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ELEVENTH MILHAM LECTURE

Native Woods of New Brunswick - An Historical Glimpse of Canadian Forestry

Rodney Arthur Savidge

No. 11 - March 22, 2000

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THE MILHAM LECTURE SERIES

The Milham Lecture Series is named for Dr. Mary Ella Milham, Professor Emerita, Classics.

Born March 22, 1922, Waukesha, Wisconsin. BA, Carroll College, 1943; MA, 1944, PhD, University of Wisconsin-Madison, 1950.

Teaching: University of Wisconsin-Madison, 1946-54; University of New Brunswick, 1954-87. First Dean of Women's Residences, 1955-59; Board of Governors, 1978-81. National Secretary-Treasurer, Humanities Association of Canada, 1966-68; Council of the Classical Association of Canada, 1968-88, becoming first woman president, 1984-86; Humanities Research Council, 1985-88, as well as long service to its committees on Grants and on Aid to Publication.

Dr. Milham's publications consist of nearly forty articles in learned journals and six books, including *Apicii decem libri qui dicuntur de re coquinaria et excerpta a vinidario conscripta,* Bibliotheca Teubneriana (Leipzig, 1969), rpt. (Madrid, 1988); and *On right pleasure and good health (De honesta voluptate et valitudine),* by B. Sacchi, called Platina, text, tr. and comm., Renaissance Society of America, 1998. She has also written a history of Classics at UNB, *Greek an' Latin an' A'* (Fredericton, 1986). In 1989, she received an Award of Merit in the Writing of Local History from the State Historical Society of Wisconsin. Other awards include fellowships from The Canada Council, 1961-62, 1967-68, and from SSHRCC, 1980-81.

Dr. Milham has worked in libraries throughout her career, chiefly on European and Latin manuscripts. She has provided a small library for the Humphrey Art Center at Carroll College, but in 1987 she established the much more ambitious **Milham Trust Fund** at UNB. Its objectives are to develop and co-ordinate the Harriet Irving Library's holdings in the Book Arts, and in addition, to make its long-established collection of New Brunswickiana as comprehensive as possible.

Anyone with similar interests is encouraged to contribute to the **Milham Trust Fund**.

PREFACE

In the 12th Milham Lecture in 2000, Dr. Rodney Savidge considers Alexander Monro's *Native Woods of New Brunswick* as an artifact of the Acadian Forest of 1862. In its 76 specimens, skillfully arranged therein by Steven Truman, there is a record of that forest's biodiversity. In Monro's description of those specimens, we learn also from Rod's lecture that there are unresolved matters of scientific inquiry concerning proper naming of species, their classification, their conservation, and ultimately their management in today's forests.

Commissioned for the New Brunswick display at the International Exhibition in London, England, in 1862, Monro's lovely book wound up in Austria after the event's close. Monro's obituary suggested that a Princess of the reigning house had taken a fancy to it.

One hundred and thirty plus years later, the book turned up in a jumble sale in England. Correspondence in the University of New Brunswick (UNB) Archives & Special Collections department reveals that the book's first steps back to New Brunswick began in August of 1998: Dr. James Morley, then of Kew Gardens, made contact with Dr. Paul Cooper, a then member of UNB's Faculty of Forestry and Environmental Management. In his message, Dr. Morley recounts having received a call from a member of the public wishing "to donate to Kew a book she found in a local second-hand charity shop." Dr. Cooper, knowing "for certain that UNB would highly value such a book," turned the query over to Ezster Schwenke, who was at that time Head of UNB's Science & Forestry Library. From there, the e-mail communication widened to include Mary Flagg, the then Head of Archives & Special Collections, and John Teskey, Director of Libraries.

The donor, a Mrs. Patricia Fellowes from Somerset, found the wood book in a bin among articles being sold to benefit a hospital charity in the west of England. She recognized that it might have some scientific value, and in return for giving it to Kew, she was interested only in receiving a small donation for the charity.

The e-mail exchanges continued over the next few months and in January 1999, Dr. Hew Prendergast, Kew's Curator at the Centre for Economic Botany and Economic Botany Collections, confirmed that the donor was willing to sell the wood book to UNB. The donor's intention was to "pass on all the proceeds to the hospice," which was Weston Hospicecare. In respect of the principle of the provenance of such special collections' materials, Dr. Prendergast wrote to Ms. Flagg, that whereas the donor thought that rather than having sold the book to an antiquarian dealer "a place like Kew would be a happy home for it," UNB was fortunate that Kew was of the "view … that New Brunswick might be an even happier home."

Dr. Ivan Crowell, a 1929 UNB forestry graduate, had made a donation to Archives & Special Collections that was designated for the purchase of something special for the Rare Book Collection. It was Dr. Crowell's generosity that led to UNB's offer being accepted January 8th, 1999. On March 25th, 1999, Alexander Monro's *Native Woods of New Brunswick* returned home.

On the occasion of its homecoming, Dr. Savidge's erudite lecture now places this wood book into a context that permits appreciation of Monro's work as a beautiful and scientifically valuable object that captures its time, and helps us to understand how we might manage New Brunswick forests in our time.

The book itself is preserved for future generations among the holdings of UNB Libraries Archives & Special Collections Rare Book Collection. Ask at the desk, and it will be retrieved for perusal and study.

Francesca Holyoke, Archivist

Author's Foreword

It was an honour to be invited to give the Milham lecture (22nd March 2000, UNB Fredericton, NB) about *Native Woods of New Brunswick – 76 Specimens,* an historical book-like artifact acquired by UNB Libraries in 1999. The invitation to speak came with the privilege of providing written comments and, after 14 years, I feel that what follows finally begins to approach a reasonable attempt to describe the wood book, its author, the historical setting and the value of the artifact to Canadian forest management. Various excuses *apropos* competing demands and my own intrinsic limitations could be advanced for the delay, but really the principal reason was deliberate hesitation, mainly because of the need to solve some puzzles, e.g., inexplicable nomenclature as written on the artifact and conflicting historical records. I had somewhat foreseen and even acknowledged those aspects during my public presentation, but only afterward as I delved further did I realize how ignorant I was, and how essential it was to communicate a broader and deeper purview of early North American botanical exploration and plant nomenclature, in order to fairly communicate the value of the artifact. I went in that direction, as I could. It has been a fascinating although I suspect less than an entirely thorough undertaking. I share below some of what was discovered and thoughts on the implications of the discoveries.

In addition to its common and scientific names, *Native Woods of New Brunswick – 76 Specimens* embodies well-preserved specimens of made-in-New-Brunswick natural products, i.e., woods from a variety of tree species. Any piece of wood upon being removed from its source, i.e., from the living tree, in essence becomes a 'fossil' embodying nature of the past and useful for future research. If the environment is conducive, that fossil will persist for millions of years (Savidge 2008). The specimens in *Native Woods of New Brunswick – 76 Specimens* appear to be in sound condition, and with careful handling they should remain so.

The formative processes underlying wood formation – the cell biology, biochemistry and biophysics – vary from one tree species to the next, and this realm of the biological sciences still needs considerable attention (Savidge 2000). Each specimen in the wood book could be likened to a computer's hard drive holding terabytes of scientific data. How to decipher that information in terms of biological processes is the challenge, and undoubtedly also the key, for advances in our understanding of how trees make wood. Thus, Monro's book is a scientific treasure in support of future research.

Native Woods of New Brunswick - 76 Specimens also provides a snapshot of a moment in both manmade and natural New Brunswick forest history. My comments attempt to position the wood book within the time-stream of human values and scientific developments, and my hope is that they will lead to the next chapter in New Brunswick forest management history being an entirely different narrative from those of past chapters.

I would like to thank David Mawhinney, archivist at Mt. Allison University, and University of New Brunswick librarians Eszter Schwenke, Francesca Holyoke, Teri Noel and John Teskey for their capable assistance in this project. Should any errors or omissions be found in the following text, I am solely responsible.

RAS, March 2014

Dedication

To my wife, Meg, who dared to accompany me into Canada's dark forest in support of my dreams to help it survive.

Native Woods of New Brunswick – An Historical Glimpse of Canadian Forestry

Rodney Arthur Savidge

SUMMARY – An artifact in book form of wood specimens produced from the Acadian Forest in 1861 is described and considered in relation to tree and shrub diversity within New Brunswick. Specimen names in this 'wood book' reveal problems in species nomenclature and classification that continue to affect forest management practices in Canada. Analysis of the historical setting prompted reflections about conservation, physiological diversity, silviculture, forestry education and tree science in relation to sustaining future survival fitness in trees.

INTRODUCTION

> *These Colonies commenced a war on the forests of America at the same time the "old Colonies" did.* - Alex Monro (1868).

Native Woods of New Brunswick: - 76 Specimens is a compact collection of wood specimens from trees and shrubs that grew in the Province of New Brunswick, Canada. Most of the specimens are presented as rectangular veneer slices, and they together with some shrub specimens were cleverly assembled together in book form. This wood book evidently was a singular production, as no copies of it are known. In 1999 the artifact was acquired by the University of New Brunswick Libraries (Special Collection, Harriet Irving Library – see Preface). Beneath the stated title of the wood book are inscribed the words:

> *Arranged by Families, with the Botanical and Common names of each; also the average heights of each; with the exports for 1860; collected and Arranged in Book form, By Alex Monro, woodwork By Steven Truman, Westmorland, N.B. 1862* (Fig. 1).

Monro's wood book was produced in response to a British 'Act of Incorporation,' enacted February 14th 1861, that led to 'The London International Exhibition on Industry and Art of 1862.' That exhibition was held from May 1st to November 1st 1862, and it followed upon the 'Great Exhibition of the Works of Industry of all Nations' in 1851 that had been a huge success (HMC 1862).

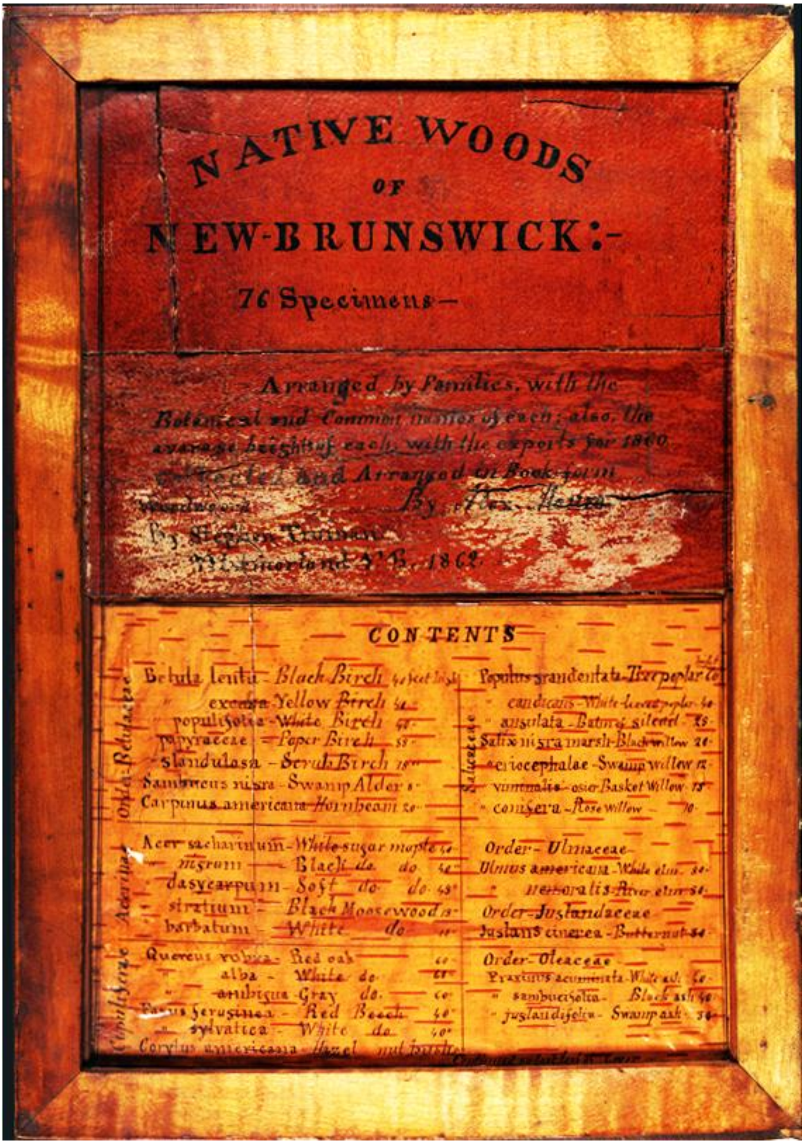

Figure 1. Title page with partial *Contents* (compare Table 3) of *Native Woods of New Brunswick.*

Some insight into what happened in Nova Scotia and New Brunswick following Queen Victoria's 1861 act of incorporation is provided in a Nova Scotia document which reads:

> *In March 1861 the Imperial Commissioners for the International Exhibition sent to the Colonial governments...invitation to have their respective provinces represented... On August 6th, 1861, a number of gentlemen, embracing members of the Legislature and private persons acquainted with the resources of the province* [i.e., of Nova Scotia]*, met...as a Provincial Board of Commissioners ... New Brunswick Commissioners were about to hold a preliminary Exhibition at Sussex Vale, on Oct. 1st; it was thought advisable that an officer of the Board should visit Sussex Vale...* - Board of Provincial Commissioners (1864).

The preliminary exhibition held at Sussex Vale in 1861 was summarized in a New Brunswick agricultural report (Provincial Board of Agriculture 1862). Therein, it was reported that "*Alexander Munroe* [sic] *of Westmorland*" received a $3.00 prize for native woods in book form. That preliminary showing evidently qualified Monro's wood book as an entry, via New Brunswick Commissioners, into the London International Exhibition of 1862.

David R. Munro also made a contribution to the Sussex Vale exhibition:

> At *the Provincial Exhibition, held at Sussex Vale, in the Province of New Brunswick, during the month of September* [sic]*,1861, the writer had on exhibition, specimens of upwards of fifty kinds of woods, with the foliage of each, which were deemed by the Commissioners so far meritorious as to be retained, along with other samples of woods in their rude state, for the World's Exhibition, to be held in London in May, 1862*. ... *Observing that there was, among the collections exhibited at Sussex Vale, no detailed description of the different woods, which would give an idea of the uses to which each kind could be applied, the writer determined to make an effort to supply the omission*. - Munro (1862).

Inexplicably, no reference to either David Munro's wood specimens or his publication about them was found in the agricultural report that mentioned Monro's wood book (Provincial Board of Agriculture 1862).

Neither the wood book assembled by Alexander Monro nor the specimens mentioned by David Munro were specifically acknowledged by either title or author in the official 1862 London International Exhibition records of the Industrial Department (HMC 1862). However, numerous categories of items were recorded as having been provided by "*New Brunswick Commissioners*" (HMC 1862). Five medals and nine honourable mentions were awarded to New Brunswick's 36 industrial exhibits, but evidently neither of those of either Monro or Munro ranked highly (HMC 1862). Years later, Fowler (1885) after reading the book produced by David Munro (1862) described the work as "*innocent to the last degree of all knowledge of Botany.*" It may have been that judges at the London International Exhibition were similarly unimpressed. Names of tree species recorded in Alexander Monro's book of wood differed from those of Munro (1862), and it can be imagined that the nomenclatural disparity puzzled the judges.

Hunt (1862) in a guide to the 1862 Exhibition noted the following:

> *The collection of colonial woods embraces more than one hundred specimens, duly named and described, <u>wood specimens in book form;</u> walking-sticks, gun-stocks; chess-boards, work-tables, frames, paper-knives, Myall wood pipes, and other illustrations of the woods*. – Hunt (1862, vol. 2, p. 328). [my emphasis]

At the close of the London International Exhibition, many of the exhibits were donated to persons and institutions in the United Kingdom (Board of Provincial Commissioners 1864). The wood book evidently went to a Princess of the reigning House in Austria (Archive 7001).

Native Woods of New Brunswick: - 76 Specimens provides an instructive example of the discord and ambiguity that existed in North American botanical nomenclature during and before its time. Both problems were considerable, as detailed below. That confusion was brought on primarily by differences between two distinct European schools of classification, the adherents of which were motivated to name and impose their particular system of order onto the many previously unknown plants of the New World. Subsequently, Canada's first forestry schools (University of Toronto - 1907, University of New Brunswick - 1908) had to come to grips with or perpetuate that same confusion in their educational programs and, in hindsight, Canada shunned the hard essential work. Consequently, uncertainty about tree species and classification remains still today (see white spruce and black birch examples below).

Below, the artifact is described, placed into historical perspective, and considered in relation to what it has to tell us about present and past attempts at forestry education and forest management within the Province of New Brunswick and Canada in general. To begin with, however, some information is provided about Alexander Monro, the author of *Native Woods of New Brunswick: - 76 Specimens*.

ALEXANDER MONRO

"Alex Monro," (1813-1896) the author of *Native Woods of New Brunswick: - 76 Specimens*, was also known as Alexander, and his surname occasionally was misspelled as Monroe or Munroe. He evidently was not in any way connected to David Ransom Munro (1828-1890), who published *Forest and Ornamental Trees of New Brunswick* (Munro 1862).

Alexander Monro was born in Scotland, and at two years of age he arrived in New Brunswick with his family. As a youth he learned his father's trade of stone masonry, and in winters he attended a log school house near Baie Verte, a few km south of Port Elgin, New Brunswick. In his latter school years he learned geometry, algebra and land surveying and, after age 21, he acquired and ran a private land-surveying business. In 1838 he was appointed Deputy Crown Land Surveyor, and in 1848 he was appointed a Justice of the Peace for the Province of New Brunswick (Archive 7645). Monro was the surveyor who ran the boundary line between Nova Scotia and New Brunswick (Trueman 1902).

