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Texas Coastal Bend Shortgrass Prairie Multi-species Recovery Plan: Including Slender Rush-Pea (*Hoffmannseggia tenella*) and South Texas Ambrosia (*Ambrosia cheiranthifolia*)

Cover Illustration: Russell Hooten, Texas Parks and Wildlife Department 2013

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Texas Coastal Bend Shortgrass Prairie Multi-species Recovery Plan: Including Slender Rush-Pea (*Hoffmannseggia tenella*) and South Texas Ambrosia (*Ambrosia cheiranthifolia*)

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For

Southwest Region
U.S. Fish and Wildlife Service
Albuquerque, New Mexico

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Approved: __DRAFT_____
Regional Director, U.S. Fish and Wildlife Service

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DISCLAIMER

The Endangered Species Act of 1973, as amended (16 U.S.C. 1531 et seq.), requires developing recovery plans for listed species, unless such a plan would not promote a particular species' conservation. In accordance with the Endangered Species Act, Section 4(f)(1), and to the maximum extent practicable, recovery plans delineate reasonable actions that are believed to be required to recover or protect listed species. The U.S. Fish and Wildlife Service publishes recovery plans. Recover Plans are sometimes prepared with assistance from recovery teams, contractors, state agencies, and other affected and interested parties. The public reviews the plans and the U.S. Fish and Wildlife Service submits them for additional peer review before adoption. Plan objectives will be attained and any necessary funds made available subject to budgetary and other constraints affecting the parties involved, as well as the need to address other priorities. Recovery plans do not obligate other parties to undertake specific tasks and may not necessarily represent the views nor the official positions or approval of any individuals or agencies involved in the plan formulation, other than the U.S. Fish and Wildlife Service. Nothing in this plan should be construed as a commitment or requirement that any Federal agency obligate or pay funds in contravention of the Anti-Deficiency Act, 31 U.S.C. 1341, or any other law or regulation. Recovery plans represent the U.S. Fish and Wildlife Service's official position only after the Regional Director signs them. Approved recovery plans are subject to modification as dictated by new findings, species status changes, and recovery task completion.

By approving this document, the Regional Director certifies that the data used in its development represents the best scientific and commercial data available at the time it was written. Copies of all documents reviewed in developing the plan are available in the administrative record, located at the Texas Coastal Ecological Services Field Office in Houston, Texas.

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DRAFT

EXECUTIVE SUMMARY

Species Status: Slender rush-pea (*Hoffmannseggia tenella*) and the South Texas ambrosia (*Ambrosia cheiranthifolia*) were both listed as endangered species by the U.S. Fish and Wildlife Service and added to the List of Endangered and Threatened Wildlife and Plants in 1985 (USFWS 1985) and 1994 (USFWS 1994), respectively. As required by state law, both species are also listed by the Texas Parks and Wildlife Department. Both species are geographically restricted to coastal shortgrass prairie habitat within Nueces and Kleberg counties, Texas. Only 8 slender rush-pea and 7 South Texas ambrosia populations remain extant with few numbers of individuals and most exist on private lands and/or have not been revisited in over 20 years.

Habitat Requirements and Limiting Factors: Both species are known from the Texas Coastal Bend within Nueces and Kleberg counties, Texas, within the Gulf Coast Prairies and Marshes Ecoregion. Native habitat includes a mix of grasses and forbs atop clay, silt, and sandy soils of the Pleistocene Delta. Both species are tied to specific drainage systems. Land conversion and habitat loss, and the alterations or abatement in current vegetation management strategies (fire, herbicide, mowing) have caused encroachment of nonnative grasses to the few remaining shortgrass prairies within this region. The genetic relationship of plants within and among populations remains an unanswered question for both species. With so few natural populations remaining across the landscape, these threats and other stochastic events could exacerbate the loss of either species or their habitat.

Recovery Strategy, Goals, Objectives, Criteria, and Actions Needed: The recovery strategy for recovery of rush-pea and ambrosia includes the long-term protection and management of the shortgrass prairie habitat needed by both species, and provides a roadmap for securing an adequate quantity of habitat of sufficient quality to sustain slender rush-pea and South Texas ambrosia long-term. A primary objective of this plan is to ensure that there are shortgrass prairie areas of sufficient size, number (20 populations of slender rush-pea and 15 populations of South Texas ambrosia), composition, and juxtaposition, determined by the most current biological information known for the species to support the continued existence of their populations that are able to persist and thrive in the wild. Using this strategy, the primary goal of this recovery plan is to ensure long-term persistence of sufficient amount and distribution of native coastal shortgrass prairie in suitable condition to support slender rush-pea and South Texas ambrosia populations and ameliorate threats such that both species can be downlisted from a status of "endangered" to "threatened" and further, recovered, or delisted, from the Federal List of Endangered and Threatened Plants.

To reach these recovery goals both species require the following recovery actions to take place:

1. Minimize further loss or fragmentation of native shortgrass prairie habitat within Nueces and Kleberg counties, such that there is sufficient habitat to support slender rush-pea and South Texas ambrosia at levels that meet recovery goals.

2. Actively manage shortgrass prairie conditions at all extant population (or subpopulation) sites of slender rush-pea and South Texas ambrosia to sustain both species at Minimum Viable Population levels or higher.

DRAFT

3. Develop reintroduction sites within the geographic range of slender rush-pea and South Texas ambrosia to help increase the number of protected populations.

4. Determine the extent and prevent depletion of rush-pea and ambrosia seed banks.

5. Promote landowner relations and habitat management throughout the occupied and historical ranges of slender rush-pea and South Texas ambrosia in the United States.

6. Determine the genetic diversity within and among populations of rush-pea and ambrosia, and prevent its loss.

7. Determine optimal habitat requirements for slender rush-pea and South Texas ambrosia.

8. Determine and implement best management practices where possible and monitor the response of slender rush-pea and South Texas ambrosia populations to these practices.

9. Monitor long-term viability of all populations of slender rush-pea and South Texas ambrosia.

10. Increase knowledge of slender rush-pea and South Texas ambrosia abundance, distribution, and ecology.

11. Acquire long-term conservation easements where feasible, or conservation agreements, for occupied sites of slender rush-pea and South Texas ambrosia within each watershed from which the species are known.

Estimated Date and Cost of Recovery: Costs estimated below reflect what is needed for specific recovery actions for these two shortgrass prairie species. Estimates do not include costs that agencies or other entities normally incur as part of their mission or normal operating expenses. Slender rush-pea could be fully recovered in 60 years (2076) and South Texas ambrosia could be recovered in 40 years (in 2056). The total cost of recovery for both species is $175,738,000. The following table provides cost estimates for the recovery actions in the Implementation Schedule (Part III). The costs are combined in five-year increments in the table.

DRAFT

Table 1. Expected recovery costs for slender rush-pea and South Texas ambrosia (costs in $1,000s).

Years	Priority 1 Actions	Priority 2 Actions	Priority 3 Actions	Total
1-5	50	330.54	120	500.54
6-10	30	123.38	21	174.38
11-15	50	81.38	13.5	144.88
16-20	30	101.38	13	144.38
21-25	50	68.9	8	126.9
26-30	30	88.9	7	125.9
31-35	50	66.4	6	122.4
36-40	30	96.4	7	133.4
41-45	25	40.9	2.5	68.4
46-50	15	50.9	4	69.9
51-55	25	40.9	2.5	68.4
56-60	15	60.9	4	79.9
TOTAL	400	1,150.88	206.5	1,757.38

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ABBREVIATIONS and ACRONYMS

ACT	Endangered Species Act
CCBG	Corpus Christi Botanical Gardens
CFR	Code of Federal Register
CPC	Center for Plant Conservation
DNA	Deoxyribonucleic acid
DOD	Department of Defense
FHWA	Federal Highway Administration
DPS	Distinct Population Segment
EO	Element of Occurrence
EPA	Environmental Protection Agency
ESA	Endangered Species Act
FR	Federal Register
GPS	Global Positioning System
Hwy	Highway
INRMP	Integrated Natural Resource Management Plan
IPCC	Intergovernmental Panel on Climate Change
KRTA	King Ranch Training Area
LO	Landowner
MOU	Memorandum of Understanding
MVP	Minimum Viable Population
NABA-NBC	North American Butterfly Association – National Butterfly Center
NASK	Naval Air Station Kingsville
NAVY	U.S. Navy
NGO	Non-governmental organization
NMFS	National Marine Fisheries Service
PMC	USDA Plant Materials Center
ROW	right-of-way
SABG	San Antonio Botanical Gardens
STXPRT	South Texas Plant Recovery Team
TAMUK	Texas A&M University - Kingsville
TDA	Texas Department of Agriculture
TPWD	Texas Parks and Wildlife Department
TXDOT	Texas Department of Transportation
TXNDD	Texas Natural Diversity Database
TZ	tetrazolium
USDA	U.S. Department of Agriculture
USDA-NRCS	U.S.D.A. – Natural Resource Conservation Service
USFWS	U.S. Fish and Wildlife Service

DRAFT

TABLE of CONTENTS

DISCLAIMER 3
ACKNOWLEDGMENTS 4
EXECUTIVE SUMMARY 6
ABBREVIATIONS and ACRONYMS 9
LIST of FIGURES 11
LIST of TABLES 11
PART I: BACKGROUND INFORMATION 12
1.0 BACKGROUND 12
1.1 Introduction 12
1.2 Status of Coastal Shortgrass Prairie Ecosystem 12
1.3 Slender Rush-Pea 18
1.4 South Texas Ambrosia 28
1.5 Threats Analyses 39
1.6 Conservation Measures 55
PART II: RECOVERY PROGRAM 60
2.1 Recovery Strategy 60
Timelines for Recovery 61
Minimum Viable Populations 62
Background to the Recovery Plan 65
2.2 Recovery Goals 66
2.3 Recovery Objectives and Criteria 66
2.3.1 Recovery Objectives 66
2.3.2 Recovery Criteria 67
2.5 Narrative of Recovery Actions 75
PART III: IMPLEMENTATION 91
3.1 Responsible Parties and Cost Estimates 91
3.2 Recovery Action Priorities and Abbreviations 91
PART IV: LITERATURE CITED 103
PART V: APPENDICES 112
Appendix A – Glossary of Terms 112

DRAFT

LIST of FIGURES

Figure 1. Gulf Coast Prairies and Marshes Ecoregion within Texas Coastal Bend Counties..... 14

Figure 2. Images of slender rush-pea 20

Figure 3. Map of extant slender rush-pea populations in Texas according to TXNDD data..... 21

Figure 4. Images of South Texas ambrosia..... 30

Figure 5. Map of extant populations of South Texas ambrosia in Texas from TXNDD data 32

Figure 6. Thatch atop slender rush-pea and South Texas ambrosia habitat..... 51

LIST of TABLES

Table 1. Expected recovery costs for slender rush-pea and South Texas ambrosia..... 8

Table 2. Vegetation Terms of Texas Coastal Bend..... 15

Table 3. Historic prairie vegetation of the Kleberg Clay Prairie of the Texas Coastal Bend 16

Table 4. List of major nonnative, invasive grasses of the Texas Coastal Bend..... 17

Table 5. Recovery Priority Numbers for slender rush-pea as outlined at the time of the original listing.. 19

Table 6. Known historic and extant populations of slender rush-pea. 22

Table 7. Soil analyses for slender rush-pea..... 26

Table 8. Common known plant associates specific to slender rush-pea. 27

Table 9. Recovery Priority Numbers for South Texas ambrosia as outlined at the time of listing 29

Table 10. Known historic and extant populations of South Texas ambrosia..... 33

Table 11. Soil analyses for South Texas ambrosia 37

Table 12. Common plant associates specific to South Texas ambrosia..... 38

Table 13. Threats tracking table for slender rush-pea and South Texas ambrosia..... 402

Table 14. Summary of extant populations of slender rush-pea and conservation efforts undertaken at these sites 568

Table 15. Minimum Viable Population for slender rush-pea adapted from Pavlik (1996)..... 624

Table 16. Explanation of the minimum number of mature individuals plants at each population for Slender rush-pea..... 635

Table 17. Minimum Viable Population for South Texas ambrosia. Adapted from Pavlik (1996) 646

Table 18. Explanation of the minimum number of mature individuals plants at each population for South Texas ambrosia 657

Table 19. Recovery Implementation Table..... 935

DRAFT

PART I: BACKGROUND INFORMATION

1.0 BACKGROUND

1.1 Introduction

The Endangered Species Act of 1973 (Act), as amended (16 U.S.C. 1531 et seq.), establishes policies and procedures for identifying, listing, and protecting species of fish, wildlife, and plants that are endangered or threatened with extinction. The Act defines an "endangered species" as "any species which is in danger of extinction throughout all or a significant portion of its range." A "threatened species" is defined as "any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range." The decision to list a species is based on a consideration of the five factors listed in section 4(a)(1) of the Act:

- Listing Factor A. The present or threatened destruction, modification, or curtailment of its habitat or range.
- Listing Factor B. Overutilization for commercial, recreational, scientific, or educational purposes.
- Listing Factor C. Disease or predation.
- Listing Factor D. The inadequacy of existing regulatory mechanisms.
- Listing Factor E. Other natural or manmade factors affecting its continued existence.

To help identify and guide species' recovery needs, section 4(f)(1) of the Act directs the Secretary to develop and implement recovery plans for listed species or populations. Such plans are to include: 1) a description of management actions necessary to conserve the species or population; 2) objective, measurable criteria that, when met, will allow the species or population to be removed from the List of Endangered and Threatened Wildlife and Plants; and 3) estimates of the time and funding needed to achieve the plan's goals, including the intermediate steps to reach the goals. Recovery plans are advisory documents. Recovery recommendations contained in such plans are aimed at lessening or alleviating the threats to the species and ensuring self-sustaining populations in the wild.

The U.S. Fish and Wildlife Service (USFWS) approved a recovery plan for slender rush-pea in 1988 (USFWS 1988), but has not previously published a recovery plan for South Texas ambrosia. This new Texas Coastal Bend Shortgrass Prairie Recovery Plan revises the 1988 slender rush-pea document and is also the first recovery plan for the South Texas ambrosia. For the remainder of the document, these species will be referred to as "rush-pea" and "ambrosia". Terms that are defined in the glossary are underlined throughout this document and can be found in Part V (p. 102).

1.2 Status of Coastal Shortgrass Prairie Ecosystem

This recovery plan, designed to restore these two endangered plants, uses an ecosystem-based approach because both species currently inhabit patches of shortgrass prairie in two Texas

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Coastal Bend counties; in several cases co-occurring at the same locations. Rush-pea and ambrosia are both perennial herbaceous species growing in historically fire-dependent prairie habitat in South Texas. Both species are geographically restricted to open grasslands where they occur in Nueces and Kleberg counties, Texas. Populations of both species occur on the fine, calcareous clays associated with Pleistocene deltas. Primary threats to both rush-pea and ambrosia stem from the present or threatened destruction, modification, and curtailment of habitat or range. This habitat loss results from conversion of native prairie to row crops, improved pastures, residential development, commercial development and Federal installations. There is also ongoing, significant habitat degradation from encroachment as a result of nonnative, invasive pasture grasses; some localized disturbance from management techniques (mowing); and, minimal damage from herbicide drift incidents onto highway right-of-ways (ROW). Drought conditions associated with climate change may exacerbate these impacts.

1.2.1 Characteristic Vegetation of the Coastal Shortgrass Prairie

All of the extant populations of rush-pea and ambrosia are found in Kleberg and Nueces counties, which lie within the Texas Coastal Bend region (Figure 1). This region also encompasses Refugio, Aransas, San Patricio, and Jim Wells counties, substantial portions of Victoria, Goliad, Bee, Live Oak counties as well as edges of Brooks and Kenedy counties (Lehman *et al.* 2005). The Texas Coastal Bend region is a geographic subset of a larger vegetation ecoregion known as the Gulf Coast Prairies and Marshes Ecoregion (Gould 1975, Correll and Johnston 1979, Poole *et al.* 2007) (Figure 1). Three terms have been used to describe this region (see Table 2); however, we acknowledge the most current ecoregion name to be Gulf Coast Prairies and Marshes and use it throughout this document.

DRAFT

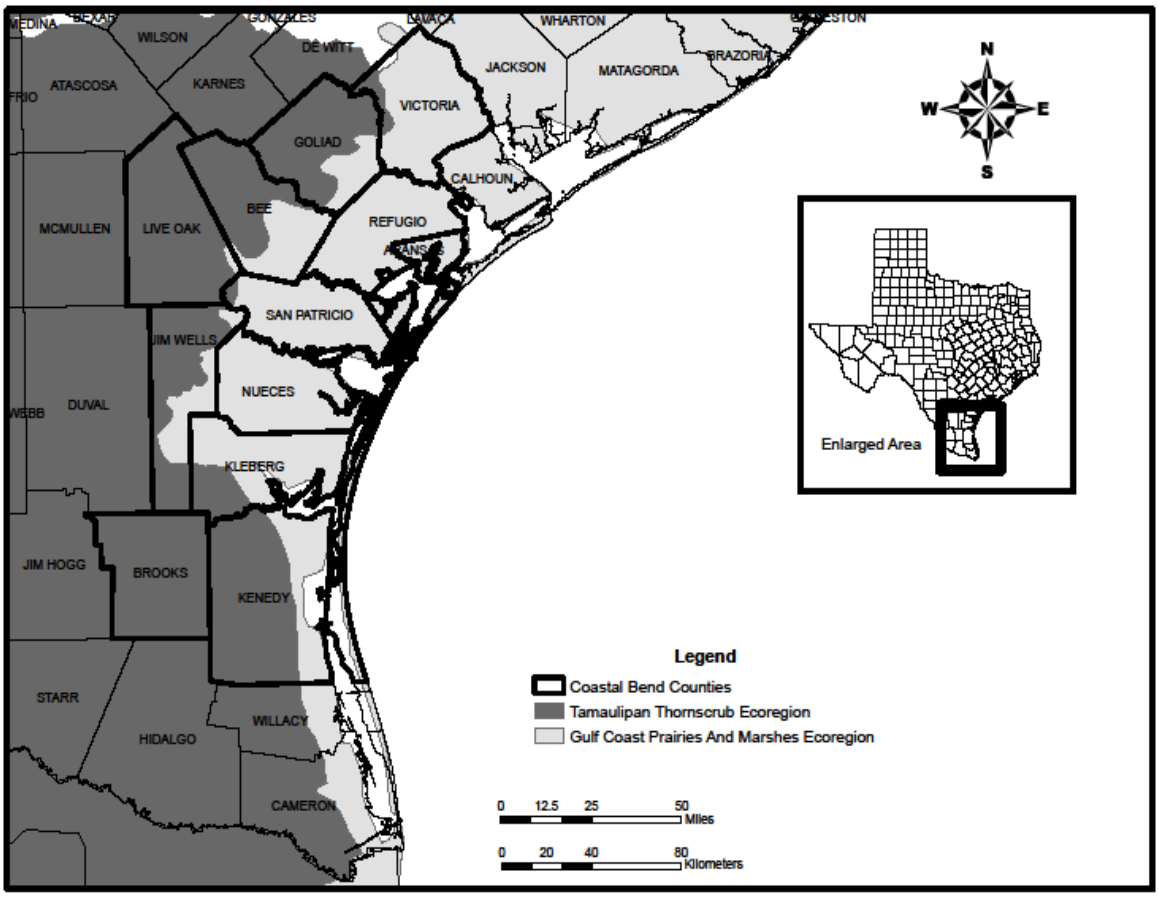

Figure 1. Gulf Coast Prairies and Marshes Ecoregion within Texas Coastal Bend Counties (Texas Parks and Wildlife Department (Texas Parks and Wildlife Department (TPWD)) 2012, http://www.tpwd.state.tx.us/landwater/land/maps/gis/data_downloads/, under Quick Downloads "ecoregpy").

Table 2. Vegetation Terms of Texas Coastal Bend.

Original Author	Classified Vegetation and associated soils included:
Hill 1901 (in Johnston 1963)	**Prairie**
Gould *et al.* 1960 (in Johnston 1963)	**Prairie**
Johnston 1963	**Kleberg clay prairies**: relics of coastal prairie on flat topography with underlying clay soils, formerly in Kleberg and Nueces counties. Prairies occupy part of the Pleistocene deltaic plain in Kleberg County. Similar small remnants could have been found in Refugio, Aransas, San Patricio, and Nueces counties due to cultivation and clearing, the rest of the area is covered with brush. Only small (sometimes only 0.25 acre), isolated patches, remain.
Gould 1975	**Gulf Prairie and Marshes**
Correll and Johnston 1979	**Gulf Prairie and Marsh**: occupies about 9.5 million acres along Texas coast and is characterized by level grasslands supporting ranching and farming. Area is of low topographic relief and upland prairie soils include heavier textured clays or clay loams, with some that are sandy loams.
Texas Natural Heritage Program 1978 (in Poole *et al.* 2007)	**Gulf Coast Prairies and Marshes Ecoregion**: most of the region is underlain by clays, silts, and sands of the Pleistocene or Holocene age.

DRAFT

Historically (more than 400 years ago), the shortgrass prairie of Nueces and Kleberg counties was primarily treeless grasslands, dominated by grasses and herbs or forbs (Hansmire *et al.* 1988; Lehman *et al.* 2005). These remnant stands of shortgrass prairie were concentrated in patches among the habitat, on the underlying substrate of clay or sandy soils (see Table 3, in Johnston 1963). Trees were locally abundant but confined to stream breaks and drainages (Furber 1848, in Johnston 1963).

Table 3. Historic prairie vegetation of the Kleberg Clay Prairie of the Texas Coastal Bend (Johnston 1963).

Grasses	
Short Grasses on clay soils	
Aristida roemeriana	purple threeawn
Buchloe dactyloides	buffalo
Hilaria belangeria	curly mesquite
Panicum hallii var. *filipes*	filly (or Hall's) panicum
Medium to Tall Grasses on sandy soils	
Cenchrus spinifex	coastal sandbur, grass bur
Chloris andropogonoides	slimspike windmill grass
Desmanthus virgatus	wild tantan
Schedonnardus paniculatus	tumble grass
Forbs	
Euphorbia albomarginata	rattlesnake-weed, whitemargin sandmat
Evolvulus sericeus	silver dwarf morning-glory

Over time however, the percent composition and distribution patterns of the native vegetation with the shortgrass prairie changed. In the early 1800s when the Irish colonists arrived in the Coastal Bend, the area became a center for trade, although livestock and ranching remained its chief industries (Lehman *et al.* 2005; Long 2012). With settlement, grazing pressures increased and the natural prairie fires decreased due to active human fire suppression and decreased fuel loads resulting from grazing. Control of fire on prairies allowed encroachment of woody vegetation and the concomitant decrease in grassland habitat (Johnston 1963; Lehman *et al.* 2005). Native woody species have expanded their distribution across the landscape, and spread via seed consumption by avian species, small animals, cattle, and horses (Lehman *et al.* 2005).

Land cultivation and farming continued to cause vegetation changes within the shortgrass prairie of the Coastal Bend. Farming of the Beaumont Formation clay soils that underlie the grasslands of the Coastal Bend portion of the Gulf Coast Prairies and Marshes Ecoregion began in earnest in the 1860s. The value of cotton and vegetables, including cabbage, onions, spinach, carrots, cucumbers, and turnips, as cash crops heavily dominated the local economy in the 1880s (Long 2012). Large tracts of land were cultivated with cotton, sorghum, and other crops (Lehman *et al.* 2005). Nueces County became a lead cotton producer for the state (Long 2012), while in Kleberg County, a farming and dairy-dominated economy was made possible by construction of railroads (Coalson 2012). Woody habitats of the ecoregion, including live and post oak mottes

DRAFT

and brush thickets, as well as marsh, and aquatic vegetation, experienced only minor changes in comparison to the coastal grasslands due to the difficulty in converting these areas to cropland or rangeland.

Today, only remnants of shortgrass prairie that had existed in the earlier part of the 19th century are left. The majority of land in the Coastal Bend is primarily used for crop production, livestock grazing, and wildlife production (for hunting purposes) (Hatch *et al.* 1999). About one-third of the land area has been converted into cultivated lands for sorghum, corn, and cotton. Primary rangeland management practices in this area include prescribed winter burns and cattle grazing. To provide for livestock, area ranchers have introduced nonnative grasses from Europe, Asia, South America, and other parts of the world (Table 4) in order to "improve" rangeland; a practice whereby they plow or otherwise break up native prairie and brush and plant introduced grasses, often resulting in a monoculture. This practice, along with planting for erosion control, has drastically changed the dominance structure of the native vegetation communities (Lehman *et al.* 2005). These exotic grasses have become established throughout southern Texas, often exhibit very aggressive, invasive properties and are becoming the dominant plants in many native settings. Seeding, sprigging, and mowing of highway and pipeline ROWs to reduce erosion has helped to increase the distribution of these nonnatives into the remaining native prairie habitat.

Table 4. List of major nonnative, invasive grasses of the Texas Coastal Bend (Mahler 1982; Kuvlesky et al. 2002; Poole et al. 2007; and Poole 1988).

Scientific Name	Common Name
Bothriochloa ischaemum	King Ranch bluestem
Cynodon dactylon	coastal bermudagrass
Dichanthium annulatum	Kleberg bluestem
Dichanthium aristatum	angleton bluestem
Pennisetum ciliare	Buffelgrass
Urochloa maxima	Guineagrass

Currently, there are no known extant populations of rush-pea nor ambrosia in Mexico. A record of ambrosia from Tamaulipas, Mexico, was collected in 1835 from a second ecoregion, the Tamaulipan Thornscrub Ecoregion (also known as the South Texas Plains, the Rio Grande Plains, or Tamaulipan Brushlands) (Figure 1). This site was described as coastal shortgrass prairie habitat even though it was found within the Tamaulipan Thornscrub Ecoregion. Although similar in topography and sharing a number of grass, forb, and woody species, the dominant vegetative land cover differs. Instead of the vast grasslands of the Gulf Coast Prairies and Marshes Ecoregion, the Tamaulipan Thornscrub Ecoregion is dominated by spiny shrubs and trees, although grasses, forbs, and succulents are also present (McGinley 2013). The flatter, deeper soils support honey mesquite (*Prosopis glandulosa*), and other woody species, sometimes found growing in dense thickets and sometimes in a savannah type of setting within a grassland matrix (McGinley 2013). So although the clay to sandy loam soils of the Tamaulipan Thornscrub Ecoregion has the potential to support ambrosia, locality information for the historic ambrosia occurrence was vague and was never re-verified. A second specimen thought to be

DRAFT

ambrosia was collected from Tamaulipas in 2005 by Alberto Contreras-Arquieta and was stored at the Universidad Autónoma de Nuevo León. However the specimen was never verified as *Ambrosia cheiranthifolia* (A. Contreras-Arquieta, pers. comm. 2014).

