Lijing Zhou

Thesis Proposal:

IMPROVEMENT, PROPAGATION AND USE OF *TAXODIUM* AS A LANDSCAPE AND COASTAL WETLAND TREE IN THE SOUTHERN USA

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Improvement, Propagation and Use of *Taxodium* As a Landscape and Coastal Wetland Tree In the Southern USA

Introduction

Forested wetlands are an important component of forested systems in the southern United States (Dickson et al. 1965). Along the Louisiana Gulf Coast, portions of these forests are under increasing stresses associated with flooding and saltwater intrusion (Williston et al.1980). For the last 50 years, 34 square miles of coastal Louisiana have been lost each year. Degradation of coastal forests and associated wetland habitats by excessive flooding and saltwater intrusion is dramatically high, especially in the Mississippi River Delta (Earles 1975). It is therefore necessary that superior trees should be selected for resisting the flooding and saltwater intrusion in coastal environment. *Taxodium* has numerous attributes that qualify it as a coastal wetland tree. *Taxodium* is an important wetland species of river and coastal floodplains of the southern USA. The species is long-lived, relatively free of pest problems, popular in landscapes and often quite tolerant of flooding, salt, alkalinity and hurricanes (Arnold 2002). Once three separate species under the same genus *Taxodium*, current taxonomy has placed all *Taxodium* into one species with three botanical varieties – baldcypress, pondcypress, and Montezuma cypress (Arnold and Denny 2006).

There remains great opportunity to find superior genotypes and clones that fit particular site requirements.

Objectives

1. Select superior Montezuma cypress clones: Plant 1000 Montezuma cypress seedlings that trace their origin to near Las Cruces, New Mexico with first selections made in the Fall 2006 with criteria based on growth rate, form, leaf color and retention.
2. Salt Tolerance: Test salt tolerance of bald cypress, Montezuma cypress, and T302 (a bald cypress X Montezuma cypress F_1 hybrid) and establish a range of experimental protocol and salt treatments suitable for future work with possible salt-tolerant genotypes.
3. Asexual propagation: To examine the factors that influence *Taxodium* propagation and determine the best methods and timing for cutting propagation.
4. To further the collection of superior clones of *Taxodium* at Stephen F. Austin State University and to plant them in the fall 2006 along La Nana creek in a documented and mapped collection.

Literature Review

Description of *Taxodium*

Taxodium is a deciduous conifer in the family Taxodiaceae, one of several genera in the family commonly known as cypresses. For the purpose of brevity, baldcypress, pondcypress, and Montezuma cypress will be referred to in this proposal as BC, PC, and MC, respectively.

Taxodium distichum (L.) Rich.var. *distichum* (Baldcypress)

Taxodium distichum var. *imbricarium* (Nutt.) Croom (Pondcypress)

Taxodium distichum var. *mexicana* Gordon (Montezuma cypress)

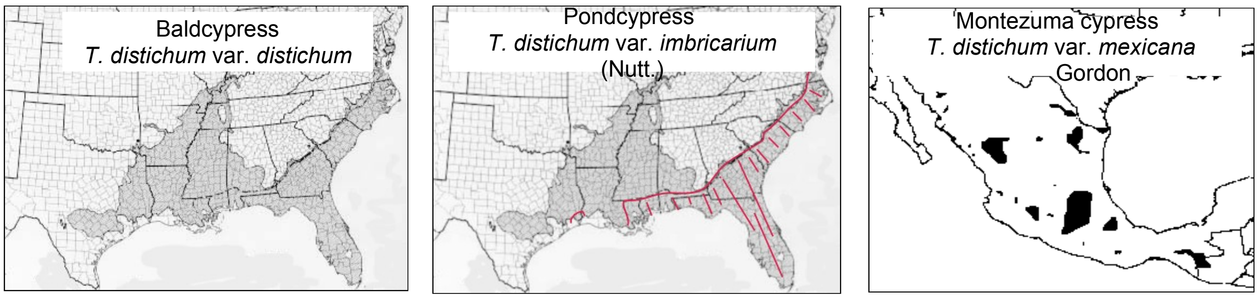

Figure 1. Ranges of *Taxodium* varieties in the USA and Mexico

Species of *Taxodium* occur in the southern part of the North American continent and are deciduous in the north and semi-evergreen to evergreen in the south. They are large trees, reaching 30-45m height and 2-3m diameter. The needle-like leaves, 0.5-2 cm long, are borne spirally on the shoots, twisted at the base so as to appear in two flat rows on either side of the shoot.

