Indiana Hardwood Dieback and Mortality: Evaluation of the FHM National Technical Report 1996 - 1999

Stephen G. Krecik[1], Philip T. Marshall[1], and William D. Smith[2]

Introduction

Starting in 1996, Indiana forests were surveyed through the Forest Service's Forest Health Monitoring (FHM) program. Indiana contains a total of 144 hexagonal plots, 38 of which are fully or partially forested. An additional panel was added subsequent to establishment in order to harmonize FHM activities with the Forest Inventory and Analysis program (FIA), resulting in the inclusion of 10 additional forested plots.

The impetus for our investigation was an unpublished paper entitled "Forest Health Monitoring National Technical Report 1996 – 1999"[1]. The Technical Report related some of Indiana's hardwood dieback (Figure 1) and mortality (Figure 2) as high compared to other Eastern hardwood forests.

Both dieback and mortality are likely to be distributed unevenly across mixed hardwood forests, especially when the cause is biotic rather than climate-related (Shurtleff and Averre 1997). As a result, certain species, forest types, and geographical locations may experience greater dieback and mortality than others.

FHM design monitors national and ecosystem-level trends. The effectiveness for this data to oversee more localized forest health conditions has not yet been conclusively demonstrated..

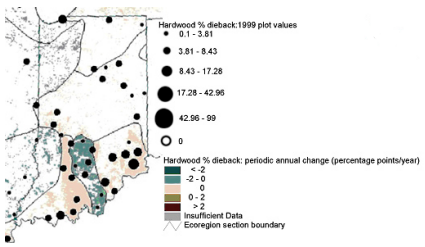


FIGURE 1: Average annual change in Indiana hardwood crown dieback, by ecosection 1996 - 1999 (Conkling, Coulston, and Ambrose, 2002).

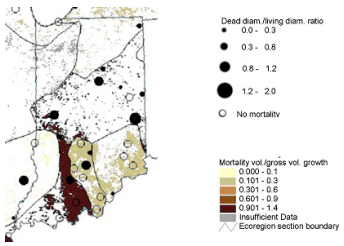
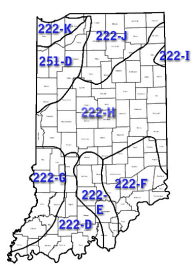


Figure 2: Indiana hardwood mortality volume to gross growth volume ratio (Conkling, Coulston, and Ambrose, 2002)[1].



Ecosection Code	Bailey's Description	Indiana Location
222D	Interior Low Plateau, Shawnee Hills Section	Limestone and other undisturbed portions of south-central and southwest Indiana
222E	Interior Low Plateau, Highland Rim Section	Shale and sandstone knobs highland section of unglaciated south-central Indiana
222F	Interior Low Plateau, Bluegrass Section	Upland flats and valleys of southeastern Indiana
222G	Central Till Plains, Oak-Hickory Section	Lower Wabash valley
222H	Central Till Plains, Beech-Maple Section	Tipton till plain; most of north-central Indiana
222I	Erie and Ontario Lake Plain Section	Lacustrine soil area of northeast Indiana, northwest of Fort Wayne; Lake Erie watershed.
222J	South Central Great Lakes Section	Glacial lakes region of northeast Indiana
222K	Southwestern Great Lakes Morainal Section	Lake Michigan area generally north and west of the Kankakee river
251D	Central Till Plains Section	Tallgrass prairie and oak savanna portion of northwest Indiana

Figure 3: Indiana ecoregion sections (ecosections) (Bailey 1995).

[1]Indiana Department of Natural Resources
Division of Forestry
P.O. Box 218
Vallonia, IN 47281

[2]USDA Forest Service
Southern Research Station
Research Triangle Park, NC

Abstract

Changes reported in the "Forest Health Monitoring National Technical Report 1996 – 1999" (Conkling, Coulston, and Ambrose 2002) suggest that some Indiana forests experienced high levels of dieback and mortality when compared with national-level data trends. To better understand these findings, Indiana FHM data was analyzed: (1) geographically, (2) by species group, and (3) by forest type. Dieback increase was insignificant across almost all species and forest types. Conversely, some species groups' dieback decreased significantly. Instances of high mortality were most common in species (such as elm) susceptible to widespread, virulent diseases. This study's short time period overstates mortality, producing high dead-to-growth volume ratios especially when large-diameter trees die. This study demonstrates strengths and limitations in applying FHM data to track forest health by species and by forest type at the local level.

Objectives

1. To determine the significance of dieback and mortality reported in the Technical Paper.
2. To examine plot-level data and determine the reasons for some plots' high dieback and mortality.
3. To analyze the effects of selected species groups and forest types on change in dieback and mortality at various geographical divisions.

