PRELIMINARY SILVICULTURAL RECOMMENDATIONS AND AN UPDATED ANNOTATED BIBLIOGRAPHY FOR BIRDSEYE SUGAR MAPLE

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Abstract.—The birdseye grain abnormality in sugar maple can greatly enhance its commercial appeal. However, birdseye has been opportunistically exploited, without exploring management strategies that can improve its potential. Even though the initiation and development processes of birdseye maple are still largely unknown, useful silvicultural advice can still be provided for timber managers. First, the identification of birdseye maples before felling, or early in the merchandising process, allows for better protection of log value. Second, protecting the residual stand while logging should likewise bolster future stand value by reducing undesired injury and mortality of the residual. Third, because birdseye abundance could be associated with stand density, it may prove advantageous to keep known birdseye trees in denser areas to ensure continued figured wood production. Finally, an additional set of 80 annotated references on birdseye is provided to further research on the topic.

INTRODUCTION

Improving the profitability of forests has long been a goal of timber managers. To date, most of this effort has concentrated on silvicultural practices for increasing growth (for example, site preparation, competition control, thinning, fertilizing). Far less emphasis has been placed on optimizing the value of certain attributes of the trees. While not always present, some of these qualities can greatly enhance the commercial potential of a stand. For instance, the birdseye grain abnormality in sugar maple (*Acer saccharum*) has long been highly prized (Bragg 2006).

However, birdseye maple has long been treated as purely an "accidental" resource, to be exploited as encountered. Such a strategy leaves little in the way of options to fully capture the potential of the birdseye resource. In this paper I will discuss a number of steps that can be taken to improve management practices regarding birdseye maple.

BIRDSEYE-RELATED MANAGEMENT ADVICE

To date, researchers have not identified the formative process(es) leading to birdseye. However, we do know that a number of suggested causes (for example, birdpeck or adventitious buds) do not produce birdseye sugar maple (Bragg 1999, Rioux and others 2003). Birdseye in sugar maple apparently arises from injuries due to pressure exerted upon cambial initial cells, causing abnormalities in their structure and function that are also reflected in associated tissues (Rioux and others 2003). While not giving a specific mechanism, Rioux and others (2003, p. 956) suggest that a physiological disorder resulting from "adverse environmental factor(s)" (perhaps stressful growing conditions, injuries, or pathogens) may lead to birdseye production. It is also possible that multiple triggers could induce birdseye formation (Bragg 1999, Rioux and others 2003), especially in light of the broad but inconsistent geographic distribution of this grain pattern (Beals and Davis 1977, Bragg 1995). Other species may develop birdseye-like grain patterns (for a partial list, see Appendix A and Bragg and Stokke [1999]), but there is no research on anatomical similarities between these grain abnormalities and birdseye in sugar maple.

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Even though we do not yet know enough about birdseye to culture this grain abnormality, there is no reason to "mine" this resource from the landscapes in which it is found. The following suggestions are geared toward increased awareness and preventative measures to protect existing birdseye resources. Unfortunately, truly prescriptive measures intended to sustain birdseye abundance are still unavailable.

Identification of Birdseye Maple

Identification of birdseye maples before felling, or early in the merchandising process, allows them to receive special treatment and thereby helps to preserve their value. Many grain abnormalities, including birdseye, can be recognized prior to harvest if certain characteristics are visible (Pillow 1955, Bragg and Stokke 1994, Velling and others 2000). For birdseye, a basal bole constriction is sometimes apparent, or the "eyes" can be spotted on the surface of the bark (Mroz and others 1990, Bragg and Stokke 1994). If these more obvious characteristics are not visible, then the bark and wood of standing trees can be further explored in a nondestructive but potentially injurious examination (Bragg and Stokke 1994). In areas with relatively abundant birdseye, timber cruisers should be trained to identify figured maples so as to improve the bidding process (Bragg 2006).

It is critical that foresters help their clients realize the value of all of the timber attributes, especially private timberland owners with little knowledge of forest products. Even if they do not have birdseye maple, other types of figured wood can be found in virtually every forest, and these may also yield valuable products (Bragg 2006). Burls or curly grain, for example, are sometimes considered an eyesore or worthless defects. However, most woodworkers prize these abnormalities, and often pay a premium for quality materials (Mitchell 1964, Velling and others 2000). Some are also willing to pay top-dollar for small (otherwise submerchantable) pieces of well-figured wood (Bragg 2006). Marketing this product may require some creativity, but can certainly reward the effort. Simply discarding, relegating to lower-value uses (for example, pulpwood rather than sawtimber or veneer), or even giving away potentially valuable wood are poor ways to maximize the value of the timber for the landowner (Hoffman 2004).

While it is best to identify birdseye maples before they are felled, it is not always possible. Their value can still be optimized, however, if they are recognized before they are fully processed. The cut faces of the logs, when exposed, can be searched for the tell-tale "vestigium" or traces that extend towards the pith, or the surface of the wood can be examined where bark is removed for the "gelasini" or indentations (Bragg 1999). If birdseye maple logs are found, it is often best to set them aside for later evaluation by a birdseye buyer, rather than attempting to buck them at the landing, since these buyers may prefer to process logs themselves. However, these logs should be discreetly placed to minimize theft, a major problem in some areas (Walters 1995, Fullerton 1996, MacLean 1997).