BC is native to much of the southeastern United States, from Delaware to Texas and inland up the Mississippi River to southern Indiana. It occurs mainly along rivers with silt-rich flood deposits. BC is a durable, long-lived deciduous conifer particularly well-adapted to wetland habitats (Cox 1988). The tree is pollution-tolerant and excels in compacted, low-oxygen or swampy conditions. It stands strong in the face of hurricanes, is amazingly long lived (1000+ years) and, with time, can become very large. BC is easy to grow from seed and is relatively free of pests and diseases. Superior clones are usually grafted but cutting propagation, while somewhat difficult, can be successful. The prevalence of knees (pneumatophores) is considered a negative in most landscaping circles

– the knees interfere with routine maintenance programs. BC in the western areas of its range is less prone to push knees and may never do so. There are over 45 cultivars of BC in the trade that include clones that are pendulous, contorted, dwarf, salt tolerant, of good form, etc. (http://www.raretrees.org/taxodium.html).

PC occurs in the southern portion of the range of BC, and only on the southeastern coastal plain from North Carolina into Louisiana, and perhaps remnants in southeast Texas. It occurs in still blackwater rivers, ponds and swamps without silt-rich flood deposits. PC is relatively easy to distinguish via the nature of the feathery foliage which is ascendant, rather than more splayed and flat as in BC, but this may not always be consistent. Hardin was first to speculate on the nature of intermediates where BC and PC ranges overlap (Hardin 1983). There are several cultivars of PC and landscapers often use the tree as a specimen particularly when moist soil conditions exist.

MC is native to Mexico, the tip of South Texas and is also found in a few remnant populations in New Mexico. MC differs from the other two varieties in being substantially evergreen. The species does not produce knees. Where adapted, MC has a much faster growth rate than BC and PC, forces new growth early in the spring, continues to grow late into the fall, and tolerates high-salt and alkaline soils. Unfortunately, the tree is not considered a superior landscape tree – it rarely forms a leader and often develops a wide and unbalanced form. Landscapers feel the tree “fails to grow old gracefully”. MC can become huge and live over 2000 years. In fact, a MC near Oaxaca, Mexico – the famous

"Arbole de Tule" is an about 17m diameter tree over 2500 years old, considered to be the world's largest tree (mass).

Value of *Taxodium*

Taxodium has numerous attributes that qualify it as a supreme urban landscape tree and as a species to mediate harsh coastal wetlands and floodplains of major rivers in the South. The tree once dominated large areas of the southern USA and has a fascinating history in early American forestry. The species was heavily cut in the late 1800s and early 1900s. Only a few patriarchs survived. Even second and third growth cuts have not prevented the species from being quite resilient when environment conditions fit its preference. The wood has long been valued for its resistance to rot and warp once cured. In addition, cypress bark is very popular in landscaping circles as a long-lived mulch that doesn't wash away in rains. Riverine swamps of BC cause floodwaters to spread out, slow down, and infiltrate the soil. Thus, these stands reduce damage from floods and act as sediment and pollutant traps.

Genetic Variation in *Taxodium*

Genetic variation in *Taxodium* has received limited attention in the USA and most trees planted in the USA are seedlings from a wide range of seed sources. Very little attention has been paid to superior genotypes as a seed source. Most of the cultivars in the trade are the result of chance finds in the wild, and are generally grafted. Clones are rarely encountered in landscapes. While most studies conclude that BC and PC are not distinctly different enough to be separate species, researchers note that there is considerable variation in characteristics and the genetic foundation for improvement is quite broad (Lickey 2002). In many landscapes across the south, a “line” of uniform bald cypress at planting almost always evolves into varied forms, growth rates, foliage color, limb structure, etc.