Methods

•Objective 1

Indiana FHM data for 1996 - 2000 was obtained for review and analysis from the Forest Service. The data was compiled from field FHM surveys conducted during the years 1996 to 2000, in Indiana FHM plots. Additional FHM plots from adjacent states were included where they shared the same ecosection as the Indiana plots. Data was grouped and analyzed using the Generalized Least Squares (GLS) model.

•Objective 2

From the Technical Report, FHM plots with exceptional dieback (Figure 1) and mortality (Figure 2) were identified on maps. Field data records were examined with FHM survey personnel, and a descriptive analysis of factors (e.g. grazing, fire, disease) that appeared to influence dieback and mortality at each survey site.

Objective 3

FHM data was aggregated according to species of interest, forest type, and geographical considerations (Table 1). Species group and forest type data were analyzed within the geographical groupings, using Generalized Least Squares (GLS) model. Once significant relationships were identified, off-plot data (Figure 2) were employed to better understand the meaning of these findings.

Table 1: Comparisons used to analyze Indiana FHM data 1996 - 2000.

Geographic
- a. At the State level
- b. Between 9 Indiana ecosections
- c. Between 3 Indiana (N, C, S) subregions

Forest Types
- a. Forest Types encountered in Indiana FHM data
- b. Forests Groups – forest types aggregated into (1) dry upland, (2) wetter mesic, (3) drier mesic, (4) bottomland, and (5) beech-maple

Species of Interest
- a. ash
- b. white ash
- c. dogwood
- d. elm
- e. hard maple
- f. red oak
- g. white oak
- h. yellow poplar
- i. walnut
- j. other species (grouped)

Table 2: Off-plot Data used to interpret analysis of Indiana FHM data 1996 - 2000.

1. Interviews with Forest Service FHM personnel (Johnson 2002);
2. Observations from FHM survey site notes;
3. State insect and disease surveys (Marshall 2002);
4. Palmer Drought Severity Index data (NOAA 2002);
5. Long-term growth and yield data from state forest inventories (Schmidt, Hansen and Solomakos 1998).

References:

Bailey, Robert G. 1995. Descriptions of the Ecoregions of the United States (2nd ed.). Misc. pup. No. 1391. USDA Forest Service. Washington, D.C.

Johnson, D. 2002. Personal communication.

Marshall, P.T. 2002. Personal communication.

NOAA (National Oceanic and Atmospheric Administration). 2002. Palmer Drought Index / Weather Statistics by State. Washington, D.C.

Conkling, B.L., J.W. Coulston, and M. J. Ambrose. 2002. Forest Health Monitoring National Technical Report 1991-1999. Report in press.

Schmidt, T.L., M.H. Hansen, and J.A. Solomakos. 2000. Indiana's Forests in 1998. USDA Forest Service. North Central Research Station. St. Paul, MN.

Shurtleff, M.C. and C.W. Averre. 1997. The Plant Disease Clinic and Field Diagnosis of Abiotic Diseases. The American Phytopathological Society Press. St. Paul, MN.

Selected Results

1) Technical Paper Analysis, 1996 - 2000 FHM Dieback Data (Figure 1)

Baseline dieback: High initial dieback **was not** significant in any ecosections. Averages were influenced by a few high-dieback plots.

Change in dieback: The ecosection (222-F) with large (≧ 2% / yr.) **increasing dieback was not significant** ($P>t$ = 0.39). A second ecosection (222-G) with large (≧ 2% / yr.) **decreasing dieback was significant** ($P>t$ = 0.06). All other changes were insignificant and/or negligible.

2) Statewide Dieback Analysis by Species

Species in statewide dieback data: Four species groups - dogwood, elm, walnut, and red oak - all experienced significant improvements in their dieback levels.

Few observations were made for dogwood (n=18) and walnut (n=42); these species trends were affected by dramatic change in a few individual trees. Examples include: (a) large changes in "99%" dieback trees (lost apical dominance); and (b) poor condition trees removed by mortality, resulting in higher surviving cohort averages.

Figure 4: 1996 Baseline and annual dieback change in Indiana FHM for 10 selected species groups.