If the birdseye logs are to be bucked, it is imperative to use the most skilled individual possible to process the wood using the least damaging technology. One of the most important things that can be done with hardwood sawtimber is to properly merchandise it; repeated studies have shown that poorly trained workers can drastically reduce value by inappropriate decisions on how to cut the logs (for example, Pickens and others 1992, Boston and Murphy 2003). It is also best to use the saw technology that minimizes kerf and fiber damage so that the birdseye logs can be converted into their highest and best use (Bragg 2006).

Protection of Residual Timber

Protection of the residual stand during and immediately after timber harvesting can help protect future asset value by reducing undesired mortality and decay in the leave trees. In general, the same advice provided for good forestry practices in uneven-aged hardwoods (for example, Godman and Erdmann 1981, Leak and Gottsacker 1985, Erickson and others 1992) holds true for stands with birdseye. For instance, if birdseye maples are to be retained for future harvest, their bole quality should be protected. Decay or stain in such trees can relegate them to low value uses rather than the prized veneer sought by buyers. The steps taken to protect individual birdseye maples, however, may prove more exacting than those used for other hardwoods. Such measures may entail reserving buffer trees around the birdseyes to ensure that felling or skidding operations do not damage the aboveground parts of the tree, or that vehicle traffic does not injure roots.

Under certain conditions, it may actually make more sense to preserve large groups of trees untouched near known birdseyes, rather than partially harvesting them to remove nonbirdseye individuals. Protection from damage is an opportunity cost that must be recognized. The great value disparity between quality birdseye maple logs and even prime but nonfigured veneer logs can justify foregoing cutting now to ensure value in the future. There may also be maintenance issues regarding stand density and birdseye production that would warrant a hands-off approach to groups of trees surrounding birdseye maples.

Density Management and Birdseye Maple

Because birdseye frequency in sugar maple is associated with stand density (Mroz and others 1990, Bragg and others 1997), keeping known birdseye maple residual trees in localized pockets of dense timber could help ensure continued production of the rare figure. Furthermore, there is at least anecdotal evidence of an abrupt cessation of birdseye grain production after competitors had been harvested (for example, Pillow 1930, Constantine 1959). Hence, heavily thinning the overstory adjacent to reserved birdseye maples may provide enough release from adverse conditions to induce the production of “normal” wood, and thus reduce or even eliminate the desired grain condition.

Even if birdseye production does not cease or decline in quality, there may be enough release from a thinning of the overstory to result in a marked increase in diameter growth. Such a change in ring width is not always desirable for veneer-grade trees, since inconsistent ring thickness degrades veneer quality (Alderman and others 2004, Cassens 2004). Birdseye value is directly related to general log quality; cull logs are of little to no value, and there are instances when birdseye becomes just another defect in low-grade sawlogs. In conventional sawlog markets, it is only in the best of logs that a true premium for birdseye is achieved.

Birdseye Maple Sustainability

To date, our inability to successfully culture birdseye maple means that every figured tree harvested may not be replaced on the landscape, suggesting that the long-term sustainability of this resource is dubious. Birdseye abundance appears to have declined from historical levels. Some reports have noted that figured maple (including birdseye) was most common in the virgin forests of places as diverse as Michigan and West Virginia (Hough 1884, Sherwood 1936, Gagnon 1996). However, this may not have been as pronounced as inferred from the literature, but rather an issue of familiarity. For instance, the present-day concentration of birdseye in northeastern Canada, Michigan, Wisconsin, northern New England, and perhaps even the mid-Atlantic is partially a matter of awareness of the resource (Bragg 1995).

Perhaps the biggest uncertainty regarding the sustainability of the birdseye maple resource is the degree of genetic control associated with this grain abnormality. Some have speculated a genetic linkage (for example, Righter 1934), but this theory has never been adequately tested. If it is true, how has the last century of forest manipulation modified the sugar maple genetic pool? Has this phenotype been lost from much of its range, or is it still present, waiting for the right conditions to express it? We simply don't know.

The desire to retain this grain abnormality, especially if genetically controlled, favors the retention of some birdseye maples in the stand to help ensure these genes remain available. While this recommendation may sound counterintuitive to foresters and landowners striving to capture the value of this figured wood, many heavily figured birdseye maples are of such poor form and vigor that their current timber value is low. These cull maples are often removed to create growing space for future crop trees, but their long-term contribution to stand value may be better served by leaving them to ensure that their genetic material is retained.

Even with these concerns, there is little risk that birdseye will ever be completely eliminated. Birdseye maple is remarkably abundant in some contemporary large-scale reserves of old-growth northern hardwoods in Michigan and Wisconsin (Bragg and others 1997). Birdseye seems destined to become increasingly rare in managed northern hardwood landscapes (Bragg 2006). However, its value should still place it in the forefront of the management of many of these areas.

UPDATES TO THE BIRDSEYE ANNOTATED BIBLIOGRAPHY

The last annotated bibliography on birdseye figured grain (Bragg and Stokke 1999) was published almost a decade ago and scores of additional useful references have been found in the meantime (Appendix B). Many of these new citations were collected from sources such as the "Making of America" (http://quod.lib.umich.edu/m/moagrp/ and http://moa.cit.cornell.edu/moa/) online historical archives and Cornell University's "Core Historical Literature of Agriculture" (http://chla.library.cornell.edu/). Some internationally published abstracts of articles were identified in digital databases like AGRICOLA and TreeCD, and others came from the archives of the U.S. Forest Service's Forest Products Laboratory in Madison, WI.

