Chinese Tallow Survey Report to Sabine River Authority of Texas and Sabine River Authority, State of Louisiana

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The primary objectives of the study were to provide a realistic and accurate account of the current extent and distribution of Chinese tallow, *Triadica sebifera* (Chinese tallow or tallow in this report) infestations within the Toledo Bend Project Boundary and adjacent lands affected by Project operations and maintenance; and determine the extent and distribution of Chinese tallow in the general region surrounding the Toledo Bend Project (study area). Ground-based and aerial reconnaissance of the study area served two purposes. First, it provided locations of tallow occurrences used in calibration and validation mapping procedures and an indication of its established spatial pattern and density. Second, it provided us familiarity of the landcover types (compositions), their spatial distributions, and their structural variability, and whether tallow was

selectively associated with certain land covers or activities. In a previous mapping of tallow occurrences in southwest Louisiana, we found tallow occurrences were not uniformly distributed across the landscape but were differentially associated with certain landcover types and activities (Ramsey et al. 2005).

**Study Area Landscape Overview**

The study area included all lands within the Toledo Bend Project Boundary and those lands affected by Project operations and maintenance. The study area also included all the lands within the US Forest Service’s Sabine National Forest and adjacent regional lands to the east and west of the Project.

Pine and hardwood forests comprised around 35% and pine plantations 27% of the study area. Grasslands, primarily including grazing lands and fallow fields existed, as did scrublands and cypress forests, but these land covers encompassed only about 11%, 4%, and 5%, respectively, of the study area. The dominant changes in the landscape were associated with the forestry silviculture. In our previous study, tallow trees were found in cypress, hardwood, and pine forests and pine and cypress plantations. Pine plantations, and some scrublands, contained some of the highest percent occurrences of tallow in previous studies. Based on those previous findings, we expected similar association with tallow occurrences.

There was widespread clear cutting that had occurred and was occurring within the forested areas of the study area. The clear cuts existed in a variety of structural forms. These forms included replanted clear cuts ranging from newly planted pine seedlings exhibiting mostly bare spaces to mature pine regrowth exhibiting dense stands. Others were freshly cleared with residual woody material still covering the cleared area while other older clearings had been cleared but without replanting. Most often, these contained grasses and shrubs. While clear cuts
dominated the more dramatic and frequent changes in the vegetated landscape, forest stand closure and its relationship to understory growth (including tallow) was also documented when observed.

**Study Methods**

We applied EO-1 Hyperion data in conjunction with reconnaissance surveys to map the occurrences of Chinese tallow in the study. Over 20 Hyperion and Advanced Land Imager images were collected of the study area in 2009 and 2010 during the fall senescence when tallow leaves turn red. Atmospherically corrected Hyperion reflectance spectra collected at ground and aerial observation locations provided the input datasets into the spectral discrimination analysis program. Spectral discrimination was used to create spectral indicator sets to best explain the spectral variance contained in the input databases. The expectation was that at least one of the indicator spectra would uniquely identify the occurrences of red tallow within the Hyperion reflectance images. No combination of Hyperion-based reflectance datasets produced a unique identifier for red tallow.

The inability to uncover a unique spectral indicator resulted primarily from the low percent occurrences (< 5% per 30-m by 30-m Hyperion pixel) of red tallow (trees or shrubs). To enhance the spectral discrimination performance, tallow leaf and canopy spectra were added to the input datasets to guide the indicator selection. In addition, input databases were segregated by land class obtained from an ALI classification in order to reduce the input variance and promote red tallow spectral discrimination. No unique red tallow spectral identifier was created with these enhanced methods; however, in some cases, associated particularly with the addition of the helicopter-based spectra, predicted spatial patterns throughout the Hyperion images revealed alignment with vegetation associations within each land class that often were observed
to contained tallow. Extension of this promising “likelihood of tallow occurrence” mapping to six of the nine Hyperion swaths and four of the nine land classes produced uncertain results that could not be evaluated for accuracy. Even though the final mapping showed promise in identifying likely tallow occurrences, the low percent occurrences still hindered mapping success. Results of the mapping suggested successful detection of tallow in the study area required a spectral sensor similar to Hyperion but with a higher ground spatial resolution.

**Field Reconnaissance**

Due to the problems encountered with determining extent and distribution of tallow using the spectral methods, the report emphasizes the findings from the field reconnaissance efforts to fulfill the study objectives.

