

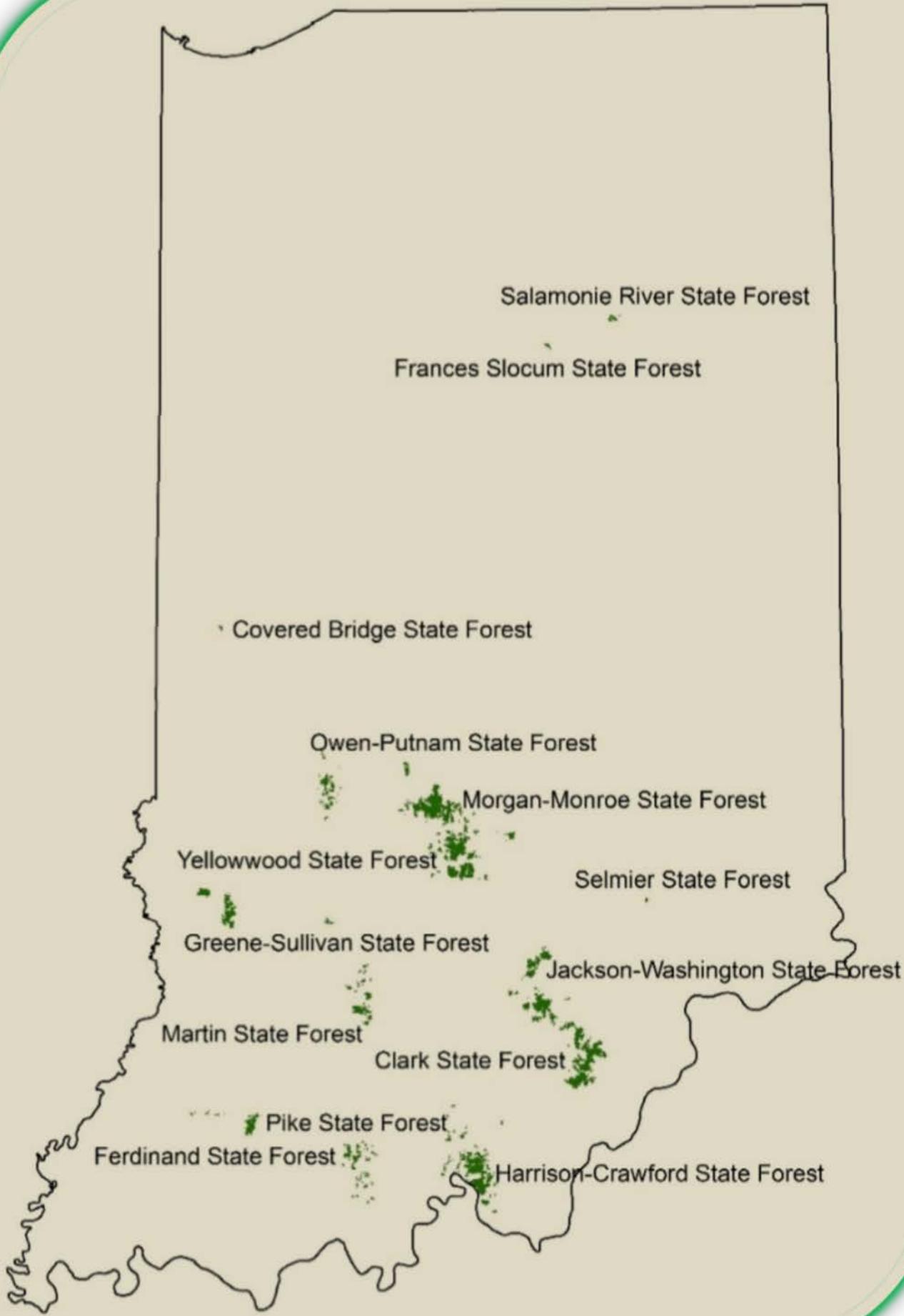
Indiana State Forest Properties –

Then and Now

A Comparative Look at Forest Attributes in 1986 and 2014

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Salamonie River State Forest

Frances Slocum State Forest

Covered Bridge State Forest

Owen-Putnam State Forest

Morgan-Monroe State Forest

Yellowwood State Forest

Selmier State Forest

Greene-Sullivan State Forest

Jackson-Washington State Forest

Martin State Forest

Clark State Forest

Pike State Forest

Ferdinand State Forest

Harrison-Crawford State Forest

BACKGROUND

At the turn of the century, our nation's forests were being rapidly cut, cleared, and burned with little thought to providing a heritage for the future. The forestry profession in general arose as a means to protect, plant and nurture our forests, and to ensure a continuity of growth for future generations.

