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MAPLE SIRUP PRODUCTiON FROM BIGLEAF MAPLE

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ABSTRACT

Bigleaf maple sap flow during the 1970-71 season ranged from none to 16.9 gallons per taphole and sugar content of the sap from 1.0 to 2.6 percent. Sugar content also varied seasonally, with the sweetest sap flowing in late January. The sirup was very flavorful, although not as strong in typical maple flavor as that made from eastern sugar maple. Sirup production appears quite feasible as a hobby. The possibility of commercial production should not be ruled out as additional local experience is gained.

Keywords: Maple sugar, bigleaf maple, *Acer macrophytllum,* sap.

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INTRODUCT/ON

Maple sirup has been made from the sap of bigleaf maple (Acer *macrophyllum*) on numerous occasions *(1,* 2, 9), but we find no record of commercial sirup production. This contrasts with the large maple sirup industry developed around the sugar maple *(Acer saccharum*) of the northeastern United States. Recent work with sugar maple is resulting in increased sap flows, greater efficiency in handling and processing, and better control of flavor. The exploratory study reported here was undertaken to evaluate sap flow characteristics of bigleaf maple and the quality of bigleaf maple sirup. In addition, we hoped to gain an initial insight into the economic feasibility of maple sirup production in the Pacific Northwest.

Bigleaf maple is the largest and most valuable western maple. Its range extends from the mountains of southern California, northward through the western parts of Oregon, Washington, and British Columbia almost to the southern tip of Alaska. It grows on a variety of soils, but best growth is on deep alluvial soils near streams. Occasionally pure stands are found, but bigleaf maple generally occurs singly or in small groups. Mature trees average about 50 feet tall and 18 inches in diameter. Growth is rapid for the first 40 to 60 years, with maturity reached at 150 years or more. Bigleaf maple is a tolerant species, especially when young, and frequently is surrounded by taller conifers (4).

Past experience with bigleaf maple in the Pacific Northwest has shown an annual sap flow of 3 to 6 gallons per tree, with about 35 gallons of sap required to make 1 gallon of sirup. Using the "Rule of 86" formula

$$\frac{66}{\text{Sap sugar content, \%}} = \text{Gallons of sap to make 1 gallon sirup}$$

the sugar content of the sap must have been about 2.5 percent. This approximates the general average for sugar maple (20).

Experience with eastern sugar maple has shown that sap flow is correlated with cool nights when temperatures drop to 34° F. or lower, followed by warming conditions up to *40°* to 50° F. the next day. The eastern sugar bush has a continental climate with prolonged periods of freezing weather, and sap flow is delayed until warming trends occur in the spring. Our study area has a mild climate with frequent warm days. Sugar weather depends on occurrence of cold nights, which may occur almost anytime during the winter. Steele [2/] found that trees producing well at the beginning of the sap-flow season continued for that season and tended to be good producers in subsequent seasons. Similar results have been reported for sugar maple (6, l0).

'Robert W. Steele. Final summary report of the maple sap study at Wind River. USDA Forest Serv. In service Rep., 6 p. (unpublished). 1948.

In contrast to an eastern sugar bush, our study area has little soil freezing. Annual precipitation is about 40 inches; mostly falling as winter rain. Soil moisture appears readily available for uptake by tree roots during the entire sap-flow season. Based on 12-year records near the study area, most bigleaf maple leaves have fallen by October 28, and buds begin to burst about March 23. The sap-flow season for bigleaf maple is tapering off about the time it begins in an eastern sugar bush.

METHODS

Tapping and Sap Collection

On November 17, 1970, about 2 weeks after leaf fall, we tapped 13 bigleaf maple trees ranging in size from 12 to 30 inches diameter breast high growing under a variety of conditions.[3] Five were in a mixed stand of maple, Douglas-fir (Pseudotsuga *menziesii),* grand fir *(Abies grandis),* and red alder (Alnus rubra) (fig. 1). The others were in a cutting area where all the conifers had been removed. These essentially were free of competition in the overstory, but there was a vigorous brush understory. We selected the healthier, full-crowned trees, although some had sustained top damage in past years. Samples of six trees showed an age range from 78 to 183 years.