Monro authored several books (see Swanick 1990). In one, published a few years before production of the wood book, Monro (1855) provided important historical information about New Brunswick and Nova Scotia including details of the forest's biodiversity. In that text, Monro (1855) employed some scientific nomenclature for various tree species, but he did not clearly explain his sources.

In his 1868 work entitled *Annexation, or Union with the United States ...* followed by his 1879 publication entitled *The United States and the Dominion of Canada*: *Their Future*, Monro argued for merger of British North American colonies with the United States:

> *Let such an union take place, and let the people put implicit trust in the Great Dispenser of events and Ruler of nations, and we have the best guarantee of prosperity...* – Monro (1868).

Although his earlier descriptive works (see Swanick 1990) had received favourable reviews, his outspoken opinion on merger with the United States failed to endear him to the ancestors of the Loyalists, or to those who had experienced the War of 1812-15 (see Daily Sun 1897).

In a newspaper obituary published December 26th, 1896, the death of "*Alex. Monroe"* [sic]*, "a land surveyor*" was described as having occurred at Port Elgin (Transcript 1896). In another obituary, "*Monro, Alexander, surveyor, office holder, JP, author and journalist*" was noted to have died 26 December 1896 in

Baie Verte (Swanick 1990). No mention of *Native Woods of New Brunswick: - 76 Specimens* was made in either of those obituaries.

A third obituary[1] included the following comments about Monro:

> *When a call was made in 1863* [sic] *to show Maritime productions at the Worlds Exhibition* [sic] *at London, under the presidency* [sic] *Prince Albert, Mr. Monroe* [sic] *collected samples of the native woods of these Provinces* [sic] *and arranged them in book form, including an index written on birch bark, showing the local and botanical names of each kind of wood and also tables showing the extent of the wood trade of the provinces. At the close of the exhibition, the book was forwarded to Austria, a Princess of the reigning House, having fancied it and expressed a wish to secure it.* – Archive 7001.

That same obituary[1] also described Monro as a self-made scholar:

> … *to make a man of cultured tastes, a student, a scholar and a publicist of acknowledged rank and value in the country, - Universities with their libraries and endowments are not absolutely necessary; social position, influential conviction and wealth are not necessary; - without such adventitious aids, what is wanted is a native taste for research and enquiry and a determination of character superior to environment*. – Archive 7001.

Steven Truman evidently prepared the panels and did all additional woodwork underlying preparation of the wood book. The fine handiwork testifies to Truman having been a highly skilled tradesman, possibly a cabinet maker. Unfortunately, no recorded information was found which would have enabled his name to be associated with a particular location or enterprise.

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1 - DEATH of ALEX MONRO: The publisher and date of publication of this obituary could not be established. The obituary begins with "*Many readers of the Post...*," but precisely which 'Post' is unclear. A copy of the obituary document is held in the archives of the Webster Chignecto Collection of Mt. Allison University, accession no. 7001. At the top of the copy is "*DECEMB*." Alexander Monro died on December 26, 1896, and thus the obituary must have been published soon after that date. No additional information about the source of the article was discovered, but it can be suggested, based on known dates when Sackville newspapers were being actively published, that the "*Post*" most probably refers to the Chignecto Post and Borderer. There is also a remote possibility that it was the Semi-Weekly Post. The only two locations known to have archives of those former newspapers are libraries at Mt. Allison and UNB, and unfortunately neither holds December 1896 issues of either.

HISTORICAL BACKGROUND

The concept of species

All plants are useful, but some are also potentially harmful. Distinguishing different kinds of plants was likely an innately pragmatic aspect of earliest human existence, for example, to satisfy needs for shelter, clothing, food and warmth, as well as for tools, medicines, toxins, dyes, etc.

Sumerians and Akkadians of the 3rd millennium BC and earlier were informed of numerous plants useful in medicinal applications (Steinkeller 1987), and the *Papyrus Ebers* document of 1550 BC revealed that early Egyptians were also highly knowledgeable (Bryan 1930). Achillo, an ancient Greek doctor, used yarrow (*Achillea millefolium* L.) to cure a wounded warrior (LeStrange 1977), and Greek and Roman soldiers carried particular plants as part of their survival kits (Haughton 1978). Hippocrates (460-377 BC) used plants routinely in his medical practice, and in 78 AD Dioscorides described in his *De Materia Medica* about 600 plant species and their medicinal properties. From the time of the 1535-36 visit to eastern Canada of Jacques Cartier and his crew, traditional knowledge about particular species of woody plants served to save lives of Europeans, following their arrival on the unfamiliar shores of the New World (MacPhail 1948). More than two hundred plant-derived indigenous drugs gained official status in *The Pharmacopeia of the United States of America* following its first publication in 1820, and Fowler (1880) noted that more than 230 plants listed in the King's American Dispensatory were to be found in New Brunswick. Numerous journals continue to publish innovative advances in pharmacognosy (a combination of two Greek words: *pharmakon*, drug, and *gnosis*, knowledge). The beginnings of pharmacognosy trace back to research aimed at discovery of useful chemicals in trees, and the science has no meaning if the species cannot be reliably identified.

In order for a plant to be distinguished from others and communicated through the medium of script, and hence be available for economic trade and export, it obviously is necessary to have a mutually acceptable system – one enforced by stringent rules – for distinguishing species both morphologically and by word. The Greek term *eidos*, emphasizing what is physically perceived as form, essence, type, or species, traces back to Aristotle (384-322 BC). A 'species' was defined by giving its *genus proximus* (nearest genus) and *differentia specifica* (Cohen 2014). The specific differences were to comprise one or more attributes which unambiguously distinguished the members of a species from members of other species within the same genus.

Dendrology, or the study of trees (e.g., Farrar 1995, Hardin et al. 1996), had its formalized beginnings with Theophrastus (c 372 - c 287 BC) in his *Historia*

Plantarum. By the Middle Ages, silvicultural practices in Central Europe were empirically well advanced and, possibly, more in harmony with nature than they are today (Mantel 1964). However, it was not until near the end of the Renaissance period that the academic pursuit of tree classification came to the fore. John Evelyn (1620-1706) in his 1664 edition of *Sylva* (the first book to be published by the Royal Society of London) often referred to "*species*." However, Evelyn (1664) used the term to mean both particular tree species as we know them today and also closely related kinds. Nicolas Denys (c. 1598 – 1688) in Acadia also thought of different kinds of trees as "*espece*" (Denys 1672). John Ray (1627-1705) explained a species as follows:

> *In order that an inventory of plants may be begun and a classification (divisio) of them correctly established, we must try to discover criteria of some sort for distinguishing what are called 'species.' After long and considerable investigation, no surer criterion for determining species has occurred to me than the distinguishing features that perpetuate themselves in propagation from seed. Thus, no matter what variations occur in the individuals or the species, if they spring from the seed of one and the same plant, they are accidental variations and not such as to distinguish a species...* - Ray (1686).

Note that observed "*variations*" in "*distinguishing features*" was the method of Ray (1686), and variation remains the crucial criterion for distinguishing, naming and classifying plants (see below). Whether differences are observed quantitatively and/or qualitatively, variation can be found between whole plants, reproductive organs, leaves, stems, roots, internal tissues, cell types, DNA sequences and organic molecules. Thus, in general, variation is the fundamental basis for recognition of different kinds of organisms. Ray (1686) distinguished species by looking at all overt parts of a plant at all stages of its development, and this was the forerunner of the "*natural system*" of classification later elaborated by Antoine Laurent de Jussieu (1748-1846), as described below.

An age of exploration by Europeans began in the early 15th century and continued into the 17th century. In general, the focus during that period was on Christian evangelization and concomitant discovery of new trade routes and riches, but those ventures also set the stage for the ensuing age of enlightenment, and they concomitantly revealed new resources in support of the forthcoming industrial age of the 18th and early 19th centuries. The 18th and 19th centuries are also known as the age of reason, and for a very few educated naturalists who had free time to study plants, North America offered them a great opportunity to demonstrate their knowledge and abilities, and to distinguish themselves by discovering and describing new plant species.

The 18th and 19th centuries also brought promulgation of new and seemingly radical scientific ideas, perceived by many to be blasphemy. In the minds of the majority of Europeans, the Holy Bible stated that God had created every species on Earth, and it also provided chronological facts that by some scholars were considered adequate for calculating the age of the Earth. All thinking tended to be tempered by man's attempts to define God and His plans (Ray 1717), and contradictions of biblical evidence had to be wrong, no matter how persuasive the scientific evidence and conjecture. But, Charles Robert Darwin (1810-1882) and earlier scientists (notably Robert Hooke, 1635-1703) had dared to challenge the *status quo*. Their observations led them to write that the Earth had to be much older than the biblical estimate of only several thousand years. In addition, the evidence for evolution logically implied that all species on Earth traced back to a single starting organism, rather than each individual species being a separate creation by God (Darwin 1859). Well before Darwin's time, Carl Linnaeus (1707-1778) had suggested that humans and monkeys were related (Linnaeus 1735), and although Linnaeus was called to task by the theological community for such an ignobling and seemingly irreverent departure, the idea had merit and persisted in the minds of objective scientists (Frängsmyr et al. 1983). However, for many people, promulgation of those scientific 'theories' was work of the devil. Religion and science became polarized and, undoubtedly, controversy and uncertainty about the concept of 'species' were fostered.

In the mid 1800's, students of Alexander's Monro's time were being taught in understandable pragmatic terms how to think of a species:

> *A SPECIES embraces all such individuals as may have originated from a common stock. Such individuals bear an essential resemblance to each other, as well as to their common parent, in all their parts.* - Wood (1851).

Nevertheless, in North America the 'liberty' following upon the American colonies' attainment of independence from British rule evidently encouraged free expression among those interested in classifying species. Hence, from the 17th to the 19th centuries, plant classification became increasingly discordant (see Tables 1 and 2). To quote from Britton and Brown (vol. I, p. ix):

> *Some species have had from 10 to 50 different names, and, worse still, different plants have often had the same name.* - Britton & Brown (1913).

Table 1. A concordance of Monro's "families" and those in earlier botanical references

1861		1813									1838-1840				
Monro's	1789	Muhlen-	1814	1818	1819	1822	1829	1833	1836	1839	Torrey	1840	1846	1848	2000
book of wood	Jussieu	berg	Pursh	Nuttall	Michaux	Clarke	Loudon	Beck	Lindley	Murray	& Gray	Hooker	Emerson	Gray	Hinds
Acerinae	-	-	-	-	-	-	**yes**	sic	**yes**	-	-	sic	-	-	Aceraceae
Amentaceae	**yes**	**yes**	-	-	**yes**	**yes**	**yes**	**yes**	**yes**	-	-	**yes**	**yes**	-	-
Betulaceae	-	-	-	-	**yes**	-	-	-	**yes**	**yes**	-	-	**yes**	**yes**	yes
Caprifolaceae	-	-	-	-	-	-	**yes**	**yes**	**yes**	-	-	**yes**	**yes**	**yes**	yes
Coniferae	**yes**	**yes**	-	-	**yes**	-	**yes**	**yes**	**yes**	**yes**	-	**yes**	**yes**	**yes**	Pinaceae
Cupuliferae	-	-	-	-	-	-	-	-	**yes**	-	-	**yes**	**yes**	**yes**	-
Ericaceae	-	-	-	-	-	-	-	sic	**yes**	**yes**	-	-	**yes**	**yes**	yes
Grassulaceae	-	-	-	-	-	-	sic	sic	sic	sic	sic	-	**yes**	sic	Grossulariaceae
Hamamelaceae	-	-	-	-	-	-	-	sic	**yes**	-	**yes**	-	**yes**	**yes**	Hamamelidaceae
Juglandaceae	-	-	-	-	-	-	-	-	**yes**	**yes**	-	-	**yes**	**yes**	yes
Leguminosae	**yes**	-	-	-	**yes**	**yes**	**yes**	**yes**	**yes**	**yes**	**yes**	**yes**	**yes**	**yes**	-
Oleaceae	-	-	-	-	-	-	-	**yes**	**yes**	-	-	-	**yes**	**yes**	yes
Rosaceae	**yes**	**yes**	-	-	**yes**	**yes**	**yes**	**yes**	**yes**	**yes**	**yes**	**yes**	**yes**	**yes**	yes
Salicaceae	-	-	-	-	-	**yes**	-	-	**yes**	-	-	-	-	**yes**	yes
Terebintaceae	**yes**	-	-	-	sic	**yes**	sic	-	**yes**	-	-	sic	-	-	-
Tiliaceae	**yes**	**yes**	-	-	**yes**	-	**yes**	**yes**	**yes**	-	-	**yes**	**yes**	**yes**	yes
Ulmaceae	-	-	-	-	-	-	**yes**	**yes**	**yes**	-	-	**yes**	**yes**	**yes**	yes

yes: the family name in this reference agrees with Monro's spelling

- : No family name was listed, or the spelling for it was dissimilar to that of Monro

[sic] - misspelled? A word very similar to Monro's choice of family was used.

Table 2. Historical listings indicative of New Brunswick's forest 'tree' biodiversity

10-feet or taller species as named and spelled in the 1861 wood book	**1819 Michaux**	**1847 Perley**	**1855 Monro**	**1862 Munro†**	**1876 Bailey&Jack**	**1913 Britton&Brown**	**1917 Morton**
Acer barbatum - white moosewood	*Acer eriocarpum*	*Acer saccharinum*	white maple	round-leaf moosewood	-	*Acer saccharum*	"no"
Acer dasycarpum - soft sugar maple	*Acer rubrum*	*Acer rubrum*	red maple	-	*Acer dasycarpum*	*Acer sacharinum*	*Acer rubrum*
Acer nigrum - black sugar maple	*Acer nigrum*	-	-	"white maples"	-	"no"	*Acer saccharum*
Acer sacharinum - white sugar maple	*Acer saccharinum*	*Acer eriocarpum*	rock maple	*Acer saccharinum*	*Acer saccharinum*	*Acer sacharinum*	*Acer saccharinum*
Acer stratium - black moosewood	*Acer striatum*	*Acer striatum*	moosewood	notch-leaf moosewood	*Acer pennsylvanicum*	*Acer striatum*	*Acer pennsylvanicum*
Betula excelsa - yellow birch	*Betula lutea*	*Betula lutea*	yellow birch	yellow birch	*Betula excelsa*	*Betula lutea*	*Betula lutea*
Betula lenta - black birch	*Betula lenta*	*Betula lenta*	black birch	black birch	*Betula lenta*	"no"	*Betula lenta*
Betula papyraceae - paper birch	*Betula papyrifera*	*Betula papyracea*	canoe birch	grey birch	*Betula papyracea*	*Betula papyraceae*	*Betula alba* var. *papyrifer*
Betula populifolia - white birch	*Betula populifolia*	*Betula populifolia*	grey birch	white birch	*Betula alba* var. *populifolia*	*Betula populifolia*	*Betula populifolia*
Carpinus americana - hornbeam	*Carpinus americana*	*Carpinus americana*	hornbeam	hornbeam	*Carpinus americana*	"no"	"no"
Cornus canadensis - dogwood	*Cornus florida?*	*Cornus florida*	mountain ash	*Cornus florida*	-	several spp.	?
Corylus americana - hazel nut	-	-	hazel	hazel	-	*Corylus rostrata* NS	-
Fagus sylvatica - white beech	*Fagus sylvestris*	*Fagus sylvestris*	white beech	white beech	-	-	-
Fagus feruginea - red beech	*Fagus ferruginea*	*Fagus ferruginea*	red beech	red beech	*Fagus ferruginea*	*Fagus ferruginea*	*Fagus grandifolia*
Fraxinus acuminata - white ash	*Fraxinus americana*	*Fraxinus americana*	white ash	white ash	*Fraxinus americana*	*Fraxinus americana*	*Fraxinus americana*
Fraxinus juglandifolia - swamp ash	-	-	yellow ash	yellow ash	-	*Fraxinus pennsylvanica* ?	-
Fraxinus sambucifolia - black ash	*Fraxinus sambucifolia*	*Fraxinus sambucifolia*	black ash	black ash	*Fraxinus sambucifolia*	*Fraxinus nigra*	*Fraxinus nigra*
Juglans cinerea - butter-nut	*Juglans cathartica*	*Juglans cathartica*	butter-nut	*Juglans cinerea*	*Juglans cinerea*	*Juglans cinerea*	*Juglans cinerea*
Kalmia angustifolia - sheep laurel	-	-	-	-	-	-	-
Kalmia latifolia - laurel	"no"	-	-	-	-	Kalmia latifolia	-
Pinus alba - white spruce	*Abies alba*	*Abies alba*	white spruce	white spruce	*Abies alba*	*Picea canadensis*	*Picea canadensis*
Pinus balsaminaeae - fir	*Abies balsamifera*	*Abies balsamifera*	fir	fir	*Abies balsamea*	*Abies balsamea*	*Abies balsamea*
Pinus canadensis - hemlock	*Abies canadensis*	*Abies canadensis*	hemlock	hemlocks	*Abies canadensis*	*Tsuga canadensis*	*Tsuga canadensis*
Pinus nigra - black spruce	*Abies nigra*	*Abies nigra*	black spruce	black spruce	*Abies nigra*	*Picea mariana*	*Picea mariana*
Pinus pendula - hacmatac	*Larix americana*	*Larix americana*	juniper	*Larix americana*	*Larix americana*	*Larix laricina*	*Larix laricina*
Pinus resinosa - Norway pine	*Pinus rubra*	*Pinus rubra*	red pine	red pine	*Pinus resinosa*	*Pinus resinosa*	*Pinus resinosa*
Pinus rigida - pitch pine	*Pinus rigida* ME	-	red pine	Prince's pine	-	*Pinus rigida*	*Pinus rigida*
Pinus rubra - red spruce	*"no"*	-	-	-	-	Picea rubens	*Picea rubra*
Pinus strobus - white pine	*Pinus strobus*	*Pinus strobus*	white pine	white pine	*Pinus strobus*	*Pinus strobus*	*Pinus strobus*
Populus angulata - balm of gilead	*Populus balsamifera*	*Popuus balsamifera*	balsam poplar	balsam poplar	*Populus balsamifera*	"no"	*Populus balsamifera*
Populus candicans - white leaved poplar	*Populus canadensis*	-	white poplar	-	-	*P. balsamifera var candicans*	-
Populus grandentata - tree poplar	*Populus grandidentata*	-	common poplar	common poplar	*Populus grandidentata*	*Populus grandidentata*	*Populus grandidentata*
Pyrus americana - wild plum	-	-	-	plum tree (*Prunus*)	*Prunus americana*	*Prunus nigra*	-
Pyrus crategus - wild hawthorn	-	-	thorn	hawthorn (*Crataegus*)	*Crataegus oxycantha*	*Crataeggus laurentiana*	*Crataegus* spp.
Pyrus mierocarpa - mountain ash	-	-	-	Rowan tree (*Sorbus*)	*Pyrus arbutifolia*	*Sorbus americana*	*Pyrus americana*
Pyrus serotina - choke cherry	-	-	choke cherry	choke cherry (*Prunus*)	*Prunus virginiana*	*Aronia atropurpurea* ?	*Prunus virginiana*
Pyrus virginiana - red cherry	*Cerasus borealis*	-	wild cherry	*Cerasus americana*	*Prunus pennsylvanica*	*Prunus pennsylvanica*	*Prunus pennsylvanica*

