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Some impacts to paper birch trees tapped for sap harvesting in Alaska

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Summary

As the non-timber forest products industry increases on a commercial scale, the need for assessments of tree health and sustainability of these practices also increases. Harvesting birch sap for subsistence purposes has occurred for decades but commercial interests in this process and resource is expanding. In this evaluation, we review literature related to birch sap harvesting practices, report on a pilot study that assessed impacts to birch trees from sap harvesting, and review the "Best Practices" guidelines for tree tapping developed by the Alaska Birch Syrupmakers' Association.

Introduction

Non-timber forest products are increasingly sought from the vast paper birch (*Betula neoalaskana*) stands of south-central and interior Alaska. One unique cottage industry that continues to grow is the harvesting of sap from paper birch trees through subsistence and commercial tapping operations. Once harvested, the sap can be processed into syrup or other food grade products that are sold statewide, nationally, and potentially internationally. In the former Soviet Union, economic effectiveness of these practices has been estimated as approximately 7 times the value of the forests per hectare if they were used for wood production (Tomchuk et al. 1973).

In 2003, eight Alaska companies harvested sap and produced nearly 1,000 gallons of birch syrup that year (Helfferich 2003). While some of these companies are no longer harvesting sap, others are interested in expanding their operations. Although sap extraction and processing is labor intensive and relatively high cost, the value of the syrup product is also high. Pure Alaska birch syrup can have a retail price of $60 per quart.

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As harvesting operations continue to expand to meet market demand, harvesters, land managers and land owners are seeking more scientific information on the sustainability of current sap harvesting practices. Sustainability assessments will help land owners make informed decisions for management of the birch tapping practices. This information is also needed as syrupmakers seek organic certification, which requires that the harvesting practices are sustainable. To date, however, no comprehensive study investigating the sustainability of sap harvesting techniques in Alaska has been conducted.

In 1993, the Alaska Birch Syrupmakers Association (ABSA) was formed. In the mid-1990's the Association developed "Best Practices" that include guidelines and recommendations for tree tapping, sap collection, sap storage, and syrup production. While the "Best Practices" have been in place for years, the impact to or sustainability of birch trees tapped for harvest with these guidelines has not been evaluated.

Determining the impact of tapping practices on birch trees necessitates both scientific data and literature review. Therefore this Biological Evaluation will 1) review selected literature relating to tree tapping and wounding, 2) report on a pilot study that evaluated stain and internal decay associated with tap holes and 3) review the ABSA "Best Practices" guidelines and recommendations for tree tapping using the literature review and pilot study. A review of the "Best Practices" for sap collection, sap storage, and syrup production is outside the scope of this Evaluation.

Literature Review

Birch sap gathering has occurred for centuries. By 1895, the practice was considered to have a long history in Russia and other European countries (Nesterov 1895 In: Tomchuk et al. 1973). However, literature specifically addressing appropriate tapping practices to maintain birch health is difficult to find, particularly in English. To date, only a few translated papers from the former Soviet Union relating to birch sap harvest practices and tree health have been located.

Proper birch tree selection for tapping is essential to maintaining tree health, achieving high sap productivity, and high sugar content. Research suggests the most productive birch trees for tapping are a minimum of 8 inches diameter at breast height (dbh) (Telishevskyj 1970). Only healthy trees, those that lack dead tops, fire damage, or evidence of fungi, are considered suitable for tapping (Telishevskyj 1970). Tapping already stressed trees is highly discouraged because these trees are unable to effectively compartmentalize or wall off taphole wounds (Houston et al. 1990).

The diameter of a birch tree affects the suggested number of tap holes per tree. Tapping practices reported from the former Soviet Union utilize one tap for birch trees 8-10" dbh, two taps for trees 10-12", and three taps for trees over 12" for harvesters using a tap and tubing system (Telishevskyj 1970). Low tap location, shallow tap depth, and tap angle was also suggested from experience in the former Soviet Union (Telishevskyj 1970, Tomchuk et al. 1973). Taps were suggested to be bored low on the tree, approximately 12-32" from the ground surface, to a shallow depth of 0.8-1.2" (excluding bark thickness), and slightly angled toward the ground.