Additionally, some references have been included as clarifications of ones cited in Bragg and Stokke (1999), either because they have been better identified or additional birdseye material related to that particular publication has surfaced. For example, the 1929 M.Y. Pillow references are identical in title and content to the Pillow (1930) citation provided in Bragg and Stokke (1999), the only distinction being that they were published in different outlets. However, references that only briefly note existing literature (for example, Cutter and others 2004) or merely mention the presence of birdseye in sugar maple are not included in this update.

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Pickens, J.B.; Lee, A.; Lyon, G.W. 1992. **Optimal bucking of northern hardwoods.** Northern Journal of Applied Forestry. 9(4): 149-152.

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Pillow, M.Y. 1955. **Detection of figured wood in standing trees.** Report 2034. Madison, WI: U.S. Department of Agriculture, Forest Service, Forest Products Laboratory. 8 p.

Righter, F.L. 1934. **On the cause of birdseye maple.** Journal of Forestry. 32: 626-627.

Rioux, D.; Yamada, T.; Simard, M.; Lessard, G.; Rheault, F.J.; Blouin, D. 2003. **Contribution to the fine anatomy and histochemistry of birdseye sugar maple.** Canadian Journal of Forest Research. 33: 946-958.

Sherwood, M.H. 1936. **From forest to furniture: The romance of wood.** New York, NY: W.W. Norton & Company, Inc. 284 p.

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APPENDIX A. TAXA IDENTIFIED AS POSSIBLY DEVELOPING BIRDSEYE OR BIRDSEYE-LIKE GRAIN ABNORMALITIES NOT REPORTED IN BRAGG AND STOKKE (1999)

Common name	Scientific name	Source reference (see Appendix B)
vine maple	*Acer circinnatum*	Ralph (1892)
Drummond's maple	*Acer rubrum* var. drummondii	Maxwell (1913)
rock maple	*Acer spicatum*	Brackett (1896)
tindalo	*Afzelia rhomboidea*	Goetz (1908)
red alder	*Alnus rubra*	Blackman (1998)
colonial-pine (or hoop-pine)	*Araucaria cunninghamii*	Anonymous (1895) Lincoln (1986)
revesa peroba	*Aspidosperma peroba*	Lincoln (1986)
birdseye calantas (or maranggo)	*Azadirachta integrifolia*	Timber Research and Development Association(1980) Lincoln (1986)
bird's-eye birch	*Betula verrucosa* f. oculosa *Betula pubescens* f. oculosa	Vaclav (1967)
Queensland-maple	*Flindersia brayleyana* *Flindersia pimenteliana* *Flindersia laevicarpa*	Cox (1949) Lincoln (1986)
British oak (or European oak)	*Quercus robur*	Laslett (1875) Cox (1949)
cypress	*Taxodium distichum*	Pelton (1961)
thuya (or thyine)	*Tetraclinis articulata* (syn. *Callitris quadrivalvis*)	Sherwood (1936) Cox (1949) Meiggs (1982) Lincoln (1986)
Pacific myrtle	*Umbellularia californica*	Cox (1949)
keyaki	*Zelkova serrata*	Lincoln (1986)

APPENDIX B. NEW ANNOTATED REFERENCES

1. Anonymous. 1810. Intelligence. The monthly anthology, and Boston review containing sketches and reports of philosophy, religion, history, arts, and manners (1803-1811). 8: 280-285. This article translates a French committee's take on the travels of "M. Michaux" (likely Andre Michaux) in the forests of the United States. Notes that the figured wood of maple was much sought after for cabinetmaking, and that tables of curly and birdseye maple have been sold at a "very high price". One of the earliest references that spells "birdseye" as it is now conventionally used.

2. Anonymous. 1832. Maine. The New-England Magazine. 2(5): 394-403. Author incorrectly states that birdseye and curly maple are almost exclusively the products of Maine's forests.

3. Anonymous. 1848. Queer fancies. Scientific American. 3(35): 275. Attributes an unnamed "late writer" with the recommendation that landscape painters be buried in a coffin built of birdseye maple to ensure the "fitness of things."

4. Anonymous. 1859. Ancient tables of wood. Scientific American. 14(41): 341. Describes how demand for birdseye maple in furniture has dropped drastically due to imitations using softwoods and stains. Birdseye maple has thus been relegated in many places to fuelwood.

5. Anonymous. 1874. The figure and color of wood. The Manufacturer and Builder. 6(10): 221. One of the earliest attempts to describe the formative mechanisms for several figured grains, including birdseye maple, which was attributed to "internal points or spines on the inside of the bark". Though the author is mistaken that these spines actually penetrate the wood and cause the indentations, the concept of bark-initiated indenting of the wood is close to current thinking (see Rioux and others 2003).

6. Anonymous. 1875. New way of cutting veneer. The Manufacturer and Builder. 7(2): 29. Details a "new" rotary cutting approach to veneer manufacturing by describing the yield of a 1,000 board foot birdseye maple log into 24,000 linear feet of veneer. More importantly, the article places a value of this figured log at $6 to $8 in 1875.

7. Anonymous. 1877. Glass veneers. The Manufacturer and Builder. 9(10): 223. Describes the process of mimicking natural birdseye maple using paint and glass. See Anonymous (1859) and Furuse and others (1994) for other means of imitating birdseye grain.

8. Anonymous. 1889. Notes. Garden and Forest. 2(81): 444. In a brief paragraph in this section of this journal, a "Professor Beal" (probably William James Beal of the Michigan State Agricultural College) is said to have found that birdseye is not found in trees less than 3 inches in stem diameter, nor higher in the crowns of even well-figured individuals. This brief report calls for the discovery of the developmental mechanism to aid in its commercial propagation.

