Forest Resources of Isle Royale National Park 2010

Resource Bulletin
NRS-73

USDA United States Department of Agriculture

Forest Service

Abstract

This publication provides a baseline overview of forest resources for Isle Royale National Park (Isle Royale) using data from the Forest Inventory and Analysis (FIA) Program of the U.S. Department of Agriculture, Forest Service. The availability of permanent FIA plots allows for the first-ever comparison of Isle Royale's forest conditions (2006-2010) to reserved and non-reserved forest land within Michigan's Laurentian Mixed Forest-Ecoprovince 212. Isle Royale's prominent forest types, structure, and species composition reflect human and natural disturbances. FIA data suggest Isle Royale's species-specific stand-size stocking, growth and mortality rates, tree densities, volume, live biomass, and aboveground and belowground carbon reflect a unique ecosystem due to a combination of factors: remote location in Lake Superior, disturbance legacy related to natural processes and mining exploration, absence of forest management for over eight decades, and 50 years of complex interactions between moose/wolf populations.

Acknowledgments

The authors would like to thank the many individuals who contributed both to the inventory and analysis of the forest resources of Isle Royale National Park and Michigan. The primary Isle Royale field crew and quality assurance staff of the 2010 inventory include Andrew Bird, Brady Boyce, Nathan Cochran, Ian Diffenderfer, Mike Downs, Ed Kloehn, Chris Lacosse, Steve Lorenz, Mark Majewsky, Jared Moilanen, Adam Morris, Charles Paulson, Greg Rekowski, Mick Reynolds, Sjana Schanning, Aimee Stephens, and Kris Williams. Data management personnel include Carol Alerich, James Blehm, Gary Brand, Mark Hatfield, Pat Miles, and Jay Solomakos.

We would also like to thank the reviewers for their comments and suggestions. These were valuable for improving the clarity of using FIA data to describe and summarize the forest resources of Isle Royale National Park.

Cover: Isle Royale shoreline. Photo by Bryan Murray, Michigan Technological University; used with permission.

Manuscript received for publication February 2012

Published by:
U.S. FOREST SERVICE
11 CAMPUS BLVD., SUITE 200
NEWTOWN SQUARE, PA 19073-3294

January 2013

For additional copies:
U.S. Forest Service
Publications Distribution
359 Main Road
Delaware, OH 43015-8640
Fax: 740-368-0152

Visit our homepage at: **http://www.nrs.fs.fed.us**

Forest Resources of Isle Royale National Park 2010

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Isle Royale, Scoville Point. Photo by Karena Schmidt, Michigan Technological University; used with permission.

Introduction

This publication provides an overview of the forest resources of Isle Royale National Park (Isle Royale). Population estimates are based upon 2010 inventory data from the Forest Inventory and Analysis (FIA) Program of the U.S. Department of Agriculture, Forest Service (USFS). To provide insights into Isle Royale's ecological traits, traditional timber attributes (i.e., stocking, volume, and biomass) were incorporated with non-timber qualities (i.e., standing dead trees and carbon stocks). These findings, in turn, were compared to reserved and non-reserved forest land in Michigan's Laurentian Mixed Forest-Ecoprovince 212. This resource bulletin is the first of its kind to investigate Isle Royale and is a result of the collaborative effort between Michigan Technological University and the USFS.

Isle Royale, aspen senescing with spruce and balsam fir understory. Photo by Auriel Fournier, Michigan Technological University; used with permission.

Isle Royale, paper birch decline. Photo by Bryan Murray, Michigan Technological University; used with permission.

Isle Royale aspen regeneration. Photo by Bryan Murray, Michigan Technological University; used with permission.

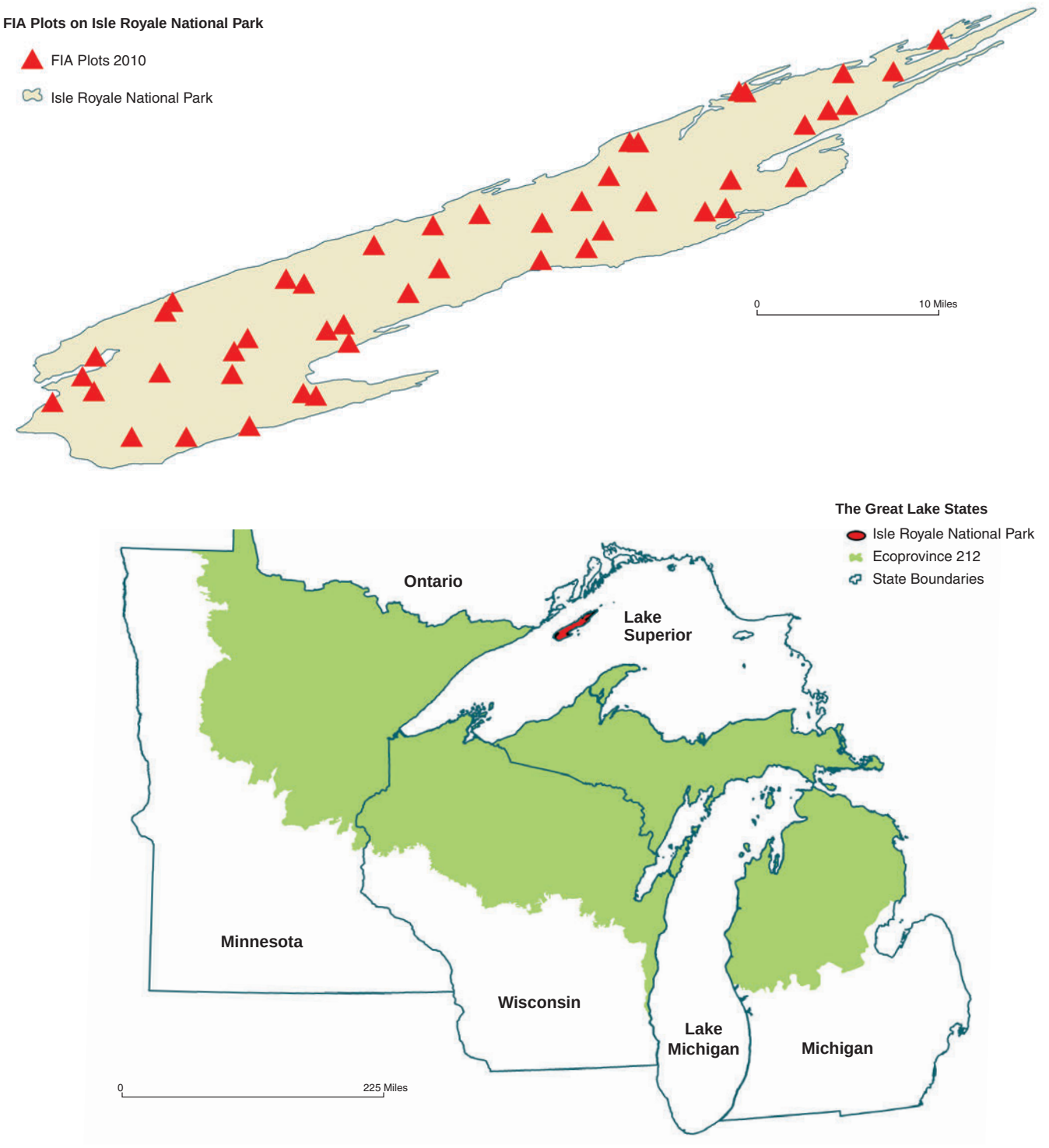

Figure 1.—Ecoprovince 212- Laurentian Mixed Forest in Minnesota, Wisconsin, and Michigan. Inset of Isle Royale National Park depicts general FIA plot locations, Michigan, 2010.

Background

Isle Royale National Park is an archipelago in the northwest part of Lake Superior, juxtaposed between the northern edge of the temperate forest and the southern edge of the boreal forest (Rowe 1972). Part of Michigan's Keweenaw County, Isle Royale encompasses more than 450 islands, has a land base of about 230 square miles, and runs parallel to the shorelines of Minnesota and the province of Ontario, Canada. The main island is 45 miles long and 9 miles wide; it is 14 miles from mainland Ontario, 16 miles from Grand Portage, MN, and 55 miles from Copper Harbor, MI (ESRI 2009). Elevation ranges from 602 to 1,362 feet above sea level (0 to 760 feet above Lake Superior); numerous inland lakes and bogs are located between the ridges orientated southwest-northeast (Albert 1995). Huber (1973) described the bedrock geology as uniform Precambrian volcanic lava flows with glacial deposits, kame moraines, and recessional moraines. Isle Royale has shallow soils in the northeast and deeper soils in the southwest.

Wallace Lake watershed, located in the northeastern portion of Isle Royale, recorded an annual precipitation average of 29.9 inches and an annual daily temperature average of 37 °F for the years 1982-96 (Stottlemyer et al. 1998). Because the National Park Service (NPS) closes Isle Royale during the winter, we also attempted to find a suitable mainland proxy. The precipitation and temperature values are nearly identical to the nearby weather station in Thunder Bay, Ontario, for 1971-2000 (http://climate.weatheroffice.gc.ca/).

Past Management

The Isle Royale archipelago has not been notably disturbed by humans for the past 80 years, with little to no forest management practiced across the main island (Primmer 1938, Rakestraw 1965). However, the current forest diversity and structure of Isle Royale partially reflect the past disturbances of mining, fire, logging, and moose herbivory.

In 1843-1900, Isle Royale was explored and mined for copper. Prospectors logged timber to support mining operations while also burning large areas of forest to expose the copper ore (Rakestraw 1965). The last large natural fires occurred in 1936 and 1948 in the central part of the main island and burned a combined 20 percent of the main island (Janke et al. 1978). For the time period of 1931-1987, there were nearly 100 documented lightning- and human-caused fires, but, with a few exceptions, each fire covered less than 1 acre (cf., Martin 1988; USDI 2004).