Climate of the Coastal Bend varies considerably. Mean annual precipitation for Kleberg County is 69.9 centimeters (cm) (27.5 inches (in)) and there was a record rainfall in 1958 of 133.8 cm (52.66 in) (Bryan *et al*. 1987). In Nueces County, mean annual precipitation is 76.7 cm (30.2 in) and record rainfall in 1960 was 112.6 cm (44.35 in) (Bryan *et al*. 1987). Droughts interspersed with high rainfall events associated with hurricanes cause variability in precipitation. Both Corpus Christi (Nueces County) and Kingsville (Kleberg County) are within zone 9b of the U.S Department of Agriculture's (USDA) plant hardiness zones, and a high number of frost-free days and high temperatures in both counties allow for a long growing season. Between 1976 and 2005, these areas experienced average annual extreme minimum temperatures ranging from -3.9 – -1.1°C (25-30°F) (USDA 2014). Generally the first frosts occurred in late December (PlantMaps online 2014).

1.2.2 Watersheds of the Texas Coastal Bend

Most rush-pea and ambrosia populations are located near or along one of four unique drainage corridors in the Coastal Bend. Historically, rush-pea and ambrosia populations were more abundant and thus were represented in more drainage systems. However, today rush-pea sites are found within the Petronila, Oso, Chilitipin Creek-San Fernando, and Alazan Bay-Baffin Bay creek basins; ambrosia is only found within the Oso, Chilitipin Creek-San Fernando, Alazan Bay-Baffin Bay, and San Getrudis creek basins. Most populations tend to be localized in remnant areas of shortgrass prairie within these drainage systems. Currently known populations of rush-pea and ambrosia are scattered in distribution and small in areal extent and numbers of plants. Therefore shortgrass prairie habitat is greatly fragmented. All extant sites are found within a relatively small geographic area that is rapidly developing; a scenario that could make both species vulnerable to extinction from catastrophic events. Such small, isolated populations can lose genetic diversity over time, leading to lower resiliency to stochastic events and a threat of extinction. Genetic studies have not been undertaken for either species to investigate the potential for genetic differences between plants from these four separate watersheds, therefore it is essential that populations from each system are managed and conserved long-term to preserve all possible genetic diversity. Improvements or diversions of water could perhaps impact either species by leading to increases or decreases in water amounts reaching natural drainage routes, causing a channelizing of natural drainage routes, and fragmenting habitat in an existing population or other potential site (USFWS 2010).

1.3 Slender Rush-Pea

1.3.1 Status of the Species

History of Listing

The rush-pea was listed as an endangered species on November 1, 1985 (USFWS 1985). Critical habitat was not designated as it was believed that it might heighten the vulnerability of rush-pea populations to collection and vandalism. At the time of listing, rush-pea received a recovery

priority number of 2 (Table 5), indicating that there was a high degree of threat but that recovery potential was also high. The final recovery plan primarily focused on two known populations of the rush-pea, one each in Nueces and Kleberg counties, Texas (USFWS 1988). On April 21, 2006, the USFWS initiated a 5-year review (USFWS 2006) of this species status which was finalized on November 11, 2008 (USFWS 2008). The 5-year review of the species' status did not recommend any change to this recovery priority number.

Table 5. Recovery Priority Numbers for slender rush-pea as outlined at the time of the original listing (USFWS 1983).

Degree of Threat	Recovery Potential	Taxonomy	Priority	Conflict
High	High	Monotypic Genus	1	1C
		Species	2	2C
		Subspecies/DPS	3	3C
	Low	Monotypic Genus	4	4C
		Species	5	5C
		Subspecies/DPS	6	6C
Moderate	High	Monotypic Genus	7	7C
		Species	8	8C
		Subspecies/DPS	9	9C
	Low	Monotypic Genus	10	10C
		Species	11	11C
		Subspecies/DPS	12	12C
Low	High	Monotypic Genus	13	13C
		Species	14	14C
		Subspecies/DPS	15	15C
	Low	Monotypic Genus	16	16C
		Species	17	17C
		Subspecies/DPS	18	18C

Current Species Listing Status

Due to the initial conversion of much of Nueces County and portions of Kleberg County to row crops, residential and industrial developments, and the continued degradation of habitat by nonnative grass species throughout its range, rush-pea is known only from remnant patches of habitat. The Texas Department of Transportation (TXDOT) and city and county owners manage habitat for grass habitat on a need-as basis at St. James Cemetery, the Highway (Hwy) 77 ROW, and Petronila Creek sites. Because the projection for climate change is a continued increase in temperature, warm-season growing species including the nonnative grasses that already plague this habitat (Table 4), may be able to grow in conditions outside of their normal range, thereby not providing any reprieve to rush-pea during its flowering season of April to November (Poole *et al.* 2007). The level of threat is high for rush-pea, but it has a high potential for recovery due to the ease with which it germinates.

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1.3.2 Description and Taxonomy

Rush-pea is an herbaceous perennial plant and is considered a valid taxon. The species was first collected in 1922 by L. J. Bottimer but it was not described until 1931 after F. E. Clements had collected rush-pea from a site between Robstown and Alice, Texas. Rush-peas's woody taproot gives rise to spreading stems and further into alternate and bipinnately compound leaves, ranging from 5-12 cm (2-4.7 in) (Poole *et al.* 2007) (Figure 2). Rush-pea is morphologically most similar to Watson's rush-pea (*Hoffmannseggia watsonii*), but is distinguished by their fruit size and their range and preferred habitat type.

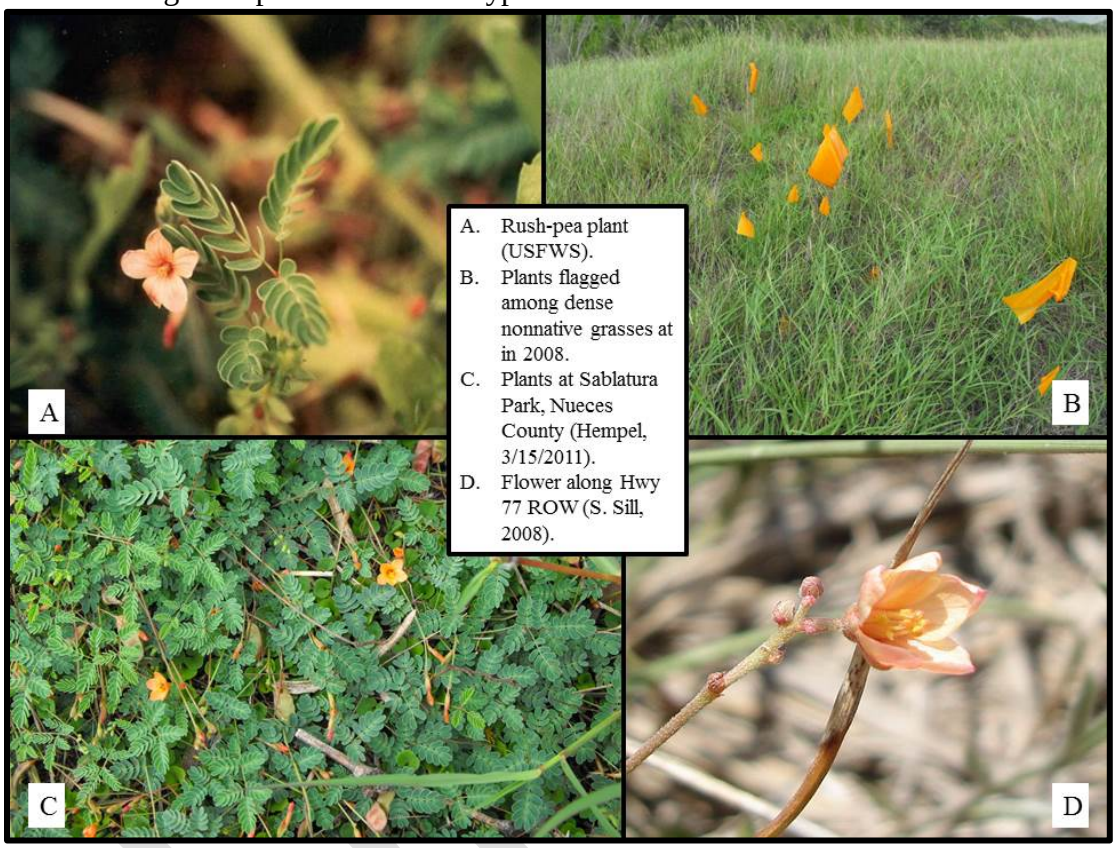

Figure 2. Images of slender rush-pea.

1.3.3 Distribution

The Texas Natural Diversity Database (TXNDD) (2013a) listed 7 EOs of rush-pea in Nueces and Kleberg counties, Texas, only two of which were then known to be extant (Petronila and St. James Cemetery). The 5-year review (USFWS 2008) determined that 2 of 10 documented collection sites (Hwy 77 and St. James Cemetery) had extant populations, 4 sites were inaccessible, 3 could not be relocated, and 1 (Petronila) appeared to be extirpated (Figure 3). As a result of the current Preventing Extinction cooperative agreement and other monitoring efforts, there are 8 extant populations (Table 6), although four of these (Hwy 77, St. James Cemetery, Bishop City Park, and a private residence in Bishop) are less than 2.5 km (1.6 miles) apart and probably function as a single metapopulation. Three of the eight (Sablatura County Park, Bishop City Park, and a private residence between St. James Cemetery and Bishop City Park) are new discoveries, and the Petronila site has been temporarily recovered through suppression of the

nonnative grass Kleberg bluestem with grass-specific herbicide. Although the KRTA sites have not been visited since 1993, the populations (probably subpopulations) are likely extant since we have no knowledge that habitat has been disturbed to the point that it is not suitable for rush-pea.

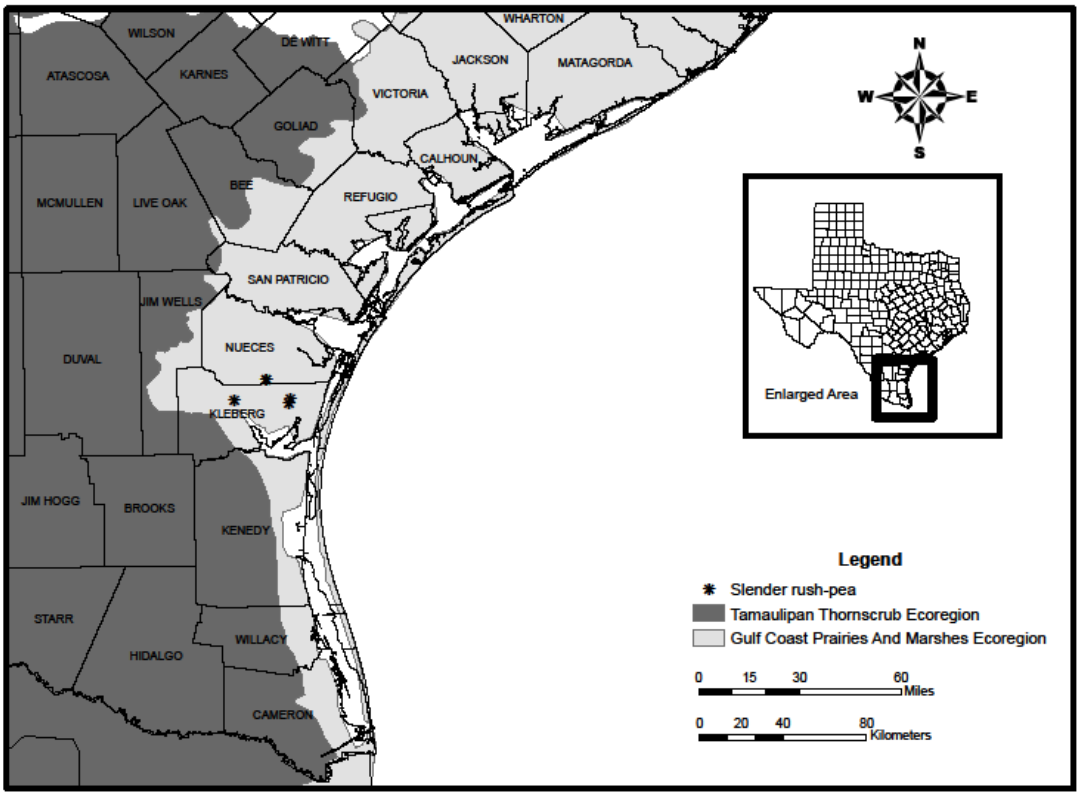

Figure 3. Map of extant slender rush-pea populations in Texas according to TXNDD data (2013a; Gould 1975, Correll and Johnston 1979).

Table 6. Known historic and extant populations of slender rush-pea. Population #'s reflect only the extant populations. EO #'s are listed in the Texas Natural Diversity Database (TXNDD 2013a), Element Occurrence Records (EOs), and information from Slender Rush-Pea Controlled Propagation and Reintroduction Plan (USFWS 2012). Watershed/basins in the table are "10 level" watersheds as designated by U.S. Geological Survey (USGS).

Pop. #	EO #	First Observer; Observation	Last Observer, Observation	County	Site Description	Watershed/ Basin	Voucher	Population Size and Observations	Status	Ownership
1	1	Correll; 1964	USFWS, TXDOT; 2016	Nueces	20 acres of a 1,014-acre tract at Petronila Creek and SH 70 bridge ROW.	Petronila Creek	Correll 28989 (1964, LL); Correll 38906 (1970, TEX, SMU); Ajilvsgi 8239 (1982, SMU), FSU, CCM	In 1986, site contained about 100 plants. This site has been visited a number of times since 1982, with the number of plants varying probably due to observer effort. As of 2004, plants were no longer visible at the site. In 2010, site was mowed and spot-sprayed with *Select* (Reilley pers. comm.2010). In May 2011 and 2012, 194 and 303 seeds respectively, were collected by the PMC. Only 50-100 plants within 0.34 acres exist (USFWS 2012). Site was visited in Oct. 2013 to collect seeds, however habitat has not recovered from vehicular damage (and drought?), therefore few plants and no seed was observed. TXDOT installed fencing and bollards to restrict vehicles from the site (summer 2013). The Nueces County Sheriff's Department plans to patrol the area. Posted signs have also been planned for the site and will likely be put up in 2014. In March 2014, TXDOT walked the hillside where they found new plants in previously disturbed areas; plants had produced seed (C. Amy, pers. comm. 2014). In July 2016, site was very dry and overgrown with invasive grasses – plants were not doing well.	E	State
	3	L. J. Bottimer; 1922	L. J. Bottimer; 1922	Nueces	Robstown, along railroad tracks in city limits.	Oso Creek	Bottimer 7 (TEX)	Single specimen was collected with fruit. Numbers of plants not reported and population was never relocated.	H	Unknown
	4	F. E. Clements; 1931	F. E. Clements; 1931	Nueces	Between Robstown and Alice.	Oso Creek	Clements 199914, 199866, 199867 (TEX)	In 1922, specimen was collected, but exact location unknown. Numbers of plants not reported and population was never relocated due to the nondescript location.	H	Unknown

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2	5	J. Poole; 1985	D. Grise, R. Cobb; 2015	Nueces and Kleberg	St. James Cemetery, Bishop	Chilitipin Creek-San Fernando Creek	Neff 88-11-4-1 (1988, TEX); Simpson 05-15-92-1 (1992, TEX)	Site has been visited frequently between 1985 and 2011. Population estimated > 1,000 plants in 1992. The population is still large but declining due to Kleberg bluestem. Experimental mowing and herbicide treatments have been completed. As of 2007, there were about 10,000 plants. About 100 seeds were collected in 2011 and are being maintained at the PMC Site has been revisited frequently between 1985 and 2011. In 2012, Dr. Rideout-Hanzak began studies on the impacts of shading. Studies to look at rush-peas response to fire were to begin in Dec. 2012, but have not been completed. Rush-pea and ambrosia are both being investigated by Dr. Overath at this site; however, no studies were anticipated for rush-pea in 2013. Site observed in fall 2015; both rush-pea and ambrosia were present but mowing at site is infrequent – habitat is overgrown with nonnatives.	E	Private
3	5	L. Elliott, R. O'Brien; 1993	A. Hempel, A. Strong; 2013	Nueces and Kleberg	U.S. Hwy 77 ROW on Nueces-Kleberg County line, both east and west side	Chilitipin Creek-San Fernando Creek		Population had an estimated 5,709 plants in May 2008. Herbicide spray incident occurred in September 2008 but plants were stable. Seeds were collected in May 2008. A bulldozing incident in ROW occurred in September 2009 and gravel was dumped on plants in April 2011. A Preventing Extinction grant funded the completion of a rush-pea Monitoring Plan in Nov. 2012. The plan will allow for the assessment of current population trends, will help to determine if management is beneficial, and verify unconfirmed and identify new populations. Population was monitored according to the plan in 2013.	E	State
4		S. Maher; 2008	2016	Nueces	Private home near Bishop and cemetery. Across the creek from St. James Cemetery.	Oso Creek		First identified in 2008 with 50-100 plants. A total of 1,197 seeds were collected on May 13, 2010 and were stored at PMC. Population is stable and is within remnant shortgrass habitat. Landowner was known in 2013 but property sold. No longer have access to the site therefore must request permission but plants still there as of 2016. Landowner is conservation-minded (2016). *This population is not the vacant lot discovered in 1976.*	E-Uv	Private
5		A. Hempel; 2010	R. Cobb, D. Grise; 2015	Nueces	Bishop City Park; site found south of creek, and one north of the trail	Oso Creek		A few plants were found in the cracks of the asphalt of a small walking path and on the water side of the path in buffalograss . The site suffers from Kleberg bluestem invasion. No seeds have been collected from this site. In December 2012, the site was overrun with grass but both rush-pea and ambrosia were present (R. Cobb, A. Miller). Site observed in fall 2015.	E	City

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6		A. Hempel; 2010	A. Hempel; 2012	Nueces	Sablatura County Park	Oso Creek		This location may be either the same or close to a historical record for rush-pea from 1913 but location info is too vague to determine if they are the same site or not. Hundreds of plants first observed on March 19, 2010. Seeds were collected in Feb. 2011 and subsequently in 2011, with 42 seeds and over 1,000 seeds, respectively. Seedlings were used for reintroduction plot in 2011 at NABA, in Mission, TX. A visit in Oct. 2012 found the population severely drought stressed. The area had also been mowed very short.	E	County
	2	F. B. Jones; 1964	F. B. Jones; 1964	Kleberg	Four miles south of headquarters, Laureles Division.	Alazan Bay-Baffin Bay	Jones 6146 (TEX, CCM)	Numbers of plants not reported. Site never revisited - no access. Site was described as pasture openings in clay loam soils.	H	Unknown
7	7	W. Carr, L. Elliott; 1993	W. Carr, L. Elliott; 1993	Kleberg	KRTA - National Guard training area lease - both sides of intermittent creek, Bordo Nueveo Windmill, San Fernando Creek.	Alazan Bay-Baffin Bay		In 1993, two populations were located at San Fernando Creek, 3 at the KRTA, and one at the Bordo Nuevo Windmill. Later in April 1993, several hundred plants with flowers and fruit were found along an intermittent creek. In May 1993, approximately 50 plants with fruit were seen across three locations.	E-Uv	Private
8		C. Best, A. Hempel; 2011	M. Rice; 2015	Hidalgo	Introduced site at NABA-NBC, in Mission			**Introduced site.** Seedlings from Sablatura Park were collected in 2011 and planted in a shortgrass refugium on Oct 27-28, 2011. In July 2012, NABA biologists mowed the site and reported that native grasses along with rush-pea were doing well. As part of the Monitoring Plan, C. Best (USFWS) and J. Reilley (PMC) collected data in Jan. 2013. The NABA director reported that the plants were doing okay on site (R. Cobb, pers. comm. 2016).	E	Private

Herbaria Key:	
CCM - Corpus Christi Museum of Science and History	**Status:**
FSU - Florida State University	H - Historic
LL - Lundell Herbarium	U - Unknown
SMU - Southern Methodist University	E - Extant
TAIC - Texas A&M-Kingsville	E-Uv - Extant but status unverifiable due to limited access

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Although rush-pea has never been reported outside of Nueces and Kleberg counties, suitable shortgrass prairie habitats range from Refugio County southward along the Gulf Coast, into northern Tamaulipas, Mexico, providing potential for its existence. The characteristic features of these habitats are vertisols supporting buffalograss-dominated vegetation (USFWS 2012). Most of this potential habitat has never been surveyed; furthermore, due to its small stature and ephemeral emergence from a perennial rootstock, the species could have been overlooked in previous surveys. Therefore, it is possible that additional, perhaps disjunct, populations may occur elsewhere within this range. A refugium population of rush-pea has been established at the North American Butterfly Association - National Butterfly Center (NABA – NBC), Hidalgo County, Texas, using seed collected from the Sablatura County Park population, Nueces County.

1.3.4 Habitat Characteristics

Soils

Primary soils of rush-pea habitat are of the Victoria Association, occupying more than 60 percent of Nueces County (Franki *et al.* 1965). A similar proportion of Victoria soils are believed to occupy Kleberg County as well. Victoria soils are highly desirable for farming, producing some of the highest crop yields for corn and sorghum (Franki *et al.* 1965). Nevertheless, the known extant and historic sites of slender rush-pea all occur near streams, where erosion may have exposed narrow bands of subsoil or different soil types that, due to their small size, are not indicated on soil maps.

Several soil analyses have been conducted at sites where both rush-pea and ambrosia occur (Hwy 77 ROW and St. James Cemetery). As later noted in the ambrosia soils section 1.4.4, the results of these soils analyses were somewhat contradictory with regard to clay versus sand content (see Table 11). The population at Sablatura County Park, along Agua Dulce Creek (a tributary of Petronila Creek), was also analyzed in 2011 and was mapped as a Clareville soil. Clareville soils are loamy clays with sandy clay loam to sandy clay subsoil, are more friable and less clayey than Victoria soils, and less calcareous than Hidalgo soils (Franki *et al.* 1965). The analyses in 2011 showed that of the three sites tested, all were loam, fine sandy loam, or sand clay loam (S. Maher, pers. comm. 2014).

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Table 7. Soil analyses for slender rush-pea.

Site	As Cited In:	Soil Observation
Sablatura County Park	Franki *et al.* 1965	Habitat is mapped as a Clareville soils which are loamy clays with sandy clay loam to sandy clay subsoil, and are more friable and less clayey than Victoria soils and less calcareous than Hidalgo soils.
	S. Maher, pers. comm. 2014	Three sites were analyzed in 2011. Textures included loam, sandy clay loam, and fine sandy loam. Effervescence (or presence or absence of calcium carbonate) was also tested. The more CaCO3 (calcium carbonate) in the soil, the more effervescence.
Hwy 77 ROW	Brannon *et al.*1997	Soils not classified as clayey, containing only 19-23 percent clay, and were classified as silty-loam.
St. James Cemetery	Franki *et al.* 1965	The site overlies the broad unit of Victoria clays (the soil series).
	Brannon *et al.*1997	Soils were not classified as clay and were composed of 40-41 percent sand with only 14-20 percent clay.

Historical and remnant rush-pea populations occur along drainage areas near creeks and streams and in uncultivated patches of habitat. This suggests that rush-pea may be specifically adapted to soils exposed along the erosional contours of watercourses. However, we cannot assume that rush-pea is naturally restricted to these riparian soils, since the vast majority of uplands in these soil series have been converted to farmland (exclusive of vast, privately-owned rangeland areas in Kleberg County where access for surveys has not been granted) and may be the only remaining available habitat for the species (USFWS 2012).

Vegetative Community

All rush-pea sites occur in barren openings or patches of native remnants of shortgrass prairie and are associated with both short and mid-grass species (Table 2). Additional native shortgrass species associated to rush-pea include Texas grama and curly-mesquite, and the tallgrass Texas wintergrass (Poole *et al.* 2007). Although rush-pea and ambrosia share similar prairie vegetation of the Coastal Bend (Table 2), rush-pea has specific associates (Table 8). The shortgrass prairie site with the most intact native vegetation is the St. James Cemetery, where it co-occurs with ambrosia.

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Table 8. Common known plant associates specific to slender rush-pea (USFWS 1988, Poole *et al*. 2007, USFWS 2008, TXNDD 2013a).

Scientific Name	Common Name
Acacia spp. [1,2,3]	acacia
Ambrosia cheiranthifolia[2]	South Texas ambrosia
Amoreuxia wrightii[2]	Wright's yellowshow
Aristida spp.[2]	threeawns
Bouteloua ridgidiseta[1,2,3]	Texas grama
Buchloe dactyloides[1,2]	buffalograss
Celtis laevigata[2]	sugar hackberry
Celtis pallida[1,2,3]	spiny hackberry
Condalia hookeri var. *hookeri*[1,2,3]	Brazilian bluewood
Condalia spathulata[2]	knifeleaf condalia
Desmanthus reticulatus[2]	netleaf bundleflower
Desmanthus virgatus[2]	wild tantan
Echeandia chandleri[2]	lila de los llanos, Chandler's craglily
Galactia heterophylla[2]	Gray's milkpea
Hilaria belangeri[2]	curly-mesquite
Jatropha cathartica[1,2]	Berlandier's nettlespurge
Justicia pilosella[2]	Gregg's tube tongue
Menodora heterophylla[2]	low menodora
Nassella leucotricha[2]	Texas wintergrass
Opuntia engelmannii var. *lindheimeri*[2]	Texas prickly pear
Plantago rhodosperma	redseed plaintain
Prosopis glandulosa[1,2,3]	honey mesquite
Salvia coccinea[2]	blood sage
Senecio tampicanus[2]	Great Plains ragwort
Stipa leucotricha[1,3]	Texas speargrass
Trichloris pluriflora[2]	multi-flowered false-rhodesgrass
Vicia sp. [2]	vetch
Castelia texana[1]	amargosa
Parkinsonia aculeata[1,3]	retama
Schaefferia cuneifolia[1]	desert yaupon
Yucca treculeana[1]	Spanish dagger
Zanthoxylum fagara[1]	colima
Ziziphus obtusifolia[1,3]	lotebush
Mammillaria heyderi var. *hemisphaerica*[1]	Heyder's pincushion cactus
Ferocactus setispinus[1]	barrel cactus
Opuntia engelmannii[3]	prickly pear

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1.3.5 Life History and Ecology

Reproduction and Genetics

At the time the recovery plan for rush-pea was finalized in 1988, information on the biology of the species was limited. The species is an herbaceous perennial legume, or pea, and member of the family Fabaceae. Rush-pea has a long woody taproot, capable of forming colonies (Poole 1988). Plants generally grow in small clusters and produce multiple stems about 40 percent of the time (Rideout-Hanzak and Wester 2013). There are five small, yellow-pink to reddish orange petals per flower, which bloom in the spring and summer months from April to November (Poole *et al*. 2007) but may flower as late as December (R. Cobb, pers. comm. 2013). Rush-pea flowering and fruiting are linked to the bimodal rainfall episodes occurring in South Texas. Flowers are only known to be open for several hours each day, normally during mid-day (Bush 1990, Poole *et al.* 2007). Effective pollinators of rush-pea have not been observed in the field or in a greenhouse setting. Rush-pea is thought to self-pollinate as the rate of fruit set is high despite the lack of observed floral visitors (Pressly 2002). Flowers are perfect monoclinous, containing both male and female reproductive parts. Pressly (2002) demonstrated that flowers that were isolated from insects with micro-mesh cloth bags prior to anthesis still produced mature fruits with viable seeds, thereby providing additional evidence of the species capability to self-fertilize.