9. Anonymous. 1895. Notes. Garden and Forest. 8(398): 410. The text cites a report from the Agricultural Gazette of New South Wales of a figure in colonial-pine (hoop-pine) (*Araucaria cunninghamii*) similar to birdseye maple.

10. Anonymous. 1905. Woodpeckers make birdseye maple, says a Maine man. The Washington Post (Washington, DC). July 23, 1905 edition, page ES8. A story written about an eccentric man from Patten, ME, named Greenleaf Davis, who worked for years to increase the density of woodpeckers near his home. Davis claims that these woodpeckers have pecked the maple trees on his property, causing them to produce birdseye. States that he had a hill near his camp with more than 300

birdseye maples that he planned to offer to the Audubon Society upon his death to sell and then donate the money for woodpecker protection. Davis was also featured in a later article by the Bangor, ME, correspondent of the Chicago Tribune and reprinted in the Washington Post in the July 7, 1907 issue (page M3).

11. Anonymous. 1908. Sugar maple. Silvical Leaflet 42. Washington, D.C.: U.S. Department of Agriculture, Forest Service. 4 p. States that the birdseye grain in sugar maple, highly prized in furniture construction, frequently results from the formation of dormant buds.

12. Anonymous. 1931. Pepper and salt. Wall Street Journal (New York, NY). October 17, 1931 edition, page 8. This feature provided (in addition to an ode to beer) a news item stating that Harvard University scientists had recently found trees buried in the tar sands near Edmonton, Alberta, Canada, of unidentified species that had "beautiful graining and coloring, the growth rings being clearly defined. It was a hard wood, with a deep, reddish color, and a grain resembling that of birdseye maple".

13. Anonymous. 1956. Tree and timber oddities. Southern Lumberman. 193(2417): 97. Attributes the formation of a birdseye-like grain abnormality in Norway birch burl to beetle larvae that tunnel into the wood, leaving a gallery that the tree eventually fills with darker colored cells. Calls this knowledge "…the only difference from birdseye maple."

14. Anonymous. 1997. Hardwood 'sinkers' salvaged to produce unusual lumber. Wood Technology. 124(8): 6. Recounts the story of the Superior Water-Logged Lumber Company (now Timeless Timber) of Ashland, WI, which salvages logs that had accidentally sunk decades ago in Lake Superior. Some of the most valuable of these logs are birdseye maple.

15. Baker, Frederick S. 1934. Theory and practice of silviculture. New York, NY: McGraw-Hill Book Company:291. Supports the assertion that birdseye maple arises from dormant buds.

16. Blackman, Ted. 1998. Use one load of logs to make eight loads of product. Wood Technology. 125(6):36-37. Notes birdseye in red alder (*Alnus rubra*).

17. Bozhok, A.A.; Vintoniv, I.S.; Ivaniv, O.S. 1985. Categories of decorativeness of the wood of sycamore growing in the Carpathians. Lesnoi-Zhurnal. 2: 117-119. This article reports on the occurrence of birdseye in sycamore maple (*Acer pseudoplatanus*) in the Russian Carpathian Mountains. According to the TreeCD abstract, the authors found birdseye sycamore maples had thin, platy bark with obvious indentations in the outer bark and leaves that fell later than non-birdseye individuals.

18. Brackett, Anna C. 1896. Among the trees. Harper's New Monthly Magazine. 93(556): 601-611. Mentions birdseye maple occurs in "rock maple," which, judging from the context, is not intended to be sugar maple. The author may have meant mountain maple (*Acer spicatum*).

19. Bragg, Don C. 1999. The birdseye figured grain in sugar maple (*Acer saccharum*): literature review, nomenclature, and structural characteristics. Canadian Journal of Forest Research. 29: 1637-1648. This review condensed most of what was known about birdseye at the time, from its geographic distribution to potential developmental mechanisms (including genetics) and describe its structural attributes by naming the obvious macrofeatures: the indentation (gelasinus), the protrusion (elatus), and the radial trace (vestigium). Four distinct varieties of birdseye maple are

identified: roundeye, fingernail, cat's paw, and distorted. Numerous pictures and references are provided.

20. Bragg, Don C. 2006. Potential contributions of figured wood to the practice of sustainable forestry. Journal of Sustainable Forestry. 23(3): 67-81. Provides a brief review of what is currently know about birdseye in sugar maple. Discusses birdseye maple and other figured grains as potential avenues to support specialized timber management regimes, including identification of the available resource, harvesting system adaptations, and improved recovery. Concludes with some thoughts on the sustainability of the current birdseye maple resource.

21. Bragg, Don C.; Stokke, Douglas D. 1999. An annotated bibliography on "birdseye" figured grain. Gen. Tech. Rep. NE-263. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Research Station. 15 p. This paper reviews 96 sources of information on birdseye and birdseye-like grain abnormalities, including a list of other species thought to contain this figure type.

22. Brown, D.J. 1846. The trees of America; Native and foreign. New York, NY: Harper & Brothers: 82-83, 86. Brown's 1831 book on dendrology was abstracted in part by the journal The North American Review, including several mentions of birdseye. Reports birdseye to be "frequently exhibit[ed]" in "platanus-like" (sycamore) maple (*Acer pseudoplatanus*). Also lists "bird's-eye maple" as a common synonym for sugar maple in Britain and Anglo-America. Lists cabinets, bedsteads, writing desks, and inlays for bureaus and piano-fortes as key uses for the "accidental forms" of sugar maple, including curly and birdseye grains. Gives "Erable moucheté" as the French name of birdseye maple. Describes the size, appearance, and distribution of the birdseyes, and recommends tangential sawing to highlight the grain pattern.