Another influence on the current conditions of Isle Royale's forests is herbivory. White-tailed deer (*Odocoileus virginianus*) were once introduced in 1912 by the Michigan State Conservation Commission, but were last recorded in the 1930s (Shiras 1935). For survey years of 1962-2009, the mean beaver (*Castor canadensis*) colony abundance was 149.9 (Romanski 2010), influencing vegetation dynamics of deciduous species associated with aquatic systems (Moen et al. 1990). The main herbivore on Isle Royale is moose (*Alces alces*), which arrived on Isle Royale in the early 1900s (Hickie 1936, Murie 1934). Wolves (*Canis lupus*) arrived in the 1940s and the resulting research into the dynamics of predator/prey populations made Isle Royale internationally famous (Peterson 1995). Within the past 50 years, the moose population has fluctuated between about 500 and 2,000 animals, and most Isle Royale vegetative investigations have focused on these changes and the resulting browsing pressure (http://www.isleroyalewolf.org). Research suggests that moose have impacted forest structure and diversity, tree densities, tree growth rates, tree regeneration success, and nitrogen cycling (McInnes et al. 1992, McLaren and Janke 1996, McLaren and Peterson 1994, Pastor et al. 1998, Risenhoover and Maas 1987, Snyder and Janke 1976).

Isle Royale's geographic location, history, and on-going research contributed to its authorization as a national park in 1931 by President Herbert Hoover, its establishment as a park in 1940 by President Franklin D. Roosevelt, its designation as wilderness in 1976 by the U.S. Congress, and its nomination as an International Biosphere Reserve in 1980 by the United Nations.

Efforts to Document Isle Royale Forest Resources

As a Biosphere Reserve, Isle Royale is considered globally important for the conservation of biological resources and the education, research, monitoring, and communication related to conservation issues. Past and current documentation of Isle Royale's forest resources include using pollen counts to describe Holocene vegetation (Flakne 2003), General Land Office notes to reconstruct pre-settlement forest (Janke et al. 1978), photographs to interpret succession following fire (Cooper 1913, 1928), vegetation sampling and classification to create cover-type maps (USDI 1999), and establishment of permanent plots to monitor forest health as part of the NPS Great Lakes Inventory and Monitoring Program (Sanders and Grochowski 2011). Although Isle Royale is globally recognized as a rare ecosystem, there is still a lack of quantitative information about it. In this resource bulletin, we use the 2010 FIA inventory to help describe the current forest conditions, provide a baseline for future inquiries, and discuss possible implications. Please refer to Isle Royale National Park FIA Methods section regarding sampling, annual inventories, and population estimates.

Ecoprovince 212 - Laurentian Mixed Forest Province

This bulletin is also the first attempt to highlight the uniqueness of Isle Royale's FIA forest resources within a regional context. Previous Michigan FIA reports contain Isle Royale estimates (part of reserved forest land totals, discussed below), but no attempt has been made to separate and compare these values given similar ecological features (i.e., temperature, precipitation, geology, and vegetation).

An ecological region (Ecoregion) is a large-scale macroclimate that has predictable patterns and is associated with distinct geology (Bailey 1995, 2004, 2009; Cleland et al. 2007). The daily and seasonal fluxes of moisture and solar radiation are the main parameters that distinguish ecoregions and are impacted by latitude, elevation, and continental/oceanic influences.

Ecoregion designation starts at the broadest scale and has four domains: polar, dry, humid temperate, and humid tropical. These domains are subdivided into ecological provinces (Ecoprovince) that have a finer spatial scale and are delineated by specific daily and seasonal temperature fluxes, seasonal precipitation amounts, soil characteristics, and late-successional vegetation (Bailey 1995, 2004, 2009). Given Isle Royale's position in northwestern Lake Superior, it is included in Ecoprovince 212, or the Laurentian Mixed Forest Province. In the United States, Ecoprovince 212 is made up of about 64.6 million acres (100,917 square miles) and includes the states of Minnesota, Wisconsin, and Michigan (Fig. 1; Cleland et al. 2007). It represents about 41 percent of the total area of these three states.

The physiography of the Laurentian Mixed Forest Province varies from flat to hilly (elevation range 580 to 1,725 feet above sea level) and reflects past glaciation with exposed bedrock, moraines, and glacial drift. The Great Lakes moderate the minimum and maximum temperatures, with an average temperature range of 39 to 43 °F. Winters are moderately long and typically have continuous snow cover. Most precipitation occurs in the summer, with an average range of 27 to 34 inches. The forest vegetation is a transition between southern deciduous and northern boreal species (Cleland et al. 2007).

Distinguishing between Forest Land, Timberland, Reserved Forest Land, and Other Forest Land

Forest land is land that is at least 10 percent stocked by live trees of any diameter size. It may include land that once had tree cover (formerly stocked), land that is not currently developed for nonforest uses, or land that will be naturally or artificiality regenerated. Forest land must be at least 1 acre in size and 120 feet wide. There is no minimum requirement for annual growth.

FIA has three categories of forest land:

- Timberland—forest land that is producing or is capable of producing crops in excess of 20 cubic feet/acre/year of industrial wood in natural stands. Land is not withdrawn from timber utilization by statute or administrative regulation, and includes inaccessible and inoperable areas.

- Reserved forest land—forest land that is withdrawn from timber utilization through statute without regard to productive status (e.g., some natural areas in state parks, national parks and lakeshores, and federal wilderness areas).

- Other forest land—forest land that is not capable of growing 20 cubic feet/acre/year due to site conditions and is not restricted from harvesting.

Forest Area

Background

Area estimates are the most basic and standard of all forest inventory attributes. Differences or changes between designated areas can be indicative of natural factors or human-caused changes. Summarizing forest characteristics provides valuable information about forest health, forest structure, sustainability, and unique features.

What we found

For the 2010 FIA inventory, Ecoprovince 212 in Michigan made up nearly 83 percent of Michigan's total forest land (16.6 million acres: Table 1). Two percent of Michigan's Ecoprovince 212 is reserved (375,503 acres) and includes nearly all of Michigan's reserved forest land. Isle Royale's area represents more than 36 percent of Ecoprovince 212 reserved forest land (138,497 acres).

What this means

Ecoprovince 212-Laurentian Mixed Forest captures more than 80 percent of Michigan's forest land, allowing us to make unique comparisons between Isle Royale, reserved, and non-reserved forest land. Isle Royale is a small component of Michigan's overall forest area (less than 1 percent), but represents more than a third of Michigan's reserved forest land. This concentration of reserved forest land on Isle Royale, versus smaller parcels scattered throughout Michigan, strengthens comparisons between Isle Royale and Ecoprovince 212 non-reserved and reserved forest land. Additionally, Isle Royale's isolation in Lake Superior minimizes the influence of surrounding

Table 1.—Area of forest land by category, Michigan, 2010

Forest land category[a]	Michigan (state totals)[b]		Ecoprovince 212 (Michigan only)		Isle Royale[c]	
	Acres	*Sampling error (%)[d]*	*Acres*	*Sampling error (%)[d]*	*Acres*	*Sampling error (%)[d]*
Timberland	19,386,095	0.5	15,954,513	0.5	--	--
Forest land (non-reserved)	19,624,601	0.5	16,192,151	0.5	--	--
Forest land (reserved)	378,867	8.4	375,503	8.4	138,497	13.5
Forest land (reserved and non-reserved)	20,003,467	0.4	16,567,653	0.4	138,497	13.5

[a]Forest land (non-reserved) includes timberland.

[b]Total is reserved and non-reserved forest land.

[c]Isle Royale is included in Michigan's Ecoprovince 212 reserved forest land.

[d]Sampling error represents the 68-percent confidence interval around the estimate.

land changes (e.g., edge effect, threats from invasive plants, insects, and diseases). Future monitoring of both reserved and non-reserved forest land will provide valuable information about changes and trends in forest health, forest structure, and sustainability.

Forest Types

Background

Forest types are a classification of forest land based on the species forming a plurality of live tree stocking. A specific forest type reflects historical events, both natural and human disturbances, as well as ongoing successional competition between species. Within stands of mixed tree-size classes and species, assignment of forest types is weighted toward the larger trees because they contribute more to stocking than smaller trees. The forest-type nomenclature reflects this dominance by indicating the presence or absence of a species (e.g., eastern white pine vs. eastern white pine/eastern hemlock). In some cases, forest types may be slightly misleading. Because Ecoprovince 212, and specifically Isle Royale, occurs at the tension zone between temperate and boreal biomes, several species are at the edges of their respective ranges. The sugar maple/beech/yellow birch forest type erroneously implies that American beech (*Fagus grandifolia*) occurs on Isle Royale and in the western Upper Peninsula of Michigan. To avoid confusion, this forest type has been changed to sugar maple/yellow birch throughout this publication. Refer to Burns and Honkala (1990) for additional information about the silvical characteristics of specific tree species. Lastly, the nonstocked forest type is land less than 10 percent stocked with live trees.

What we found

According to the 2010 inventory, Michigan has 56 forest types, with 47 occurring in Ecoprovince 212. There are 21 reserved forest types and eight of these forest types occur on Isle Royale: paper birch, sugar maple/yellow birch, aspen, northern white-cedar, white spruce, black spruce, balsam fir, and eastern white pine/northern red oak/white ash. An estimated 80 percent of Isle Royale's area is divided among the top four forest types; the three hardwood types (paper birch, sugar maple/yellow birch, and aspen) make up 67 percent of Isle Royale (Fig. 2, Table 2). The top four forest types by area, although not ranked in the same order, are the same on Isle Royale and in Ecoprovince 212 reserved (Fig. 3).