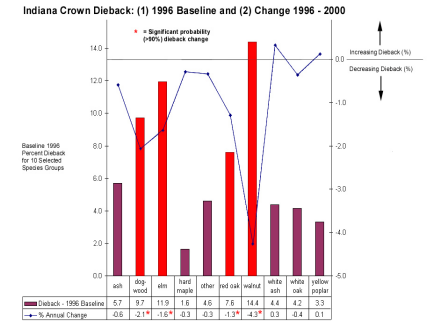


Table 3: 1996 baseline and annual dieback change in Indiana hardwoods, by selected species groups

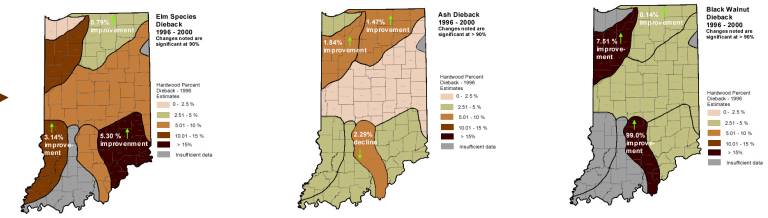
1) Annual dieback change colored blue indicated improvement; red indicates decline; '*', '**', and '***' indicate change significant at 90%, 95%, and 99% probability, respectively.
2) Means followed by letters are significantly different from other species at probability > 90%

	(a) ash	(b) dog-wood	(c) elm	(d) hard maple	(e) other spp.	(f) red oaks	(g) walnut	(h) white ash	(i) white oaks	(j) yellow-poplar
All Indiana	-0.6 g	* -2.1 hj	** -1.6 deg hj	-0.3 cg	-0.3 bcg	* -1.3 gh	*** -4.3 acd efhij	0.3 bcfg	-0.4 h	0.1 cdgh
ECOSECTION										
222-D		-1.0		-0.6	-0.2	-0.9		0.6	-0.7	-0.4
222-E	* 2.3 cef ghi	-1.2	-2.5 a	-0.7 h	-0.3 ah	-0.9 afh	**-99.0 ah	-0.7 adef gij	-0.3	-0.5
222-F			* -5.3	0.3 h	0.0	h	-0.4	2.4 df	-0.5	0.1
222-G	0.0		-3.1	0.0	-0.7	0.1		-1.9	0.2	0.2
222-H	-0.4 cg	** -4.9	-0.7 adef ghij	0.1 cg	0.0 cg	-2.0 cg	-0.9 acd efj	0.0 cg	-0.5 cg	-1.3 cg
222-I				-0.8	-0.8				-0.8	-0.8
222-J	** -1.5 i		** -0.8 i	** -0.6 i	** -1.2 i	0.5 i	* -0.1 i	0.0 i	* 5.7 acdef gh	
222-K			0.0	0.0	-1.5			0.0	0.0	
251-D			-0.4 f	-0.5 f	-0.6 f	-0.3 cdehi	*** -7.5 h	* -1.8 fg	-0.1 f	

3) Ecosections - Dieback by Species

A. Species x ecosection: annual dieback change and means comparisons - Species group dieback means were analyzed for differences. Significant differences were found between some species' dieback changes.

Figure 5 - 7: 1996 baseline and annual dieback change in Indiana elm, ash, and walnut, by ecoregions.

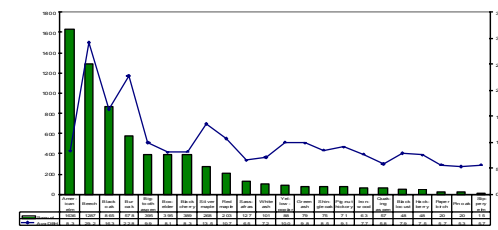


B. Mapping ecosection baseline and annual dieback by species: Baseline and annual dieback change differences were found between Indiana ecosections for several species. Species such as elm, prone to Dutch elm disease, experience much higher average dieback than other species. Ecosection averages for less common species (such as walnut) may be influenced by individual trees with extreme dieback conditions when sample size is small (e.g. ecosection 222-E in Figure 7).

4. Mortality

A total of 37 trees died during the study period, out of 1,336 observed. Some individual plots experienced nearly 1,500 ft² of dieback. Such plots experienced high volumes of dieback per unit volume of growth, resulting in high mortality ratios.

American elm experienced the greatest number (7) and volume (1,636 ft2 or 24%) of mortality, followed by black oak and big-toothed aspen (3 each); box elder, black cherry, sassafras, white ash, and quaking aspen (2 each).



Conclusions

1. Baseline and annual change in Indiana FHM foliage dieback (1996 - 2000) was significantly different between some species groups and geographic regions. Forest type comparisons were inconclusive.
2. With small sample size, trees that experience severe dieback from apical dominance loss events (typically wind or lightning damage) can distort actual FHM crown condition averages.
3. Mortality volume may exceed growth in the short run. This is generally nothing to be too concerned about.
4. In this short-term study, chronic diseases (such as ash yellows) are not overwhelmingly evident in FHM crown condition indicators, while more acute diseases (such as Dutch elm disease) are more demonstrable from FHM data.

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