Prunus serotina*)												
Lyreleaf sage (*Salvia lyrata*)												
Winecup (*Callirhoe involucrata*)												
Ohio spiderwort (*Tradescantia ohiensis*)												
Spicebush (*Lindera benzoin*)												
Prairie penstemon (*Penstemon cobaea*)												
Fragrant sumac (*Rhus aromatica*)												
Roughleaf dogwood (*Cornus drummondii*)												
Blunt-leaf milkweed (*Asclepias amplexicaulis*)												
White Barbara's-buttons (*Marshallia caespitosa*)												
Rose gentian (*Sabatia campestris*)												
Prickly pear (*Opuntia engelmannii* var. *engelmannii*)												
Green milkweek (*Asclepias viridis*)												
Butterfly milkweed (*Asclepias tuberosa*)												
Purple coneflower (*Echinacea purpurea*)												
American basket-flower (*Centaurea americana*)												
Common prickly pear (*Opuntia macrorhiza*)												
Dwarf palmetto (*Sabal minor*)												
Purple horsemint (*Monarda citriodora*)												
Firewheel (*Gaillardia pulchella*)												

Western Gulf Coastal Plain Native Plant List

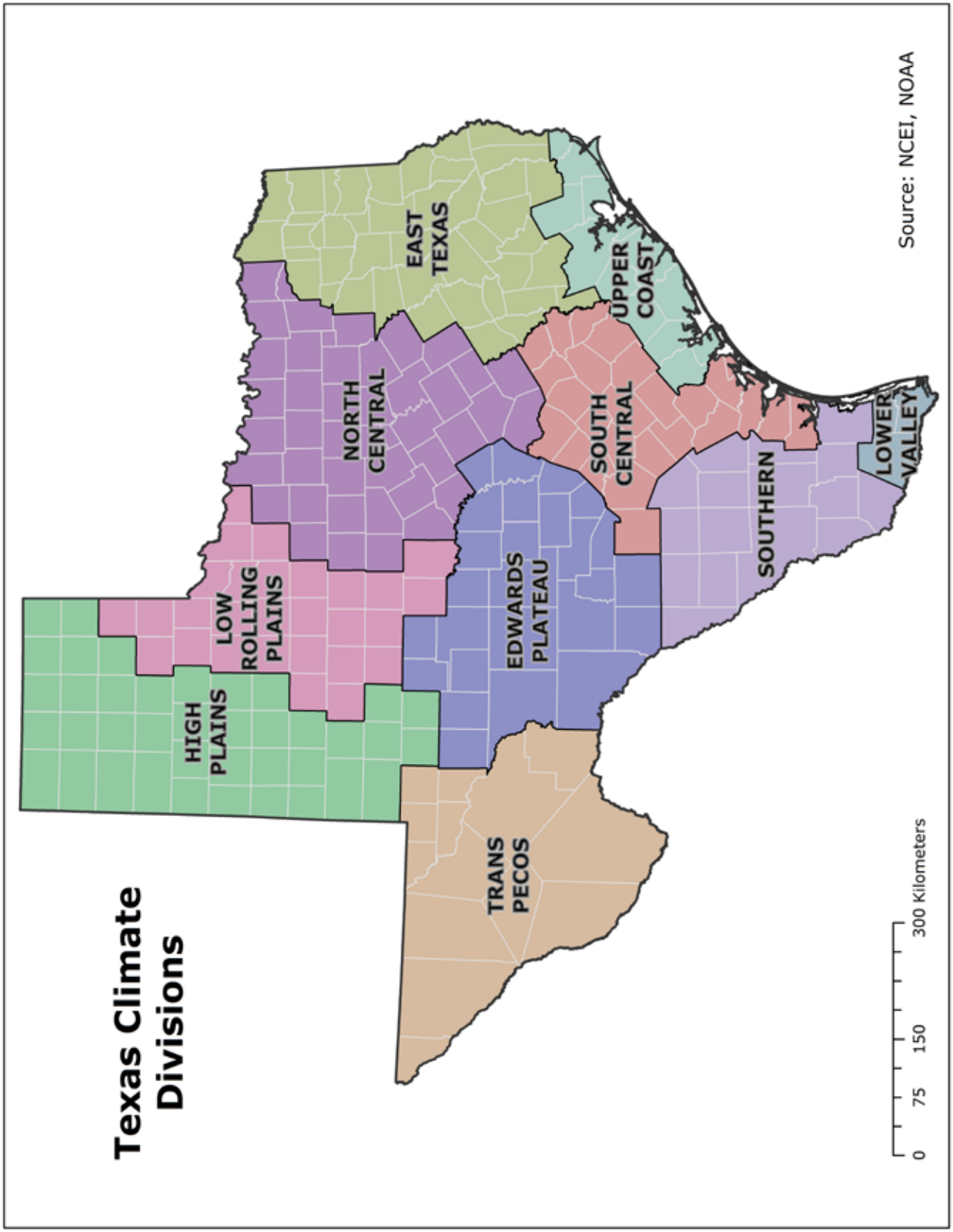
Species	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
Rattlesnake master (*Eryngium yuccifolium*)												
Smooth sumac (*Rhus glabra*)												
Illinois bundleflower (*Desmanthus illinoensis*)												
Halberdleaf hibiscus (*Hibiscus laevis*)												
Whorled milkweed (*Asclepias verticillata*)												
Ashy sunflower (*Helianthus mollis*)												
Black-eyed susan (*Rudbeckia hirta*)												
Narrow-leaf gayfeather (*Liatris mucronata*)												
Pink-scale gayfeather (*Liatris elegans*)												
Prairie blazing star (*Liatris pycnostachya*)												
Rough sunflower (*Helianthus hirsutus*)												
Big blue sage (*Salvia azurea*)												
White boneset (*Eupatorium serotinum*)												
Swamp sunflower (*Helianthus angustifolius*)												