Table 2 (continued)

10-feet or taller species as named and spelled in the 1861 wood book	**1819 Michaux**	**1847 Perley**	**1855 Monro**	**1862 Munro†**	**1876 Bailey&Jack**	**1913 Britton&Brown**	**1917 Morton**
Quercus alba - white oak	*Quercus alba* ME	-	-	white oak	-	"no" ME	*Quercus macrocarpa*
Quercus ambigua - gray oak	*Quercus ambigua* ME	*Quercus borealis*	grey oak	grey oak	-	-	-
Quercus rubra - red oak	*Quercus rubra* ME	*Quercus rubra*	red oak	red oak	*Quercus rubra*	*Quercus rubra*	*Quercus rubra*
Rhus typhina - sumac	-	-	-	sumac	*Rhus typhina*	*Rhus hirta* NS	*Rhus typhina*
Robinia pseudo-acacia - locust tree	Can	-	-	-	-	nn	-
Salix conifera - rose willow	-	-	-	-	-	- *Cornus amomum* ?	"75 Salix
Salix eriocephalae - swamp willow	-	-	"several	swamp willow	-	*Salix discolor*	species
Salix nigra - marsh black willow	"no"	Salix nigra	varieties"	black willow	*Salix nigra*	*Salix nigra*	in
Salix viminalis - osier basket willow	-	-	-	basket willow	*Salix viminalis*	*Salix viminalis*	Canada"
Thuja occidentatis - cedar	*Thuya occidentalis*	*Thuya occidentalis*	cedar	*Juniperus americana*	*Thuja occidentalis*	*Thuja occidentalis*	*Thuja occidentalis*
Tilia americana - basswood	Can	Tilia americana	-	*Tilia americana*	*Tilia americana*	*Tilia americana*	*Tilia americana*
Ulmus americana - white elm	*Ulmus americana*	*Ulmus americana*	white elm	white elm	*Ulmus americana*	*Ulmus americana*	*Ulmus americana*
Ulmus nemoralis - river elm	*Ulmus rubra* ME Can	*Ulmus rubra*	red elm	red elm	-	-	-
Vaccinia vitis-idaea - billberry	-	-	-	bilberry (*Vaccinum*)	-	*Vaccinium uliginosum*	-
Additional species not included in the wood book:							
	Acer negundo - "no"	*Acer montanum*	alder	alder (*Betula*)	*Acer spicatum*	*Amelanchier sanguinea*	*Acer spicatum*
	Acer montanum NS	*Alnus glauca*	common beech	American aspen	*Alnus incana*	*Cephalanthus occidentalis*	*Alnus incana*
	Alnus glauca	*Alnus serrulata*	grey pine	apple tree (*Pyrus*)	*Amelanchier canadensis*	*Crataeggus chrysocarpa*	*Amelanchier canadensis*
	Alnus serrulata	*Carpinus ostrya*		black hemlock	*Castanea vesca* - nn	*Juniperus virginiana* NS	*Hamamelis virginiana*
	Betula rubra	*Cerasus virginiana*		crab apple (*Pyrus*)	*Cornus alternifolia*	*Lonicera involucrata*	*Juniperus virginiana*
	Carpinus ostrya	*Cerasus borealis*		cranberry (*Oxycocus*)	*Crataegus coccinea*	*Ostrya virginiana*	*Ostrya virginiana*
	Cerasus virginiana ME	*Cupressus thyoides*		*Castanea vesca* - nn	*Crataegus tomentosa*	*Pinus banksiana*	*Pinus banksiana*
	Juniperus virginiana ME	*Pinus rupestris*		elder (*Sambucus*)	*Fraxinus pubescens*	*Populus alba* nn	*Populus tremuloides*
	Pinus banksiana ME,NS	*Populus tremuloides*		lilac (*Syringa*)	*Hamamelis virginica*	*Prunus nigra*	*Prunus serotina*
	Populus tremuloides	Salix ligustrina		pasture beech	*Juniperus virginiana*	*Rhus glabra* NS	
		Salix lucida		white hemlock	*Ostrya virginiana*	*Rubus occidentalis*	
					Pinus banksiana	*Salix cordata*	
					Populus tremuloides	*Salix interior*	
					Prunus serotina	*Salix petiolaris*	
					Salix lucida	*Salix sericea*	
					Sambucus canadensis	*Sorbus scopulina*	
					Sambucus pubens	*Vaccinium atrococcum*	
					Viburnum opulus	Viburnum alnifolium	
						Viburnum dentatum	
						Viburnum opulus	
						Viburnum cassinoides	

- : not mentioned at all
nn : present but said to be "not native" to New Brunswick
"no" : said not to be present in New Brunswick
NS: said to be in Nova Scotia
ME: said to be in Maine
Can: said to be in pre-Confederation 'Canada'
?: equivocal
† : some Latin binomials were provided, but elsewhere only genus was used with common names

A corroborating statement was made in a footnote by W.F. Ganong in his 1908 English translation of Denys (1672):

> *Throughout this work I shall give ... only the common English names of animals and plants, largely for the reason that the quarrels among themselves of the zoologists and botanists of this country over nomenclature have rendered the common names more stable and distinctive than the scientific names.* - Ganong, in Denys (1672).

Such confusion in scientific nomenclature had developed despite recognition that a serious problem existed. Admonitions to maintain order had been pleaded at least a century earlier. For example, Bigelow (1816) commenting on plant species in New Hampshire, expressed the following:

> ... *we should strictly beware of hastily changing names, and establishing new species on slight or doubtful distinctions. Botany at present, knows no other mode of distinguishing plants, than that by their external forms, and to this, in the present state of the science, we must rigidly adhere... A zeal for the discovery and establishment of new species, however laudable in its general object, has been productive of much mischief to the Botany of this country... Different Botanists without communication or intercourse with each other, have described the same plants under different names, and different plants under the same names in various parts of the country. There is at present, no greater obstacle to the progress of Botany here, than the load of uncertain synonyms, doubtful species, and superfluous names with which many of our best books are encumbered*. – Bigelow (1816).

Similarly, botanist and international plant explorer Constantine Samuel Rafinesque-Schmaltz (1783-1840) criticized works of many North American botanists, and he pursued his own classification system:

> *I felt the need of revising and combining all my botanical labors, both published and unpublished, while I was engaged in printing my New Flora of North America, a kind of Mantissa or Supplement to all the previous Floras of that continent by Linneus, Clayton, Michaux, Muhlenberg, Pursh, Robin, Nuttal, Torrey, Beck, Bosc, Lamark, Hooker, Elliot, Eaton, Riddell, Bigelow, &c. Besides the numerous plants unnoticed by them, I found so many Species and Genera blended or in disorder, that it required a very extensive critical survey of those connected thereto elsewhere, to compare and ascertain the truth*. – Rafinesque (1836).

The vast majority of colonists in North America were probably oblivious to the nomenclatural discord. It was enough for them to be able to distinguish and communicate about plants in the vernacular, principally for pragmatic ends. For example, François André Michaux (1770-1855) writing about the northeastern United States observed that:

> *... the inhabitants of the country, and mechanics who work in wood, take notice only of certain striking appearances in forest trees, such as the quality of the wood, its colour and that of the bark; and that, from ignorance of botanical characters, they give different names to the same tree, according to certain variations in these respects arising from local circumstances.* - Michaux (1819, v 3, pp 177-78).

Ironically, although Michaux considered himself well informed of "*botanical characters*," beginning in the early 20th century some of the scientific names given by Michaux (1819) came under similar criticism to that earlier directed by him at North American settlers (Britton and Brown 1913). For example, Michaux (1819) insisted that red spruce (*Picea rubens* Sarg.) was one and the same species as black spruce (*Picea mariana* (Mill.) BSP), and that the two appeared different only when they grew on different soils.

Although individuals of Monro's day felt they knew intuitively, if not based on formal study, what 'species' implied and how to distinguish tree and shrub species, it was not until several years after the 1862 London Exhibition that a useful system of universal rules for plant classification was proposed (De Candolle 1867). And, it was not until the beginning of the 20th century that those rules began to be widely accepted in North America (Britton and Brown 1913). Not surprisingly, American rules varied from those in Europe. In the *Vienna Rules* (Briquet 1906), there was a requirement for a Latin description before publication of the name for a new 'taxon' was permissible, but a Latin description was not a requirement of the rival *American Code* (Arthur et al. 1907). Not until 1930 did the two codes become reconciled, and since then the international rules of plant nomenclature have been revised and amended many times, most recently in July 2011 at the 18th International Botanical Congress, Melbourne, Australia (McNeill et al. 2011). Ironically, following a century of work to achieve ordered plant classification, DNA research has re-'opened the box' and revealed the need to reassess much if not all of it (e.g., Lamont 2006, Moore 2006).

In addition, not all extant plant species – and probably thousands of fossil plant morphotypes (i.e., species) – have yet been discovered. Any individual may propose existence of a new taxon. In order to do so, a written description, a name, and a type specimen must be provided; the type specimen (e.g., a pressed dried plant, or a fossil specimen) typically is deposited in an enduring location, such as in a museum of nature. The type specimen becomes the reference for authenticating inclusion of other plants in the same taxon[2].

Early North American flowering plant taxonomy

The history of plant classification in Canada extends back to the beginning of the 17th century (Young 2000). Marc Lescarbot (1570 -1641) was one of the first to comment on tree species and biodiversity north of the Bay of Fundy (then known as "*baye Françoise*"). Lescarbot (1610) did not personally see sassafras, chestnut and walnut trees, but he had been informed that they, as well as a number of other tree species, were present. The northern ranges of the mentioned species are now considered to be considerably farther south (Farrar 1995).

Plant classification in North America began even earlier, in Virginia, when Thomas Hariot (1560-1621) described more than 300 plant species using vernacular names (Hariot 1588). Many of Hariot's dried and pressed plants were shipped to Britain and subsequently named and described by John Ray in his volumes of *Historia Plantarum Generalis* (Ray 1686, 1688, 1704). Similarly, Jan Frederick Gronovius (1686 -1762) in the Netherlands used specimens collected by John Clayton (1694-1773) to produce *Flora Virginica* (Gronovius 1743).

In *Genera Plantarum*, Linnaeus (1737b) working in Europe grouped plant species on the basis of their variation in numbers of reproductive organs; nearly a thousand distinct genera emerged. Linnaeus' approach involved ranking of each perceived species systematically into its kingdom, division, class, order,

2 - Depending on whether a taxonomist is a 'lumper' or a 'splitter,' observed plant features can be used to assign the plant the name of a new species (or subspecies, or variety, or cultivar), or for placing an existing plant species into a different genus or family or order, so long as the proposed name and the plant's description respect the rules of the Melbourne code, otherwise known as the International Code of Nomenclature for algae, fungi and plants, or ICN (McNeill et al. 2011). Consistent use throughout the scientific world of ICN-accepted binomials to refer to and distinguish species depends on ICN rules being voluntarily accepted by authors, editors, and others. The ICN has no legal status, and its rules in relation to any individual advancing a new taxon are equivocal and allow for subjective judgement. ICN rules are principally concerned with crediting of persons and the names they proposed, particularly in terms of chronological priority. Each taxon must be uniquely named and sufficiently described/diagnosed to enable it to be distinguished from all other taxa, but there is no requirement for genuine biological understanding of the organisms being named, or for any explanation of the basis for the novel variation underlying each taxon, or even for confidence that a morphotype can persist stably when propagated, either from seed or otherwise.

family, genus, and species. His classification system was based on counts of stamens and pistils; it was simple and, being concerned with organs of reproduction, seemed to be at the core of the meaning of life. Linnaeus acknowledged that it was an "*artificial system*," but it garnered rapid acceptance.

Prior to Linnaeus, Latin names for plants had come to embody lengthy descriptions. They were unwieldy and prohibitive of facile communication. In his first edition of *Systema Naturae*, Linnaeus (1735) began using two Latin terms, now known as the 'binomial,' in order to distinguish each species within its genus, and he also began to impose his approach to plant classification by developing a set of rules for naming plants. One rule, reaching back to Aristotle's logic (see above), was that the name of a species should distinguish the plant from all others of the genus (Linnaeus 1737a). Linnaeus (1753) later published *Species Plantarum* and gave almost 6000 plant species, including many from North America, Latin binomials. The earlier nomenclatural assignments by Ray, Gronovius and others served Linnaeus (1753) in his own binomial dispensations. Linnaeus is not known to have ever visited the Americas, but one of his students, Pehr Kalm (1716-1779), collected plants in northeastern United States and southeastern Canada from 1748 to 1751 on his behalf. Linnaeus also had available for examination dried, pressed specimens. In addition, he grew live plants from North American seeds that had been gathered by Clayton.

Following upon the work of Ray (1686), Bernard de Jussieu (1699-1777) considered the varied morphological characteristics of the plants growing in France's Royal Trianon Garden near Paris and thereby laid the groundwork for the first "*natural system*" of classification. Jussieu arranged and catalogued the plants based on their homologous and heterologous morphological characteristics (Rompel 1910). Bernard de Jussieu later shared his classification approach with his nephew, Antoine Laurent de Jussieu, who formally introduced the natural classification system in his *Genera Plantarum* (Jussieu 1789). Jussieu (1789) retained the convention of Latin binomial nomenclature earlier initiated by Linnaeus (1735). Jussieu's natural system was strongly embraced by some, for example by Lindley (1836) and Emerson (1846). However, Linnaeus had the greater international reputation, and many botanists exploring North America continued to promulgate the artificial system. A few botanists (notably Michaux 1819 and Loudon 1829) attempted to cope with both systems.

During the early 19th century, there was a flurry of botanical classification activity in North America by Europeans individually schooled in either the artificial or the natural system. For example, André Michaux (1746-1802) traveled much of Canada and then authored *Flora Boreali-Americana* (published posthumously, in 1803; see also Brunet 1864). Subsequently, on behalf of the Government of France, André's son published a three-volume work between 1811 and 1819 on the trees of North America (Michaux 1819). The younger Michaux evidently visited both Nova Scotia and New Brunswick, but he made reference only rarely to New Brunswick; he never visited "*Canada*" and acknowledged that he had relied on his father's observations (Michaux 1819). Other contemporary United States botanists included F. Heinrich E. Muhlenberg (1753-1815) who provided a catalogue of both native and naturalized plants (Muhlenberg 1813); Frederick Pursh (1774-1820) who published a two-volume description (Pursh 1814); and Thomas Nuttall (1786-1859) who published an extensive work on North American plants (Nuttall 1818). Fowler (1880) evidently was first to begin production of a comprehensive collection of the plants in New Brunswick, and Fowler (1885) overlooking Perley (1847, 1854) and Monro (1855), noted that flora listings earlier than 1862 were unavailable.

Between 1838-1840, John Torrey (1796-1873) and Asa Gray (1810-1888) produced major reference works about plants north of Mexico (Torrey and Gray 1838-1840). Gray also independently published several extensive botanical works (Moore et al. 2010). The classification approach employed by Torrey and Gray (1838-1840) ostensibly used Jussieu's natural system, but it contained a strong element of independent American thinking. Gray's classification in his successive manuals of botany (e.g. Gray 1848), though highly focused on plants of the northern United States as opposed to Canada, became the standard reference for indoctrination of Canada's high school students into botany (e.g., Spotton 1883)[3].

Early North American conifer taxonomy

The sexual emphasis of Linnaeus (1753) put conifers in the order Monadelphia, into which his artificial system also included flowering plants, such as cucumbers (e.g., *Cucumis sativus* L.). Monadelphia indicated the existence within flowers of stamens united into a singular tube-like bundle. However, conifers are not flowering plants; moreover, their male and female reproductive organs ('strobili' or cones) are morphologically distinct and separate. Within Monadelphia, Linnaeus (1737c) initially distinguished the conifer genera *Pinus*,*Thuja*, *Cupressus*, and *Abies*, and his genus *Abies* comprised "*Picea, Cedrus, Larix and Abies*" trees

3 - High school instruction in botany is no longer standard, and a recent statement in New Brunswick that "*We have universities drifting away from their core mandate... and are becoming the equivalent of what a high school used to be*" (Chislett 2014) has another nuance: today's university programs might be hard pressed to rival the educational achievements that were expected of high school students a century ago.