Table 2.—Area and number of plots by Isle Royale forest types, Michigan, 2010

Isle Royale forest type[a]	Area	Plots	Sampling error[b]	Sampling error[b]
	Acres	*Number*	*Percent*	*Acres*
Paper birch	41,892	12.4	26.6	11,160
Sugar maple/yellow birch	30,350	9.1	31.8	9,648
Aspen	19,970	5.8	37.3	7,455
Northern white-cedar	17,964	5.5	40.1	7,198
White spruce	11,348	3.5	48.0	5,443
Black spruce	6,946	2.0	67.7	4,702
Balsam fir	6,554	2.0	49.1	3,219
White pine/red oak/white ash	3,473	1.0	96.1	3,337
Total	138,497	41.4	13.5	18,642

[a]The eastern white pine/northern red oak/white ash is abbreviated as white pine/red oak/white ash forest type.
[b]Sampling error represents the 68-percent confidence interval around the estimate.

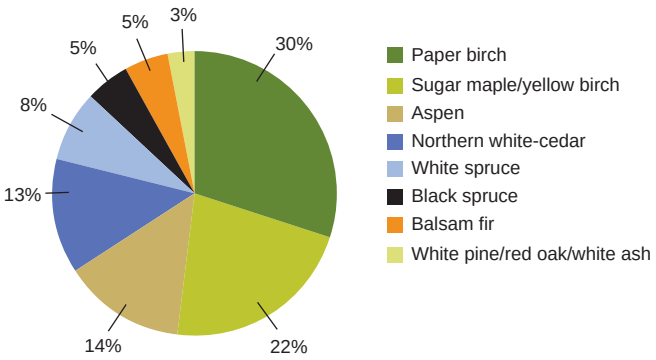

Figure 2.—Distribution of eight forest types found on Isle Royale by area, Michigan, 2010. Note: the eastern white pine/northern red oak/white ash forest type is abbreviated as white pine/red oak/white ash.

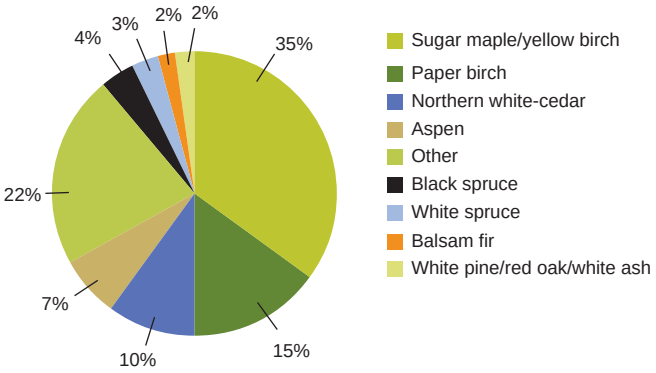

Figure 3.—Distribution of prominent reserve forest types found in Michigan Ecoprovince 212 by area, Michigan, 2010. "Other" forest type includes jack pine, balsam fir, red pine, tamarack, northern red oak, red maple/lowland, eastern white pine/northern red oak/white ash, red maple/upland, nonstocked, willow, white oak/red oak/hickory, other hardwoods, and eastern white pine. Note: the eastern white pine/northern red oak/white ash forest type is abbreviated as white pine/red oak/white ash.

The age-class distribution indicates that Michigan's non-reserved forest land is fairly young. Live trees under the age of 41 equate to 23 percent of the forested area, while trees under the age of 80 make up 80 percent of the forest land. The age-class distribution of reserved forest land, which includes Isle Royale, indicates relatively older conditions, with 4 percent of live trees under age 40 and only 47 percent under age 80. In contrast, Isle Royale forest land resembles the non-reserved age-class distribution with 27 percent under age 40 and nearly 80 percent under age 80 (Fig. 4).

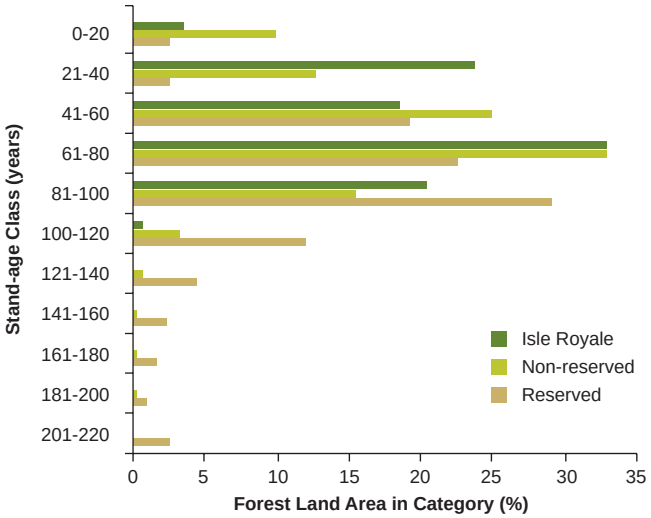

Figure 4.—Forest land by stand-age class, Michigan, 2010.

Two forest types—aspen and paper birch—demonstrate how Isle Royale age distribution is more similar to non-reserved than reserved forest land. The vast majority of the aspen forest type is 80 years and younger on Isle Royale and non-reserved forest land (82 percent and 94 percent, respectively), but only 47 percent on reserved forest lands (Fig. 5). With the paper birch forest type, 83 percent of Isle Royale and 89 percent of non-reserved forest land is 80 years or younger, but only 65 percent of reserved forest land is that age (Fig. 6).

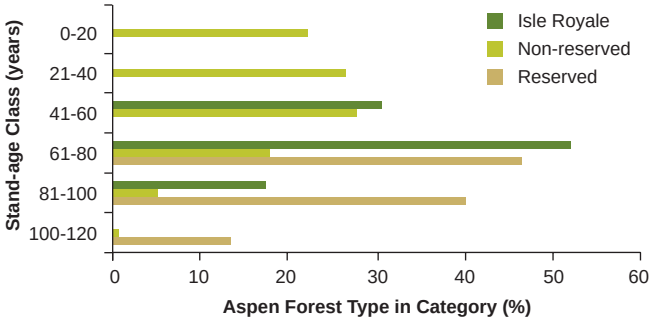

Figure 5.—Aspen forest type by stand-age class, Michigan, 2010.

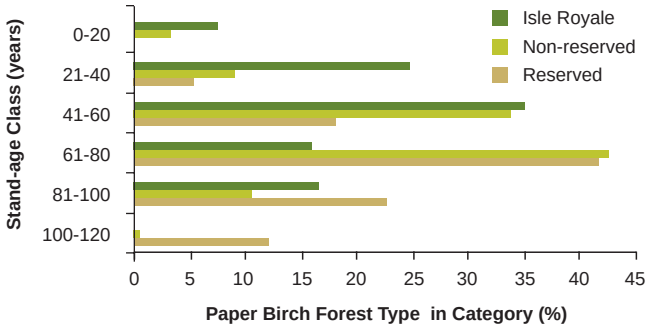

Figure 6.—Paper birch forest type by stand-age class, Michigan, 2010.

What this means

Fewer than half of the forest types across Michigan's Ecoprovince 212 are within reserved forest lands. Because Isle Royale makes up 36 percent of reserved and less than 1 percent of Michigan's Ecoprovince 212 forest land, all forest types except sugar maple/yellow birch are disproportionately represented on Isle Royale, making these Isle Royale forest types important contributors to overall reserved and non-reserved forest-type areas. Within the context of reserved forest lands, the forest types of paper birch, aspen, and white spruce are nearly exclusive to Isle Royale.

On Isle Royale, the early-successional forest types of paper birch and aspen reflect past fire and wind disturbances. The proportional area of Isle Royale aspen forest type is similar to Michigan's Ecoprovince 212 reserved lands at 14 and 15 percent, respectively. The paper birch forest type is 30 percent of the area on Isle Royale and contributes 72.6 percent to reserved and 17.5 percent to Michigan's Ecoprovince 212 total forest land. Without any future major disturbances, these forest types will give way to late-successional forest types, potentially reducing the overall number of Isle Royale forest types. In the case of the paper birch forest type, a decline on Isle Royale could have a substantial impact on the total area of paper birch forest type found within Michigan Ecoprovince 212.

Aspen and paper birch represent about 45 percent of Isle Royale forest types, and the respective stand-age distributions indicate the majority of stands initiated between 40 and 100 years ago. As a result, they have a considerable influence on Isle Royale's overall stand-age distribution. Although protection of Isle Royale began in the 1930s, the relative young age of aspen and paper birch forest types may have several causes. The stand-age distribution represents the last of the forest-clearing mining fires at the turn of the 20th century, the 1936 and 1948 fires, and the recent rapid increase in the moose population that inhibited regeneration and recruitment. Regeneration following these disturbances may have been hindered if there was not a suitable seedbed due to fire intensity, inadequate nearby seed sources, or heavy browsing. We should also note that overall stand-age distributions of reserved forest land would be significantly older if Isle Royale values were removed. The similarity in age classes between Isle Royale and Michigan's non-reserved forest land indicates a common theme: most of today's stands regenerated after large-scale disturbances, including the clearing of forests related to timber and mining exploitation.

Number of Trees

Background

Forest land stand-size classification indicates the predominant diameter size of live trees that contribute to the majority of stocking. Forest types are categorized by stand-size classes while species are categorized by tree-size classes. The large-diameter stand-size class (or sawtimber tree-size) consists of softwoods 9.0 inches in diameter (at breast height, 4.5 feet or d.b.h.) and greater and hardwoods 11.0 inches in diameter and greater. The medium-diameter stand-size class (or poletimber tree-size) includes softwoods 5.0 to 8.9 inches in diameter and hardwoods 5.0 to 10.9 inches in diameter. The small-diameter stand-size class (or sapling tree-size) includes saplings or trees between 1.0 and 4.9 inches in diameter.

What we found

Isle Royale forest types are dominated by large- and medium-diameter stand-size classes (Table 3). The sugar maple/yellow birch forest type is composed entirely of the large-diameter stand-size class. Only the balsam fir forest type had higher stocking in small- diameter stand-size classes.

