

SPATIAL TRENDS IN RELATIVE STOCKING POINT TO POTENTIAL PROBLEMS IN FOREST HEALTH

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Abstract: The term "forest health" means many things to many people and we do not know how to measure it. Baseline standards for conducting a physical examination of a stand of trees do not exist. One factor that can be considered when making judgments about the health of a particular forest tree species is change in the relative stocking of that species, that is the extent to which the species is gaining or losing ground in its ecosystem. The forest survey unit at the Northeastern Forest Experiment Station is using remeasured forest inventory plot data to estimate current average annual change in the relative stocking of common forest tree species in the Northeast. Spatial shifts in the relative stocking of individual species are being mapped. The procedure can be readily extended to other species in other regions. Information on shifts in relative stocking can provide a symptomatic guide to recognizing problems of forest health, and it gives us a better understanding of the complex workings of a dynamic ecosystem.

INTRODUCTION

The health of our Nation's forests has become a major issue. Unfortunately, the term "forest health" is vague. It means many things to many people and we do not know how to measure it. Baseline standards for conducting a physical examination of a stand of trees do not exist. The Northeastern Forest Experiment Station's Forest Health Monitoring Program and other organizations are working on how to assess the dimensions of forest ecosystem health and how to analyze and report health trends.

Until clearly defined baseline standards are developed, one factor that can be considered when making judgments about the health of a particular forest tree species is change in the relative stocking of that species, that is, the extent to which the species is gaining or losing ground in its ecosystem. This we can measure with the help of forest inventory plot records.

STOCKING AS A MEASURE OF SITE OCCUPANCY

Stocking is another term that means different things to different people. In this application, it is a measure of the extent to which trees utilize a plot of forest land. Stocking is expressed as a function of the number, size, and basal area of trees. Formulae for calculating stocking levels have been developed for a number of individual species. For example, the equation we use for sugar maple is : $s = .00694(DBH)^{1.86}$, which was obtained by translating the tree-area ratio developed by Stout and Nyland (1986) to a power function of diameter. Solving this equation for one tree on an acre of forest land tells us how much that tree contributes to stocking on the acre. When a stocking formula is not available for a particular species, the formula for a species with similar characteristics of growth and competitiveness is used.

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ESTIMATING CHANGE IN RELATIVE STOCKING

Stocking equations can be applied to remeasured forest inventory plot data to estimate the average annual change in relative stocking (RS) for any tree species on any acre. The following example demonstrates the process.

	<u>Stocking (%)</u>	
	<u>1978</u>	<u>1989</u>
Sugar maple	16	18
All species	64	90

The relative stocking of sugar maple on the acre for 1978 was $16/64 = 25\%$. The relative stocking of sugar maple for 1989 was $18/90 = 20\%$. The average annual change in relative stocking for sugar maple on the acre is:

$$\begin{aligned} & [\text{RS}(1989) - \text{RS}(1978)] / \text{Years between inventories} \\ & \text{or} \\ & (20-25)/11 = -0.45\% \text{ per year} \end{aligned}$$

Note, that even though the absolute stocking of sugar maple increased on this acre, the change in its relative stocking was negative. In other words, in a relative sense, sugar maple was losing ground to other species between inventories.

The USDA Forest Service updates timber-resource information statewide approximately every 10 years. For land that remains in forest, remeasured plot records provide a history of change in the inventory of all live trees 5 inches and larger in d.b.h. By design, each inventory plot represents a proportional share of the forest area in a state; so, appropriate weights can be assigned to plot data to derive statewide and regional averages of current annual change in relative stocking for individual species. We applied this procedure to Kentucky, Maryland, Ohio, Pennsylvania, and West Virginia where a network of approximately 6,000 permanent inventory plots were remeasured during the most recent inventories in each state (Alerich 1990, Frieswyk and DiGiovanni 1988, Griffith et al. 1993, Alerich 1993, and DiGiovanni 1990).

OVERALL STOCKING IS UP

At the time of the most recent forest inventories, the stocking of all live trees 5.0 inches d.b.h. and larger per acre of forest land averaged about 59 percent in the five-state area (Table 1). At the time of previous inventories, stocking averaged only 51 percent. Obviously, growth on original trees plus ingrowth of new trees into the 5.0-inch size class more than offset losses to cutting and mortality between inventories. Stocking has increased an average of at least one percent per year in each of the five states.

Table 1. Change in stocking between inventories, by state.

State	Average Stocking		Change(%)
	Previous	Most Recent	
	-----Percent-----		
Kentucky	44.4	52.2	7.8 (18)
Maryland	54.2	59.5	5.3 (10)
Ohio	43.0	52.3	9.3 (21)
Pennsylvania	57.3	63.4	6.1 (11)
West Virginia	54.8	65.3	10.5 (19)
All States	51.3	59.3	8.0 (15)

All but a few forest inventory subunits of the five-state area recorded healthy increases in average stocking (Figure 1). One of the exceptions was south-central Pennsylvania where gypsy moth defoliation, drought, cutting, bark beetles, root rot, deer browsing, and other agents took a heavy toll on the oak resource during the 1980's. Growth of residual oaks, maple, black gum, yellow-poplar, cherry, and other species counter balanced the oak loss. But, gains in average stocking for all species combined remained minimal. On the lower Eastern Shore of Maryland, declines in the relative stocking of oak were offset by increases in loblolly pine, red maple, black gum, beech, and other hardwoods. Thus, average stocking there remained about the same.

