TREE-RING RESEARCH, *Vol. 57(1), 2001, pp. 3–13*

TREE-RING DATING AND THE ETHNOHISTORY OF THE NAVAL STORES INDUSTRY IN SOUTHERN GEORGIA

HENRI D. GRISSINO-MAYER

Department of Geography
The University of Tennessee
Knoxville, TN 37996-0925, USA

HARRY C. BLOUNT

Department of Geography
The University of South Carolina
Columbia, SC 29208, USA

and

ALISON C. MILLER

Department of Physics, Astronomy, and Geosciences
Valdosta State University
Valdosta, GA 31698, USA

ABSTRACT

Since the mid-1700s, slash (*Pinus elliottii* Engelm.) and longleaf (*Pinus palustris* Mill.) pines growing in the coastal plain region of the southeastern United States were intentionally wounded ("boxed" and/or "chipped") to induce the production of resin, which was then collected and distilled into turpentine and its derivatives (termed "gum naval stores"). Relicts from this once-dominant industry are seen throughout southern pine forests as boxed and chipped stumps or (rarely) still living trees. In this study, we dated the years of chipping on slash pines growing in two locations in Lowndes County, Georgia, to (1) better understand past forest land use patterns, and (2) raise public awareness of the ethnohistorical importance of these trees to the cultural heritage of southern Georgia. We collected cores from ten living trees with characteristic chipped surfaces ("catfaces") from Taylor-Cowart Memorial Park (TCMP) in Valdosta, Georgia, and cross sections from ten chipped stumps in the area surrounding Lake Louise, 12 km south of Valdosta. We conclude that chipping at TCMP occurred in 1947–1948, while two chipping events occurred at Lake Louise around 1925 and between 1954–1956. Our dating was facilitated by observing periods of growth suppression, distorted and/or discolored rings, and the absence of some growth rings that may indicate possible chipping events. We recommend that these chipped stumps and living trees be preserved intact for their ethnohistorical significance, educational importance, and potential for future research.

Keywords: turpentine industry, gum naval stores, slash pine, *Pinus elliottii* Engelm., Georgia, southeastern US.

INTRODUCTION

The term "naval stores" is used to describe the first and longest-lasting commercial industry in North America (Butler 1998). As early as 1605, English colonists in the eastern United States collected resin from pine trees that were "boxed" or "chipped" (*i.e.* removal of bark, phloem, and usually the outer xylem) with axes (Veitch 1936; Malone 1964; Frost 1993; Butler 1998). Today, relict stumps and living trees are occasionally encountered in second- and third-growth forests through-

Copyright © 2001 by the Tree-Ring Society

out the South that display the characteristic V-shaped streaks (caused by chipping) and rusted metal gutters (that routed resin to cups). These trees and stumps serve as unrecognized historic memorials of an industry that helped support the southern states during the difficult period of reconstruction that followed the American Civil War (Veitch 1936; Forney 1987; Branch and Persico 1990).

In physical appearance, the chipped longleaf and slash pine trees of the coastal plain region resemble the ponderosa pines (*Pinus ponderosa* Dougl. ex. Laws.) and other tree species that were debarked (or "peeled") by Native Americans throughout western North America (Swetnam 1984; Towner *et al.* 1999; Kaye and Swetnam 1999). Such trees are known as culturally modified trees, or CMTs (Stryd 1998). CMTs are archaeologically important because they provide critical information for understanding Native American subsistence patterns, migration patterns, religious practices, and medicinal practices. Although not fashioned by Native Americans, chipped longleaf and slash pines have been culturally modified. These chipped CMTs stand as reminders of the once-dominant naval stores industry and to the type of work that employed many people in the pine savannas of the coastal plain for several hundred years. Tree-ring dating of chipping events could reveal not only when the industry was practiced within a certain area, but also emphasize the ethnohistorical significance of these trees to the cultural heritage of the coastal plain region.

The discovery of chipped stumps and living trees in protected areas in Lowndes County, Georgia, provided an opportunity to use tree-ring dating techniques to learn about past land use practices, and to study the impact of human disturbances on forest ecosystems. The goals of our study were to (1) determine the dates of modification of chipped stumps and living trees, (2) apply these data to better understand past forest use patterns in the area, and (3) create public awareness concerning the significance of these stumps and trees to the cultural heritage of south Georgia. Furthermore, these relict trees and stumps could serve to educate students in the geosciences by simultaneously teaching basic principles of dendrochronology, biogeography, and ecology.