Abundant fruits and viable seeds are produced in the wild and in propagated populations at the San Antonio Botanical Gardens (SABG) and the USDA Plant Materials Center (PMC). Fruiting has been documented from February to July (USFWS 1988). Fruit and seed dispersal mechanisms are unknown. Seed dispersal in other legumes involves mechanical means whereby seeds are either forcibly or gradually released. Germination does not require a dormancy period (Pressly 2002).

Researchers from several institutions collected genetic samples from rush-pea plants, and by the end of 2006 had developed a library of clones from microsatellite-enriched DNA fragments (J. Manhart, pers. comm. 2006), but the work was never completed past this point due to a lack of funding (Overath and Grisé 2014). We lack complete information on the genetic structure of rush-pea populations and on the species' reproductive biology.

1.4 South Texas Ambrosia

1.4.1 Legal Status of the Species

A 1983 status report of ambrosia provided sufficient information on biological vulnerability and threats to support preparation of the proposed rule to list ambrosia as endangered (Turner 1983). The ambrosia was listed as endangered under the Act on August 24, 1994 (USFWS 1994). The listing rule indicated that the species was believed to be vulnerable to collecting pressures and vandalism, therefore the USFWS determined that critical habitat designation was not prudent. Recovery priorities for listed species range from 1 to 18, with 1 signifying the highest recovery potential. The final listing rule for ambrosia (USFWS 1994) designated a recovery priority of 8, indicating a moderate degree of threat to the species but with high recovery potential (see Table 9).

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Table 9. Recovery Priority Numbers for South Texas ambrosia as outlined at the time of listing (USFWS 1983).

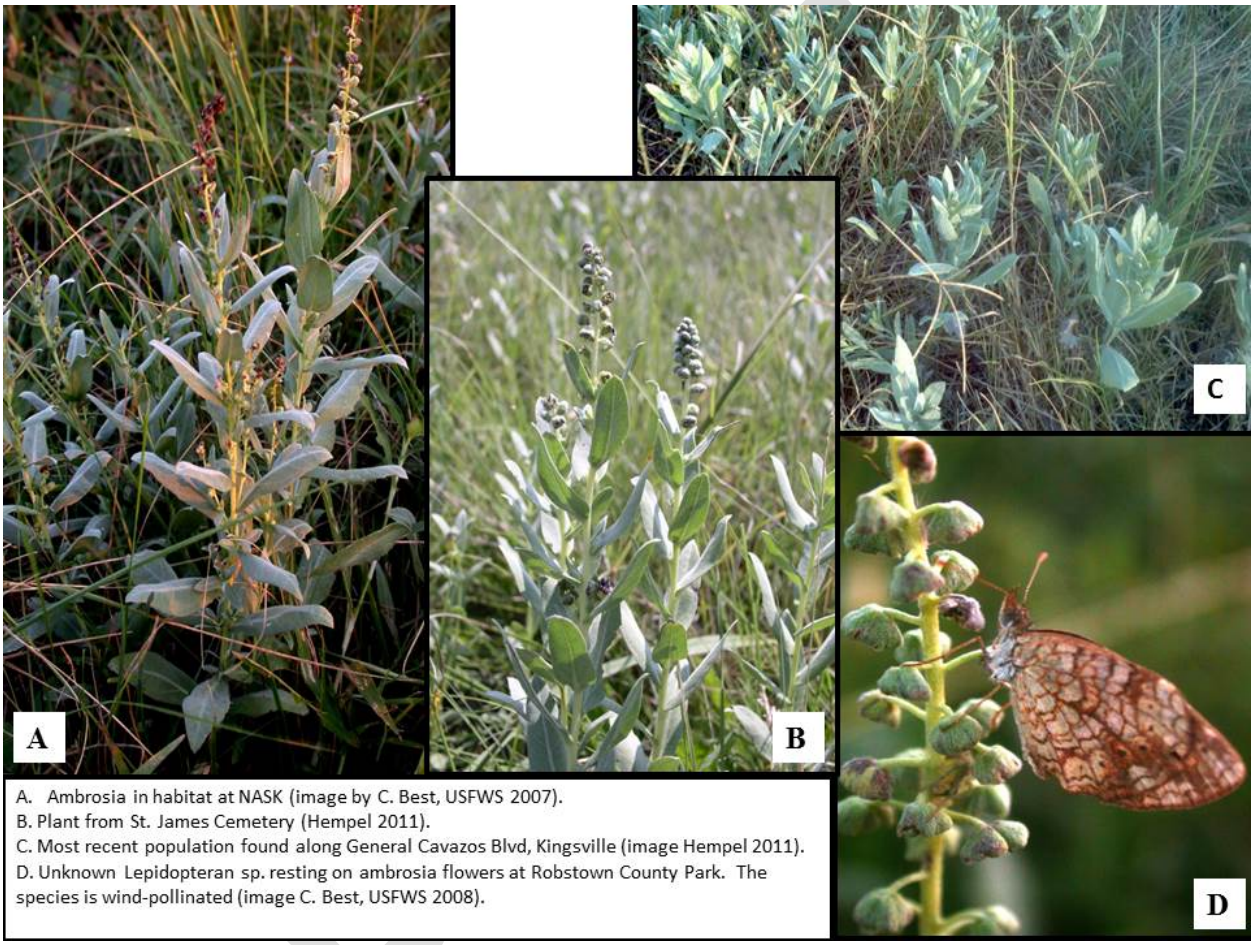
Degree of Threat	Recovery Potential	Taxonomy	Priority	Conflict
High	High	Monotypic Genus	1	1C
		Species	2	2C
		Subspecies/Distinct Population Segment (DPS)	3	3C
	Low	Monotypic Genus	4	4C
		Species	5	5C
		Subspecies/DPS	6	6C
Moderate	High	Monotypic Genus	7	7C
		Species	8	8C
		Subspecies/DPS	9	9C
	Low	Monotypic Genus	10	10C
		Species	11	11C
		Subspecies/DPS	12	12C
Low	High	Monotypic Genus	13	13C
		Species	14	14C
		Subspecies/DPS	15	15C
	Low	Monotypic Genus	16	16C
		Species	17	17C
		Subspecies/DPS	18	18C

A 5-year review was conducted for the ambrosia in 2010, and is the most comprehensive status review of the species to date (USFWS 2010). Based on this status review, the continued fragmentation and conversion of Texas Coastal Bend shortgrass prairie habitat, coupled with the increasing encroachment of nonnative grass species, constitutes a high level of threat to the ecosystem throughout the region. However, these threats are moderated at the extant ambrosia sites due to ongoing management by the Federal government, local government, and private landowners and therefore a change to its listing status was not recommended (USFWS 2010). Given this moderated threat level, and the fact that ambrosia has been successfully propagated from cuttings, thereby providing potential restoration opportunities, the USFWS determined that the current recovery priority number of 8 for ambrosia required no change and captured the status of threats and recovery potential (USFWS 2010).

1.4.2 Description and Taxonomy

Ambrosia is an herbaceous, ashy blue-gray, rhizomatous perennial in the Asteraceae Family (sunflowers) (Figure 4). Stems of the plant stand erect and are approximately10–60 cm (3.9–23.6 in) tall. The number of individuals at any site is difficult to count as stems from closely-spaced colonies due to rhizomatous growth habits, thus inhibiting accurate stem number counts. The leaves are usually opposite at the base, and alternate above. The leaves are mostly oblanceolate or oblong-lanceolate, 2–7 cm (0.8–2.8 in) long, depending on the area of placement and the age of the stem, with the blade narrowing gradually at the base. Most leaves are unlobed

and entire, although the lower and larger leaves of juvenile plants may be undulate or shallowly-pinnate. Both sides of the leaves appear whitened due to a fine and short appressed pubescence, giving the leaf an ashy, blue-gray color. The inflorescence is usually unbranched and composed of separate, inconspicuous male and female flowers. The male flowers occur in a terminal raceme 5–10 cm (2–4 in) long, composed of 10–12 small, light yellow, saucer-shaped flowers that are about 4 mm (0.16 in) broad with 4–6 acute, triangular lobes. The female flowers are in small clusters in the axils of the leaves. The fruit is an achene, somewhat angled and long with a stout beak. The fruit has 4-5 blunt spines spread across the surface (Poole *et al.* 2007). Ambrosia is primarily wind pollinated.



A. Ambrosia in habitat at NASK (image by C. Best, USFWS 2007).
B. Plant from St. James Cemetery (Hempel 2011).
C. Most recent population found along General Cavazos Blvd, Kingsville (image Hempel 2011).
D. Unknown Lepidopteran sp. resting on ambrosia flowers at Robstown County Park. The species is wind-pollinated (image C. Best, USFWS 2008).

Figure 4. Images of South Texas ambrosia.

Ambrosia is distinguished from a similar looking species, the false ragweed (*Parthenium confertum*), by its distinctive ashy-blue-gray color (S. Maher, pers. comm. 2012). Even given the distinctive color, it can be difficult to locate because taller native and introduced grasses easily obscure this species (Turner 1983). In winter, upper portions of the plant, including the inflorescence, become dry and rigid with a very characteristic silver-grey color (Bush *et al.* 1994). In spring, new foliage appears as a basal rosette with deeply-lobed leaf margins. The first ambrosia collection on record was taken by Luis Berlandier in 1835 in San Fernando, Tamaulipas, Mexico (USFWS 1993). In 1859, Asa Gray named the plant *Ambrosia*

cheiranthifolia (Payne 1964). In 1932, the first collection of *Ambrosia cheiranthifolia* in the United States was taken from an area near Barreda (now Russelltown) in Cameron County, Texas, by Robert Runyon (Turner 1983).

1.4.3 Distribution

Historical or Unverified Sites of South Texas Ambrosia

Although the vast majority of remaining ambrosia sites are concentrated in the northern part of the range, from north central Nueces County to south central Kleberg County (Figure 5), there were historic records that the range extended from Nueces County south to San Fernando, Mexico. Yet, numerous ambrosia occurrences are now considered historic and have not been relocated in over 20 years or lack a confirmation of identification (or a voucher) (Table 10). A historical site is one for which a record exists, but either the site could not be re-verified after it was first reported, or the species has not been found at the site for a number of years even though surveys have been conducted and the habitat is more or less intact. These historical occurrences are discussed in more depth in the 5-year review (USFWS 2008). There are two sites that do not have voucher specimens and are no longer considered historic nor ever were extant sites for ambrosia. One site in Jim Wells County lacks a voucher specimen to confirm its location therefore relocating the site has been difficult. The other record was from a 2005 collection from Tamaulipas, Mexico, that has never re-verified and is no longer considered extant.

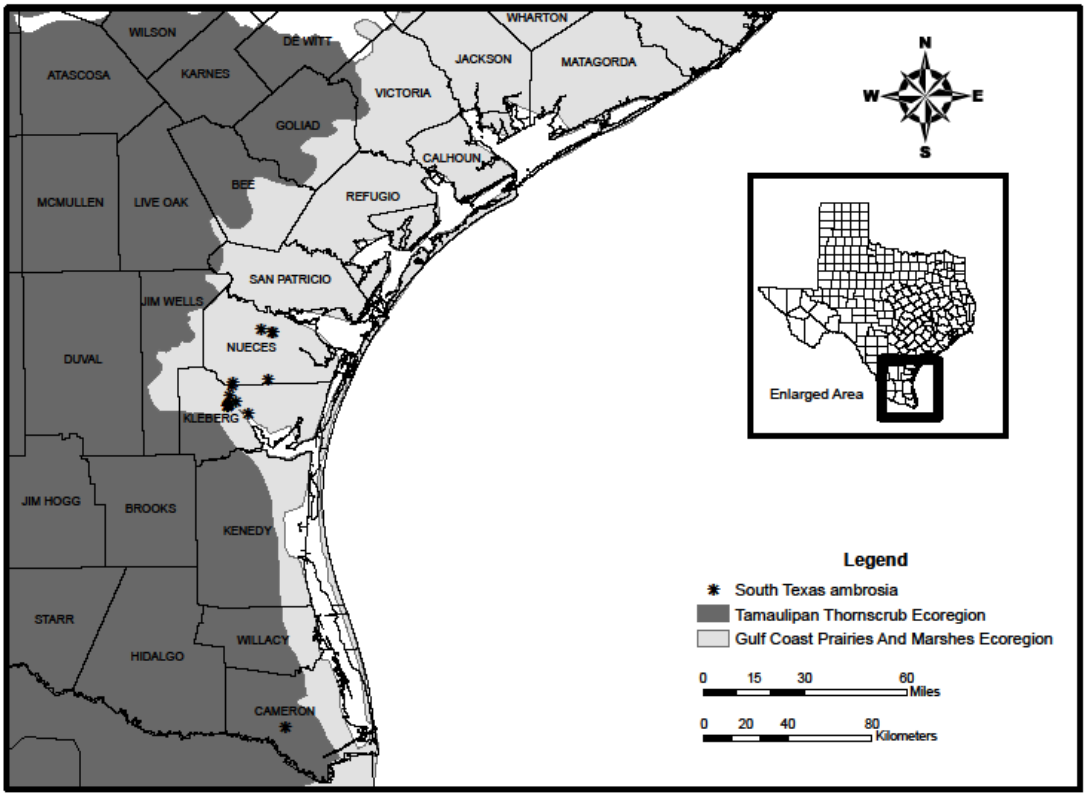


Figure 5. Map of extant populations of South Texas ambrosia in Texas from TXNDD data (2013b; Gulf Coast Prairies and Marshes Ecoregion map data online (Gould 1975, Correll and Johnston 1979)).

Extant Sites of South Texas Ambrosia

As of 2014, there are seven extant, or presumed extant, ambrosia populations from north-central Kleberg County through central Nueces County. One site occurs on state lands, on both the north and southbound ROWs of US Hwy 77. The largest population occurs on Federal land at the Naval Air Station Kingsville (NASK). There are two sites on city or county-owned lands: the Bishop City Park and the Nueces County Park in Robstown. Two sites are located on private land, including a large population at the St. James Cemetery in Bishop and a small group of plants on a lot in Kingsville (General Cavazos Boulevard). Additionally, a National Guard training area formerly leased from a private landowner, known as the King Ranch Training Area (KRTA) has several sites (Table 10); these KRTA populations became inaccessible and thus unverifiable after the lease expired. Observations using Google Earth show the habitat still exists and the ambrosia is assumed to be extant. All of these separate KRTA occurrences are <1.0 kilometer (km) (3, 280 feet (ft)) apart and are therefore, likely to be a single population. The close proximity between occurrences allows for the genetic exchange between each occurrence, or sub-population. As such, this population may constitute a single metapopulation based on these distances. See Section 1.4.5 for more detail on the reproductive strategy of ambrosia.

Several occurrences of the ambrosia consist of scattered sites or subpopulations that are located in close proximity to one another, with the largest being the population at NASK. The annual survey completed in November 2014 by the Naval Facilities Engineering Command Southeast found that there were 30 scattered, discrete patches of ambrosia covering 1.86 acres (Gulf South Research Corporation 2015). This population may constitute a single metapopulation based on separation distances of less than 1.0 km (USFWS 2010). Larger distances between populations or metapopulations, resulting from land cover conversion, improved pasture, and residential and commercial development, may serve as barriers for continued gene flow (NatureServe 2004).

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Table 10. Known historic and extant populations of South Texas ambrosia. Population #'s reflect only the extant populations, where metapopulations are labeled with letters (i.e., a-f). Element Occurences (EO) #'s are listed in the Texas Natural Diversity Database (2013b) and Carr (pers. comm. 2012). Watershed/basins in the table are "10 level" watersheds as designated by U.S. Geological Survey (USGS).

Pop. #	EO #	First Observer, Observation	Last Observer, Observation	County	Site Description	Watershed/Basin	Voucher	Population Size and Observations	Status	Ownership
	1	F.B. Jones; 1968	T. Ayers and B.L. Turner; 1979	Nueces	Bank of Petronila Creek, Hwy 70 crosses over bridge	Petronila Creek	Jones 7455 (1968, CCM); Turner s.n. (1979, TEX)	In 1979, found 100 plants. In 2008, no plants were found; plants have not been seen in 15-20 years. The habitat is overgrown with invasive grass and brush. In March 2014, TXDOT walked the hillside where they found new rush-pea plants in previously disturbed areas, however no ambrosia was found (C. Amy, pers. comm. 2014).	H	State
	4	M.D. Huettel, E. Szafir, and F. B. Jones; 1969	D. Price; 2004	Nueces	North side of Route 44, east of junction with St.Rt.24, west of Violet	Oso Creek	Szafir s.n, (1969, TEX); Huettel MH69151 (1969, TEX); Miao 89106 (1989, TEX); Carr 11569 (1991, TEX), CCM (O'Brien 1484,1986)	Found 100-1,000 stems in 1991 and 30-40 stems in 2000. Site may have been visited between 2004 and 2005 but plants were not found onsite. Two site visits in 2008 and 2009 did not find plants. Site was visited in 2010 and no plants; herbicide damage apparent at the site. Site visited in 2016 (R. Cobb, USFWS) but area is overgrown with invasive grasses.	H	State
	26	W. Carr; 1993	W. Carr; 1993	Nueces	North of RT 44 in Robstown, edge of cemetery at foot of railroad tracks	Oso Creek		In 1993 found 50 stems. Surveys done in 2000 and 2009 (A. Hempel) failed to find any plants. The City does on-site maintenance.	H	State
1	6	R. O'Brien; 1988	Rideout-Hanzack, USDA PMC; D.Overath, 2014	Nueces and Kleberg	St. James Cemetery	Chilitipin Creek-San Fernando Creek	Carr 11268 (1991, TEX); CCM (1988)	In 2005, found thousands of stems. A 2009 survey showed an average of 10 stems per sq. meter. This is the largest population known in Nueces County. Overath conducted fires studies (2013 and 2014) to determine effects to population density and flowering.	E	Private

2		1993	R. Cobb, C. Best; 2016	Nueces	West side of Hwy 77, southwest of Carreta Creek and east side of Hwy 77 south of Nueces/Kleberg line	Chilitipin Creek-San Fernando Creek		1,737 stems (1993). 4,201 stems (1994). 30 stems (2000). 592 stems (2002). Fire destroyed vegetation in 2008, however, this population recovered. Site visits in 2009 showed herbicide damage on East side and disturbance with what appears to be a decline in populations on both the east and west side of the ROW. Site observed in 2013 (A. Hempel). In spring/summer 2016, all patches were surveyed. The east patch along ROW was doing great and plants were spreading onto private land. West side population was doing best along fenceline. At this time plants were in flower (R. Cobb, pers. comm. 2016).	E	State (expanding onto private land)
3	28	D. Price and L. Pressly; 2001	R. Cobb; 2016	Nueces	Nueces County Park in Robstown (Bishop)	Oso Creek		Sahadi initially located small number of plants in one park field. In 2006, a pilot reintroduction effort was started in another area of the park. Two new subpopulations found alongside park perimeter road in 2009. Plants looked good in 2011 in pilot site (R. Cobb, pers. comm. 2012). Found in patchy distribution along road. Overath surveyed the site in 2013, 2014, and Nov 2015. No changes in stem density/polygon were observed between 2013 and 2014; fewer stems in one polygon was observed in 2015 survey (D. Overath). Park visited in August 2016; plants were observed.	E	Municipal lands
		J. F. Sinclair; 1940	J. F. Sinclair; 1940	Kleberg	Coast near Kingsville	Upper Laguna Madre	Sinclair 42-156A (1942, TEX)	Historical record, but unable to relocate site due to inadequate location information.	H	Unknown

4	7	P. Clayton; 1991	Coastal Ecological Service Staff; 2014	Kleberg	NASK	Chilitipin Creek-San Fernando / Santa Gertrudis Creek	Carr 11413 (1991, TEX); Carr 12070 (1992, TEX)	Since 2005, systematic monitoring of NASK patches has ranged from 25 to 27 sites. These subpopulations are in close relative proximity (only about 1 km. apart) and may constitute a single meta-population (Garvon 2005). The 2008 survey showed impacts from invasive grasses. The 2009 survey was not completed. In 2013, there were 28 patches base-wide. A fence-to-fence survey was completed in November 2014 where an additional in which 30 total patches of ambrosia were recorded; this is thought to be a single metapopulation based on distance between patches.	E	Federal
5	19	W. Carr; 1993	W. Carr; 1993	Kleberg	KRTA	Alazan Bay-Baffin Bay		Most recent survey (1993) found thousands or tens of thousands of stems.	E-Uv.	Private
5a	19	W. Carr; 1993	W. Carr; 1993	Kleberg	KRTA; Pinto creek	Alazan Bay-Baffin Bay		Most recent survey (1993) found hundreds, of stems.	E-Uv.	Private
5b	21	W. Carr; 1993	W. Carr; 1994	Kleberg	KRTA; Pinto pasture. Contains an east and west subpopulation.	Alazan Bay-Baffin Bay		In 1993, found hundreds of stems. Found tens of thousands of stems in 1994.	E-Uv.	Private
5c	19	W. Carr; 1993	W. Carr; 1994	Kleberg	KRTA; road to Pinto Creek	Alazan Bay-Baffin Bay		In the most recent survey, found hundreds of stems.	E-Uv.	Private
5d	19	W. Carr; 1993	W. Carr; 1995	Kleberg	KRTA; south towards Ramos Well	Alazan Bay-Baffin Bay		Several thousand stems.	E-Uv.	Private
5e	19	W. Carr; 1993	W. Carr; 1993	Kleberg	KRTA; southwest of Bordo Nuevo Windmill	Alazan Bay-Baffin Bay		Hundreds, but not thousands of stems.	E-Uv.	Private
5f	19	W. Carr; 1993	W. Carr; 1994	Kleberg	KRTA; road through Pinto pasture	Alazan Bay-Baffin Bay		Hundreds of stems.	E-Uv.	Private

6		A. Hempel; 2011	A. Hempel; 2016	Kleberg	Kingsville, on E. General Cavazos Blvd. west of intersection with 6th Street	San Getrudis Creek		At least half a dozen "patches" comprised of 100's of stems each, in an area about 250 sq. m (2,691 sq. ft.); might occupy larger area. Property has been put up for sale. Site was observed in Jan. 2016 and plants were still present although nonnative invasive grasses were encroaching site. The For Sale sign was not posted in the yard – selling status is unknown (A. Hempel, pers. comm, 2016).	E	Private
	2	R. Runyon, 1932	R. Runyon, 1938	Cameron	near Barreda	Rio Grande / Nueces	Runyon 1440 (1932, LL, TEX0; Runyon 3291 (1938, TEX); U.S. Nat'l Herbarium (1941)	Unknown: no population size documented. Historical site has never been reconfirmed.	H	Unknown
	5	F.B. Jones; 1977	F.B. Jones; 1977	Jim Wells	East of Petronila, west of Violet, in Robstown, Bishop	Petronila Creek		Record published in Flora of Texas Coastal Bend (Jones and Jackson 1977). Locality information too vague to relocate.	H	Unknown
		L. Berlandier; 1835		Mexico	Municipio of San Fernando	Río San Fernando		First specimens of *Ambrosia cheiranthifolia* collected (No. 1513 and 3013). Specimens named in 1859 by Asa Gray (as published in Emory 1859).	H	Unknown
7		W. Carr, C. Bush, R. O'Brien, R. Cobb; 1992	R.Cobb, D. Grise; 2015	Nueces	Bishop City Park on northeast side of Carreta Creek; both sides of drainage ditch	Chilitipin Creek - San Fernando Creek		Recorded hundreds of stems in earliest surveys (no counts). Site visited in 2008 - no information. Site visited in fall 2015.	E	City

Herbaria Key:	**Status:**
TEX - University of Texas at Austin Herbarium	H – Historic
CCM - Corpus Christi Museum of Science and History	U – Unknown
LL - Lundell Herbarium	E – Extant
	E-Uv - Extant but status unverifiable due to limited access

1.4.4 Habitat Characteristics

Soils

Ambrosia is known to occur on various soils derived primarily from the Beaumont clay series, ranging from heavy clays to lighter-textured sandy loams typical of the Texas Coastal Plain (Turner 1983, Poole *et al.* 2007). A soil analysis has been completed for NASK, the KRTA, St. James Cemetery, and Hwy ROW 77 (Table 11).

Table 11. Soil analyses for South Texas ambrosia.

Site	As Cited In:	Soil Observation
NASK	Garvon 2005	Soils are mainly composed of clay or sandy loams, specifically Raymondville clay loam, Hidalgo fine sandy loams, Clareville clay loam, and Czar fine sandy loam.
	Overath 2013a	Subpopulations sites on NASK showed little or no significant difference between the soils from sites containing ambrosia populations to soils in the surrounding area. Planned to complete soil analyses to determine if textural differences along with a distinct shortgrass flora cover were different from the surrounding dominant mid-grass coastal prairie; as of December 2013, this had not been completed.
KRTA	TXNDD 2013b; W. Carr, pers. comm. 2007	Soils described as "lightly colored and textured, with a grayish silt or sand, being noticeably different from black clays on adjacent uplands."
Hwy 77 ROW	Brannon *et al.* 1997	Soils not classified as clayed, containing only 19-23 percent clay, and were classified as silty-loam.
St. James Cemetery	Franki *et al.* 1965	The site overlies the broad unit of Victoria clays (the soil series).
	Brannon *et al.* 1997	Soils were not classified as clay and were composed of 40-41 percent sand with only 14-20 percent clay.

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Vegetative Community

The vegetative community for ambrosia consists of open prairies, savannas, and grasslands scattered with mesquite at elevations between 8-20 m (26–66 ft). Most of the sites where ambrosia is found contain only remnants of shortgrass prairie and are typically unplowed but mowed. Known sites are found within railroad and Hwy ROWs, cemeteries, mowed park fields, and erosional areas along creek systems. In its native habitat, associated prairie species are often associated with ambrosia (Table 12). Slender rush-pea co-occurs at three sites with ambrosia (Poole *et al.* 2007) but it is not a dominant species. Several native woody plants found within and adjacent to ambrosia include honey mesquite, huisache (*Acacia*), huisachillo, brasil, granjeno, and lotebush (USFWS 1994).