(vernacular). Subsequently, Linnaeus (1753) placed all except *Thuja* and *Cupressus* genera into the genus *Pinus*. The *Pinus* group envisaged by Linnaeus was promulgated for more than a century thereafter (see Table 4, *Contents* in Monro's wood book). In contrast, Jussieu (1789) and his followers segregated *Abies*, *Larix* and other conifer genera from the *Pinus* genus, and Jussieu (1789) is credited with having introduced the formal name "*Coniferae*" as a term to include all conifer genera. (Presently, conifers are placed in the division Pinophyta, still sometimes referred to as division Coniferophyta or division Coniferae.) However, Jussieu (1789) made no distinction between fir and spruce trees; both were within the genus *Abies*. The order Pinales was established by Dumortier (1829), and that order presently comprises extant conifer species native to Canada.

Today, the *Pinus* genus comprises only pine trees. The spruce, or formally the *Picea*, genus only came into being after Dietrich (1824, pp. 793-798) called Europe's Norway spruce *Picea rubra*. Earlier, it had been *Pinus Abies* L.; *Pinus Picea* DuRoi, and *Pinus Excelsa* Lam. Dietrich (1824) provided no justification for changing the genus to '*Picea*' (by the nomenclatural rules he did not have to), but adopting a vernacular term as the generic name resolved long-standing disagreement over competing names. Ironically, the binomial *Picea rubra* was later declared invalid, and Norway spruce was named *Picea (Pinus* L.*) Abies* by G.C.W. Hermann Karsten (1817-1908) within the artificial classification system (Karsten 1880 -1883). Karsten was credited for an acceptable name, and Norway spruce is presently known as *Picea abies* (L.) H. Karst.

'Picea' as vernacular for both spruce and fir trees had been in use long before Gordon and Miller (1730) described them, informally, as "pitch" trees, and more formally as "*sorts*" of "*Firr*" or "*Abies*" trees. Pliny the Elder in his *Naturalis Historia* (AD 77-79) distinguished "*Picea*" trees from pines and other conifers (Schouw 1848), and Evelyn (1664) also recognized "*Picea*" as trees different from pines. Denys (1672) writing in French distinguished "*Prusse*" from "*Pins*" and "*Sapins*" "*espece*" (and those from other kinds of trees), evidence that early North Americans of French descent, at least those in the New Brunswick region, considered spruces, pines and firs to be distinct species. Thus, not surprisingly, the inclusion by Linnaeus (1753) of spruce trees in the genus *Pinus* evoked Miller (1763) to write that the "*Fir has always been separated from the Pine trees, by all the writers on Botany before Dr. Linnaeus*."

Miller (1763) also noted that North Americans referred to their trees "*by the titles of Black, White and Red Spruce*" and that the "*White Spruce Fir*" was also known as the "*Newfoundland Spruce*." Canada's white spruce tree was "*Abies Canadensis*" in the mind of Miller (1763), who began growing it in England in 1724 from seeds received from Newfoundland. Lambert (1803) noted that white spruce had also previously been known as *Pinus alba* L. Willd., *Pinus laxa* Ehrh., *Pinus Canadensis* DuRoi, and by longer epithets. However, Conrad Mönch (1744-1805) in Germany called white spruce "*Pinus glauca*" (Mönch 1785, p. 73) using the briefest of descriptions, i.e.: "*PINUS glauca, foliis solitariis, sparsis, tetragonis, glaucis; strobilis pendulis.*" That change within the artificial system was accepted until Andreas Voss (1857-1924) stated, more than a century later, that *Pinus glauca* was *Picea glauca* (Voss 1896). Thus, today, white spruce is known as *Picea glauca* (Moench) Voss, and earlier white spruce binomials, e.g., *Picea Alba* (Aiton) Link and *Picea Canadensis* (Miller) Britton, Sterns, & Poggenburg were, by priority rules of nomenclature, deemed invalid. The confusion attending use of two distinct classification methods and different names, followed later by rules focused on nomenclatural priority and implicitly assuming existence of species, are major reasons for Canada's 'white spruce' trees having been lumped together and given less than thorough treatment. Thus, although white spruce of eastern Canada was long ago assumed by the tree-improvement community to be resolved as a species (Little 1953), still today its full and correct classification remains on shaky ground (see below).

History of development of New Brunswick forest diversity

Consideration of the origin of New Brunswick's native forest biodiversity necessarily begins about 14,000 years ago, when the ice sheet of the last or 'Wisconsinin' glacial period was about to melt away from the Province. For thousands of year before, the landscape had been beneath a tremendous glacial burden (Clayden 2000). It is probable that during, if not before, the commencement of deglaciation, all macroscopic life-forms that had existed in pre-glacial New Brunswick experienced '*tabula rasa*' (Savidge 2012). That is, any remnant of surviving pre-glacial vegetation was spewed away in the melt-water flowing from beneath the grinding, crushing, moving glaciers as the ice sheet slowly receded northward.

Following deglaciation, sand, pebble and rock-strewn landscapes become re-vegetated through a gradual process of reinstatement of successive spore-producing species, beginning with a few exceptionally tolerant pioneering organisms, namely rock-degrading bacteria, lichens, algae, and mosses. Over centuries, those organisms slowly generate organic litter which accumulates among particles of mineral matter, and eventually this gives rise to a shallow blanket of organic matter overtop the mineral matter. Formation of that organic blanket is crucial for vegetation reestablishment in cold dry climates; it not only holds moisture and reduces evaporative losses during the warm dry summer months, together with snow it also prevents winter temperatures dropping so low that root systems are killed. Cold-hardy species having root systems, such as *Dryas* spp., ground-hugging willows (*Salix* spp.) and dwarf birches (*Betula* spp.), are the first to establish on glaciated sites having a thin blanket of organic matter, and with passage of time their additional litter input augments soil formation, hence enabling additional species of flowering vascular plants to gain a foothold (see Savidge 2012). A variety of white spruce known as Porsild spruce (*Picea glauca* var. *porsildii* Raup) is North America's northernmost conifer and the first evergreen tree to establish on deglaciated sites after lichens, mosses, willows and birches have laid the groundwork (Savidge 2012, 2014). Thus, starting from refugial populations to the south, white spruce was probably the first conifer species to track northward across New Brunswick as the ice sheet melted back (Savidge 2013). As the climate continued warming, and soils continued developing, other tree and shrub species followed.

Theoretically, the process of successful northward migration of a vascular plant species is primarily a function of its ability to tolerate unpredictable survival challenges, in particular unusual and abrupt environmental changes which directly or indirectly test an organism's fitness. A few examples of such survival fitness tests include wintertime freezing of the root system, severe frost during the summertime period of active growth, and extreme wintertime warming of transpiring evergreen foliage when soil water remains unavailable. These types of tolerance presumably vary by species and even within a species[4].

After the post-Wisconsinin melt-back of the ice sheet had begun, the 'Younger Dryas' chilling event occurred from approximately 12,800 to 11,500 years ago, at which time temperatures in the New Brunswick region grew colder,

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4 - Data from rigorously controlled experiments are needed before intrinsic physiological factors determining survival fitness can be identified with certainty. In principle, meaningful research can be attempted with potted plants using growth chambers capable of providing varied above-ground environments. However, much of the basis for establishment and survival in the wild, beginning from seeds fallen onto the forest floor, appears to reside in root-system physiology and properties of the surrounding soil, particularly during the seedling's early life (Savidge 2012). Environmental growth chambers fall short in their ability to simulate the subterranean component, mainly because it includes a continuum of physical and chemical gradients extending from forest floor into mineralized matter deeply below. Consequently, knowledge about how a tree as a whole tolerates environmental change and survives extreme tests remains mostly assumptive. Insight toward identifying Canada's most tolerant plant species was provided more than a half century ago (see Savidge 2012), but those observations remain to be followed up with investigations to explain the physiological basis for what, evidently, is exceptional hardiness and survival fitness in Canada's northern species. It will be appreciated that within the uncertainties of ongoing climate change (Jackson 2004, McKinney et al. 2007), the present ignorance about environmental tolerance and survival in Canada's tree species has the potential to foster hasty and potentially regrettable forest management decisions, particularly if nature's wild genotypes continue to be supplanted by stock of uncertain survivability.

and glaciers began to reform (Mayle and Cwynar 1995). Thereafter, temperatures gradually warmed until the Holocene's maximum temperatures were reached, between 6,000 and 5,000 years ago, and temperatures continued relatively warm until the years of the Little Ice Age (1350 - 1850 AD), a period when winters again were especially harsh. Pollen data from cored soils indicate that New Brunswick's forest biodiversity was probably greater 6000 years ago than it is today (Jetté and Mott 1995, Mott et al. 2009).

The Period of the Little Ice Age (1350 AD – 1850 AD)

Based on observations of pollen in sediments, most and possibly all of the indigenous biodiversity in New Brunswick's Acadian forest prior to the 16th century AD had become well established several thousand years earlier (Jetté and Mott 1995; Mayle and Cwynar 1995; Mott et al. 2009). In response to the Little Ice Age's 500 years of relatively cooler temperatures, some biodiversity losses or declines may have occurred within New Brunswick. However, all written records of forest species in Atlantic Canada date back only to within the period of the Little Ice Age, at the end of which Monro prepared his wood book.

The ecological disruptions resulting from clearcutting and tree planting began in Canada after the end of the Little Ice Age. In this light, Monro's wood book is an important authentic record of species – at least of putative species – that were present in the Acadian Forest during that transitional period.

DESCRIPTION OF *Native Woods of New Brunswick: - 76 Specimens*

Physical aspects

Native Woods of New Brunswick: - 76 Specimens comprises eight thick 'sheets' of wood. The book measures approximately 25 x 37 cm and the total thickness of the eight sheets is approximately 9 cm. The sheets are bound together by means of common clasp hinges positioned at four locations along the spine, each location having two tiers of hinges (Fig. 2).

On the book's inside back cover are 20 small-diameter bark-clad stem segments cut from woody shrubs, each approximately 7.5 cm in length (Fig. 3). Eighteen of those specimens were sliced at an oblique angle and display wood, pith and some bark; the other two were sliced longitudinally. It is remarkable that all specimens, wood panels, shrub segments and bark, appear to have remained dimensionally stable. They display minimal warp, discolouration or decay still today.

Figure 2. The spine of Monro's wood book, showing the eight 'sheets' and their metal hinges.

The exteriors of the front and back covers of the wood book are plain wood, but portions of their insides are layered with birch bark, evidently that of *Betula papyrifera* Marshall. Upon the bark, the *Contents* were listed in black ink. The inner six sheets contain carefully planed, precisely fitted and labeled rectangular panels of clear (i.e., knot-free) veneer. Approximately two-thirds of each panel is varnished, and an unvarnished portion on the left hand side of each panel displays its natural untreated state. The panels are held in place picture-frame like, by narrow wood strips (Fig. 4).

The Contents

The table of *Contents* on the inside front cover of the wood book lists 31 species (Fig. 1, Table 3) and another 45 are listed on the inside back cover (Fig. 3, Table 4). The script is handwritten and not everywhere perfectly clear. For example, one binomial may be *Digynia spiraea* or *Disyrfia spiraea* for a shrub also referred to as "*hardhack.*" However, a literature search produced neither binomial (plausibly, it was *Spiraea tomentosa* L., the present hardhack in New Brunswick).

Tables 3 and 4 reproduce the wood book's *Contents*. Both Latin binomial (or "*botanical*") and "*common*" names were entered in the *Contents*, whereas only common names were indicated on the pages of wood panels (compare Figs. 1 and 3 with Fig. 4). No authorities were associated with the Latin binomials. As explained below, Monro evidently resorted principally to Lindley (1836) for his "*families*," also referred to by him as 'orders' (see Table 1).

There are actually 81 distinct specimens in the wood book, a number not in agreement with 76 as written on the title page and listed in the *Contents*. It can be suggested that the discrepancy is because some wood panels are duplicates of the same species. Some panels lack an ID label, and some names listed in the *Contents* are not represented by a label. For example, no panel is

Table 3. Inside front cover, reproduced verbatim (compare Figure 1).

Contents

Order Betulaceae				Salicaceae			height
Betula	*lenta*	Black Birch	40 feet high	*Populus*	*grandentata*	Tree poplar	60 ”
“	*excelsa*	Yellow Birch	40 ”	“	*candicans*	White-leaved poplar	40 ”
“	*populifolia*	White Birch	40 ”	“	*angulata*	Balm of gilead	25 ”
“	*papyraceae*	Paper Birch	58 ”	*Salix*	*nigra*	marsh Black willow	20 ”
“	*glandulosa*	Scrub Birch	18 ”	“	*eriocephalae*	Swamp willow	12 ”
Sambucus	*nigra*	Swamp Alder	8 ”	“	*viminalis*	osier Basket willow	12 ”
Carpinus	*americana*	Hornbeam	20 ”	“	*conifera*	Rose willow	10 ”
Acerinae				Order - Ulmaceae			
Acer	*sacharinum*	White sugar maple	40 ”	*Ulmus*	*americana*	White elm	80 ”
“	*nigrum*	Black do. do.	40 ”	“	*nemoralis*	River elm	80 ”
“	*dasycarpum*	Soft do. do.	43 ”				
“	*stratium*	Black Moosewood	18 ”	Order - Juglandaceae			
“	*barbatum*	White do.	10 ”	*Juglans*	*cinerea*	Butternut	30 ”
Cupuliferae				Order - Oleaceae			
Quercus	*rubra*	Red oak	60 ”	*Fraxinus*	*acuminata*	White ash	40 ”
“	*alba*	White do.	68 ”	“	*sambucifolia*	Black ash	40 ”
“	*ambigua*	Gray do.	60 ”	“	*juglandifolia*	Swamp ash	30 ”
Fagus	*feruginea*	Red Beech	40 ”				
“	*sylvatica*	White do.	40 ”				
Corylus	*americana*	Hazel nut bush		Continued on last leaf of cover			

labeled as an elm although *Ulmus americana* and *U. nemoralis* are both indicated to be present (Fig. 1, Table 3). Labels presumably became dislodged as the book traveled internationally. One of the shrub specimens is labeled as “*red rose*” and, possibly, that corresponded to “*wild rose*” (or another name) in the *Contents.* To authenticate questionable species designations and determine which wood panels are merely duplicates and which are unlabelled singular specimens, destructive investigations into wood anatomy and chemistry would be necessary. Such investigations were not attempted.

No information was found concerning the precise locations in New Brunswick from where each specimen originated. Nor was information found about how the specimens were prepared. A number of presently distinguished tree and shrub species capable of achieving 10 feet or more in height and believed to be native to New Brunswick (Hinds 2000) were not included in Monro’s wood book. Some of those presumably indigenous species are indicated in Table 2, and additional ones as well as introduced exotic species are named in Hinds (2000). The reason for Monro excluding some and including other species can only be guessed: the London Exhibition was announced to the Colonies in March 1861, and Monro’s preliminary exhibit had to be ready for New Brunswick’s Sussex Vale exhibition a half-year later. Monro and Truman likely had less than adequate time to refine the wood book’s character, much less to procure a comprehensive collection of all species available within New Brunswick.

Monro's classification system

The *Contents* of the wood book clearly were penned in haste. Several of the binomial species designations (Tables 3, 4) are of unusual spelling; some probably are simply hasty misspells (e.g., "*papyraceae, stratium, grandentata*"). Some of the binomials could not be found in any of numerous botanical treatises published before 1861 (see Literature cited section for treatises that were consulted). As described above, this was an age of botanical confusion within North America, and Monro in preparing the *Contents* of his wood book was quite unfettered in his liberty to pick and choose names from various sources.

The most useful clues to Monro's source(s) are his names for families (Table 1). For example, "*Acerinae*" was used relatively rarely (e.g., in Beck 1833, Lindley 1836). However, the *Contents* include several families not in Beck (e.g., "*Betulaceae, Cupuliferae, Terebintaceae*"), and the wood book presents others in different spelling (e.g., "*Hamamelaceae*" and "*Ericaceae*") and places *Cornus* into Caprifolaceae. By judicious reading of Lindley (1836), it was determined that all families that were named in the wood book's *Contents* are similarly spelled therein. Even so, there is not perfect concordance between the *Contents* and Lindley (1836) – for example, "*Grossaceae*" as spelled by Monro was clearly an error and should have been Grossoceae. Lindley (1836) would appear to have been consulted by Monro for the family names, but there were numerous additional reference sources published prior to 1862 to which Monro might have had access, and it is quite possible that one or more has been overlooked here.

Overall, it appears that Monro had little if any formal training in or understanding of systematic botanical classification. For example, Monro listed "*Pyrus*" within both "*Rosaceae*" and "*Amentaceae*." "*Sambucus*" was also placed within two families, "*Betulaceae*" and "*Caprifolaceae*" (see Tables 3, 4).

Monro drew heavily upon the natural system for his broadleaved species but turned to the artificial system for the conifers. However, it can be doubted if Monro actually consulted either original source, as by 1861 both Linnaeus (1753) and Jussieu (1789) were very dated. Recall that the introduction of a formal American system of nomenclatural rules was still a half-century pending (Arthur et al. 1907).

Lindley (1836) did not treat individual species. Thus, if Monro consulted Lindley (1836) for family names, some other reference(s) must have been his source for the binomials. Earlier, Alexander Monro (1855) referenced Gesner (1847) as one of his sources for forest plant species, and Gesner (1847) referred

Figure 3. Second *Contents* page (compare Table 4) of *Native Woods of New Brunswick.* Twenty shrub specimens are at the bottom.