ETHNOHISTORY OF THE NAVAL STORES INDUSTRY

The original method used for producing resin during the Colonial period was to burn the base of the tree, thus causing the pine to exude crude gum that was collected in a hole dug beside the tree (Herndon 1968; Butler 1998). To prevent debris from collecting in the resin, a new method was later adopted that used a cavity called a "box" cut into the base of the tree (Schorger and Betts 1915; Veitch and Grotlisch 1921; Snow 1949; Dyer 1960; Butler 1998) (Figure 1). Above the box, workers would "streak" the tree once a week during the growing season with a special ax called a "hack" (Snow 1949). The lower portion of this worked area was called a "catface," while the entire streaked surface was called a "face" (local people still refer to standing trees as "catheads"). This "boxing" method of collecting crude gum dominated the naval stores industry in the US for 300 years until *ca.* 1900. As early as 1715, this method was recognized as a waste of forest resources because of its destructiveness to individual trees and depletion of entire forests (Snow 1949; Wright 1979; Butler 1998).

The intentional wounding of pines caused large amounts of resin to be produced (Veitch and Grotlisch 1921; Gerry 1922; McReynolds *et al.* 1989; Butler 1998), perhaps as a defense mechanism by the tree to inhibit additional internal damage from disease and insects (Verrall 1938). In fact, the first streak made on the tree was called the "healing" streak for this very reason (Shelton 1976). Turpentine was distilled from the resin collected from living trees (Veitch 1936; Perry 1968; Wright 1979) to create spirits of turpentine, rosin, soap, varnish, candles, and pine oil (Butler 1998). This process comprised the "gum naval stores" industry. Resin was also distilled from dead resinous pines (called "lightwood") collected on forest floors to create tar (Wright 1979; Butler 1998), the "wood naval stores" industry. Tar was used as a lubricant or further distilled (actually burned) into pitch and used to coat and seal gaps between tim-

Figure 1. A worker "boxing" the base of a pine tree *ca.* 1903. The basal cavity will collect resin that exudes from streaks that will eventually be cut at angles into the tree above the cavity (from Butler 1998).

bers of sailing vessels (Herndon 1968; Perry 1968). Pitch was a necessity on every wooden sailing ship (hence the term "naval stores") to ensure a water-tight vessel, to protect the wood from shipworms, and to coat and protect the sails. Tar and pitch comprised two of the major exports to England during the Colonial Period (Malone 1964; Herndon 1968; Butler 1998).

After the Revolutionary War, New England and central Atlantic forests became depleted of trees necessary for the production of resin (Malone 1964; Wright 1979; Butler 1998), and the industry moved southward into the extensive longleaf pine forests that stretched along the Atlantic and Gulf coasts from southeastern Virginia to eastern Texas (Veitch 1936; Malone 1964). Longleaf pine soon became the preferred tree species for the production of resin (Perry 1968; Frost 1993; Butler 1998). By 1850, North Carolina (the "Tar Heel State") became the leading supplier of naval stores (Perry 1968; Thomas 1977; Frost 1993), but depletion of its forests soon caused workers to migrate southward. Between 1869–1879, South Carolina was the industry leader in gum naval stores (Perry 1968; Butler 1998). As early as 1849, the naval stores industry reached Georgia near coastal Savannah (Perry 1968), although tar and pitch had been produced in small quantities for export since the pre-Revolutionary War period (Herndon 1968). Between 1889–1899, Georgia was the leading supplier of gum naval stores (Perry 1968; Thomas 1977). Eventually, Florida capitalized on its extensive longleaf pine forests in the northern and central portions of the state, and led the industry in production between 1899–1909 (Perry 1968). Beginning in the 1920s, Georgia again assumed dominance in the industry, and continues to produce the majority of gum resin in the United States.

Beginning in the mid-1800s, petroleum-based products supplanted the need for tar and pitch. In addition, the turpentine industry also declined, initially from competition with the wood naval stores industry (Thomas 1977), and later (mid-20th century) because the prolific pulp and paper mills could more easily distill turpentine (called "tall oil") as a by-product of the pulping process (Butler 1998). As early as 1920, the naval stores industry was regarded as a dying industry (Range 1954), despite efforts to salvage the industry by such organizations as the American Turpentine Farmers Association (ATFA), which formed in the late 1930s in Valdosta, Georgia (Thomas 1977; Gerrell 1997). The production of gum naval stores remained a major employer in Georgia until the 1960s, largely by exploiting planted second- and third-growth slash pine forests that emerged following the near-destruction of the longleaf pine forests (Wright 1979). Beginning in the 1950s, economic growth in the Southeastern US focused on the pulp and paper industry, and the once-vast longleaf pine forests that dominated the pre-settlement landscape in the coastal plain were soon replaced by heavily managed plantations of slash pines. Today, 19 gum producers remain working 14 crops, all located in southern Georgia (Butler 1998).