Table 12. Common plant associates specific to South Texas ambrosia (Poole et al. 2007[1], USFWS 1994[2]).

Scientific Name	**Common Name**
Acacia schaffneri[2]	huisachillo
Acacia spp.[2]	acacia
Ambrosia psilostachya[1,2]	cuman ragweed
Bouchetia erecta[1,2]	painted tongue
Bouteloua rigidiseta[1,2]	Texas grama
Buchloe dactyloides[1,2]	buffalograss
Clematis drummondii[1,2]	Drummond's clematis
Condalia hookeri[2]	brasil
Glandularia bipinnatifida[1,2]	Dakota mock vervain
Celtis spp.	sugar hackberry[2], granjeno
Grindelia microcephala[1,2]	littlehead gumweed
Hilaria belangeri[1,2]	curly-mesquite
Hoffmannseggia tenella[1,2]	slender rush-pea
Indigofera miniata[1,2]	coastal indigo
Malvastrum coromandelianum[1,2]	threelobe false mallow
Melochia pyramidata[1,2]	pyramidflower
Nassella leucotricha[1,2]	Texas wintergrass
Parthenium hysterophorus[1,2]	Santa Maria feverfew
Prosopis glandulosa[2]	honey mesquite
Ruellia nudiflora[1,2]	violet wild petunia
Setaria leucopila[1,2]	streambed bristlegrass
Verbesina microptera[2]	Texas crownbeard
Ziziphus obtusifolia[2]	lotebush

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1.4.5 Life History and Ecology

Reproduction and Genetics

More often than not, ambrosia is seen reproducing vegetatively by rhizomatous regrowth in the upper portion of the soil. As a result, a single individual may be represented by several-to-hundreds of stems, depending on the age of the plant (Turner 1983). The most current scientific information suggests that ambrosia patches represent several disjunct members of a larger metapopulation, as is thought to be the case on NASK. In 2010, Dr. Overath began work on NASK ambrosia to answer a number of these genetics-related questions including variation within patches (whether dominated by one or a few clones) and relatedness among patches; as well as to analyze the genotypes within patches. Overath (pers. comm. 2012) found little genetic variation among ambrosia samples collected and compared to 13 genetic markers, implying that patches on NASK are likely part of one larger population (or metapopulation). Small patches of ambrosia may be part of the same clone, but larger patches are not composed of single clones (Overath 2013b). However, these genetic studies did suggest that some NASK ambrosia patches (2013b) were reproducing sexually or they had in the relatively recent past. Overath's genetic studies are still underway to determine the reproductive mode at other sites, including the St. James Cemetery (Nueces County).

1.5 Threats Analyses

Current Threats to Shortgrass Prairie Ecosystem and Coastal Prairie Species

The assessment considers the threats identified in the original species listings (USFWS 1985, 1994) as well as threats documented more recently, as they appear in the rush-pea and ambrosia 5-year reviews (USFWS 2008, USFWS 2010), information from the South Texas Plant Recovery Team meetings (Jan 18, 2011, and Nov 11, 2013), and ongoing studies by academics, partners, and landowners or land managers. As outlined in the Act, all 5 listing factors are addressed in the section below (see Section 1.1 and Table 13). The greatest threat to the shortgrass prairie habitat and rush-pea and ambrosia are the loss, fragmentation, and other degradation of habitat. Currently, these species are most affected by the introduction of nonnative grass species.

DRAFT

Table 13. Threats tracking table for slender rush-pea and South Texas ambrosia.

Threats	Affected Species	Recovery Criteria No.	Recovery Actions
***Listing Factor A**: Present or threatened destruction, modification, or curtailment of its habitat or range*			
Lack of knowledge	Both	2	3.1.1. Study soils and underlying geology.
Land conversion; habitat fragmentation	Both	2	3.1.3.1. Study the response to current natural disturbance and land use practices.
Land conversion	Both	2	3.1.3.2. Study the response to past natural disturbance and land use practices.
Land conversion; habitat fragmentation	Both	2	3.1.3.4. Investigate the fire ecology of both species and their habitat.
Habitat fragmentation	Both	1, 2	3.2.1. Analyze the demographic structure of all populations.
Habitat fragmentation	Both	1	3.2.3. Determine the primary means of reproduction in the wild.
Habitat fragmentation	Both	1, 2	5. Cooperatively work with landowners and land managers to restore additional shortgrass prairies sites located in one or more of the drainage areas from which rush-pea and ambrosia are known to co-occur.
Habitat fragmentation	Ambrosia	1	7.1. Develop a USFWS-approved controlled propagation and reintroduction plan for ambrosia.
Habitat fragmentation	Both	1	7.6.1. Develop a long-term monitoring program to assess success of reintroductions or introductions.
Habitat fragmentation	Both	1	7.7. Use information gained from the long-term monitoring program to adjust both species' reintroduction plans.
Land conversion	Both	2	8.1. Develop any necessary educational or outreach materials.
Land conversion	Both	2	8.2. Provide educational and outreach materials to landowners and land managers.
Land conversion	Both	2	8.3. Provide educational and outreach materials to interested parties including agencies, engineering and consulting firms, developers, utilities, county road associations, and others.
***Listing Factor D**: Inadequacy of existing regulatory mechanisms*			

DRAFT

Inadequacy of existing regulations	Rush-pea	1	7.2. Adhere to guidelines established in the Slender Rush-pea Controlled Propagation and Reintroduction Plan (USFWS 2012).
Inadequacy of existing regulations	Both	1, 2	7.3. Appoint a coordinating team to help plan and oversee the reintroduction programs.
Inadequacy of existing regulations	Both	1, 2	7.4. Incorporate reintroduction into applicable agency land management plans.
Inadequacy of existing regulations	Both	1	10.1. Maintain the STXPRT to help review the status of both species and assess the effectiveness of the management plans and other recovery tasks.
Listing Factor E*: Other natural or manmade factors affecting its continued existence*			
Small population size; Lack of knowledge	Both	1	3.1.2. Determine the plant community structure for both species.
Climate change	Both	2	3.1.3.3. Study the response of both species and their habitat to seasonal or periodic cyclical events including drought, extreme heat events, freezes, and flooding.
Limited knowledge of pollination biology	Both	1	3.2.4. Study pollination biology and determine effective pollination requirements and effective pollinators.
Small population size	Both	1	3.2.5. Study seed production and dispersal.
Small population size	Both	1	3.2.6. Study seedling recruitment.
Small population size	Both	1	4. Survey for additional populations of rush-pea and ambrosia.
Small population size	Both	1	5.3. Introduce experimental populations of rush-pea and ambrosia.
Small population size	Rush-pea	1	6.1. Ensure seed is collected and banked from each rush-pea site, including newly discovered populations.
Small population size	Rush-pea	1	6.2.1. Ascertain whether any changes in a rush-pea refugium system are needed, including any need for additional refugia.
Small population size	Both	1	9.1. Investigate both species' genetics to ensure long-term persistence.
Small population size	Both	1, 2	9.2. Develop traditional Minimum Viable Population estimates for both species.
Small population size	Both	1, 2	9.3. Reassess the Minimum Viable Population size when new information is made available.
Lack of knowledge	Both	1, 2	10.2. Revise the recovery plan as needed.

DRAFT

Multiple Listing Factors			
A., D.	Both	1, 2	1.1.1. Maintain contact with all landowners or land managers each year.
A., D.	Both	2	1.1.2. Educate landowners about the extreme rarity and significance of both the ecosystem and species' on their property.
A., D.	Both	2	1.1.3. Encourage the long-term stewardship of the shortgrass prairie at these sites through technical assistance to landowners; also potentially through long-term leases, easement, and conservation agreements.
A., D.	Both	1	1.2.1. Cooperate with willing landowners to determine short- and long-term land use goals and their effects on both species.
A., D.	Both	1, 2	1.2.2. With all cooperating landowners, develop and implement management plans that are beneficial to the species as well as acceptable to landowners and land managers.
A., D.	Both	1, 2	1.2.3. Develop a monitoring program that is reviewed by the USFWS and other interested parties, with voluntary landowner assistance, to evaluate the effects of management practices on the species and ensure consistent and reliable monitoring of plant populations and management.
A., D.	Both	2	1.3.1. Work with regulatory agencies (DOD-NASK, TXDOT, TPWD, USDA-NRCS, and through internal USFWS coordination) to ensure that existing regulations are used to provide adequate protection of current habitat.
A., E.	Both	1	2.1.1. Monitoring plan will include abundance measures to ascertain plant abundance and spread.
A., E.	Both	All	2.1.2. Monitoring plan will include measurements of habitat condition, ecological integrity, and conservation status of sites.
A., E.	Both	2	2.2. Use the approved monitoring plans to annually monitor ambrosia and rush-pea, their habitat, management actions, and threats at extant sites.
A., E.	Both		2.3. Monitor species and biotic communities and assess ecological integrity and conservation status of historic sites.
A., E.	Both	2	3.1.3.5. Study both beneficial and detrimental interactions with other species.
E.	Both	2	3.2.2. Characterize phenology and assess the most vulnerable stages of life cycle.

DRAFT

A., E.	Both	1	3.2.7. Study population genetics to determine the genetic diversity within and among populations.
A., D.	Both	2	5.1.1. Cooperate with willing landowners to determine the best means possible for providing permanent protection and active habitat management of a site/s to maintain native shortgrass prairie. Conservation management could be implemented through cooperation with a Federal, state, municipal government, or NGO, or one in which the landowners or manager agrees upon.
A., E.	Both	2	5.2. Carry out restoration, including reintroductions, at a site/s such that it hosts a complement of the native shortgrass prairie grasses and forbs commonly associated with rush-pea and ambrosia.
A., E.	Both	1	6.3.1. Study cultivation requirements.
A., E.	Ambrosia	1	6.4. Continue experimentation with seed germination and effectiveness of ambrosia propagation from seed.
A., E.	Ambrosia	1	6.5. Continue vegetative propagation of ambrosia for purposes of reintroduction.
A., E.	Both	1	7.5. Perform experimental plantings at selected natural sites as pilot projects.
D., E.	Both	1, 2	10.3. Develop a post-recovery monitoring plan when appropriate.

Key:
1 = South Texas ambrosia – downlisting and/or delisting criteria 1
2 = South Texas ambrosia – downlisting and/or delisting criteria 2

1 = Slender rush-pea – downlisting and/or delisting criteria 1
2 = Slender rush-pea – downlisting and/or delisting criteria 2

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1.5.1 Factor A: The Destruction, Modification, or Curtailment of Habitat or Range

Habitat Loss and Conversion of Shortgrass Prairie in Kleberg and Nueces Counties

As is true of most counties within the Gulf Coast Prairies and Marshes, Nueces and Kleberg counties have experienced significant land cover changes. Few remnant sites of shortgrass prairie exist in Nueces County today; most habitat has been converted into row crops and improved pastures (intentionally planted with nonnative grasses), or otherwise been urbanized (USFWS 2008, USFWS 2010). The extent of shortgrass prairie loss in Kleberg County is not as clear. Both counties are major cotton and sorghum producers (Haile and Brezina 2012). Conversion to these crops constitutes a total loss of native habitat because production of cotton and sorghum entails annual plowing, planting, harvesting, and tilling; practices that do not allow the persistence of native vegetation. Within Nueces County, between 60 and 70 percent of the land has been converted to row crops (Long 2012). Although a substantial part of northern Kleberg County has also been converted to row crops, a much larger portion of this county (mostly the southern half) remains rangeland than is true in Nueces County; albeit, the condition of the native vegetation on this rangeland is unknown. Rangeland in Kleberg County supports cattle production and wildlife habitat; land uses that are not incompatible with the continued existence of native shortgrass prairie species. Additional land uses in both counties that have contributed to habitat loss include residential and commercial development; the impact from this type of land use being greater in Nueces County due to the more numerous and larger population centers.

Habitat Degradation and Fragmentation – Introduction and Competition of Nonnative Grasses

Currently, the primary threat to the continued existence of native shortgrass prairie species in the Texas Coastal Bend and their habitat is the continuing spread and habitat degradation by nonnative invasive grasses. Numerous grass species from Africa and Asia were introduced into much of Texas and Mexico in the 20th century for rangeland improvement, erosion control, re-vegetation of plowed or graded areas, or to be used as fodder (Gabbard and Fowler 2006). Cattle farmers in southern Texas have developed a reliance on forbs and several nonnative species which are commonly planted into pastures following root-plowing or other clearing measures. Some of these exotic grasses are also seeded into highway ROWs (see Table 4). These species threaten the integrity of the native shortgrass prairie of this region. Since their original introductions into this part of the country, these grass species have expanded their ranges from the highway ROW's, rangelands, and urban landscapes where they were originally planted (Strong 2012) and are now well established throughout much of the native prairie.

Most, if not all, of rush-pea and ambrosia sites have at least one species of introduced, nonnative grasses present, and in some cases a population site is overgrown with dense monocultures of these nonnative grasses. Land conversion and planting of nonnatives to reduce erosion have produced only remnant strips of suitable shortgrass prairie habitat where both species have been able to persist. Therefore extant populations of both species in Nueces County now only remain on small pieces of land that have not undergone disking and deep plowing, such as cemeteries, highway ROWs, and municipal parks.

DRAFT

Introduced, nonnative grasses exhibit highly invasive properties including rapid growth, tall growth form, and in combination with a lack of disease and pests, they can out-shade and out-compete rush-pea for light, space, and nutrients (Pressly 1998). The shallow, fibrous roots of many grass species such as Kleberg bluestem allow quicker absorption of moisture and nutrients than is capable by tap-rooted species, such as rush-pea, which must wait for deeper moisture penetration (D'Antonio and Mahall 1991). Pressly conducted two experiments to test these hypotheses. In her root competition (nutrient absorption) study with rush-pea, results showed that plants taken from the PMC and grown in conjunction with Kleberg bluestem, suffered a rate of mortality at 93 percent. Pressly suggested that the faster growing grasses absorbed nutrients more quickly than the native rush-pea, contributing to a higher growth rate in the nonnative grasses. Pressly (2002) alluded to potential allelopathic properties of Kleberg bluestem, which may have been a factor that hindered rush-pea growth, an observation supported by research showing Kleberg bluestem inhibits seed germination of other South Texas forbs (Kuvlesky *et al.* 2002). A second part of her study investigated effects of shading rush-pea using greenhouse shadecloth with the goal to demonstrate the differences in petiole heights and lengths between non-shaded (controls) and shaded treatments and also differences in growth patterns (Pressly 2002). Non-shaded plants grew in a prostrate manner while the petioles of the shaded plants grew upwards; however, rush-pea did not show significant mortality at 30, 40, and 50 percent shading (Pressly 2002).

A tailored herbicide application has shown to be suitable to control select invasive grasses in some Texas prairie habitats (Simmons *et al.* 2007). As of August 2012, Dr. Rideout-Hanzack began experiments to examine the herbicide and manual removal treatments of neighboring plants of rush-pea in the St. James Cemetery. Neighboring plants within 1.0 m (3.3 ft.) radius of 33 randomly-selected rush-pea plants had their above-ground growth manually removed while neighboring plants within 1.0 m. radius of 34 randomly-selected rush-pea plants had their above- and below-ground growth removed by an herbicide application (McCloughan *et al.* 2013). A second aspect of this study was to determine the effect of fire on rush-pea as well as the effectiveness of fire management on invasive grasses. Burns were carried out in summer 2013, so results of this portion of the study as well as the study on herbicide response are still forthcoming and anticipated for 2014 (McCloughan *et al.* 2013). Anecdotal evidence suggests that nonnative grasses out-shade ambrosia plants as well however we lack sufficient research and results to confirm such information that shows nonnatives also compete with ambrosia for light, space, and nutrients.

All extant populations of rush-pea and ambrosia in Nueces County now remain only on small pieces of land that have not undergone disking and deep plowing, such as cemeteries, highway ROWs, and municipal parks. The extant Kleberg County rush-pea population is found on a remnant piece of shortgrass prairie alongside a highway. The ambrosia co-occurs with the rush-pea in this highway ROW area and is also found on another road ROW in Kingsville. In contrast to the rush-pea that is only known from small tracts, the ambrosia also occurs in a number of scattered patches on the federally owned NASK. Both species were documented on rangeland adjacent to a creek on a large private ranch immediately south of the NASK as recently as the 1990s, but their continued existence there has not been reconfirmed since 1993 due to lack of access for surveys. Besides causing the direct loss of plants and underlying habitat at sites within both counties, land cover conversions whether to cropland, improved pasture, or

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development can also have more long-term and indirect effects on remaining populations by reducing genetic diversity (associated with range contraction) and loss of genetic exchange between populations that have become isolated (USFWS 2008, USFWS 2010).

Habitat Degradation – Modification of Natural Fire Regimes

Alteration of natural fire regimes resulted in invasion of prairie sites by native and nonnative woody species as well as potentially aiding the spread of nonnative grasses (Mahler 1982, USFWS 1988, Ruth 2000). Fire was an integral part of the grassland ecosystem by naturally restricting the growth of woody species as well as stimulating growth of prairie grasses and forbs. This natural process is thought to have played the central role in the formation of the Great Plains grasslands (Scheintaub *et al.* 2009) as well as other grasslands within the United States. However, fire suppression which came into vogue when Europeans settled in the Coastal Bend, combined with other anthropogenic activities like grazing cattle, significantly altered the natural landscape by modifying and fragmenting the habitat. Cattle grazing, in conjunction with natural herbivory, decreased the fuel loads, thereby altering the fire frequency. Combined, human activities and fewer fires allowed for nonnatives and woody species to compete for light and nutrient availability more effectively than the native grassland species including the rush-pea and ambrosia. Using fire as a management tool for both encroaching woody and nonnative grasses is being evaluated for both rush-pea and ambrosia.

Fire is a major influence in the ecology of shortgrass prairie ecosystems; however, in many areas humans have altered (halted or diminished in frequency) the normal fire regimes on these landscapes. We have learned more about ambrosia's response to fire through formal studies and incidental and prescribed burn events in 2008 and 2009. A subpopulation of ambrosia along the southbound Hwy 77 ROW burned to ground level on June 30, 2008 (Hempel 2008). For several months following this roadside burn, Hempel gathered global positioning system (GPS) points for ambrosia and other vegetation at the site. Plants were again monitored in mid-October and ambrosia had recovered significantly (Hempel 2008). Prior to the roadside fire, the dominant grass was Kleberg bluestem and subsequent monitoring at the site showed that although the ambrosia was among the first plants to show a positive response post-burn, the aggressive, invasive Kleberg bluestem had overgrown the native vegetation within a relatively short time; however, the burn did not appear to change the dynamic between the native and exotic vegetation. Long-term monitoring has not been undertaken to determine the full response and effects of this fire on ambrosia. In 2009, prescribed burns were carried out on select fields of NASK (R. Riddle, pers. comm. 2009); however, we do not have the data that details the species' response. These results indicate that fire, whether prescribed or natural, does not appear to kill ambrosia plants but may act to stimulate new growth (USFWS 2010). The most recent fire study conducted by Overath *et al.* (2014) indicated that fire had little effect on flowering and/or the species as a whole.

Landscape management tools such as the application of prescribed fire, herbicide use, and mowing have been applied to combat nonnative species. However, these efforts have had mixed results, often because the native grassland species share similar physiological and phenological characteristics with the invading nonnative species, thereby making management difficult (Pollak and Kan 1996, Smith and Knapp 1999, DiTomaso *et al*. 2001, and Lesica and Martin 2003). Restorative fire practices, whether the fires are a natural occurrence a prescribed fire,

may not be successful in managing nonnative grasses in the shortgrass prairie. Biologically, nonnative grasses are better equipped to respond to fire since they are both warm and cool season growers; therefore, managing by fire can provide an opportunity for their growth.

Habitat Degradation – Herbicide Use

Widespread herbicide applications in the Texas Coastal Bend occur on row-crop fields before or during planting to maximize crop productivity; or in fall to improve harvesting. Any remaining shortgrass prairie patches that occur near crop fields could be negatively affected by overspray or drift. Incidents where herbicide drift has occurred into habitat with both species have been recorded (Hempel 2008). Herbicides are also used in other environments from which rush-pea and ambrosia are known, including suburban and urban areas where these chemicals can be applied on lawns, parks, and golf courses such as the NASK, St. James Cemetery, or the city or county park locations. Herbicides are also used to manage brush control of woody species in rangeland (Scrifes *et al.* 1981) (potentially occurring in rangeland throughout the range of rush-pea and ambrosia), and in bodies of water to control aquatic weeds (Folmar *et al.* 1979). Depending on the type of application (hand or broadcast), management can be difficult since both the native grassland species and nonnative grasses share similar physiological and phenological characteristics (Pollak and Kan 1996, Smith and Knapp 1999, DiTomaso *et al*. 2001, and Lesica and Martin 2003). Across the two-county area, we lack information on how widespread herbicide damage to the shortgrass prairie ecosystem has been.

Habitat Degradation – Mowing, Disturbance, and Grazing

Mowing and grazing can be tools for use across the Texas Coastal Bend to manage remaining native shortgrass prairie habitat. Highway construction, ROW and pipeline maintenance procedures, and excavation for utility lines has caused localized disturbance for rush-pea and ambrosia. The Texas Department of Transportation has provided forthcoming accounts where construction contractors within the ROW have piled equipment and/or materials on plants.

Mowing

Mowing is an important tool for management and conservation of prairie vegetation (Wilson and Clark 2001) and occurs on all known rush-pea and ambrosia sites; however, the frequency and blade height vary between sites. Mowing is a non-selective tool used to manage both nonnative and native prairie species, but adjusting mowing heights can target specific species (Hover and Bragg 1981, Mitchell *et al.* 1996). Mowing may generally increase the clonal growth of some nonnatives and grasses (van Mierlo and van Groenendael 1991, Hansson and Persson 1994, and Zechmeister *et al.* 2003), but regular mowing can continuously suppress nonnative growth enough to allow slower-growing natives an opportunity to grow in the same area. However, proper timing and frequency of mowing should be examined on a site-by-site basis to provide the most effective means of management.

Impacts from mowing set at lower heights have been observed at the St. James Cemetery. Damage associated with equipment tracking through the population, and from piling of cleared brush onto plants, was also observed at the cemetery in the past. Consequently, TPWD recommended a mowing height of no less than 15 cm (6 in) which was incorporated into

cemetery grounds-keeping procedures (Perez 1992). The Memorandum of Understanding (MOU) between TXDOT and TPWD includes recommendations about mowing frequency and heights for rush-pea populations along Hwy 77 ROW. That agreement called for mowing four times per year, as well as keeping a strip mowed every six weeks between May through December (USFWS 2008).

A regular mowing schedule and a prompt removal of cut material is the single-most effective management tool for ambrosia. Regular mowing may increase the density of clonal stands (Grahl 1994) and may prove especially important to the management of ambrosia. Two studies on NASK showed the effects of varied mowing regimes on ambrosia subpopulations. Carol Bush (Corpus Christi Botanical Gardens (CCBG) botanist) and associates observed that ambrosia plants in the NASK's monthly mowing treatment (one of the four study treatments) were the hardiest and suggested that areas mowed weekly would benefit from less frequent mowing, especially under the hot, dry conditions of the summer months (Bush *et al.* 1994). Both Bush *et al*. (1994) and Garvon (2005) concluded that mowing at certain heights on NASK subpopulations less frequently allowed ambrosia to flower, helping to reduce competitive pressures from invading nonnative grasses. Despite these results, the U.S. Navy (Navy) has not been following any routine mowing regimes; mowing is performed on a need only basis. Maintenance of thatch (cut material, i.e. hay) generated by mowing is also performed on a need only basis. On NASK, subpopulations located in fields were commercially hayed, and at the St. James Cemetery, grass overgrowth became so dense that it was also cut for hay (Figure 6). At both sites, the fields were cut and hay remained on the vegetation without being raked up. Cuttings can smother rush-pea, ambrosia, and other underlying native species; reduce the photosynthetic processes; increase heat caused through degradation process of the hay; and, increase plant susceptibility to disease by creating an imbalance in the bacteria and mold counts. Removing cut material within a few days and then raking and removal of the thatch may be an adequate resolution in avoiding their deleterious effects. To date, ambrosia management plans do not provide guidance for mowing and thatch maintenance; however the Navy and other entities should consider investigating these two management tools within their current plans.

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Figure 6. Thatch atop slender rush-pea and South Texas ambrosia habitat (St. James Cemetery). (Photo: Hempel 2011).

Grazing

Unlike mowing, grazing is not occurring at any of the known listed plant sites although it is reasonable to assume that grazing is taking place across a large portion of the remaining rangeland in Kleberg County. Horses were only recently (within the last few years) removed from a NASK pasture with ambrosia; however, observations prior to their removal showed that horses preferred other vegetative types, not ambrosia, thus decreasing its competition with nonnative grasses. Grazing animals may also prefer foraging on nonnative grasses (Parker and Hay 2005), creating openings for recruitment of native grass seedlings. Despite the beneficial impacts, rotating grazing animals on different habitats or allowing animals to roam across a landscape, can spread unwanted nonnative seeds into new areas through their droppings; by trampling, digging, and plowing up plants (Hobbs and Huenneke 1992); and by transferring soils and seeds into additional intact habitats, such as the shortgrass prairie. In fact, the huge increases in livestock numbers used by European settlers, has been implicated in the decline of native perennial grasses and their replacement with nonnative grasses (Moore 1970; Mack 1981, 1989). Altering the timing of mowing and grazing when the species is dormant so as to avoid the most sensitive part of either plant's life cycle (flowering or fruiting) could alleviate these threats.

Habitat fragmentation - Loss of genetic diversity

Due to the loss and conversion of shortgrass prairie habitat, the remaining patches, including those with rush-pea and ambrosia, are often widely separated across the two-county area and remaining shortgrass prairie species in these patches are frequently reduced in number. The reproductive capabilities of some shortgrass prairie species are likely negatively impacted by the lack of availability of genetic exchange between populations.

1.5.2 Factor B: Overuse for Commercial, Scientific, or Educational Purposes

At the time when rush-pea and ambrosia were listed in 1985 and 1994, respectively, overutilization of either species for commercial and/or recreational purposes was not a threat. Turner (1983) had postulated that ambrosia may contain compounds possessing anti-tumor agents with the potential to be manufactured for future use (USFWS 2008 however; there have not been any collection incidents recorded to date. Federal regulations (50 CFR 17.61) make it unlawful to sell or to offer for sale in interstate or foreign commerce any endangered plant. There is no evidence of commercial overutilization of rush-pea and ambrosia, and therefore this is not a threat.