23. Chovanec, D. 1992. 'Sleeping eyes'—a special feature of wood (Spiace ocka—zvlastna kresba dreva). Drevo. 47: 6, 150-152. This Slovakian publication with an English abstract apparently describes how birdseyes are identified, as well as some possible origins. Source identified using a TreeCD search.

24. Churchill, Edwin A. 2000. The painted furniture of Maine. Antiques. 157(5): 778-787. Describes some of the practice of painting furniture to appear as more valued species or figured grains, included birdseye maple.

25. Collingwood, G.H.; Brush, W.D. 1964. Knowing your trees. Washington, DC: American Forestry Association: 28-29. Describes how the "pebbled" appearance on the surface of boards sometimes leads to lodgepole pine (*Pinus contorta*) being labeled "bird's eye pine."

26. Cox, H.A. 1949. Wood specimens. London, UK: The Nema Press. 206 p. In addition to sugar maple and other true maples, this book also mentions birdseye in Queensland-maple (*Flindersia brayleyana*), thuya (*Tetraclinis articulate*), Pacific myrtle (*Umbellularia californica*), European oak (*Quercus robur*), and briar root (*Erica arborea*). Many of the pictured examples of birdseye in these species are more similar to burr or burl figures.

27. Doane, R.W.; Van Dyke, E.C.; Chamberlin, W.J.; Burke, H.E. 1936. Forest insects. New York, NY: McGraw-Hill Book Company: 392-393. This reference identifies a group of pitch midges (*Retinodiplosis inopsis*, the gouty pitch midge, and *Retinodiplosis resinicoloides*, the western pitch midge), whose boring into the wood of several pine species leads to a defect that causes the label of "bird's-eye pine" to be given to ponderosa pine (*Pinus ponderosa*).

28. Eyres, H.T. 1950. Introducing wood: Facts for all who handle it. London, UK: Sir Isaac Pitman & Sons: 40. Describes birdseye as at one time being popular paneling for yacht cabins. Dismisses the bird-peck theory of birdseye origin in favor of one suggesting that fungi retards radial growth, producing the grain pattern.

29. Forest Products Laboratory. 1929. Forest Products Laboratory research program 1929-1930. Unpublished report. Madison, WI: U.S. Department of Agriculture, Forest Service: 132, 134. This program description briefly describes a grafting study initiated by M.Y. Pillow intended to determine if scions of birdseye maple and figured walnut would work with ordinary root stock. This work almost certainly corresponds to Leopold's citation of a 1928 progress memo by Pillow and Bates.

30. Furnas, R.W. 1884. Reports on the forest condition and lumber and wood trade of western states and territories. In: Egleston, Nathaniel H. (ed.). Report on Forestry. Washington, DC: U.S. Department of Agriculture: 248. Notes "extraordinarily fine" birdseye in Oregon maple.

31. Furuse, Kyoko; Masuda, Minoru; Aota, Yoshiaki. 1994. Imitation of three dimensional glosses of wood by using micro-embossed lines—imitation of glosses of wavy grain figure and bird's eye figure. Journal of the Society of Materials Science, Japan. 43(485): 147-151. English abstract, text in Japanese. Mentions the emulation of birdseye grain using micro-embossed lines in a sheet of polyvinyl chloride.

32. Gayer, K. 1896. Schlich's manual of forestry. Volume V: Forest utilization (translated by W.R. Fisher from "Die Forstbenutzung"). London, UK: Bradbury, Agnew, & Co.: 65. Refers to birdseye maple as one type of burr, attributed to the extension production of dormant buds, which causes the fibers to abnormally twist around them.

33. Gibson, H.H. 1913. American forest trees. Chicago, IL: Hardwood Record: 428, 434-435, 440. The author reports birdseye occurs mostly in sugar maple, and less commonly, red and Oregon maples. Attributes birdseye formation to adventitious buds that fail to emerge, and reports a "pin-like core, resembling a fine thread, [that] connects the birdseye with the tree's pith". However, no such structure has been observed with microanatomical studies (see Rioux and others 2003).

34. Goetz, C.H. 1908. Structural characteristics of some Philippine woods. Forestry Quarterly. 6: 52-57. Mentions a birdseye figure in tinaldo (*Afzelia rhomboidea* or *Eperna rhomboidea*), a legume with good potential for cabinetmaking.

35. Harrar, E.S. 1958. Hough's encyclopedia of American woods, volume II. New York, NY: Robert Speller & Sons: 160-165. Briefly describes the commercial use of birdseye maple in modern stylings, including decorative panels.

36. Hopkins, A.D. 1894. The woodpecker and bird's-eye poplar. Garden and Forest. 7(343): 373. Attributes a birdseye-like grain abnormality in yellow-poplar to damage from woodpeckers, but is not sure if this mechanism is responsible for birdseye maple (although he implies the link due to downy woodpecker's fondness for sugar maple sap).

37. Hough, Franklin B. 1884a. Report on the forest conditions and lumber and wood trade of New Hampshire and West Virginia. In: Egleston, Nathaniel H. (ed.). Report on forestry. Washington, DC: U.S. Department of Agriculture: 379, 387. Mentions that birdseye is found in the sugar

maple of West Virginia, and reports “large lots” of black walnut and figured maple in the headwaters of streams such as the New River.

