The Effects of Native Prairie Plants on Wild Bee Diversity

Over the last hundred years, agriculture has begun to dominate the landscape (Citation). In order to combat the increase in agriculture and the potential impacts, the United States Department of Agriculture created The Conservation Reserve Program (CRP) (citation). The Conservation Reserve Program was signed into law in 1985 and is a voluntary program whereby farmers and land owners remove private land from agricultural production for 10-15 years. This conservation land must be converted into one of ten conservation initiatives. Each initiative contains one or more practices, for example CP42 Pollinator Habitat is found within the Pollinator Habitat Initiative (citation). CRP was designed to help improve the health and quality of the environment, specifically to combat the effects of extremely high amounts of soil erosion citation). Its long-term goal is to re-establish native lands, improve water quality, decrease erosion, and much more through the various program initiatives (citation). The increase in agriculture has created fragmented landscapes that provide very little support to pollinator communities. This has led to the development of the Pollinator Habitat Initiative, CP-42. Agricultural or other lands are replaced with seed mixes that are designed by private industry with the help of the United States Department of Agriculture’s (USDA) National Resources Conservation Service (NRCS) and Farm Service Agency (FSA).

The Pollinator Habitat Initiative, was created to reverse the declines in honey bee (*Apis mellifera* L.)*,* and native pollinator populations (USDA-FRS 2018). CP-42 is designed to improve pollinator populations by increasing food plant diversity. In conjunction with private industry, the USDA-NRCS and USDA-FRS have worked to produce seed mixes that contain at least nine species of “pollinator friendly” wildflowers, legumes, and shrubs. The program requires species to bloom throughout the growing season so pollinators have access to both nectar and pollen throughout the agricultural season.

Wild bee species are some of the most sensitive organisms to land-use changes (Hendrickx et al. 2007). Wild bees are essential to the pollination and reproduction of at least two thirds of known flowering plant species, and are responsible for pollinating over $153 billion dollars in agricultural crops (Gallai et al. 2009, Potts et al. 2010). Present and past land-use changes are impacting wild bee species throughout the world (Kennedy et al. 2013), but the magnitude is unknown. Human-based activities such as agricultural intensification and habitat fragmentation have led to landscape simplification and decreased biodiversity (Bengtsson at al. 2005; Carrié et al. 2017). Such land-use changes have led to a decline in bee populations because resources such as pollen and nectar have been reduced. The cause of this reductions is due to a decline in the relative abundances of native plant species (Carrié et al. 2017). Due to recent declines in pollinator populations and pollinator diversity, it important to understand the consequences surrounding the agricultural intensification of current landscapes.

The Southern High Plains, or Llano Estacado is a large, dry region found in eastern New Mexico and western Texas (Reeves 1970). This region is roughly 77,700 square kilometers and is a remnant of the Rocky Mountains. This region is surrounded on three sides by a steep escarpment of Pliocene caliche, and further south merges with the Edwards Plateau (Reeves 1970). This region contains an estimated 22,000 playa basins (Bolen et al. 1989) which occupy approximately 2% of the landscape (Smith et al. 2011).

Texas is the largest cotton producing state, responsible for over 25% of the US cotton Crop (TAMU 2013). The Southern High plains specifically contains the ten highest producing counties of cotton in the United States (NASS 2016a). Cotton is the state’s largest cash crop and responsible for over three billion dollars’ worth in agriculture (NASS, 2016b). Although this region is responsible for the majority of cotton, it may not be the ideal location (Mauget et al. 2017). This region’s growing conditions are not ideal for cotton, and the soil does not contain the compounds necessary for maximum production, and this may lead to the need for chemical fertilizers (Peng et al. 1989; Morrow and King, 1990). Lastly, cotton requires large amounts of water, and this region simply doesn’t provide the required rainfall thus farmers depend on irrigation from the Ogallala aquifer which is being depleted at an alarming rate ([McGuire, 2007](https://www.sciencedirect.com/science/article/pii/S0168192317302253" \l "bib0135), [Sophocleous, 2010](https://www.sciencedirect.com/science/article/pii/S0168192317302253" \l "bib0205), [Scanlon et al. 2012](https://www.sciencedirect.com/science/article/pii/S0168192317302253" \l "bib0190), [Haacker et al. 2016](https://www.sciencedirect.com/science/article/pii/S0168192317302253" \l "bib0080)).

