A Review

Production of Oleoresin From Southern Pine Trees

T. A. Harrington

"Pyne trees, or ffir trees, are to be wounded within a yarde of the grounde, or boare a hoal with an agar the third pte into the tree, and lett yt runne into anye thinge that may receyve the same, and that such issues owte will be Turpentyne worthe 18 pounds per Tonne. When the tree beginneth to runne softelye it is to be stopped vp agayne for preserveinge the tree."

Abstract

Developments in techniques, methods, and equipment for producing oleoresin from the living pine are discussed. Particular emphasis is given to the need for mechanized production methods if this ancient industry is to survive the competition from other sources of rosin and turpentine.

So reads an excerpt from the "Instructions for suche things as are to be sente from Virginia," drafted in 1610 to guide Captain John Smith (1). This may be the first set of instructions ever prepared by a government to instruct oleoresin[1] producers in conservative techniques for obtaining gum from the living pines. Certainly it has not been the last.

Gum production was a vital element in the utilization of our southern timberlands even in the earliest settlements. In good times and bad, pine gum, pitch, tar, spirits of turpentine, and rosin—the naval stores of our wooden sailing ships—have been an important and dependable cash crop. Furthermore, the production of oleoresin has had an enormous influence on the utilization of our trees for other products.

Only two species of southern pine, longleaf pine (*Pinus palustris* Mill.) and slash pine (*Pinus elliottii* Engelm. both var. *elliottii* and var. *densa* Little & Dorman), have ever been important for gum production. The oleoresins of the other southern pines tend to crystallize rapidly upon exposure to air and moisture, and the gum does not flow freely following regular wounding.

[1]Pine oleoresin, although not a true gum, is commonly referred to as pine gum. The terms gum and oleoresin will be used interchangeably in this review.

Oleoresin from the living pine is just one source of turpentine and rosin for the naval stores industry. Similar products can also be obtained from steam-distilled pine stumps and from the black liquor soap produced in the Kraft pulping process. Amazingly, the annual total production of these raw materials from all sources in the United States has not varied greatly over the past 70 years, averaging close to 1 billion pounds of rosin and 30 million gallons of turpentine.

Initially, all of this production came from pine gum. With the advent of steam distillation of longleaf and slash pine stumps in 1910, and the recovery of turpentine from the sulfate pulping process, beginning about 1928, the source of naval stores gradually shifted away from gum, yet in 1930, gum naval stores still accounted for

The author is Principal Silviculturist, Southeastern Forest Experiment Station, Naval Stores and Timber Production Laboratory, Olustee, Florida.

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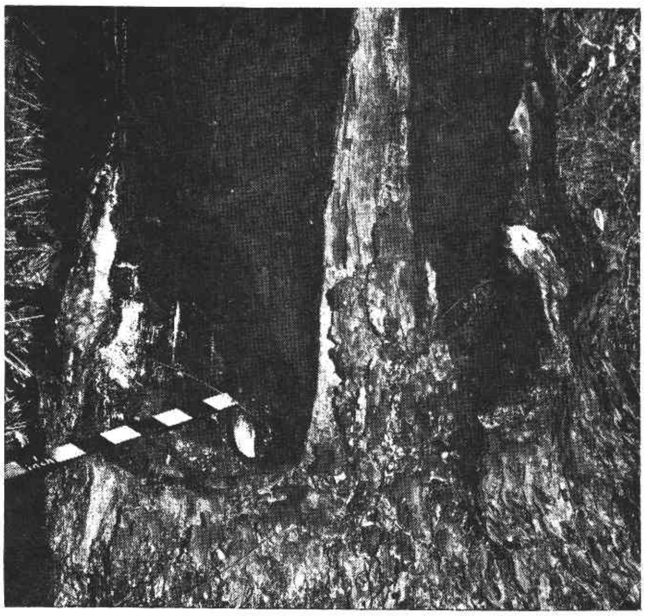

Figure 1. — Destructive cut boxes, used for more than 300 years, seriously damaged the trees and made them most susceptible to fire because of the proximity of the "gum box" to the forest floor. Worked-out trees were frequently left unharvested.