38. Hough, Franklin B. 1884b. Report on the production of maple sugar in the United States and Canada. In: Egleston, Nathaniel H. (ed.). Report on forestry. Washington, DC: U.S. Department of Agriculture: 406. In a brief section describing the wood of sugar maple, Hough mentions that he knew of $1,000 being paid for a single birdseye maple tree.

39. Hough, Romeyn B.; Leistikow, Klaus Ulrich. 1888. The American woods: exhibited by actual specimens and with copious explanatory text, part I. Lowville, NY: Romeyn Hough: plate 7b. In this self-published collection, Hough and Ulrich classified birdseye (which they also called “pin maple”) and “blister maple” as a species (*Acer saccharinum*) distinct from straight-grained sugar maple (*Acer saccharum*). *Acer saccharinum* is currently the accepted scientific name for silver maple. The authors also provide German (“Augen Ahorn”), French (“Erable oeil d’oiseau”), and Spanish (“Arce ojo de paxaro”) names for birdseye maple.

40. Hubert, Ernest E. 1931. An outline of forest pathology. New York, NY: John Wiley & Sons, Inc.:12-14. Brief reference interesting primarily in that it lists birdseye as a tree disease resulting from stimuli related to a “chemical unbalance within the plant or from an unbalancing of physiological or environmental factors”.

41. Johnson, Tim. 2000. Birdseye maple. American Woodworker. 81: 28-29. Provides advice for procuring and woodworking with birdseye maple.

42. Kellogg, R.S. 1914. Lumber and its uses. Chicago, IL: The Radford Architectural Company: 115, 117, 180, 276. Suggests that for birdseye maple, the use of “two thin coats of pure grain alcohol white shellac evenly applied directly on the wood…sandpapering thoroughly each coat… [and] waxing…will give splendid results.” Notes that birdseye and curly maple are often used to construct harp boxes.

43. Koehler, Arthur. 1926. Identification of furniture woods. Miscellaneous Circular 66. Washington, DC: U.S. Department of Agriculture:19. Although the author does not attribute a specific cause of birdseye, he states that birdseye differs from burl in not having a pith associated with a bud. Also states that birdseye occurs almost exclusively in a small percentage of maple.

44. Kormanik, Paul P.; Brown, Claud L. 1967. Adventitious buds on mature trees. Research Note SE-82. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station. 7 p. While this note never mentions birdseye, the grain patterns shown related to adventitious buds look similar in many ways to birdseye maple. However, the pith apparent in bud traces is a distinguishing characteristic not found in birdseye.

45. Laslett, Thomas. 1875. Timber and timber trees, native and foreign. London, UK: Macmillan and Co.: 53. Identified a figure in British oak (*Quercus robur*) that resembles birdseye maple.

46. Leopold, Aldo. 1929. Some thoughts on forest genetics. Journal of Forestry. 27: 708-713. Briefly speculates on the roles of genetics and site conditions on birdseye formation, including the mention of an attempt by M.Y. Pillow and C.G. Bates in 1928 to breed birdseye maple. To date, this memo had not been uncovered, but Leopold cites it as: Pillow, M.Y.; Bates, C.G. 1928. Bird’s-eye maple study, memorandum of progress in 1928, June, 1928. Forest Products Laboratory and Lake States Forest Experiment Station.

47. Lincoln, William A. 1986. World woods in colors. New York, NY: Macmillan Publishing Company. 320 p. Identifies a number of species with birdseye or birdseye-like grain abnormalities, including hoop-pine (*Araucaria cunninghamii*), revesa peroba (*Aspidosperma peroba*), birdseye calantas (*Azadirachta integrifolia*), ponderosa pine (*Pinus ponderosa*), Queensland-maple (*Flindersia brayleyana*, *Flindersia pimenteliana*, and/or *Flindersia laevicarpa*), thuya (*Tetraclinis articulate*), and keyaki (*Zelkova serrata*).

48. MacLean, Rick. 1997. Against the grain. New Brunswick Telegraph Journal: A1-A2. November 3, 1997. Describes the problem New Brunswick's crown forests are having with the theft of birdseye—an estimated 80 percent of the hundreds of timber theft cases annually reported during this period involved birdseye. A number of legal cases are cited, including the penalties involved. The act of cutting out a piece of bark to examine the bole for birdseye maple (xylemic examination) is called "prospecting".

49. MacLean, Rick. 1997. DNA tests could be a weapon in helping catch tree rustlers. New Brunswick Telegraph Journal: A1. November 4, 1997. Suggests the use of DNA testing to help identify stolen timber, including birdseye maple logs, but notes the lack of funding to develop the techniques required.

50. Maxwell, Hu. 1913. Uses of the commercial woods of the United States. Beech, birches, and maples. Bull. 12. Washington, D.C.: U.S. Department of Agriculture: 34, 38-39, 41-42, 49, 53. This monograph describes a number of species with birdseye, including sugar maple, bigleaf maple, and Drummond's maple (*Acer rubrum* var. drummondii). The Drummond's maple reference identifies a "peculiarly fine class" of birdseye from the lower Red River in Louisiana that was used for gunstocks and violins. Other uses listed by the author for birdseye included furniture, pianos, harps, and veneer. Maxwell favors the dormant bud theory of birdseye formation.

51. McCabe, Carol. 2003. Figured woods. Early American Life. 34(2): 50-55. An article on the use of figured wood in furniture by early American craftsman. Repeats most conventional theories on birdseye formation without favoring any in particular. Also mentioned some "folk wisdom" repeated by Lou Irion that some "old-timers" believed birdseye was caused by the rocking of cold trees in the wind. Notes the use of birdseye in a Portsmouth Federal-style chest of drawers and a Sheraton sewing table, both circa 1810, as well as by more modern designers.