The global population of honey bees has been declining since the 1940’s, and both Europe and North America have lost significant populations of honey bees (Potts et al. 2010, van Engelsdorp et al. 2008, NRC 2007). Currently, over 20,000 pollinator species have been identified throughout the world, but it is unknown if the population declines in these species is similar to that of the honey bees (Bartomeus et al. 2013, Goulson et al. 2015). Pollinators are responsible for pollinating almost 35% of the world’s food supply (Klein et al. 2007), within the US, this attributes to over 3.07 billion dollars’ worth of pollination services by wild pollinators (Losey and Vaughan 2006).

Honey bees and bumble bees are two of the most widely researched pollinator species. Most research conducted on them has found that there are many possible causes for their population declines. Such factors are the Varroa mite, (*Varroa destructor* Anderson & Trueman), small hive beetle, (*Aethina tumida* Murray) (Spiewok and Neumann 2006), viruses such as Deformed Wing Virus (Genersch et al. 2006), *Paenibacillus larvae* (Genersch 2010), and fungi such as *Nosema* spp. (Graystock et al. 2013). In 2006, some honey bee hives declined by up to 90%, and “Colony Collapse Disorder” was created to describe such drastic losses (Evans et al. 2009). “Colony Collapse Disorder” is a misunderstood term that is used to explain honey bee losses, but may be caused by a variety of factors as well as interactions between factors. Honey bees play a vital role in the economy, valued at over $14 billion due to their pollination services both directly and indirectly (Ellis et al. 2009). Due to the sharp declines of honey bee populations in the last few decades, wild pollinator populations have become more responsible for pollination services.

Current research indicates numerous threats towards honey bees and bumble bees, the two most researched pollinators. Little research has been conducted on wild pollinator species, and it is unknown if many of the threats to honey bees and bumble bees may be the same potential threats for wild pollinator species. For example, *Nosema ceranae* has been transferred from the Asian honey bee (*Apis ceranae*)many other *Apis* species including the western honey bee (*Apis mellifera*) (Graystock et al. 2013). Recently, scientists have found cases of *N. ceranae* in bumblebee species, which indicates a jump from honey bees to bumblebees (Li et al. 2012; Plischuk et al. 2009). Many bumblebee species are critically endangered and others are important pollinators of crops (Goulson et al. 2015). Based upon this transfer effect from honey bees to bumblebees, it is unknown if wild bee populations are at risk from the same pathogens.

Wild bees play a critical role in the pollination and reproduction of plant species with over 70% of the world’s most important crops dependent upon their pollination services (Klein et al. 2007). Farmers throughout the world have started to take notice of the pollination benefits of wild and understudied bee species (Gallai et al. 2009). Agricultural producers often rely on the honey bee (*Apis mellifera*) for pollination for crops such as apples, almonds, and various cucurbits (Calderone 2012), but it has been shown that native bee species may fully pollinate certain crops as well as wild bees (Mallinger and Gratton 2015). Research has shown that some plant species such as cherries and apples, respond directly to wild bee pollinators, but not to honey bees (Holzschuh et al. 2012, Mallinger and Gratton 2015). As a result of their benefits and pollination services, many wild bee species are managed for their pollination benefits (Gallai et al. 2009). For example, the wild bee species *Osmia lingaria* (Bosch and Kemp 2002) is managed for fruit pollination, and the leaf cutter bee *Megachile rotundata* (Pitts-Singer and Cane 2011) is managed for increased pollination services in select crops.