Seed and plant material have been collected for both species to use in biological studies, yet collection pressures on either species is not considered a threat. Rush-pea seeds have been collected from Petronila Creek (194 seeds in 2011; 330 seeds in 2012); St. James Cemetery (100 seeds in 2011); Hwy 77 ROW (802 seeds in 2008 and an estimated 1,000 in 2013); a private residence near Bishop (1,197 seeds in year 2010); and Sablatura County Park (two collections of 42 and several thousand seeds in year 2011) (USFWS 2012). Some of the seeds collected have been banked at refugia locations. One such collection has allowed for the establishment of plants into a shortgrass prairie refugium site NABA-NBC in Hidalgo County in 2011. The objective of these seed collection efforts was to obtain representative samples of the extant genetic diversity without harming wild populations and was done in accordance with the Center for Plant Conservation (CPC) guidelines. Ambrosia seeds have been collected but have not been used to germinate seedlings for reintroduction into ex-situ habitats. Seed collecting procedures from the CPC outline the strict protocols used to collect seeds and reintroduce plants into an ex-situ habitat. The CPC and the USFWS mandate procedures for propagating seeds and plant material (2000 FR 65). An approved propagation and reintroduction plan should be developed prior to transplantations. Given these measures and that seed collection has not been a threat for either species in the past, we do not consider that overutilization from commercial, recreational, scientific, or educational means to be a current threat to rush-pea or ambrosia.

1.5.3 Factor C: Disease or Predation

Observations of rabbit herbivory were noted on four rush-pea plants at the Petronila site (Poole 1986). Although it is possible that cottontails (*Sylvilagus floridanus*) and jackrabbits (*Lepus californicus*) might be concentrated in remnant patches of native prairie in Nueces County, information on these species' abundance and distribution is not known. Also, evidence, anecdotal or otherwise, about the effects of grazing or browsing, are poorly documented for rush-pea. Bean or pea weevils of the beetle family Bruchidae have been collected from rush-pea seed at Petronila Creek, Sablatura County Park, and Hwy 77 ROW. No observable damage to rush-pea plants was found. Plants may at times be susceptible to insect predation but effects have not been documented; therefore, disease and predation are not currently known to be a threat to rush-pea.

Since the listing of ambrosia in 1994, the occurrence of disease has not been recorded for this species. Beetle predation has been observed at 1 site in 2000 and 2001 (TXNDD 2013b). Hempel (2008) noted that seeds collected at this site for the purpose of reintroduction, were quickly damaged by insects. It is unclear if insect predation to seeds collected at other sites

would be equally impacted. Although higher rates of seed predation have been recorded within the family Asteraceae (Pickering 2009), it is an unlikely threat to ambrosia (USFWS 2008). Damage to stems or rhizomes of plants from severe trampling or grazing was considered possible in situations where livestock had access to ambrosia (i.e., the NASK site) but the plant was left alone, suggesting that it may be unpalatable to horses (USFWS 2010). Therefore, disease and predation are not considered a threat to ambrosia.

1.5.4 Factor D: Inadequacy of Existing Regulations Mechanisms

Federal Law

For an endangered species, it is prohibited under Section 9(a)(2)(B) of the Act to remove and reduce to possession and to maliciously damage or destroy any such species in areas under Federal jurisdiction, or to destroy endangered plants on non-federal areas in knowing violation of state law or regulations or in the course of any violation of a state criminal trespass law. The Act does not provide protection for plants on private lands unless it is in violation of state law or via section 7 consultation if a project on private land has a Federal nexus. Only one population of ambrosia occurs on Federal lands; there are no rush-pea populations known to exist on Federal land.

NASK is the only federally-owned land supporting ambrosia and is managed by the U.S. Department of Defense (DOD). The Sikes Act Improvement Act of 1997 requires implementation of an Integrated Natural Resource Management Plan (INRMP) to provide "integrated fish and wildlife management, land and forest management, wetland resources, and enforcement of natural resource laws and regulations without interfering with the military readiness or mission." Under section 7 of the Act, other Federal agencies are required to consult with the USFWS on projects that they fund, authorize, or permit that may disturb suitable native habitat or reduce the number of individuals of any listed species, including rush-pea and ambrosia. Reasonable and prudent measures that are outlined under a section 7 consultation can help to produce additional benefits to a federally-listed species by increasing the interest levels and coordination of other Federal agencies. For example, the USFWS with the assistance of a contractor, state agencies, academic collaborators, and other affected and interested parties prepared a management plan for NASK (Garvon 2005). This management plan was the result of the Navy's desire to work with the USFWS through measures outlined in its Integrated Natural Resource Management Plan (INRMP that would help avoid potential future land use restrictions. The management plan has not been amended since its creation in 2005; however, Project 9 in the 2013 Final INRMP would update the 2005 management plan by implementing surveys and data collection and include development of recommendations for mowing and prescribed burn regimes (Navy 2013; p. 3-55). This management plan should be updated with any newer information that becomes available regarding ambrosia, including recent pertinent information on the species' reproductive nature or its response to management practices.

State Law

Under Chapter 88 of the Texas Parks and Wildlife Code, any Texas plant that is placed on the Federal list as endangered is also required to be listed by the state in the same manner; therefore, both ambrosia and rush-pea are listed as endangered by TPWD. The state prohibits taking and/or possessing listed plants for commercial sale from private land except by permit, and sale of all or any part of an endangered, threatened, or protected plant from public (state or local government

owned) land. Scientific permits are required for purposes of collection of endangered plants or plant parts from public lands for scientific or education purposes. State owned lands for ambrosia include the TXDOT-controlled ROW of Hwy 77 and a second population adjoining the State Hwy 70 ROW where it crosses Petronila Creek, however the presence of ambrosia plants at this site has not been confirmed in over 18 years.

Two populations of rush-pea but only one confirmed population of ambrosia are found on state land, along the TXDOT controlled ROW of Hwy 77 (both species) and along the ROW of Petronila Creek (rush-pea). A highway expansion and relocation project along Hwy 77 has been slated for major expansion as part of the Interstate-69 corridor. The Federal Highway Administration (FHWA) determined that upgrades to Hwy 77 would not have a significant impact on the human or natural environment (FHWA 2012) however, this development could further fragment habitat and increase the likelihood of impacts from catastrophic events. To ameliorate impacts, the USFWS recommended that orange construction fencing be installed during construction activities and future surveys where rights-of-entry have not been granted, be implemented (FHWA 2012). Construction is anticipated to begin in 2014.

Private Lands

The Act does not provide protection for plants on private lands unless an action is in violation of state law (trespass laws) or there is a Federal nexus for a project located on private lands. Most private lands where ambrosia has been found in the past have not been accessed in more than 15 years and habitat conditions and threats are unknown. The exception is the St. James Cemetery that resides in both Nueces and Kleberg counties. Coordination with the St. James Parish of the Catholic Diocese of Corpus Christi, landowner at the St. James Cemetery, has provided opportunities to perform monitoring and management. At this site, rush-pea and ambrosia co-exist and the habitat is the best remaining example of the native shortgrass prairie species assemblage of all the sites known to support either species. Although long-term protection is not guaranteed at the cemetery, the land manager has indicated that no development of gravesites is planned in the portion of the property where rush-pea is found for the next 100 years. The landowner of the site has also been receptive to management suggestions offered by the USFWS and TPWD. The KRTA sites (which likely constitute one large metapopulation) in Kleberg County also have both rush-pea and ambrosia and have not been accessed in 20 years. The habitat and threats at these sites are unknown. In 2008, a private residence near the town of Bishop and the St. James Cemetery was identified with both rush-pea and ambrosia. Seeds were collected and are being stored at the PMC; however, we no longer have access to this site and need to request permission to access.

1.5.5 Factor E: Other Threats

Genetic Drift

The rarity of both species and loss of genetic diversity because of fragmentation could lead to genetic drift which can restrict genetic variability, reducing the species' ability to overcome environmental stresses, especially during stochastic events or in response to climate change, and render the populations vulnerable to extirpation and extinction (Shaffer 1981). The remaining accessible extant populations of both species are found in remnant patches surrounded by row-crop agriculture, ranching, and residential and commercial construction. This scenario of small,

disjunct populations found on remnant, fragmented habitats could potentially be contributing to genetic drift. Due to the continued existence of a large area of ranchland on the southeastern side of the both species' Coastal Bend range, it is possible that the species may exist in a natural setting of shortgrass prairie that is maintained by grazing and prescribed burns (known management practices on this rangeland), however the presence or absence of populations, condition of the plants, and any knowledge of the genetic makeup of these populations is unverifiable.

Small Population Size

Small population size can cause genetic inbreeding and inbreeding depression. Where populations are experiencing isolation from other populations, self-fertilization (selfing) may occur. Typically, characteristically selfing species may be less susceptible to inbreeding depression than outbreeding (outcrossing) species. In plants, this relationship is not always so straightforward. As a self-pollinating species, rush-pea may be more threatened by the inbreeding impacts that are related to small population sizes than would be ambrosia, a species that reproduces both sexually and asexually. Genetic inbreeding and inbreeding depression are potential threats to the small populations of rush-pea and ambrosia but we have no evidence that this has actually occurred.

Limited Genetic Diversity

The limited geographic range of both species may be expected to result in a lower genetic diversity due to a lack of gene flow through the dispersal of pollen, ramets, or seed between populations or sub-populations (in the case of ambrosia) (Poole *et al.* 2007). The fragmented and patchy nature of these existing populations could limit potential for cross-pollination and thereby restrict genetic variability and reduce the species' ability to overcome environmental stresses from stochastic events. Certain management and habitat changes may also reduce the genetic diversity of rush-pea and ambrosia among populations if the species' ability to flower and/or produce seed is affected, or if the plant is only able to reproduce asexually. The spread of nonnative grasses, in conjunction with a lack of management, may also isolate populations, thereby further reducing genetic diversity.

Effects of Herbicide Drift

Cropland is adjacent to only the Hwy 77 ROW population where both rush-pea and ambrosia are located, and potentially to the KRTA population(s) (ambrosia only), so herbicide drift is not considered to be a widespread threat to known rush-pea and ambrosia populations. One herbicide drift incident occurred in 2008 along the east side of Hwy 77 at the top of the ROW slope near the fenceline. Affected ambrosia plants demonstrated a color change at the tips of plants, yet no plants died (Hempel 2008). Herbicide use on cropland or to maintain ROWs could constitute a threat to any undiscovered populations if they occur close enough to crop fields to receive significant amounts of overspray. Within Texas, herbicide applications and permits are regulated by the Texas Department of Agriculture (TDA). The TDA Endangered Species Program is a state-wide program to help manage pesticide use in endangered species habitats. By working with the Environmental Protection Agency (EPA), TPWD, and the USFWS, the TDA has organized regional teams to help identify where suitable habitat occurs and to compile

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information about land use, crops grown, and chemicals typically applied in the immediate vicinity (TDA 2014). However, at this time there are no regional teams within Nueces and Kleberg counties and therefore no current attempts to protect rush-pea and ambrosia sites via this team approach.

Climate Change

Our analyses under the Act include consideration of ongoing and projected changes in climate. The terms "climate" and "climate change" are defined by the Intergovernmental Panel on Climate Change (IPCC). "Climate" refers to the mean and variability of different types of weather conditions over time, with 30 years being a typical period for such measurements, although shorter or longer periods also may be used (IPCC 2007). The term "climate change" thus refers to a change in the mean or variability of one or more measures of climate (e.g. temperature or precipitation) that persists for an extended period, typically decades or longer, whether the change is due to natural variability, human activity, or both (IPCC 2007). Various types of changes in climate can have direct or indirect effects on species. These effects may be positive, neutral, or negative and they may change over time, depending on the species and other relevant considerations, such as the effects of interactions of climate with other variables (e.g. habitat fragmentation) (IPCC 2007). In our analyses, we use our expert judgment to weigh relevant information, including uncertainty, in our consideration of various aspects of climate change.

Climate change may act alone or synergistically with both habitat fragmentation and the invasion of nonnative species. Pollen and fossil evidence shows that species in the past responded to changing climates by altering their distributions via dispersal and migration (Davis and Shaw 2001, Pearson and Dawson 2005). Small, isolated remnants of suitable habitat limit options of dispersing to areas with preferred climatic conditions (Opdam and Wascher 2004). Surrounding habitat destruction from development and agriculture divides continuous habitats which could reduce the number of individuals if plants are unable to shift due to geographic barriers created by inhospitable conditions. Furthermore, climate change is predicted to increase the spread of invasive species, including those nonnative plants that out-compete native varieties (Archer and Predick 2008). The Fifth Assessment Report of the IPCC (2013) projects the following changes by the end of the 21st century, relative to the 1986 and 2005 climatic averages: most land areas will experience warmer and/or fewer cold days and nights; warmer and/or more frequent hot days and nights; an increase in the frequency and/or duration of warm spells and heat waves; and a likely increase in the frequency, intensity, and/or amount of heavy precipitation in mid-latitude land masses; and, a likely increase in the intensity and/or duration of droughts on a regional to global scale.

All known rush-pea and ambrosia sites occur in specialized habitats in small, isolated populations (or subpopulations) distributed over a rapidly developing, restricted geographic area type. As a result, the species may be vulnerable to localized catastrophic events such as drought or flooding, as well as to broader climate changes that could decrease suitable habitat, make conditions more conducive to exotic grass invasion, or alter pollinator phenology. However, while it appears reasonable to assume that rush-pea and ambrosia may be affected, we lack sufficient certainty to know specifically how climate change will affect either species.

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1.6 Conservation Measures

To date, conservation measures for rush-pea and ambrosia and have included: 1) propagation and reproductive efforts; 2) surveys; 3) seed collection; 4) management; and 5) research.

1. Propagation Studies:

In 2008, the USFWS obligated funding (originating from the USFWS Recovery Initiative's Preventing Extinction grants) to the Nueces County Soil and Water Conservation District through a cooperative agreement in order to carry out recovery actions for the rush-pea that included collecting, banking, and increasing of seeds from wild populations; controlled propagation; and establishment of refugia populations. The project also provided for development of a monitoring protocol for rush-pea and for a reintroduction plan. This agreement was amended to add tasks and funding in 2010, with a work extension granted through 2014. The Director of the PMC served as the Project Officer for this project that turned out to be a cooperative effort between the USFWS, PMC, Texas A & M University-Kingsville (TAMUK), TXDOT, SABG, and the NABA-NBC.

The Slender Rush-Pea Controlled Propagation and Reintroduction Plan, produced under the cooperative agreement mentioned above, summarized the history as well as current status of propagation efforts; see USFWS 2012 for more detail.

Ambrosia has successfully been propagated from root cuttings taken by the SABG from the Nueces County Park in Robstown (Price 2007). The plants grown from these cuttings then served as donor material for a 2006 introduction into a pilot area created within the same park. Researchers planted 200 1-year old plants in the fall of 2006 that increased to 300 plants by 2007. Results of the introduction showed that watering of seedlings was essential to the success of ambrosia. Tall grasses and other nonnatives impacted ambrosia's establishment and reduced the growth in the individual size of plants as well as the overall stem counts in the initial year following planting. When these species were removed from the experimental plot, ambrosia was successful in producing abundant fruits (burs) and also began to expand into other areas of the plot by clonal growth (USFWS 2010). In 2007 and 2008, Hempel used the Nueces County Park in Robstown to study the germination capabilities of ambrosia. See Hempel (pers. comm.) 2010 for her methodology and results.

2. Surveys:

Biologists from the USFWS, TPWD, and a botanical consultant (formerly a TAMUK professor), have undertaken surveys of accessible sites for rush-pea, including those populations on state, municipal, and private lands at Petronila Creek, along Hwy 77 ROW, Bishop City Park, Sablatura County Park, and St. James Cemetery, on an irregular basis in order to monitor site and population conditions and to get a rough estimate of population size.

The USFWS, TPWD, TXDOT, and other agencies, academia, and interested parties have coordinated to complete annual surveys of patch size (areal extent of patches), habitat and population condition, and a cursory assessment of population size of ambrosia, on NASK since 2005. Other sites (Hwy 77 ROW, Bishop City Park, the Nueces County Park, and St. James

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Cemetery) have been assessed for various aspects of population health and size on irregular schedules. Observations in drought years have shown a significant decrease in the number of stems, but a realistic number is difficult to record. The current survey techniques for populations (subpopulations) on NASK are outlined in Garvon's 2005 plan. Recent observations indicate that ambrosia favors clonal (asexual) reproduction. Therefore, the current practice of counting plants by stems may not be appropriate because it is difficult to say where the plant starts and ends. Survey techniques and data collection practices should be continually reviewed and updated in appropriate management plans. Protection of all existing populations is essential and funding should be allocated to survey for additional populations which, if found, should also be protected. These surveys should be attempted annually by partners of the USFWS (TPWD, TXDOT, PMC, and other organizations) at all accessible sites to monitor population size and conditions, and the status of existing and new threats.

3. Seed Collection:

About 49 percent of all federally-listed species have fewer than 5 extant wild populations and in addition, nearly 74 percent of those remaining wild populations contained fewer than 100 individuals (Kennedy 2004). Populations with such decreased individual numbers are at a higher risk for inbreeding depression and are also likely to have reduced viability due to fluctuations in gene frequencies; therefore, these species are at a higher risk for extinction and impacts from environmental events (Kennedy 2004). Older methods of conservation simply tried to conserve the species in situ. Since sufficient amounts of habitat might not be lacking or the habitat that is available may be too fragmented to maintain the genetic integrity of the species, a better approach may be to collect seed for seed banking and replanting seeds or seedling into restored habitat, new populations, refugia, or *ex-situ* populations. Seeds have been collected from all but one rush-pea population (Bishop City Park). Seed collection efforts were summarized in Table 14, detailing seed collection and conservation efforts.

Table 14. Summary of extant populations of slender rush-pea and conservation efforts undertaken at these sites (USFWS 2012).

Site Name	TXNDD EO # / EO_ID	County	Current Status	Seed Bank (Unless noted all seed held at PMC	Refugium
Petronila Creek	1/4744	Nueces	From 50 to 100 individuals in about 0.14 hectares (0.34 acres); Kleberg bluestem temporarily suppressed.	291 seeds collected May 2011 (194 seeds left); 330 seeds collected May 9, 2012.	97 seeds (May 2011 collection) produced 69 live plants now in seed increase at isolated nursery.
St. James Cemetery	5/6517	Nueces	Population estimated >10,000 in 1992, still large but in decline due to competition from Kleberg bluestem.	±2,000 seeds collected from SABG greenhouse plants; ±50 seeds collected off SABG plants Fall 2009; ±50 seeds collected off SABG plants in	None. Plants were grown and held by the SABG. Plants were later transferred to the PMC in 2009. All plants lost vigor over the years and

				2010; ± 100 seeds collected in 2011 from the cemetery.	died.
U.S. Hwy 77	5/6517	Kleberg	Population had an estimated 5,709 plants on May 28, 2008. Apparently stable despite herbicide drift Sep 2008, bulldozing in ROW Sep 2009, and gravel dumping Apr 2011.	802 seeds collected May 28, 2008 (from estimated total of 29,000 seeds); unknown number of pods collected April 15, 2011 from the gravel dump site; ±1,000 seeds collected March 2013.	320 seedlings (produced from the 802 seeds collected May 28, 2008) planted in experimental plots at PMC, ± 50 percent survival. PMC plot replanted in Dec 2013 (from seeds collected in March 2013).
Bishop City Park	n/a	Nueces	Population extant, size unknown, intense competition from Kleberg bluestem.	No seeds have been collected.	None.
Bishop private residence	n/a	Nueces	Stable population in remnant shortgrass at private residence across creek from St. James Cemetery, accessed with permission from owner (site now under new ownership).	1,197 seeds collected on May 13, 2010	None.
Sablatura County Park	n/a	Nueces	Population of many hundreds discovered Mar 19, 2010.	48 seeds collected Feb 17, 2011; several thousand collected in 2011.	539 seedlings (from later 2011 collection) planted in shortgrass prairie refugium on Oct 27-28, 2011 at NABA-NBC, Mission, TX.

Attempts to germinate ambrosia from seeds have been largely unsuccessful. The PMC analyzed some seeds before attempting to germinate; however the seed fill was very low and there was a poor germination rate (Miller 2013) suggesting long-term storage of seeds in a seed bank may not be possible. Currently, ambrosia plants are only propagated from root cuttings and are being housed at the SABG and at Mercer Arboretum.

4. Management:

The Texas Department of Transportation and TPWD currently have an MOU that attempts to negate any (or all) impacts to rush-pea on ROWs. This includes any mowing, maintenance, or new ROW projects. More information on the MOU can be found in section 1.5.1.

DRAFT

Ambrosia management and associated actions have included: development of management plans with NASK, TPWD, and TXDOT; management activities (i.e. mowing); and seed collection management.

Management Plans: Currently, the only ambrosia site with an official management plan that includes provisions for ambrosia is NASK with an INRMP and the Navy's 2005 management plan. The Final INRMP (Navy 2013) included projects and management strategies to support the goals and objectives established for rare, threatened, and endangered species management, including those addressing ambrosia. Project 9 in the INRMP provided for continued annual monitoring for ambrosia to determine the areal extant cover on NASK (Navy 2013). Data collected during these surveys will then be used to update the 2005 management plan and the mowing recommendations and prescribed burn regimes (Navy 2013). New information, such as data on the reproductive nature of ambrosia or its response to management practices, will be used to update the management plan. Haying of fields and the subsequent maintenance of hay fields and thatch produced should be reviewed in management plans. The Texas Parks and Wildlife Department and TXDOT currently have an MOU for protection of ambrosia on state land. The MOU attempts to "maintain, reduce, or avoid the potential environmental….effect of a ROW highway project or maintenance" (TPWD 2014). The Texas Park and Wildlife Department is responsible for providing recommendations that "will protect fish and wildlife resources to local, state, and federal agencies that approve, permit, license, or construct development projects" and to provide "information on fish and wildlife resources to any local, state, and federal agencies or private organizations that make decisions affecting those resources" (TPWD 2014). Beside the MOU, TXDOT mows the Hwy 77 ROW to maintain the grass height, aids in biological surveys for both rush-pea and ambrosia on-site, and coordinates with the USFWS for projects occurring within the ROW so as to avoid potential impacts.

All other accessible ambrosia sites also have ongoing management in the form of mowing, although the benefit to the ambrosia is mostly a side effect of the landowner's desire to keep some type of uniform plant height or to otherwise control vegetation growth. This maintenance activity on the part of landowners is not necessarily undertaken to conserve shortgrass prairie plants including rush-pea and ambrosia, but it may well be the primary reason that this vegetation is able to persist in the face of encroachment by invasive nonnative grasses and native woody vegetation. Research by Bush *et al.* (1994) at NASK indicates that occasional cutting may be beneficial to the ambrosia. Ambrosia may respond positively to some other management actions, however activities such as soil disturbance through continual plowing, some applications of herbicides, or the complete removal of disturbance (e.g. lack of mowing encouraging overgrowth by invasive grasses) may lead to its extirpation.

Management Activities: Mowing takes place on NASK, the Hwy 77 ROW, St. James Cemetery, Bishop City Park, and Nueces County Park in Robstown, where mowing frequency and height of mower blades differs from site to site. We have no knowledge that any of these sites has mowing with management of the rush-pea and ambrosia or as the primary objective or with the species and their habitat in mind. For ambrosia, prior to mowing it is important to first identify whether ambrosia plants at the site are flowering or contain seed that has not been liberated from the plant in order to assure that the plants have some opportunity for cross-pollination and sexual reproduction. To assure this, outreach activities should continue with NASK environmental staff

as well as developing conservation partnerships with state, county, and city employees responsible for roadside and/or parkland maintenance employees to integrate best management plans for the maintenance of ambrosia sites.

Management of Seed Collection: The objective of seed collection is to obtain representative samples of the extant genetic diversity without harming wild populations in accordance with the CPC guidelines. The CPC guidelines provide that, within each population or sub-population, seeds can be collected from all reproductive individuals if there are less than 50, and from at least 50 if more than 50 reproductive individuals are present (Guerrant Jr. *et al.* 2004). More frequent, less intense collection is preferable and entails collecting up to 10 percent of seeds from each population not more than 3 times per year every 10th year from populations that can be readily accessed. However, if sites cannot be accessed as frequently, then collecting up to 25 percent of seeds not more than once per year is appropriate. Only in extreme cases, where a site might become extirpated within 5 years, is 100 percent of available seed collection considered to be allowable from a given population.

5. Research:

Dr. Rideout-Hanzack at TAMUK, initiated a study to investigate the competition and effectiveness of various management scenarios on rush-pea. For more information see section 1.5.1.. No further studies for rush-pea have been undertaken.

Since ambrosia was listed in 1994, propagation and reproductive investigations have been carried out and findings are published in the South Texas Ambrosia 5-Year Review (USFWS 2010). Along with the INRMP for the ambrosia population on NASK, the 5-year review also provides detail on management strategies for the ambrosia including the effects of mowing and fire, of which are both discussed in section 1.5.1. Dr. Overath conducted fire studies for ambrosia on St. James Cemetery in 2013 and 2014 to investigate the effects of fire on population density and flowering. The final reports are in publication, but preliminary findings suggest that there is little statistical difference between burned and unburned plots and stem density per polygon. Her findings also suggest that fire (burned versus unburned plots) has little effect on the flowering events of ambrosia.

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PART II: RECOVERY PROGRAM

The following sections present a strategy to recover the rush-pea and ambrosia and to restore and maintain their shortgrass prairie habitat and its unique native flora. This recovery strategy includes objective and measurable recovery criteria to achieve downlisting and delisting of these two plants, as well as site-specific management actions to monitor and reduce or remove threats, as required under Section 4 of the Act. The recovery plan also addresses the five statutory listing and recovery factors (section 4(a)(1) of the Act or section 1.1 of this document) to demonstrate how the recovery criteria and actions will lead to removal of both plant species from the lists of Threatened and Endangered Species.

2.1 Recovery Strategy

The USFWS's goal in developing and implementing recovery plans is to improve the status of listed species to the point that protection under the Act is no longer required. The strategy for recovery of rush-pea and ambrosia includes the long-term protection and management of the shortgrass prairie habitat needed by rush-pea and ambrosia, and provides a roadmap for securing an adequate quantity of habitat of sufficient quality to sustain them long-term.

A primary objective of this plan is to ensure that there are shortgrass prairie areas of sufficient size, number (20 populations of rush-pea and 15 populations of ambrosia), composition, and juxtaposition, determined by the most current biological information known for the species to support the continued existence of rush-pea and ambrosia populations that are able to persist and thrive in the wild. Under current conditions, both species occur on remnant portions of land, and this occupied habitat is generally disjunct, as a result of the aggressive spread of nonnative, invasive grasses and conversion of much of their habitat into row crops, developed areas, and improved pasture. At a minimum, protection of these remnant portions of habitat is required for these species to be maintained at the status quo. A priority recovery need includes continuing outreach to private landowners and other property owners (TXDOT, NASK, and municipal governments) and attempting to secure long-term conservation easements or agreements. Most of the shortgrass prairie habitat within the geographic range of both species is privately owned and it may not be possible to acquire, via fee title or conservation easement, these areas for long-term conservation. Therefore, landowner coordination and cooperative conservation efforts are especially important. In order to maintain genetic and ecological diversity, at least one population with sufficient numbers of individuals, in each watershed (or drainage system) should be protected long-term. Every extant population within its watershed should also be represented in seed collections, refugia establishments, augmentation, or reintroduction efforts.