**Ground-based field reconnaissance**

Ground-based field reconnaissance occurred on 5 time periods from 2009 through 2010 at 233 locations throughout the study area (Table 1, Figure 1). Ground-based observations were restricted to accessible lands tracts. This restriction resulted in observations emphasizing edges mainly associated with public roadways, powerlines, and where accessible, changes in forest stand structure, primarily related to an abrupt transition from planted pine or scrubland to mature forest. There were excursions into the forested areas; however, the overlapping tallow senescence and hunting seasons severely limited these forays. Where agriculture lands, mostly grasslands for grazing, pine plantations, or scrublands occurred along the roadways, these were observed from the fence line. Low density development observations also were emphasized because of accessibility; however, single residences reachable by a private roadway normally were not visited. Public facilities were included in the survey (e.g., camp grounds, launches). These public locations provided most of the Toledo Bend Reservoir lakeside observations. Even
though the reconnaissance was not without limitations, sometimes severe, the ground-based observations provided a sense of the magnitude and distribution of tallow occurrences in the study area.

Table 1. Field Reconnaissance Surveys.

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Measurement of Leaf Spectral Properties

During the ground-based reconnaissance, we found several tree species and one shrub species exhibited similar senescing foliages as tallow. Because the mapping of tallow occurrences depended on the uniqueness of the red tallow foliage in the landscape, leaf spectral measurements were obtained in order to determine the spectral contrast between tallow leaves and all other co-occurring plants within the project area. Small branches were collected from tallow trees and Red Maple and Sweetgum trees located during the ground surveys that exhibited senescence colors similar to tallow. Leaf samples collected and analyzed within 24 hrs included
green, yellow, and red leaves and leaves exhibiting progressive color changes between these primary colors (Figure 2). Leaf reflectance spectra were obtained by using a handheld radiometer fitted with a diffuse sample sphere. The various spectral measurements and replicates were entered into post-processing algorithms that calculated the average diffuse reflectance for each leaf. Full details concerning the measurement methods and post-processing analyses are found in Ramsey et al. (2005).

**Fixed-wing Observations**

The fixed-wing flights, which occurred on 4 November 2010 and 5 November 2010, collected observations at 554 vegetated locations throughout the project area (Table 1, Figure 3). Aerial surveys were added to widen the breadth of ground-based observations and permit observations in inaccessible land tracts due to access restrictions.

All photographs were oblique. In all but a few cases, the nominal direction of the target in the photography was recorded as well as a general description of the target. Although the fixed-wing reconnaissance gained more thorough coverage of the study area, it did not allow identification of herbaceous vegetation except into broad categories such as pine and hardwood, and a non-descript shrub category. As illustrated in the leaf reflectance results, differentiation between Red Maple, Sweetgum, and tallow shrubs and trees exhibiting green or red foliage was unattainable. An herbaceous shrub, poison sumac, may have also added to the red foliage observations. Because of the lack in differentiability between the three species, observations were aggregated as shrubs and trees with red foliage as “red trees.”

Visually, senescing hardwoods exhibited different foliage tones that seemed for the most part separable from red trees in the fixed-wind reconnaissance. Understory red trees in mature pine and hardwood forests were at times observable, but these were mainly limited to when red
trees occurred in forest gaps, or observations were near vertical (Figure 4). Subcanopy red shrubs and trees were most often observed at transition edges from pine plantation or scrubland to mature forest. For the most part, these edge subcanopy “red tree” occurrences were associated with elongated and narrow hardwood stands surrounded by a pine plantation (Figure 5). Photography was collected also of land covers that did not include red trees. These photographs were obtained to document the various landcover types in the project area. By far, however, photography was taken when red trees were observed.

Field Data Documentation and Classification

The field site name, location, photography, and description were catalogued. At sites with ground or helicopter observations, the presence or absence of red or green foliated tallow was noted. At sites observed from the fixed-wing aircraft, the presence or absence referred to Red Maple, Sweetgum, or red tallow trees or shrubs, and possibly poison sumac. All aerial and ground site locations were overlain on the EO-1 Satellite Advanced Land Imager scenes rectified to Louisiana and Texas 2010 Digital Ortho Quarter Quads (DOQQs) (Figures 1 and 3). Different symbols were used to identify each location with the date and type of reconnaissance activity. For clarity, a separate map was created showing only the fixed-wing and ground-based tallow and other red tree observations (Figure 6). Helicopter observations were grouped with the ground observations. In some of the fixed-wing sites where red tree had been observed during the flight, the associated photography does not clearly identify red trees. In these cases, the color of the “red tree” symbol was changed slightly.