52. Meiggs, Russell. 1982. Trees and timber in the ancient Mediterranean world. Oxford, UK: Clarendon Press. 553 p. Discusses the use of figured woods by the ancient Greeks and Romans for furniture, especially tables. Mentions "citrus-wood" (*Callitris quadrivalvis*, synonymous with *Tetraclinis articulata*) and unspecified maples (*Acer* spp.) as producing birdseye-like figure.

53. Patterson, Douglas. 1988. Commercial timbers of the world, 5th ed. Brookfield, VT: Gower Technical Press: 177. Attributes birdseye in sugar maple to an insect attack.

54. Pelton, B.W. 1961. Furniture making and cabinet work: a handbook. Princeton, NJ: D. Van Nostrand Company, Inc.: 475. Suggests applying a thin coat of walnut stain, followed by shellac, gloss varnish, and dull varnish for "bird's-eye or curly grain cypress" (i.e., baldcypress, *Taxodium distichum*).

55. Pillow, M.Y. 1929a. "Bird's eyes" in maple are not due to dormant buds. Wood Working Industries. 6(3): [number of pages not given]. Identical to Pillow (1930) reference in Bragg and Stokke (1999).

56. Pillow, M.Y. 1929b. “Bird’s eyes” in maple are not due to dormant buds. Furniture Manufacturer. 38(6): 106, 108. Identical to Pillow (1930) reference in Bragg and Stokke (1999).

57. Powell, G.W. 1879. American forests. Harper’s New Monthly Magazine. 59(351): 371-374. Author decries the loss of birdseye maple and other figured grains destroyed by slash-and-burn agriculture in pioneer America.

58. Ralph, Julian. 1892. Canada’s El Dorado. Harper’s New Monthly Magazine. 84(500): 171-189. Identifies a figure closely resembling birdseye in vine maple (*Acer circinnatum*) along the coast of British Columbia.

59. Rioux, D.; Simard, M.; Rheault, F.J.; Lessard, G. 1997. Fine anatomy of birdseye sugar maple. In:CTIA/IUFRO International Wood Quality Workshop. Quebec City, Canada: Forintek: IX-17. This abstract describes preliminary anatomical work conducted by the authors that eventually is published in much greater detail in Rioux and others (2003). See also Rioux and others (1999).

60. Rioux, D.; Yamada, T.; Simard, M.; Lessard, G.; Rheault, F.J.; Blouin, D. 2003. Contribution to the fine anatomy and histochemistry of birdseye sugar maple. Canadian Journal of Forest Research. 33: 946-958. The most detailed anatomical and biochemical assessment of the birdseye grain in sugar maple published to date. Using light and transmission electron microscopes, this seminal publication identified numerous physiological properties of birdseye, including inclined axial elements, shorter and smaller vessels, occasional gaps between xylem cells, abnormal secondary wall thickenings in vessels, and an absence of multiseriate rays. The authors reported no evidence of pith or dormant buds in their examinations. Collapsed and hypertrophied cells were observed, indicating cambial initial injuries arising from the pressure exerted by inner bark fibers. Abnormalities also appeared in the phloem and rays. Contains many detailed micrographs identifying key deformations and differences with normal sugar maple wood.

61. Rioux, D.; Yamada, T.; Simard, M.; Lessard, G.; Rheault, F.J.; Blouin, D. 1999. Anatomy and cytochemistry of birdseye sugar maple. Canadian Journal of Plant Pathology. 21: 204-205. This abstract expands upon the work of Rioux and others (1997) by including cytochemical work indicating that birdseyes are less lignified than normal xylem. As with Rioux and others (1997), this work is extensively updated in Rioux and others (2003).

62. Roth, Filibert. 1895. Timber: An elementary discussion of the characteristics and properties of wood. Washington, D.C.: Government Printing Office:11, 23. Lists birdseye panels in ship saloons and palace cars. Associates the small (less than 1/8 inch) eyes with dormant buds and labels the expression of this structure in the wood as “landscape”.

63. Sargent, C.S. 1885. Woods of the United States. New York, NY: D. Appleton and Company: 20, 22. Mentions birdseye grain in bigleaf and sugar maple, and notes the “accidental forms [curly and birdseye maple]… are common and highly prized”.

64. Sherwood, Malcolm H. 1936. From forest to furniture. New York: W.W. Norton & Company: 45-49, 95, 110, 115, 213. This citation is an expansion of the original provided in Bragg and Stokke (1999). Four additional references to birdseye or birdseye-like figured grains were found in this text, including reference to good birdseye maple being used as an economical substitute for different burls, and how similar-looking thuya (*Tetraclinis articulata*) burlwood is to birdseye maple. This reference may have served as the source for the factoid reported in Anonymous (1956)

about the origin of a birdseye-like grain abnormality in Norway birch, attributed to tunneling beetle larvae.

65. Stone, Herbert. 1904. The timbers of commerce and their identification. London, UK: William Rider & Son, Ltd.: xvii, 55, 58, 260 (Plate XX). Holds that birdseye maple arises from an insect attack. Includes “bird’s-eye maple” as a common alternative name for sugar maple. Reports that Oregon maple’s birdseye figure is “very beautiful”. This reference also contains two pictures of birdseye maple, with a caption labeled “the worm-eaten [b]ark, showing the origin of the figure”.