Appendix B. Select Native Pollinator/Flower-visitor Species of Greatest Conservation Need in Texas.

Scientific Name	Common Name	Known County Distribution	Ecological Notes
Andrena scotoptera	Mining bee	Atascosa, Bee, Dimmit,Hidalgo, Jim Hogg, and Zapata	Strong foraging preferences for pricklypoppy species (Argemone).
Apodemia chisosensis	Chisos metalmark	Brewster and Terrell	Larvae feed on Havard's plum (Prunus havardii)
Bombus pensylvanicus	American bumblebee	Statewide (most counties have the potential to host this species)	A broadly distributed bumble bee in Texas. Will visit a wide variety of plant species for nectar and pollen.
Bombus sonorus	Sonoran bumblebee	Bandera, Brewster, Culberson, Grimes, Hidalgo, Hunt, Jeff Davis, Kent, Kerr, Kimble, Pecos, Presidio, Real, Reeves, Sutton, Terrell, Uvalde, Val Verde, and Ward	Most frequently encountered bumble bee in western Texas. Will visit a wide variety of plant species for nectar and pollen.
Celotes limpia	Scarce streaky-skipper	Brewster, Culberson, Jeff Davis, and Presidio	Several mallow species are used as larval hostplants including globemallow (Sphaeralcea) and texasfan (Meximalva filipes).
Colletes bumeliae	Cellophane bee	Bastrop and Blanco	Strong foraging preferences for bully species (Sideroxylon). Nests in sandy soil.
Colletes saritensis	Cellophane bee	Cameron, Kenedy, and Zapata	Strong foraging preferences for prairie clover species (Dalea). Known mostly from areas with sandy soils.
Decinea percosius	Percosius skipper	Cameron	Larval hosts include several grass species.