Tsumura et al. (1999) found very little genetic differentiation between BC and PC, but their study included only 20 individuals from each of six populations of BC and seven populations of PC in Florida and extreme southern Georgia. Beilman (1947), Flint (1974), McMillan (1974), and Sharma and Madsen (1978) reported on seed source and provenance variation. Faulkner and Toliver (1983) found source effects for cone size and seed weight, but failed to find geographic variation for number of insect galls per cone, height, and diameter, but because the scope of their work was rather limited they were unable to detect geographic variation. In another study, the seed characters and young seedling growth of BC from 11 locations in six U.S.A. states were studied in and the results indicated there were significant differences among 34 progenies concerning the measured variables that include seed length, 1000-seed weight, seed vigor, the length of leaves of 60-day-old seedlings, height growth of young seedlings, diameter growth and biomass of seedlings (Cao Fuliang et al. 1995). In another study, seed origin of MC had no effect on cumulative germination percentage for two seed sources from New Mexico (St. Hilaire 2001).

BC is a flood-tolerant species, and this may be associated with the rapid recovery of stomatal conductance, transpiration and photosynthesis after the removal of flooding. In one study, four different water treatments (normal growth water conditions, light drought water stress, growth under soil water saturation and growth with soil submersion) were applied to examine the photosynthetic characteristics of BC seedlings in the hydro-fluctuation belt of the Three Gorges Reservoir Area. The results showed that different water treatments could effectively influence BC seedling' content of photosynthetic pigment, leaf gas exchange and apparent resource use efficiency. The results verified that BC takes on the features of a water-tolerant and hydrophilic plant, and should be considered as one of the species for the building of a protection forest system for the hydro-fluctuation belt in the Three Gorges Reservoir Area (Li Chang-Xiao, Zhong Zhang-Cheng, and Liu Yun. 2005).

All of the above-mentioned studies dealt with *Taxodium* as a forest tree and not as an ornamental for the nursery / landscape industry. Denny et al. are currently screening genotypes for salt tolerance and good landscape form in Texas A and M University. They have reported that there is influence of seed source on tolerance to salt, high pH and alkalinity, and Mexico MC and western BC were generally less adversely affected by higher alkalinity levels than more eastern populations (Denny, Arnold, and Bryan 2006). Rockwood in Florida is evaluating *Taxodium* seed sources and field trials are underway (personal communication, 2006). Finally, Krauss at the Wetlands Research Center, is evaluating a wide range of salt-tolerant BC from various provenances in the coastal south.

Hybrids

Chinese scientists are convinced that controlled *Taxodium* hybridization promises to combine the best characteristics of superior parents. In 1988, clones T302 (a BC X MC), T401 (PC X MC), and T202 (PC X BC) were selected in China primarily for growth rate and tolerance to alkaline and salt-rich coastal floodplains. All hybrids are intermediate types so far as photosynthetic activities are concerned and the genetic influence of the male parent was greater than that of the female. The height and breadth of the hybrids have positive correlation with photosynthetic intensity (Wu Shoupeng et al. 1990). The results of stem analysis of T302 and BC grown on alkaline low-land areas show that the height, DBH and volume growth of T302 are 147%, 149% and 331% of BC. The mean annual increment and current annual increment curve of volume indicate that T302 grows well under alkaline soil condition (pH≤8.5), while BC would be comparatively inhibited (Zhou Kang et al. 2000). T302 is also recommended in China for soils with pH 8.0~8.5 and salt concentrations < 0.2%. T301, T401, T302 have higher salt tolerance than BC and PC. Other attributes of T302 included 159% faster growth than BC, good columnar form, longer foliage retention in fall and early winter, and no knees.

In one Chinese study, growth rate (height and root diameter) and biomass above-ground as well as twig structure of the first backcrossed generations of (BCF1) *Taxodium* ‘Zhongshansha 302’ X MC were monitored during continued three years. The results showed that “the average growths of height and biomass above ground of $BCF_1$102, $BCF_1$118, $BCF_1$61 and $BCF_1$149 were significantly higher than the mother plant T302. Experiments in saline-alkali soil (pH 8.5) indicated that the growth rates of $BCF_1$102, $BCF_1$118 and $BCF_1$149 were superior to T302 except the growth of $BCF_1$61 was inhibited partly. The relationships between twig structure and tree height were concluded by path analysis, it showed that twig number was a determinative factor to the growth of height" (Yin Yunlong et al. 2003). Yin Xiaoming et al. (2002) analyzed the isohyets of peroxides (POD) and super oxide disputes (SOD) in leaves of MC, T302 and four strains of their hybrids. The result showed that "SOD expressed only in May and POD isohyets had a certain difference among of six samples in May and July, but notable differences existed in September and POD isohyets was a suitable enzyme system to distinguish the various hybrids."