Pollination by wild bees is an underutilized and overlooked resource. Compared to wild pollinators, honey bees are thought to be better and more efficient pollinators. Accruing evidence may be showing otherwise (Javorek et al. 2002, ). For example, previous studies have found that fruit set in cherries was significantly influenced by wild bee visitation compared to honey bee visitation (citation). Similar evidence has been found in blueberries and watermelon; in blueberries, *Andrena* bees deposit far more pollen than do honey bees (Javorek et al. 2002), and wild bees were found to be more efficient pollinators in watermelon, depositing more pollen than honey bees (Winfree et al. 2007). The differences in pollination efficiency may be due to the idea that wild bees collect pollen and feed on nectar at the same time, thus coming in contact with all reproductive parts of the flower. In contrast, honey bees are though to only feed on nectar, thus having less contact with the reproductive organs of plant species (Horzschuh et al. 2012).

Within a landscape, bees require two food sources, nectar and pollen (Westrich 1996). Nectar is a high energy food source composed mainly of simple sugars but may also contain trace amounts of amino acids and lipids (Somme et al. 2015). The energy that bees receive from nectar is directly related to the quantity of nectar gathered and the sugar concentration (Somme et al. 2015). Nectar quality and quantity vary from species to species, with a median value of 40% sugar (Pamminger et al. (2018). Research by Pamminger et al. (2018) found that wild plants exhibit stronger variations in sugar concentrations compared to crop plants. Pollen consists of proteins, sugars, vitamins, and sterols and is primarily used for reproductive purposes (Somme et al. 2015). Bees make use of pollen and nectar compounds for energy, nitrogen, hormonal production, and for eggs (Somme et al. 2015). Quantity and composition of pollen and nectar vary among plant families and species (Somme et al. 2015).

The foraging range of bee species must include resources for feeding and reproduction (Gathmann and Tscharntke 2002), including pollen, nectar, nesting sites, and components for creating nests (Gathmann and Tscharntke 2002). According to Greenleaf et al. (2007), the foraging range of bee species is related to their body shape and size, and foraging distance increased with body size disproportionately. For example, most solitary wild bee species have a foraging range between 150 m and 600 m, but large bees like *Xylocopa violacea* Molitor may travel upwards of 1200 meters. Gathmann and Tscharntke (2002) found that bee foraging distance may be correlated to the feeding habits of wild pollinators as well as to habitat richness, where foraging distance decreased as plant richness increased.

Pollen utilization by wild bees is vastly different than that of eusocial honey bees. Most wild bees unlike honey bees are not eusocial and must provide pollen resources for themselves and their offspring. Eusocial bees such as stingless bees and bumble bees are the most similar to honey bees in terms of pollen usage (Cane et al. 2017). Wild stingless bees (Meloponini) feed on pollen, and much like honey bees create secretions for their larvae and queens; however, unlike honey bees, the queens may also ingest pollen (Cane et al. 2017). Bumble bees (*Bombu*s sp.) including the queen feed on pollen, but their larvae require secretions (Cane et al. 2017). In contrast, most wild bees are solitary. Unlike eusocial bees, solitary bees build their own nests. Upon hatching, larvae feed upon a cache of pollen and nectar that the female bee has previously deposited (Michener 1974).

Accurate assessment of wild bee pollen foraging and feeding behavior is difficult. Wild bee species may travel vast distances, up to 1200 meters away to collect floral provisions, but some species may never travel 300 meters from their nest (Gathmann and Tscharntke 2002). The variations in distances causes difficulty in the accurate assessment of bee foraging behaviors and the pollens they may collect. Two main methods of assessing bee pollen are floral visitation observations and assessing pollen found on wild specimens (Dalmazzo and Vossler 2015); however, floral visitation may not accurately depict the flowers that had been previously attended or will be attended outside of the assessment time window. According to Dalmazzo and Vossler (2015), the most thorough assessment of pollen feeding was found when nest provisions, floral visitation, and pollen analysis were combined. The combination of visitations, pollen analysis, and nest provisions allows bees to be classified as either oligolectic or polylectic. Oligolectic bees only collect pollen from one plant family or genus, and polylectic bees collect pollen from many plant families (Danforth et al. 2006, Minckley 2008). Currently, pollen analysis is being utilized to assess the impacts of land-use land cover changes on bee species and the pollens that they may gather in fragmented ecosystems. (citation)

Pollination by wild bee species may be directly correlated to habitat diversity (Holzschuh et al. 2011, 2012). Pollinator-dependent crops have been shown to exhibit a significant increase in fruit set as the proportion of high-diversity habitat increases. It is thought that increased diversity of natural habitats benefits wild pollinator species by providing resources throughout the agricultural season. Cash crops provide little resources and flower for a short period of time and at once (Krewenka et al. 2011, Roulston and Goodell, 2011). Thus a monetary advantage is gained by producers by providing native habitat to wild pollinator species.