85 percent of the total production. When tall oil rosin entered the picture after World War II, the shift was rapidly accelerated. In 1950, gum furnished 40 percent of the turpentine and rosin. Production dropped to 20 percent in 1960 and to 10 percent in 1967. At the present time, steam distilled wood supplies 50 percent of the rosin and 20 percent of the turpentine. Tall oil rosin represents the final 40 percent of our rosin supply, and 70 percent of our turpentine comes from sulfate pulping (15, 22).

The reason for this shift of source is simple. Under present conditions, more than 60 percent of gum-production costs are associated with labor and supervision. Semiskilled labor cannot produce naval stores products as efficiently as highly mechanized operations and quality-controlled chemical processes. Consequently, gum rosin and gum turpentine are priced higher than nearly identical materials from other sources.

Early Production Methods

Gum farmers have been slow to seek or to accept changes in production methods. In fact, for the first 300 years, turpentining was carried out in the southeast with no changes in techniques. Nearly all the timber worked was virgin longleaf. New crops were started during the winter months by cutting one or more boxes or cavities in the base of each tree. The size of these boxes varied with the size of the timber, generally ranging from 10 to 14 inches wide, 5 to 7 inches deep, and $2\frac{1}{2}$ to $3\frac{1}{2}$ inches from front to back. The gum flowed from the worked faces into these cavities.

The regular wounding, called chipping, to stimulate gum flow was done at weekly intervals from March through October. A fresh streak 10 to 14 inches in length was chipped across each face with a wood hack. The hack cut a streak $\frac{1}{2}$ to 1 inch high, and penetrated into the xylem of the face about 1 inch. Each week the freshly applied streak was more distant from the box. The total of 32 to 34 streaks applied during a full season produced an annual face length of 20 to 30 inches.

Gum was gathered, or dipped, from the boxes every 3 to 4 weeks during the producing season. A steel dip iron was used to transfer the gum from the boxes into a bucket, and thence into barrels for delivery to the distillery. By the end of each season, a large amount of oleoresin had hardened on the face. This "scrape" was also removed and collected in barrels for distillation (25).

The disadvantages of this gum production system were numerous (Fig. 1). The boxes and deep chipping seriously reduced the vigor of the trees; windthrow was common; fire, insects, and disease caused tremendous losses; oleoresin was wasted; and a large number of semiskilled laborers were required. Each worked face was visited 40 to 50 times per season to obtain 8 to 9 pounds of crude gum.

With all these disadvantages, however, the gum naval stores industry produced an excellent cash crop for 300 years (1600-1900) from what were then classed as practically worthless timberlands. As one stand of virgin trees was turpentined, an equally good stand became available to the south or west. Even though early research by Fernow (12) proved that turpentining