Table 4. Inside back cover, reproduced verbatim.

|Continued from first leaf of Cover|

Order – Rosaceae			
Pyrus	*crategus*	Wild hawthorn	12 feet high
"	*virginiana*	Red cherry	10 " "
"	*serotina*	Choke cherry	10 " "
"	*americana*	Wild plum	10 " "
Arona	*arbutifolia*	Cake berry bush	8 " "
Rosa	*parviflora*	Wild rose	8 " "
Rubus	*strigosus*	Red raspberry	3 " "
"	*occidentatales*	Black do.	3 " "
Rosa	*rubiginosa*	Sweet brier	1 " "
Caprifolaceae			
Cornus	*canadensis*	Dogwood	13 " "
Viburnum	*oxycoccus*	Tree cranberry	8 " "
Sambucus	*canadensis*	Black or Peth elder	4 " "
"	*pubescus*	Red berried elder	4 " "
Viburnum	*lantanoides*	Moose bush	5 " "
"	*acerifolia*	Maple guilder rose	4 " "
Coniferae			
Pinus	*strobus*	White pine	80 to 100 " "
"	*rigida*	Pitch do.	70 " "
"	*resinosa*	Norway do.	60 " "
"	*rubra*	Red spruce	40 " "
"	*alba*	White do.	60 " "
"	*nigra*	Black do.	80 " "
"	*pendula*	Larch, Hackmatac	60 " "
"	*canadensis*	Hemlock	40 " "
"	*balsaminaeae*	Fir	35 " "
Thuja	*occidentatis*	Cedar	25 " "
Taxus	*canadensis*	Ground hemlock	2 " "
Juniperus	*communis*	Ground juniper	3 " "

Order - Hamamelaceae			
Hamelis	*verginica*	Witch hazel	5 feet high
Order - Grassulaceae			
Ribes	*triflorum*	Wild gooseberry	2 " "
"	*trifloridum*	Black currant	2 " "
"	*rubrum*	Red currant	2 " "
Order - Tiliaceae			
Tilia	*americana*	Basswood, Lime tree	80 " "
Order - Leguminosae			
Robinia	*pseudo-acacia*	Locust tree	18 " "
Order - Terebintaceae			
Rhus	*typhina*	Sumac	10 " "
Order - Ericaceae			
Vaccinium	*resinosum*	Black whortleberry, huckleberry	8 " "
Kalmia	*latifolia*	Laurel	12 " "
"	*angustifolia*	Sheep laurel	11 " "
"	*glauca*	Swamp laurel	2 " "
Comptonia	*asplenifolia*	Sweet fern	1 " "
Digynia	*spiraea*	Hardhack	3 " "
Vaccinium	*pensylvanica*	Blueberries	1 " "
Order - Amentaceae			
Berberis	*vulgaris*	Barberry	1 " "
Myrica	*cerifera*	Bayberry	1 " "
Vaccinia	*vitis-idaea*	Billberry	12 " "
Pyrus	*mierocarpa*	Mountain ash	12 " "

Exports in 1859 & 1860: –

Deals, Battans, Boards, (1860)	£ Sterling
Plank and Scantling - 278,396,470 feet	
Pine timber – tons 304 492 -- -- -- --	560 000
Birch timber – " 14 038 -- -- --	17 413
Other forest products -- -- -- -- --	85 176
Total, exclusive of 42000 tons - shipping	£ 662 589

-------- 1859

Deals etc. 325,967,000 feet
Pine timber 76,002 tons
Tons of shippings 538 330

Note.—The shrubs are placed on last leaf of cover.
This Book is made of native wood, & writing executed on barks

Of the woods, 30 different kinds are used in mechan-
-ical operations; 15 are used for medicinal purposes;
3 produduces [sic] nuts, and 20 edible berries; 30 are hig-
-hly ornamental and may be cultivated.

Figure 4. One of the ‘pages’ in *Native Woods of New Brunswick*

to Murray (1839) in the same context. However, treatment of "*natural families*" by Murray (1839) included only seven of the 17 used by Monro (Table 1), and thus it seems unlikely that Monro used Murray (1839) for the wood book's binomials.

If Monro had no other reference available, it can be imagined that he might have drawn on a local source, such as the *Report on the Forest Trees of New Brunswick* authored by Moses Henry Perley (1804-1862). Perley (1847) provided no family names, and the Latin binomials employed by Perley (1847) and in the wood book *Contents* are in disagreement in a number of instances. For example, Perley (1847) referred to gray oak as *Quercus Borealis* whereas Monro referred to it as *Quercus ambigua*. Perley (1847) had butternut as *Juglans Cathartica* whereas Monro referred to it as *Juglans cinerea*. Perley (1847) indicated that he accepted the terminology of Michaux (1819). Perley (1854) also produced a handbook for immigrants that, though a valuable historical summary of New Brunswick's trees, contained few if any Latin binomials. Thus, it is improbable that either of Perley's listings of trees was a source for the binomials in the wood book's *Contents*. D. R. Munro (1862) in *A Description of the Forest & Ornamental Trees of New Brunswick* employed terminology almost entirely consistent with usage by Perley (1847). Thus, the absence of concordance in Table 2 would appear to indicate that Monro resorted to none of those sources.

Because the Latin binomials used in Monro's wood book were not referenced to an authoritative source and some do not appear to agree with any known source, it could be that the nomenclatural assignments were based merely on common names provided to him by contemporary woodworkers, followed by hasty attempts to match those common names with Latin binomials found in eclectic manuals of botany. The two opposing systems of classification (artificial vs. natural) and their respective nomenclatures must have been confusing for everyone, and woodsmen and botanists of Monro's time and earlier had little other than tradition supplemented with subjective ideas to decide what was what.

Despite the nomenclatural uncertainty, the panels of wood in Monro's artifact were painstakingly prepared, remain well preserved and, in principle, could still be resolved as to the species. Thus, the present scientific value of *Native Woods of New Brunswick – 76 Specimens* is primarily in the specimens *per se* and their potential for future investigation. The wood book's *Contents* serve mainly to demonstrate vernacular usage, but they also provide a useful example of the taxonomic discord reigning throughout North America during the 1860's and earlier.

CONCERNING FOREST MANAGEMENT

New Brunswick forest management in historical perspective

Destructively careless forest management in Canada had its beginnings in New Brunswick. By 1861 the Province had been home to French Acadians, English, Scots, Irish and Welsh, Planters, explanted Loyalists, and others (Lescarbot 1610, Denys 1672, Fisher 1825, Murray 1839, Gesner 1847, Perley 1854, Monro 1855). New Brunswick's exported timber had become renowned for its high quality (Munro 1862, Lower 1973, Loo and Ives 2003). For example, in describing New Brunswick's contribution to the 1862 London Exhibition, Hunt (1862) wrote:

> *The principal article of export from New Brunswick is the produce of her forests. In the manufacture of lumber thousands of her people are engaged, and a large amount of capital is invested. ... The quality of the timber sent from New Brunswick is of the finest description, a fact to which even the lumber manufacturers of Canada bear testimony... The principal exports are spruce, pine, and birch; but the province produces hacmatack, fir, maple, cedar, butternut, oak, ash, and a variety of other woods, all of which are used in a greater or lesser degree in the manufacture of articles of home consumption.* – Hunt (1862)

However, by 1862, the Acadian Forest had served Europeans and settlers for more than two centuries, and it is unlikely that any exploiter had stopped to ask if anyone really knew precisely what species were being felled. Timber was still wanted, not only by Britain and the United States, in support of shipbuilding industries at several locations along the Bay of Fundy, the Northumberland Strait and the Bay of Chaleur (Fisher 1825, Lower 1973). Lumber, barrel staves, caskets, furniture, etc., were also needed by the colonists. During the 18th and 19th centuries, the harvests of Canada's indigenous forest spread northwestward from Acadia to Lower and Upper Canada, and the felled forests both literally and economically built Canada. With decline of the ship-building industry, there arose need for railway ties, boardwalks and lumber to build new towns, and by the end of the 19th century the morning newspaper had become common, hence requiring an ongoing supply of pulpwood (Saunders 1938, Lower 1973). Thus, during the 18th and 19th century, harvesting in New Brunswick progressed through the forest's remaining large to mid-sized to smaller diameter tree trunks (Wynn 1981, Parenteau 1992). Federal and Provincial governments made no serious attempt to limit the lucrative wholesale destruction.

Writing about Northumberland County in New Brunswick just prior to the Great Miramichi forest fire, Fisher (1825) noted that:

It is a great lumbering county, and furnishes more squared timber annually than the whole Province besides ... One hundred and forty-one thousand three hundred and eighty-four tons of timber were shipped at the port of Miramichi in 1824. … A stranger would naturally suppose, that such a trade must produce great riches to the country ... That large towns would be built—that the fair produce of such a trade would be seen in commodious and elegant houses, extensive stores and mercantile conveniences, in public buildings for ornament and utility, good roads and improved seats in the vicinity of the sea-ports, with Churches, Kirks, Chapels, &c.: All these with many other expectations would be but a matter of course. But here he would not only be disappointed, but astonished at the rugged and uncouth appearance of most part of this extensive county. ... The wealth that has come into it, has passed as through a thoroughfare to the United States.... The persons principally engaged in shipping the timber have been strangers who have taken no interest in the welfare of the country; but have merely occupied a spot to make what they could in the shortest possible time. ... the forests are stripped and nothing left in prospect ... the woods swarmed with American adventurers who cut as they pleased. These men seeing the advantages that were given them, and wishing to make the most of their time, cut few but prime trees, and manufactured only the best part of what they felled, leaving the tops to rot; by this mode more than a third of the timber was lost. This with their practice of leaving what was not of the best quality after the trees were felled, has destroyed hundreds of thousands of tons of good timber: And when this was stopped by permitting none but British subjects and freeholders to obtain licenses, the business was not much mended as any person wishing to enter into the trade could, by purchasing a small sterile spot for a small trifle (provided he was a British subject) get in the way of monopolizing the woods. These are some of the causes that have and still do operate against the prosperity of the country. Men who take no interest in the welfare of the province, continue to sap and prey on its resources. – Fisher (1825)

Records from the 1800's and earlier of diverse mature timber trees in New Brunswick and its neighbouring provinces are sufficiently well documented to allow confidence that the trees standing in the original Acadian Forest were far superior in size to those remaining within New Brunswick today (Champlain 1608, Lescarbot 1610, Denys 1672, Michaux 1819, Fisher 1825, Murray 1839, Hooker 1840, Perley 1847, Monro 1855, Hunt 1862, Munro 1862, Bailey and Jack 1876). It is possible that not only the once-common mature stands of high-quality timber, but also some smaller tree, shrub and additional species, have been lost.

Conservation and sustainability of natural forest ecosystems

The total number of species on Earth today remains uncertain. Evidently, there could be 10 million 'eukaryotes,' i.e., species having a nucleus (May 2011), and a great many more prokaryotes probably exist. Depending on whether treated as trees or shrubs, Canada has 150 ± 10 recognized indigenous tree species, and various other obvious plants and animals of its wild forests can be tallied. However, there has never been a serious effort to document and estimate the total number of indigenous species within the forests of Canada. Inconspicuous life-forms remain poorly researched, phenomena yet to be discovered, and thus ignorance prevails about the biological fullness of Canada's natural forests. Regardless of the total number of species, there is concern that Earth is in the process of rapid mass extinction. Mayhew et al. (2008) predicted imminent extinction of 50% of all plant and animal species, and Thomas et al. (2004) estimated that a million species are likely to become extinct by the year 2050[5].

Should humanity be concerned? Just as tide marks on seashore cliffs reveal that major climate change has occurred numerous times in the past, variation in the fossil record provides persuasive evidence that a number of catastrophic extinction events modified the Earth's biosphere over geological time. Given that climate change and natural extinctions have both repeatedly occurred throughout a billion years or more of Earth's history, could humanity not simply adopt the philosophy of accepting diversity changes one day at a time?

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5 - Whether by ignorance of history or deliberate negligence, forest-management policies and practices have worked to deny Canada's natural biological heritage. New Brunswick forestry continues to favour cold-hardy northward-migrating spruce and fir species and to treat the majority of the better acclimated and potentially higher value Acadian Forest species as of secondary importance (Province of New Brunswick 2014). It is improbable that the quality of softwood timber exported today from New Brunswick would receive any genuine praise for being at all exceptional, much less the high praise given products of the former Acadian forest, as quoted above (Hunt 1862). Many broadleaved and a number of coniferous species within the Acadian mixed-wood Forest continue to be unappreciated, manually thinned or subjected to herbicide treatments in favour of only a few species.

Tree planting has become the great forestry deception for gaining public confidence and support. It, together with claims of "improved" trees, has been used to defend clearcutting and gross disruption of forest ecosystems. The general public has been encouraged to believe that the full spectrum of plant species is comprehensively known and that the fullness of biodiversity is being conserved. However, in the absence of clear definition of each 'species' (as provided through intensive and ongoing biodiversity and physiology research – see below), there exists no truly credible mechanism of accountability. Armchair concepts such as conservation, protected "natural" areas, notated areas of riparian habitat, and rare and endangered species have been used to bolster management's defence of its actions, but actual forest practices tend to be assumptive and careless of the biological harm caused by the interventions. The on-site 'interveners' who do road building, harvesting, thinning, scarification, and chemical or biochemical spraying are merely doing their jobs, as are the tree planters who unwittingly assist to distort natural biodiversity.

In this light, careless or deliberate actions adversely affecting survival of some species could be considered as just another natural process which, although recognized as happening, really merits no great concern[6].

Ecological land classification (ELC) subdivides the Province of New Brunswick into ecoregions based on considerations of topography, climate, soil, geology, hydrology and species associations (Zelasny 2007). As such, ELC is a highly important aid enabling forest managers to communicate, plan and justify how they hope to manage the forest sustainably, and concomitantly to conserve its biodiversity. However, in relation to having adequate biological knowledge to manage New Brunswick's full forest diversity, ELC is only a start – actually still only coarse modeling of nature – one that in the absence of improved definition and ongoing research has potential to mislead managers and encourage forest management practises which overlook fundamental highly important issues.

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6 - The questions posed in this paragraph are tongue-in-cheek. Humanity has dominion over all other kinds of life on Earth, and our awareness of that dominion, in conjunction with the fact that most if not all people really do care about (and benefit from) other kinds of life, is in a sense our 'problem,' one that we have no choice but to confront and solve. We cannot deny our food, shelter and other needs, and if we have any integrity we cannot in our awareness plead ignorance to our own consciences. If we choose to do nothing to advance understanding and improve management capability, our folly will forever shame us. Canada will be forever in disgrace if, in its knowing and caring domination of its part of the biosphere, it continues to work against rather than with nature. We can begin to do better by acknowledging that variation within a wild forest ecosystem is nature's 'normal,' not something to be waged war against, rather part of ourselves that needs to be understood and respected.

Humanity, in the anthropocentric interest of its own survival, must never forget that a key defining feature of Earth is the presence of free molecular oxygen in its atmosphere. If oxygen levels were to fall too far, the balance in the biosphere would tip toward proliferation of anaerobes. The primary source of atmospheric oxygen is photosynthesis. During each daily rotation of Earth, plants while in the Sun's light release into the atmosphere oxygen and concomitantly reduce the level of carbon dioxide which swelled during the dark hours. On the global scale, each clear-cut forest 'patch' may seem insignificant but, when summed with all others, the impacts on diurnal oxygen production and carbon dioxide removal are considerable. The oxygen in our atmosphere is ours to manage, or lose (Savidge 2001). Forest diversity includes variation in each species' ability to produce oxygen and to assimilate carbon dioxide into organic compounds, in the process sequestering carbon as wood and other useful tissues and compounds.

Equivocal definitions of 'species' and shortcomings in education may be at the heart of economic interests overruling true stewardship of Canada's forests (see below), but the ongoing encouragement of unacceptably ignorant and scientifically assumptive management practices trace back to carelessness within governments and industries in relation to respecting the long-term intangible, or non-economic, priorities of importance to nature. Canada has responded to the great gifts provided by its forests like a spoiled foolish youth lacking sincere gratitude, taking but giving nothing but folly in return. There is need for government and industry to support relevant programs of fundamental tree science research to produce greater insight into the ecophysiological role fulfilled by each tree. However, no amount of such research can provide real answers for ensuring the future of Canada's forests until there exists clear definition of the diverse organisms present in the forest.

Those fundamental issues concern ancestry, intrinsic ecophysiological attributes and the need for clearly defined criteria to distinguish Acadian-Forest species. This concern is particularly important in relation to sustaining evolving and ever-migrating forests into future millennia. Northward progression has been underway since the Younger Dryas, but glaciation will occur again (Savidge 2012).

Predictions generally have New Brunswick experiencing warmer climatic conditions and associated changes over the coming century, and hence the pace of northward migration of southern species has been accelerating (Jackson 2004, McKinney et al. 2007). Based on empirical observation, foresters believe that survival fitness varies, that each tree 'species' has an ecological niche restricting its survival to within a limiting range of geographic latitudes. This is an example of how the 'lumping' approach in species classification, thus also in forest management, can be generalized and superficially treated. Alternatively, with the 'splitting' approach, each 'species' comprises a range of morphologically similar but nevertheless physiologically distinct trees, each individual having its own intrinsic tolerances and survival fitness. Plant hardiness zones assigned by the Government of Canada are based on only very limited physiological data; instead, they subjectively assume survivability based on estimates of minimum winter temperatures, length of frost-free period, amount of summer rainfall, maximum temperatures, snow cover, January rainfall, maximum wind speed and other environmental variables (McKenney et al. 2001). In relation to the wild forest species inferred as fit to survive in particular hardiness zones, the assumptions and estimates have little if any genuine biological substantiation, and contradictions can be readily provided.[7] Successful conservation of organisms exceptionally fit to survive in wild ecosystems will require, firstly, that their individual existences are known, not merely coarsely as traditional 'species' rather also physiologically as distinct organisms having varied fitnesses, secondly, that the basis for survival fitness is understood and, thirdly, that policies and measures are in place to monitor and conserve such physiological diversity.