The early process of "boxing" was highly destructive as trees were weakened and vulnerable to wind damage, insects, and disease (Schorger and Betts 1915; Westveld 1935; McReynolds *et al.* 1989). By 1903, a new method of collecting crude gum was developed that used gutters to route the flowing gum into hanging cups (Figure 2) (Thomas 1977; Gerrell 1997; Butler 1998). Beginning in the early 1940s, a spray (and later a paste) containing a sulphuric acid mixture was applied directly to the new streak (Ostrom 1945; Snow 1949), eliminating the need for chipping deeply into the xylem. This process increased gum production (by keeping resin ducts from clogging) and ensured preservation of the wood for lumber (Thomas 1977). During the same period, turpentiners in some areas of the Southeastern US chipped trees using long vertical streaks called "French faces" to increase gum yield and maintain tree vigor (Harper 1931; Westveld 1935). Eventually, most chipped pines were logged above the face 5–10 years after first being streaked.

STUDY SITES

Taylor-Cowart Memorial Park (TCMP) is a maintained municipal park located within the city limits of Valdosta, Georgia (Figure 3). The park contains several large-diameter slash pines that were once chipped for turpentine as noted by the V-shaped streaks with rusted metal gutters still attached. Surprisingly, these trees were not soon logged, the common fate of most pines chipped for turpentine. Most of the pines at TCMP contained extensive interior decay and could be considered structurally unsound. This decay likely occurred because the intentional wounding of the bark, phloem, and xylem by chipping facilitated the entrance of decaying fungi.

Lake Louise is a nutrient-poor, acidic, blackwater sinkhole lake located 12 km south of Valdosta, Georgia (Figure 3). The lake is best known for sediment cores collected for palynological reconstructions of the vegetation that existed in the coastal plain region during the late Pleistocene/early Holocene (Watts 1971; Wright 1974). Most of the littoral zone surrounding the lake consists of perennially saturated wetlands surrounded by sand ridges. Pre-settlement forests on these upland surfaces typically supported vast forests of longleaf pines, but this ecosystem is now considered perhaps the most decimated of all North American ecosystems (Landers *et al.* 1995; Means 1995; Platt 1999). The absence of repeated low-intensity surface fires has hindered successful establishment of longleaf pines (Frost 1993), although recent prescribed burns have caused the re-establishment of some longleaf pine seedlings. All trees are second- and third-growth following extensive logging that began in the late-1800s (Platt 1999), due in large part to the completion then of an extensive network of rail lines that penetrated deep into coastal forests (Westveld 1935). Past human disturbances in the immediate vicinity include construction of extensive unmaintained dirt roads and fire breaks, logging, turpentining, agriculture, and livestock grazing.

On the southeastern side of the lake, we discovered many 1–2 m high slash pine stumps that had been chipped. In the absence of fire, the faster-growing slash pine regenerates well and replaces longleaf pine as the dominant pine species. Slash pine was also preferred for its greater production of crude gum compared to longleaf pine (Shelton 1976). Some stumps contained two or more faces

Figure 2. Streaked pine trees with the cup and gutter system used later after the practice of boxing the base of the trees declined (from Butler 1998).

fashioned during the same or subsequent seasons, whereas other stumps suggested a considerable number of years (15–30) had lapsed between chipping. These stumps represent a forest once dominated by pines, but which now consists of a mixed hardwood forest that shows little evidence of successful pine re-establishment. The decline in pine density is likely due to fire exclusion since the end of the naval stores industry, because pine species found in the Atlantic coastal plain region are highly adapted to repeated low-intensity surface fires (Wright and Bailey 1982). Fire was routinely used to clear areas around trees from which gum was to be extracted (Butler 1998).

METHODS

Field Methods

At TCMP, we used a 50 cm Haglof increment borer to extract cores from trees that displayed