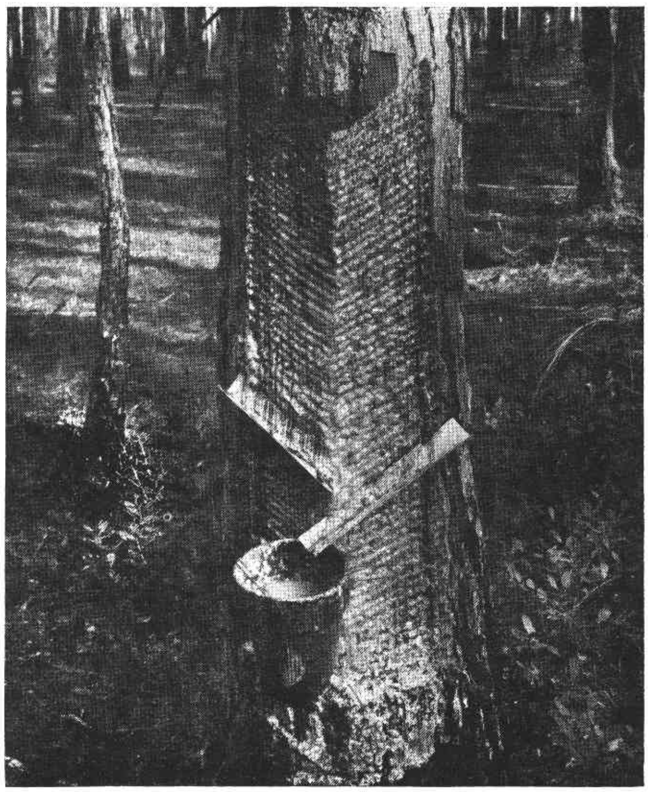

Figure 2. — The Herty system, developed in 1903, revolutionized the industry. Metal gutters were placed in incisions made with a mallet-driven broadax. Clay pots replaced the cut boxes. Although an improvement over the ancient practices, the deep chipping—about an inch into the xylem—and the broadax wounds reduced the tree's vigor. Because the heavy metal gutters were frequently left in the face, trees were generally jump-butted when harvested.

mature trees did not adversely affect the strength of the lumber, the butt cut was generally wasted or used as fuel wood. Frequently, the worked-out trees were not even harvested.

By 1900, naval stores operators finally recognized that the pine forests of the Southern States were coming to an end. If the naval stores industry was to be perpetuated, a method of gum production had to be found that was not so destructive as the chopped box.

Dr. Charles Herty revolutionized the industry in 1903 when he introduced a successful cup and gutter system to replace the cut boxes (12). Herty's system involved the use of two strips of galvanized iron, each 2 inches wide and 6 to 12 inches long (Fig. 2). The strips were placed in broadax incisions below the face to divert the gum flow into a clay pot. This system resulted in less injury to the tree, and the cup and gutters could be moved up the face each year as the chipping surface advanced.

An undesirable outgrowth of this technique was the working of small trees for gum, often as small as 6 inches in diameter. In an effort to stem these destructive turpentine practices and the rapid exploitation and depletion of the southern wood supply by all types of timber-based industries, the Forest Service established one of its first research units in Florida.

From the start, this unit had the primary objective of integrating gum and wood production into a sound management system for our southern pine forests. Beginning in 1910, the staff of the National Forests in Florida had demonstrated that high gum yields, a longer working life, and less mortality resulted from shallow and low chipping (23). Dr. Eloise Gerry furnished the scientific proof of this fact by showing that wounding stimulated the production of resin ducts above the worked face, and chipping unnecessarily high streaks wasted this gum producing tissue (13).

Figure 3. — Following World War II, spiral gutters, double-headed nails, bark chipping, and acid treatment replaced the old-time gum production methods of deep wood chipping and inserted gutters.

Further investigations by Dr. Gerry, Austin Cary, Lenthall Wyman, and other Forest Service researchers resulted in guidelines for the optimum size of streaks and chipping frequency, the tree sizes best suited to gum production, the optimum number of faces per tree, the effects of turpentining on tree growth, improved methods of cup and gutter installation, and other practical techniques for conservative gum production. This information, combined with forest management recommendations, was published as a Naval Stores Handbook (34).

Many of the techniques presented in this Handbook were put into use promptly, because of the Forest Service's Naval Stores Conservation Program in cooperation with the Agricultural Stabilization and Conservation Service. Starting in 1936, this very effective program distributed small incentive payments to gum producers for the adoption of good management practices. N.S.C.P. Foresters gave on-the-ground assistance to timberland owners and gum producers. The program played a major role in teaching producers to work only trees 9 inches d.b.h. and larger, to adopt other conservation practices, and to manage their timber stands for the production of both gum and wood.

Development of Modern Methods

This period also marked the beginning of more modern methods of gum production. Research on chemical gum flow stimulants by Russian and German scientists precipitated similar investigations by the Forest Service at Olustee, Florida, in 1936. At that time rosin and turpentine were in surplus supply, and no one was interested in new techniques for increasing production. However, war demands for naval stores soon exceeded supply, and research on chemical stimulation was increased in 1942.