The United States Department of Agriculture (USDA) Farm Service Agency (FSA) has developed the Pollinator Habitat Initiative, which is part of the Conservation Reserve Program (CRP). CRP CP-42 is a ten-year contract that requires farmers to plant at least 0.2 hectare blocks or strips with native grasses, flowering plants, or seed mixes, with the option to create woody habitat using tree limbs for wood-nesting bees. This program was designed to support pollinators by planting seed mixes containing at least nine species of flowering legumes and wildflowers within CRP fields. These seed mixes aspire to promote healthy pollinator communities, by including species that flower progressively throughout the agricultural season. CRP CP-42 is necessary to protect native bee species by providing food resources and habitat; however, it is unknown if CRP land in Texas is effective at this (USDA-FAS, 2018). Little research has been conducted on CRP CP-42, so little is known about the seed mixes, their components, or their benefits. For example, physiological traits of the flowers within these blends have not been studied in depth, and little is known about the possible impacts that the seed mixes have on native pollinators of the Southern High Plains. The purpose of my research project is to help fill gaps that are critical to the production of CRP seed mixes and the health of native bee communities in this understudied yet agriculturally important region.

Research by Rowe et al. (2018) indicates that many of the plant species that are from a given location are thought to be beneficial for pollinator species turn out to be lackluster at best. Their research indicated that a majority of the plant species that they used received few pollinator visits. Their research also indicated that wild bees have different floral preferences from honey bees or *Bombus* spp. (Rowe et al. 2018). Many wild species have specific feeding requirements that may only be satisfied by a few plant species (Michener 2000, Gibbs et al. 2017).

The loss of wild pollinators will heavily impact pollinator-dependent crops (Garibaldi et al. 2011). The loss of wild bee nesting sites and natural habitats may be contributing to a decline in crop pollination services contributed by wild bees (Ricketts et al. 2008). Currently, it is unknown if major crops have been seriously impacted by the loss of natural habitats and the loss of wild bee pollinator services (Holzschuh et al. 2012).

The Southern High Plains region is dominated by agricultural production systems such as cotton and sorghum. The increase in agricultural production has led to a decline in pollinator populations. This decline in pollinator populations and diversity are not strictly due to the decline of habitat diversity or habitat fragmentation, but is most likely a combination of many factors. The results of habitat fragmentation and a decline of pollinator habitat have been poorly studied within the Southern High Plains region, because these land-use changes have occurred relatively recently. Within the last 150 years this region has changed from a region plagued with droughts to an agriculturally dominated region surviving on the Ogallala Aquifer (Allen et al. 2008). It is critical to understand the impacts that these drivers are having on pollinator communities, partly because these pollinator communities may be beneficial to agricultural producers.

My research focus will be to investigate a few of the various seed blends that are developed by the NRCS and private industry to restore pollinator habitat. The seed mixes within the region have not been studied and must only conform to the guidelines of the CP-42 initiative. The two seed mixes to be used within these experiments contain many of the same plant species (Table 1). The two seed mixtures from Native American Seed Company and Bamert Seed Company are extremely similar and slightly vary in terms of species used and overall composition of the seed mixes (Table 1). As seen in Table 1, many of the species are found within the family Asteracea, commonly known as the sunflower or aster family. I will build upon previous studies and conduct research on the pollinator communities that are supported by the seed mixes.