Li Han completed a genetic analysis of 18 *Taxodium* genotypes and found considerable diversity using RAPD (Random Amplified Polymorphic DNA). According to the cluster analysis, the results showed that "the genetic relationship between *Taxodium distichum* Rich. and *T.ascendens* Brongn. is nearer; the genetic relationship of first crossed generation (F_1) *Taxodium* 'zhongshansha 302' [Taxodium *distichum* (Linn.) Rich. X *T. mucronatum* Tenore] is closer to the female parent *Taxodium distichum* (Linn.) Rich.. When the threshold is 5.0, the first backcrossed generations (BCF_1) belong to 3 groups: $BCF_1$149 is the first group; $BCF_1$102 is the second group; BCF_1 1, 27,118,140, 86,136 formed the third group, the clustering results were in consistence with that of the analysis of morphology. $BCF_1$149 might be used as the type of fast-growing ornamental forest. $BCF_1$118 and $BCF_1$102 might be used as the type of fast-growing timber forest" (Li Han 2006).

Chen Yunpeng et al. conducted RAPD analyses on genetic polymorphisms of twelve fir genotypes to identify their relationships (Chen Yunpeng et al. 2002). These genotypes included eight suspected hybrid MC forest samples and the hybrid female parent—MC and the same class of hybrid male – parent—*Cryptomeria fortunei* Hooibrenk and sugi C. *Japonica* (L.f.) D.Don. The results revealed that "the genetic relationship of sample No.11 in three *Cryptomeria* genotypes is the closest to the original male-parent; samples No.1, 4 and 9 are most possibly the true hybrid MC populations; sample No.5 may be the false hybrid."

T302 has been in the USA since January 2002 and is currently under evaluation in over 30 locations in southern USA. The clone was named 'Nanjing Beauty' in 2004 as a cooperative introduction of the SFA Mast Arboretum and Nanjing Botanical Garden. In March 2005, the SFA Mast Arboretum received two new clones from Professor Yin Yunlong's program at the Nanjing Botanical Garden; T140 and T27 are considered more evergreen than T302 and both demonstrate strong salt tolerance. The clones were selected from a field population of T302 X MC – with strong MC characteristics and improvements in growth rate, salt tolerance, form and vigor. T140 grows faster than T27, which produces a wider profile. Nanjing scientists believe they have selected another clone, T1, that may be superior to both T140 and T27, but more genotype X environment studies are needed. The foundation of the most recent selections comes originally from crosses made by Professor Chen and Liu in 1992 at the Nanjing Botanical Garden. Pollen from MC was applied to a female T302 and fifteen selections were made in 1995. The main characteristics for selection were 1) fast growth rate, 2) dark green color during the growing season and a red-orange leaf color in the autumn, and 3) evergreen leaves. In 2006 or 2007, the results from T140 and T27 will be reported and registered with the Chinese Forestry Department. It will be at least five years before T140 and T27 enter commerce. In June, 2005 there were less than 100 each of these two clones. T118, T120 and T149 have already been registered with the Chinese Forestry Department at the provincial level, while T302 has been registered at the national level.

A new intergeneric hybrid X *Taxodiomeria peizhongii* Z.J.Ye, J.J.Zhang et S.H. Pan (a cross between MC and *Cryptomeria fortunei* Hooibrenk ex Otto et Dietr.) was made in Nanjing, China in 1963. The hybrids are semi-evergreen, grow fast, hold up to strong winds, have no butswells and buttresses. The trunk is usually divided at a height of 5-8 m into two or more primary branches. They thrive in ordinary garden soil, wetlands and saline sea-shores with a soil pH ranging from 6.5 to 8.6. The trees can grow in saline soil with 0.4% salt. They are useful for landscape planting as well as for large-scale windbreaks in reverie and coastal regions (Zhang Jianjun et al. 2003).