MAPLES AND YELLOW-POPLAR GAIN WHILE BLACK LOCUST AND OAKS LOSE GROUND

Red maple is a pioneer species--a shade tolerant, prolific seeder and sprouter that can occupy a wide variety of forest sites. So, it is no wonder that red maple has recorded significant gains in relative stocking throughout the five-state area (Figures 2-7). Overall, the annual gain in relative stocking of red maple averaged 0.31 percent between inventories.

There has been much recent concern over the demise of sugar maple. Not too long ago (12/7/86) an article in the New York Times suggested that sugar maple was becoming extinct because of damage from acid rain. Such news prompted establishment of The North American Maple Project and the installation of plots to measure annual trends in the condition of this valuable hardwood species. It is too soon to draw conclusions from that study. But, our analysis indicates that, on the whole, sugar maple is doing quite well. In terms of gaining ground, it ranks right behind red maple. Substantial increases in the relative stocking of sugar maple were recorded in all five states.

Another prevalent species that made significant regional gains in relative stocking was yellow-poplar. White pine also recorded significant increases in states where it is common.

At the opposite end of the scale were black locust and the oaks (particularly chestnut, black, white, and scarlet oak). Black locust lost ground at a rate of 0.30 percent per year across the region. And why not? Forest land in this area has undergone significant increases in average tree size and density in recent years. Black locust is sensitive to competition and intolerant of shade. Under stress, it falls easy prey to locust borers, leaf miners, heart rot, and other insects and diseases.

Much of the oak decrease can be associated with gypsy moth. But oaks are also losing ground in areas where the pest is not yet a problem. Sharp declines in the relative stocking of hard pines are noteworthy. Virginia pine in Maryland, Ohio, and West Virginia; pitch pine in West Virginia and Kentucky; and shortleaf pine in Kentucky are all losing ground at significant rates (Huntley 1990).