Aimed at stopping erosion and restoring the productive potential of the land, the Indiana State Forest system began with the establishment of Clark State Forest in 1903. Since then, the State Forest system has evolved into 14 State Forests containing nearly 158,000 acres. When the state acquired what is now State Forest property, almost every acre was consisted of eroding farm fields, pasture or cutover timberland and was considered to have little value to anyone. Most of the existing woodland had been high-graded, with the residual trees often exhibiting defects from forest fires and livestock grazing.



Figure 1. Clark County State Forest Arboretum, Administration Building, circa 1927. Made up of 22,979 acres now, Clark State Forest was the first state forest in Indiana. It was established in 1903, and Indiana's first forest nursery began there in 1925. The forest lies chiefly in Clark County but extends into Scott and Washington counties. Credit: Indiana Historical Society

State Forests are managed by professional foresters and resource specialists to demonstrate a working forest concept. A working forest is actively managed under a stewardship plan that guides its activities to accomplish the desired goals. Working forests provide a variety of goods and services such as watershed protection, recreation, wildlife habitat, scenic beauty and wood products.

OVERVIEW

This report presents a comparative analytical view of forest attributes in 1986 and 2014 based on data gathered by the Forest Inventory & Analysis (FIA) program, which is a research unit of the U.S. Forest Service. The area of interest is timberland owned and managed by the Indiana DNR Division of Forestry (state forest properties). A subset of FIA plots circa 1986 (56 plots) and 2009-2014 (41 plots) that fell within the state forest circa 1986 IDNR GIS shapefile were used. The total land and water area for that GIS dataset was 139,077 acres. Lands have been added since 1986 to bring the total to 157,989 acres (circa 2014 GIS shapefile); however, these added acres were excluded in the comparison so that only the lands that were owned/managed in 1986 (and still in 2014) were used.

The FIA program was first implemented in Indiana in 1950 (Winters 1953, Hutchison 1956). Later inventories were completed in 1967 (Spencer 1969), 1986 (Spencer *et al.* 1990, Smith and Golitz 1988), 1998 (Schmidt *et al.* 2000), 2003 (Woodall *et al.* 2005), 2008 (Woodall *et al.* 2011), and 2013 (Gormanson *et al.* 2016).

Refer to the FIADB User Manual (O'Connell and others 2016) and FIA field data collection procedures guide (USDA Forest Service 2015) for detailed code lists and attribute descriptions, sample layout explanations, collection protocols, and glossary terms. Links for the two documents are in the reference section of this report. In addition, Bechtold *et al.* 2005 provides sampling design and estimation procedures.

RESULTS

- In 1986, the total area owned and managed by the Indiana DNR Division of Forestry was 139,077 acres. This included acres not considered timberland (i.e., campgrounds, recreation areas, rights of way, water, etc.). For this study, only acres meeting the FIA definition of timberland were considered. Due to plot expansion factors differing from 1986 to 2014 from a change in plot design and sampling procedures, the estimated timberland totals in 1986 were 113,952 acres and in 2014 were 116,829 acres, a 2.5% increase (Table 1).
- FIA estimates that the number of live trees $\geq 1''$ diameter at breast height (d.b.h.) totaled 55,512,287 trees in 1986, or 487 trees per acre. Estimates for 2014 totaled 45,130,094 trees, or 386 trees per acre, which represents a decline of 18.7%. The number of standing dead trees at least 5'' d.b.h. in 1986 was 2,447,270 or 21 trees per acre. In 2014, this number declined to 1,311,650 or 11 trees per acre (Table 1).

As forests mature, the species composition at a particular site goes through what ecologists call “forest succession.” During this continuous process, long-lived plants that can tolerate shaded conditions replace short-lived plants that need full sunlight to thrive. Succession is influenced by disturbances from natural and human sources. Examples of forest disturbance on Indiana’s State forests include wildfires, ice and wind storms, droughts, outbreaks of insect pests (such as the emerald ash borer), logging, and land clearing followed by abandonment. The interaction of these and other factors over time has influenced size and number, volume, and composition and distribution of tree species on State Forest lands. An understanding of trends in these characteristics is helpful in fully appreciating Indiana’s State Forest resource and in making wise decisions about its future.