Figure 1 .-Bigleaf maple tree surrounded by taller conifers.

Initially, 11 trees were tapped with one taphole and two of the larger trees with two, for a total of 15. Taphole diameter was one-half inch and depth, 2-1/2 to 3 inches. Metal sap spouts were sterilized in an autoclave, and a germicidal pellet containing 250 milligrams paraformaldehyde was inserted in each taphole to retard

[3] The authors gratefully acknowledge permission to tap maple trees on property owned by Starker Forests, Philomath, Oregon, and School of Forestry, Oregon State University, Corvallis, Oregon.

microbial action. Rubber rain guards were placed around the spouts to prevent rainwater coming down the stem from running into the plastic sap collection bags (fig. 2). A supplemental test comparing flow from old and new tapholes was carried out on three trees January 25 to February 8. Consequently, on February 8, old tapholes were abandoned in the remaining trees and new tapholes tapped about 6 inches away.

Two trees were completely abandoned on January 18 as nonproducers. Six new trees were added at this time. Five were bored with one taphole and one tree with two tapholes. Sap collections were continued at about weekly intervals until bud bursting began in the spring.

U. S. Weather Bureau observations at Corvallis, Oregon, about 5 miles distant and at about the same elevation, were used to characterize conditions at the study area.

A portable refractometer was used in the field beginning December 16 to approximate the sugar content of the sap in degrees Brix[4]/ from each taphole at each collection. The average Brix reading from each taphole was used to compare sweetness of the sap among the trees.

'Same density as a solution containing a percentage of sugar numerically equal to the Brix value. The density of sap is due to a mixture of sugar and small amounts of other dissolved solids, and the refractometer does not distinguish between the density due to sugar and that due to other solids.

Laboratory Brix readings were taken on the pooled sap from each collection date and used to evaluate seasonal changes in sugar content of the sap.

Sap Processing to Sirup

The sap was concentrated to sirup in 2- to 20-gallon, steam-jacketed stainless steel kettles. The steam pressure was 55 pounds per square inch. Large batches of sap were concentrated in larger kettles first and then transferred to smaller kettles for final concentration. Most sap was processed immediately after collection from the field, but some was stored in a cold room at 33" F. for up to 24 hours.

The sap was brought to boiling quickly; then the heat was reduced to maintain a gentle, steady boiling. Scorching of sirup was at a minimum. The foam formed during the early part of the boiling was skimmed continuously. The finishing point of the sirup was determined with a laboratory refractometer. Although attempts were made to finish the sirup at 65° Brix, it was difficult to be precise because small quantities of sirup permitted rapid changes in Brix readings.

In contrast with the steam kettle method available here, commercial procedure with sugar maple sirup involves rapid boiling in large, shallow evaporators. This method brings out a better flavor than that attainable with small-scale laboratory procedures.