Pilot Study

In 2018, a pilot study was undertaken within the Plant and Soil Sciences and Horticulture Greenhouses at Texas Tech University. The primary objectives of this study were to identify and determine what plant species within the seed mixes germinate and grow. The seed mixes contain many species with differing germination requirements and characteristics. This experiment was undertaken to determine if none, few, or all of the species germinate and grow. This experiment consisted of two parts: a germination test and a secondary growth test. The germination test was conducted in clear storage boxes, measuring approximately 34.6 cm x 12.4 cm x 21.9 cm. Prior to assessment, each container had 8, 0.95 cm holes drilled in the bottom for drainage. Sixteen containers were filled three-quarters of the way with a soil mixture and saturated with water to produce a dense soil for adequate seed germination, but retaining natural air pockets. After 72 hours of drying, 20 seeds were planted at one of the four treatment depths: 2.54 cm, 1.27 cm, 0.635 cm, or directly on the surface. During planting, soil was deposited over the planted seeds, and pressed down, the soil layer was measured until the given depth was achieved. These depths were chosen because the NRCS recommends planting seeds either on the surface via a dispersal method or no deeper than the length of the seed. Accordingly, I would expect no germination to be achieved at a rate deeper than 1.27 cm for most species. Seeds were watered with 0.3175 cm every other day for two weeks to determine germination.

The results of this experiment were difficult to determine, but interesting nonetheless, and although lackluster, indicated that current planting methods designated by the USDA-NRCS of using a cultipacker may produce poor germination. My results found that seeds that were planted on the surface or in the top 0.0635 cm did not germinate well, and if they did, died within the first 48 hours. Unfortunately due to the amount varieties within the seed mixtures and quick death it is difficult to determine what species germinated. This experiment will be reproduced in the greenhouse, but individual seeds have been purchased to determine germination rates of each seed type.

The future experiment will be conducted under the same conditions, within the Plant and Soil Sciences Greenhouse. Three seeds of each species will be placed within a pot (sizes TBD) and covered at the same rates as previously studied. Undergoing the same treatments, I will be able to determine the species of seeds that germinate at a given depth, under the same watering protocol.

In the secondary growth test approximately 150-200 of each seed type was placed within a 0.1 cubic meter tote. The seeding amount was chosen because the NRCS recommends increasing the seeding rate by 50% or more when dispersing seeds on the surface. This tote measured approximately 72.5 cm x 49.8 cm x 38.9 cm. Each tote was filled approximately ¾ of the way, or commerical bag of soil. Each tote was drilled with eight 0.95 cm holes for drainage. After potting soil was added, the totes were saturated and left to dry for approximately four days. Before planting, the top inch of soil was removed to be used to cover the seeds, seeds were placed down, covered with soil, and manually pressed down. Afterwards, the totes received either 0.3175 cm of water three days a week (Monday, Wednesday, Friday) or twice a week (Tuesday, Thursday) via a calibrated sprinkler system.

The results of this experiment are again, difficult to determine. I believe this is due to species competition and limited space. It is important to note that the sunflowers outcompeted most of the plant species within the totes. Sweet alyssum, lanceleaf coreopsis, and partridge pea all performed well and flowered. Milkweeds performed poorly and were not counted, and Texas bluebonnets grew mold from the humidity and physiology of the leaf, which is designed to trap water. A fertilizer was added (dbl check name) because the soil contains very little nutritive value. Therefore, this test will be redone, but individual seeds will be placed and labelled accordingly so that I may accurately and adequately assess the overall physiological properties of the plants and flowers.

Proposed Studies

The first set of objectives will be to determine the germination rates of the species that make up the Bird and Butterfly seed mix by Native American Seed and the Bee Happy seed mix by Bamert Seed Company. This experiment will take place within the Plant and Soil Sciences and Horticulture Greenhouses at Texas Tech University. The germination experiment will be conducted in a randomized block design structure. Four seeds of a variety will be placed within a 7.62 cm x 7.62 cm square growing pot, the pots will contain one of three soil compositions. The first will be a soil to sand mix of 70/30, then 50/50 and 30/70. These proportions are designed to simulate the sandy and clay loam soils that are found within the region (Allen et al. 2007). Prior to planting, the soil will be soaked and left to dry for 48 hours. The purpose for this is that the soil will naturally compact and create a solid environment suitable for prairie plants. Seeds will be placed at depths of 0.635 cm, 1.27 cm, and on the surface. Seeds that are placed within the soil will undergo the process of soil compaction, seed placement, and then covered with soil that will be manually compacted much like a cultipacker will do under a field environment. Seeds placed on the surface will be compacted into the soil using the same process.