66. Timber Research and Development Association. 1980. Timbers of the world, volume 2. Lancaster, UK: The Construction Press, Ltd.: 26. Describes a “birdseye calantas” (also called maranggo in the Philippines) found in *Azadirachta integrifolia*.

67. Vaclav, E. 1967. Bird’s-eye birch and flamy birch, two important forms of birch. Sbornik-Vedeckeho, Lesnickeho Ustavu Vysoke Skoly Zemedelske v Praze. 10: 117-136. TreeCD describes this work as illustrated. The author identifies two technical forms (f.), *f. oculosa* (birdseye) and *f. flammifera* (flamy) in *Betula verrucosa* (silver birch) and distinguishes *f. oculosa* from *f. carelica*. Also lists *f. oculosa* as occurring in *Betula pubescens* (European white birch).

68. Vaclav, E.; Kucera, B.; Rezabkova, J. 1971. The anatomical, physical and mechanical characteristics and properties of the wood of curly, bird’s-eye and flamy birch. Sbornik-Vedeckeho, Lesnickeho Ustavu Vysoke Skoly Zemedelske v Praze. 12: 111-127. TreeCD lists this as a “more detailed” version of a previous article.

69. Van Goethem, Larry. 1996. “Common sense” guides Upper Michigan logger. The Northern Logger & Timber Processor. 44(11): 12-14. Describes some of the life of logger Jeff Carlson, including his skills in finding, cutting, and selling birdseye maples. Mentions interest by a timber buyer for a Japanese cello-maker looking for the “finest quality” birdseye maple logs.

70. Vaughan, Melville M. 1896. A California principality: Humboldt and its redwoods. Overland Monthly and Out West Magazine. 28(165): 328-368. Stated that redwoods developed “immense bird’s eye burls”.

71. Velling, P.; Viherä-Aarnio, A.; Hagqvist, R.; Lehto, J. 2000. Valuable wood as a result of abnormal cambial activity—the case of *Betula pendula* var. *carelica*. In: Savidge, R.A.; Barnett, J.R.; and Napier, R. (eds.). Cell and molecular biology of wood formation. Oxford, UK: BIOS Scientific Publishing, Ltd.: 378. Holds that visually similar figured grains like curly birch and birdseye maple have different developmental mechanisms.

72. Walck, Christa; Strong, Kelly C. 2001. Using Aldo Leopold’s land ethic to read environmental history: The case of the Keweenaw forest. Organization & Environment. 14(3): 261-289. Mentions that birdseye maples from the Keweenaw Peninsula in northern Michigan were the most highly valued of all maples. They quote a manager of a local timber company reporting stumpage prices of between $5,000 and $50,000 per 1,000 board feet, or up to $25,000 for an individual tree.

73. Walters, Brady. 1995. Birdseye prized: high demand means Keweenaw commodity more rare, valuable. The Daily Mining Gazette (Houghton, MI). Tuesday, May 2, 1995 edition, page 1B. Reviewed research on birdseye maple at Michigan Technological University. Interviewed several

individuals involved with the birdseye maple trade in the Upper Peninsula of Michigan, and reported the theft of birdseye logs by helicopter.

74. Weck, Johannes. 1966. Dictionary of forestry. Amsterdam: Elsevier Publishing Company: 154, 246. Provides the German (Maserholz), French (bois m madré), Spanish (madera f veteada), and Russian (свилеватая древесина) terms for "bird's eye". Also lists the following names for birdseye: Vogelaugenmaser (German), madrure f en oeil de perdrix (French), veteado m de ojo de perdiz (Spanish), and узор m "птичий глаз" (Russian).

75. Weyerhaeuser Company. 1956. Characteristics of modern woods. 6th ed. Tacoma, WA: Weyerhaeuser Company, Wood Products Division: 38. Provides a listing for birdseye maple, a rare occurrence most commonly found in sugar maple. Describes the distribution of birdseye in a stand as unpredictable, and notes that some trees with birdseye have it only as patches or stripes irregularly distributed along the bole.

76. White, Marshall S. 1980. Wood identification handbook: commercial woods of the United States. New York, NY: Charles Scribner's Sons: 55-56. Reports that birdseye can be seen in the bark of sugar maple logs and is "eagerly" sought by log buyers, who turn these figured logs into veneers often 1/64th of an inch thick (or less).

77. Williams, E. 1991. Tug Hill, a threatened paradise. Conservationist. 45(5): 2-7. The author claims that for a couple of decades during the middle of the 19th Century, two-thirds of all of the birdseye maple veneer produced in the world came from the Tug Hill Plateau in New York.

78. Wiman, Erastus. 1889. The greater half of the continent. North American Review. 148(386): 54-73. The author claims that Canadian forests contain "enormous supplies" of birdseye maple.

79. Zuikhina, S.P. 1975. Abnormal structure of the wood in *Acer pseudoplatanus* in the Carpathians. Probl. Onkol. I Teratol. Rastenii. [no volume listed]: 191-193. This Russian-language account, abstracted in TreeCD, mentions birdseye as one of the figured grains of sycamore maple studied in plantations. States that birdseye maples, occurring in 10 percent of trees considered, are distinguishable by the fine pitting of the bark's surface. Abstract information is very similar to another work credited by TreeCD to Zuikhina in 1976 and may prove to be the same material.

80. Zuikhina, S.P. 1976. Anomalous structure of sycamore (*Acer pseudoplatanus*) wood in the Carpathians (Abomal'noe stroenie drevesiny klena belogo v Karpatakh). Probl. Onkol. I Teratol. Rastenii. [no volume listed]: 191-193. See Zuikhina (1975) entry.