APPENDIX C
OAK WILT MANAGEMENT PLANNING DOCUMENTS

OAK WILT IDENTIFICATION IN THE FIELD at CSSA

Adapted from Texas Cooperative Extension Oak Wilt Series #2 Publication

Oak wilt has been observed at Camp Bullis, but has never been observed at CSSA. Oak wilt is caused by a fungus that infects the vascular system of susceptible trees. It has killed trees in 55 Texas counties. Major losses have occurred in the Texas Hill Country. Shumard oak, Spanish oak, blackjack oak, water oak, pin oak and live oak trees are the most commonly infected trees. Post oak, and other members of the white oak group, such as bur oaks, rarely are infected with the oak wilt fungus, and when infected, damage is minor and death seldom occurs.

Proper identification of the disease is the first step to developing a management program. Field identification based on symptoms is sometimes possible. Infected trees will develop several different foliage symptoms. It's important to recognize the difference. It is common to find as many as three different symptoms on a single live oak tree. In the case of Spanish, Shumard oaks and other red oaks, symptoms are less reliable in identifying an infected tree. Laboratory identification is recommended if the disease has not been identified from that area before.

Field Identification:
LIVE OAK

Four distinct leaf symptoms may indicate live oak trees infected with oak wilt. The only symptom that is a certain diagnosis for oak wilt is when the veins develop the reddish-brown color. Other symptoms can be caused by stress conditions, herbicides or other toxic materials. Vein coloration is distinct. Between the veins, color varies from light green to a normal green.

This symptom should not be confused with the autumn turning of leaves where the veins are sometimes brown but the line between the brown and the green is fuzzy. The vein coloration symptom is visible on leaves still on the tree. Once the leaf falls, the veins will remain dark brown while the area between the veins is light tan. Leaves will hold this color pattern for several weeks after falling to the ground. Sometimes leaf veins remain dark green and the areas between them are light green to yellowish green. Short reddish-brown areas along the veins will develop on some leaves. The tip of the leaf may be brown (necrotic).

The third symptom is when the leaf is a light yellow and the leaf margin is necrotic. This is less common than the first two symptoms. On a small percentage of diseased trees all of the leaves will turn a reddish brown. Affected trees develop this symptom quickly, usually in the early spring when the new leaves near maturity.

Leaf shed (defoliation) is rapid for the first three symptoms. If all the leaves on the tree turn reddish brown, the leaves are retained on the tree for several weeks after death. Infected red oaks tend to hold their leaves.

Live oaks have died within 30 days after symptoms were observed. In most cases, it will

take from one to six months for a live oak tree to die of oak wilt. In areas where oak wilt is found (oak wilt centers), as many as 10 percent of infected live oak trees survive. The trees generally have reduced canopies, from 20 to 50 percent, remaining after infection. These trees do not die immediately but remain in this weakened condition for many years. They never fully recover.

Once an oak wilt center is formed, the disease spreads outward until it is stopped by a natural or manmade barrier that breaks the root connections between susceptible trees. Native live oaks often have common root systems that promote a greater rate of spread than for other oak species. Live oaks, native or planted, also form root grafts with nearby trees. Also, sap-feeding beetles can infect trees. This gives a random appearance to new infection centers.

RED OAKS (SHUMARD, SPANISH, BLACKJACK, WATER and PIN OAKS)

Leaf symptoms are less distinct for the red oak group. The first noticeable symptom is wilting leaves. They often have an oily or greasy appearance. Soon after wilting, leaf tips begin to turn reddish brown. This browning moves inward toward the midvein until the entire leaf is brown. Leaf symptoms commonly develop on one limb and then quickly spread to the entire tree. Leaves stay on the tree for several weeks after death. Diseased trees look similar to a healthy tree that develops fall color at the wrong time of year. Red oaks have died in 10 days or less after symptoms are observed. But death usually occurs within 30 days after symptoms develop.

Once infected with oak wilt, red oaks do not survive.