Generally, as forest stands mature and trees become larger, the number of trees per acre decreases. This is due, in part, to natural selection. All trees compete for water, nutrients from the soil, and sunlight. Sunlight is used in photosynthesis to turn these nutrients into food for the tree to grow. Growth rates of individual trees differ as they compete for these soil nutrients and sunlight. Some may be impeded by insects or diseases. Some may become damaged, which could inhibit their growth. Naturally, as the forest ages, some individuals will fall behind and succumb to the healthier/stronger individual trees. Because of this, the decrease in the number of trees stated above is expected as stands mature.

Likewise, as forest stands mature and trees become larger, stand volume increases. As an example, let’s assume two different trees each grow 4 inches in diameter in a given amount of time. They both contain a 16’ merchantable log. One tree started at 12” d.b.h. (29 bdft Doyle) but now is 16” d.b.h. (72 bdft Doyle) so it gained 43 bf of volume. The second tree started at 22” d.b.h. (174 bdft Doyle) and is now 26” d.b.h. (266 bdft Doyle); therefore, it gained 92 bf of volume. Both grew 4 inches in diameter, but the larger tree added much more volume than the smaller tree. This helps explain the following bullet points concerning volume comparisons between 1986 and 2014:

- The net volume in live trees ≥ 5 ” d.b.h. in 1986 was estimated to be 182,462,163 cubic feet (ft^3) which was 1,601 ft^3/acre . In comparison, in 2014, this volume had grown to 294,015,056 ft^3 or 2,517 ft^3/acre ...a 61% increase (Table 1).
- Looking at net volume of sawtimber trees (trees ≥ 11 ” d.b.h., in board feet (bdft) International $\frac{1}{4}$ inch rule, it was 647,907,615 bdft or 5,686 bdft/acre in 1986. In 2014, this too had grown to 1,170,094,081 bdft or 10,015 bdft/acre. This is an 80.6% increase (Table 1).
- Most in Indiana use the Doyle rule instead of International $\frac{1}{4}$ inch rule. Using Doyle rule, the net volume of sawtimber trees was 390,944,563 bdft or 3,431 bdft/acre. In 2014, this estimate had grown to 795,383,864 bdft or 6,808 bdft/acre, increasing 103.5% in that time period (Table 1).

Average annual net growth of trees between this time period (1986-2014) was 3,790,688 ft³ or 32 ft³/acre/year. Annual mortality in this same time period was 2,861,565 ft³ or 24 ft³/acre/year (Table 1).

FURTHER DISCUSSION

On the surface, all of this may seem to be good news. When we look at the details perhaps there is a different story to be told. Along with general forest dynamics of fewer trees with greater volume as stands mature, succession occurs without disturbance. Forest succession is the replacement of one tree community by another and occurs in slow integrating stages without major disturbances.

In Indiana forests, this can be defined as early successional stands such as cherry-ash-poplar transitioning into what we currently have as oak-hickory, and then ultimately into shade-tolerant beech-maple forest types. Without major natural disturbances such as wind events and fire, or man-mimicked disturbances through forest management techniques such as harvesting or prescribed fire, this natural trajectory is expected.

The transition from oak-hickory to beech-maple can be inferred if you look at the details of the data. We used cubic foot volume (trees 5 inches and greater) in the following graphs, but the sawlog volume (trees 11 inches and greater) show similar trends. Figure 2 shows Indiana's state forests overall are maturing; trees are becoming larger, and more voluminous.