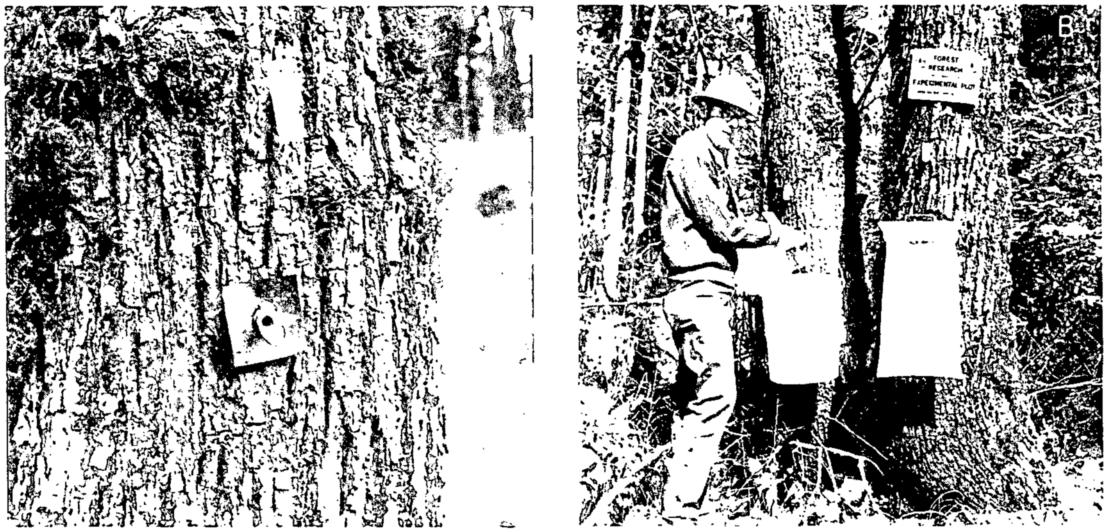

Figure 2.-Bigleaf maple trees tapped for sap collection. A, Metal sap spout. The rubber rain guard prevents rainwater from running into the sap bags. B, Method *used* to collect sap from sap bags.

Laboratory Analyses

Samples of sirup **from each** collection were sent to the Eastern Marketing and Nutrition Research Division of the Agricultural Research Service at Philadelphia for evaluation by their Maple Investigations Group. The sirups were filtered through a medium-porosity, fritted-glass filter to remove the "sugar sand." Samples too small for filtration were let stand in test tubes until they clarified by sedimentation. As the size of many of the samples, especially those from the December runs, was too small for a complete analysis, various constituents and physical constants were run on selected samples in such a manner that a general evaluation of the season's sirup could be made. Acidity values were determined with an in-line pH meter. Conductivity constants were measured with a Wheatstone bridge according to the official method of the Association of Official Analytical Chemists (AOAC) (3). Brix readings were made with a hand refractometer. Ash content was determined by the official method of the AOAC. The invert sugar value was by the Berlin method according to the AOAC. Flavor ratings were made by the members of the Maple Investigations Group.

RESULTS

Sap Flow

Sap started flowing right after tapping on November 17, increased between December 4 and 7, continued to flow intermittently at a somewhat lower level through January 21, then tapered off rapidly in late January in spite of apparently favorable sugar weather (fig. 3). This reduced sap