Thus, beyond conservation of 'species' diversity, a more fundamental need within wild forests is to sustain intrinsic attributes of survivability as they existed prior to the onset of forest management activities. 'Intrinsic' here refers to inherited attributes, and 'survival fitness' refers to physiological competence of

7 - In 2009 three sugar maple seedlings were transplanted from New Brunswick (hardiness zone 4b) to the Yukon (hardiness zone 0); one died but two grew and were still surviving in 2014 (RA Savidge, unpublished data). Examples of species growing in hardiness zones where in theory they should not be able to survive are not hard to find upon visiting communities in Canada's North, but providing a physiological explanation for this unpredictable tolerance awaits research.

individual organisms, not to artificial methods of biasing tree survival in plantation populations as, for example, by herbiciding to 'release' suppressed trees or by spraying of chemicals to suppress insect populations. Artificial methods deny natural selection its purpose of ensuring fitness to survive in future generations[8].

Forest managers necessarily are farsighted, but even they rarely think beyond a century. A vision extending millions of years forward is needed if there is to be confidence about the future nature, or even existence, of Canada's forests. Moreover, with humanity's growing population and its resource needs and wants, that vision necessarily must also be meshed with contemporary economic objectives. Do foresters sincerely want to understand what they are attempting to manage? That is, if the profession is untrue to its role of forest stewardship, the world's forests have little chance of remaining genuinely healthy. A healthy diverse forest is also an optimally productive forest (Savidge 1997). It is difficult for governments to see beyond the next election, and industry cannot but be focused primarily on its economic considerations. There is hope in Canada's National Park system, if its conservation and non-disturbance policies are maintained and strengthened. Management of trees and shrubs in woodlots could also emerge as crucially important for Canada's future (Vaughan 2003).

Some of the species named in Monro's wood book bring out aspects of forest 'classification' and conservation management which have yet to receive their deserved attention, despite the concerted and ongoing efforts in recent decades to improve forest management practices. A lengthy treatise could undoubtedly be devoted to each species within the wood book. The white spruce and black birch examples below illustrate how superficial classification and short-sighted research have worked to restrain Canada's conservation efforts.

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8 - Two options are available for attempting to conserve physiological diversity as it was achieved by nature prior to the advent of forest management. One is to be aware of and to attempt to micromanage for it, as well as for other values, in managed forests. This requires detailed knowledge of physiological diversity and judicious decisions aimed at conserving all that is essential for sustainability. By clearcutting, monoculture planting and use of biocides, silviculture mimics farming practice and actively, deliberately destroys natural diversity. Clearcutting, planting and bmociding can be avoided if forests are managed as mixed-wood, uneven-aged, shelter-wood self-regenerating, and individual-tree selection-harvested ecosystems. The latter approach serves to sustain diversity and, prior to the Industrial Age, had become common practice (Mantel 1964). The other option is to set aside protected wilderness areas. In principle, protected wilderness is the easier and more comprehensive way to ensure future survivability, because at least in theory it allows ecosystem evolution to proceed naturally. However, latitudinally restricted wilderness areas surrounded by areas of human disturbance – the case for many of Canada's National Parks – are problematic. For ongoing diversity conservation, wilderness areas should be conducive to uninterrupted North – South migration, i.e., they should extend at least 2000 km over the N-S span of Canada.

White spruce (**Pinus alba** ***in Monro's wood book)***

The species thought of as 'white spruce' is said to exist from Newfoundland and Labrador to the Yukon (Farrar 1995). White spruce has long been considered Canada's ecologically and economically most important forest tree (Morton 1917), and it is probably the most intensively managed 'species' within New Brunswick. It grows as far north as the Beaufort Sea (Arctic Ocean), and the southern edge of its geographic range is propagating northward in step with climate warming (Savidge 2012). Its preference for a cold climate has long been empirically recognized; for example, Lambert (1803) wrote that "*It is found...from the forty-third degree of north latitude northward...requiring a very cold climate*." Nevertheless, and despite climatic warming in eastern Canada, white spruce remains favoured for reforestation. The envisaged economic value of future white spruce timber has been used to justify herbiciding of forest lands, careless of the impact of herbicides on the broadleaved species of the Acadian Forest.

White spruce trees are susceptible to herbivory by the spruce budworm (*Choristoneura fumiferana* Clemens), and by many other insects. Again, for economic reasons, insecticide spraying programs have been justified since the early 1900's (Gridgeman 1979), essentially through fear-mongering alarms that timber productivity would be adversely affected. Insect-killed trees contain useful wood, and new trees do establish where spruce stands die, but warnings of reductions in wood supply due to tree mortality nevertheless bought a century of forest-entomology research. The budworm's probable role in facilitating north-south migration of white spruce remains unappreciated and poorly investigated.

The biology of white spruce trees *per se* has been treated only weakly. Major opportunities for innovation, particularly in terms of conserving survival-fitness genetic diversity, have perceivably been overlooked (Savidge 2013). For example, in northern British Columbia, Yukon and Alaska, in recent decades there was severe devastation of spruce forest by a bark beetle (*Dendroctunus rufipennis* Kirby), but recently was it noted that a particular white spruce variety – known as Porsild spruce (*Picea glauca* var. *porsildii*) – displayed resistance to the bark beetle despite nearby non-Porsild white spruce trees being killed by it (R. A. Savidge, unpublished data). Insect resistance in Porsild spruce has an uncertain basis at present, but content and composition of terpenoids are hypothetical explanations (Savidge 2013). Ancestors of Yukon Porsild spruce trace back to never-glaciated Beringia, where populations were repeatedly tested over millions of years of climate-change and rises and falls in insect populations (Savidge 2012, 2013). Thus, although Porsild spruce trees may overtly be mistaken as merely a curious phenotype of white spruce, on the inside their biochemistry evidently is different, modified by natural selection in support of survival fitness.

Only recently was it discovered that Porsild spruce is also present in New Brunswick (Savidge 2013, 2014). An indication of how superficially foresters have managed the wild forest resides in the fact that the smooth blister-barked Porsild spruce of eastern Canada has not been distinguished from scaly-barked eastern white spruce for more than three centuries (Savidge 2013, 2014). Porsild spruce clearly has exceptional survival attributes, and if it should be confirmed that it is resistant to insect herbivores, research into its biochemistry could produce an alternative to spruce-insect spraying programs. The existence of this hitherto unappreciated forest tree in two distantly separated populations, at diagonally opposite ends of Canada, raises the possibility that Porsild spruce may be a surviving remnant of Canada's primeval pre-glacial forest (Savidge 2013). The research focus needs to shift from attempts at managing insects to a new one, *viz*., understanding trees.

Black birch (*Betula lenta *in Monro's wood book)

Black birch, otherwise known as sweet birch, is presently not considered to have ever been indigenous to New Brunswick. Nevertheless, historical literature distinguished "*black birch*" from other birch species and, consequently, it remains unclear precisely what modern-day species black birch was. Denys (1672) in his old age wrote in French about his observations of nature in Acadia; he evidently was the first to comment on the presence of black birch as a distinct species within the area presently occupied by the Province of New Brunswick:

> *Le Mignogon est une espece de boaleau, mai le bois en est plus rouge, l'on en peut faire aussi de bons bordages, & n'est pas trop fendant: on a'en sert pour la monture des fuzils, il seroit bon à mettre à la fleur d'un navire, pour le presseintes & pour le haut...*.

W.F. Gagnon, in the preface to his 1908 English translation of Denys (1672), explained that mignogon is "*without doubt a form of the Micmac Indian Nimnogŭn-k, meaning the black birch.*" In Quebec, two centuries later, Mercier (1889) called black birch "*merisier rouge*," but today black birch is also no longer recognized as an indigenous tree within the Province of Quebec (Farrar 1995).

Lindley (1836) noted that "*the Black Birch of North America is one of the hardest and most valuable...*" woods shipped to England. That was no small praise, because Evelyn (1664) had earlier described English birch as "*of all other the worst of timber*."

Writing of Nova Scotia and New Brunswick, Murray (1839) stated that "*Betula lenta*, *known by the names of black birch, cherry birch, sweet birch, and mountain mahogany, is a large and graceful tree, affording timber of great value.*"

Several years before production of the wood book for the 1862 London International Exhibition, Alexander Monro (1855) wrote a book for New Brunswick immigrants and recorded the following:

> *The black birch is much used in ship-building...the cabinet-maker employs it in the construction of tables, bedsteads, and various other kinds of furniture... It is very durable and close grained, and frequently attains great height and size of trunk. Large quantities of the timber are annually exported to Britain... It is found most plentifully on a deep alluvial soil, and its presence always indicates good land...there are numerous species of the birch - the yellow, white, grey and black birch, all of which are applicable to various purposes; but the last is the most valuable and most extensively useful*. – Monro (1855).

The references to "*deep alluvial soil*" and "*good land*" are important clues for explaining what may have happened to black birch. Black-birch trees probably were felled not only for their valuable timber but also in support of agricultural land clearing.

For example, Inches (1878) wrote about New Brunswick agriculture:

> *The very growth of wood on the ridges of New Brunswick, north of the Tobique, evince the quality of the soil. Here are no forests of scrubby black spruce, or lands covered with white birch...but rock maple, birch and cedar of enormous size are everywhere found...* - Inches (1878).

David R. Munro (1862) also mentioned black birch in New Brunswick:

> *This tree* [black birch] *is produced in unlimited numbers, and grows to a height of fifty and sixty feet, and upwards of four feet in diameter. The wood is prepared into large baulks, and shipped to the markets of Great Britain and elsewhere.* – Munro (1862).

Bailey (1864) made no mention of black birch, but Bailey and Jack (1876) recorded that "*black birch*" ... *the most valuable of the Birches, is found in all parts of New Brunswick..."*

Two other plant experts in New Brunswick also mentioned black birch. Fowler (1878) expressed the view that it was one of the "*finest and most valuable forest trees,*" and Lugrin (1886) recorded the following:

Black and Yellow Birch may be considered together as they are exported indiscriminately under the name of Birch. The grain of Black Birch is very fine, close and pretty, it takes a bright polish and is used to some extent in furniture and the interior finish of houses. It is practically indestructible under water, and therefore is admirably adapted for pile and wharves. These birches grow upon the best of soils and the supply in the Province is yet very great, although, in many districts, the larger trees, suitable for heavy timber, have been cut. – Lugrin (1886).

Bailey and Jack (1876) made a clear distinction between black and yellow birch. Black birch is a common tree species within Massachusetts and surrounding States, and Bailey and Jack (1876) referenced Emerson's (1846) treatise on Massachusetts trees as their source for New Brunswick binomials (see Table 2). They must have been aware that forest trees varied in northern distribution, and that New Brunswick was some 3° in latitude farther north. It seems improbable that Bailey and Jack (1876) would have mentioned black birch in New Brunswick if they had thought it was actually yellow birch.

Decades passed, and Morton (1917) in the first edition of *Native Trees of Canada* wrote:

...the sweet birch does not extend much beyond those parts of Quebec and New Brunswick that border on the Canada – United States boundary, where the tree enters Canada from the south. – Morton (1917).

Then, in the 4th edition of *Native Trees in Canada* (Anon 1950), it was stated that:

The range of this species in Canada is not well known ...sweet birch is limited to a small area in eastern Ontario and southwestern Quebec. – Anon (1950).

By the time Hosie (1969) published his version of *Native Trees of Canada,* black-birch trees had never been in either Quebec or Atlantic Canada, and Farrar (1995) reinforced that interpretation.

Being a large tree that provided highly valued logs, and also being an indicator species of agricultural land, black birch may well have been extirpated. Major mortality of Canada's eastern yellow- and paper-birch trees occurred in the 1930-1940 era, and black birch may also have been harmed. The precise cause of that 'dieback' was never actually identified. Or, the species may have been 'thought' out of existence by writers who had limited knowledge of either Atlantic Canada's Acadian Forest or its history. Another possibility is that New

Brunswick's black birch was a divergent genetic polymorph of yellow birch. The two species do have similar leaves and catkins. Plausibly, only older or larger diameter yellow-birch trees yielded the acclaimed higher quality rose-coloured heartwood ascribed to black birch. Actually, recent observations of yellow-birch heartwood appear to indicate otherwise (Havreljuk et al. 2013). Moreover, Perley (1847) in New Brunswick noted differences between yellow- and black-birch trees and explained distinguishing characteristics of black birch as follows:

> *The bark upon the trunk of trees less than eight inches in diameter, is smooth, grayish, and perfectly similar in colour and organisation to that of the cherry-tree. On old trees the outer bark is rough, and of a dusky gray colour; it detaches itself transversely at intervals, in hard, ligneous plates, six or eight inches broad....When bruised, the leaves diffuse a very sweet odour, and as they retain the property when dried and carefully preserved, they afford an agreeable infusion...* – Perley (1847).

Similarly, in 1854 Perley wrote:

> *There are four species of birch in New Brunswick, all of them tall trees. Of these, the black and yellow birch are the most valuable, and furnish timber of the largest size. The grain of the black birch is fine and close, whence it is susceptible of a brilliant polish; it possesses also very considerable strength. It is much used in ship-building, for the keel, lower timbers and planks of the vessels, and as it is almost indispensable under water, it is well adapted for piles, foundation timbers, sluices, and in general, for any purpose where it is constantly wet. The wood of the yellow birch is believed to be somewhat inferior to that of the black birch...*
> – Perley (1854).

Voluminous archival shipping records document former existence of "*black birch*" exports from New Brunswick. The logs were distinguished by timber merchants in far-away Britain, and the distinction likely would have been made even if botanists had insisted that black birch was not present in New Brunswick. Having been ignored over a century of forest management, it is unclear what happened to New Brunswick's once-bountiful and highly valued black birch[9].

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9 The author has encountered young birch trees at several locations within New Brunswick, from the Bay of Fundy to the Bay of Chaleur, that fit the description of Perley (1847) and that may be vestigial survivors of the original black birch population. A putative mature specimen of black birch, or possibly a black X yellow hybrid, stands on private land at Wickham (coordinates: 45.63876, -66.07202), and other similar mature trees can be found on the south side of Bellisle Bay, N.B.

NATURE'S SPECIES

Variation

It could be said that the history of systematic classification embodies scientists' attempts to stop, if not to deny, the ongoing tendency toward achievement of natural disorder – otherwise described as phenotypic variation (and ultimately viewed as biological entropy) – despite the fact that both fossil and extant records of life indicate that change is the irreversible course of evolution. Geological and biological data are not at variance; they indicate clearly that the crust of the Earth has experienced countless changes, both physico-chemically and biologically. Present-day climate changes are a confirmation that change will be ongoing.

Wild, pristine, human-untarnished ecosystems inform us, unequivocally, that variation in outward appearance of individuals within a 'species' is normal (Savidge 2012). Such variation logically is at the heart of ongoing evolution and natural selection in support of future life. Variation within our perceived 'species' and also within forest communities such as those of the mixed-wood Acadian Forest was once achieved naturally, without regard for human industry. Survival is nature's first priority. If it were otherwise, it is doubtful that any life would be on Earth today. Underlying overt morphological differences between individual trees are differences in biochemistry, but there are additional expressions of molecular variation which are invisible in terms of attending morphological change. In other words, it is not what we can see, rather what we cannot see, that must be understood in order to achieve anything approaching intelligent management in relation to sustaining both survival fitness and gaining products from the forest.

Diversity is nature's way of sustaining itself, but so-called tree 'improvement' and silviculture programs have worked precisely toward the opposing goal of achieving uniform non-diversity, i.e., fast-growing trees of 'good' form. That bias has concomitantly imposed human (economic) values which have worked to eliminate unappreciated phenotypes and 'species.' More recently, pinpoint focus on genetic engineering of particular biochemical pathways in support of industry has become normal and, most definitely, the efforts loom as a prelude to clonal forest plantations (Savidge 1995). The major shortcomings of all such efforts are that the fullness of nature's variation is not merely unappreciated. Its basis really is not at all well understood but in abstract ways (see below), nor can Earth's future biospheric environment be accurately predicted. The ongoing ignorance is exacerbated by Canada's research-funding programs, skewed as they are toward economic 'innovation' rather than creation of new fundamental knowledge. Both government and industry exert subtle pressure on scientists to seek short-term economic outcomes in their research.

Plantation trials to identify faster growing trees of favoured 'species' have been conducted outdoors for many decades (Savidge 2013). They were started by the planting of widely spaced seedlings on prepared sites, rather than in natural forest. Interest in enhancing disease resistance through plantation trials was once thought to be important (Farrar 1969), but growth rate, tree form and wood density gained dominance. The phenotypes selected at conclusion of such plantation trials, after a couple decades of field testing, were still juvenile trees that had grown under intensively managed widely spaced conditions, not at all representative of wild nature. Moreover, climate change was not foreseen; the favoured genetic lines had not run that environmental gamut before being selected. Thus, they remain 'unknowns.' That is, future survival of the favoured lines, after their progeny have been planted into the forest, cannot be confidently predicted, particularly in relation to their fitness to tolerate extreme environmental changes. The physiological connections between tree growth, development and survival remain poorly understood, and no one can state with any certainty what abrupt environmental change may arise to test tree-survival in Earth's future. Assumptive leaps over major distances have been made to link the physical expression achieved by a tree with gene expression as it supposedly occurs at the molecular level within the tree and ensures that the tree remains fit to survive.

The full spectrum of diversity provided by nature in wild forest has not been 'good enough,' in the minds of the tree improvement and biotechnology research communities, who have impatiently worked to transform the genetic makeup of 'species' and introduce them into the forest. The underlying philosophy, that a tree species can almost instantly (i.e., within a few decades) be 'improved' beyond what nature provided, has become pervasive in forestry despite the fact that Gregor Mendel opened our minds to genetics only relatively recently (Mendel 1866), whereas the geological record indicates that trees have been on Earth for 396 million years (Savidge 2008). Trees survive in Canada because some seeds (i.e., embryos) – certainly not all – have inherited from their ancestors the wherewithal to pass extreme tests of survival fitness. This fact has long been known; for example, Lambert (1803) remarked (about white spruce) that "...*experience shews that there is difficulty in raising trees from the seed, and although they come up, and look well the first year, yet they are often lost in the second or third cold winter*."