There is no published information available on the long term impacts of the tapping practices on the health of birch trees. This section presents an overview of wounding effects on tree health. Birch has a much lower tolerance to wounding and compartmentalization of wounded tissues than maple (Shigo and Larson 1969). Tapped birch, therefore, will more readily develop stain and decay than tapped sugar maples. This suggests that to maintain birch tree health, the number of taps per tree and the number of years a tree can be tapped should be more conservative than those used for sugar maple. Recommendations are one tap per year per sugar maple tree (*Acer saccharum*) up to 14 inches diameter, two taps in trees 15 to 19 inches, and three taps in trees 20 inches or more (Walters and Shigo 1978). Additionally, sugar maple trees are routinely tapped for several decades due to the tree's tolerance for wounding and excellent ability to compartmentalize (Houston et al. 1990).

The installation of sap collection taps is a practice that wounds birch trees. Once wounded, birch naturally develops a red-brown discoloration, called red-heart, associated with the injured area (Campbell and Davidson 1941, Siegle1967). The precise cause of red heart stain has not been determined, however, wood inhabiting fungi are associated with the process of stain formation (Campbell and Davidson 1941, Siegle 1967). Fungi associated with red heart appear to be the primary producers of phenol oxidases which catalyze the discoloration process (Siegle 1967). Stain advances in the tree, primarily vertically and somewhat horizontally, as long as the wound remains open (Shigo and Larson 1969). Research on the discoloration resulting from increment borings in paper birch (*Betula papyrifera*) found that wood above and below every borer hole was stained for 2.5 to 4.5 ft within two years (Lorenz 1944). While the discolored wood does not cause harm to the tree, a succession of microorganisms typically invades (Shigo and Marx 1977). Maple syrup producers avoid tapping into stained wood because of the reduction of sap flow in these areas and the potential reduction of sap quality due to the high likelihood of microorganisms in the stained wood (Ministry of Agriculture, Food and Rural Affairs 2008).

Tapping practices create an open wound that potentially allows introduction of decay-causing organisms. If wounds are not closed quickly, insects and fungi that cause decay are able to pass through the outer defenses of the tree. Over time, decay development can impair tree function, weaken tree stability, and may contribute to premature tree death. The degree to which wounding affects tree health and the introduction of decay organisms depends on many factors including number of wounds, size, depth, location of wound, time of year, and health of the tree prior to wounding (Nevill 1997).

Birch trees defend against decay and discoloration by compartmentalizing the wound (Walters and Shigo 1978). Compartmentalization is a process that isolates the wounded part of a tree through the development of physical and chemical boundaries that resist the spread of disease into surrounding wood (Shigo and Marx 1977). The weakest "boundaries" are above and below the wound, and on both sides. The strongest boundary typically confines the invasion of microorganisms to the wood present at the time of wounding. Even when the strongest boundaries of compartmentalization are effective, zones of defect may occur above and below wounds (Houston et al. 1990). If compartmentalization is successful, new tree rings that form are protected from invasion unless new wounds are inflicted. When new wounds are inflicted at a later time, however, multiple columns of defect can develop (Shigo and Marx 1977).

Plugging increment borer wounds in birch with sterile dowls has not been shown to be effective in reducing the development of stain or canker fungi. Lorenz (1944) found that every borer hole in birch had stain regardless of plugging treatment. Approximately half of the plugged holes had *Nectria galligena* cankers surrounding them. The quick healing of wounds was correlated with general vigor of the trees and not whether trees were plugged.

Pilot Study

A pilot study was undertaken in summer 2007 near Fairbanks to 1) fell and dissect a sample of birch tapped trees at each of two sites, and 2) assess the signs and symptoms of internal and external pathogen introduction associated with the tapping. Two sites were located: Cache Creek near Murphy Dome, northwest of Fairbanks and Eva Creek in Ester, southwest of Fairbanks. Both sites were tapped for sap collection by the same permitted harvester. Records indicate that Eva Creek was tapped only once, in 1990, while Cache Creek site was tapped two or three times between 2001 and 2007.