Red oaks die more randomly than do live oak trees because spread must be by either root grafts or insect spreads. Red oaks are single trees and don't have common root systems like live oak trees. Sometimes isolated trees escape infection as the disease front advances. In some areas, red oaks have developed oak wilt symptoms but also quickly developed additional symptoms of Hypoxylon canker. Since Hypoxylon canker infects and kills weakened or stressed trees, it is thought that oak wilt weakens the tree and then Hypoxylon canker fungus moves in and kills the tree. Since oak wilt fungus is not a good competitor with other fungi, the Hypoxylon fungus is the only one found when a laboratory diagnosis is made.

FIELD IDENTIFICATION OF OAK WILT

	Live Oak Family	Red Oak Family
LEAF PATTERN		
Veinal necrosis	YES	NO
Veins remain green, but area between veins is light green to yellow	YES	NO
Tip of leaf turns brown	YES	NO
All leaves on tree turn reddish-brown	YES	YES
Wilting and necrosis progress inward from tips	NO	YES
TREE DEFOLIATION		
Leaves retained on tree for a short period after death	NO	YES
TREE MORTALITY RATE		
7-30 days	NO	YES
30-90 days	YES	NO
SPREAD PATTERN		
Tree to tree	YES	Not Always
Isolated trees	YES	YES

OPPORTUNITIES FOR FOREST AND RANGE RESTORATION IN THE TEXAS HILL COUNTRY

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Over the past 200 years, the forest and range conditions in the southeastern region of the Edwards Plateau in Texas (Hill Country) have changed dramatically. The mid-and tallgrass prairies have been greatly altered. In many places, overgrazing has caused severe erosion and diminished the productivity of the rangeland. Overgrazing and the exclusion of wildfire have allowed Ashe juniper (*Juniperus ashei*) (or cedar, as it is known locally) and Plateau live oak (*Quercus fusiformis)* to become more densely populated and extend their range into the prairies and savannas. Oak wilt disease (caused by the fungus *Ceratocystis fagacearum*); the invasion of Ashe juniper; importation of exotic plants, big game animals, and livestock; and increased white-tailed deer populations have contributed significantly to the decline of the native Hill Country hardwood forest. Present conditions reflect man's past land management practices. Even though these conditions present tremendous challenges, great opportunities exist for managers to restore some of the amenities and productivity the land once sustained. These opportunities are even available to those with wide-ranging stewardship objectives, like the cattle rancher interested in increasing pasture productivity while restoring the diversity of plant and wildlife habitats for hunting or birdwatching. Under proper management, all can be accomplished on the same property.

THE HILL COUNTRY:

The Edwards Plateau covers nearly 23,000 square miles of southwest Texas[10]. The southeastern region of the Edwards Plateau encompasses most of what is known locally as the Hill Country. The Hill Country is not precisely defined geographically. For this paper, it includes all or portions of ten counties (roughly 4,500 square miles). The City of Kerrville is near the geographic center of the Hill Country (Fig.1).

The Hill Country consists mostly of an uplifted limestone seabed that has eroded over the millennia creating a rugged topography averaging about 1800 feet above sea level. It is dotted with caves, and clear rivers run through it. The region is one of the most appealing places (scenically and climatically) in Texas to live or retire. The Hill Country has relatively dry summers and mild winters. Being physiographically isolated from other areas of the state, numerous endemic and endangered plant and animal species occur within its borders. While nearly all plant and animal species originally found in the Hill Country are still present, it is the change in species abundance and the introduction of exotics that have changed the natural character of the Hill Country the most.

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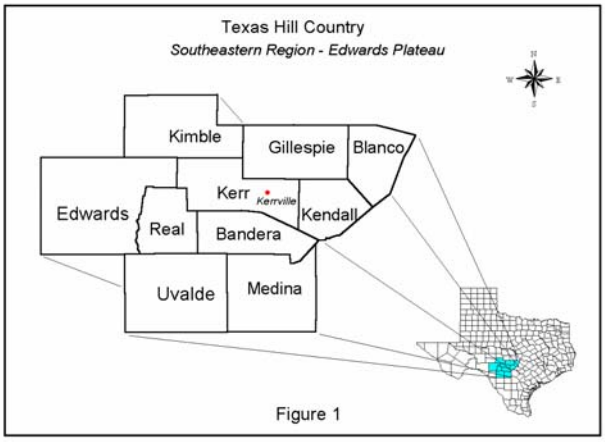