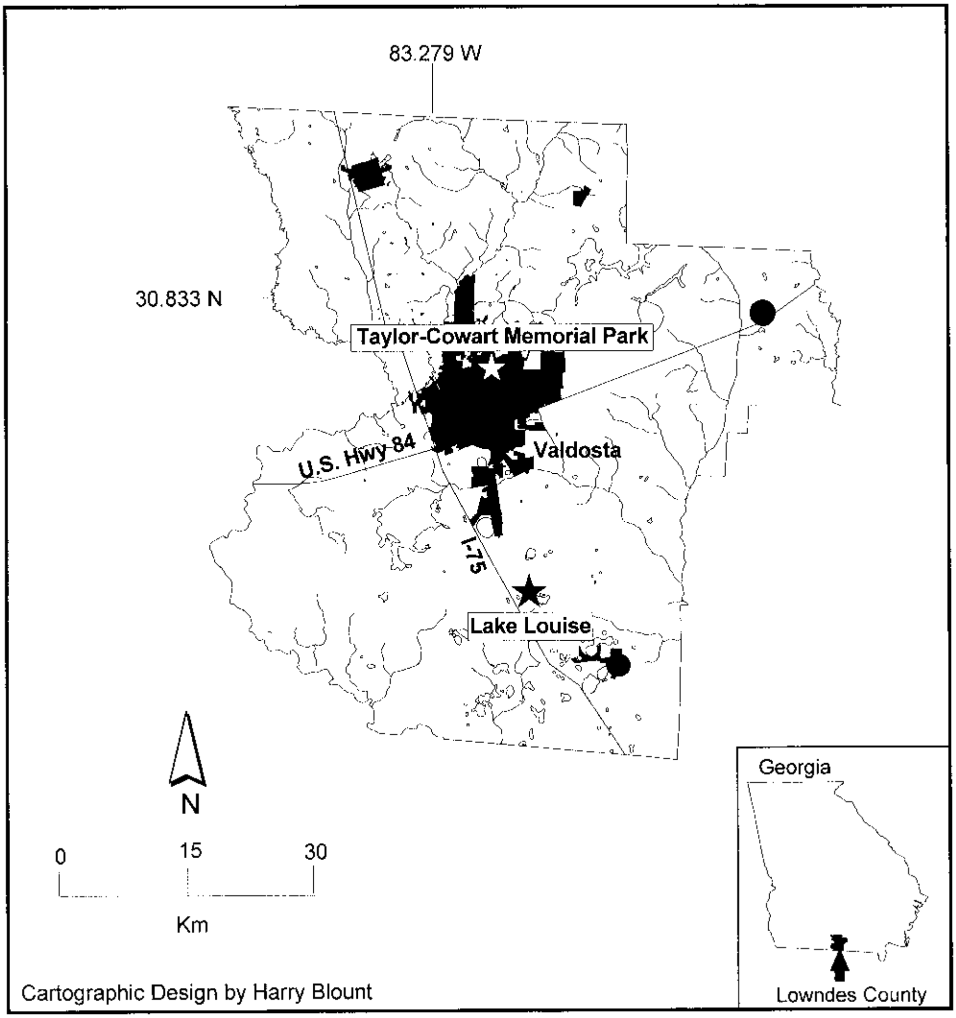

Figure 3. Location of the two study sites within Lowndes County.

chipped surfaces. At least one core was extracted through the scar surface itself. Another core was extracted opposite from the chipped surface, extending through the tree to the chipped surface on the other side. In this way, at least two sound cores were obtained with the chipped surface attached. Additional cores were extracted on either side of the chipped surface through the curl of the overgrowing tree tissue. Care was taken to avoid the metal gutters that now are often embedded into the tree itself. Cores were placed in paper straws and labeled, and information on the individual trees (including diameter at breast height, approximate height, and crown condition) was recorded on a standard form. A sketch of the surrounding area included a relative location of the tree to other prominent features and other sampled trees within the study area.

At Lake Louise, we located suitably sound stumps and obtained cross-sections from ten chipped trees with a chain saw. Occasionally, two sections were collected, one low near the base and another higher up the trunk. We found that sections taken lower on the tree were often more sound than sections taken higher. Sections were then labeled and wrapped in strapping tape to minimize breakage. To facilitate crossdating, six cores were extracted from one living chipped slash pine to help verify the chipping dates on the cross sections. All relevant tree and sample information was recorded on a standard form.

Laboratory Methods

All cores were air-dried for 3–5 days, then glued to grooved core mounts and secured with masking tape. To ensure maximum ring definition, care was taken to ensure that all cores were mounted with cells vertically aligned (Stokes and Smiley 1968). Cross sections were first cut using a band saw to dimensions suitable for microscopic study. We then sanded all cores and cross sections with a belt sander using progressively finer grit sand paper, beginning with a 40 grit and ending with a 320 grit. This procedure produced a clean, blemish-free surface that ensured the cellular structure of the rings would be visible under standard 10× magnification. We crossdated all tree rings from both sites using skeleton plots (Stokes and Smiley 1968; Swetnam *et al.* 1985) compared against a longleaf pine master chronology created previously for the south Georgia area (Palik and Pederson 1996, on file at the International Tree-Ring Data Bank in Boulder, Colorado). We next recorded the outermost date on the chipped surface, the outermost ring on the tree, the innermost ring on the tree, and an estimated pith date when possible. We used program FHX2 (Grissino-Mayer, 2001) to generate graphs showing the temporal distribution of chipping dates and injuries related to the chipping process.