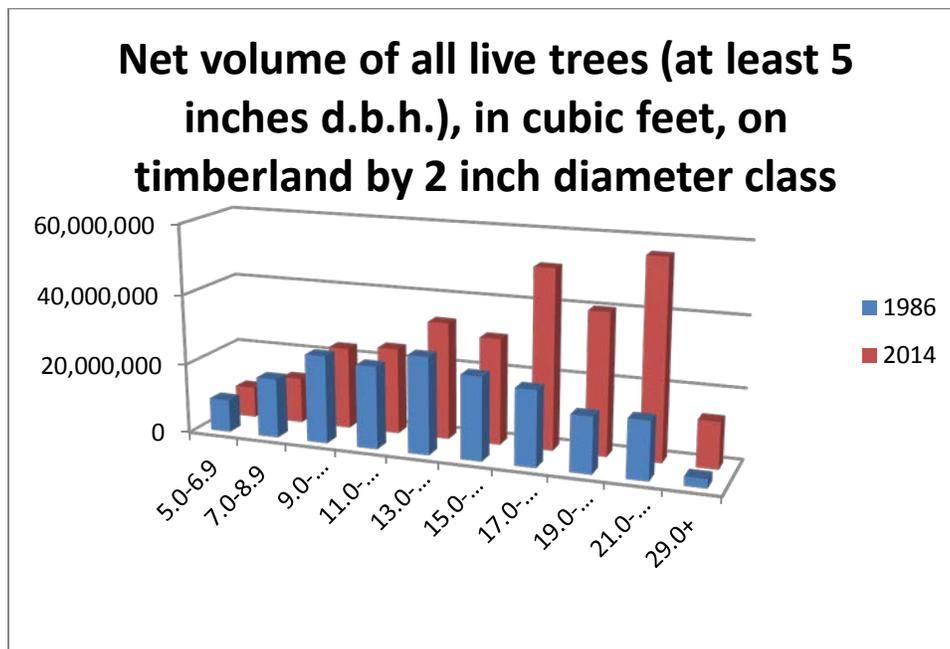
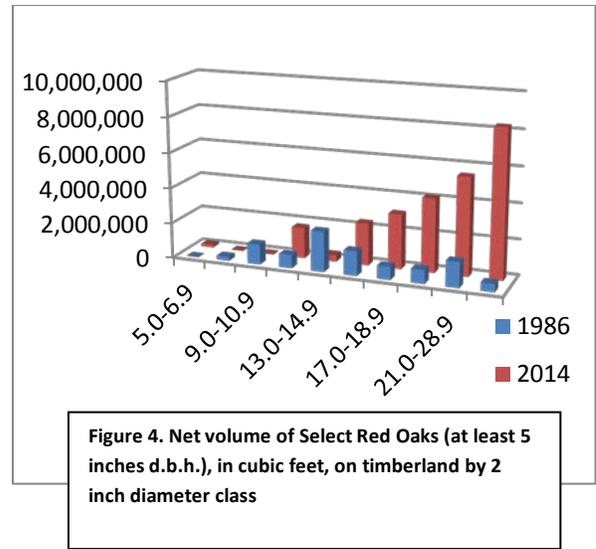
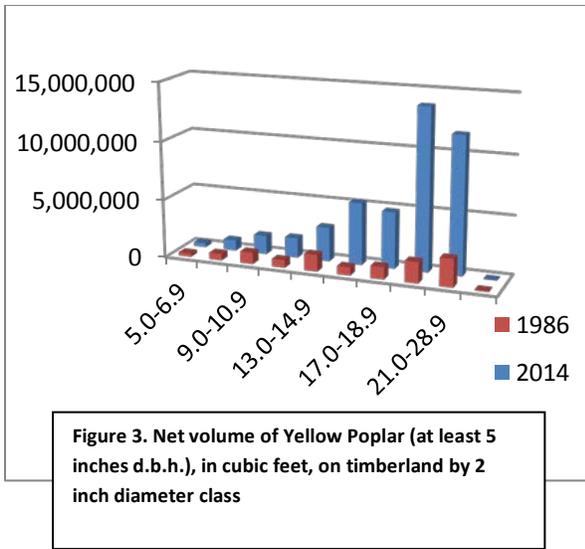
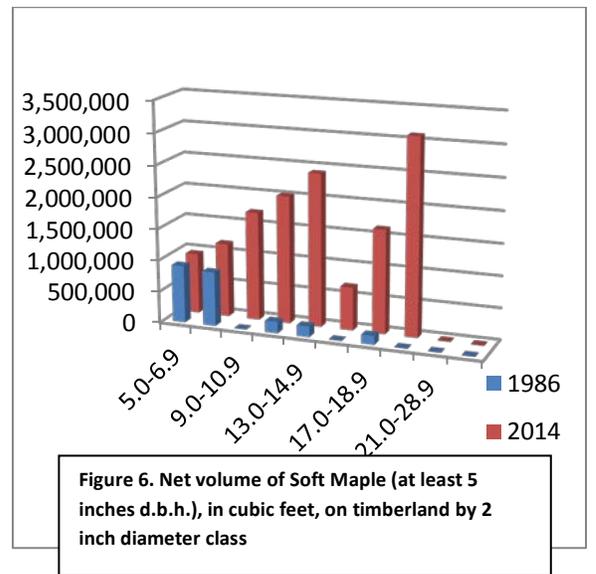
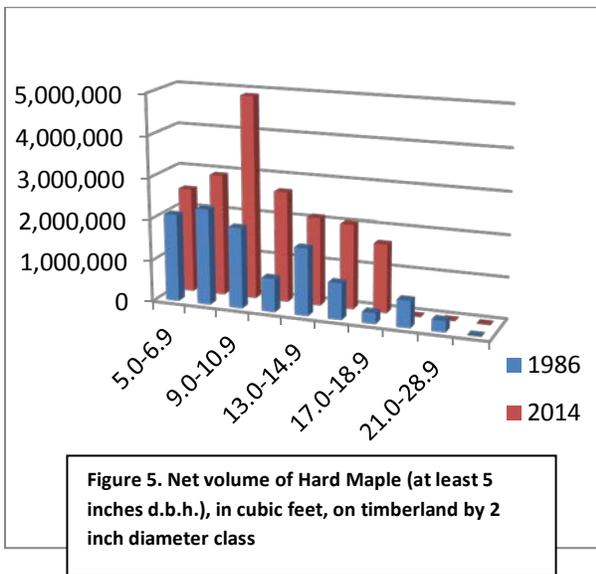