Figure 1

PRESENT CONDITIONS:

The vegetation composition found in the Hill Country during pre-colonial times was roughly 50% mid-and tallgrass prairie and savanna; and 50% relatively closed Ashe juniper-hardwood-woodland or forest (personal communication Fred Smeins, TAES). Historical evidence shows there were extensive areas of "cedar brakes" on the escarpments as well as bald cypress (*Taxodium distichum*) stands dominating the banks of perennial creeks and rivers[20].

Today, the mid-and tallgrass prairies have been reduced to a few relic stands. Grass savannas were created and maintained by frequent natural and Native American-caused fires as well as from periodic but intensive grazing by bison and antelope[3]. Migrating bison herds were exterminated and fires have largely been eliminated. Early European settlers necessarily suppressed fires. Dry Ashe juniper fence posts burned easily in a grass fire and accumulated dry vegetation (fuel) next to barns and structures presented a fire hazard. By grazing off the fuel necessary to carry a fire, goats, horses, sheep, cattle, and more recently exotic big game animals have reduced the incidence of wildfires. With the advent of barbed wire fencing, wells, and windmills to provide water for livestock water tanks, overgrazing became the rule[12]. This is especially true in the early years when pasture rotation schemes and the knowledge of livestock carrying capacity were not yet widely practiced nor understood. These conditions contributed to severe soil erosion and allowed the establishment of invasive woody perennials (i.e., Ashe juniper) and annual “weeds,” many of which are non-native. The introduction of the exotic grasses (i.e., King Ranch bluestem in the 1940s and 1950s) has created virtual monocultures in many places and choked out more nutritious and palatable native grasses and forbs. This situation has been difficult to reverse. Increased land fragmentation and the new home construction it brings make prescribed burning and other broad-scale land management recommendations difficult to implement.

Fire played a natural role in the ecosystem. Its suppression has allowed Ashe juniper and live oak to dominate much more of the landscape. In the past, Ashe juniper was restricted mostly to canyons, rocky hilltops, escarpments, and other areas that burned infrequently. Ashe juniper (found mostly in the eastern half of the Edwards Plateau) does not regenerate from root crowns once cut or burned to the ground. In contrast, redberry juniper (*Juniperus pinchotii)* (which grows largely in the western half of the Edwards Plateau) resprouts vigorously when the aboveground portion of the plant is cut or killed by fire. The dry grass that once surrounded Ashe juniper seedlings provided sufficient fuel to generate enough heat to kill them. Today, young stands of Ashe juniper occupy millions of acres and represent the healthiest and most vigorous vegetation component found throughout much of the Hill Country.

The development of vigorous stands of Ashe juniper affects the landscape in several ways. These stands compete with the grass resource and lower the livestock and wildlife carrying capacity of the land. Hillsides full of new Ashe juniper growth can lower water tables and dry up springs[10]. This is due largely to the ability of their crowns and leaf litter to intercept rainfall[11]. Ashe junipers have a much greater leaf area index than most plants of the same size and they are evergreen. Dense stands choke out desirable trees (including live oak) and prevent hardwoods from regenerating. They also create a fire hazard during prolonged droughts, especially when it is windy and under heavy fuel loads. When left unmanaged, the landscape tends toward an Ashe juniper monoculture at the expense of other plant or animal diversity.

The distribution and density of live oaks have increased similarly. In the past, live oaks were restricted mostly to scattered mottes in a “sea” of grassland or found stunted and suppressed among Ashe juniper on the hillsides[20]. Mottes are groups of live oaks that share an interconnected root system. Unlike Ashe juniper, new live oaks sprout from this existing root system. When quick and relatively “cool” fires periodically swept through the dry grasses, enough heat was generated to kill off these tender young sprouts. These grass fires typically did not produce enough heat to create a canopy fire and kill the larger oak trees. Periodic burning

prevented the encroachment of live oak into the surrounding savanna. Today, as with the Ashe juniper, live oaks have become more densely populated throughout their range. Unlike Ashe juniper, however, live oaks are regarded as the most desirable feature tree in the Hill Country around homesteads. They also provide valuable shade for livestock during the summer, are a staple browse plant for deer, and the acorns are an important food source for wildlife during the fall.