Recently, the authenticity of the new intergeneric hybrid (X *Taxodiomeria peizhongii* Z. J. Ye, J. J. Zhang et S. H. Pan) has been questioned. To confirm the authenticity of the intergeneric hybrid, Shanghai China scientists analyzed the rbcL gene and the internal transcribed spacer (ITS) of 26S–18S ribosomal RNA gene of the three species using polymerase chain reaction-restriction fragment length polymorphism (PCR-RFLP) and arbitrarily primed PCR (AP-PCR), and obtained the following results: "(1) *Taxodiomeria peizhongii* had the same RFLP maps of the rbcL gene and the ITS as MC, but was different from *C. fortunei*; (2) a 311-bp PCR amplification product was obtained in *C. fortunei* by AP-PCR of ITS, but was not found in *Taxodiomeria peizhongii*. Their results have demonstrated that *C. fortunei* did not provide any genome for *Taxodiomeria peizhongii*, implying that *T. peizhongii* is not an intergeneric hybrid between the two species" (Ling Yan et al. 2006).

<u>Salt Tolerance</u>

Many coastal wetlands of the southeastern United States are threatened by increases in flooding and salinity as a result of both natural processes and man-induced hydrologic alterations (Craig etal.1979, Wicker et al. 1981, Templet and Meyer-Arendt 1988, Conner and Toliver 1990, Allen 1992). If predicted climate changes occur, the consequent rise in sea level will cause flooding and salt water intrusion in many coastal areas (Titus 1988, Smith and Tirpak 1989, Kerr 1991, Daniels 1992, Wigley and Raper 1993). Salt can damage trees in two ways. Salt within the soil can adversely affect soil structure and damage a tree's roots, causing the crown to thin; however, aerial deposition of salt on the above-ground parts of a plant causes the most damage. And ocean spray is the primary culprit. During extreme conditions, such as hurricanes, salt spray can affect plants as far as 50 miles inland, although most damage occurs within 1,000 feet of the shore. Salt damage may take various forms: delayed bud break, reduced leaf size, desiccated leaf margins and tips, premature fall coloration and leaf fall, bud and stem dieback, and reduced shoot growth. Salt produces these symptoms by altering osmotic pressure and, where soil is salty, upsetting the mineral nutritional balance. Damage to trees can be minimized by avoiding the use of salt around landscape plants. But, obviously, the salt content of ocean spray or storm-caused inundations can not be changed. It is therefore essential species selected for landscape planting in areas exposed to ocean spray be able to survive and remain attractive in such environments. The species selected for landscape planting should have the characteristics of salt tolerance. Salt-tolerant trees can withstand concentrations up to 40,000 parts per million (ppm) of salt water. Wahome et al (2001) define salt tolerance as "the ability of a plant to maintain growth and metabolism under saline conditions".

Pezeshki, DeLaune, and Choi (1995) found salt tolerance differences among populations of BC. In that study, populations from freshwater provenances had greater height growth, net shoot biomass, and net root biomass, when compared to brackish populations. They identified a need for further investigation to explore population variations in performance to identify plants tolerant of environmental stresses. In another study, the salt tolerance of BC from different provenances was varied and individuals exhibited good pollution tolerance (Wang Guibin and Cao Fuliang 2002). In another study, compared to *Nyssa aquatica*, BC seedlings were able to grow unaffected by fly ash concentrations up to 10% in sand, concluding that BC was highly recommended for wetlands containing fly ash (McLeod et al. 1997). In Louisiana, Krauss et al. (1996, 1998, and 1999) studied intraspecific variation of salinity tolerance in BC and found genotypes with significantly improved tolerances.

Wang Guibin and Cao Fuliang reported the effects of salt stress on growth and uptake of nutrients of BC under varying soil water content. The results showed that “there were significant effects of soil water contents (W1, flooding; W2, 75% of field water capacity; W3, 25% of field water capacity) and soil salt (NaCl) contents (0, 0.15%, 0.3% and 0.45% of dry weight of soil) on growth and uptake of nutrients of BC. The relative height growth, relative ground diameter growth and biomass increment decreased with increase of soil salt content and decrease of soil water content. The total N, P and Na content in root, stem and leaf and the total Ca and Fe content in leaf increased with increase of soil salt content under the soil condition of flooding, while the total Fe, Ca and Mg content in stem and root had little significant difference. The total N, Na, Ca and Fe content in root, stem and leaf and the total P, K and Mg content in stem and leaf increased in a different degree with increase of soil salt content under the soil condition of W2 (75% of field water capacity), while the total P, K and Mg content in stem decreased under higher soil salt content. The total N, P and K content in leaf, the total Ca and Mg content in stem and leaf and the total Na content in root, stem and leaf increased in a different degree with increase of soil salt content under the soil condition of W3 (25% of field water capacity), while the total N, P and K content in stem and root and the total Fe content in root, stem and leaf decreased with increase of soil salt content” (Wang Guibin and Cao Fuliang 2004 a and b).