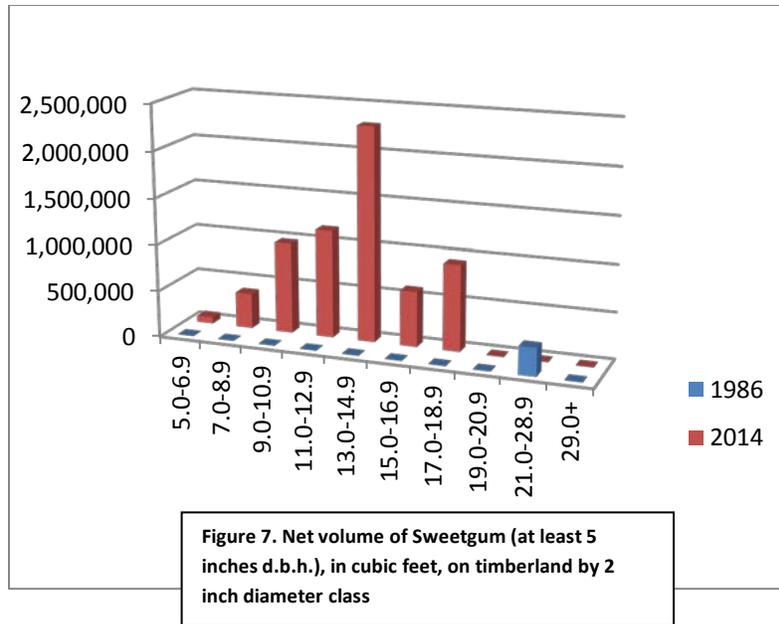
Figure 2.

When we study what individual species are doing we can see successional traits occurring. Figures 3 and 4 show Yellow Poplar and Red Oak...early to mid-successional species showing diameters getting larger and volumes increasing at very high rates.



Figures 5, 6, and 7 show hard and soft maple and sweetgum...climactic species showing much growth in the smaller diameter classes and therefore “ready to take over” as the oaks give way.





CONCLUSION

The continued shift to larger trees and the increase in area of sawtimber-size stands indicates that Indiana state forests are maturing. Increases in tree size have also brought about an overall improvement in stocking levels and contributed to Indiana's economy by supporting the timber products industry and presented opportunities for forest management. Managing these stands can keep them growing optimally.

But these stands are at a key turning point in time. Without manipulative intervention through forest management practices or major natural disturbances, these forests are primed to turn from our traditional oak-hickory forest types into the shade-tolerant beech-maple species mix. Forests are maturing, and through the process of forest succession, shifting to different forest types in many places throughout Indiana and the entire Central Hardwood region (Abrams 2003, Aldrich et al. 2005, Schmidt et al. 2000, Woodall et al. 2005). As maturing oaks and hickories die, they often are replaced by other competing species, such as sugar maple and yellow-poplar, rather than young oaks or hickories. Driving these shifts are significant reductions or even failures in oak/hickory regeneration (Aldrich et al. 2005, Gormanson et al. 2016, IN DNR 2008, Lorimer 1993, Woodall et al. 2005). If the perpetuation of the oak/hickory forest type is a primary goal for the state forests of Indiana, natural resource managers will need new management strategies and practices to change the current trends, which could take decades to alter.

TABLES

Table 1.—Indiana State Forest summary statistics, change between 1986 and 2014 on circa 1986 lands