Adequate quality of habitat at any given population site refers to the habitat's ability to meet the needs of the species such that at least the Minimum Viable Population (MVP) goal can be met at the site. Within the area occupied by the shortgrass prairie species, for the habitat to be considered in good condition it should be devoid of nonnative grass species as much as possible, include the composition of native grasses and forbs outlined in sections 1.3.4. and 1.4.4., and through the application of continued active management, should be able to maintain these conditions for the next 60 and 40 years for rush-pea and ambrosia, respectively. High priority

DRAFT

recovery actions that can improve or maintain the quality of habitat include management such as routine mowing; other methods to prevent and control nonnative grasses and invading woody vegetation; minimization of disturbance; and minimization or restriction of contraindicated herbicide use. Research needed to understand management implications includes studies to determine response of nonnative grasses, as well as rush-pea and ambrosia, to fire; and genetics work on both species to determine genetic relationships between and among populations.

Timelines for Recovery

For both species, we anticipate that by 1) securing long-term conservation of the current and potential habitat within its natural range and drainage systems; 2) proper management of these sites; 3) filling in the biological and ecological data gaps; and, 4) determining and maintaining the MVP at each site, recovery, as reflected by delisting, can be attained within the next 60 and 40 years for rush-pea and ambrosia, respectively.

There are fewer populations of rush-pea within its geographic range, and the largest and most robust known population is on private land. With the exception of a small population in a residential lot in the town of Bishop and sites on a large private ranch south of the NASK, other populations are on state-owned land (Hwy 77 ROW) or municipal land (Bishop City Park and Sablatura County Park). With regard to threats, rush-pea has been shown to suffer negative effects from competition when surrounded by Kleberg Bluestem, the most prevalent invasive grass at rush-pea sites. Unlike ambrosia, none of the rush-pea populations are managed under a binding agreement such as the Navy's INRMP. Securing long-term conservation easements and agreements will also be difficult since the private land includes a cemetery, a residential yard, and areas on a private ranch. Therefore, given the current status of the shortgrass prairie habitat, the needs of the species, and the difficulty in obtaining long-term protection, we foresee that delisting for rush-pea will take at least 60 years.

Ambrosia appears to be a hardy species that has responded well to small disturbance events, including accidental fires. Therefore, it is anticipated that with even slight improvements in the current management conditions, the species will likely respond well. The most widespread population of ambrosia is found on federal NASK property where the species is managed under an INRMP outlining a management scenario. The most robust population at the St. James Cemetery is not under any protection. Securing long-term conservation easements and fee title agreements on other sites, including private lands, will take time and energy, if even possible at all, and therefore, it is appropriate to assume that recovery will at least take 40 years. Given the few opportunities for long-term management and conservation of the native shortgrass prairie, quality habitat needs to be restored managed, and protected long-term to ensure ambrosia can be delisted within 40 years.

These recovery timelines should be reassessed prior to the delisting (recovery) timeframes listed in this plan to ensure that recovery is still feasible and attainable. New information on either species should predicate adjustments to the MVP and recovery timeframes as well, if necessary.

DRAFT

Minimum Viable Populations

Calculating an MVP size is one approach for determining an abundance goal for recovery purposes. A conventional MVP, as outlined in Pavlik's guidelines (1996), uses the biological information known about a species to estimate an MVP size (or plant and population numbers) in order to reach recovery. A conventional MVP has not been calculated for rush-pea or ambrosia as we do not possess the entirety of the baseline data needed to perform these calculations; however Tables 15 and 16 are adaptations of Pavlik's 1996 guidelines until we have sufficient data to conduct more thorough assessments. Each characteristic (i.e. longevity, breeding system, etc.) appears in the first column. Slender rush-pea and ambrosia are either more closely related to the characteristic in column A or column B or somewhere in the midst of the continuum. A trait in column A would have MVPs near 50 individuals; species with traits in Column B would have MVPs of upwards of 2,500 individuals. The **bold** letters in each Tables 15 and 16 indicate values, if known, for rush-pea and ambrosia. Using the best scientific information available for each species, the South Texas Plant Recovery Team (STXPRT) determined which characteristic each species was more closely tied to and estimated MVP values (listed in parenthesis). The recommendations could change with the introduction of additional information on reproductive biology, gene flow, and/or population size, density, and distribution.

Slender Rush-pea

As indicated in **bold** letters in Table 15, rush-pea is a perennial, selfing, herbacious plant with relatively low fecundity and low survivorship. Reproduction is by seed only, with seeds having a long duration. Environmental variation is high and the dynamic shortgrass community where rush-pea is found has undergone succession. Given that the STXPRT (in 2013) determined five characteristics in Table 15 require more individuals, and four characteristics require fewer individuals, it is rational to estimate the MVP for rush-pea at an intermediate value.

Table 15. Minimum Viable Population for slender rush-pea adapted from Pavlik (1996). Source STXPRT meeting November 20, 2013 (Miller 2013).

Characteristic:	A. 50 Individuals	B. 2,500 individuals	Rationale:
Longevity	**Perennial** (1,000)	Annual	Rush-pea is generally a short-lived perennial species. The STXPRT estimated that the lifespan may be 4-5 years, but not typical therefore, the Team estimated that rush-pea was more closely tied to the characteristic in Column A.
Breeding system	**Selfing** (250)	Outcrossing	Pressly's (2002) research demonstrated that self-fertilization is possible for rush-pea. Although pollination needs to be studied, the STXPRT estimated that rush-pea is more closely tied to the characteristic in Column A.
Growth form	Woody	**Herbaceous** (2,500)	Rush-pea is only herbaceous, not a known woody species. Therefore, it is more closely tied to the characteristic in Column B.
Fecundity	High	**Low** (2,000)	Rush-pea typically produces 2-4 seeds per plant (Strong 2012), but

			may produce 10+ pods per year. The STXPRT estimated that the species had a lower fecundity.
Ramet Production	Common	**Rare or none** (2,500)	Ramets are not produced in rush-pea; therefore, the species' characteristic is tied to Column B.
Survivorship	High	**Low** (1,000)	The survivorship of rush-pea is unknown. However, to make a conservative estimate, the STXPRT decided to estimate that the survivorship of rush-pea is low.
Seed duration	**Long** (250)	Short	Seed duration of a hard seeded legume, like rush-pea, is typically long.
Environmental Variation	Low	**High** (2,500)	The climatic conditions of the Texas Coastal Bend are extremely variable, therefore there's high environmental variation.
Successional Status	**Climax** (250)	Seral or ruderal	There is some disturbance in the shortgrass prairie community but it seems that it is in a climax state.

In order for the STXPRT to estimate the number of mature individual plants needed for a viable population, all of Pavlik's characteristics (9 in total) were combined and averaged (Table 16); this final average was rounded to determine that a minimum of 1,500 mature individual plants at each population were needed for rush-pea to reach recovery within 60 years.

Table 16. Explanation of the minimum number of mature individuals plants at each population for Slender rush-pea.

Characteristic	*Number of Individuals Needed per Population*
Perennial	1,000
Selfing	250
Herbaceous	2,500
Low Fecundity	2,000
No Ramet Production	2,500
Low Survivorship	1,000
Long Seed duration	250
High Environmental Variation	2,500
Climax successional species	250
Total	12,250
Average (**rounded**)	1,360 (**1,500**)

South Texas Ambrosia

As indicated in **bold** letters in Table 17, ambrosia is a perennial, outcrossing, herbacious plant with relatively low fecundity and low survivorship. The species does not often reproduce by

DRAFT

seed and seeds do not remain viable for extended periods of time. Environmental variation is high and the dynamic shortgrass community where ambrosia is found has undergone succession. Given that six characteristics in Table 17 require more individuals, and three characteristics require fewer individuals, it is rational to estimate the MVP for ambrosia at an intermediate value.

Table 17. Minimum Viable Population for South Texas ambrosia. Adapted from Pavlik (1996). Source STXPRT meeting on November 20, 2013 (Miller 2013).

Characteristic:	**A. 50 Individuals**	**B. 2,500 individuals**	**Rationale:**
Longevity	**Perennial** (50)	Annual	Ambrosia is a perennial species only therefore Column A is most appropriate.
Breeding system	Selfing	**Outcrossing** (2,500)	Ambrosia is most likely an outcrossing species.
Growth form	Woody	**Herbaceous** (2,000)	This species is generally known as a herbaceous species.
Fecundity	High	**Low** (2,000)	May only produce one seed per flower head therefore, the fecundity is low.
Ramet Production	**Common** (50)	Rare or none	Species does not reproduce often by seed.
Survivorship	High	**Low** (2,000)	Gene survivorship is low.
Seed duration	Long	**Short** (1,500)	Seeds do not remain viable for an extended period of time.
Environmental Variation	Low	**High** (2,500)	The climatic conditions of the Texas Coastal Bend are extremely variable, therefore there's high environmental variation.
Successional Status	**Climax** (250)	Seral or ruderal	Although ambrosia has shown some response to disturbance, the dynamic shortgrass community has undergone succession.

In order for the STXPRT to estimate the number of mature individual plants needed for a viable population, all of Pavlik's characteristics (9 in total; see Table 17 above) were combined and averaged (Table 18). This final average was rounded to determine that a minimum of 1,500 mature individual plants at each population were needed for ambrosia to reach recovery.

DRAFT

Table 18. Explanation of the minimum number of mature individuals plants at each population for South Texas ambrosia.

Characteristic	*Number of Individuals Needed per Population*
Perennial	50
Outcrossing	2,500
Herbaceous	2,000
Low Fecundity	2,000
Ramet Production is common	50
Low Survivorship	2,000
Short Seed duration	1,500
High Environmental Variation	2,500
Climax successional species	250
Total	12,850
Average (**rounded**)	1,430 (**1,500**)

Since ambrosia is a clonal species, we applied a correction factor to the population estimate (unlike rush-pea). We estimated that conservatively ambrosia will produce 10-15 stems per plant per year in periods with good to adequate precipitation, or rain, events. Climatic conditions will cause stem production to vary per year; under poor conditions, ambrosia is likely to produce 5 stems per year and under good conditions, ambrosia might produce 10 stems per year. Therefore, after applying this correction factor, each population would need between an estimated 7,500 – 15,000 mature individuals to reach recovery (see below).

The following further explains the correction factor used for ambrosia:

Under poor conditions, ambrosia might produce 5 stems per year:

(1,500 individuals) x (5 stems per year) = 7,500 stems per year

Under good or adequate conditions, ambrosia might produce 10 stems per year:

(1,500 individuals) x (10 stems per year) = 15,000 stems per year

Background to the Recovery Plan

In the 1988 Slender Rush-pea Recovery Plan, overarching objectives rather than specific recovery criteria were designated. These objectives included management of existing plants and their habitat to protect them from destruction resulting from human activities and to maintain, through management, healthy populations at levels sufficient to downlist, and eventually delist the species. Objectives included: maintenance of existing populations through cooperation with landowners and habitat management; provision of permanent USFWS or conservation organizations' protections for the known populations; establishment of additional populations in natural habitats; obtaining the biological information needed for effective management; and developing public support for the preservation of the species (USFWS 1988). Although some of these objectives have been partially accomplished, none have been fulfilled to the extent that they would ensure the continued existence of the rush-pea.

DRAFT

Many of the overarching objectives from the 1988 Slender Rush-pea Recovery Plan are the same as for ambrosia, given that both species share the same habitat conditions. Therefore, this document constitutes the revised recovery plan for rush-pea and the first recovery plan for the ambrosia.

2.2 Recovery Goals

Ensure long-term persistence of native coastal shortgrass prairie in sufficient amount, distribution, and condition to support rush-pea and ambrosia populations at levels that both species can be 1) downlisted from a status of 'endangered' to 'threatened' and 2) ultimately removed, or delisted, from the Federal List of Endangered and Threatened Plants (50 CFR 17.12). Recovery criteria form the basis from which to gauge whether the species should be reclassified to threatened (downlisted) or delisted (recovered).

2.3 Recovery Objectives and Criteria

When considering if a species warrants downlisting or delisting, the USFWS considers whether the species meets the definition of endangered or threatened. The Act (1973) refers to a threatened species as, "any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range" and refers to an endangered species as "any species that is in danger of extinction throughout all or a portion of its range." Recovery objectives are the parameters (demographic, threat reduction or elimination, or other vulnerabilities or biological and ecological factors) which, when taken together, characterize the conditions under which a species may be reclassified or delisted. Criteria are standards for measurement of the parameters needed to determine that a species has achieved its recovery objectives and may then be reclassified or delisted. All criteria must be objective and measurable (Act 4(f)(1)(B)(ii)).

2.3.1 Recovery Objectives

This recovery plan contains objectives to secure the rush-pea and ambrosia perpetually in the wild. These objectives are not necessarily in order of importance but include:

1. Minimize further loss or fragmentation of native shortgrass prairie habitat within Nueces and Kleberg counties, such that there is sufficient habitat to support rush-pea and ambrosia at levels that meet recovery goals.

2. Actively manage shortgrass prairie conditions at all extant population (or subpopulation) sites of rush-pea and ambrosia to sustain both species at Minimum Viable Population levels or higher.

3. Develop reintroduction sites within the geographic range of rush-pea and ambrosia to help increase the number of protected populations.

4. Determine the extent and prevent depletion of rush-pea and ambrosia seed banks.

DRAFT

5. Promote landowner relations and habitat management throughout the occupied and historical ranges of rush-pea and ambrosia in the United States.

6. Determine the genetic diversity within and among populations of rush-pea and ambrosia, and prevent its loss.

7. Determine optimal habitat requirements for rush-pea and ambrosia.

8. Determine and implement best management practices where possible and monitor the response of rush-pea and ambrosia populations to these practices.

9. Monitor long-term viability of all populations of rush-pea and ambrosia.

10. Increase knowledge of rush-pea and ambrosia abundance, distribution, and ecology.

11. Acquire long-term conservation easements where feasible, or conservation agreements, for occupied sites of rush-pea and ambrosia within each watershed from which the species are known.

2.3.2 Recovery Criteria

Along with the statutory requirements of recovery criteria being "objective and measurable", they too should evaluate the current and future condition of a species, reflecting the specie's needs for resiliency, redundancy, and representation across its geographic range, a principle collectively known as the "3R's" (Shaffer and Stein 2000, Carroll *et al.* 2010, Wolf *et al.* 2015). Criteria should represent areas of significant geographic, genetic, or life history variation (Carroll *et al*. 2010, Wolf *et al*. 2015). Resiliency refers to the capacity of a population to withstand stochastic disturbance events, and addresses threats abatement and recovery of ecologically effective populations. Redundancy spreads potential risks to the species among multiple populations to minimize the potential loss of the species from catastrophic events. Representation is having the breadth of genetic makeup of the species to adapt to changing environmental conditions. Together, the 3R's comprise the essential characteristics that contribute to a species' ability to sustain populations in the wild over time (Carroll *et al*. 2010, Wolf *et al*. 2015).

The STXPRT met on January 11 and 12, 2016 to determine appropriate downlisting and delisting criteria for both rush-pea and ambrosia. Given the best scientific information available for both species, the STXPRT determined that it was necessary to conserve the potential genetic variations occurring within each of the drainage systems where extant populations are found and include additional populations that are restored, augmented, or created; therefore the recovery criteria in Sections 2.3.2.1 and 2.3.2.2. reflect these determinations. Based on the extant number of populations for rush-pea (eight in total), the STXPRT estimated that having a minimum of five populations per each of the three drainage systems (15 in total) would provide appropriate representation for downlisting. The delisting criteria state that rush-pea requires a total of 20 total populations (5 more in addition to the downlisting criteria) that can be found in any drainage or a combination of drainages. For ambrosia, the STXPRT recommended that for downlisting that a minimum of three populations were represented at each drainage system,

therefore a total of nine. To delist ambrosia, the STXPRT recommended increasing the numbers of populations needed per drainage from the downlisting criteria, to include at least three populations per drainage or genetically distinct populations.

Slender Rush-Pea Recovery Criteria

Implementation of the actions in this recovery plan should protect, conserve, and restore the rush-pea to a status where it could be considered for downlisting in 35 years, with potential delisting within 60 years. Anecdotal evidence (repeated observations) suggests that rush-pea responds well to mowing, at least in part due to its small stature that makes it less likely to be damaged by mower blades. There are anecdotal observations which suggest a positive correlation between increased effects from mowing and a more open and less invaded shortgrass prairie. Rush-pea is likely more sensitive than ambrosia to the negative impacts of shading and competition from nonnative grasses, and more vulnerable to stochastic events. Although rush-pea has proven easy to grow from seed and has been planted in experimental fashion in two refugia where it receives some level of care, there have not been any experimental plantings into existing wild populations. Therefore it is unknown whether augmentation or reintroduction will work. There are few known extant populations and a number of those are in close geographic proximity to each other, allowing easy access for genetic flow between each sub-population; these occurrences are potentially part of one metapopulation. The low numbers of populations, small population sizes, widely separated geographic distribution (except for the metapopulation), degraded habitat due to invasive grasses and woody species, and uncertainty regarding the success of the species in reintroductions could make meeting the recovery criterion for rush-pea more difficult than for ambrosia. Therefore, we believe it will take longer to reach rush-pea's down- and delisting goals compared with ambrosia.

> Downlisting Criteria 1: To downlist rush-pea, 15 populations should have an estimated 1,500 mature individual plants per population. Downlisting may be possible if each of these populations is stable or increasing over the next 35 years. The extant populations (eight total), as well as any that may be restored, augmented, or created, should be maintained with at least five natural populations located in each of the drainage systems (Petronila, Oso, Chilipitin Creek-San Fernando, Alazan Bay-Baffin Bay Creek basins) where the species is known to naturally occur to ensure genetic representation.
>
> Justification: Because rush-pea populations were historically known from four main drainage systems, and are currently found in three of those, to maintain the genetic integrity of the species, and to provide adequate representation and genetic resiliency throughout the species range, it is necessary to protect at least one population in each drainage system throughout its range.
>
> Downlisting Criteria 2: Each rush-pea site should be managed for and support high quality shortgrass prairie habitat. High quality shortgrass prairie habitat has these characteristics: 1) occurs in unplowed, relatively undisturbed soils; 2) has a high diversity and high vegetative cover of native grasses and forbs; 3) has a low vegetative cover of introduced grasses; and, 4) has a low vegetative cover of woody species (i.e. native brush). High quality shortgrass prairie habitat should contain species commonly

DRAFT

associated with rush-pea (Table 8). As is true with ambrosia, prolific and aggressive nonnative grasses should not constitute more than small patches within each high quality shortgrass prairie site and invasive grasses and woody species should not be spreading throughout the site or inhibiting growth and reproduction of rush-pea. Each rush-pea site should be managed and monitored appropriately to ensure the maintenance and restoration of high quality shortgrass prairie habitat conditions and to minimize and control threats over a period of 35 years.

Justification: The continual encroachment of nonnative grasses into rush-pea's range remains the preeminent threat to the species. As is true for ambrosia (see Justification for ambrosia's Downlisting Criteria 2), it is unlikely that the nonnative grasses within the Texas Coastal Bend shortgrass prairie will be fully eradicated. The continued existence of rush-pea, ambrosia, and their co-occurring suite of native shortgrass prairie species is possible only through ongoing and intense management (control of nonnatives and native woody plants). Greenhouse experiments where Kleberg bluestem and slender rush-pea were planted together demonstrated that rush-pea does poorly when the nonnative Kleberg bluestem grows densely around it (Pressly 2002). However, rush-pea has survived at the Petronila Creek population site in the presence of Kleberg bluestem and the absence of active management. It has even shown modest increases following mowing and applications of grass-specific herbicides in the recent past. If active management is ongoing and populations are monitored at least annually as directed for this species using USFWS-approved plans, downlisting may be possible within the 35-year time frame.

Delisting Criteria 1: A recommended minimum of 20 populations are necessary for delisting and should have at least 1,500 mature individual plants per population. Delisting may be possible if each of these populations remains stable or increasing over a period of 60 years. All existing populations including those that have been restored, created, or reintroduced, are protected and a minimum of five natural populations are extant within each drainage system (Petronila, Oso, Chilipitin Creek-San Fernando, Alazan Bay-Baffin Bay Creek basins).

Justification: Because all known rush-pea populations have been found in association with drainages and the populations are limited to drainage systems in Nueces and Kleberg counties, it is important to keep at least one population per drainage system stable. In comparison to ambrosia, rush-pea is more sensitive to habitat encroachment from nonnatives (see Section 2.1 for more details) therefore, the STXPRT recommended that both the downlisting and delisting requirement be more stringent. This criterion will help to maintain the genetic integrity and provide species' representation throughout its range. Because we lack information on the long-term impacts of invasive species on Texas Coastal Bend shortgrass prairie, meeting the 60-year time requirement as well as an MVP standard will indicate that the species has achieved stability over a fairly long term period, although it likely will need active management. If the MVP standard and the Delisting Criteria 2 (below) are met prior to the 60-year benchmark, the timeframe itself will not preclude consideration of a recovery designation.

DRAFT

Delisting Criteria 2: Populations will be protected long-term (protection in perpetuity being optimum) through fee titles, conservation easements, or conservation or management agreements. Species-specific, USFWS-approved annual monitoring and management plans will guide these efforts. Each population should have high quality shortgrass prairie habitat as described earlier. High quality shortgrass prairie habitat has these characteristics: 1) occurs in unplowed, relatively undisturbed soils; 2) has a high diversity and high vegetative cover of native grasses and forbs; 3) has a low vegetative cover of introduced grasses; and, 4) has a low vegetative cover of woody species. High quality shortgrass prairie habitat should contain species commonly associated with rush-pea (Table 8). Invasive, nonnative grasses and woody species (including natives) should not constitute more than small patches within each high quality shortgrass prairie site, and should not be spreading throughout the site or inhibiting growth and reproduction of rush-pea.

Justification: Only remnants of shortgrass prairie habitat remain that support rush-pea. Because these are mostly privately owned sites and some in state or municipal government-ownership, formal long-term agreements for management of the species and its habitat are necessary to ensure the continued existence of the species in the wild. The persistence of rush-pea in its current locations may be due to these sites being some of the only occupied patches of shortgrass prairie habitat that were not plowed or built over in the species' range. There is a likelihood that the species may still occur on private ranches in Kleberg County, but due to lack of access the extent or condition of shortgrass prairie in this part of the range is unknown. Since the only access to rush-pea populations is in habitat that is highly fragmented and has been subjected to a number of disturbances, information is lacking on what constitutes a "healthy" rush-pea site with regard to the percent cover of nonnatives or woody species. All long-term agreements and easements should have updated management strategies for removal and control of nonnatives. With ongoing active management and monitoring of these sites, delisting is possible within a 60-year time frame.

South Texas Ambrosia Recovery Criteria

If recovery criteria are achieved within downlisting and delisting timeframes, it may be possible to downlist the ambrosia within 20 years of implementation of this plan with full recovery possible in 40 years.

Ambrosia is readily propagated from cuttings, easily established in garden or field settings, and persists in the field with application of active management, thereby enhancing its conservation potential. Although information is lacking on the genetics, the relationship of individuals within and among populations, and the species' mode of reproduction; in the wild, ambrosia does propagate easily, helping in establishing refugia, creating introduced populations, or augmenting existing populations. The species can also benefit from active management techniques, as evidenced by ambrosia's positive response to fire and mowing (Section 1.5.1.). However, some discretion is required when managing with mowing since frequent mowing and low height of mower blades can produce negative outcomes as well (Section 1.5.1.). The species establishment in three refugia to date, and its persistence at seven extant natural sites, leads us to believe that the species has high potential for recovery with the application of active

management, and in some cases, restoration of shortgrass prairies. Although the levels of protection for ambrosia vary across the different land ownerships, the largest population of ambrosia exists on federally-owned land. In addition to protection on Federal lands, one small patch of ambrosia is found on a state highway ROW where the TPWD requires permits to collect it and where consultation under the Act is sometimes required; the county park that supports ambrosia has shown a willingness to protect it as evidenced by their pilot reintroduction project; and the species has persisted in the St. James Cemetery under existing management regimes since it was first reported there.

In light of these positive factors, a potential timeframe of 20 years to downlist and 40 years to delist the ambrosia is considered attainable, so long as appropriate active management and conservation at the population site can be assured.

> Downlisting Criteria 1: A recommended minimum of nine populations are necessary for downlisting and should have at least 7,500-15,000 mature stems per population. Each population should be stable or increasing over the next 20 years. The extant populations (seven total), as well as any that may be restored, augmented, or created, should be maintained with at least one natural population located in each of the drainage systems (Oso, Chililpitin Creek-San Fernando, Alazan Bay-Baffin Bay, and San Getrudis Creek basins) where the species is known to naturally occur to ensure genetic representation.
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> Justification: Ambrosia occurrences have been documented from sites that lie within the three afore-mentioned drainage basins. Although we do not yet fully understand the genetic composition of ambrosia because results of genetic studies are still preliminary, we believe that it is necessary to maintain a minimum of one natural population per each of the three drainage systems throughout ambrosia's range to ensure genetic representation. An increase from the known populations (seven) to nine populations would maintain the genetic integrity and provide redundancy in the case of a stochastic event (i.e. drought, disturbance). Ambrosia is known to reproduce vegetatively in the wild and in cultivation, but the role of sexual reproduction in the wild is not well understood. Early results of genetic analysis indicate that patches of ambrosia on NASK are clones (Overath 2013b). Based on the evidence collected to date, we are considering plants or patches of plants occurring within a 1.0 km (3,280 ft) radius of each other as potential clones, allowing easy access for genetic flow between each sub-population. Therefore, this site would constitute as a single metapopulation, due to the likelihood of them being genetically related.
>
> An MVP is based on the most current and sound biological information available for a species. A conventional MVP has not been calculated for ambrosia as we do not possess enough baseline data to adequately carry out these calculations. However with existing data, we attempted a preliminary MVP calculation using Pavlik's methodology (Pavlik 1996) (Table 17). This method produced a MVP of 7,500-15,000 mature stems per population for resiliency. As more information on ambrosia becomes available, an updated and more rigorous MVP should be developed. In order to ascertain whether the species is meeting the current MVP requirement, a methodology to count plants was needed. Separating individual plants in the field has been shown to be difficult, especially with the clonal nature of the species. Therefore, stem counts are the most

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effective method to estimate plant abundance in any given year. The STXPRT decided a correction factor of 5 or 10 stems per individual per year should be applied in order to account for stem production in years with poor or good environmental conditions, respectively (Section 2.1). This downlisting criterion will be met when populations have maintained the estimated MVP (based on stem counts) for at least 20 years.