Wang Guibin and Cao Fuliang reported the effects of soil water and salt contents on photosynthetic characteristics. The results showed that “the net photosynthetic rate, stomatal conductance, chlorophyll a concentration, chlorophyll b concentration, and chlorophyll content decreased with increasing of soil salt (NaCl) contents (0, 0.15%, 0.3% and 0.45% of dry weight of soil) at varying soil water contents (W1: flooding; W2: water logging; W3: 75% of field water capacity; W4: 50% of field water capacity; W5: 25% of field water capacity), but transpiration rate and respiration rate had different changing tendency; The net photosynthetic rate decreased with decreasing of soil water content at varying soil salt contents, and the water treatment of W3 among five soil water levels had a highest intercellular CO_2 concentration, chlorophyll a concentration and chlorophyll content, but stomatal conductance, transpiration rate, respiration rate, chlorophyll b concentration and chlorophyll a/b had different changing tendency” (Wang Guibin and Cao Fuliang 2004 c).

Wang Guibin and Cao Fuliang reported the effects of soil water contents on nutrient uptake and allocation of BC. The results are as follows: “(1)The total N concentration of root, stem and leaf of BC increased with increasing of soil water contents, and the total P concentration of root, stem and leaf of W3 among five water treatments (W1, flooding; W2, water logging; W3, 75% of field water capacity; W4, 50% of field water capacity; W5, 25% of field water capacity) was the lowest, flooding or drought stress increased the total P concentration, and the total Ca, K, Na, Mg and Fe concentration in root, stem and leaf had different changing tendency; (2) The order of total N, P, Ca, K, Na, Mg and Fe concentration in root, stem and leaf was in the order of leaf>root>stem; (3) The total accumulation of nutrients in BC decreased with decreasing of soil water contents, and the allocation ratio of root and stem increased with decreasing of soil water contents, while the allocation ratio of leaf decreased significantly with decreasing of soil water contents" (Wang Guibin and Cao Fuliang. 2004 d).

Wang Guibin, Cao Fuliang and Wang Qi reported the effects of soil salt contents on uptake of nutrients of BC. The results are as follows: "(1) The total N, Ca, Na and Fe concentration of root, stem and leaf increased with increasing of soil salt content (0, 0.15%, 0.3% and 0.45% of dry weight of soil), and total P, K and Mg concentration of root decreased with increasing of soil salt content, and total P, K and Mg concentration of stem and leaf increased with increasing soil salt content; (2) Ca/Na of root increased with increasing soil salt content, and Ca/Na of stem and leaf, K/Na, Mg/Na and Fe/Na of root, stem and leaf decreased with increasing of soil salt content; (3) The order of total N and P concentration of root, stem and leaf was leaf>root>stem, and total Ca concentration was leaf>stem>root, and total Fe concentration was root>leaf>stem, and the order of total K, Na and Mg concentration of root, stem and leaf was different with varying soil salt contents" (Wang Guibin, Cao Fuliang and Wang Qi. 2004).

<u>Propagation</u>

It is a common propagation experience that mature BC seeds freshly harvested from dried cones in the late fall or early winter will germinate at high percentages, most seeds emerging in 21 – 28 days depending on temperature.

Some propagators suggest a brief soak in rubbing alcohol followed by a water rinse removes the oily resin on the surface of the seed, and can improve germination.

In the USA, the vast majority of BC trees used in the landscape trade are from seeds and the variation is often quite distinct when the tree reaches five to ten years of age. Variation includes tree size, tree form, foliage color, branching, density of branching, and other visual characteristics. Superior varieties are generally grafted and thus more costly to produce. Cutting propagation offers a robust method to quickly multiply a clone to significant nursery numbers but rooting percentages are often low and the species is considered “difficult to root”.

Yunlong reports that T302, selected in 1988, is no longer easy to root, a condition attributed to chronological and physiological age factors. To counter lower rooting percentages, a strict protocol for achieving success has been developed. Chinese nurserymen encourage one year old clones to produce vigorous cutting wood in the second year. T302 plants are field planted at close spacing. The plants are grown one year and then cut back in the winter to 1’ – 3’ tall. These severe pruning results in vigorous upright shoots that provide cuttings that root in good percentages, and produce upright growing plants of better form than trees produced from side branches. Cuttings are rooted under part shade using intermittent mist and a well drained mix in rooting beds. While rooting hormones are utilized, cutting wood quality and maintaining good turgor are recognized as critical for high rooting percentages. One upright shoot is left on the stock tree to grow for the rest of the season – a tree that can then be dug for sale as a straight 6 – 8' tree at the end of the second year.