Timberland	1986 estimate	Sampling error (percent)	2014 estimate	Sampling error (percent)	Percent change since 1986
Area (acres)	113,952	13.01	116,829	12.66	2.5%
Number of live trees ≥ 1 in diameter	55,512,287	15.01	45,130,094	16.15	-18.7%
Number of standing-dead trees (at least 5 inches d.b.h./d.r.c.), on timberland	2,447,270	23.95	1,311,650	22.65	-86.6%
Net volume live trees ≥ 5 in diameter (ft ³ /yr)	182,462,163	14.35	294,015,056	15	61.1%
Net volume of sawtimber trees, in board feet (International 1/4-inch rule), on timberland	647,907,615	15.35	1,170,094,081	15.54	80.6%
Net volume of sawtimber trees, in board feet (Doyle rule), on timberland	390,944,563	15.35	795,383,864	15.54	103.5%
Aboveground dry weight of live trees (at least 1 inch d.b.h./d.r.c.), in short tons, on timberland	5,208,626	14.16	7,608,341	14.39	46.1%
Average annual net growth of growing-stock trees (at least 5 inches d.b.h.), in cubic feet, on timberland	--	--	3,790,688	36.49	--
Annual mortality of growing-stock trees ≥ 5 in (ft ³ /yr)	--	--	2,861,565	39.5	--

Per acre estimates	1986 estimate	2014 estimate	Percent change since 1986
Number of live trees ≥ 1 in diameter	487	386	-20.7%
Number of standing-dead trees (at least 5 inches d.b.h./d.r.c.) on timberland	21	11	-47.7%
Net volume live trees ≥ 5 in diameter (ft ³ /yr)	1,601	2,517	57.2%
Net volume of sawtimber trees, in board feet (International 1/4-inch rule), on timberland	5,686	10,015	76.1%
Net volume of sawtimber trees, in board feet (Doyle rule), on timberland	3,431	6,808	98.4%
Aboveground dry weight of live trees (at least 1 inch d.b.h./d.r.c.), in short tons, on timberland	46	65	42.5%
Net growth of growing-stock trees ≥ 5 in (ft ³ /yr)	--	32	
Annual mortality of growing-stock trees ≥ 5 in (ft ³ /yr)	--	24	

Total Land and Water area in 1986	139,077	139,077
Percent Timberland	81.9%	84.0%
Number of plots used for estimate	56	41

Table 2. Net volume of live trees (at least 5 inches d.b.h.), in cubic feet, on timberland