My second objective will be to identify the growth rates of plant species within the seed mixes, and gather pollen for analysis. The purpose of this study is to identify the various growth patterns and possible pollination patterns that these prairie plants undergo. As required by the NRCS, seed mixes must have flowers that bloom periodically throughout the growing season. A greenhouse experiment will be conducted to assess which species flowers are most likely to grow and flower at a given point during the season. When these flowers bloom, samples from each will be placed within vials containing ethanol and shaken, following the protocols developed and conducted within other pollen experiments (). A small sample of the ethanol will be placed under a slide, and the total pollen will be counted, and multiplied by the remaining liquid to quantify pollen per plant species.

The third set of objectives for my study will be to assess the plants and pollinator communities attracted by the seed mixtures. There is no research that indicates whether or not the seed mixes for CP-42 work in promoting pollinator habitat or diversity. A series of field experiments at the Texas Tech Quaker Research Farm will be used to assess pollinator diversity and flower attractiveness. The first field experiment will be conducted on six plots each measuring 4.57 m by 45.72 m. Each plot will be planted via the producers’ recommendation, Bamert Bird and Butterfly blend will be planted at a rate of 16.79 kg per hectare, and Native American Seed Bee Happy mix will be planted at 22.40 kg per hectare. Seeds will be sowed prior to the summer months to allow for proper overwintering. Each plot will have subsurface irrigation that will be turned on and off by a manual switch. Each plot will be given adequate water until seeds have germinated and the largest plants have reached five centimeters in height. After proper growth, the plots will receive either 0.3175 cm weekly, 0.3175 cm bi-weekly, or will be given no water. These amounts have been chosen because Lubbock on average receives 0.3175 cm of rain per week. Bee bowls, which are small solo cups that have been colored either yellow, blue, or left uncolored will be placed throughout the plots. Manual sampling such as sweep netting and timed observations will occur within these plots to assess pollinator species that are attracted to or live within these species rich habitats. Timed observations will begin when flowering has occurred and will continue until flowering has commenced in a bi-weekly manner.

The second experiment will be conducted on individual plants within the seed mixtures. Each sub-plot will receive ample seeds to encourage growth. Each plant species will be measured weekly, and flowering dates recorded, and pollen collected. When a species flowers, a sample will be taken to assess the overall flowers within each sub-plot. I will follow the protocols used within Rowe et al. (2018) in regard to plant and pollinator sampling. Flowering dates will be used to assess when each plant within the seed mixture matures which will allow me to recommend an ideal blend. Bee bowls and manual sampling for pollinators will occur within each plant species to identify pollinator species that are attracted to or collect pollen. It is unknown if the plant species found within many CRP-CP42 seed mixes provide adequate resources for wild bees. For example, research suggests that polylectic, oligolectic, and monolectic species respond differently within a habitat, and it is unknown how these various feeding strategies are accounted for in seed mixes. As found in Table 1, most of the species are asters, it is unknown if these only attract or support a few pollinator species. Thus it is important to understand the pollinator community as a whole to include plant species that support many rare species compared to plants that support few common species.

Constraints

Previous research indicates that there are various constraints when sampling pollinator species. Landscape structure as well as floral resources may influence pollinator community diversity (Rowe et al. 2018). Plant species may differ locally in terms of pollen and nectar resources that may not provide species all necessary resources (Hicks et al. 2016). Previous studies addressing habitat restoration have failed due to poor seed establishment because many seeds may not grow without ideal or specific conditions (Suding 2011, Brudvig 2017, Zirbel et al. 2017). Znobia Wootan of Native American Seed indicated via personal communication that many native prairie seeds within her company’s seed blends may take years to establish and species will take turns dominating the landscape depending upon weather conditions. Bee bowls are one of the most widely used forms of pollinator sampling (Droege et al. 2010) because they are extremely efficient in capturing bees (Westphal et al. 2008) and extremely easy to use and replicate (Shapiro et al. 2014). (MOVE) Bee bowls however are not the best sampling tool and sometimes collect more small bees than larger bees, possibly because smaller bees can’t climb out of the soapy water (Droege et al. 2010). Shapiro et al. (2014) indicates that up to 30 bee bowls may be sufficient for most landscapes; however, extremely diverse communities may require 30 or more bowls to account for the entire population. Lastly, research is unsure about where to place bee bowls, some research indicates that on the ground collects more species, but these results have not been replicated (Droege et al. 2010).