Sap collection procedures at both sites involved the installation of a tap and plastic tubing system. (Figures 1 and 2). In each selected birch, one or more taps were installed. Tubing was connected to the tap and the sap ran downhill through the tubes to a central collection point.


Figures 1 and 2: Spout and tubing within a birch grove.

At the Eva Creek site, the harvester estimated that 2,000-3,000 trees were tapped in 1990. Each tree held one or two taps. The site was not used after 1990. The harvester had subsequently irrigated and corked some tapped trees. The Eva Creek tapped trees provided a unique look at the long term impacts of corking as well as a 17 year post-harvest assessment of tapping practices.   In contrast, tapping at the Cache Creek site occurred more recently with a higher number of taps per tree, up to 14. The harvester estimated 1,600 tapped trees at Cache Creek with approximately 4,000 taps installed in 2001. Examination of the Cache Creek trees provided a unique look at trees with a high number of recently installed tap holes. None of the trees at Cache Creek had been corked.

<u>Methods</u>

The study involved felling trees at Cache Creek in late May and at Eva Creek in August 2007. At each site, different criteria were used to select trees for felling due to differences in tapping frequency and the presence of corks at one site. Tree selection was also based on a judgment of whether the tree could be safely felled. At Cache Creek, 9 trees were randomly selected for sampling with three trees felled from each category: untapped, less than 6 taps/tree, greater than 11 taps/tree. Trees with corks could not be located at Cache Creek. At Eva Creek, 12 trees were randomly sampled. With only 1 or 2 taps/tree, three trees were selected in each category: untapped, tap hole closed naturally, tap hole corked, tap hole corked but cork now missing. Records were not clear on which post-harvest year that tap holes were corked. Untapped or control trees were selected from within or immediately adjacent to harvest permit boundaries.

Prior to felling, measurements of dbh, height to lowest tap, and height of highest tap were taken. Post-felling measurements of total tree length and length of live crown was taken. Trees were assessed for general crown and stem health, and external signs of pathogens such as presence of conks, mushrooms, or cankers. Each felled tree was bucked in 1 ft sections from the base to 10 ft. If internal decay or staining occurred, it was traced to determine if associated with the tap holes. Photographs were taken of each tree prior to and post felling. Tree sections were cut near the tap hole and taken to the USFS lab in Anchorage for further analysis.

<u>Results and Discussion</u>

A total of 21 birch trees were felled at the two sites, 9 trees at Cache Creek and 12 trees at Eva Creek. Three untapped trees were included at each site for comparison. Data on trees from Cache Creek is in Table 1; data for Eva Creek trees is in Table 2.

Table 1. Data for trees at the Cache Creek site, initially tapped in 2001.

Tree #	DBH (in.)	Live Crwn Ht. (ft.)	Total Ht. (ft.)	# of Taps	Tap Height (ft.) Lowest l Highest
1	13.3	39.8	73.0	14	3.0 - 5.3
2	16.9	25.6	71.9	14	4.7 - 5.9
3	10.2	18.8	59.0	11	4.6 - 6.1
4	11.7	30.3	60.7	5	4.8 - 6.2
5	8.7	34.7	54.6	6	3.7 - 4.4
6	13.2	33.7	57.5	3	4.1 - 5.0
7	11.9	13.6	61.9	0	n/a
8	14.6	45.0	78.4	0	n/a
9	13.4	31.7	64.6	0	n/a

Table 2. Data for trees at the Eva Creek site; tapped one year, in 1990.

Tree #	Category*	DBH (in.)	Live Crwn Ht. (ft.)	Total Ht. (ft.)	# of Taps	Tap Height (ft.) Lowest l Highest
10	C/no cork	9.0	19.5	72.7	1	4.4 n/a
13	C/no cork	13.9	23.6	72.0	2	3.2 - 3.9
45	C/no cork	11.9	33.0	72.0	1	4.2 n/a
18	cork (+)	10.2	45.0	75.0	2	2.5 - 3.3
21	cork (+)	11.7	43.0	72.6	2	2.7 - 3.0
35	cork (+)	8.2	19.5	61.0	1	3.3 n/a
26	cork (-)	11.2	32.0	69.0	2	3.2 - 4.0
28	cork (-)	8.7	40.0	69.0	2	3.6 - 4.1
29	cork (-)	9.6	25.0	61.5	2	2.7 - 4.7
52	No tap	9.6	36.0	69.0	0	n/a
53	No tap	11.2	28.0	73.0	0	n/a
54	No tap	13.8	29.0	80.0	0	n/a