Each reconnaissance location on Figures 1 and 3 was linked to the information contained in a summary database that contains variables defining the presence or absence of tallow or red trees. The tallow presence or absence variable is only associated with ground-based or
helicopter-based observations. The red trees variable is associated with the fixed-wing observations. Each reconnaissance location observation is also linked to a class variable. The class variable defines the prominent or most important land feature at each reconnaissance location. At most observation locations, multiple features used in this study to define the landscape and landuse features were often captured within the associated photography. However, the class variable would define only the most meaningful single feature at each location. For instance, clear cuts, hardwoods, and planted pines may be all represented at a single location; however, hardwoods contained the tallow or red trees. In that case, the class variable would be hardwood. The class variables included: (1) pine forest, (2) hardwood forest, (3) mixed pine and hardwood forest, (4) planted pine (not including mature planted pine), (5) cypress forest (including all observed swamps), (6) scrublands (regrowing clear-cuts to dense mixtures of shrubs and trees of different varieties), (7) grassland-agriculture (grazing and fallow fields), (8) clear-cuts (associated with logging and containing minimal vegetation), (9) bare surface (mudflats to parking lots), (10) water (along the lake, pond, or stream shorelines), (11) fence line, and (12) edge (an abrupt change in land cover).

**Class Descriptions related to the Ground-based and Fixed-wing Reconnaissance**

*Tallows on Forest Edges.* Although not a landcover class, where tallow trees (or red trees in aerial reconnaissance) were observed, it was often along a forest edge. In the ground-based survey, one of the most common tallow observations was associated with shrubs and trees in the subcanopy at the edge of forests adjacent to pine plantation, scrublands, roadways, clearings, and grasslands.
**Tallow at the Water’s Edge.** Tallow trees occurred along ponds, streams, and the lake shoreline. Although found adjacent to water, most often tallow occurred along an obstruction near to the water’s edge, such as a roadway guard rail, fence, or shrub line. At only a couple locations did tallow occur right at or slightly in shallow water.

**Tallows along Fences.** As forest and water edges, tallow trees and shrubs were relatively common along abrupt edges, in this case formed by fence lines.

**Land Cover Classes**

**Pine Plantations.** In previous tallow mapping, we found young and shrub pine plantations were susceptible to the establishment of tallow (Ramsey et al. 2005). In ground-based observations during this study, we found only one young plantation out of eight visited contained any tallow. In the aerial survey, only 17 out of the 56 documented pine plantations contained red trees, and these occurrences for the most part were nearby hardwood fingers protruding into the plantation. In contrast, two seemingly abandoned pine plantations contained a fair amount of red trees, reminiscent of occurrences found in southwest Louisiana.

**Mature Pine Forests.** Mature pine forest included both non-planted and planted pines. The canopy structure or openness of the non-planted and planted pine canopies appeared different, and as surmised in previous tallow mapping (Ramsey et al. 2005), canopy gaps provide opportunities for tallow establishment. Based on aerial observations, mature pines contained among the highest observances of red trees. The red tree observations were most often of understory red leaf trees or shrubs that were observed at nearer vertical orientations. As Figure 4 suggests, however, opportunistic establishment within the gaps and open canopy of the mature pine forests is not limited to tallow. In addition, where pine forests abruptly adjoined a scrubland
or pine plantation, red trees were at times observed at the forest edge during the aerial reconnaissance.

**Hardwood Fingers.** Hardwood fingers were separated from Hardwood forests because of the difference in stand structure, particularly in relation to the length of exposed edges. As illustrated in Figure 5, hardwood fingers penetrating into regrowing clear-cuts or scrublands, and pine plantations provided a high percentage of forest to shrub edges in relation to stand area. We also noted in this study as well as in the southwest Louisiana tallow mapping that abrupt edges seem to be conducive to the establishment of tallow. Although not a statistical survey, in our aerial observations, only scrublands were associated with a higher occurrence of red trees than hardwood fingers. This same association was not prevalent where hardwood fingers were interlaced within mature pine forests. In these cases, red trees were not often detected, possibly because they were hidden by the dense overstory canopy or hadn’t become established due to the lack of abrupt forest edge.

**Hardwood Forests.** Hardwood forests exhibited an aerial red tree observation frequency close to that associated with mature pine forests. As in pine forests, red trees occurred most often in canopy gaps or where the canopy abutted a pine plantation, grassland, or scrubland. Again, as in the pine forest red tree observations, often only one or two red trees in the subcanopy comprised the total number of observed red trees at any documented location.

**Pine and Hardwood Mixed Forests.** Pine and hardwood were often mixed into a composite forest structure. The association of red trees within the mixed forest followed the same pattern as in either the pine or hardwood forests.

**Grasslands-Agriculture.** This landcover class for the most part comprised agriculture fields used for grazing or fallow fields. Although scattered throughout the study area, grasslands did not
dominate the landscape. In aerial observations of grasslands, only two contained red trees. In ground-based observations, however, grasslands containing clumps of trees and shrubs were some of the most likely places to find tallow. Most often these trees and shrubs occurred next to ponds within grass fields. In one case, tallow shrubs occurred fairly ubiquitously throughout a fallow field. Even this relatively dense occurrence was fairly scattered and unremarkable except when compared to general lack of tallow in all the grasslands observed. Although more common in the grassland-agriculture class than all other landcovers except scrublands, tallow occurrences were uncommon in grasslands and those occurrences tended to comprise a few shrubs or isolated trees that exhibited a good proportion of green leaves.