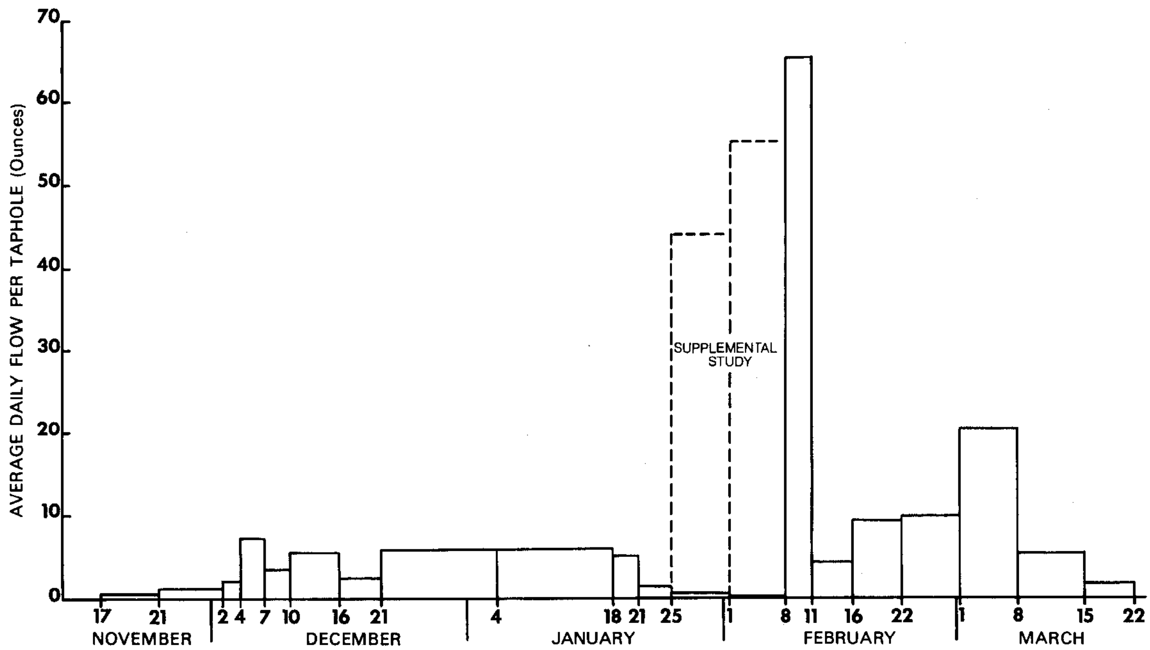

Figure 3.—Average daily bigleaf maple sap flow per taphole. Basis 15 tapholes tapped November 17, 1970; new taps February 8, 1971.

flow led us to suspect microbial activity or some other problem in the tapholes and prompted the supplemental test comparing flow from old and new tapholes in the same tree. Sap flow from the new tapholes in this supplemental test was excellent. New tapholes tapped February 8 began to flow immediately and the sap volumes measured for the February 8-11 period were the highest of the season. This was followed by several heavy flows through March 8.

The new trees tapped January 18 produced high sap flows January 18-21 and February 1-11 (fig. 4). Flows from all trees tapered off in mid-March and only a trace of sap flowed after March 22. Bud bursting was about March 29.

Total 1970-71 season sap flow per taphole for trees originally tapped November 17, 1970, ranged from zero to almost 17 gallons (table 1). Similar wide variation occurred among the seven tapholes in trees added to the study January 18. Sap flow from these trees ranged from 1.2 to 7.9 gallons per taphole. During the study, we collected 132 gallons of sap and made about 1.8 gallons of sirup.

During the sap-flow season, there were over 40 nightly minimums below 32° F. followed by daily maximums above freezing (fig. 5). Minimum soil temperature measured at 4-inch depth in the mineral soil was never below 33° F.

Sugar Content

Sweetness of bigleaf maple sap varied among individual tapholes from 1.0 to 2.6 degrees Brix (table 2). Average sap sweetness varied during the season with a peak of 1.4 degrees Brix reached about January 25 (fig. 6).

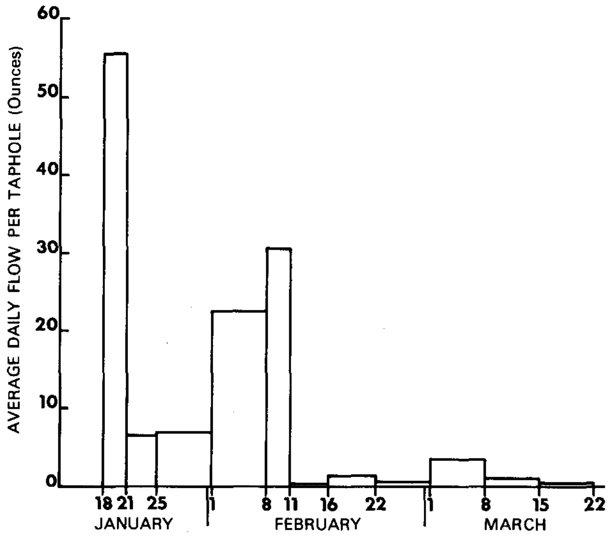

Figure 4.—Average daily bigleaf maple sap flow per taphole. Basis 7 tapholes tapped January 18, 1971.