Downlisting Criteria 2: Each ambrosia site should be managed for and support high quality shortgrass prairie habitat. High quality shortgrass prairie habitat has these characteristics: 1) occurs in unplowed, relatively undisturbed soils; 2) has a high diversity and high vegetative cover of native grasses and forbs; 3) has a low vegetative cover of introduced grasses; and, 4) has a low vegetative cover of woody species (i.e. native brush). High quality shortgrass prairie habitat should contain species commonly associated with ambrosia (Table 17). Although ideally, high quality shortgrass prairie habitat would be located in unplowed/undisturbed habitat areas, this scenario is only remnant in Nueces County which has been largely converted to cropland, and in those parts of Kleberg County that can be accessed for plant surveys. As a consequence, high quality prairie patches may need intensive restoration or habitat may need to be created on areas that are currently devoid of vegetation due to previous land use. Unplowed/undisturbed habitats should be sought out and restored prior to creation of habitat amidst disturbed shortgrass prairie. Prolific and aggressive nonnative grasses and woody species should not constitute more than small patches within each high quality shortgrass prairie site and these undesirable species should not be spreading throughout the site or inhibiting growth and reproduction of ambrosia. Each ambrosia site should be managed and monitored appropriately to ensure the maintenance and restoration of high quality shortgrass prairie habitat and to minimize and control threats over a period of 20 years.

Justification: The encroachment of nonnative grasses into all native shortgrass prairie within ambrosia's range remains the primary threat to the species. Eradication of these nonnative grasses throughout the specie's range is not currently realistic, however control of the extent of these grasses within a population site is possible through continued persistent, and sometimes intensive management. From field observations, we know that ambrosia can co-exist with Kleberg bluestem, the most prevalent invader in its habitat, if the bluestem does not dominate the plant community and instead only constitutes a scattered representation. Due to the aggressive spread of these invasive grasses throughout South Texas and their resistance, and sometime positive response to control techniques (mowing, fire, and herbicide) and stochastic events (drought, disturbance), it is likely that they are present at all ambrosia habitat sites. We lack information from the literature or from field observations on a measureable percent composition of native and nonnative species that constitutes a high quality shortgrass prairie habitat and viable ambrosia site. We realize the tenuous relationship between natives and nonnatives within this ecosystem due to competition for space, light, and nutrients and therefore believe that a viable shortgrass prairie site that supports an ambrosia population can include small, isolated, dense stands of nonnative grasses. To maintain such a population, we believe that active management will be required. Due to the expectancy that nonnative grasses

will continue to pose a threat over the long-term, a USFWS-approved annual monitoring plan should deliver active management on ambrosia sites over a 20-year period.

Delisting Criteria 1: A recommended minimum of 15 populations are necessary for delisting and should have at least 7,500-15,000 mature stems per population. Delisting may be possible if each of these populations remains stable or increasing over a period of 40 years. All extant populations, as well as any that are restored or created in the future, are secure. Also, a minimum of one natural population or genetically distinct population is extant within each drainage system (Oso, Chililpitin Creek-San Fernando, Alazan Bay-Baffin Bay, and San Getrudis Creek basins).

Justification: Given the justification for Downlisting Criteria 1, an additional 20-year period of species-specific annual monitoring of these populations will show that the ambrosia has maintained the specified abundance (7,500 – 15,000 stems per population) and that the number of populations has remained stable or has increased over a period of at least 40 years, at which time it may be considered recovered and eligible for delisting. An increase from the known ambrosia populations (seven) to 15 populations would maintain the genetic integrity of the species and provide redundancy in the case of a stochastic event (i.e. drought, disturbance). Although we do not yet fully understand the genetic composition of ambrosia because results of genetic studies are still preliminary, we believe that it is necessary to maintain a minimum of three natural populations per each of the three drainage systems throughout ambrosia's range to ensure genetic representation.

Delisting Criteria 2: At least seven of the populations that meet the delisting MVP minimum will be protected long-term (protection in perpetuity being optimum) via fee title acquisitions, conservation easements, or conservation agreements. These agreements will be held between the USFWS, TPWD, or conservation organization and landowners or land managers with areas that are reasonably unplowed/undisturbed, who carry out active management under USFWS-approved monitoring and management plans. High quality shortgrass prairie habitat has these characteristics: 1) occurs in unplowed, relatively undisturbed soils; 2) has a high diversity and high vegetative cover of native grasses and forbs; 3) has a low vegetative cover of introduced grasses; and, 4) has a low vegetative cover of woody species. High quality shortgrass prairie habitat should contain species commonly associated with ambrosia (see Table 12). Habitat at ambrosia population sites should consist of a diversity of native grasses and forbs and a low frequency (restricted to small patches) of nonnative grasses and encroaching woody species that are not spreading throughout the site or inhibiting growth and reproduction of ambrosia.

Justification: There are so few extant ambrosia populations that it is necessary to conserve all existing populations. Additionally, at least one additional restored or created site will serve as a conservation plot for ambrosia, rush-pea, and other representative shortgrass prairie species in perpetuity. Commitment to long-term protection under Federal, state, or non-governmental organization (NGO) stewardship, or under private landowner stewardship that is guaranteed by conservation easements or agreements is

DRAFT

needed to insure that some populations will be protected long-term. Habitat management and monitoring plans are necessary to insure that invading nonnative grasses and native and nonnative woody plants do not degrade the habitat quality at ambrosia populations. As previously explained, we believe that nonnative grasses and woody plants should not constitute more than a minimal representation of the plant cover within the site. It should also be obvious that management (control) actions are limiting their spread. Nonnative grasses and woody species are known to encroach into native shortgrass prairie habitat quickly. Therefore, all long-term agreements and easements should have updated management strategies for removal and control of nonnative grasses and woody species.

DRAFT

2.5 Narrative of Recovery Actions

1. Habitat protection and management of all known population sites of both species in the United States.

1.1. Establish positive working relationships with landowners and land managers of all known sites.

Contact landowners and land managers of all sites. Cooperative partnerships between the USFWS and landowners are critical to the survival of the species. By developing a spirit of cooperation and commitment among landowners, conservation organizations, and state and Federal agencies, the necessary conservation goals can be achieved.

1.1.1. Maintain contact with all landowners or land managers each year.

Landowners and land managers of all sites should be notified of the presence or potential presences of either species on or near their property, every 2-3 years. Contact will be through one-on-one contact by the USFWS as well as written notification. The notification should explain the Act and its protections for the species. The USFWS will explain to the landowner/land manager that if they are provided with funds to permit, fund, or carry out a project on their private lands, an intra-USFWS section 7 consultation will be needed for any project that the USFWS funds.

1.1.2. Educate landowners about the extreme rarity and significance of both the ecosystem and species on their property.

Educate landowners about the extreme rarity and significance of the populations on their property. The rarity and importance of the species, as well as the unique nature of the surrounding natural community, should be expressed to landowners. The USFWS should continue to make personal contacts and one-on-one meetings with area landowners annually to inform them of the need for additional surveys, review the sorts of studies and activities that might be expected in efforts to conserve the species, and outline the technical and other types of assistance available to achieve these needed actions. Landowners should be reassured about conservation agencies' concerns and plans, and informed of how Federal and state endangered species laws apply to their land use goals.

1.1.3. Encourage the long-term stewardship of the shortgrass prairie at these sites through technical assistance to landowners; also potentially through long-term leases, conservation easements, and conservation agreements.

Encourage the establishment of long-term stewardship and conservation of the shortgrass prairie habitat. Stewardship opportunities should be addressed in long-term management strategies. Owners of property with known populations should be encouraged to protect the species and be commended for their efforts.

DRAFT

1.2. Cooperate with landowners and land managers to develop and implement management plans that address landowner and species goals.

Work with landowners to develop and implement management plans for the species that mesh with the landowner's own short- and long-term land use goals. Well-designed management plans should be developed cooperatively among Federal, state, city, county, and private landowners. These plans should address short- and long-term goals for protection and management of populations found on their lands, maintenance of shortgrass prairie habitat, and land use goals of the landowner. Any assistance required by the landowner for specific species or shortgrass prairie management tasks should be provided or allocated by conservation agencies. Implementation goals, fiscal needs, resources, and responsibilities should be clear.

1.2.1. With willing landowners, determine short- and long-term land use goals and their effects on both species.

Short-term management should be identified promptly to sustain the species and the shortgrass prairie habitat while long-term management plans, requiring results from research, should be developed as the recovery efforts continue. Short-term plans should include an inventory of each population location and condition, as well as identification and prompt removal (with landowner approval) of easily corrected threats. To guarantee the long-term survival of the species, the goal of a long-term plan for all populations is to ensure that viable, self-perpetuating populations persist in conjunction with landowner land use goals. Therefore, the involvement and endorsement of many landowners and land managers will be necessary. Short- and long-term management plans as well as the effects of common land use management practices should initially be assessed on an annual basis. All interested parties, including agencies, landowners, land managers, researchers, etc., should be involved in their review and revision to benefit from each other's knowledge and expertise.

1.2.2. With all cooperating landowners, develop and implement management plans that are beneficial to the species as well as acceptable to landowners and land managers.

With landowner cooperation, simple site evaluations should be made for each population, detailing and evaluating its present condition and any obvious actions that should be taken to prevent decline. Following the initial evaluation, a short-term plan should be developed in cooperation with the landowner, with practices designed to protect against threats and maintain the population until comprehensive long-term management strategies can be developed. Management actions should be minimal to avoid harm due to a lack of information about the species. As information becomes available about critical needs and the plant's responses to management actions, tasks should be incorporated that will

DRAFT

effectively allow habitat conservation or improvement, preservation of population integrity, and possible restoration following disturbances.

Already established management plans such as the DOD's INRMP on NASK should be used to provide management strategies for ambrosia. Additional management plans should be developed for both species where landowners and land managers approve. These plans should be routinely assessed (with a goal to review on an annual basis) and updated with new biological, ecological, and management information. Encourage consultation between planners and the USFWS, TPWD, and other agency staff.

1.2.3. Develop a monitoring program that is reviewed by the USFWS and other interested parties, with voluntary landowner assistance, to evaluate the effects of management practices on the species and ensure consistent and reliable monitoring of plant populations and management.

All populations and the shortgrass prairie habitat should be monitored on a regular basis to assess management practices and the overall status of the species; annual monitoring is encouraged. During the initial stages of recovery, monitoring may be more frequent and should include visits during flowering, fruiting, dispersal, and establishment. If possible, all populations should be monitored at the same time using the same methodology. Monitoring should provide the basis for evaluations of stability, reproductive success, and effectiveness of management activities. Comparisons should be made between populations on a regular basis to help differentiate normal population fluctuations from conditions that reveal stress or decline. If monitoring reveals a significant decline in the population due to management practices or the lack thereof, all parties should be notified. Management revisions should be a coordinated effort and should be developed to alleviate and reverse the decline.

1.3. Enforce applicable laws and regulations.

All management and biological studies should strictly adhere to existing regulations.

1.3.1. Work with regulatory agencies (DOD– NASK, TXDOT, TPWD, USDA-NRCS, and through internal USFWS coordination) to ensure that existing regulations are used to provide adequate protection of current habitat.

Enforce applicable laws and regulations. All Federal and state laws concerning commercial trade, permits, collecting, interagency consultation, and federally-reviewed activities that might threaten the species should be enforced. If willing, landowners and land managers should be assisted in posting signage on their property to discourage trespassing and encouraged to enforce trespassing laws if doing so will assist in addressing threats to the species.

2. Monitoring both species on an annual basis.

DRAFT

2.1 Develop a monitoring plan for ambrosia.
Develop a comprehensive monitoring plan for ambrosia to track changes in abundance, distribution, reproductive output, and vigor of the species and the habitat as well as responses to management actions, threats, and habitat changes.

2.1.1. Monitoring plan will include abundance measures to ascertain plant abundance and spread.

Abundance measures are crucial to track population fluctuations on an annual basis and to relate such changes to climate, management, threats, or other factors. Such measures should include a "red flag" trigger when abundance drops a set percentage, that attention will be focused on alleviating the causes if possible. Abundance measures will also determine whether and when the MVP estimate is reached and has remained stable. Abundance goals should be routinely reviewed to ensure that monitoring is based on the best scientific and commercial data available to ambrosia.

2.1.2. Monitoring plan will include measurements of habitat conditions, ecological integrity, and conservation statues of sites.

A well-designed plan includes pertinent data about the habitat at each ambrosia site, including only historic sites with precise location coordinates. Vegetation transects at each site could provide data on native plant community and species composition including frequency, dominancy, and abundance. Additional data outside these transects should be collected to provide information about encroaching nonnatives and woody species, changes in land use practices, and implications for future monitoring and management action. Data on the occurrence and severity of threats should be collected at each site so effective management and conservation goals can address each threats and ameliorate when possible.

2.2. Use the approved monitoring plans to annually monitor ambrosia and rush-pea, their habitat, management actions, and threats at extant sites.

Monitoring plans will be used to determine: the abundance of plants, especially whether and when a traditional MVP has been attained as well as any critical changes in abundance, significant changes in individual distribution within the population, the condition of the habitat and plants, and response to management, threats, and climate. Analysis of monitoring data may elucidate if and what type of management actions are needed, and any additional research needs revealed by newly observed ecological or biological interactions. The action lead for the monitoring plans should be identified well in advance of the actual monitoring.

2.3. Monitor species and biotic communities and assess ecological integrity and conservation status of historic sites.

DRAFT

Historic sites that contain precise enough location information such as GPS (Global Positioning System) coordinates that are within tenths of miles from road intersections, etc., that can be relocated (and not simply county locations), should be assessed to determine if shortgrass prairie habitat remains and is intact. These historic sites could be used as potential reintroduction sites.

3. Initiate studies to gather biological information needed for effective management and recovery of rush-pea and ambrosia.

Most information available to date is based on qualitative observation. Additional information is necessary to evaluate limiting factors, determine life history, and prescribe management activities.

3.1. Determine specific habitat requirements (specifically limiting factors).

Characterization of the habitat where both species now naturally occur will help in evaluating the potential for recovery. These data could help in locating additional populations, selecting appropriate reintroduction sites, and identifying management activities needed for preservation.

3.1.1. Study soils and underlying geology.

A detailed characterization of the geology, soils, and hydrology in the areas where the species occurs should be compiled. These studies may reveal unrecognized patterns or small scale irregularities that need to be taken into consideration when developing management plans or selecting suitable reintroduction sites. The studies should also help to maintain current vegetation and habitat characteristics at each site, locate additional populations, and create and restore experimental and reintroduced populations. Analysis of soils sustaining the species, particularly of parameters critical to plant growth, such as parent material, texture, porosity, pH, soil water potential, and nutrient level, is a necessary step. A comparative summary and evaluation should be performed for all known sites to determine any critical factors.

3.1.2. Determine the plant community structure for both species.

Understanding the community features, variability, and dynamics of vegetation in areas where the species occurs could help in locating additional populations. This information is necessary for planning management of existing sites, searching for additional populations, and evaluating habitat for future reintroduction efforts. Careful documentation and measurement of plants present in the habitat throughout the growing season as well as across several years may reveal diagnostic features. Documentation of relative dominance, density, frequency, and constancy is important baseline information necessary for evaluating the status of the area and managing protected sites over time.

DRAFT

3.1.3. Study community dynamics/ecology.

Information is needed about changes in historical community conditions, their cause(s) and impacts on the species, and how the community responds to various management activities and disturbance. Characterization of seasonal events, such as rainfall and temperature regime, is required. The influence of seasonal or periodic processes, including fire, drought, freeze, and flooding events should be evaluated. The study of positive and negative interactions with other species (herbivory, disease, seed dispersal, and influences on seed bank conditions) is necessary for the formulation of management plans to address maintenance and restoration, as well as for assessment of reintroduction feasibility.

3.1.3.1. Study the response to current natural disturbance and land use practices.

Successful management of the species and the shortgrass prairie habitat will require that current knowledge and understanding of the activities that are occurring across the landscape that are impacting or could potentially impact the plants.

3.1.3.2. Study the response to past natural disturbance and land use practices.

Successful management of the species will require knowledge of the plant's responses to various natural events and land use activities. Comparative observation of known populations and analyses of history of land use, management, and disturbance would be helpful. A comparative study will provide at least a preliminary indication of the effects of different disturbances and management practices.

3.1.3.3. Study the response of both species and their habitat to seasonal or periodic cyclical events including drought, extreme heat events, freezes, and flooding.

The impact of cyclical or more infrequent events, such drought, freezes, heat waves, and flooding events should be evaluated for effects on mortality, dispersal, and reproduction. The plant's life cycle or periods of growth and mortality should be investigated in response to these events.

3.1.3.4. Investigate the fire ecology of both species and their habitat.

Fire, once a very important part of the coastal shortgrass prairie community, is now largely absent, and therefore could be a very important cause of the decline of both species. We lack data on how each species responds to fire, particularly prescribed burning, and when it is most efficient to burn (as target nonnative species may respond differently

DRAFT

depending on seasonality of burns). Prescribed burning may help to further stop encroachment of habitat from woody species.

3.1.3.5. Study both beneficial and detrimental interactions with other species.

Depending on the species, beneficial or detrimental interactions are possible. Provisions may need to be made in management plans when certain critical interactions are identified. We should specifically emphasize the need to study the impact of introduced (nonnative), invasive grasses. This should include controlled, replicated field trials using grass-specific herbicides to suppress nonnative grasses at existing sites. Effective eradication of grasses, such as Kleberg bluestem and King Ranch bluestem, may require repeated, well-timed applications of herbicide over a period of months. Treated areas should be re-seeded with native shortgrass species. If grass-suppression is shown to be beneficial, this could lead to effective, larger-scale restoration of existing populations threatened by invasive grasses. A cost analysis should be developed to determine the most cost-effective management strategies.

3.2. Study population biology.

The status of populations in terms of stability, viability, and reproductive biology (type of reproduction, phenology, pollination biology, seed biology and dispersal, etc.) needs further analysis. Studies are necessary to evaluate the condition and stability of existing populations and to assist in formulating effective management plans.

3.2.1. Analyze the demographic structure of all populations.

Demographic studies of all sites could prioritize conservation needs among the sites based on the time, effort, and funding needed for conservation. Determining viable population structure may take many years because populations occur in an environment subject to climatic extremes. Populations should be visited several times during the year, preferably during flowering, fruiting, dispersal, germination, and establishment, to determine percent success at each stage. Studies should provide information needed to assess the demographic stability of populations, and should develop recommendations and targets for numbers of individuals of various ages needed to maintain a population. Viable population structure data will aid in long-term management needs and strategies such as demographic augmentation and the desired demographic structure for newly established populations.

DRAFT

3.2.2. Characterize phenology and assess the most vulnerable stages of life cycle.

General times of flowering are known, but the relation and fluctuation as affected by climate (drought, late frosts, etc.) are unknown. Plants may be more susceptible to natural and human-made disturbances during certain phenological phases. Identifying critical times in the natural history of the species, and determining the cause and frequency of mortality and its importance to population survival, are vital to the development of monitoring and management plans.

3.2.3. Determine the primary means of reproduction in the wild.

For ambrosia, clonal production may be the primary form of population growth. Several studies are in progress to determine whether ambrosia also reproduces sexually. Additional studies are needed to document sexual and asexual reproduction scenarios, and the contribution to the reproductive output of the species. This information is needed before long-term management of wild populations, a cultivation program, or restoration and recovery work, would be successful. Currently the only way to maintain this species ex-situ is with living collections. We lack the data on the genetic diversity of the species in order to make knowledgeable choices about which plants to maintain in living collections

Although Pressly (2002) showed that rush-pea is self-compatible, its overall contribution to the reproductive output of the species is unknown. Research needs to be conducted to determine the types and contributions of all reproductive methods to this species. As vegetative reproduction has not been noted in this species, seeds could continue to be collected from wild populations and maintained for future reintroduction projects. Procedures for seed collection such as the amount of seed to collect, from which populations, how often, etc. should be reviewed and assessed on a routine basis to ensure that collecting pressures do not become an issue (consult the CPC guidelines).

3.2.4. Study pollination biology and determine effective pollination requirements and effective pollinators.

Little is known of rush-pea's pollination biology. The specific mechanisms (insect, wind, etc.), insect visitors or pollinators, pollen development, pollen predation, pollen viability, and other aspects of pollination biology are necessary to determine as failure of any aspect of the pollination system could cause a reduction in normal fruit production.

Ambrosia is wind pollinated and the impact of taller grasses and woody species may have some impact on the efficiency of wind transport of pollen. More detailed study of the sexual reproduction of the plant may indicate if this is an additional concern.

DRAFT

3.2.5. Study seed production and dispersal.

The amount and variation in seed production should be examined as well as seed longevity, viability, dormancy (if any), and germination requirements. Dispersal mechanism(s) and dispersal distances of seed should also be studied as well as the presence of seed banks and their dynamics. Losses of seed crops due to disease and possible predation should be monitored. This information is needed for cultivation programs, restoration, and reintroduction planning.

3.2.6. Study seedling recruitment.

The relationship between seed production, seed reserves (seed banking, longevity), and rates of seedling recruitment should be established. Changes in rates of recruitment with different site conditions and optimum conditions for seedling recruitment should also be determined. This information is necessary for determining management needs for regenerating populations.

3.2.7. Study population genetics to determine the genetic diversity within and among populations.

As populations are located and before reintroduction projects are initiated, the need for genetic information becomes invaluable. Such information is useful for measuring the amount of genetic diversity of individuals within and among populations, the degree of total genetic diversity between all populations, and the genetic distance between two populations. In addition, information on the rate of gene flow between populations, as well as quantitative information on reproduction modes (self-fertilization versus out-crossing versus vegetative cloning) will help guide long term conservation strategies for the species.

4. Survey for additional populations of rush-pea and ambrosia.

As more information about the habitat and biology of each species becomes available, determining areas capable of supporting the species may be more predictable. Models will be developed showing the vegetative and edaphic characteristics of occupied sites. This information will help to determine where coastal shortgrass prairie habitats might remain intact and/or where the species could be located. These additional surveys should be performed for new populations and potential reintroduction sites in the United States.

5. Cooperatively work with landowners and land managers to restore additional shortgrass prairie sites located in one or more of the drainage areas from which rush-pea and ambrosia are known to co-occur.

5.1. Locate and acquire (fee title or permanent conservation easement) an area containing patches of existing shortgrass prairie (even if in degraded state) for purposes of restoration and long-term shortgrass prairie conservation.

DRAFT

Because there are so few known locations of shortgrass prairie and even fewer with permanent protection, in order to achieve recovery for these species, additional shortgrass prairies should be located and restored. Once restored, such locations would be ideal reintroduction sites for rush-pea and ambrosia.

5.1.1. Cooperate with willing landowners to determine the best means possible for providing permanent protection and active habitat management of the site to maintain native shortgrass prairie. Conservation management could be implemented through cooperation with a Federal, state, municipal government, or NGO, or one in which the landowner or manager agrees upon.

Long-term ownership and management for conservation purposes are often more secure in the hands of government agency or non-governmental organization. Agreements for habitat management can often be spread amongst such agencies and organizations.

5.2. Carry out restoration, including reintroductions, at this site such that is hosts a complement of the native shortgrass prairie grasses and forbs commonly associated with rush-pea and ambrosia.

Restoration and management of the native shortgrass prairie vegetation community could help to preclude encroachment of nonnative grass and growth of woody species into these sites. Each site should be looked at on a case-by-case basis to determine which method of management is best (such as herbicide application, mowing, prescribed burning, etc.). Additional sites, such as those slated for reintroduction, should also be restored and managed to conserve the integrity of the native shortgrass prairie vegetation community.

5.3. Introduce experimental populations of rush-pea and ambrosia.

Seek private landowners or other land managers who are willing to conserve or restore shortgrass prairie sites on their land. Using data obtained from habitat characterization studies, habitat can be restored to be as similar as possible in species composition, including animal components (pollinators, dispersers, etc.). After development and the landowner's cooperation to support these efforts and approval of rush-pea and ambrosia reintroduction plans, the species could be reintroduced at the site.

6. Establish seed or propagule banks and *ex-situ* (botanical garden, refugium, research institute, etc.) populations for each species. These banks and *ex-situ* populations will be established using approved reintroduction plans for both species (see Recovery Action 7 below).

Seed banks and cultivated conservation collections at secure botanical facilities should be established to prevent extinction of the species and extirpation of their wild populations and to provide material for future restoration activities or research. Use responsible seed collection guidelines, outlined by the CPC, to prevent harming the wild populations. If long-term storage is an option, periodic testing and any necessary propagation should also be done by the facility. If seed storage is not an option, a genetically representative collection of cultivated plant materials

may be necessary. All cultivated and seed storage material should be housed with responsible institutions that maintain scientifically accurate records of provenance, number of propagules, cultivation and storage methods. Due to the small population sizes of each species and the threats from nonnative grasses and stochastic events, seed collection, banking, and propagation are important tools in both species recovery.

6.1. Ensure seed is collected and banked from each rush-pea site, including newly discovered populations.

Methods of seed collection and information to obtain during collections should follow the USFWS-approved, Controlled Propagation and Reintroduction Plan (USFWS 2012). Rush-pea can reproduce in as little as 6 months to produce abundant, viable seed both in the wild and in cultivation; therefore, all propagation for seed banking, seed increase, refugia, augmentation, and reintroduction will be from seeds rather than by vegetative means (USFWS 2012).

6.2. Continue to monitor and document conditions at all existing rush-pea refugia.

Monitor and maintain accurate records of rush-pea refugia sites, including information from the source populations (such as location, date collected, collector(s), number of propagules collected, any post-collection treatment, type and length of storage, post-storage treatment, etc.), seeds collected from refugia (with similar documentation), and the distribution or use of those seeds (including amount and date delivered) to seed banks, augmentation sites, and reintroduction sites, etc. In the cases where experimental trials have been conducted, document the methods and results. Monitoring efforts should be more frequent (maybe weekly for a month, biweekly for a season, then followed by monthly for the first year) for new refugium sties and may include presence/absence surveys. Over time, monitoring efforts should be adjusted to fit the life span of the species. These monitoring efforts should document numbers of flowers and fruits (to compare to monitored natural sites to determine adequate reproduction), invasive plants, response to climate (drought, freezing, or rainfall), insect herbivores, and insect visitors, and pollinators (USFWS 2012).

6.2.1. Ascertain whether any changes in a rush-pea refugium system are needed, including any need for additional refugia.

Detailed monitoring records should be kept and used to determine the success of the species at the refugia. Additional refugia may be deemed necessary if: threat levels increase; a revised MVP determines that populations are not viable; or other circumstances where introduction into refugia was not successful. If an introduction is not successful, at either a refugium or an introduction site, detailed data and analysis should compiled and reviewed before future introductions are attempted.