RESULTS

Taylor-Cowart Memorial Park

Although each individual core did not necessarily contain a scar, we were still able to determine dates for chipping by observing (1) distorted, irregular ring widths, caused by the curling of overgrowth xylem around the callous tissue, (2) abrupt growth suppression for one or more years following chipping, (3) one or two missing rings following chipping, and (4) discoloration of rings due to excessive resin production. In general, the most common response by these pines to chipping was growth suppression, sometimes lasting 3–6 years (see *e.g.* Gerry 1922; Schopmeyer 1955). For example, TCP001 contained a scar dated at 1940. However, a severe growth reduction occurred from 1947–1955 on two of the five cores extracted from this tree. TCP006 displayed very narrow rings in the early 1950s due to an injury the tree received sometime prior to 1950. The rings for 1948–1949 on TCP008 were barely distinguishable due to the injury from chipping. We are confident that these narrow rings were not caused by climate because the master dating chronology for the area shows no such reduction in growth among other trees during this interval.

The narrow rings with faint latewood we termed "chipping rings." The degree of suppression, however, varied considerably within and between trees. Within a single tree, a core taken near the chipped surface may display considerable suppression beginning in the late 1940s, but a core taken away from the chipped surface may show no evidence of suppression whatsoever. On some trees, all cores showed some degree of growth suppression, but all cores from other trees showed only minimal effects due to chipping. These differential responses by pines to chipping may have occurred due to the varying age, size, and vigor of the trees at the time of chipping, as well as by the width and depth of the streaks (see *e.g.* Schopmeyer 1955).

All but two trees yielded a dated scar surface that indicated chipping occurred sometime between 1940–1949 (Figure 4). Several pines had chipped surfaces dated at 1947, while a core from one pine, TCP004, contained irrefutable evidence of a chipping date of 1948. The position of the scar within the ring suggests chipping occurred in the spring of 1948 during the early portion of the growing season. Historical records on naval stores production confirms that chipping began during the early spring (Butler 1998). Trees TCP002 and TCP006, which did not contain a clear datable surface on any of their cores, did contain indirect evidence of chipping as noted by excessive resin production within the tree rings following the chipping event. We are confident that these lines of evidence suggest chipping dates of 1947–1948 for the pines at Taylor-Cowart Memorial Park.

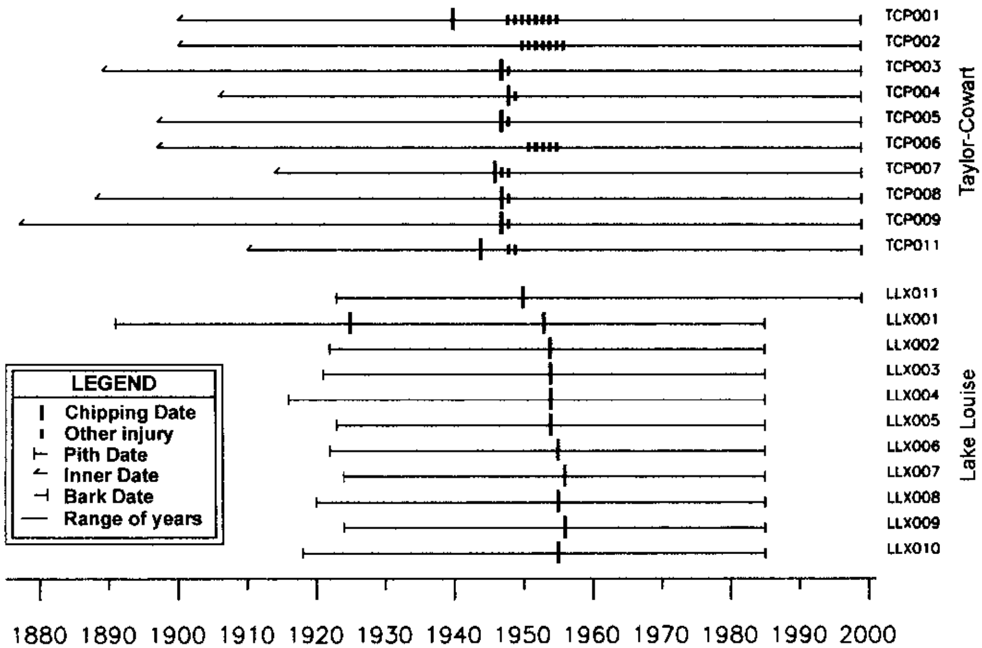

Figure 4. Chipping dates for slash pine trees at TCMP and Lake Louise. Each horizontal line represents the period spanned by an individual tree. Long vertical bars represent the year of the chipped surface, while short vertical bars indicate an injury related to the chipping process (growth suppression, missing rings, discoloration, and excessive production of resin).