Because forest types are a mix of different species of different sizes, how does non-reserved, reserved, and Isle Royale tree densities compare to that of species in Ecoprovince 212? Isle Royale has 20 tree species that equate to more than 97 million trees (greater than 1 inch d.b.h.), or about 708 trees per acre (t.p.a.). When factoring in the sampling error, this overall density is comparable to Michigan's Ecoprovince 212 non-reserved (741 t.p.a.) and reserved forest lands (614 t.p.a., Fig. 7). Both Isle Royale and reserved forest lands have higher stocking in large-diameter trees and lower stocking in smaller diameter trees when compared to non-reserved forest land.

Northern white-cedar is the most common species on Isle Royale, estimated at more than 25 million trees. The most common species following northern white-cedar are white spruce (*Picea glauca*, 17.8 million trees), balsam fir (*Abies balsamea*, 14.9), paper birch (*Betula papyrifera*, 12.8), yellow birch (*Betula alleghaniensis*, 6.9), black spruce (*Picea mariana*, 5.4), sugar maple (*Acer saccharum*, 5.0), black ash (*Fraxinus nigra*, 3.3), eastern white pine (*Pinus strobus*, 2.7), and quaking aspen (*Populus tremuloides*, 2.0). Nearly 2 million trees are divided among the following species: pin cherry (*Prunus pensylvanica*), jack pine, white ash (*Fraxinus americana*), chokecherry (*Prunus virginiana*), tamarack (*Larix laricina*), red maple (*Acer rubrum*), willow spp. (*Salix* spp.), American mountain-ash (*Sorbus americana*), green ash (*Fraxinus pennsylvanica*), and balsam poplar (*Populus balsamifera*).

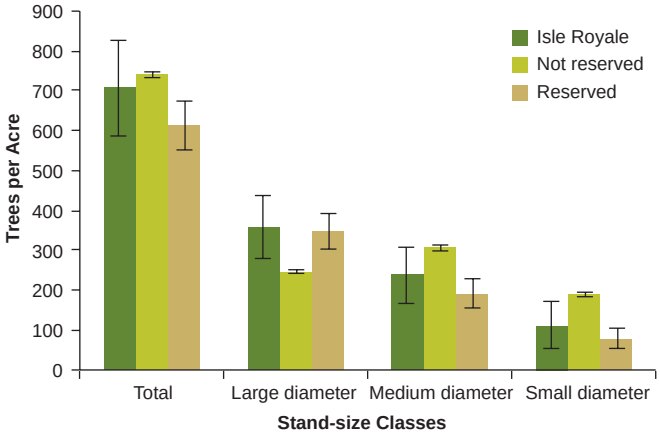

Figure 7.—Trees per acre by stand-size class, Michigan, 2010. Error bars represent the 68-percent confidence interval around the estimate.

Table 3.—Stocking (trees at least 1 inch d.b.h.) by stand-size class of Isle Royale forest types, Michigan, 2010

Isle Royale forest type[a]	Total		Large diameter		Medium diameter		Small diameter	
	Thousand trees	*Sampling error (%)[b]*	*Thousand trees*	*Sampling error (%)[b]*	*Thousand trees*	*Sampling error (%)[b]*	*Thousand trees*	*Sampling error (%)[b]*
Paper birch	25,011	32.4	6,735	43.5	16,281	45.3	1,996	100.3
Sugar maple/yellow birch	19,633	37.9	19,633	37.9	-	-	-	-
Northern white-cedar	14,983	44.7	8,738	60.8	2,424	69.6	3,821	100.3
Aspen	11,235	44.6	2,161	62.6	7,564	61.4	1,511	96.1
Balsam fir	9,260	74.0	-	-	960	96.1	8,300	81.9
White spruce	7,462	52.2	6,337	59.1	1,125	96.1	-	-
Black spruce	5,944	75.5	5,944	75.5	-	-	-	-
White pine/red oak/white ash	4,553	96.1	-	-	4,553	96.1	-	-
Total	98,082	17.1	49,547	22.2	32,906	30.4	15,628	51.9

[a]The eastern white pine/northern red oak/white ash is abbreviated as white pine/red oak/white ash forest type.
[b]Sampling error represents the 68-percent confidence interval around the estimate.

Nearly all the prominent species have saplings that make up more than 71 percent of the total stocking by tree size (Fig. 8). Only paper birch (46 percent) and quaking aspen (13 percent) have lower values. Quaking aspen is the only species where sawtimber (55 percent) exceeds poletimber stocking (32 percent). Although the aspen forest type is the fourth largest on Isle Royale, the species itself is the tenth most common. Overall, conifer species are more common in small-diameter classes than deciduous species.

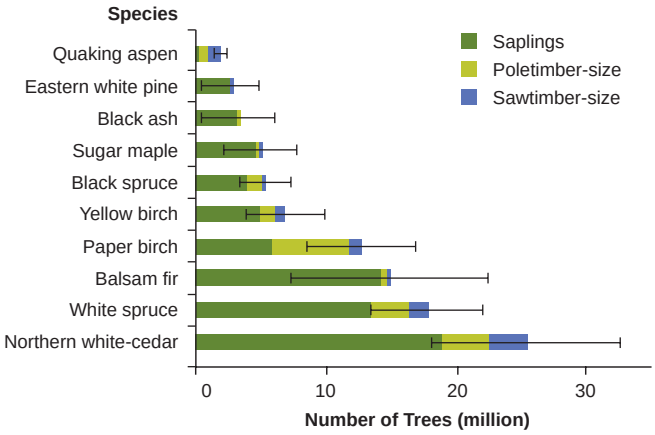

Figure 8.—Number of live trees (at least 1 inch d.b.h.) on Isle Royale by tree-size class and species, Michigan, 2010. Error bars represent the 68-percent confidence interval around the total estimate of selected prominent species. Not shown are pin cherry, jack pine, white ash, chokecherry, tamarack, red maple, willow spp., American mountain-ash, green ash, and balsam poplar.

What this means

The patterns of overall tree density, species frequency, and species distribution by tree size tell an intriguing story. Two pioneer tree species—paper birch and quaking aspen— require significant disturbance for regeneration. The low stocking values in the sapling class, combined with mortality rates (see Growth and Mortality section), would suggest that paper birch and aspen have not experienced a disturbance since the early- to mid-1900s (Cooper 1928, Janke et al. 1978; McLaren and Janke 1996). Without a major disturbance (i.e., fire and/or windthrow) that provides regeneration and recruitment opportunities, paper birch and aspen will likely continue to decline in numbers.

Although there is considerable sampling error with balsam fir, the stocking pattern of this third most common species may be a result of severe moose browsing, the pattern and frequency of windthrow and fire disturbance, and the presence of both temperate and boreal species on Isle Royale. According to McLaren and Janke (1996), balsam fir (and to some extent, white spruce) had lower densities on the southwest end of Isle Royale while densities were higher on the northeast end. They attributed the higher densities and basal area to the 1936 and 1948 fires (creation of suitable seedbeds), more frequent windstorms (increased sunlight availability), and reduced competition because moose favor the palatable species of aspen, paper birch, and hazel *(Corylus cornuta)*. Observations support these findings, with the northeast end of Isle Royale resembling a dog-hair thicket (Charles Paulson and Suzanne Sanders, pers. comm.).

What will Isle Royale forest types and species distribution look like in the future? With the combination of infrequent natural disturbances and constant browsing pressure, the current low stocking of small-diameter paper birch and quaking aspen may not be sufficient to become future seed sources. Conversely, northern white-cedar's abundance and low palatability may mean an increase in stocking. Previous findings on Isle Royale indicated that when northern white-cedar was an available food source, it made up less than 1 percent of a moose's diet (Aldous and Kreftling 1946). In general, as mortality impacts overstory species and creates gap openings, one would expect shade-tolerant and non-palatable species to increase in frequency. Under this scenario, Isle Royale will gradually shift to conifer species.

Stocking

Background

Stocking is defined as the degree of occupancy of land by live trees, measured by basal area and/or the number of trees in a stand by size or age and spacing, compared to the basal area and/or number of trees required to fully use the growth potential of the land. If a stand is overstocked, it may indicate an increased probability of forest health problems and lower growth rates; a poorly stocked stand may indicate poor site quality or a stand that is converting back to a forested condition following a major disturbance.

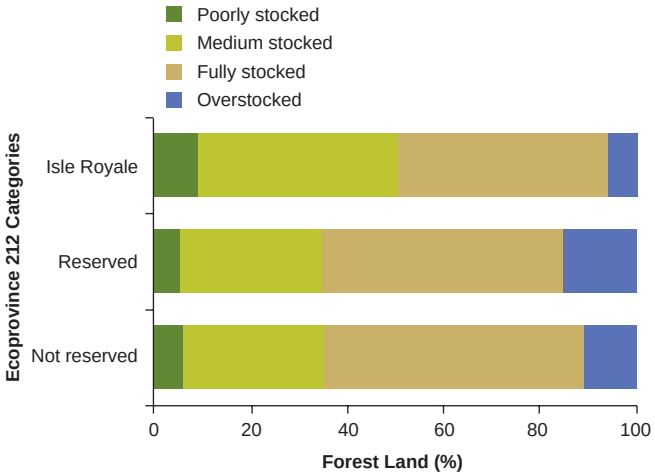

Figure 9.—Percentage of forest land by stocking class within Michigan's Ecoprovince 212, Michigan, 2010. "Nonstocked" category not shown.

What we found

Within Isle Royale, 85 percent of the area is considered medium or fully stocked. This area compares favorably to reserved forest land (80 percent) and non-reserved forest land in Michigan's Ecoprovince 212 (84 percent, Fig. 9). Only two Isle Royale forest types were considered overstocked: balsam fir (24 percent) and sugar maple/yellow birch (23 percent, Fig. 10). This stocking pattern was also seen in reserved forest land, but did not carry over to non-reserved forest land, because overstocking rates for balsam fir (9 percent) and sugar maple/yellow birch (7 percent) were much lower. The Isle Royale balsam fir forest type was also the most varied in stocking because each stocking category was represented.