The oak wilt fungus has killed hundreds of thousands of live oaks and Spanish oaks throughout Central Texas and caused property value losses worth millions of dollars in recent decades. The increase in the population density of live oaks and the propensity of live oaks to form root grafts and grow in interconnected mottes have created conditions that favor the current oak wilt epidemic[4]. Forests with greater species diversity and age distribution of trees are better able to defend against insect and disease epidemics. Insects and diseases are generally host specific, and when they enter into a diverse forest, their impact is often less destructive. A greater diversity of plant life also provides more varied wildlife habitats.

White-tailed deer populations have soared recently to an all-time high. This is due largely to the eradication of the screw worm parasite in the 1950s, the development of manmade water and food sources, favoring hunting of bucks over does, and to a much lesser degree elimination of predators (i.e., wolf, mountain lion, and coyotes). A buck : doe ratio of nearly one to three and an average deer density of one deer to six acres are common in many areas of the Hill Country (personal communication Matt Wagner, TPWD). A one to one buck : doe ratio, and a density of one deer to every 8-35 acres (under good range conditions), are ideal goals for wildlife managers in the Hill Country[14].

The increased population of deer along with high stocking rates of goats and exotic big game animals have put heavy pressure on the forest resource and contributed to an overall decline in forest health. Much of the native hardwood diversity is being lost to browsing. The forest structure is alarmingly lacking in regeneration of such species as Texas madrone (*Arbutus xalapensis)*, Spanish oak (*Quercus buckleyi*), escarpment cherry (*Prunus serotina var. eximia)*, and bigtooth maple (*Acer grandidentatum).* These species are highly preferred over Ashe juniper in deer and goat diets. Predictably, as their regeneration is consumed by browsers, they only occupy the overstory (a non-sustainable even-aged forest stand structure). The hardwood overstory is becoming senescent (the process of aging, loss of vigor, and death). Left unchecked, in its place an Ashe juniper stand will develop, mature, senesce, accumulate fuel, and may burn explosively in a crown fire on a windy summer day during a prolonged drought.

OPPORTUNITIES FOR RESTORATION:

A typical landowner in the Hill Country may own a 100-acre parcel with a primary or secondary home. Usually, the principal goals of owning the land are for residential and recreational purposes (while there are working ranches in the area, their numbers are diminishing rapidly). For many, livestock are raised in order to maintain a lower tax status for agriculture purposes. However, changes in state law in 1995 allow Texas landowners to focus on wildlife management while maintaining their agriculture exemption[1].

In general, landowners are interested in being good land stewards, which entails the sustainable management of grass, trees, livestock, wildlife, soil, and water resources. In order to achieve specific landowner-defined objectives, conservation or stewardship plans can be written for individual properties. A multidisciplinary team of natural resource management professionals from the Natural Resources Conservation Service, Texas Parks & Wildlife Department, Texas Forest Service, and Texas Agriculture Extension Service is available upon request to assist landowners in attaining specific forest and range management/restoration objectives.

A landowner may wish to restore productive grasslands and/or native hardwood forests. Many properties can easily accommodate both, since hardwoods generally grow on steep rocky areas, along creeks, or in draws; while grasses better occupy valleys and lowlands with deeper soils or

upland divides. Some owners may wish to manage wildlife habitat for hunting dove, quail, turkey, or deer. Others may find it more appealing to manage for songbird habitat. Most, however, will seek a combination of specific objectives that will assure the sustainable production of various natural resources and manage the ecosystem holistically.