In a Chinese article, the selection of *Taxodium 'zhongshansha'* cutting medium, cutting of wood and maintenance of three main ecological factors (temperature, moisture and illumination after cutting cultivation) and their effects on taking root were provided. The result showed that T302 had higher rootage ratio (52.4%) using sandy loam as the cutting medium in a plastic shed than that in other two different environmental conditions (Lu Xiaoqing et al. 2004). In another Chinese study, the breeding technique of "three layers of keeping warm" of *Taxodium* 'Zhongshansha' was introduced. They adopted this technique using plant ash and garden soil as the cutting substance and using 1.5 mg/L NAA X IAA as the rhizogenic accelerant, the rootage ratio was about eighty-seven percent (Dong Bihui 2005). Huang Libin et al.(2000) found that significant variation existed among the provenances and families in Genus *Taxodium* in six rooting characteristics (survival rate, rooting rate, sum of adventitious roots, total length of adventitious roots, rooting perform indexes and length of terminal shoots).

Proposed Methods of Study

<u>1. Selection of superior MC clones:</u>

Jeff Anderson of Las Cruces, New Mexico has supplied this project with seed from a disjunct population of MC in a region reported to reach -25 degrees Fahrenheit. This population appears to carry cold hardiness above that of most MC commonly found mostly in Mexico. Seeds will be sown in early March 2006 and transplanted into two seedling rows in the lines of vines of the SFA Mast Arboretum. I propose growing 1000 seedlings and making first selections in the Fall of 2006, with criteria based on growth rate, tree form, leaf color, and leaf retention into the winter.

<u>2. Salt Tolerance</u>

Salt Tolerance of *Taxodium* will be evaluated in containers with four treatments of varying sea salt concentrations. The treatments will include a control with no sea salt, a low sea salt concentration (0.1%), an intermediate sea salt concentration (0.35%) and a high sea salt concentration (0.6%). Experimental design is a 2-way Factorial design with Randomized Blocks. There are 18 *Taxodium* (6 BC, 6 MC, and 6 T302) for each treatment of salinity in each block and 288 plants (96 BC, 96 MC, 96 T302) for the entire study. The plants will be randomly assigned to four treatments. The design will be repeated 4 times (four blocks). The treatments will be applied one time per week for 12 weeks. Plant growth and leaf nutrient content will be determined at the end of the experiment. The salt tolerance level of T302 will be compared with that of BC and MC.

<u>3. Propagation</u>

Time of cutting collection study: Seventy-two cuttings of T302 cuttings will be collected per month from January 2006 to October 2006. The cuttings will be trimmed and divided into three groups. Each group of cuttings will be 5-second dipped into three root hormone treatments—0, 1000, 2000 PPM K-IBA respectively for five seconds and then placed into a 24-deep cavity flat with media. The water treatment is the control group. The flats will be placed on a mist bench in the greenhouse for twelve weeks and then will be moved out. We will inspect the flats frequently to insure that the mist is functioning properly. At the conclusion, rooting percentage and a root density ranking will be recorded. This study will help in determining the optimum time of year for successful cutting propagation.

In June 2006, cuttings will be taken from a range of BC and MC to compare rooting success using K-IBA treatments of 0, 1000 PPM, 2000 PPM and 5000 PPM.

4. Genotype growth and performance

We have acquired thirteen genotypes from Florida (seven plants per genotype), three genotypes from Louisiana (six plants per genotype) and nine T302. We planted them in the same size containers. Plant height and trunk diameter of *Taxodium* will be taken to evaluate plant growth and will be compared. Form and landscape character of them will be monitored.

A large plenty of various *Taxodium* genotypes and cultivars will be planted along La Nana creek at SFASU in the fall 2006. That side-by-side collection will be mapped and databased for future reference.

Table 1: Germplasm available for genotype growth and performance study.