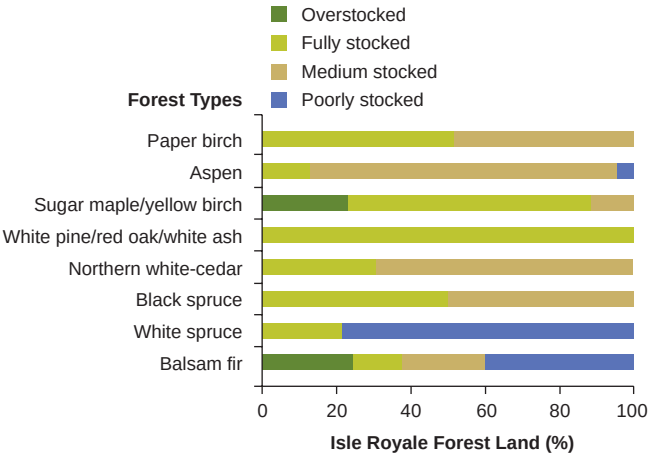

Figure 10.—Percentage of Isle Royale forest land by stocking class and forest type, Michigan, 2010. Note: the eastern white pine/northern red oak/white ash forest type is abbreviated as white pine/red oak/white ash.

What this means

The high percentage of fully and medium stocked forest land in Isle Royale is beneficial for maintaining forest health. Although lower stocking levels would be expected on poorer quality sites (e.g., wetter soils of northern white-cedar), it was not evident on Isle Royale. The sugar maple/yellow birch forest type tends to have higher stocking values given the shade tolerance of the compositional species (i.e., sugar maple), while the stocking variability of the balsam fir forest type can be attributed to sampling error, balsam fir's shade tolerance, past disturbance regimes, influence of moose, and ability to exist on a variety of sites.

Volume

Background

Volume is similar to stocking because it characterizes forest resources and is easily compared between species and forest types. Volume also incorporates net growth, removals, and mortality. Estimates of live-tree volumes are in cubic feet and include all live trees at least 5 inches d.b.h.

What we found

On Isle Royale forest land, there are about 243 million cubic feet of growing stock, or about 1,575 cubic feet / acre. Northern white-cedar (25 percent), paper birch (21 percent), yellow birch (16 percent), white spruce (15 percent), and quaking aspen (13 percent) contribute 89 percent of this total volume (Fig. 11).

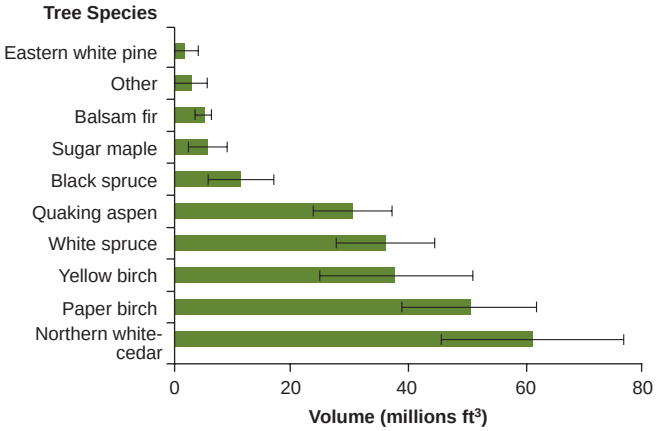

Figure 11.—Volume estimates of growing stock on Isle Royale forest land by species, Michigan, 2010. Error bars represent the 68-percent confidence interval around the estimate. "Other" includes tamarack, jack pine, red maple, black ash, green ash, balsam poplar, pin cherry, willow spp., and American mountain-ash.

Michigan's Ecoprovince 212 non-reserved forest lands have an estimated 25.3 billion cubic feet (1,567 cubic feet/acre); reserved forest lands have about 830 million cubic feet (2,211 cubic feet/acre). The top five species contributing to total volume estimates for Ecoprovince 212 non-reserved forest land are sugar maple (17 percent), red maple (13 percent), northern white-cedar (10 percent), red pine (8 percent), and quaking aspen (6 percent). On reserved forest land, 58 percent of the volume can be attributed to sugar maple (17 percent), northern white-cedar (12 percent), eastern hemlock (10 percent), yellow birch (10 percent), and paper birch (9 percent).

Overall, Isle Royale contributes nearly 2 percent to the total forest land volume of Michigan's Ecoprovince 212, although this varies by species. For example, paper birch represents more than 8 percent of the total paper birch volume within Michigan's Ecoprovince 212. Yellow birch and white spruce contribute 6 percent to total volume estimates, respectively. Although Isle Royale makes up less than 1 percent of Michigan's Ecoprovince 212 forest land, northern white-cedar, quaking aspen, balsam fir, and black spruce disproportionately contribute at least 1 percent to total volume estimates.

Of Isle Royale's high volume species (northern white-cedar, paper birch, yellow birch, white spruce, and quaking aspen), 70 percent of this volume is contained within the sawtimber-size class. This percentage is similar to other reserved forest land for these same species. However, about 58 percent of Michigan's non-reserved forest land volume is categorized as sawtimber-size diameter. Comparing each species' proportional volume of poletimber-size classes to sawtimber-size classes indicates that Isle Royale and reserved forest land allocate more volume in the sawtimber-size trees of northern white-cedar, yellow birch, and quaking aspen (Fig. 12).

Isle Royale, Daisy Farm yellow lady slipper. Photo by Karena Schmidt, Michigan Technological University; used with permission.

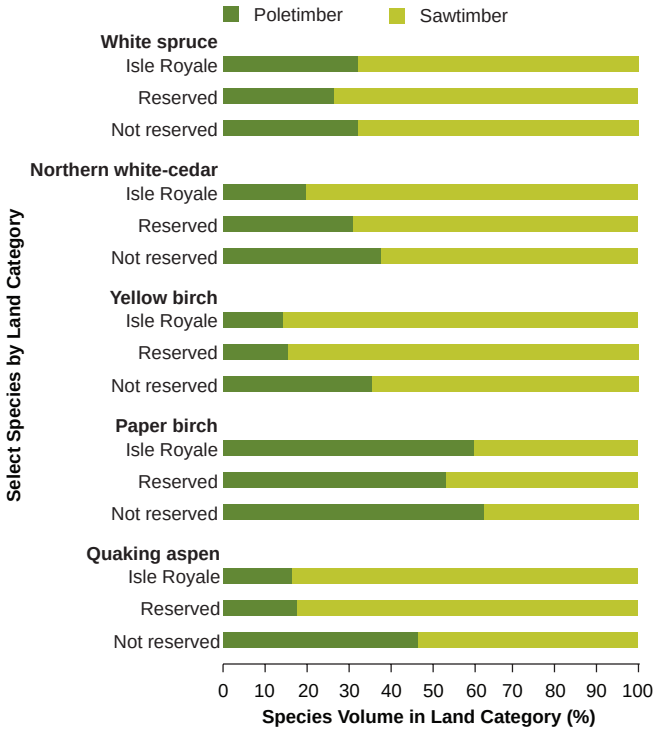

Figure 12.—Prominent species volume by tree size for each land category, Michigan, 2010.

What this means

Volume is an important component of forest structure because it is a function of tree height and diameter. Areas or species that have disproportionate contributions indicate bigger (d.b.h.), taller, and older trees. The volumes and respective contributions of paper birch, yellow birch, and white spruce to Michigan's forest resources reflect the fully stocked stands of medium- and large-diameter trees on Isle Royale. As these medium-stocked stands shift to large-diameter stand-classes and as older and larger trees senesce, changes in volume estimates will have a potentially substantial impact on Isle Royale's forest resources.

Biomass and Carbon

Background

The topics of biomass and carbon are drawing much public interest. Biomass estimates are valuable in determining fuel availability, fuel loading, carbon allocation, carbon sequestration, and changes in carbon pools. The ability of an individual tree or forest to act as a carbon sink is important because of global and regional climate change concerns. Because about half of a tree's biomass is carbon, understanding forest carbon stocks is critical to carbon credit markets, management strategies, and carbon cycle dynamics.

Biomass estimates include bole volume plus bark and branches of all live trees 1 inch in diameter and greater, and are reported in oven-dry short tons (tons). Carbon is reported as short tons (tons) and uses five categories, or pools, for classification. Following standards based on the U.S. National Greenhouse Gas Inventory, forest carbon pools are delineated as live aboveground, live belowground, dead wood, litter, and organic soil (U.S. EPA 2010). Generally, trends in biomass and carbon follow those in volume.

What we found

On Isle Royale, live aboveground biomass is an estimated 5.4 million tons, which averages to 38.9 tons/acre. This biomass distribution was concentrated in the two largest forest types by area: sugar maple/yellow birch (36 percent) and paper birch (29 percent, Fig. 13). Per acre averages were similar across non-reserved and reserved forest land (39.1 and 52.7 tons/acre, respectively).

The per acre average of the sugar maple/yellow birch forest type was consistently greater than overall averages (Table 4). Although non-reserved and reserved biomass in Michigan's Ecoprovince 212 were not concentrated into as few forest types as on Isle Royale, sugar maple/yellow birch contributed 28 percent to non-reserved biomass and 50 percent to reserved biomass. Also, although Isle

Table 4.—Live aboveground tree (minimum 1 inch d.b.h.) biomass by forest type and Ecoprovince 212 forest land regions, Michigan, 2010

Forest type	Michigan's Ecoprovince 212						Isle Royale		
	Non-reserved			Reserved					
	Million dry tons	*Dry tons sampling error (%)*[a]	*Dry tons/ acre*	*Million dry tons*	*Dry tons sampling error (%)*[a]	*Dry tons/ acre*	*Million dry tons*	*Dry tons sampling error (%)*[a]	*Dry tons/ acre*
Sugar maple/yellow birch	177.9	2.8	53.0	9.9	15.9	74.8	1.9	32.5	63.7
Paper birch	8.7	11.9	36.5	2.4	24.3	40.9	1.6	28.8	37.8
Aspen	72.9	4.1	29.4	0.7	34.0	26.4	0.5	38.9	25.5
Northern white-cedar	48.4	5.0	38.2	1.3	30.6	34.2	0.5	44.0	26.6
Other	325.3	1.8	36.8	5.6	19.4	45.6	0.9	39.3	31.3
Total	633.2	0.9	39.1	19.8	10.0	52.7	5.4	15.7	38.9

[a]Sampling error represents the 68-percent confidence interval around the estimate.