Table 1.--*Total bigleaf maple sap flow per taphole, 1970-71 season, trees originally tapped November 17, 1970*

Taphole number 1/	Original taps	New taps	Total
	- - - - - - -	*Gallons* - - - - - - -	
1	2/6.28	3/9.93	16.21
2	2/4.08	3/12.82	16.90
3	1.30	3/8.29	9.59
4	1.78	1.04	2.82
5	4/6.09	.54	6.63
6	.74	4/7.53	8.27
7	1.65	2.93	4.58
8	1.36	6.30	7.66
[9	4/3.81	5.26	9.07
10]	2.32	3.43	5.75
[11	--	.31	.31
12]	.25	.66	.91
5/13	--	--	--
5/14	--	--	--
15	2.47	12.05	14.52
Total	32.13	71.09	103.22

1/ Brackets indicate tapholes in same tree.
2/ Sap bag vandalized and 1 collection lost.
3/ Sap volume from supplemental study included.
4/ Sap bag overflowed on 1 occasion.
5/ Abandoned January 18.

Sirup Quality

Results of laboratory tests on bigleaf sirup are shown in table 3. Analysis was same as that for commercial maple sirup. Typical values for a good commercial sugar maple sirup also are shown. These include a low invert sugar content and an average color toward the lighter end of the scale--reflecting recent quality improvements. The bigleaf maple sirup was concentrated in steam kettles, and this procedure is not equivalent to the commercial open-pan evaporator, where the intense heat brings out more flavor. The flavor comparison, therefore, is approximate.

Although the bigleaf maple sirup was very tasteful, all the samples were low in typical sugar maple flavor. This low level of the usual predominant flavor allowed other flavors to be identified. One was a detectable but not too objectionable varnishlike taste in some of the late-season samples. To determine the effect of additional heat, selected samples were autoclaved for 30 minutes at 15 pounds per square inch, but this did not improve the flavor. Rather, the "varnish taint" was increased in those late season samples that had it. The color of the Oregon sirup was dark for a product concentrated in steam kettles, and this does not correlate with the low value for invert sugar. Research has shown that color is proportional to the invert sugar in the sirup; the higher the invert, the darker the sirup (*5*).

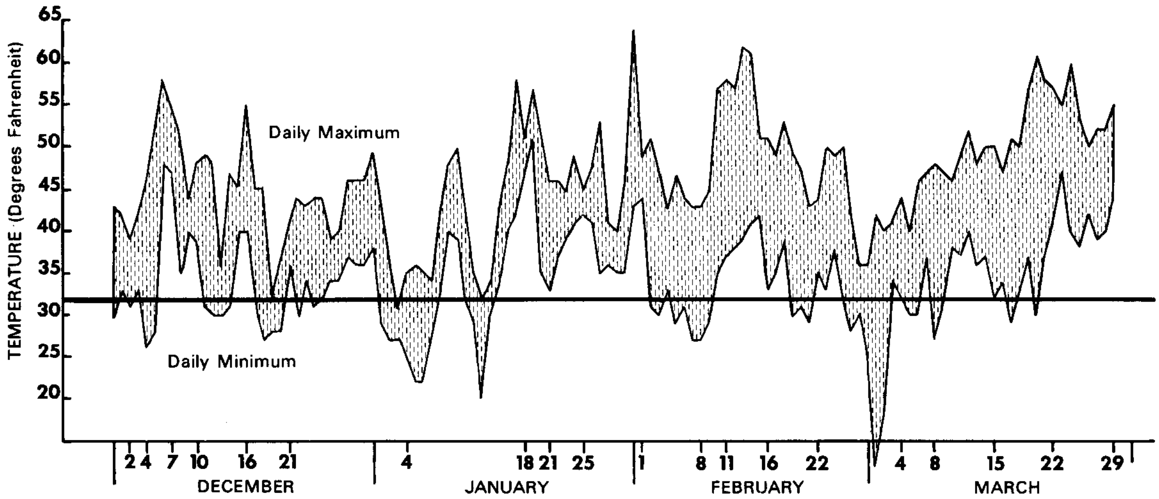

Figure 5.—Daily temperature variation during the sap flow season, Corvallis, Oregon, 1970-71.