Restoration of grasslands may entail introducing prescribed fire (where practical), using sound livestock grazing management principles, seeding with native range grasses, and controlling brush. Prescribed fire can be used to reduce hazardous fuels, prepare sites for seeding, improve wildlife habitat, dispose of woody debris, manage competing vegetation, control diseases, improve forage for grazing, enhance appearance, open access, perpetuate fire dependent species, recycle nutrients, and manage endangered species.[18] Sound grazing management includes keeping pastures stocked at or below carrying capacity and practicing rotational grazing systems (i.e., HILF – high intensity low frequency). Reintroducing native grasses which have good-excellent forage values (such as big bluestem, little bluestem, Indian grass, and switch grass) into pastures can be highly productive.[8] Controlling brush generally involves clearing or sculpting[5] second-growth Ashe juniper. This can be accomplished by hand cutting, herbicide sprays, mechanical means (bulldozer) or prescribed fire.

Restoration of native hardwood forests may involve managing oak wilt through prevention and control methods, reducing deer populations through increased hunting, reintroducing locally-grown native hardwoods, releasing targeted trees from Ashe juniper competition, and protecting seedlings and natural regeneration from animal damage with appropriate fencing. Oak wilt is managed preventatively by painting wounds on oak trees immediately after they occur, by eliminating or girdling infected red oaks in-place, by abstaining from using or storing unseasoned red oak firewood, and by treating live oaks with Alamo™ fungicide. Methods to control oak wilt spread are generally limited to trenching around expanding oak wilt centers to sever common root systems. Since new outbreaks of oak wilt are common (especially in areas with high numbers of diseased red oaks), control measures may only be temporary. Appropriate management might include enrichment plantings of native hardwoods, particularly those resistant or immune to oak wilt and able to tolerate droughts and high alkaline soils. Individual cages around hardwood regeneration or planted trees will allow them to grow beyond browsing heights. Larger fenced areas to exclude livestock from springs, riparian zones, or critical habitats of endangered species can not only preserve select plants, but also prevent excessive soil erosion, maintain high water quality, and protect feeding and breeding grounds of targeted wildlife.

While site-specific recommendations are beyond the scope of this paper, the following federal and state agencies provide relevant information and technical services free of charge to landowners in Central Texas:

Farm Services Administration (FSA): FSA (formerly known as the Agriculture Stabilization and Conservation Service-ASCS) is a federal agency charged with providing cost-share and incentive program payments. Several programs are currently in operation: Environmental Quality Incentive Program (EQUIP), Stewardship Incentive Program (SIP), Conservation Reserve Program (CRP), Tree Assistance Program (TAP), Livestock Feed Program (LFP), Wildlife Habitat Incentive Program (WHIP), Ashe juniper clearing, and the Disaster Reserve Assistance Program (DRAP). The first four provide cost-share funds for tree planting. The Kerr/Bandera County FSA office can be reached at (830) 896-4911.

Natural Resources Conservation Service (NRCS): This federal agency was formerly known as the USDA Soil Conservation Service. Technical agency personnel help ranchers and farmers prepare Conservation Plans, develop prescribed burning plans, assist with Ashe juniper control, establish farm ponds, build terracing, and control erosion. NRCS also publishes soil surveys for each county. . The Kerr/Bandera County NRCS office can be reached at (830) 896-4911.

Texas Agricultural Experiment Station (TAES): TAES is an agency within the Texas A & M University System. It is charged with conducting scientific research related to agriculture throughout Texas. In central Texas, much of this research is focused on range issues such as forage production, Ashe juniper control, rangeland ecology, hydrology, prescribed burning, and agricultural economics. The regional TAES office can be reached at (409) 845-5573.

Texas Agricultural Extension Service (TAEX): TAEX a member of the Texas A & M University System, employs county agents within each Texas county. Various specialists provide a wide range of public services and information related to agriculture (including fruit and nut tree production, lawn care and gardening), range management (i.e., grazing management and vegetation manipulation), management of livestock (sheep, cattle, and goat), and 4H program implementation. The Kerr County TAEX office can be reached at (830) 257-6568

Texas Forest Service (TFS): TFS is also a member of the Texas A & M University System**.** TFS personnel assist landowners with specific forest-resource-related matters including oak wilt identification and management, tree health evaluations, selection and purchase of appropriate tree seedlings for reforestation, arboricultural consultation, and prevention and control of rural wildfires. TFS administers federal programs such as the Oak Wilt Suppression Project and Stewardship Incentive Program which offer cost-shares to qualified landowners in most Central Texas counties. The TFS Kerrville office can be reached at (830) 257-7744.