Species Group	Year	Total	5.0-6.9	7.0-8.9	9.0-10.9	11.0-12.9	13.0-14.9	15.0-16.9	17.0-18.9	19.0-20.9	21.0-28.9	29.0+
Total	1986	182,462,163	9,306,522	16,936,627	25,011,439	23,457,667	27,629,963	23,687,107	21,524,030	15,904,472	16,432,703	2,571,633
	2014	294,015,056	8,847,283	12,991,136	23,343,349	24,585,560	33,366,784	30,185,448	51,018,516	40,261,268	56,205,231	13,210,482
Loblolly and shortleaf pine	1986	667,985	93,806	427,649	45,437	48,773	52,320	-	-	-	-	-
	2014	1,157,397	-	-	473,295	245,005	439,097	-	-	-	-	-
Other yellow pines	1986	7,732,407	944,339	479,725	1,991,743	2,153,789	1,645,061	517,751	-	-	-	-
	2014	9,801,584	27,855	313,992	966,742	1,211,557	3,224,924	2,133,419	893,135	1,029,959	-	-
Eastern white and red pine	1986	3,548,928	197,261	779,572	798,185	308,396	1,465,514	-	-	-	-	-
	2014	2,171,725	390,490	707,593	873,256	200,386	-	-	-	-	-	-
Jack pine	1986	1,323,761	54,378	326,124	505,767	275,634	-	161,859	-	-	-	-
	2014											
Other eastern softwoods	1986	1,324,579	-	117,002	282,607	494,213	-	-	430,756	-	-	-
	2014	5,231,762	252,538	423,960	148,138	479,543	1,151,704	-	791,322	-	1,984,557	-
Select white oaks	1986	42,873,654	231,484	2,932,571	5,448,820	5,488,190	6,602,521	8,591,617	4,635,971	4,283,558	3,822,219	836,703
	2014	43,812,503	401,173	1,157,329	1,212,672	4,168,943	3,899,049	5,144,333	10,725,771	5,258,776	9,634,722	2,209,734
Select red oaks	1986	9,150,397	-	222,928	1,146,460	749,446	2,267,615	1,372,566	730,278	776,579	1,425,651	458,874
	2014	25,691,656	154,240	-	-	1,738,122	376,140	2,375,371	3,086,438	4,153,596	5,505,175	8,302,574
Other white oaks	1986	21,836,171	96,262	1,145,705	1,864,081	3,417,918	4,651,654	3,648,666	3,651,252	2,131,280	1,229,352	-
	2014	14,927,233	213,350	241,860	746,768	2,231,761	1,324,620	2,459,657	3,691,022	-	4,018,194	-
Other red oaks	1986	27,079,678	323,262	587,353	1,855,349	3,029,139	2,882,720	5,460,676	5,483,422	3,674,001	3,431,927	351,828
	2014	29,899,566	131,337	445,064	-	822,176	1,183,410	486,192	10,763,392	5,076,138	10,991,857	-
Hickory	1986	10,202,777	763,528	876,512	2,556,857	2,167,680	1,436,124	661,689	1,073,880	253,070	413,437	-
	2014	21,656,270	610,786	505,721	2,057,829	852,145	5,411,174	4,109,691	4,181,392	1,056,077	2,871,457	-
Hard maple	1986	10,827,102	2,096,593	2,302,484	1,946,729	806,024	1,624,165	875,546	259,130	646,191	270,240	-
	2014	18,804,962	2,520,133	2,924,248	4,886,303	2,661,741	2,117,190	2,042,185	1,653,162	-	-	-
Soft maple	1986	2,244,464	906,566	856,253	-	179,676	164,442	-	137,527	-	-	-
	2014	13,700,022	957,164	1,168,377	1,715,744	2,019,555	2,417,371	682,376	1,637,965	3,101,469	-	-
Beech	1986	5,944,459	167,145	361,229	-	274,470	565,102	225,829	1,333,906	597,324	1,549,739	869,716
	2014	9,435,716	536,794	634,070	490,864	214,246	-	571,519	-	2,752,114	1,537,934	2,698,174
Sweetgum	1986	300,610	-	-	-	-	-	-	-	-	300,610	-
	2014	6,401,233	69,104	380,538	976,211	1,157,704	2,294,525	595,599	927,550	-	-	-
Tupelo and blackgum	1986	538,127	-	204,978	-	169,928	163,221	-	-	-	-	-
	2014	2,405,701	625,468	149,924	906,817	-	723,492	-	-	-	-	-
Ash	1986	6,684,889	307,680	599,881	1,462,954	792,215	1,259,625	477,357	1,105,721	402,584	276,870	-
	2014	10,749,088	614,757	1,006,030	1,586,854	760,235	407,219	1,180,052	1,617,138	2,091,623	1,485,181	-
Cottonwood and aspen	1986	1,766,565	207,936	372,270	657,405	270,700	258,254	-	-	-	-	-
	2014	6,190,988	-	-	181,950	583,402	461,039	-	2,502,104	-	2,462,493	-
Basswood	1986	876,080	-	-	-	-	-	181,435	-	329,307	365,338	-
	2014	268,373	-	-	-	268,373	-	-	-	-	-	-
Yellow poplar	1986	9,912,913	288,366	564,047	990,761	660,241	1,425,307	696,924	1,051,498	1,799,925	2,381,332	54,512
	2014	43,093,953	348,575	896,066	1,613,055	1,704,380	2,918,441	5,304,085	4,815,049	13,792,166	11,702,136	-

Black walnut	1986	1,241,303	-	139,444	311,184	342,458	-	186,149	-	105,511	156,557	-
	2014	721,800	-	-	142,478	-	-	579,322	-	-	-	-
Other eastern soft hardwoods	1986	14,896,345	2,277,088	2,966,348	3,005,980	1,571,614	1,166,319	629,041	1,630,688	905,143	744,125	-
	2014	26,844,944	783,803	1,971,303	4,210,076	3,066,573	4,597,590	2,521,648	3,733,076	1,949,349	4,011,526	-
Other eastern hard hardwoods	1986	1,423,661	350,829	674,552	141,120	257,161	-	-	-	-	-	-
	2014	958,660	119,795	65,060	154,295	199,712	419,798	-	-	-	-	-
Eastern noncommercial hardwoods	1986	65,308	-	-	-	-	-	-	-	-	65,308	-
	2014	89,920	89,920	-	-	-	-	-	-	-	-	-

Table 3. Net volume of sawtimber trees, in board feet (Doyle rule), on timberland