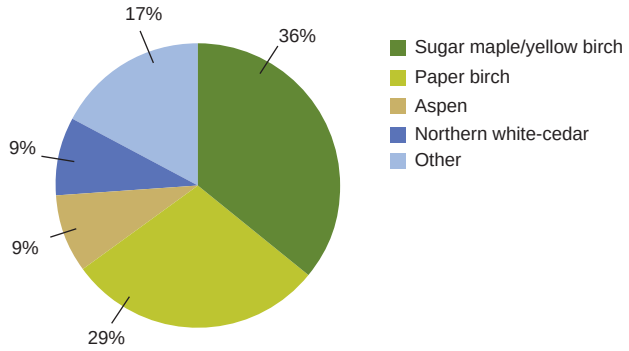

Figure 13.—Percentage of live-tree aboveground biomass by forest type on Isle Royale, Michigan, 2010. "Other" forest types include white spruce, black spruce, balsam fir, and eastern white pine/northern red oak/white ash.

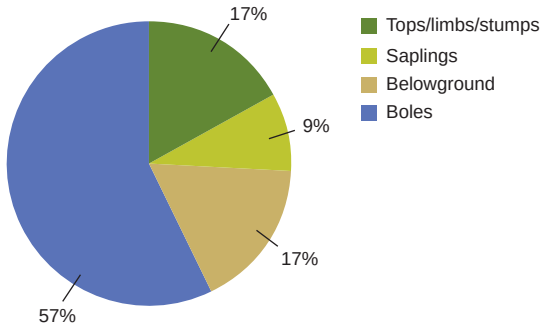

Figure 14.—Percentage of live-tree biomass (tons) on Isle Royale by aboveground and belowground components, Michigan, 2010. Saplings include trees at least 1 but less than 5 inches d.b.h. Stumps are from ground level to 1 foot in height. Belowground represents live saplings and trees. Boles are merchantable portions from 5 inch d.b.h. to a 4-inch top.

Royale's total biomass contribution to Michigan's overall biomass volume was equal to the land mass ratio (less than 1 percent), 14 percent of Michigan's paper birch forest type biomass was attributed to Isle Royale.

Forest land live biomass can be broken into four categories: belowground for saplings and trees, tops/limbs/stumps, saplings, and boles. On Isle Royale, tree boles contributed 57 percent of the total biomass, while belowground (i.e., roots) biomass was the same as the live-tree tops/limbs/stumps value at 17 percent (Fig. 14).

Isle Royale's forests have more than 16 million tons of carbon or about 119 tons/acre. The largest component is organic matter in mineral soil, contributing 67 percent (11 million tons, Fig. 15). Live aboveground and belowground carbon was 3.3 million tons, or 20 percent of the carbon on Isle Royale. For comparison, non-reserved and reserved forest land contains 1,690.8 and 45.5 million tons of carbon, respectively. This averages to 105.8 and 121.5 tons/acre for non-reserved and reserved forest land, respectively. The organic matter in soil was also similar in Isle Royale and reserved and non-reserved forest land (59 and 64 percent, respectively).

The northern white-cedar forest type covers the fourth largest area on Isle Royale (10 percent) but contains the third most carbon (17 percent, Fig. 16). The majority of this contribution is from carbon from organic matter within mineral soil. Although the prominent forest types of Isle Royale typically had organic soil amounts between 65 and 70 percent, sugar maple/yellow birch had 50 percent (Fig. 17).

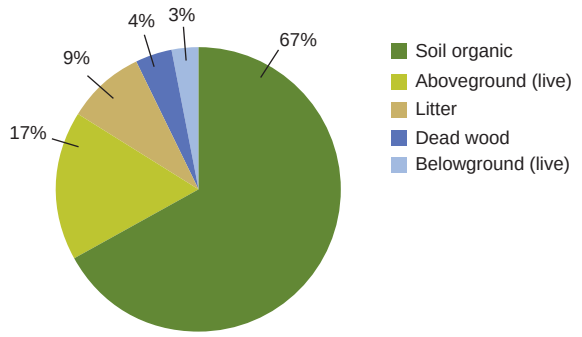

Figure 15.—Isle Royale forest land carbon stock (tons) by component as classified by Intergovernmental Panel on Climate Change (IPCC), Michigan, 2010. Litter includes leaves and small woody debris (branches less than 3 inches in diameter). Mineral soil occurs below the O horizon.

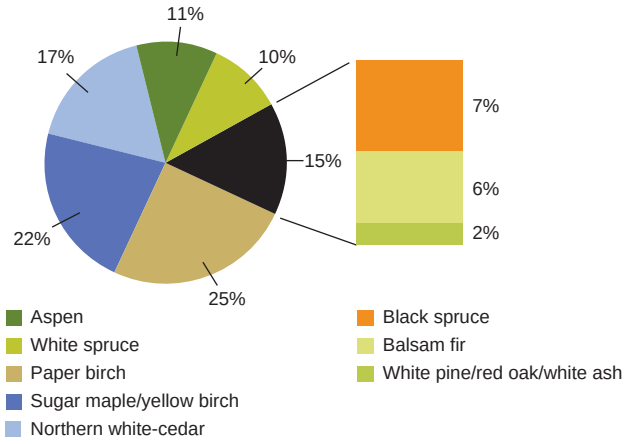

Figure 16.—Isle Royale forest land carbon stock by forest type as classified by IPCC, Michigan, 2010. Note: the eastern white pine/northern red oak/white ash forest type is abbreviated as white pine/red oak/white ash.

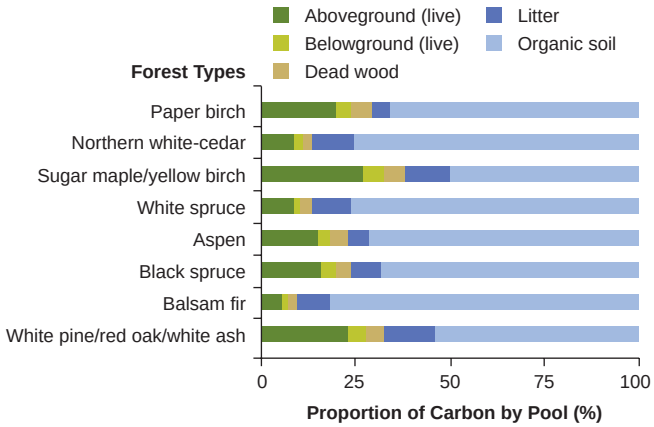

Figure 17.—Isle Royale forest type carbon stock by component as classified by IPCC, Michigan, 2010. Note: the eastern white pine/northern red oak/white ash forest type is abbreviated as white pine/red oak/white ash.

What this means

Tree boles contain the greatest amount of Isle Royale's total biomass, and the majority of the biomass is found in sugar maple/yellow birch and paper birch forest types. Future increases in biomass will be a result of trees making the transition from small-diameter to large-diameter stand-size classes. Isle Royale biomass stocks will increase at a slower rate compared to Ecoprovince 212 non-reserved forest land because Isle Royale has less area allocated to small-diameter stand-size classes.

Estimates of live aboveground and belowground biomass help us understand carbon pools within and between areas, but the forest soils typically contain most of ecosystem carbon. Forest soils that have higher moisture content tend to have more carbon per acre as water impedes microbial decay rates, allowing carbon allocation rates to exceed carbon release due to decomposition (Schlesinger and Andrews 2000, Trumbore 2000). This is evident in the northern white-cedar forest type and the higher amounts of stored carbon on a per acre basis.

Additionally, stand structure and age can act as a surrogate for carbon allocation and sequestration rates as a function of time from a previous disturbance (Pan et al. 2011). In other words, following a recent disturbance, the vigorous growth of a young stand will accumulate carbon at a faster rate than an established forest, yet will have lower overall carbon amounts.

Conversely, large-diameter stands reflect a longer time since disturbance. These stands can have larger carbon pools but may sequester carbon at lower annual rates. On Isle Royale, no active management or documented large-scale disturbance has occurred since the 1930s and 1940s, and those areas were concentrated on the northeast side of the island (Janke et al. 1978). In the case of sugar maple/yellow birch, located on the southwest part of Isle Royale, the large-diameter stand-size classes within fully stocked stands contributed to higher aboveground carbon than other forest types.

Growth and Mortality

Background

Growth and mortality analysis provides information on forest dynamics related to succession, disturbance, productivity, sustainability, forest health, competition, and biotic and abiotic factors. Average annual net growth (growth including ingrowth minus mortality and cull) is computed by measuring trees at two points in time and determining the average annual change in volume over that period. Although species dependent, a lower growth rate (the percentage of annual net growth to current volume) is generally indicated by a percentage less than or equal to 1.0. Moderate growth rates range from 1.0 to 3.0 percent; high growth rates exceed 3.0 percent. Negative values indicate mortality is exceeding growth.