Life in the wild forest undergoes continual fitness testing, selection and evolution. Similar testing does not occur in greenhouses and nurseries where seedlings destined for forest plantations are mass produced. In the wild, probably less than 0.1% of germinated seedlings survive to grow into trees, whereas >90% may survive during production of planting stock. Foresters may posit different views about this essentially qualitative difference in survival between wild regeneration and planted stock, but in scientific terms the reasons remain incompletely understood. What is certain is that Canada's natural forests have been altered by introducing 'improved' but unproven nursery-coddled seedlings as the starting material for new forests. Again, seedlings transplanted into the forest are derived from stock which itself was first planted and decades later selected on the basis of superior growth rate, but growth that occurred under less than fully natural conditions, including conditions brought on by ongoing climate change. Now that nation-wide shuffling of germplasm of uncertain survival fitness has occurred, the residue of Canada's wild once-'fit' native populations are being pollinated by the introduced trees. There is no genuine knowledge yet of how this poorly researched approach to forest management may impact future survival of Canada's forests.

There can be no doubt that time-tested nature knows best, but some humility is needed on the part of the professional forestry community to take a step backward. Until researchers have capability to simulate severe natural changes which can abruptly occur on Earth and which test survival capability (note that trees cannot take shelter), and until forestry makes tree survival in the face of such tests the first priority in tree-improvement programs, there can be no confidence that forest management is serving either humanity or the forest.

Within Canada, the key decisions remaining to be made in relation to the sustainability of its future forests concern what area of the forest landscape should be 'preserved' as entirely wild and undisturbed, what area as shelterwood naturally regenerated (only) ecosystems, and hence by default what remaining fraction may be allocated to managed plantations or other purposes in support of industry and human settlement. In relation to sustaining ecosystems where natural regeneration and selection are encouraged to function unimpeded, the decision to outlaw tree-planting activity once taken must be an enduring covenant, not one ever to be subject to modification.

P=G x E

No one has full insight into the nature of any organism but, in an abstract way, biologists have nevertheless captured any and every organism within the expression $P = G \times E$, where P is the phenotype, G the genetic constitution, and E the environment. The phenotype is what we discern visually or by some spectroscopic or other physical measurement approach. Simplistically, G comprises all of the many thousands of genes within an individual which encode and regulate the organism's competence for growth and development and determine whether it lives or dies in response to changing environments. E, again simplistically, comprises all of the physical and chemical phenomena present both inside and external to the organism, or any part thereof. Thus, the expression P

= G x E is a concise summative way of stating that genes and environmental phenomena interact to produce what we are able to discern in an individual. P = G x E also indicates that every organism has a high probability of being a unique entity, an individual distinct from all others, regardless of what nomenclature and classification approach may be used to group individuals together.

P is the product of G x E, but G is merely non-living molecular stuff in the absence of E (i.e., no gene can be expressed in the absence of water, enzymes, co-factors, precursors, warmth and other environmental factors), and E is nothing but lifeless physicochemical phenomena in the absence of G. Again, P is what we discern by observation, whether it be of a seed, a seedling, a full grown tree, a bud or leaf or flower or fruit, a log or a piece of wood or wood fibres, or organelles or macromolecules or soluble organic molecules. In order to have and sustain any living organism, management necessarily must be concerned with G and E, with individual components of both as well as with their interactions.

In an ideal management world, there would be knowledge of every component of G and every component of E and how all affect one another. However, both G and E comprise innumerable components. Thus, countless multi-factorial controlled experiments are needed to provide full knowledge of how any individual organism grows, develops and functions. The amount of research work remaining to be done, before anything approaching a complete level of knowledge becomes available, is likely to require another millennium. It can be suggested that identification of and focus on key priorities is essential and, again, it can be further suggested that the top priority should be to identify and understand those G x E interactions which sustain fitness-to-survive within an ever-changing unpredictable biosphere. Plants are the primary producers, and if their survival fitness should be compromised, so will it also be for humanity.

Within the concept of evolution, the initiation of what a scientist discerns to be a new species or evidence for 'early speciation' implicitly involves change in one or more aspects of G x E, modifications that pass from parent to progeny. Such after-the-fact change is most readily detected by visual examination, but whether viewed as morphological, histological or anatomical variation, all have as their basis underlying biochemical variation. Again, however, it is not an 'if and only if' relationship.' An alteration in some aspect of biochemistry is evidently always essential in order to achieve an altered structural feature; however, a biochemical change does not invariably lead to a structural change. For example, morphologically identical flowers or butterfly wings can display different colours due to differences in biochemistry, and autumn's coloured leaves are the identical structures that were green earlier in summer. As with agriculture and floriculture, individual variation among trees – those which by rules and subjective interpretations become included within one ‘species’ – in their biochemistries is well documented. Such variation is the basis for selections of genetic lines for various non-timber forest products, for example to obtain more latex from rubber trees, sweeter oranges, redder apples, etc. The field of chemotaxonomy distinguishes species and subspecies in this way, detecting qualitative differences and measuring quantitative differences in organic molecules, followed by deductive inferences about the molecular data in relation to speciation.

Future research needs

Beyond the current emphasis on growing trees to satisfy the wants and needs of humanity, there is an entire world of plant science awaiting recognition for its value to help humanity better understand the organisms within the wild forest. For example, *Arabidopsis thaliana* (L.) Heynh. is a small annual that likely would be considered by many as a useless weed were it encountered on the forest floor. Nevertheless, research into *A. thaliana* has been strongly supported, probably with more funding over the last two decades than Canada has allocated to all of forest science over its entire history. Major funding support for *A. thaliana* research has been provided because of the international scientific community’s recognition of the need to advance knowledge in molecular genetics, evolution, population genetics, and biochemistry. Thus, *A. thaliana* is serving as a model species for flowering plants, and progress with it has opened the door to screen individual plants of other species, to ensure that flowering plants in general possess not only genes to grow and produce crops in support of humanity’s needs, but also the fitness attributes needed to tolerate abrupt environmental change and continue to survive (Lipka et al 2005).

A limitation inherent to the *A. thaliana* genome and very relevant to forestry is that it is an annual plant, whereas trees are perennials. However, particular genes have been identified that begin to explain the genetic basis for annual versus perennial survival (Melzer et al. 2008). In principle, Canada could support tree research programs to build upon the progress made in the *A. thaliana* program but focused upon perennial species. In fact, some minor progress in that direction has already been made using *Populus balsamifera* L. However, *A. thaliana* and *P. balsamifera* are flowering plants, and most of Canada’s forest comprises non-flowering conifers whose ancestors were on Earth much earlier than flowering plants (Savidge 2008). It is not a simple matter to bridge conceptually from flowering to non-flowering physiology or genetics and, thus, there is need to give conifer species far greater research attention.

The basis for chemical variation among individuals perceived to be of the same species resides in underlying variation in the activities of biochemical pathways, themselves encoded within genes. This is where the major research effort is needed in order to understand physiological diversity. Canadian forestry has focused on P = G x E using readily measured outward physical expressions, i.e., mainly tree dimensions as a function of time, as a route to increased wood productivity. However, again, this bias was imposed in the absence of due diligence to ensure future sustainability. If long-term sustainability of Canada's forest tree species actually is the first priority, then logically the former overemphasis on productivity should be checked in deference to identification of genotypes having intrinsic fitness to tolerate survival tests, such as epidemic insect feeding, heat shock, drought, protracted mid-winter warm periods followed by extreme cold, etc. Increasing evidence indicates that chemical variation is the fundamental basis for survival in wild forest trees (e.g., O'Reilly-Wapstra 2013).

In addition to the need to ensure ongoing survival fitness, it is important to distinguish between anthropocentrically imposed speciation and the existence of genuinely distinct species and genera. Whether a binomial is applied to a type specimen and processed through an 'artificial' or a 'natural' classification system, in reality our efforts to infer the existence of a species, or to differentiate among species, are merely intellectual games. Rafinesque (1836) felt that "*names realize entities*" and, yes, they certainly do for type specimens, but does the entity extend beyond the type specimen? In the final analysis, a species as deduced and named by a taxonomist or other biologist must be viewed as an individual, i.e., the type specimen and only that. Projecting beyond a type specimen embodies assumptions which could well be oversimplifications of nature. On the other hand, a species without a name simply does not exist in the minds of those who manage ecosystems. Thus, Rafinesque (1836) also proclaimed:

> *Vegetation produces only individuals...whose permanence is limited by their life. Our Species, Genera, Families, and Orders are well known to be mere abstract terms of successive groups, formed by a Synthetic operation of our mind, in order to study more conveniently such collective groups of Individuals...* – Rafinesque (1836).

Lindley (1836) put the thought into practical context:

> *Our genera, orders, classes, and the like, are mere contrivances to facilitate the arrangement of our ideas with regard to species. A genus, order, or class, is therefore called natural, not because it exists in Nature, but because it comprehends species naturally resembling each other more than they resemble any thing else. The advantages of such a system, in applying Botany to useful purposes, are immense, especially to medical men, with whose profession the science has always been identified*. – Lindley (1836).

In other words, the name that is given to an organism in no way changes its true intrinsic nature or worth. Each individual organism is a unique phenomenon, and no matter what we call it, it alone is what it truly is. What humanity perceives to be weak or unproductive or unworthy of continuing life, and hence to be shamelessly eliminated, pales in the face of nature's priorities. The real aims of biological scientists are to understand and represent the nature of living organisms accurately, not to hang onto or trip over traditions, conventions and unnatural rules which impede progress in understanding and distract from the primary purpose of managing the biosphere sustainably for future generations.

Nevertheless, as expressed by Stevens (2001):

> *Systematics is a profoundly historical discipline, and we forget this at our peril. Only with a phylogeny can we begin to understand diversification, regularities in patterns of evolution, or simply suggest individual evolutionary changes within a clade.* – Stevens (2001).

Biologists recognize more than ever the importance of having a functional and objective classification system. Recent progress in DNA science has persuaded many plant scientists that they can gain accurate insight into genetic affinities and past evolutionary trends by an innovative phylogenetic classification approach known as cladistic systematics, or simply as cladistics. Rather than ranking taxa based on morphological structures into kingdom, division, class, order, family, genus, and species, the science of cladistics groups organisms into clades (Valentine 2006). A clade comprises an ancestor and all of its descendants. A monophyletic clade contains its common ancestor within the group, whereas a polyphyletic group is one where a common ancestor cannot be identified (until further research is done).

Within molecular genetics, members of a clade are expected to have a greater semblance to one another than to members of another clade. Thus, for example, children grow into adults who resemble their grandparents and great-great grandparents more than they resemble others, both in appearance and in the nature of their DNA. However, until supported by DNA or other scientific evidence, a perceived clade is merely a hypothetical abstraction (Valentine 2006), and even with supporting data there may be interpretation errors (Mathews 2009).

The cladistics approach requires provision of precise scientific data to substantiate a phylogenetic classification, whereas rank-based classification systems as applied over the last several centuries have promulgated subjective interpretations of genetic affinity based on descriptions and singular (unique) type specimens. Despite this subjectivity, progeny raised from seeds have in general authenticated concepts of species and evolution and, thus, they have given credence to both artificial and natural classification approaches (Ray 1686, Mendel 1866). However, as any experienced forestry greenhouse or nursery worker knows, progeny from seeds of a singular 'species' – indeed, from even a single mother tree – invariably yield varied phenotypes. Such variation has a rational basis within concepts of Mendelian genetics, hybridisation and mutation; however, again, Canadian forestry has biased outcomes toward growth/productivity phenotypes, and it has quite incorrectly assumed that other phenotypes are weak or non-useful in relation to wild nature.

The International Society for Phylogenetic Nomenclature is actively developing the PhyloCode (i.e., the international code of phylogenetic nomenclature – www.phylocode.org) for molecular (DNA-based) phylogeny. In phylogenetic taxonomy, the intention is to group organisms on the basis of inferred evolutionary relatedness, without regard to morphological variation. Ranking is not required within the PhyloCode and, at least in principle, organisms that would be undistinguished within a rank-based classification approach could be treated on the basis of individual genotypic variation within the PhyloCode.

In 1998 an angiosperm phylogeny group (APG) system of flowering plant classification was initiated, based on variation in nucleotide sequences discoverable within three genes. Attempts to include gymnosperms (e.g., conifers) began in 2005 (Stevens 2001 onward, Ran et al. 2010; Christenhusz et al. 2011). The APG system has now been superseded by the APG III system, and the system continues to undergo revision (APG 2009). A perceived difficulty with the APG system is that it has been based on the analysis of only a few eclectically and, arguably, subjectively selected genes, without consideration of the thousands of other genes contributing to the genotype.

Other objections to implementation of the PhyloCode exist and reflect concerns that Linnaeus (1735, 1753) himself attempted to address by introducing his binomial system, *viz*., that unless the employed nomenclature is unequivocal, concise and bound by a set of stringent rules, confusion will reign (e.g., see Nixon et al. 2003). Arguably, Linnaeus succeeded in addressing those concerns in a pedantic sense, and his rank-based classification approach has certainly kept a great many scientists busy for a very long time. However, Linnaeus did not succeed in the realm of greatest importance, to develop a truly intelligent classification system based on physiological tolerances and needs of each organism. Only a physiologically based classification system will enable the biosphere to be managed sustainably into the future. An obvious implication of developing such a system is that the number of taxa may increase by several orders of magnitude. Nevertheless, giving short shrift to nature serves no one.

Science advances when nature's components are clearly resolved and characterized. In physics or chemistry, gross phenomena are systematically reduced until phenomenological resolution is achieved and clear definition can be provided of each phenomenon's 'species.' Defining a problem is half of the solution. Nebulous concepts and the attending subjectivity attending arbitrary inferences about biological 'species' – in the absence of emphasis on achieving clear definition – has prevented similarly rigorous reductionism. That has been the case, but now nucleotide sequence analysis of the genetic code enables individual organisms to be characterized as 'genotypes' and compared using clearly defined molecular terms. In an exploitative biological field such as forestry, the ongoing absence of clear definitions has served evasive exploitation of the forest, and the shortcomings have also engendered defeatist service to nature in terms of not doing the needed research. The past has passed; forestry is at a fork in the road. One signposted as 'rigorous science' leads to clear non-ambiguous definition of each of the forest organisms being managed.

The molecular precision introduced by analysis of genes has already resulted in some species being merged and others being moved into different genera (e.g., see Lamont 2006, Moore 2006). In the process, knowledge of ancestry and genetic relations among species, genera and families is growing. Such knowledge has immense relevance to the futuristic aims of ensuring that forests remain sustainably biodiverse and productive, but it is especially important in the face of uncertain fitness tests which may impact species survival.

Phylogeny, whether or not rank-based, helps us to deduce evolutionary history and support interpretations about how different species may have arisen from the genes of previous species. Thus, phylogeny aids us in our attempts to develop a logical framework for understanding the course of evolution. However, no classification system provides sufficient knowledge for projections into the distant future with any real accuracy, for example, to state what current species will still exist in the next millennium or what new species are likely to be on Earth in another million years. Humanity's approach to managing the biosphere is likely to be the key deciding factor in such a climate of uncertainty. The genetic engineering realm of biotechnology has opened the door to immense, previously unimaginable change in the biological world, and what the future will bring depends primarily on how that technology is regulated, what we choose to do and not to do.

Research funding considerations

The Government of Canada and Canada's provincial governments have reaped huge economic benefits from Canada's forests, but in terms of supporting fundamental tree science research they have given little in return. The National

Research Council of Canada (NRCC) inaugurated its Division of Biological Sciences in 1928, and from 1928-1941 Robert Newton, a plant biochemist, was its director. Although the forestry sector was by far the economically more important to Canada, agricultural plant rather than forest tree research was prioritized. According to Gridgeman (1979), NRCC president E.W.R. Steacie felt strongly that NRCC was there "*to do long-term things that no industrial firm can or will do for itself*." However, in hindsight the NRCC excluded the truly long-term endeavours of relevance to Canadian forest management. The Canadian Forest Service also has a disappointing legacy of inconstancy, failing to support the visionary fundamental science that needs to be done. Superficial treatment of essential topics, such as 'Native Trees of Canada' and plant hardiness zones, belie its stated purpose as a "*forest service*" agency. The huge void in knowledge about physiological attributes of Canada's forest trees also belies the "*renewable resource*" concept that has repeatedly been advanced by industrial forest managers and governments in support of clearcutting and silvicultural practices. This irrational 'war' against the Canadian forest continues to be waged.

Trees and shrubs for the biologist are highly complex, long-lived and rather daunting organisms to attempt research on, hence to understand. They undergo phase changes from seed to seedling to juvenile to mature to old-aged to decaying trees, and concomitantly they undergo changes in reproductive capability and also in the kinds of wood and other tissues which they produce. In order to understand trees, they necessarily must be investigated at successive stages throughout their lives. Ideally, trees would be grown for a century or more in massively tall, football-field-sized, controlled-environment greenhouses in support of such research.

Medical research receives huge support out of selfish interest, but humanity also needs photosynthesizing plants to survive. Trees rival humans in complexity, and their sizes and lifetimes are not amenable to research progress within the short-term 'publish-or-perish' working environment of competitive science. Moreover, in addition to trees, there are much more readily researched annuals, spore-producing land plants, and algae available for interesting and equally important botany research. Canadian forestry companies tend to be biased toward supporting applied research projects of commercial importance. Agriculture and horticulture have their own concerns distinct from long-lived wild forest organisms. Research grants in support of fundamental tree science research in Canada have been funded primarily through the Natural Sciences and Engineering Research Council of Canada (NSERC), but support in that realm has been weak and inconsistent. The needed funding of fundamental long-term biochemical, biophysical and molecular genetics research into Canada's forest trees has always been limited and, consequently, progress has been constrained.