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| --- |
| Bottomland Hardwood Trees Initiative |
| Duck Nesting Habitat Initiative |
| Floodplain Wetlands Initiative |
| Highly Erodible Lands Initiative |
| Honey Bee Habitat Initiative |
| Longleaf Pine Initiative |
| Non Floodplain Wetlands Initiative |
| Pollinator Habitat Initiative |
| State Acres for Wildlife Enhancement (SAFE) Initiative |
| Upland Bird Habitat Buffer Initiative |
| Practice CP12 Wildlife Food Plot |
| Practice CP15A Contour Grass Strips |
| Practice CP16A Shelterbelt Establishment |
| Practice CP17A Living Snow Fences |
| Practice CP18B Establishment of Permanent Vegetation to Reduce Salinity |
| Practice CP1 Establishment of Permanent Introduced Grasses and Legumes |
| Practice CP21 Filter Strip |
| [Practice CP22 Riparian Buffer](https://www.fsa.usda.gov/Assets/USDA-FSA-Public/usdafiles/FactSheets/2015/CRPProgramsandInitiatives/practice_cp22_riparian_buffer_jul2015.pdf" \o "Practice CP22 Riparian Buffer" \t "_blank) |
| Practice CP23A Wetland Restoration Non Floodplain |
| Practice CP23 Wetland Restoration on Floodplains |
| Practice CP25 Rare and Declining Habitat |
| Practice CP27, 28 Farmable Wetlands Program |
| Practice CP2 Establishment of Permanent Native Grasses |
| [Practice CP30 Marginal Pastureland Wetland Buffer](https://www.fsa.usda.gov/Assets/USDA-FSA-Public/usdafiles/FactSheets/2015/CRPProgramsandInitiatives/practice_cp30_marginal_pastureland_wetland_buffer_jul2015.pdf" \o "Practice CP30 Marginal Pastureland Wetland Buffer" \t "_blank) |
| Practice CP31 Bottomland Timber Establishment on Wetlands |
| Practice CP33 Habitat Buffers for Upland Birds |
| Practice CP36 Longleaf Pine Establishment |
| Practice CP37 Duck Nesting Habitat |
| Practice CP39 Farmable Wetlands Program Constructed Wetlands |
| Practice CP3 Tree Planting |
| Practice CP4B Wildlife Habitat Corridors |
| Practice CP4D Permanent Wildlife Habitat |
| Practice CP5A Field Windbreak Establishment |
| Practice CPBA Grass Waterway |
| Practice CP9 Shallow Water Areas for Wildlife |
| Practice CP29 Marginal Pastureland Wildlife Buffer |
| Practice CP42 Pollinator Habitat |