Some factors that cause mortality are native and invasive plant competition, insects, disease, wind, fire, drought, floods, and air pollution (this mortality analysis does not include harvesting or land conversion). Mortality may have single or multiple causes that may arise from one incident or over multiple years. For example, a lightning strike may weaken a tree's defense and make it susceptible to a pest attack that then takes several years to cause mortality. Although the true cause may be undetermined, mortality is a concern when it surpasses the growth and regeneration rates of the forest, increasing fuel loads. Similar to annual net growth, the average annual mortality of the forest is compared to the current standing volume. Also species dependent, lower mortality rates are less than or equal to 1.0 percent. Moderate rates of mortality range between 1.0 and 3.0 percent; high mortality rates exceed 3.0 percent.

What we found

Average annual net growth of live trees on Isle Royale was 2.6 million cubic feet for the 2010 inventory. The average annual net growth of northern white-cedar and white spruce actually exceeded Isle Royale's total (2.9 million cubic feet) because paper birch and quaking aspen had negative average annual net growth (1.2 million cubic). The sampling error at the 68-percent confidence interval does introduce high amounts of variability, so some caution should be used when interpreting these results (Fig. 18).

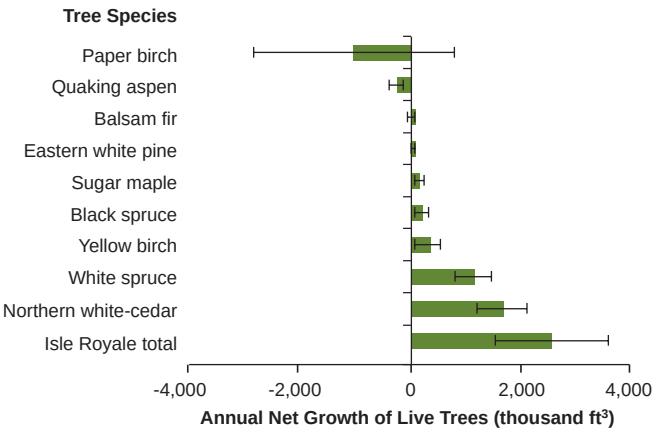

Figure 18.—Average annual net growth for live trees (at least 5 inches d.b.h.) on Isle Royale by species, Michigan, 2010. Error bars represent the 68-percent confidence interval around the estimate of selected prominent species.

This annual net growth estimate for Isle Royale is about 1.1 percent of all live-tree volume and is considered a moderate rate of growth (Fig. 19). Of the top nine species by volume, three species had moderate growth rates (balsam fir, black spruce, and northern white-cedar), three species had high growth rates (sugar maple, white spruce, and eastern white pine), one species exhibited slow growth (yellow birch), and two species had mortality exceeding growth (paper birch at -2.0 and quaking aspen at -0.7). As with the variability in the average annual net growth of all live trees, caution should be used with these results.

The average annual mortality volume of Isle Royale was 3.8 million cubic feet, of which two species made up 80 percent (paper birch at 1.9 and quaking aspen at 1.2 million cubic feet). Of the prominent species by volume, sugar maple and eastern white pine did not have any annual mortality for the 2010 inventory (Fig. 20). The ratio of average annual mortality to current volume of Isle Royale was 1.6 percent, indicating a moderate rate of mortality (Fig. 21). Of the prominent species experiencing mortality, four species showed a lower rate of mortality (yellow birch, black spruce, white spruce, and northern white-cedar), balsam fir had a moderate

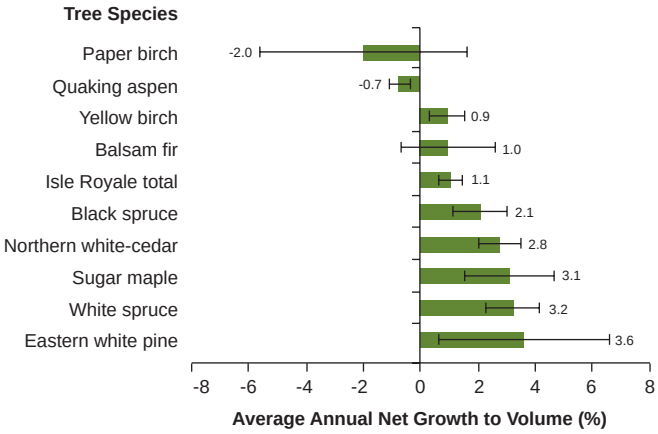

Figure 19.—Ratio (percent) of average annual net growth to current volume of live trees (at least 5 inches d.b.h.) on Isle Royale, Michigan, 2010. Error bars represent the 68-percent confidence interval around the estimate of selected prominent species.

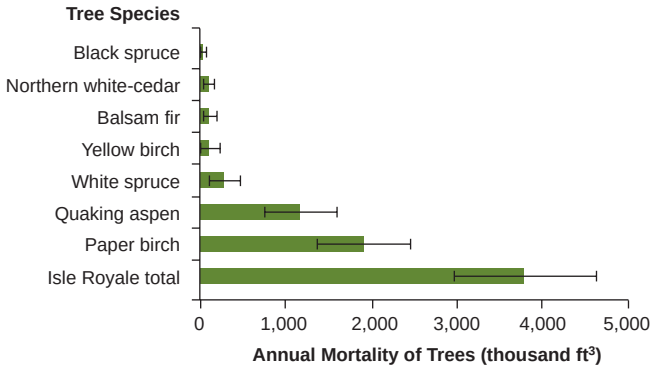

Figure 20.—Average annual mortality of trees (at least 5 inches d.b.h.) on Isle Royale by species, Michigan, 2010. Error bars represent the 68-percent confidence interval around the estimate of selected prominent species.

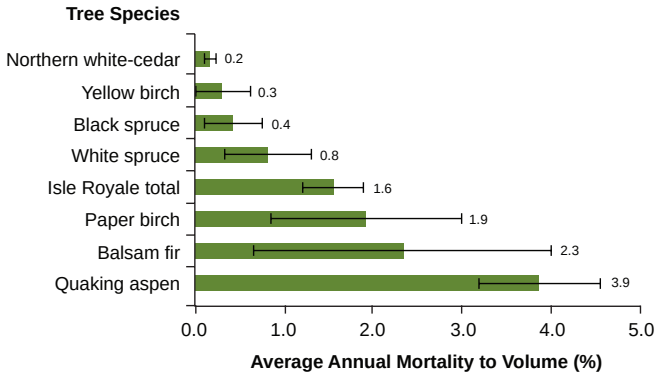

Figure 21.—Ratio (percent) of average mortality to current volume of live trees (at least 5 inches d.b.h.) on Isle Royale, Michigan, 2010. Error bars represent the 68-percent confidence interval around the estimate of selected prominent species.

rate of mortality, and two species had a high rate of mortality (paper birch and quaking aspen).

How does Isle Royale's ratio of average annual net growth and mortality to current volume compare to non-reserved forest land in Michigan's Ecoprovince 212? Although there are differences between Isle Royale and non-reserved forest land, growth and mortality rates both fall in the moderate category with rates between 1.0 and 3.0 percent (Fig. 22).

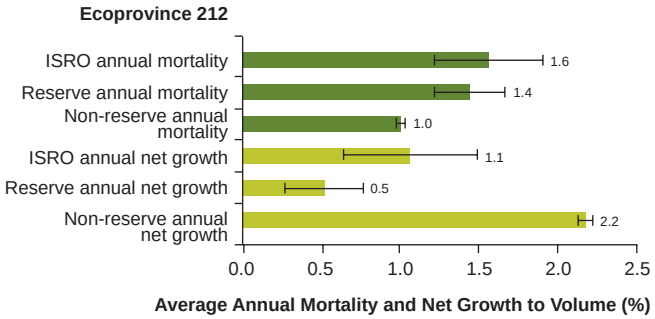

Figure 22.—Ratio (percent) of average annual mortality and net growth to current volume of live trees (at least 5 inches d.b.h.) on Isle Royale (ISRO), and Ecoprovince 212 reserved, and non-reserved forest lands, Michigan, 2010. Error bars represent the 68-percent confidence interval around the the estimate of forest land categories.

What this means

Isle Royale's annual net growth is considered moderate for all live trees, although it is lower than that of non-reserved forest lands. This rate was negatively influenced by the pioneer species of paper birch and quaking aspen because these two species are becoming overmature and recruitment stocking is relatively low. White spruce, sugar maple, and northern white-cedar exhibited the greatest level of annual net growth, which may be attributed to at least two reasons: little to no moose browse pressure and canopy-gap creation by senescing paper birch and quaking aspen that allows mid- to shade-tolerant species to reach the upper canopy.

Although Isle Royale's mortality rate was higher than that of non-reserved forest lands, it is still considered moderate. One important distinction between Isle Royale and non-reserved forest lands is that non-reserved

forests are actively managed, allowing for the removal of live trees that may potentially die between inventories. Quaking aspen and paper birch provide the majority of mortality volume on Isle Royale due to their advanced age, although balsam fir did exhibit the second highest average annual mortality to volume (2.3 percent). This moderate rate may have at least two factors: long-term moose browse pressure and, while undocumented on Isle Royale, the spruce budworm attack in the late 1990s and mid to late 2000s in Michigan's forest lands (Pugh et al. 2009).

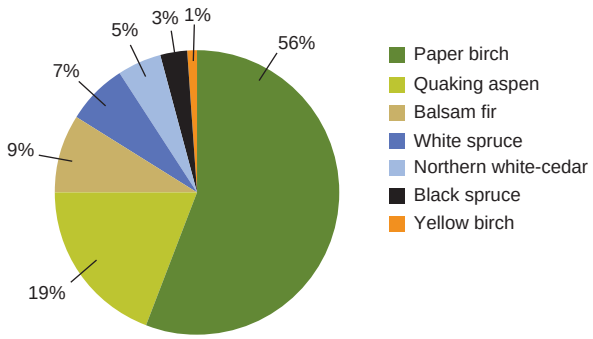

Figure 23.—Distribution of standing dead trees (at least 5 inches d.b.h.) by species on Isle Royale, Michigan, 2010.