Species Group	Year	Total	9.0-10.9	11.0-12.9	13.0-14.9	15.0-16.9	17.0-18.9	19.0-20.9	21.0-28.9	29.0+
Total	1986	390,944,563	6,273,451	47,173,596	71,671,336	71,419,401	70,559,656	55,657,485	59,999,772	8,189,865
	2014	795,383,864	3,115,041	46,801,580	76,917,721	88,800,864	163,788,911	137,689,329	228,969,326	49,301,092
Loblolly and shortleaf pine	1986	385,668	80,981	127,498	177,189	0	0	0	0	0
	2014	2,744,269	798,815	586,217	1,359,237	0	0	0	0	0
Other yellow pines	1986	16,798,445	3,549,920	5,630,266	5,571,221	2,047,038	0	0	0	0
	2014	30,376,472	1,615,590	2,871,418	9,729,690	7,689,025	3,649,063	4,821,687	0	0
Eastern white and red pine	1986	7,191,829	1,422,623	806,189	4,963,018	0	0	0	0	0
	2014	1,992,568	1,499,452	493,116	0	0	0	0	0	0
Jack pine	1986	2,261,915	901,419	720,539	0	639,957	0	0	0	0
	2014									
Other eastern softwoods	1986	3,533,520	318,508	1,291,890	0	0	1,923,121	0	0	0
	2014	12,489,294	0	631,901	0	0	2,924,896	0	8,932,498	0
Select white oaks	1986	102,355,263		11,118,197	16,545,852	26,401,952	16,054,555	15,922,335	12,660,992	3,651,380
	2014	127,401,967		8,574,734	8,964,684	14,440,719	32,710,994	17,176,990	35,201,055	10,332,790
Select red oaks	1986	23,345,007		1,340,180	5,801,753	4,217,877	2,149,255	2,886,609	5,614,726	1,334,607
	2014	97,285,565		3,571,283	948,632	6,974,763	10,039,101	14,661,065	22,122,420	38,968,302
Other white oaks	1986	54,111,316		6,892,158	11,685,518	11,212,347	11,686,205	7,286,382	5,348,705	0
	2014	43,511,292		4,351,830	3,529,145	7,349,184	12,070,769	0	16,210,365	0
Other red oaks	1986	75,550,139		5,392,692	7,308,004	16,137,039	18,989,339	12,868,348	12,907,056	1,947,661
	2014	99,382,372		1,685,544	3,011,029	1,407,214	34,638,521	14,383,526	44,256,538	0
Hickory	1986	16,339,779		4,130,114	3,771,701	2,033,361	3,718,892	940,688	1,745,023	0
	2014	56,824,189		1,765,708	13,684,027	11,933,423	13,494,992	3,693,536	12,252,503	0
Hard maple	1986	9,119,851		1,152,092	3,822,608	2,690,529	0	1,454,623	0	0
	2014	19,004,582		5,009,674	3,000,829	5,790,415	5,203,664	0	0	0
Soft maple	1986	799,754		367,875	431,879	0	0	0	0	0
	2014	24,772,901		3,158,983	5,412,139	1,761,858	4,719,528	9,720,394	0	0
Beech	1986	14,182,215		561,963	1,072,361	693,966	4,251,097	2,220,295	4,126,315	1,256,217
	2014	15,290,060		452,856	0	1,679,016	0	6,811,097	6,347,092	0
Sweetgum	1986	1,319,497		0	0	0	0	0	1,319,497	0

	2014	11,807,048		2,179,182	5,341,156	1,590,635	2,696,075	0	0	0
Tupelo and blackgum	1986	776,585		347,917	428,668	0	0	0	0	0
	2014	1,681,575		0	1,681,575	0	0	0	0	0
Ash	1986	12,631,256		1,622,029	3,308,159	1,160,170	3,829,159	1,496,448	1,215,291	0
	2014	23,872,315		1,430,970	960,748	3,270,727	5,055,274	7,168,277	5,986,318	0
Cottonwood and aspen	1986	943,753		554,247	389,506	0	0	0	0	0
	2014	21,506,883		1,145,678	1,190,117	0	8,531,992	0	10,639,096	0
Basswood	1986	3,385,229		0	0	557,553	0	1,224,060	1,603,616	0
	2014	566,600		566,600	0	0	0	0	0	0
Yellow-poplar	1986	27,642,278		1,351,802	3,743,292	2,141,631	3,641,369	6,690,461	10,073,723	0
	2014	149,821,607		3,593,109	7,740,908	16,325,933	16,437,835	53,004,794	52,719,028	0
Black walnut	1986	1,929,203		701,153	0	572,036	0	0	656,014	0
	2014	1,674,062		0	0	1,674,062	0	0	0	0
Other eastern soft hardwoods	1986	15,992,082		2,714,815	2,650,610	913,945	4,316,663	2,667,236	2,728,814	0
	2014	54,768,785		4,934,133	10,754,178	6,913,890	11,616,208	6,247,963	14,302,414	0
Other eastern hard hardwoods	1986	349,979		349,979	0	0	0	0	0	0
	2014	1,353,726		384,862	968,864	0	0	0	0	0
Eastern noncommercial hardwoods	1986	0		0	0	0	0	0	0	0
	2014									

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