Currently in the SFA Mast Arboretum or Pineywoods Native Plant Center

BC	Missouri - Botany Shop, Michael Shade	11/8/04

BC	Atchafayala Basin, Loos	1/9/2003
BC	Daniel's Ranch FM 787@Trinity , Loos	1/9/2003
BC	SWTS, Loos	1/9/2003
BC	Cajun Snowfall, Stanley and Sons	9/23/2003
BC	Cave Hill, Stanley and Sons	9/23/2003
BC	Fastigiat, Stanley and Sons	9/23/2003
BC	Peve Minaret, Stanley and Sons	9/23/2003
BC	Cajun Snowfall, Stanley and Sons	12/6/2002
BC	Cascade Falls, Stanley and Sons	11/14/2001
BC	Fastigata, Stanley and Sons	11/14/2001
BC	Pendens, Stanley and Sons	11/14/2001
BC	Secrest, Stanley and Sons	11/14/2001
BC	Peve, Yellow Stanley and Sons	2005
BC	Monarch of Illinois, Arbor Village	11/16/2001
BC	Pendens, Arbor Village	11/16/2001
BC	Shawnee Brave, Arbor Village	11/16/2001
BC	Secrest - Bill Caldwell	
BC	Autumn Gold PDSI	11/12/2001
BC	'weeping' – Yadkinville Nursery, NC	
PC	Nutans, Arbor Village	11/16/2001
PC	Prairie Sentinel, Arbor Village	11/16/2001
MC	Pendulum, Stanley and Sons	2005
MC	D13-04 – Yuccado collection Mexico	
MC	Sentido, Paul Cox	3/28/2001
MC	Sentido, Treesearch	3/22/2002

Taxodium X 'Nanjing Beauty' – Nanjing Botanical Garden, numerous plants
Taxodium X 'T27' – Nanjing Botanical Garden, China
Taxodium X 'T140' – Nanjing Botanical Garden, China

Acquired in Dec 2005 from Florida

Donald L. Rockwood, Professor, School of Forest Resources and Conservation, University of Florida, Box 110410, Gainesville, FL 32611-0410; office: 352 846-0897; 352 846-1277 (fax); email: dlr@ifas.ufl.edu

Fla 61
Fla 108
Fla 132
Fla 154
Fla 172
Fla 190
Fla 263
Fla 327

Fla 339
Fla 342
AK-1
FLA BC
FLA PC

Acquired in Jan 2006 from Louisiana's National Wetlands Center:

Ken W. Krauss, Ph.D. Research Ecologist, U.S. Geological Survey,
National Wetlands Research Center, 700 Cajundome Blvd, Lafayette, LA 70506
office: 337-266-8882; 337-266-8592 fax; E-mail: kkrauss@usgs.gov
http://www.nwrc.usgs.gov/

KRAUSS SC
KRAUSS GA
KRUASS LA

Texas A and M University inventory available for the thesis:

BC	Austin, Texas, USA
BC	Blanco, Texas, USA
BC	Waring, Texas, USA
BC	Hunt, Texas, USA
BC	*Vanderpool, Texas, USA
BC	Leakey, Texas, USA
BC	Sabinal, Texas, USA
BC	Poteet, Texas, USA
BC	New Braunfels, Texas, USA
BC	San Marcos, Texas, USA
BC	Tiawichi Creek, Texas, USA
BC	Lake Cherokee, Texas, USA
BC	Orange, Texas, USA
BC	Franklin, Louisiana, USA
BC	Lake Verret, Louisiana, USA
BC	Vidalia, Louisiana, USA
BC	Mobile Bay, Alabama, USA
BC	Dapqhne, Alabama, USA
BC	*Fairhope, Alabama, USA
BC	*Biloxi, Mississippi, USA
BC	Columbia, Mississippi, USA

PC	*Weeks, Louisiana, USA
PC	Paradise Beach, Florida, USA
PC	Mobile Bay, Alabama, USA
PC	*Mobile Bay, Alabama, USA
PC	Fowl River, Alabama, USA

PC Biloxi, Mississippi, USA
PC Kiln, Mississippi, USA

MC Rio Nazas, Durango, Mexico
MC San Juan Teotihuacan, Estado de Mexico, Mexico
MC Bolleros, Estado de Mexico, Mexico
MC Sabinas, Coahuila, Mexico
MC Salineno, Texas, USA
MC Progresso, Texas, USA
MC Southmost, Texas, USA

* denotes probable hybrid

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