*Categories were as follows: C/no cork = tap hole closed naturally, no cork was ever used; cork (+) = a cork was placed in the open tap hole post-tapping and remains in the tree; cork (-) = evidence that a cork was placed in the open tap hole post-tapping but as of 2007 cork is missing; No tap = tree was never tapped, control tree.

Regardless of the number of tap holes, years since tapping, or tap hole treatment, all tapped trees at both sites had sapwood red heart staining associated with every tap hole (Figure 3 and Figure 4). All taps could be readily distinguished and counted within a cross-sectional disk at 4.5 feet. The pattern of stain in the sapwood generally mimicked the length and shape of a tap hole, but was up to three times wider than the original 5/16th inch tap hole. A higher number of tap holes in a tree resulted in a higher proportion of stained sapwood (Figure 3 and Figure 4).

Sapwood stain columns from the tap holes all ended within the first 10 foot log, averaging 6.3 feet in length in the Cache Creek trees and 6.6 feet in the Eva Creek trees. Red heart stain not associated with the tap holes did occur in the main heartwood column of all tapped trees. This stain apparently pre-dated the tapping operations. Untapped trees at both sites, used as controls, had some red heart stain in the heartwood (Figure 5 and Figure 6); however, no signs of red heart stain or wood decay occurred in the sapwood of the control trees. The control trees provided confirmation that while red heart stain typically occurs in the heartwood of older birch, the introduction of stain into the sapwood of tapped trees was due to the tap holes.

Figure 3: Cache Creek tree 1 with stain around all 14 tap holes.

Figure 4: Eva Creek tree 26 with stain associated with both tap holes.

Figure 5: Cache Creek tree 8, a control tree, lacked sapwood stain.

Figure 6: Eva Creek tree 53, a control tree, lacked sapwood stain.

Eva Creek trees, tapped 17 years ago, had decay associated with tap holes in 55% of the trees (5 of 9) (Figures 7 and 8). Decay columns associated with the tap holes averaged 2.8 ft in length. Decay was present in tap holes regardless of treatment - corked, missing a cork, or never corked. Decay was confined or compartmentalized within the red heart stain.

Figures 7 and 8: Stain and decay associated with tap holes in Eva Creek trees 10 and 21, cut at 4.5 ft.

In the Cache Creek trees, softened and decayed wood was present in the tap holes of 1/3 of the dissected trees tapped since 2001 (Figures 9 and 10). Additionally, each tree at Cache Creek had at least one or more stained tap holes with dark streaks and black discoloration, suggesting that decay organisms may have invaded some tap holes, though decay has not yet had time to develop. Pre-existing stem decay was present in most of the Cache Creek trees complicating the connection between decay entering the tap hole via spores or invading through the pre-existing column. Regardless of how the decay was introduced into the tap hole, the presence of decay in the sapwood potentially reduces the health and vigor of a tree.

Decay columns associated with the tap holes did not exceed 1 foot; pre-existing decay columns, however, typically exceeded 10 feet at Cache Creek. Stem analysis of the control trees indicated that none developed sapwood decay over the same time period.

Figures 9 and 10. Cross-sectional cuts at dbh for Trees 3 and 6 at Cache Creek. Decay was present at some tap holes (red arrows) in each of these trees.

Some trees at the Eva Creek site were corked or had spouts still in the trees since 1990. Many tap holes were difficult to locate 17 years post harvest because the trees had effectively closed the tap hole naturally (Figure 11). Trees that were corked at some time in the past 17 years were in various states of retaining or losing the cork (Figures 12 and 13). The presence of corks and imbedded spouts both inhibited the natural closing of the tap holes. Where corks had popped out, the wounds were re-opened to insects and decay organisms.

Figures 11, 12, and 13: From left to right, effectively closed tap hole that was never corked, cork half way protruding from the tree, cork deeply imbedded in the tree.