Students of nature who love trees but lack interest in pursuing economic or 'resource' aspects of forestry as a vocation are not in short supply. They have much to contribute to Canada's forestry future, but career opportunities have not been there. Moreover, because of government and industry biases, knowledgeable university instructors needed to mentor students interested in researching non-industrial aspects of trees are also in short supply.

Considering contributions by and costs attending government and university science laboratories in general, it can be suggested that instead of government itself (e.g., the Canadian Forest Service) having prerogative to oversee and perform long-term fundamental research into trees, it would be more efficient, productive and innovative to transfer that responsibility fully to universities. For this to occur, it would be necessary for government to commit long-term (meaning at least a 25-year period) financial support for particular research programs within university laboratories.

For example, if the program were one to ensure that Canada's spruce trees continue to have intrinsic insect and fungal resistance, an intelligent contemporary research approach would be to screen populations, i.e., individual trees within populations, for their contents of the molecular classes known as terpenoids and stilbenes, respectively, in accompaniment with DNA and biochemistry research to elucidate the underlying basis for variability in resistance (Nagel et al. 2014, Hammerbacher et al. 2011). Implementing and supporting such a program in Canada would be no small undertaking. The appropriate action would be to establish at least one laboratory in every Province and Territory, in order to gain insight into distinct geographic populations and how they compare. Each laboratory's research activity would necessarily involve at least four scientists, an equal number of laboratory technicians, equipment operators, maintenance personnel and field personnel for sampling the many populations of spruce within each Province or Territory. Data would go into gene banks and the PhyloCode. Novel genotypes would emerge, and individual genomes could be captured within propagation programs.

One of the more important advantages of long-term funding of university centres, vis-à-vis current government laboratories, would be academic freedom for scientists to discover and characterize nature uninhibited by incompletely informed concerns, without need to justify the research in short-term financial terms, and free from government and political interference. At present, university researchers devote major amounts of time, which could otherwise be devoted to performance of actual research, to preparing research proposals, in the hope that one will garner some funding support. Too often, highly capable and motivated scientists receive no funding, and the situation serves no one well.

The total number of researchers active in all scientific disciplines within Canada today would probably fall far short of the number actually needed to address all of the outstanding problems in relation to sustaining Canada's forest trees. It can be questioned whether any tree species of New Brunswick – or, for that matter, of Canada in general – has yet been adequately described, much less understood, such that it can be clearly and unequivocally differentiated in terms of its survival fitness. Each species certainly deserves to be, if our forest is to be sustainably and wisely managed. Achievement of the needed insight will require resources for fundamental research dedicated to each species.

For ensuring Canada's forestry future, some fundamental questions need to be answered. For example, should each woody species be thought of as nested variants or, in the traditional context, as a distinct entity? 'Nested' in the morphological sense that each whole tree or shrub comprises two macrosystems – root and shoot –, and each macrosystem comprises organs that comprise tissues that comprise cells that comprise organelles, cell sap and additional cellular contents. Also 'nested' in the sense that DNA encodes RNA that encodes proteins which 'encode' catalytic competence for the chemical reactions which create the varied structures which we, upon observation, use to distinguish 'species.' 'Variant' in the sense that regardless of the nesting level which may be investigated, quantitative variation is found when any two outwardly similar or even identical organisms are compared morphologically and/or metabolically.

A LOOK AT FORESTRY EDUCATION IN CANADA

In 1861, when Monro exhibited his wood book in Sussex Vale, Loring Woart Bailey succeeded James Robb as UNB professor of Chemistry and Natural History (Montague 1992). Bailey favoured geology, but he also described some plant species (Bailey 1864, Bailey and Jack 1876). Fowler (1878, 1880, 1885), although not officially affiliated with UNB, actually made the greater early contribution toward identifying the fullness of New Brunswick's flora. Not until 1891 was a Bachelor of Science degree program instituted at UNB, and the simplest beginnings of forestry education had to wait until 1908. By then, the big timber was gone, the pulpwood industry was growing rapidly, and the original indigenous forest was only a fuzzy memory captured in a scant few photographs and a very few brief written commentaries.

The starting point in conservation of nature's diversity, whether that diversity be considered in terms of diverse species or variation within a species, is the ability to differentiate accurately and with precision among plants. A way for a student to begin is to have someone, or some book, authoritatively inform the learner of each organism's distinguishing features and its Latin binomial, and then for the learner to match the two while walking about viewing nature. In other words, the learning approach involves memorization and matching (M&M).

University forestry students are indoctrinated into M&M when they learn about Canada's tree species. Students then build on M&M by learning something about silvics and ecological associations. In principle, M&M as a means to become familiar with the forest is as good a way to start as any; however, it is only a start, and yet it has been taken no further in forestry curricula. The aim has not been to produce well-trained biologists or well-informed naturalists who examine forest organisms with critical interest, rather to graduate management foresters. The M&M indoctrination simultaneously has instilled the notion that scientific names for trees and other plants are written in stone, not to be pondered nor disputed, and it is implicit within M&M and attending instruction that every tree species in Canada has already been described. There is no real science involved in M&M, and there has been no demand within Canada for critical inquiry aimed at clarifying species and enlarging understanding of variation in intrinsic survival fitness or related aspects, beyond M&M and subjective assumptions.

Cloaked by M&M is the very real possibility that some, perhaps all, of the rote impositions upon actual forest diversity are incorrect, due to historical ambiguity, armchair nomenclatural rules taking priority over real field and laboratory investigations, or implicit carryover from the post-19th century never-substantiated assumption that the vast majority, if not all, of Canada's plant species had already been discovered and adequately described/named. In addition, the indoctrination process has discouraged students from seeing and thinking about the individual plant. In effect, the fullness of nature has been denied. In retrospect, neglect of the fundamentals of species nomenclature is at the heart of forestry's reputation in today's world.

Dendrology reference books published under the sponsorship of the Government of Canada and used by forestry students beginning early in the 20th century reflect the nature of forestry education over that period. The first edition of *Native Trees of Canada* was authored by Morton (1917), as Bulletin 61 of the Forestry Branch, Department of the Interior, Canada. Morton (1917) wrote at some length about the importance of knowing common names for trees but, by not mentioning anything about the background to Latin binomials used in the book, the impression was that the species were unequivocally resolved and could be readily distinguished by the experts. In 1933, Bulletin 61 was revised, and a third edition containing more revisions appeared in 1939, but the emphasis remained on the common names. In a 1949 edition, further changes were made in an effort to make the book more appealing "*to those who have not made a* *study of botany*" (D. A. MacDonald, preface in Anon 1950), but although minor changes in spelling of some Latin binomials were made, the book still failed to confront prevailing uncertainties about the species actually present in the forest.

Hosie (1969) prepared the 7th edition of *Native Trees of Canada*, then the 8th edition a decade later. He noted that "*botanists use a scientific name to ensure positive identification of a tree*," and in appendices he provided commentary on "*botanical authors*,"... "*meanings of* [Latin] *tree names*" and some references. Hosie (1969) unapologetically explained that he had resorted to an American text (Little 1953) as "*the reference for all botanical names used*…" Hosie (1969) made no comment about the unsettled state of forest tree nomenclature as it had and still did exist within Canada.

Farrar (1995) changed the title to '*Trees in Canada'* "*to reflect the inclusion of the many tree species from outside Canada that are now widely planted in our urban areas and commercial forests*." The book reiterated Hosie's botanical authors and meanings of tree names, and it also enlarged on the bibliography. Farrar (1995) was the first author in the series to explain that "*In scientific classification the family is the level above the genus*," an aspect given no mention in the eight preceding editions of *Native Trees of Canada*. However, Farrar (1995) made no mention of problems of which he probably had become well aware, *viz*., that nomenclature for Canada's forest trees remains to be fully and clearly resolved, that responsible forest management requires knowledge of what kinds of trees are present in the forest, and that the credibility of the forestry profession depends on foresters having clear definition of what they are attempting to manage.

Most of the instruction provided students in Canada's university forestry degree programs has had the explicit approval of professional forestry associations, beginning with the Canadian Society of Forest Engineers in 1914 followed by the Canadian Institute of Forestry and since 1989 by the Canadian Federation of Professional Foresters Association (CFPFA). The original profession of forest 'engineering,' meaning forest harvesting, silviculture and ancillary activities, gained dominance over forest science soon after the outset of professional forestry within Canada (Rodgers 1951, Fensom 1972). The emphasis was not to be on forest science, rather on producing timber harvesting and silviculture managers. People who could 'see' and manage wood supply at the scale of forest stands were needed. That professional 'win' was attained not without a battle between the two sides, and still today students and instructors who "cannot see the forest for the trees" remain polarized from those who "cannot see the trees for the wood."

The Canadian forestry profession has as its 20th century legacy scientific superficiality and the implicit denial of intensively critical scientific enquiry aimed at fully understanding what it purported to be managing. Even more tragically, still today Canada as a nation remains to inculcate within its youth the need for, and the excitement of, scientific discoveries about trees, shrubs and forest life in general that one might reasonably expect would be a normal part of a "bachelor of science in forestry" degree program[10].

The forest manager has one of the most important jobs on Earth, vital for sustaining the biosphere. Rather than having undergraduate forestry degree programs where students are provided only brief introductory information about the scientific fundamentals of relevance to the forest's nature, it can be suggested that a better approach might be for accredited university programs in forestry to be available only as higher degrees (e.g., Masters or Doctor of Forest Management). Higher degrees in forest management could be offered to students having essential undergraduate preparation suited to the management speciality. Such a change would not adversely affect and actually would probably enhance the need for forest technologists, i.e., graduates of schools of forest technology.

Specialized university undergraduate instruction focused on particular aspects of forestry could (and definitely should) also be implemented. For example, four-year degree programs are needed in forest microbiology, tree physiology, natural products chemistry, molecular biology and biochemistry. Each of those areas of biological nature embodies immense breadth and depth of subject matter, yet such specialized program are wanting within Canada.

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10 An ongoing misunderstanding on the part of government, industry and public resides in the expectation that professional forestry education imparts adequate knowledge of both forest science and forest management within a singular undergraduate degree program. In fact, a weak grounding in science largely explains why, from the outset of professional forestry within Canada, naturalists with science degrees and professional foresters with 'science of forestry' degrees have repeatedly expressed polarized viewpoints. This problem persists still today.

The nature of the forest is hugely complex, and responsible forest stewardship requires that all fields of relevant knowledge be well understood and integrated. Forest managers in order to be competent professionals must be proficient in physics, chemistry, all fields of biology, geology and tree science before proceeding into meteorology, soil science, ecological science, remote sensing and fire science. The fact is that they are not. The philosophy of life-long learning has some redeeming value, but the first step is to provide a truly solid science foundation at the university level.

In addition, the forest-production or wood-supply manager simply must be well versed in mathematics, statistics, computing software, ecology, management, sociology, economics, geographic information systems, government policy and regulations, and ancillary fields. It is a lot to expect of anyone, yet the complexity of the forest, its environment and its multiple values for both humanity and the biosphere make such preparation essential.

CONCLUDING REMARKS

Canada was forested for millions of years prior to the Wisconsinin glacial period, and throughout its history the landscape has experienced numerous glacial and interglacial periods (Savidge 2012). Canada's primeval forests undoubtedly were subjected to fire, population explosions of tree-eating insects, strong tree-felling winds, diseases and other challenges to their survival fitness. Some 'species' did not survive; those that did passed the fitness tests. The only manager throughout those pre-human 'interventions' was Mother Nature, and when Europeans arrived on the shores of Atlantic Canada they were confronted with a seemingly never-ending forest of diverse species, a bountiful harvest for the future timber merchants. No forest manager 'grew the timber;' nature provided it. Forestry practitioners should want to understand how.

The New World's forests in the minds of the colonists were fearful places. That of Atlantic Canada was neither a natural science laboratory for erudition nor a 'resource' worthy of renewal, rather a dark and dangerous wild land, the sooner destroyed the better. As noted by Monro (1868), "*war*" was waged upon it. Arguably, decisions made in the offices of management foresters continue to embody the profession's innate fear of natural wild forest, but it is time to view nature in a more favourable light. It is time to revisit and refine knowledge about Canada's natural 'species.' Education is the key to lifting humanity out of its darkness and fearful imagination, regardless of the setting.

Every surviving plant species is actively evolving, and each is a marvel of complexity waiting to be better understood. In this sense, Canadian forestry has so far behaved like a 'bull in a china shop.' For the future of our biosphere and hence for the future of humanity, it has become important to understand each and every tree species more carefully. In other nations, DNA data are supplementing historical classifications based on morphological features, and this new approach has potential to redress some of the past shortcomings within Canada. Every putative species in Monro's book of wood remains a topic for dedicated research, a textbook yet to be written. No person feeling reverence for nature should in any way be apologetic about devoting his or her full lifetime to the creation and sharing of knowledge about only one kind of tree or shrub.

Professional forestry associations represent their membership as stewards of the forest, but the truth is that professional foresters over the last century have continually had to try to perform a balancing act between being stewards of wood supply versus stewards of nature. A steward cannot, with integrity, serve two masters. In order for Canada's natural forest diversity to have a future, someone – not the registered professional forester focused on wood supply – must undertake trustworthy service to forest life within Canada as the top priority. To this end, Canada would be well advised to enact a new profession of forest stewardship, one empowered to oversee, even overrule, wood- supply and related economic decisions made by forest managers. Having backups of nature's time-tested diversity, as it still can be found in some 'wild' areas, is the only realistic insurance policy for Canada's forest lands to recover from the potential adverse effects of assumptive forestry. Again, the National Parks system, if well supported for its currently important and potential roles, offers hope for future generations of both Canadian people and forest organisms.

Regardless of how intensively, expensively and exclusively forests of Atlantic Canada may be managed for softwood products, the forest industry cannot be expected to compete with locations on Earth where climate is much more conducive to rapid tree growth. In global perspective, the rate of unharvested timber increment has, for many years now, exceeded growth in market demand (Adams 2002). Regions producing timber more quickly at lower cost have major advantages in terms of securing export markets at competitive wholesale prices. Despite this reality, its most recently approved forestry sector strategy indicated that New Brunswick would favour having only 'one basket of eggs' (Province of New Brunswick 2014).

Centuries ago, the natural forest trees of New Brunswick displayed impressive dimensions that today would be market competitive anywhere on Earth. That timber was cut and largely forgotten (Lower 1938, Loo and Ives 2003). A century or more of growing time is needed to reproduce phenotypes having similar size and quality of wood (Savidge 2003b). Over that century, throughout large areas of southeast Asia, South America, New Zealand and elsewhere, fast-growing eucalypt and pine plantations will provide ten or more harvests of similar-sized or even larger trees.

An alternative forest management approach to that of plantation-based production forestry is to work with nature, to help it be as it would in the absence of human interventions; to permit the Acadian Forest to achieve unhindered its natural biodiversity by respecting intrinsic silvical characteristics, including the varied longevities and shade tolerances of each species; to acknowledge that migration of species across landscapes is a natural process pursuant upon and in harmony with climate change; to monitor and capitalize on the changing biodiversity; and to permit natural selection to take its course (Savidge 2003a).

Looking back a century or more at past manufacturing activity involving New Brunswick woods, there once was substantial industry in furniture and cabinet making, flooring, musical instruments, canoes, doors and sashes and many additional higher value commodities, most of which utilized indigenous broad-leaved and conifer species that today have fallen out of favour (Monro 1855, Hunt 1862, Fowler 1878, Lugrin 1889). Global population growth is certain to increase humanity's needs and wants, and the Acadian Forest has the diversity of tree species, and hence the economic potential, needed to become a niche market for such higher value wood products. However, for those former industries to re-emerge, tree trunks of large diameter are needed. Both extraordinary vision and government commitment for conservation of all of the natural diversity of New Brunswick's wild Acadian forest are needed.

Canadians owe a debt of gratitude to Alexander Monro and Steven Truman for having produced *Native Woods of New Brunswick: - 76 Specimens.* The wood book will serve as a reminder of our past offering hope for our future.

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ABOUT THE AUTHOR

Rodney Arthur Savidge

Professor Rodney Savidge started his career at the University of New Brunswick beginning in 1985, as the Faculty of Forestry's first instructor in tree physiology. Prior to that, Rodney worked for six years following his high schooling in the northern 'bush' of Manitoba, British Columbia, Yukon, Alberta, and Ontario in surveying, timber cruising, mineral exploration, road building and railway maintenance. During 1968-70, while employed to acquire geophysical and geochemical data within the extreme environment of Yukon Beringia, he became interested in how the trees there survived and grew, unwittingly setting the stage for his future career. Unaware that a bachelor-of-science degree in 'forestry' was a university offering, Rodney's aim upon entering Carleton University in 1971 was to become a geophysicist. However, near the end of his second year at Carleton, while searching shelves in the library, a pamphlet about forestry at the University of Toronto fell onto the floor before him. Rodney transferred his credits to U of T where he completed a forestry degree (BScF-1976) and then obtained the MScF degree (1977). His MScF thesis focused on cellular adjustments underlying spiral-grain formation in conifers, including an examination of the phenomenon as it occurs in subalpine white spruce of Beringia. His doctoral investigations at the University College of Wales, Aberystwyth, (1977-1982) probed the intrinsic phytohormonal physiology, cell biology and biochemistry of cambial growth and wood formation in lodgepole pine trees. As post-doctoral fellow, he worked on the biochemistry and biophysics of bacterial cellulose production in the Biological Sciences Division of the National Research Council of Canada (1982-1985) before moving to Fredericton with his family to take up an NSERC University Research Fellowship at UNB. Dr. Savidge's research spans the disciplines of ecophysiology, tree physiology, cell biology, biochemistry, biophysics and palaeobotany.