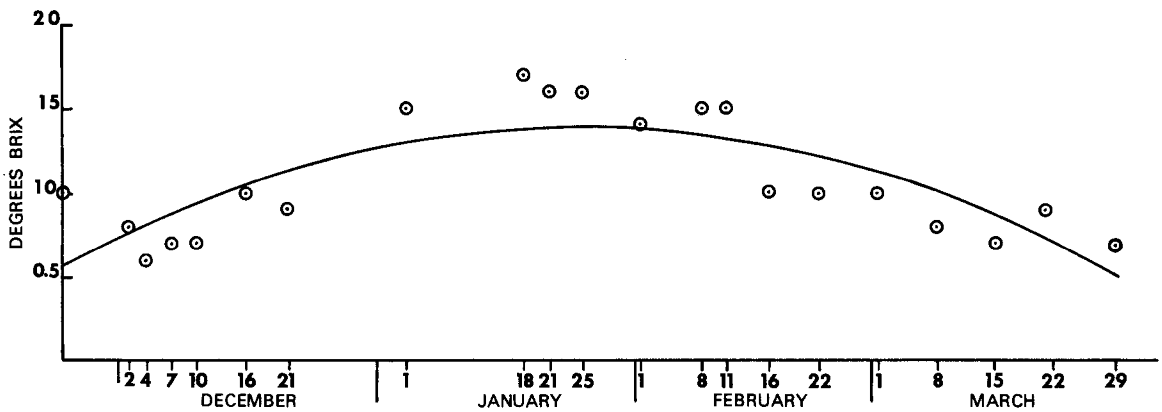

Figure 6.—Seasonal variation in sweetness of sap collected from bigleaf maple trees, 1970-71 season.

Table 2.--*Sweetness of bigleaf maple sap from individual tapholes*

Taphole number[1]	Sap sweetness
	°*Brix*[2]
1	1.3
2	1.1
3	1.0
4	1.2
5	1.0
6	1.2
7	1.2
8	1.3
[9	1.5
10]	1.3
[11	1.2
12]	1.3
15	1.0
16	1.2
17	1.0
18	1.0
[19	1.2
20]	1.3
21	1.5
22	2.6

1/ Brackets indicate 2 tapholes in 1 tree.

2/ Approximately equal to percent sugar content.

The pH of eastern maple sirup is normally just above 7. The Oregon sirups were significantly more acidic, ranging from 4.9 in December to 6.9 for later season sirup. This may explain the lack of a typical maple flavor. Sap from sugar maple is slightly acid (pH 6.5 to 6.9), but as soon as it begins boiling it becomes alkaline, often reaching a pH of 9 (*5*). This alkaline condition is necessary for development of good maple flavor.

The ash content and conductivity values of the bigleaf maple sirup were both much higher than for normal sugar maple sirup. As the conductivity of the sirups is due to their salt content, these two values should and did parallel one another. The high values for the western sirup may reflect the relatively low sugar content of the bigleaf maple sap. It has been noted with all types of maple trees that sap with low sugar content produces high ash sirup due to the greater concentration needed to produce standard density sirup.

Table 3.--*Quality comparison between bigleaf maple sirup and a fancy number 1 sugar maple sirup*

Determination[1]	Bigleaf maple			Sugar maple range
	Number of samples	Average	Range	
Ash percent	6	3.3	2.0-5.5	0.5-1.1
pH	10	6.3	4.9-6.9	6.9-7.2
Conductivity	9	630	476-885	105-158
Invert sugar percent	2	0.32	0.31-0.32	0.25-2.30
Color grade[2]	18	B	A-C	AA-A
Eastern sugar maple flavor	18	Poor	Fair-poor	Excellent-good

1/ On sirup with 66 percent solids.