For longleaf and slash pine, a 50-percent water solution of sulfuric acid, applied to fresh wounds every 2 weeks, proved to be the most suitable treatment (31, 32, 33). Physiological studies found that the acid did not stimulate the production of oleoresin, but merely facilitated the outflow by prolonging the time during which the resin ducts remained open after wounding (24). In addition, Snow (31) found that removing a narrow strip of bark across the face was the only wound needed in conjunction with sulfuric acid. Because deep wood chipping was not necessary, he devised a new hack that would cut only through the bark and phloem, instead of deep into the xylem. Bark chipping was easier than deep wood chipping. With acid stimulation, faces were only chipped at 2-week intervals and man-day production for chipping laborers was virtually doubled.

Many people worked on techniques for applying the acid to the fresh wound. At first, cloth swabs and insect sprayers of the "flit gun" type were used. Next, a glass or lead "lung-powered" spray gun was developed by Bourke and Dorman (5). From this research, the presently used plastic squeeze bottle evolved (27, 28).

Other important developments during this period also contributed greatly to the naval stores industry. Figure 3 shows the system used after World War II. New spiral gutters and curved aprons, attached to the round faces with double-headed nails, suitably deflected gum into the cups, were easily removed from the worked-out trees, and had virtually no adverse influence on tree vigor (26). Larger turpentine cups reduced dipping expenses without affecting gum yield or grade (9). To assist the producers, manuals were prepared that described currently accepted methods (7, 11).

These new production techniques have had a profound effect on the utilization of faced timber. When deep chipping and inserted gutters or cut boxes were used, the heavily scarred butt portion of the worked-out tree was considered worthless. With bark chipping, acid treatment, and removable gutters, the face is not severely damaged by the wounding. The worked-out butt section, if free of metal, can now be readily used for pulpwood, poles, ties, or lumber (2, 14, 30, 33).

Management Practices

Although chemical stimulation and nail-on gutters do not seriously reduce the tree's vigor, they do have about the same effect on tree growth as the old technique of wood chipping (6, 16, 30). A good rule of thumb is that one face will reduce volume growth about 25 percent each year the tree is worked, and two faces will reduce growth about 50 percent. Table 1 illustrates how the value of gum produced easily compensates for any reduction in overall wood volume. Of course, to minimize growth effects, the worked-out tree must be cut promptly at the end of the naval stores cycle.

Table 1. — VALUES OF GUM YIELD COMPARED WITH VALUES OF DEFICIT IN WOOD VOLUME PRODUCED BY WORKING SINGLE FACES ON SLASH PINE.

Volume and value variables		D.b.h. of tree at start of gum production		
		10 inches	12 inches	14 inches
Total height	(feet)	66	72	74
Merchantable volume[1]	(cords)	0.198	0.318	0.437
Expected annual volume increment of an unworked tree[1]	(cords)	.0132	.0149	.0185
Annual volume deficit of a turpentined tree[1]	(cords)	.0033	.0037	.0046
Annual gum yield per tree[2]	(pounds)	9.9	13.1	16.3
Value of annual volume deficit[3]	(dollars)	.04	.04	.06
Net value of annual gum yields per tree[3]	(dollars)	.13	.18	.22

[1]Based on local volume tables for Olustee Experimental Forest, Baker County, Fla., using 90 as factor to convert cubic feet to cords.

[2]Data are from Bengtson and Schopmeyer (3), and values are based on a 30-percent crown ratio.

[3]Based on pulpwood at $12 per cord, stumpage, and gum at $30 per barrel (435 lb.). Trees are normally leased for gum production at a lease rate of 20 percent of the gross value of the gum produced.

Table 2. — FIRST-YEAR GUM YIELDS FROM A CROP OF 10,000 FACES ON SLASH PINES.[1]

D.b.h. (inches)	Gum yields by crown ratios of— 0.20	0.40	0.60
		Barrels	
9.0	172	208	244
10.0	209	245	281
11.0	246	282	318
12.0	283	319	355
13.0	320	356	392
14.0	357	393	429
15.0	394	430	466

[1]Data are from Bengtson and Schopmeyer (3). Trees were single-faced and treated with 16 biweekly streaks. Gum yields are given in standard barrels of 435 pounds each.

With the current turpentining practices, good timber management and pine gum and wood are now compatible products in the Southeast. The production of gum and wood makes a more profitable operation than the production of either product alone (4). Even-aged management is best because adequate numbers of trees of suitable size are available at several periods during the life of the stand, and a cycle of regular rough-reduction burning is possible (10).