6.3. Once reintroduction plans are developed and approved, propagate and maintain both species for reintroduction.

DRAFT

Propagation using seed, cuttings, or other techniques, such as tissue culture, should be investigated and documented for use in propagating plants for reintroduction. More likely for ambrosia, clonal techniques present challenges in maintaining needed levels of genetic variability for natural populations. However, if done correctly, these techniques may be used in producing materials for research and restoration activities with minimal impact on wild populations. Plant material can be acquired from a conservation facility (such as SABG or something similar) for reintroduction efforts. Only seed, not vegetative material, should be used for reintroduction work with rush-pea.

6.3.1. Study cultivation requirements.

Off-site cultivated collections and seed banks should be established, and additional studies are needed to provide a successful long-term management program for both natural and cultivated populations. Propagation techniques need to be documented along with detailed information on propagule sources and numbers, collection dates, storage locations, etc. All *ex-situ* plants or populations should also have similar information documentation.

6.4. Continue experimentation with seed germination and effectiveness of ambrosia propagation from seed.

As with rush-pea, determine seed requirements for successful propagation of seed. More than one seed storage and preservation facility should be willing to preserve and store seeds long-term, as well as perform research on propagation techniques which would give important insights into habitat and management needs.

6.5. Continue vegetative propagation of ambrosia for purposes of reintroduction.

Anecdotal evidence suggests that ambrosia is not successfully propagated by seed. Therefore, it is important to future reintroduction and management that we continue to collect and maintain healthy plants for uses of reintroduction. However, the most available and current information on the genetic variability of ambrosia should be used in determining future reintroduction and management needs. Vegetation propagation techniques, particularly those that maintain or result in genetic diversity of propagules, should be developed.

7. Conduct a reintroduction program on public and private lands where there are willing partners.

Evaluate and document the success of different cultivation techniques, site preparation, and other management techniques based on research, and assess any additional information necessary to attempt reintroduction. If reintroduction is feasible, a USFWS-approved Propagation and Reintroduction plan should be developed and implemented for ambrosia. This should provide for all phases of reintroduction, including site selection, site preparation, monitoring, and short- and long-term management strategies, particularly the effective management (eradication and

DRAFT

prevention) of nonnative, invasive grass species. Reintroduced populations for both species should not be considered successful until they are established, reproductively active, self-perpetuating, and demonstrated to be demographically and genetically viable.

7.1. Develop a USFWS-approved controlled propagation and reintroduction plan for ambrosia.

Develop a USFWS-approved controlled propagation and reintroduction plan that provides reference to the existing germination studies controlled propagation efforts completed for ambrosia; and refugia, augmentation, and reintroduction of the species. The plan should follow the USFWS and the National Marine Fisheries Services (NMFS) Policy on Controlled Propagation, published on September 20, 2000 (FR 65 56919). Collection procedures will strictly follow the CPC guidelines so as to not deplete seeds from the wild. Measures of success for reintroductions and augmentations should be determined before such work begins.

7.2. Adhere to the guidelines established in the Slender Rush-pea Controlled Propagation and Reintroduction Plan (USFWS 2012).

The purpose of the plan is to provide guidance on the following activities: establishment of refugium populations; production of individuals for research and technology development; production of individuals for supplementing (augmentation) extant populations; and production of individuals for reintroduction to suitable habitat within the species' historic range. Determine measures of success for reintroduction.

7.3. Appoint a coordinating team to help plan and oversee the reintroduction programs.

Careful coordination and good communication are necessary to minimize repeats of research projects and activities on wild or reintroduced populations, to maximize the use of limited research funding and cultivated materials, and to avoid having activities from one study interfere with monitoring efforts or other research studies. Landowners, Federal and state agencies, NGOs, and researchers will need to carefully plan and coordinate field activities and lab investigations, working in teams and sharing data whenever possible.

7.4. Incorporate reintroduction into applicable agency land management plans.

If reintroduction sites are established on Federal or state lands, agencies should work closely with the coordinating team to incorporate the established reintroduction program into their land and resource management plans.

7.5. Perform experimental planting at a selected natural site as a pilot project.

Augmentation and reintroduction of plant populations are costly and labor-intensive, and rely on extensive research to select the proper natural habitat and prepare adequate

DRAFT

amounts of demographically and genetically suitable propagative material. Pilot projects are essential to determine the time, cost, feasibility, and to determine the effectiveness of the full-blown study design prior to its execution. Each pilot project should contain realistic goals and measurable objectives that take into consideration the biological constraints and challenges, site protection and access, financial support throughout the life of the project, and should address technical and logistical concerns (USFWS 2012).

7.6. Using results from Action 7.5, reintroduce populations on private and public lands, where possible

7.6.1. Develop a long-term monitoring program to assess success of reintroductions or introductions.

While similar to monitoring natural populations, reintroductions or introductions require more intensive monitoring in order to be able to accurately determine success or failure and the reasons for it. Reintroduction monitoring needs to be more frequent, at least initially, as most mortality occurs then. Also, measures of growth, not often necessary in established natural populations, are needed to help measure success. Once the plants have reached maturity, evidence of seedlings or new stems (in the case of ambrosia) and their eventual maturity will need to be carefully monitored to assess reintroduction success.

7.7 Use information gained from the long-term monitoring program to adjust both species' reintroduction plans.

As reintroduction is a relatively new tool in the recovery of these species, new information can be used to update the reintroduction plans. This should be on a regular basis.

8. Develop an education and outreach program.

8.1. Develop any necessary educational or outreach materials.

Develop educational materials for use in raising public awareness and appreciation for the unique habitat needs of the coastal shortgrass prairie and the two endangered South Texas plants found within them. Materials should be current and focus on the community itself, the ecosystem processes (fire), and habitat management guidelines. Materials could include brochures, photos, posters, and digital media. Outreach opportunities with schools, environmental programs, landowner contact programs, etc. would benefit from these materials.

8.2. Provide educational and outreach materials to landowners and land managers.

Provide information to landowners and land managers of extant and potential sites to demonstrate the importance of intact shortgrass prairie habitat for other wildlife as well

DRAFT

as the species at hand. The preferred method to deliver outreach materials should be in person; however, providing them electronically may be sufficient.

8.3. Provide educational and outreach materials to interested parties including agencies, engineering and consulting firms, developers, utilities, county road associations, and others.

Educational materials should be provided to interested parties. This may have a profound impact on the current and/or long-term management or land use decisions. Providing these materials early to these groups will allow sufficient opportunities for integration of conservation into their land use planning needs.

9. Conduct Population Viability Analyses and update the existing MVPs for each species based on current biological and ecological information.

9.1. Investigate both species' genetics to ensure long-term persistence.

A species that is sufficiently represented across its range will reduce its overall risk of extinction. Representation of sufficient populations for both species from across the known geographic range of the species should be determined, and are especially desirable because of their contribution to the genetic diversity of the species.

9.2. Develop traditional MVP estimates for both species.

Using the best scientific and commercial data available for both species, maintain the current estimates of the MVP developed using the Pavlik model (2006). A more traditional MVP analysis should be done. Long-term monitoring should be collected using guidance from MVP specialists to determine which factors are most important to monitor and with what frequency. Due to the clonal nature of ambrosia, this may be extremely problematic.

9.3. Reassess the MVP size when new information is made available.

Established MVP assessments should be routinely updated as new information on the species distribution, status, population abundance, and characters (see Pavlik's table) become available.

10. Review and track recovery.

10.1. Maintain the STXPRT to help review the status of both species and assess the effectiveness of the management plans and other recovery tasks.

Assess the progress of both species towards recovery. Determine if current goals remain appropriate for the conservation needs and requirements of the species and its habitat.

10.2. Revise the recovery plan as appropriate.

DRAFT

The Recovery Plan can and should be, rewritten or simply updated as needed to address changing habitat conditions, threat status, or discovery of new and substantial bio/ecological information that could impact the recovery objectives, criteria, and actions.

10.3. Develop a post-recovery monitoring plan when appropriate.

Section 4(g)(1) of the Act requires that the USFWS monitor the status of all recovered species for at least five years following delisting. In keeping with this mandate, a post-delisting monitoring plan should be developed by the USFWS in cooperation with TPWD, additional Federal, state, and local governments, academic institutions, and other appropriate entities. This plan should outline indicators that will be used to assess the status of the delisted species (considering population and threat monitoring), develop monitoring protocols, and evaluate factors that may trigger consideration for relisting.

DRAFT

PART III: IMPLEMENTATION

The following implementation schedule (Table 19) outlines priorities, potential or responsible parties, and estimated costs for the specific actions for recovering the shortgrass prairie as well as its listed species, rush-pea and ambrosia. It is a guide to meeting the goals, objectives, and criteria from Section II Recovery Program, of this recovery plan. The schedule: 1) lists the specific recovery actions, corresponding outline numbers, the action priorities, and the expected duration of actions; 2) recommends agencies or groups for carrying out these actions; and 3) estimates the financial costs for implementing of the actions. These actions, when complete, should accomplish the recovery of both the rush-pea and ambrosia and restoration of the shortgrass prairie habitat.

3.1 Responsible Parties and Cost Estimates

The value of this plan depends on the extent to which it is implemented; the USFWS has neither the authority nor the resources to implement many of the proposed recovery actions. The recovery of the rush-pea and ambrosia is dependent upon the voluntary cooperation of many other organizations and individuals who are willing to implement the recovery actions. The implementation schedule identifies agencies and other potential "responsible parties" (private and public) to help implement the recovery of these species. This plan does not commit any "responsible party" to carry out a particular recovery action or to expend the estimated funds. It is only recognition that particular groups may possess the expertise, resources, and opportunity to assist in the implementation of recovery actions. Although collaboration with private landowners and others is called for in the recovery plan, no one is obligated by this plan to any recovery action or expenditure of funds. Likewise, this schedule is not intended to preclude or limit others from participating in this recovery program.

The cost estimates provided are not intended to be a specific budget but are provided solely to assist in planning. The total estimated cost of recovery, by priority, is provided in the Executive Summary. The schedule provides cost estimates for each action on an annual or biannual basis. Estimated funds for agencies included only project-specific contract, staff, or operations costs in excess of base budgets. They do not include ordinary operating costs (such as staff) for existing responsibilities.

3.2 Recovery Action Priorities and Abbreviations

Priorities in column 1 of the following Implementation Schedule are assigned as follows:

Priority 1 - An action that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future.

Priority 2 - An action that must be taken to prevent a significant decline in species population or habitat quality or some other significant negative impact short of extinction.

DRAFT

Priority 3 - All other actions necessary to provide for full recovery of the species.

The assignment of these priorities does not imply that some recovery actions are of low importance, but instead implies that lower priority items may be deferred while higher priority items are being implemented.

DRAFT

Table 19. Recovery Implementation Table.

Priority No.	Action No.	Action Description	Target Species	Threats	Is the USFWS the lead? If no, then who is the lead?	Action Duration (Years)	Responsible Parties		Cost Estimate by FY (by $1,000s)												
							FWS Program	Others	Total Cost ($1,000s)	FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 26-30	FY 31-35	FY 36-40	FY 41-45	FY 46-50	FY 51-55	FY 56-60
2	1.1.1.	Maintain contact with all landowners or land managers each year.	Both	A, D	Yes	Annual	ES	TPWD, USDA-NRCS, PMC, TAMUK	166.4	20.8	20.8	20.8	20.8	10.4	10.4	10.4	10.4	10.4	10.4	10.4	10.4
2	1.1.2.	Educate landowners about the ecosystem and species' on their property.	Both	A, D	Yes	Continual	ES	TPWD, USDA-NRCS, PMC	100	10	10	10	10	10	10	10	10	5	5	5	5
2	1.1.3.	Encourage long-term stewardship of habitat at these sites.	Both	A, D	Yes	Continual	ES	TPWD, USDA-NRCS, PMC, NASK	100	10	10	10	10	10	10	10	10	5	5	5	5
2	1.2.1.	Determine short- and long-term land use goals and the effects on both species.	Both	A, D	Yes	Periodic	ES	LO, land managers, TPWD, NASK	25	5		5		5		5		2.5		2.5	

DRAFT

2	1.2.2.	With cooperating landowners, develop and implement management plans that are beneficial to the species and acceptable by the landowner and land manager.	Both	A, D	No; both the ES and TPWD.	5	ES	Academics, LO, land managers, TPWD, TXDOT, USDA-NRCS, PMC	50	50											
2	1.2.3.	Develop monitoring program that is reviewed by the USFWS and other interested parties, with voluntary landowner assistance, to evaluate the effects of management practices on the species and ensure consistent and reliable monitoring of plant populations and management	Both	A, D	Yes	1-2 years (start-up); annual	ES	LO, land managers, TPWD, TXDOT, USDA-NRCS, PMC	95	40	5	5	5	5	5	5	5	5	5	5	5
2	1.3.1.	Work with regulatory agencies to ensure existing regulations are used to provide adequate protection of current habitat.	Both	A, D	Yes	Continual	ES	TPWD, TXDOT; intra-USFWS, LO, land managers, NASK	50	5	5	5	5	5	5	5	5	2.5	2.5	2.5	2.5

DRAFT

2	2.1.	Develop monitoring plan for ambrosia (Actions 2.1.1. and 2.1.2.).	South Texas ambrosia	A, E	No; both the ES and TPWD.	1	ES	TPWD, NASK, LO, land managers, TAMUCC, TAMUK	20	20											
2	2.2.	Use the approved monitoring plans to annually monitor ambrosia and rush-pea, habitat, management actions, and threats at extant sites.	Both	A, E	No; both the ES and TPWD.	Annual	ES	TPWD, NASK, LO, land managers, TAMUCC, TAMUK	50	5	5	5	5	5	5	5	5	2.5	2.5	2.5	2.5
3	2.3.	Monitor species and biotic communities, and assess ecological integrity and conservation status of historic sites.	Both	A, E	Yes	Annual	ES	TPWD, LO, land managers, academics	50	5	5	5	5	5	5	5	5	2.5	2.5	2.5	2.5
3	3.1.1.	Study soils and underlying geology.	Both	A	No; academics	1	ES	academics, LO, land managers, TAMUCC	14	14											
3	3.1.2.	Determine the community structure.	Both	E	No; academics	3-5+	ES	academics, LO, land managers, TAMUCC, TAMUK	14	14											
3	3.1.3.1.	Study response to natural disturbance and current land use practices.	Both	A	No; academics	3-5+	ES	academics, LO, land managers	14	14											

DRAFT

3	3.1.3.2.	Study response to natural disturbance and past land use practices.	Both	A	No; academics	3-5+	ES	academics, LO, land managers	14	14											
3	3.1.3.3.	Study response of both species, as well as the habitat, to seasonal and periodic cyclical events including drought, extreme heat events, freezes, and floods.	Both	E	No; academics	≥ 3	ES	LO, land managers, academics, TPWD, TAMUK, NASK, Robstown County Park	10.5	10.5											
2	3.1.3.4.	Investigate the fire ecology of both species and their habitat.	Both	A	No; academics	≥ 3		Academics, NASK, LO, land managers, PMC, TAMUCC	10	10											
3	3.1.3.5.	Study both beneficial and detrimental interactions with other species.	Both	A, E	No; TPWD and academics	≥ 3	ES	academics, LO, land managers	2	2											
3	3.2.1.	Analyze the demographic structure of all populations.	Both	A	No; academics	Periodic (multiple times per year);10 years total	ES	academics, LO, land managers	10	5	5										
3	3.2.2.	Characterize phenology and assess the most vulnerable stages of life cycle.	Both	E	No; academics and ES	2	ES	academics, LO, land managers	2	2											
2	3.2.3.	Determine the primary means of reproduction in the wild.	Both	A	No; academics	3	ES	academics, LO, land managers, USDA-NRCS, PMC	8	8											

DRAFT

3	3.2.4.	Study pollination biology and determine effective pollination requirements and effective pollinators.	Both	E	No; academics and ES	2+	ES	academics, LO, land managers	5	5											
2	3.2.5.	Study seed production and dispersal.	Both	E	No; academics	2-3 yrs	ES	academics, LO, land managers	12	12											
2	3.2.6.	Study seedling recruitment.	Both	E	No; academics	2-3 yrs	ES	academics, LO, land managers	10	10											
2	3.2.7.	Study population genetics to determine the genetic diversity within and among populations.	Both	A, E	No; academics , ES, and others.	6	ES	academics, LO, land managers, TAMUCC (currently underway)	12	10	2										
2	4	Search for additional populations.	Both	E	Yes	5-10 yrs.	ES	academics, LO, land managers, USFWS, TPWD	20	10	10										
1	5.1.1.	Willing landowners will help determine the best means possible in order to provide permanent protection and active habitat management of the site to maintain native shortgrass prairie. Conservation management should….	Both	A, D	Yes	20-60	ES	academics, LO, land managers, USFWS, TPWD	100	20		20		20		20		10		10	

DRAFT

1	5.2.	Carry out restoration at this site, including reintroductions, such that it hosts a complement of the native shortgrass prairie grasses and forbs commonly associated with both species.	Both	A, E	Yes	20-60	ES	academics, LO, land managers, USFWS, TPWD	300	30	30	30	30	30	30	30	30	15	15	15	15
2	5.3	Introduce experimental populations of rush-pea and ambrosia	Both	E	Yes; ES	Continual	ES	LO, land managers	45	5	5	5	5	5	5	2.5	2.5	2.5	2.5	2.5	2.5
2	6.1	Ensure seed has been collected and banked from each site, including newly discovered populations.	Slender rush-pea	E	No; academics	1	ES	academics, LO, land managers, USDA-NRCS PMC, SABG, CCBG	25	25											
3	6.2.1.	Ascertain whether any changes in refugia systems are needed including any need for additional refugia.	Slender rush-pea	E	No; academics	3-5 yrs	ES	academics, LO, land managers, USDA-NRCS, PMC, NABA-NBC, CCBG	5	5											

DRAFT

2	6.3.1.	Study cultivation requirements.	Both	A, E	No; academics	4 years propagate; then continual	ES	academics, LO, land managers, CCBG, USDA-NRCS, PMC	45	20	3	3	3	3	3	3	3	1	1	1	1
3	6.4.	For ambrosia, continue experimentation with seed germination and effectiveness of propagation from seed.	South Texas ambrosia	A, E	No; academics	5+	ES	LO, land managers, SABG, USDA-NRCS, PMC, other *ex-situ* possibilities	12	12											
2	6.5.	Continue vegetative propagation for purposes of reintroduction.	South Texas ambrosia	A, E	No; academics	Continual	ES	USDA-NRCS PMC, SABG, other *ex-situ* possibilities	20	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5				
2	7.1.	Develop a USFWS-approved controlled propagation and reintroduction plan.	South Texas ambrosia	A	Yes	1-2 years	ES	LO, land managers, academics, USDA-NRCS, PMC, CCBG, SABG, others	20	20											
2	7.2.	For rush-pea, adhere to guidelines established in the Slender Rush-pea Controlled Propagation and Reintroduction Plan.	Slender rush-pea	D	Yes	Continual, 10 years	ES	LO, land managers, academics, PMC, SABG, CCBG, other *ex-situ* possibilities, others	20	10	10										
2	7.3.	Appoint a coordinating team to help plan and oversee the reintroduction programs.	Both	D	Yes	10-20 years	ES	TPWD, LO, land managers, academics, USDA-NRCS, PMC, NABA-NBC	10.4	4.16	2.08	2.08	2.08								

DRAFT

2	7.4.	Incorporate reintroduction into applicable agency land management plans.	Both	D	Yes	Periodic	ES	NASK, TPWD, TXDOT	2.08	2.08											
2	7.5.	Perform experimental planting at a selected natural site as a pilot project.	Both	A, E	Yes	5	ES	NASK, TPWD, academics, LO, land managers, USDA-NRCS, PMC	8	8											
2	7.6.1.	Develop a long-term monitoring program to assess success of reintroductions or introductions at all sites where this work has been undertaken.	Both	A	Yes	Continual	ES	NASK, TPWD, academics, LO, land managers, others	60	6	6	6	6	6	6	6	6	3	3	3	3
2	7.7.	Use information gained from the long-term monitoring program to adjust both species reintroduction plans.	Both	A	Yes	Periodic	ES	TPWD, LO, land managers, others, academics	5	1		1		1		1		0.5		0.5	
3	8.1.	Develop any necessary outreach materials.	Both	A	Yes	Continual	ES	academics, LO, land managers, others	29	10	5	5	2	2	1	1	1		1		1
3	8.2.	Provide information to landowners and land managers developed in Task 8.1.	Both	A	Yes	Continual	ES	academics, LO, land managers, others	12	5	1	1	1	1	1		1		0.5		0.5

DRAFT

3	8.3.	Provide outreach materials to interested parties.	Both	A	Yes	Continual	ES	academics, LO, land managers, others	10	2.5	2.5	2.5	2.5								
2	9	Conduct a Population Viability Analyses and update the existing MVPs for each species based on current biological and ecological information (includes Actions 9.1, 9.2, and 9.3).	Both	E	Yes	Continual	ES	TPWD, LO, land managers, academics	124												
2	9.1.	Investigate both species' genetics to ensure long-term persistence.	Both	E	Yes	Periodic	ES	TPWD, LO, land managers, academics, TXDOT, others	100		20		20		20		20		10		10
2	9.2.	Develop traditional MVP estimates for both species.	Both	E	Yes	Periodic	ES	TPWD, LO, land managers, academics, TXDOT, others	15		3		3		3		3		1.5		1.5
2	9.3.	Reassess MVP size when new information is made available.	Both	E	Yes	Periodic	ES	TPWD, LO, land managers, academics	15		3		3		3		3		1.5		1.5

DRAFT

2	10.1.	Maintain STXPRT to help review status of the species and assess the effectiveness of the management plans and other recovery tasks.	Both	D	Yes	Continual	ES	TPWD, LO, land managers, academics, others	12	1	1	1	1	1	1	1	1	1	1	1	1
3	10.2.	Revise the recovery plan as appropriate.	Both	E	Yes	Continual	ES	TPWD, LO, land managers, academics, others	5		2.5		2.5								
2	10.3.	Develop a post-recovery monitoring plan when appropriate.	Both	D, E	Yes	1	ES	TPWD, LO, land managers, academics, others	20								10				10

DRAFT

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PART V: APPENDICES

Appendix A – Glossary of Terms

The Glossary of Terms defines technical and/or biological terms that are underlined throughout the plan. A page number will follow the definition to denote where in the recovery plan the term can be found.

TERM	DEFINITION
Achene	dry, one-seeded fruit that does not open to release the seed
Allelopathic	Secretion of substances into the environment by an organism that is harmful to other organisms
Anthesis	the period when a flower is receptive to fertilization
Appressed pubescence	having fine short hairs arranged so they are facing each other
Bimodal	having two distinct probability peaks
Binpinnately	Plant leaflets of themselves divided into smaller leaflets (Free Dictionary Online)
Climax succession	late, relatively stable stage of ecological succession
Clonal	a population of genetically identical individuals
Endangered Species	"…any species which is in danger of extinction throughout all or a significant portion of its range other than a species of the Class Insecta determined by the Secretary to constitute a pest whose protection under the provisions of this Act would present an overwhelming and overriding risk to man." U.S. Congress 1988
ex-situ population	conserving a population "off-site", or outside of natural habitat to remove from threats
Fodder	food for cattle or livestock
Friable	Soil that is easily broken into smaller and smaller pieces
Genotype	The genetic composition of a cell, organism, or individual (Wikipedia 2012)

DRAFT

Herbicide drift	the movement of herbicide from the target area to areas where herbicide application was not intended (Dexter 1993)
Improved pastures	that have been planted with specific foraging species
Inflorescence	complete flower head of a plant including stems, stalks, bracts, and flowers
Microsatellite-enriched DNA	Repeating sequences of 2 to 6 base pairs in DNA that may be used as genetic markers in kinship and population studies (Wikipedia 2012)
Minimum Viable Population	The fewest individuals required for a specified probability of survival over a specified period of time (Pavlik 1996; Mace and Lande 1991); see Population Viability Analysis
Monoclinous	having both male and female reproductive parts in the same flower (bisexual, hermaphrodite)
Mottes	a small stand of trees on a prairie (Free Dictionary online)
Oblanceolate	lance-shaped; with the thin end at the base
Perennial herbaceous	a plant that lives two or more years, surviving each winter as underground storage or perennating organs (like bulbs, corms, rhizomes, or stem and root tubers)
Phenology	the study of the effects of climate on living organisms. Includes seasonal events like flowering, migration, and growing seasons, and long-term effects as well
Pinnate	on a compound leaf; having leaflets arranged on either side of the stem, typically in pairs opposite each other
Pleistocene deltas	deltaic plain laid down primarily by the Nueces and San Antonio Rivers during the Pleistocene or Ice Age (Lehman *et al.* 2005, p. 8)
Population Viability Analysis	Statistical models used to predict the probability of extinction of a population after a specified period of time
Raceme	unbranched, indeterminate type of inflorescence bearing flowers with pedicels (short floral stalks) along its axis

DRAFT

Ramets	An individual, genetically-identical plant reproduced as a clone of the parent plant
Rhizomatous	underground stem that grows horizontally and, through branching, acts as an agent of vegetative reproduction when they root at intervals
Ruderal	early stage of succession (colonization); plant that grows on or around human dwellings, agricultural land, or wastelands
Scarification	Degradation of an impervious seed coat by physical, chemical, or biological means to allow imbibition
Seral	An intermediate developmental stage in ecological succession (Wikipedia 2013)
Shortgrass prairie	landscape that included relatively treeless stream bottoms and uplands dominated by blue grama and buffalo grass, two warm-season grasses that flourish under intensive grazing. Most of the habitat is dominated by invasive perennial and annual species, whose presence is attributed to overgrazing by domestic livestock and dryland farming
Sprigging	vegetative planting by placing sprigs (section of stem with crowns and roots that is cut from a rhizome or stolon) at spaced intervals in furrows/holes (University of Tennessee 2007)
Staminate	a flower possessing only male parts (filament and anther; the androecium)
Stratification	Seed treatment consisting of maintaining specific conditions, such as temperature and moisture levels, for specified periods of time. Treatment method is required for seeds that need a period of chilling before they germinate.
Subsoil	the layer of soil beneath the topsoil and above the parent material
Thatch	a loose, intermingled organic layer of dead and living shoots, stems, and roots that develops between the zone of green vegetation and the soil surface. Thatch build up begins when turf produces organic debris faster than it can

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	be broken down. Those parts of grass plants that are the most resistant to decay — stem nodes, crowns, fibers of vascular tissues, and roots — make up the bulk of thatch (Peter Landschott, accessed online 1/16/2014)
Threatened Species	"…any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range." United States Congress 1988
Undulate	having a wavy surface or edge
Vertisols	clay-rich soils that shrink and swell with changes in moisture content

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