Lake Louise

The major chipping event at Lake Louise occurred between 1954–1956 (Figure 4) as indicated by the outermost rings on the chipped surface on most samples. The majority of cross sections, however, suggests the likeliest year for the initial chipping was 1954, followed by 1955. These dates confirm historical documents and oral interviews with local residents that revealed these trees were chipped from 1954–1956. We also found an earlier chipping event that occurred in 1925 on sample LLX001. This corroborates the historical observation that certain larger diameter pines with healthy crowns were often used more than once by turpentiners (Schorger and Betts 1915; Veitch and Grotlisch 1921; Westveld 1935), and this tree may represent such reuse. This tree was at least 35 years old at the time of the 1925 chipping event. All other sampled pines were still juveniles (probably 2–5 years old, based on age at sampling height) at the time of the 1925 chipping, and were too young and too small to be effective gum producers (Butler 1998).

DISCUSSION

The dates for chipping at TCMP and Lake Louise indicate the naval stores industry was present in Lowndes County as late as the 1940s–1950s. These pines, however, were utilized in the later years of the turpentine industry, which ceased to operate in the county by 1960. The pines at TCMP were chipped, but not harvested, contrary to the usual logging that soon occurred after the trees no longer produced sufficient gum. We also observed that the pines at Lake Louise had significant overgrowth around the chipped surface, suggesting these trees remained standing for several decades after chipping. Interviews with local residents confirmed that these pines were not harvested until the mid-1980s (J. T. Brown, personal communication). The fact that the pines at both sites were not logged soon after gum extraction corroborates ethnohistorical data that indicate the industry died out in the area shortly after chipping (Butler 1998), and the properties passed into the hands of non-industry interests.

Rather than finding a clearly defined year for a single chipping event at both sites, we instead found a range of dates for the chipped surfaces that likely occurred due to two reasons. First, historical records clearly show that pines used in the naval stores industry were chipped for 2–10 growing seasons. Therefore, the initial chipping event at TCMP most likely occurred in 1947, while the 1948 date represents chipping in the second year for the stand. At Lake Louise, 1954 was the most likely year of chipping for most of our sampled trees, while 1955 represents the second year of chipping. Second, the chipping process itself removed xylem along with the bark and phloem. This removal of rings would contribute to a range of chipping dates because of variation in the dates for the outermost ring. Surprisingly, our sample trees were clearly streaked with significant removal of interior wood, despite the fact that turpentining with a sulphuric acid spray, which began in the 1940s, required only debarking.

The chipped stumps sampled at Lake Louise were remarkably sound, largely resulting from the excess production of resin due to the chipping process itself. When a pine is injured (as during chipping or due to fire), traumatic resin ducts are formed, often in groups within the annual ring (Schorger and Betts 1915; Gerry 1922; Dyer 1960). Eventually, the xylem becomes saturated with resin, a process known as resinosis, which occurs behind the wound site and extends radially towards the pith (Hays and Cottle 1989). Vertical resin ducts increase by as much as ten fold 0.5–1.0 m above the wound site, and these ducts are interconnected in the radial direction with horizontal resin ducts (Snow 1949; Dyer 1960; McReynolds *et al.* 1989). The result is pine wood that is extremely dense, highly resinous, and very impervious to decay agents. This resinous wood was often used as an illuminant and for kindling, and is known throughout the coastal plain region as "lightered wood," "lightwood," or "fatwood." The collection and distillation of this lightwood made up the wood naval stores industry. In southern pines, resinosis is usually indicative of damage due to diseases, such as root-infecting fungi in longleaf pine, which has been implicated as a contributor to the overall decline in numbers of longleaf pine (Otrosina *et al.* 1999).

In addition to their ethnohistorical significance, chipped trees are also important because they can be used by educators to teach basic principles of ecology, biogeography, and dendrochronology. We have used such trees to reinforce the importance of reading the natural and cultural landscape, and to help students of the environmental sciences recognize features that lead to improved interpretations of ecosystem processes. Students therefore gain a better understanding of past forest use practices that include what may now be considered a non-traditional use (*i.e.* naval stores). Coastal areas of Florida, South Carolina, North Carolina, Alabama, Mississippi, and Georgia are all potential sources of future research concerning tree-ring dating of chipped pine trees. The potential also exists for locating original old-growth longleaf pines in the coastal plain region that were chipped, some of which may approach 450–500 years in age. Because such trees are highly resinous due to the chipping, their preservation qualities may be enhanced, and may be valuable for clarifying episodes of century-scale climate change in the southeastern United States.