Several trees at the Eva Creek site developed the stem canker fungus *Nectria galligena* at corked tap holes or surrounding imbedded spouts (Figure 14). No signs of *N. galligena* were found associated with uncorked holes or tap holes that healed naturally at Eva Creek. To date, there are no signs of this fungus on the Cache Creek trees. *N. galligena* is a common canker fungus of birch in Alaska that readily invades wounds and dead branches. It results in cambial death and increased stem breakage at the infection site (Holsten et al. 2001). The ability of *N. galligena* to exploit the corked tap holes and old imbedded spouts is similar to that reported by Lorenz (1944). He found that nearly half of increment borer holes plugged with sterile dowls had *N. galligena* cankers surrounding them.

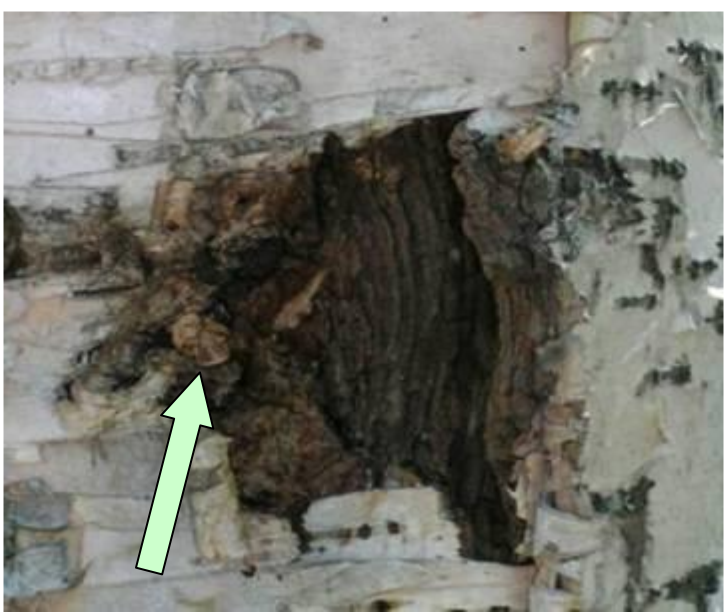

Figure 14: The canker fungus *Nectria galligena* associated with a corked tap hole. Arrow points to the cork remnant. Dead flaring bark and concentric sapwood rings to the right of the cork are signs of invasion by this canker fungus.

Corking tap holes does not appear to be an effective means of inhibiting stain and decay or preventing infection by the canker fungus *N. galligena*. It is likely that the corks may be trapping fungal spores effectively providing an entrance court for fungi, rather than preventing their introduction. Corking thus appears to be an unnecessary, and perhaps harmful, treatment for tapped birch trees. We suggest that taps be removed in a timely manner after harvest operations to reduce the likelihood of canker fungi introduction.

Although our sample size in the pilot study was small, our findings were consistent within and between sites. A higher sample size may reveal additional stain and decay trends. Thus, we recommend more sampling to confirm our findings.

Review of ABSA Best Practices Guidelines

Since the mid-1990's, the Alaska Birch Syrupmakers Association (ABSA) has recommended "Best Practices" that include guidelines and recommendations for tree tapping. The "Best Practices" have been modified slightly through the years, but have not been evaluated for their impact to or sustainability of the tapped birch tree resource. As of April 2007, the following guidelines were recommended by ABSA (Dulse Ben East, ABSA President, pers. comm., February 2008).

Alaska Birch Syrupmakers' Association
BEST PRACTICES
For Producing Quality Birch Syrup

Tree Tapping Guidelines and Recommendation

1. Time to tap varies by location; usually first part of April.
2. Tap holes: 1 ½ - 1 ¾" deep, slight upward angle, using a 5/16-7/16" bit, depending on spout used.
3. Location of hole: 2-4 feet high, to the side of previous holes
4. Tap healthy trees; 8" dbh or larger
5. Do not tap trees that have ever had pesticides sprayed on or around.
6. One tap per tree.
7. Use plastic, nylon, or stainless steel spouts, or tubing supplies commercially available through local and maple syrup equipment suppliers.
8. Do not drive taps too deep – wood can split causing leakage.
9. Sterilize taps before use.
10. Tap trees when the sap flow is continuous.
11. Tap trees only where access is good and equipment will not compromise ground cover. Minimize damage to trails during break-up.
12. Remove spouts at end of season; may spray hole with pure water. Cork tap holes upon removal with appropriate sized cork (available through local suppliers).