Table 1. Conservation Reserve Program Initiatives

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Native American Seed Bee Happy Mix | | | Bamert Bird and Butterfly Mix | | |
| Common Name | Species | Family | Common Name | Species | Family |
| Rattlesnake master | *Eryngium yuccifolium* | *Apiaceae* | Lemon mint | *Mondarda citriodora* | Acanthaceae |
| Rose milkweed | *Asclepias incarnata* | *Apocynaceae* | Showy milkweed | *Asclepias speciosa* | Apocynaceae |
| Butterflyweed | *Asclepias tuberosa* | *Apocynaceae* | Black-eyed Susan | *Rudbeckia hirta* | Asteraceae |
| American basketflower | *Centaurea americana* | *Asteraceae* | Perennial gaillardia | *Gaillardia aristata* | Asteraceae |
| Golden-wave | *Coreopsis basilis* | *Asteraceae* | Purple coneflower | *Echinacea purpurea* | Asteraceae |
| Lanceleaf coreopsis | *Coreopsis lanceolata* | *Asteraceae* | Dwarf coneflower | *Echinacea spp.* | Asteraceae |
| Purple coneflower | *Echinacea purpurea* | *Asteraceae* | Annual gaillardia | *Gaillardia spp.* | Asteraceae |
| Cutleaf daisy | *Engelmannia peristenia* | *Asteraceae* | Dwarf red coneflower | *Ratibida columnifera* | Asteraceae |
| Indian blanket | *Gaillardia pulchella* | *Asteraceae* | Dwarf plains coreposis | *Coreopsis tinctoria* | Asteraceae |
| Gayfeather | *Liatris pycnostachya* | *Asteraceae* | Lanceleaf coreopsis | *Coreopsis lanceolata* | Asteraceae |
| Tahoka daisy | *Machaeranthera tanacetifolia* | *Asteraceae* | Sweet alyssum | *Lobularia maritima* | Brassicaceae |
| Black-eyed Susan | *Rudbeckia hirta* | *Asteraceae* | Annual candytuft | *Iberis amara* | Brassicaceae |
| Bush sunflower | *Simsia calva* | *Asteraceae* | Siberian wallflower | *Cherianthus allionii* | Erysimum |
| Greenthread | *Thelesperma filifolium* | *Asteraceae* | Perennial lupine | *Lupinus perennis* | Fabaceae |
| Frostweed | *Verbesina virginica* | *Asteraceae* | Blue flax | *Linum lewisii* | Linaceae |
| Lazy daisy | *Aphanostephus sp.* | *Asteraceae* | Scarlet flax | *Linum grandiflorum* | Linaceae |
| Common sunflower | *Helianthus annuus* | *Asteraceae* | Dwarf godetia | *Clarkia amoena* | Onagraceae |
| Maximillian sunflower | *Helianthus maximiliani* | *Asteraceae* | California poppy | *Eschschozia californica* | Papaveraceae |
| Blue mistflower | *Conoclinium coelestinum* | *Asteraceae* | Rocket larkspur | *Delphinium consolida* | Ranunculaceae |
| Texas bluebonnet | *Lupinus texensis* | *Fabacaea* |
| Purple priaire clover | *Dalea purpurea var. purpurea* | *Fabaceae* |
| White prairie clover | *Dalea candida var. candida* | *Fabaceae* |
| Partridge pea | *Chamaecrista fasciculata* | *Fabaceae* |
| Illinois bundleflower | *Desmanthus illinoensis* | *Fabaceae* |
| Lemon mint | *Monarda citridora* | *Lamiaceae* |
| Winecup | *Callirhoe involucrata* | *Malvaceae* |
| Annual winecuo | *Callirhoe leiocarpa* | *Onagraceae* |
| Missouri primrose | *Oenothera missouriensis* | *Onagraceae* |
| Foxglove | *Penstemon cobaea* | *Plantaginaceae* |
| Prairie verbena | *Glandularia bipinnatifida var. bipinnatifida* | *Verbenaceae* |

Table 2. Species found within two CRP seed mixes

Proposed Timeline

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Fall 2017 | Spring 2018 | Fall 2018 | Spring 2019 | Fall 2019 | Spring 2020 | Fall 2020 | Spring 2021 |
| Start Ph.D. |  |  | Last Semester of Classes | COMPS |  |  |  |
|  |  |  |  | Analyze Data | Analyze Data | Analyze Data | Analyze Data |
|  |  |  | GH Exp. | GH Exp. | GH Exp. | GH Exp. | GH Exp. |
| TA | TA | TA | TA | TA | TA | TA | TA |
| 9 Credits | 9 Credits | 9 Credits | 9 Credits | 9 Credits | 9 Credits | 9 Credits | 9 Credits |
|  |  |  |  |  |  |  | GRADUATE |

|  |  |  |  |
| --- | --- | --- | --- |
| Summer 2018 | Summer 2019 | Summer 2020 | Summer 2021 |
| Pilot Study | Field Study | Field Study | Field Study |
| TA | TA | TA | TA |
| 3 Credits | 3 Credits | 3 Credits | 3 Credits |