Standing Dead Trees

Background

Snags, or standing dead trees, reflect stand succession and are key components of wildlife habitat, structural diversity, and carbon storage. The frequency of standing dead trees per area, total volume by species, and aboveground biomass by species are some of the common measurements for understanding the value of standing dead trees. To be considered a standing dead tree, the tree must have a d.b.h. of at least 5 inches and be at least 4.5 feet tall.

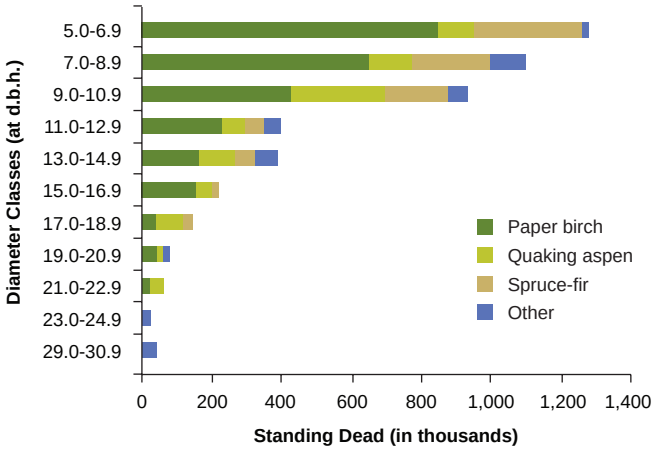

Figure 24.—Trees species distribution of standing dead trees by diameter class on Isle Royale, Michigan, 2010. "Spruce-fir" indicates balsam fir, black spruce, and white spruce. "Other" indicates yellow birch, eastern white pine, jack pine, and northern white-cedar.

What we found

The standing dead trees on Isle Royale are estimated at about 4.7 million. Paper birch and quaking aspen made up 74 percent of this value (Fig. 23). Of the prominent species, only sugar maple had no estimated standing dead trees. Standing dead trees on Isle Royale averaged 33.7 t.p.a., with paper birch the most abundant at 18.5 t.p.a. Quaking aspen averaged about 6 t.p.a., while balsam fir, white spruce, black spruce, and northern white-cedar averaged between 1 and 3 t.p.a. The overall frequency of standing dead trees is inversely related to tree diameter with about 88 percent of standing dead trees between 5 and 14.9 inches d.b.h. and about 12 percent larger than 15 inches d.b.h. (Fig. 24).

On Isle Royale, there are about 34 million cubic feet of volume and 0.8 million tons of biomass of standing dead trees, which averages to about 246 cubic/acre (6 tons/acre). As found with standing dead trees, paper birch and quaking aspen combined represent 67 percent of the volume and 71 percent of the biomass of standing dead trees found on Isle Royale. When compared to non-reserved forest land in Michigan's Ecoprovince 212, per acre values are 89 cubic feet of volume and 0.02 tons of biomass of standing dead trees.

What this means

Paper birch and quaking aspen on Isle Royale are the dominant standing dead species in regards to frequency,

diameter distribution, volume, biomass, and proportion of standing dead to live basal area. These patterns again reflect the successional events that initially created high populations across wide areas of both quaking aspen and paper birch that are now senescing. Additionally, the relatively low values per acre found on Michigan's non-reserved forest land reflect management that typically removes low vigor trees.

Isle Royale National Park FIA Methods

The national FIA plot design consists of a series of permanent plots randomly located in a matrix of hexagonal cells (Overton et al. 1990). Each plot consists of four fixed-radius subplots covering about 0.17 total acres. Since 1999, FIA has implemented annual inventories in which about 20 percent of the plots are visited each year (Smith 2002). After 5 years of data collection, analysis and reports are completed based upon this set of data, or cycle, of plots. Each additional year of remeasurements creates an annual moving window of 5-year cycles and reports. The last year of the cycle is used to identify the full set of plots. In this report, the cycle of plots measured from 2006 through 2010 are collectively labeled the 2010 inventory.

The national standard sampling intensity is about one plot per 6,000 acres. However, Michigan had triple intensity sampling in 2006 through 2007 (one plot per 2,000 acres). The average area represented per plot in the 2010 inventory for Michigan is about 2,755 acres of land, noncensus water, and inland census water. For the 2010 inventory, 44 plots on Isle Royale and 10,682 plots in Michigan were measured. Experienced field crews measure many condition variables (e.g., forest type, stand size, and stand age) and tree-level attributes (e.g., species, diameter, and height) that are used to estimate additional attributes (e.g., volume, biomass, carbon, net growth, and mortality) across regions (e.g., national forests and states) with associated measures of reliability (U.S. Forest Service 2007, 2011).

The quality of the estimates is affected by sampling, measurement, prediction, and nonresponse error. Several times within this report, sampling error (SE) is used as the primary measure of the reliability of an estimate and is based on one standard error. This error indicates that 68 percent of the time (two out of three chances), while using the same methods, a complete inventory of the entire population would have been within the limits indicated. For example, the 2010 FIA inventory estimates the Isle Royale paper birch forest type has 41,892 acres (SE 26.64 percent) with 25,011,488 live trees (SE 32.41 percent) 1-inch d.b.h. or larger. For the individual attributes, the SE is ± 11,160 acres and ± 8,106,223 trees. For additional information about sampling design, sampling error, and specific limitations with FIA population estimates, refer to Bechtold and Patterson (2005).

These population estimates are available to the public via the U.S. Forest Service FIA DataMart, an online database (http://apps.fs.fed.us/fiadb-downloads/datamart.html). Woudenberg et al. (2010) provides documentation on database structure, calculations of population estimates, and explanations of codes and table attributes. Results for this publication were taken from 2006-2010 USFS FIA data accessed via the USFS EVALIDator 4.01 (http://apps.fs.fed.us/Evalidator/tmattribute.jsp). More information on usage can be found online at http://fia.fs.fed.us/tools-data/other/default.asp.

Isle Royale, Rock Harbor black morel. Photo by Karena Schmidt, Michigan Technological University; used with permission.

Summary

This report is the first-ever attempt to use FIA data to provide baseline quantitative information about the forest resources of Isle Royale National Park. This FIA bulletin reflects a unique application of using timber and non-timber attributes for reserved forest lands. With the national permanent plot system, the FIA 5-year remeasurement cycle allows for the opportunity to further monitor Isle Royale's forest dynamics.

The forest conditions of Isle Royale (2010 inventory) are compared to those of Michigan's Ecoprovince 212 reserved and non-reserved forest lands. Isle Royale represents 36 percent of Michigan's reserved forest land and less than 1 percent of non-reserved land. Isle Royale's four prominent forest types (paper birch, sugar maple/yellow birch, aspen, and northern white-cedar) and four tree species (northern white-cedar, white spruce, balsam fir, and paper birch) are important contributors to Michigan's overall forest resources.

Human-caused and natural fires between 1847 and 1948 on Isle Royale created large tracts of early-successional species (i.e., paper birch and trembling aspen), while current vegetative disturbances following the establishment of the park (post-1930) can be somewhat attributed to the arrival of moose. These factors have resulted in similarities and differences between Isle Royale and non-reserved forest land in Michigan's Ecoprovince 212. Isle Royale's per acre estimates of tree densities, volume, live biomass, and aboveground and belowground carbon were similar to those found in Michigan's non-reserved and reserved forest land. Stand-age structure was more similar between Isle Royale and Michigan's non-reserved forest land than reserved forest land.

However, important differences in species-specific stand-size stocking, growth, and mortality were detected. About 85 percent of Isle Royale's stands are considered medium to large in diameter, with balsam fir providing a notable amount of stocking in small-diameter stand size. The low stocking values of small-diameter deciduous species (i.e., paper birch, trembling aspen, yellow birch, sugar maple, and black ash) may also be inadequate for self-replacement, allowing Isle Royale to gradually shift to conifer species. This transition is supported by the average annual net growth of both white spruce and northern white-cedar exceeding Isle Royale's total.

Isle Royale, archipelago. Photo by Linda Nagel, Michigan Technological University; used with permission.

Although growth and mortality rates on Isle Royale and non-reserved forest land were considered moderate, differences were found when looking at individual species. Mortality exceeded growth for both paper birch and trembling aspen on Isle Royale, with nearly 75 percent of the standing dead trees attributed to these species. These patterns again reflect the successional events that initially created large populations across wide areas of both quaking aspen and paper birch that are now senescing. Conversely, the relatively low values per acre found on Michigan's non-reserved forest land reflect management that typically removes low vigor trees.

Overall, FIA data suggest Isle Royale's forests are a unique ecosystem due to a combination of factors: existence of boreal and temperate biomes, remote location in Lake Superior, disturbance legacy related to natural processes and mining exploration, absence of forest management for over eight decades, and 50 years of complex interactions between moose/wolf populations.

Isle Royale, Lake Richie hepatica flower and lycopodium. Photo by Karena Schmidt, Michigan Technological University; used with permission.

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This publication provides a baseline overview of forest resources for Isle Royale National Park (Isle Royale) using data from the Forest Inventory and Analysis (FIA) Program of the U.S. Department of Agriculture, Forest Service. The availability of permanent FIA plots allows for the first-ever comparison of Isle Royale's forest conditions (2006-2010) to reserved and non-reserved forest land within Michigan's Laurentian Mixed Forest-Ecoprovince 212. Isle Royale's prominent forest types, structure, and species composition reflect human and natural disturbances. FIA data suggest Isle Royale's species-specific stand-size stocking, growth and mortality rates, tree densities, volume, live biomass, and aboveground and belowground carbon reflect a unique ecosystem due to a combination of factors: remote location in Lake Superior, disturbance legacy related to natural processes and mining exploration, absence of forest management for more than eight decades, and 50 years of complex interactions between moose/wolf populations.

KEY WORDS: reserved forest land, inventory, forest area, volume, mortality, growth, forest health, biomass, carbon, disturbance, ecoprovince, succession

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