Lintneria eremitoides	Sage sphinx	Hunt, Kerr, Kimble, Terrell, and Uvalde	Larvae feed on sage species (Salvia).
Perdita atriventris	Mining bee	Burleson and Robertson	Strong foraging preferences for members of the Aster family (Asteraceae).
Perdita dolanensis	Mining bee	Val Verde	Strong foraging preferences for sage species (Salvia).
Perdita fraticincta	Mining bee	Dimmit and Willacy	Strong foraging preferences for members of the Aster family (Asteraceae).
Perdita tricincta	Mining bee	Cameron, Hidalgo, and Starr	Strong foraging preferences for members of the Aster family (Asteraceae).
Piruna haferniki	Chisos skipperling	Brewster	
Protandrena maurula	Mining bee	Archer, Coleman, Gillespie, and Throckmorton	Strong foraging preferences for germander species (Teucrium).
Satyrium polingi	Poling's hairstreak	Brewster, Culbertson, El Paso, Jeff Davis, and Presidio	Larvae feed on gray oak (Quercus grisea) and potentially Emory oak (Q. emoryi).
Stallingsia maculosus	Manfreda giant-skipper	Aransas, Bee, Bexar, Cameron, Hidalgo, Jim Wells, Karnes, Kinney, Kleberg, Medina, Nueces, San Patricio, Starr, and Wilson.	Larvae feed on Manfreda species.

Appendix C. Climatic Regions of Texas



Appendix D. Resources

Bee Identification

BugGuide Native Bee Families
www.bugguide.net/node/view/8267

Collecting and Processing Bee Specimens

The Very Handy Manual: How to Catch and Identify Bees and Manage a Collection
www.pwrc.usgs.gov/nativebees/Handy Bee Manual/The_Very_Handy_Manual.pdf

European Honey Bee Control

Texas Apiary Inspection Service: Bee Removal
www.txbeeinspection.tamu.edu/bee-removal

Feral Hog Control

Control Techniques for Feral Hogs (Texas AgriLife)
www.agrilife.org/texnatwildlife/feral-hogs/control-techniques-for-feral-hogs/

iNaturalist

Basics and Introduction to Users
www.inaturalist.org/pages/help

Bees and Wasps of Texas
www.inaturalist.org/projects/bees-and-wasps-of-texas

Milkweed

Milkweed Seed Finder
www.xerces.org/milkweed-seed-finder

Milkweeds: A Conservation Practitioner's Guide
www.xerces.org/milkweeds-a-conservation-practitioners-guide

Texas Milkweed Identification Guide
www.tpwd.texas.gov/huntwild/wild/wildlife_diversity/nongame/publications/media/TPWD-Identification-Milkweeds-Texas.pdf

Monarch Butterfly Citizen-Science

Journey North
www.learner.org/jnorth/monarch

Monarch Larval Monitoring Project
www.mlmp.org

Monarch Watch
www.monarchwatch.org

Native Plants

Lady Bird Johnson Wildflower Center Native Plants Database
www.wildflower.org/plants

Texas Parks and Wildlife Department

Agricultural Tax Appraisal Based on Wildlife Management
www.tpwd.texas.gov/landwater/land/private/agricultural_land

Nongame and Rare Species Program
www.tpwd.texas.gov/huntwild/wild/wildlife_diversity/nongame

U.S Department of Agriculture/National Resources Conservation Service

Conservation Practices Standards
http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/technical/cp/ncps/

Monarch Butterfly Resources
www.nrcs.usda.gov/wps/portal/nrcs/detail/national/plantsanimals/pollinate/?cid=nrcseprd402207

Using the 2014 Farm Bill Programs for Pollinator Conservation
www.xerces.org/wp-content/uploads/2013/04/using-farmbill-programs-for-pollinator-conservation-2ndEd.pdf

The Xerces Society of Invertebrate Conservation

Bring Back the Pollinators
www.xerces.org/bringbackthepollinators

Bumble Bee Watch
www.bumblebeewatch.org

Citizen-scientist Bee Monitoring Guide
www.xerces.org/download/pdf/PA_Xerces Guide.pdf

Managing Pesticides to Protect Bees
www.xerces.org/pollinator-conservation/agriculture/managing-pesticides-to-protect-bees

Establishing Pollinator Meadows from Seed
www.xerces.org/establishing-pollinator-meadows-from-seed

Pollinator Habitat Assessment Form and Guide: Natural Areas and Rangelands
www.xerces.org/wp-content/uploads/2014/12/PollinatorHabitatAssessment_NaturalAreasRangelands_web.pdf

Streamlined Bee Monitoring Protocol for Assessing Pollinator Habitat
www.xerces.org/wp-content/uploads/2014/09/StreamlinedBeeMonitoring_web.pdf

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