Few people today, however, can recognize a chipped pine tree, much less the heritage it represents. We believe that chipped pine trees should be officially recognized as cultural landmarks to help ensure their protection from unnecessary destruction. The remaining living chipped pines are quite rare in the heavily managed, forested landscape of the coastal plain region, and every effort possible should be made to preserve them. Such trees could be vital in programs that seek to preserve the cultural heritage of the naval stores industry (see *e.g.* Carlton and Ferguson 1977; Forney 1987; Branch and Persico 1990). We have discovered two rare box-cut stumps in the dense forests surrounding Lake Louise, including one with two box cuts at the base of what once was a slash pine approximately 120 cm in diameter. These will be cordoned off along a proposed nature trail, and used to teach future visitors about the once-dominant industry of coastal Georgia and the unique cultural heritage it fostered.

ACKNOWLEDGMENTS

Our interest in the tree-ring dating of pines used in the naval stores industry and the use of lightered pine wood in dendrochronology was inspired by Jake Huffman, Professor Emeritus of Forestry at the University of Florida, Gainesville. Stacy Carnine and Jeffrey Givens conducted the initial study at TCMP to help develop a master reference chronology. Vickie Holton helped survey the site at Lake Louise and gathered information on the history of Lake Louise via interviews with local residents. Jeff Tepper was invaluable for his advice concerning the Lake Louise Research Station, and for his help and support in the field and in the laboratory. Jessie Brown provided valuable information on the location of chipped stumps on his property, gave permission to sample on his property, and provided information on methods used in the turpentining industry when he was younger. Permission was granted to sample at TCMP by the City of Valdosta's Parks, Recreation, and Community Affairs Department, to whom we are grateful.

REFERENCES CITED

Branch, R. G., and R. Persico, Jr.
1990 Catface country: A case study in cultural conservation. In "Cultural Heritage Conservation in the American South," edited by B. J. Howell, pp. 87–95. *Southern Anthropological Society Proceedings* 23. The University of Georgia Press, Athens.

Butler, C. B.
1998 *Treasures of the Longleaf Pines: Naval Stores.* Tarkel Publishing, Shalimar, Florida.

Carlton, C., and D. Ferguson
1977 Making tar. In *Foxfire 4,* edited by E. Wigginton, pp. 252–256. Anchor Press, Garden City, New York.

Dyer, C. D.
1960 *The Physiology and Management of Naval Stores Pines and the History of the Naval Stores Industry.* M.F. thesis, The University of Georgia, Athens.

Forney, S. J.
1987 The importance of archeological sites related to the naval stores industry in Florida. In "Current Topics in Forest Research: Emphasis on Contributions by Women Scientists," pp. 105–107. USDA Forest Service, *General Technical Report* SE-46.

Frost, C. C.
1993 Four centuries of changing landscape patterns in the longleaf pine ecosystem. In "The Longleaf Pine Ecosystem: Ecology, Restoration, and Management," edited by S. M. Hermann, pp. 17–43. *Proceedings of the Tall Timbers Fire Ecology Conference* 18.

Gerrell, P.
1997 *The Illustrated History of the Naval Stores (Turpentine) Industry.* Southern Yellow Pine Publishing, Crawfordville, Florida.

Gerry, E.
1922 Oleoresin production: a microscopic study of the effects produced on the woody tissues of southern pines by different methods of turpentining. United States Department of Agriculture *Bulletin* 1064.

Grissino-Mayer, H. D.
2001 FHX2—software for analyzing temporal and spatial patterns in fire regimes from tree rings. *Tree-Ring Research* 57(1):115–124.

Harper, V. L.
1931 French face experiments in turpentining. *Journal of Forestry* 29:225–232.

Hays, J. T., and W. Cottle
1989 New sources. In *Naval Stores: Production, Chemistry, and Utilization,* edited by D. F. Zinkel and J. Russell, pp. 200–221. Pulp Chemicals Association, Atlanta, Georgia.

Herndon, G. M.
1968 Naval stores in colonial Georgia. *Georgia Historical Quarterly* 52:426–433.

Kaye, M. W., and T. W. Swetnam
1999 An assessment of fire, climate, and Apache history in the Sacramento Mountains, New Mexico. *Physical Geography* 20(4):305–330.

Landers, J. L., D. H. Van Lear, and W. D. Boyer
1995 The longleaf pine forests of the Southeast: requiem or renaissance? *Journal of Forestry* 93(11):39–44.