Texas Parks & Wildlife Department (TPWD): This state agency provides technical assistance to landowners on all aspects of native wildlife and habitat management, including game, nongame, and endangered species. Experts are available to assist in the preparation of detailed wildlife management plans.

Recommended Reading and References:

1) Comptroller of Public Accounts. 1996. **Texas Property Tax Guidelines for Qualification Agricultural Land in Wildlife Management Use.** 15 p.

2) Cox, P.W., and P. Leslie. 1988. **Texas Trees-A Friendly Guide**. Corona Publishing Company. San Antonio, TX. 374 p.

3) Lewis, H.T. pp: 45-67. 1982. **Fire Technology and Resource Management in Aboriginal North America and Australia.** In Resource Managers: North American and Australian Hunter-Gatherers, Williams, N.M., and E.S. Hunn (eds.). Westview Press, Boulder CO.

4) Reisfield, A.S. pp: 133-8. 1995 . In: **Oak Wilt Perspectives: The Proceedings of the National Oak Wilt Symposium, June 22-25, 1992.** Appel, D.N., and R.F. Billings (eds.). 1995 Austin, TX.. TX Agricultural Experiment Sta.217 p.

5) Rollins, D., D.N. Ueckert, and C.G. Brown (eds). 1998. **Brush Sculpters: Symposium Proceedings**. August 21-22, 1997, Uvalde, Texas and September 17-19, 1997, Abilene, Texas. TAMU Research & Extension Center 7887 US Hwy. 87 N., San Angelo, TX 76901-9714. 150 p.

6) Scifres, C.J., and W.T. Hamilton. 1993. **Prescribed Burning for Brushland Management. The South Texas Example**. Texas A&M University Press. College Station, Texas. 246 p.

7) Simpson, B.J. 1988. **A Field Guide to Texas Trees-Texas Monthly Press Field Guide Series**. Texas Monthly Press. Austin, TX. 372 p.

8) Stubbendieck, J., S.L. Hatch, and C.H. Butterfield. 1993. **North American Range Plants**. Fourth Edition. University of Nebraska Press. Lincoln, NE. 493 p.

9) Texas Agricultural Extension Service. 1991. **Prescribed Range Burning in Texas**. Austin, TX. 8p.

10) Texas Agricultural Experiment Station. 1997. **Juniper Symposium Proceedings**. Technical Report 97-1, Texas A&M Research and Extension Center, San Angelo, TX. 227 p.

11) Texas A&M University Research Station at Sonora. 1994**. Juniper Symposium Proceedings.** Technical Report 94-2. 80 p.

12) Texas Parks and Wildlife Department. 1991. **Managing Habitat for White-tailed Deer in the Hill Country Area of Texas.** Austin, TX. 16 p.

13) Texas Parks and Wildlife Department. **Texas Wildscapes Packet**. Austin, TX.

14) Texas Parks and Wildlife Department 1991. **Vegetation of the Kerr Wildlife Management Area and its Preference by White-tailed Deer**. Austin, TX. 16 p.

15) Texas Parks and Wildlife Department. 1981. **Deer Management in the Edwards Plateau of Texas**. Austin, TX. 21 p.

16) USDA Forest Service. 1995. **How to Identify and Manage Oak Wilt in Texas**. Southern Research Station, New Orleans, LA. 2 p.

17) USDA Forest Service. 1994. **Agroforestry and Sustainable Systems: Symposium Proceedings.** General Technical Report RM-GTR-261. 276 p.

18) USDA Forest Service. 1989. **A Guide for Prescribed Fire in Southern Forests** – Technical Publication R8-TP11. 56 p.

19) USDA Soil Conservation Service. **Soil Survey** (Available for each county in Texas)

20) Weiniger, Del. 1984. **The Explorers' Texas**. Eakin Press, Austin, TX. 224 p.