2/ USDA standards.

DISCUSSION AND CONCLUSIONS

Sap production of bigleaf maple may vary widely from year to year, as it does with eastern sugar maple, and the 1970-71 season studied here may prove to be above or below average. Assuming 1970-71 to be an average season, we conclude that sirup production from bigleaf maple appears fully feasible as a hobby.

Several approaches have the potential for greatly increasing production. The slowdown in late January could have been avoided by boring new tapholes sooner. A still more efficient approach might be to delay boring any tapholes until early December, thus avoiding the early season period of low sap flows. The same would apply to late flows in the spring. Collections could have been terminated in early March. This decision should be based on local freezing-thawing cycles, which will vary considerably within the range of bigleaf maple.

Production can be increased by finding new trees to replace low producers. Three of our original tapholes produced over 14 gallons of sap, even though the original tapholes were used too long, some sap bags overflowed, and some bags were vandalized. One hundred tapholes like these three should provide about 1,500 gallons of sap. Assuming an average Brix value of 1.5, this would make about 26 gallons of sir-up. Two of these three high producers were intermixed with conifers, indicating that such trees indeed should be considered in searching for the best trees. However, experience with sugar maple is that open-growth trees produce more and sweeter sap than trees growing under crowded conditions.

Additional production should come from selection of trees with high sugar content. There was considerable variation among the study trees, with sap from one taphole containing 2.6 percent sugar, more than twice the average of the other trees. The tree with this taphole was growing in the logged-over area. Many sugar producers in the East believe it does not pay to process sap which tests less than 1.5 percent. Availability of inexpensive fuel in the West may reduce this somewhat, but possibilities of commercial production will be greatly enhanced if sweeter trees can be found. The low sugar content of early and late season sap flows is further argument for limiting sap collections to the main part of the sap-flow season.

Besides placing of germicidal pellets in the tapholes, two additional techniques developed with sugar maple offer possibilities for increased efficiency and further increases in sap production. One is the use of flexible plastic tubing for collecting sap. The tubing is connected directly to sap spouts so the sap will run by gravity directly into large collection tanks. This system eliminates the need for a large labor force to collect sap and permits one- to two-man operations to handle 1,000 or more taps. The second is the use of vacuum pumping on an unvented tubing system to increase sap yields. Fourfold increases in sap flow have been reported in some studies (7). To our knowledge, neither technique has been tried with bigleaf maple.

If the above approaches do indeed lead to production increases, commercial production may be possible. The scattered distribution of bigleaf maple trees will always be an obstacle to efficient production. The best opportunities will be in occasional pure stands or where numerous trees are accessible along all-weather roads. The composition of bigleaf maple in a stand can be improved by thinning the other species, and, of course, pure stands can be developed by planting.

Standard practice in the East is that sap must not remain in the buckets or sap bags more than a few hours before it is collected; otherwise it will ferment and spoil (10). We were not able to visit the study area frequently enough to follow this practice, and some sap remained in bags a week or more. No sign of fermentation was noted. Perhaps microorganisms in the sap were killed by solar radiation transmitted through the sap bags (8). On the other hand. this delay may have adversely affected the flavor of the sirup.

In any event, the quality of the sirup made from the bigleaf maple trees in this study was lower than sirup from the sugar maple, being generally comparable to sirup made from eastern soft maples, such as red and silver maple. The sap from the soft maples, like the bigleaf maple sap, often is low in sugar content. Some of the bigleaf samples did have a trace of an unfamiliar "varnish" taste, but this was not too objectionable. It occurred only in late-season sap collections which may not warrant collection anyway because of low sap flow. With experience in collecting and processing bigleaf maple sap, procedures surely will be found to make a good, marketable sirup, even if its flavor may be different from that of sugar maple.

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