Malone, J. J.
1964 *Pine Trees and Politics: The Naval Stores and Forest Policy in Colonial New England, 1691–1775.* University of Washington Press, Seattle.

McReynolds, R. D., S. V. Kossuth, and R. W. Clements
1989 Gum naval stores methodology. In *Naval Stores: Production, Chemistry, and Utilization,* edited by D. F. Zinkel and J. Russell, pp. 84–121. Pulp Chemicals Association, Atlanta, Georgia.

Means, D. B.
1995 Longleaf pine forest, going, going .... In *Eastern Old-Growth Forests: Prospects for Rediscovery and Recovery,* edited by M. B. Davis, pp. 210–229. Island Press, Washington.

Ostrom, C. E.
1945 Chemical boosters provide more gum from southern pine. *Chemurgic Digest* 4(14):240–243.

Otrosina, W. J., D. Bannwart, and R. W. Roncadori
1999 Root-infecting fungi associated with a decline of longleaf pine in the southeastern United States. *Plant and Soil* 217(1–2):145–150.

Palik, B. J., and N. Pederson
1996 Overstory mortality and canopy disturbances in longleaf pine ecosystems. *Canadian Journal of Forest Research* 26(11):2035–2047.

Perry, P.
1968 The naval-stores industry in the Old South, 1790–1860. *The Journal of Southern History* 34(4):509–526.

Platt, W. J.
1999 Southeastern pine savannas. In *Savannas, Barrens, and Rock Outcrop Plant Communities of North America*, edited by R. C. Anderson, J. S. Fralish, and J. M. Baskin, pp. 23–51. Cambridge University Press, New York.

Range, W.
1954 *A Century of Georgia Agriculture: 1850–1950*. The University of Georgia Press, Athens.

Schopmeyer, C. S.
1955 Effects of turpentining on growth of slash pine: first-year results. *Forest Science* 1(2):83–87.

Schorger, A. W., and H. S. Betts
1915 The naval stores industry. United States Department of Agriculture *Bulletin* 229.

Shelton, J. T.
1976 *Pines and Pioneers: A History of Lowndes County, Georgia, 1825–1900*. Cherokee Publishing Company, Atlanta.

Snow, A. G., Jr.
1949 Research on the improvement of turpentine practices. *Economic Botany* 3:375–394.

Stokes, M. A., and T. L. Smiley
1996 *An Introduction to Tree-Ring Dating*. The University of Arizona Press, Tucson.

Stryd, A. H.
1998 *Culturally Modified Trees of British Columbia: A Handbook to the Identification and Recording of Culturally Modified Trees*. British Columbia Ministry of Forests, Vancouver.

Swetnam, T. W.
1984 Peeled ponderosa pine trees: a record of inner bark utilization by Native Americans. *Journal of Ethnobiology* 4(2):177–190.

Swetnam, T. W., M. A. Thompson, and E. K. Sutherland
1985 Using dendrochronology to measure radial growth of defoliated trees. US Department of Agriculture, Forest Service *Agricultural Handbook* 639.

Thomas, K. H., Jr.
1977 McCranie's turpentine still: Atkinson County, Georgia. Institute of Community and Area Development, The University of Georgia, Athens.

Towner, R. H., L. Sesler, and T. Hovezak
1999 Navajo culturally modified trees in the Dinétah. In *Diné Bíkéyah: Papers in Honor of David M. Brugge*, pp. 195–209. The Archaeological Society of New Mexico.

Veitch, F. P.
1936 The naval stores industry. *Journal of Forestry* 34:230–234.

Veitch, F. P., and V. E. Grotlisch
1921 Turpentine: its sources, properties, uses, transportation, and marketing. United States Department of Agriculture *Bulletin* 898.

Verrall, A. F.
1938 The probable mechanism of the protective action of resin in fire wounds on red pine. *Journal of Forestry* 36:1231–1233.

Watts, W. A.
1971 Postglacial and interglacial vegetation history of southern Georgia and central Florida. *Ecology* 52(4):676–690.

Westveld, R. H.
1935 *Applied Silviculture in the United States*. Edwards Brothers, Inc., Ann Arbor.

Wright, G. G.
1979 *Turpentining: An Ethnohistorical Study of a Southern Industry and Way of Life*. M.A. thesis, The University of Georgia.

Wright, H. A., and A. W. Bailey
1982 *Fire Ecology: United States and Canada*. John Wiley and Sons, New York.

Wright, H. E., Jr.
1974 Landscape development, forest fires, and wilderness management. *Science* 186:487–494.

Received 7/16/00; accepted 1/05/01.