With the exception of corking the trees (guideline 12), the ABSA "Best Practices" appear to minimize tree wounding and allow trees to naturally heal after wounding. The "Best Practices" are generally similar to practices used in the former Soviet Union (Telishevskyj 1970, Tomchuk et al. 1973). The recommendations of shallow tap holes, tapping only healthy trees over 8 inches, and sterilizing taps prior to use should serve to keep the wound impact to a healthy tree at a minimum. We suggest that the definition of healthy trees be expanded to include those that lack dead tops, cracks, wounds, fire damage, or evidence of fungi.

The recommendation of one tap per tree (per year) is more conservative than is used in the former Soviet Union and in the maple syrup industry (Telishevskyj 1970, Houston et al. 1990). This seems appropriate since birch is less able to compartmentalize wounds than maple. Also, the pilot study indicated that stain readily develops associated with the tap holes, and decay organisms may invade. Limiting the number of taps to one per year will reduce the number of wounds and may increase the tree's ability to compartmentalize the wounded tissues, potentially reducing long term impacts.

Guideline 12 recommends corking tap holes upon removal of taps, however, this treatment is not supported by the pilot study. The cork treatment was not effective in preventing stain or decay in sampled trees. Corks inhibited the natural closing of the tap holes, may seal fungal spores within the tap hole, and were associated with the presence of a canker fungus, *Nectria galligena*. Thus, corking trees after sap harvest appears unnecessary and may even be harmful to birch trees. We recommend that the ABSA revise their guidelines to eliminate reference to corking. Tree tapping Guideline # 12 should read "Remove spouts at the end of **each** season; may spray hole with pure water".

Sustainability of tapping practices

Tapping trees for sap harvest results in a wound. The pilot study indicated that stain consistently develops in association with the tap holes. Decay development is less consistent but modest decay columns occurred in approximately half of the sampled trees at the oldest tapping site. While stain in living trees does not compromise tree health, decay can. Wood decay alters both the chemical and physical properties of wood, resulting in loss of wood strength. Once initiated, decay columns continue to expand within a tree. Stem breakage commonly occurs in trees with extensive wood decay. Trees have a high rate of failure when less than 1/3 of the radius (or diameter) is sound (Harvey and Hessburg 1992).

The ABSA "Best Practices" appear to be reasonable and prudent guidelines to use for birch tapping operations in Alaska, with the exception of tree corking. The ABSA practices were used at the Eva Creek site and decay columns after one season of tapping were not substantial enough to compromise tree health. Extrapolating this information to multiple tapping years suggests that decay columns would continue to develop and expand within tapped trees.

Based on the current information, it is difficult to determine how many consecutive years that birch trees can be tapped using the ABSA "Best Practices" without compromising tree health. The State of Alaska Plant Materials Center and Division of Mining, Land and Water recently completed the document *Alaska Non-Timber Forest Products Harvest Manual for Commercial Harvest on State-Owned Lands* (Larsen et al. 2008) that pertains to harvesting on state lands. For birch sap harvesting they recommended using the ABSA "Best Practices" and specified that "Each tree may be tapped once a year for five years. After a two year recovery period, tapping for another 5-year period may resume. This cycle may be repeated three times for a total of 15 tapping seasons per tree in a 19-year period, after which the tree must be retired." We believe that this approach is reasonable provided the stands are carefully monitored. We suggest that evaluations and dissections are undertaken by the permitter on a sample of birch trees after each 5 year cycle to assess tree health and determine whether another tapping cycle is reasonable.

Land owners should recognize that the development of stain and decay in tapped trees may limit the use of these trees in the future for other purposes. We suggest that land owners carefully select stands for tapping operations where some degree of stain and decay is acceptable.

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