Trees should be selected for cupping at least a naval stores cycle in advance of any anticipated thinning or the harvest cut. Naval stores cycles are commonly 4 years in length, 2 years on the front face, and 2 years on the back face. Some cycles may run 6 to 8 years or longer. The cupped trees must be 9 inches d.b.h. or larger, with a minimum live crown ratio of 30 percent. Stocking should be regulated during the life of the stand to maintain at least this amount of crown. The importance of diameter and crown development to gum yield is shown in Table 2 (3).

A minimum of 20 faces per acre, capable of yielding in excess of 200 standard barrels (each 435 pounds net) of crude gum per crop of 10,000 faces per year, is required for an operable naval stores chance. Considering the investment in the present cup and gutter system, trees should be worked at least 2 years.

Logging should be restricted in and adjacent to stands currently being worked for gum to minimize the hazards of a buildup in bark beetle populations. These timber stands should also receive extra fire protection. A hot wildfire can put the gum producer out of business and force an early harvest of the timber. If the timber stand suffers defoliation and severe stem burn, gum production should be discontinued. Fire-injured trees yield little gum and are highly susceptible to attacks by bark beetles (17). However, under present naval stores practices and in the absence of wildfire or bark beetle epidemics, the mortality in naval stores stands is not significantly different from normal mortality in unworked stands.

Future of the Industry

Even though oleoresin production can be fitted easily into integrated multiple products management and is an important contributor to our rural economy, the gum naval stores industry appears to be failing rapidly. Low-grade gum is being produced because of iron contamination from old cups and sloppy woods work. High costs and a rapidly dwindling supply of laborers make gum production a rather unattractive business. Currently, two man-days of hard work and 10 miles of walking are required to produce each barrel of crude gum. Naval stores laborers are finding easier ways of making a living. A practical system of mechanization is badly needed if the naval stores industry is to survive (18, 20).

In 1966, sulfuric acid paste was introduced as a relatively safe chemical stimulant for prolonging gum flow up to 28 days (8). This new acid formulation will produce good gum yields with a monthly chipping interval and again double the man-day production of chipping laborers. Supervision is greatly simplified because the bead of paste can be easily seen. Also, the paste is easier to apply correctly, gives more uniform stimulation, and is safer than the acid water spray (19).

Because the acid paste stays in place on the face, ordinary materials can now be used to collect the gum. At this time, 1-gallon disposable paper gum bags are being evaluated on commercial operations (Fig. 4). The containers are larger than the presently used metal cups, and only 4 dippings will be necessary during the season instead of the usual 8 or 9.

Figure 4. — Acid paste is safer to use, and it stimulates gum flow for longer periods than does the acid-water solution. Chipping and streaking can be done on a monthly basis, rather than every 2 weeks. When paste is used, materials other than metal—such as this disposable paper bag—can be used to collect the gum.

These bags are attached to the face with staples; the operation lends itself to mechanization. The bags are lightweight, easy to store and transport, do not contaminate the gum, require only a small initial investment, and do not need aprons or gutters. The soft staples should not constitute a hazard to saws or knives when the trees are later processed into other timber products.

The bag is torn from the face each time the gum is collected, and a new bag is attached immediately under the freshly chipped streak. By moving the bag up the face several times during each season, low-grade scrape can be eliminated. With acid paste and paper bags, a high-grade raw material can be produced with one-half of the present labor requirements.

Other possibilities for making the woods work easier and more attractive involve powered tools and a self-propelled power source. The U.S. Forest Service is presently investigating the possibilities of using pneumatic tools, powered by a Scuba tank carried on the workman's back. Pneumatic bark hacks capable of cutting a chip 2 inches wide, and pneumatic staple guns for fastening the disposable gum bags to the trees are currently being evaluated. The ultimate objective is to design or modify a woods vehicle to carry the man and the powered tools from tree to tree.

The goal of marketing gum rosin and gum turpentine at a competitive price appears to be achievable within 5 years. The biggest problem we now face is to keep the gum naval stores industry alive long enough to get it mechanized.

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