**Scrublands.** Of the land covers, scrublands were the most likely to contain tallow. Tallows or red trees were more frequently observed in scrublands than any other landcover. Even so, red tallow (or red trees) occurrences in scrublands were scattered and largely not observed. Based on ground and aerial observations, however, scrubland was a minor landcover class and largely comprised yet to be planted clear cuts and scattered and most often small sized patches.

**Bare/Developed.** Even though bare surface resulting from clear-cutting can provide a more conducive environment for tallow establishment, we observed no tallow occurrences in these land covers. Tallow occurrences in Developed areas were mostly associated with ornamental yard trees, abandoned homes or businesses, or along-side slackly maintained roads.

**Summary of Field Reconnaissance**

Results of the ground-based reconnaissance surveys suggested tallow occurrences were scattered and uncommon. In addition, where tallow did occur, its occurrence density within a forest stand, scrubland, or grassland was low. Even though the field survey objective was to locate tallow not provide a statistical sample, the pattern of tallow observations based on the
ground and aerial surveys did not suggest preferential establishment nearer the Toledo Bend reservoir. In fact, the spatial distribution of tallow seemed more associated with landscape features rather than the location and landcover type.

Forest edges and fence lines were some of the most likely places to locate tallow. Edge of ponds, streams, and along the Toledo Bend Reservoir shoreline or an embayment also provided likely locations to find tallow. Each of these landscape features tends to indicate tallow brought in through seed transfer by birds. There were two locations, however, where tallow was growing on the edges of a stream and within the shallow water on the Reservoir edge.

Tallow was not widely established within the numerous pine plantations throughout the study area. Although we found two seemingly abandoned planted pine locations that had a fair establishment of tallow, these were an exception to the observed pine plantation land cover. The highest observed occurrences of red trees within pine plantations were in association with hardwood fingers. Based on aerial reconnaissance, hardwood fingers had even a higher propensity for formation of edges than large stands of pine and hardwood forests abutting plantations, scrublands, or grassland. In our observations, edges seemed to provide a conducive landscape feature for the establishment of tallow. Whether or not there is an association between these hardwood fingers and the occurrence of tallow cannot be established without ground-based observations.

Hardwood, pine, and mixed hardwood and pine forests exhibited scattered and infrequent observations of red trees. Even though ground-based excursions were limited to driving accessible logging roads into these forests, we did not observe any substantial occurrences of tallow in the subcanopy. Observations from the fixed-wing platform provided glimpses of red
trees in the subcanopy and at times within canopy gaps; however, the subcanopy observations were infrequent and occurrence at any locations few.

Our ground-based and aerial observations suggest that tallow trees exist primarily along forest edges, water edges, and fence lines probably most in line with seed dispersal by birds. Even though densities were low, tallow trees were observed to be more densely dispersed within some scrublands and grasslands than was observed for red trees in pine, hardwood, and mixed forests. Excluding a couple seemingly unmanaged planted pine fields, we did not observe any notable establishment of tallow in the ubiquitous pine plantations. If the observed understory red trees in the hardwoods fingers are tallow, the highest potential threat is most likely through the close spatial association of pine plantations and hardwood fingers.

Even though tallow trees are an uncommon occurrence in the study area, our surveys show the scattered and low percent occurrences are widely distributed throughout the study area. These scattered occurrences combined with the landscape dynamics and the in-place avian dispersal mechanism provides the potential for the further spread of tallow in the study area unless natural forces or management act to contain it.

**References**

Figure 1: Ground field sites are represented with squares, yellow color for sites with tallow, green color for sites without tallow.
Figure 2: Representative reflectance spectra of green, yellow, and red Maple, Sweet Gum, and tallow leaves collected in the Toledo Bend project area. Notice the high spectral overlap between leaves of the same color between species (e.g., the red leaves of Maple, Sweet Gum, and tallow).
Figure 3: All fixed wing sites shown in circles, yellow color for sites with red trees, green color for sites without red trees and darker yellow color for sites where red trees were observed during the fixed wing reconnaissance but they not were not captured on the photography.
Figure 4: Red trees in mature Pine forests. Figures A and B depict red trees in a dominantly pine forest, from an aerial view (A) and ground view (B). Even though (A) and (B) do not depict the same forest stand, the red tree in (B) is a senescing maple suggesting caution in the interpretation of red trees in the aerial observations.
Figure 5: Red trees in Hardwood fingers. Figures A and B show red trees and shrubs occupying the understory of hardwood fingers surrounded by planted pine.
Figure 6: Fixed wing (light and dark yellow circles) and ground (yellow squares) field sites where red trees and tallow were observed.