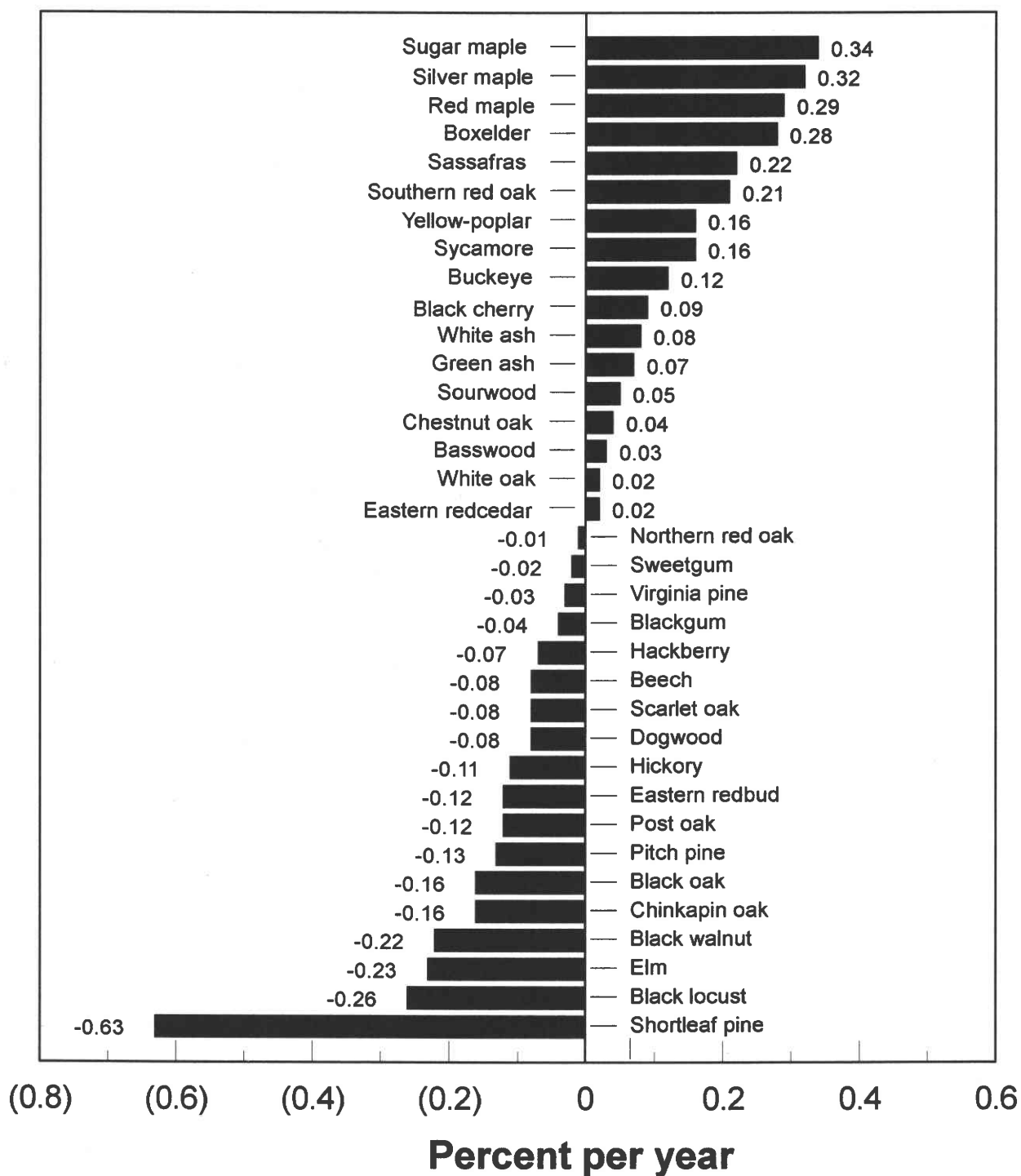


Figure 2. Average annual change in the relative stocking of some common forest tree species in Kentucky, 1975-1988.

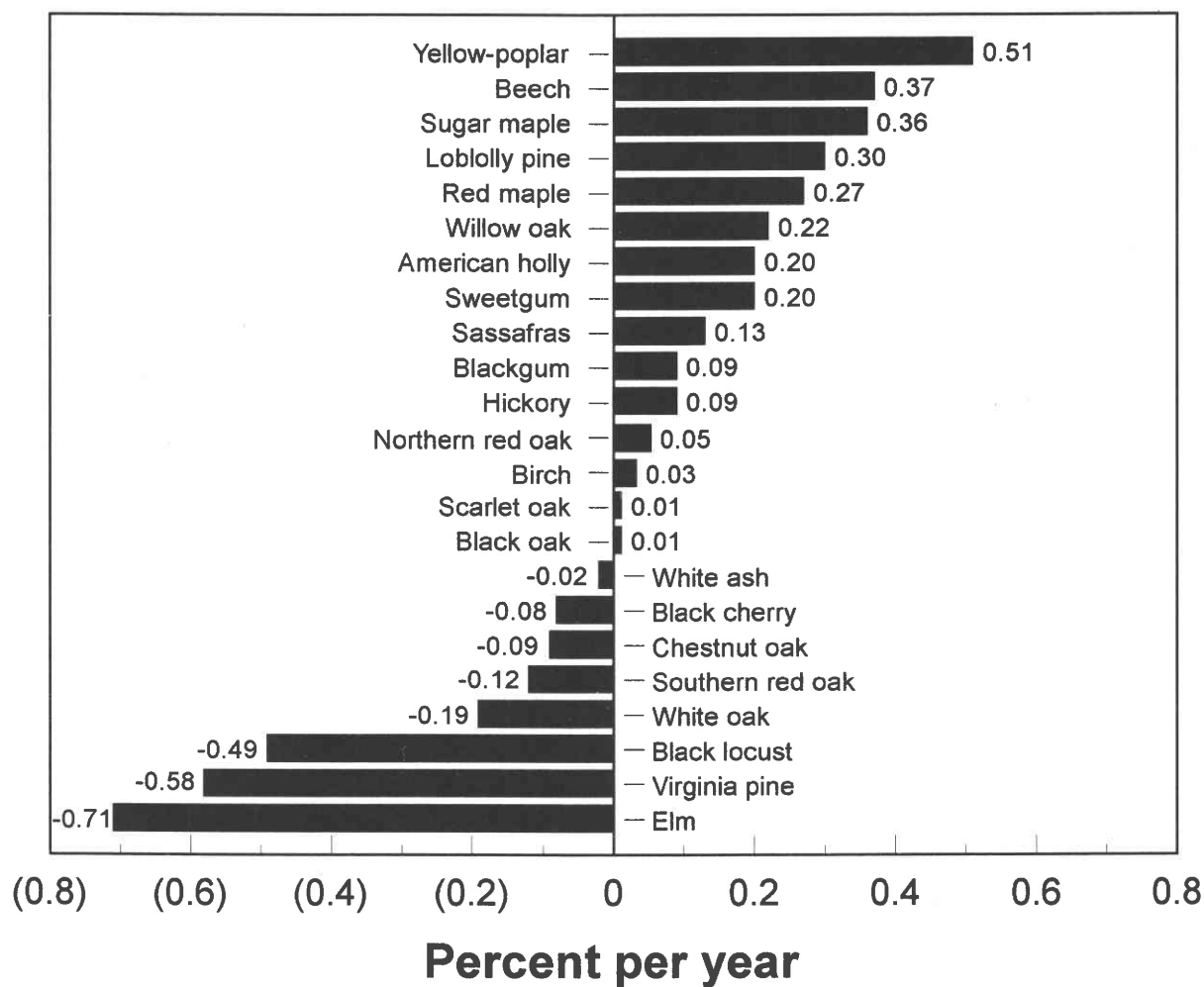


Figure 3. Average annual change in the relative stocking of some common forest tree species in Maryland, 1976-1986.

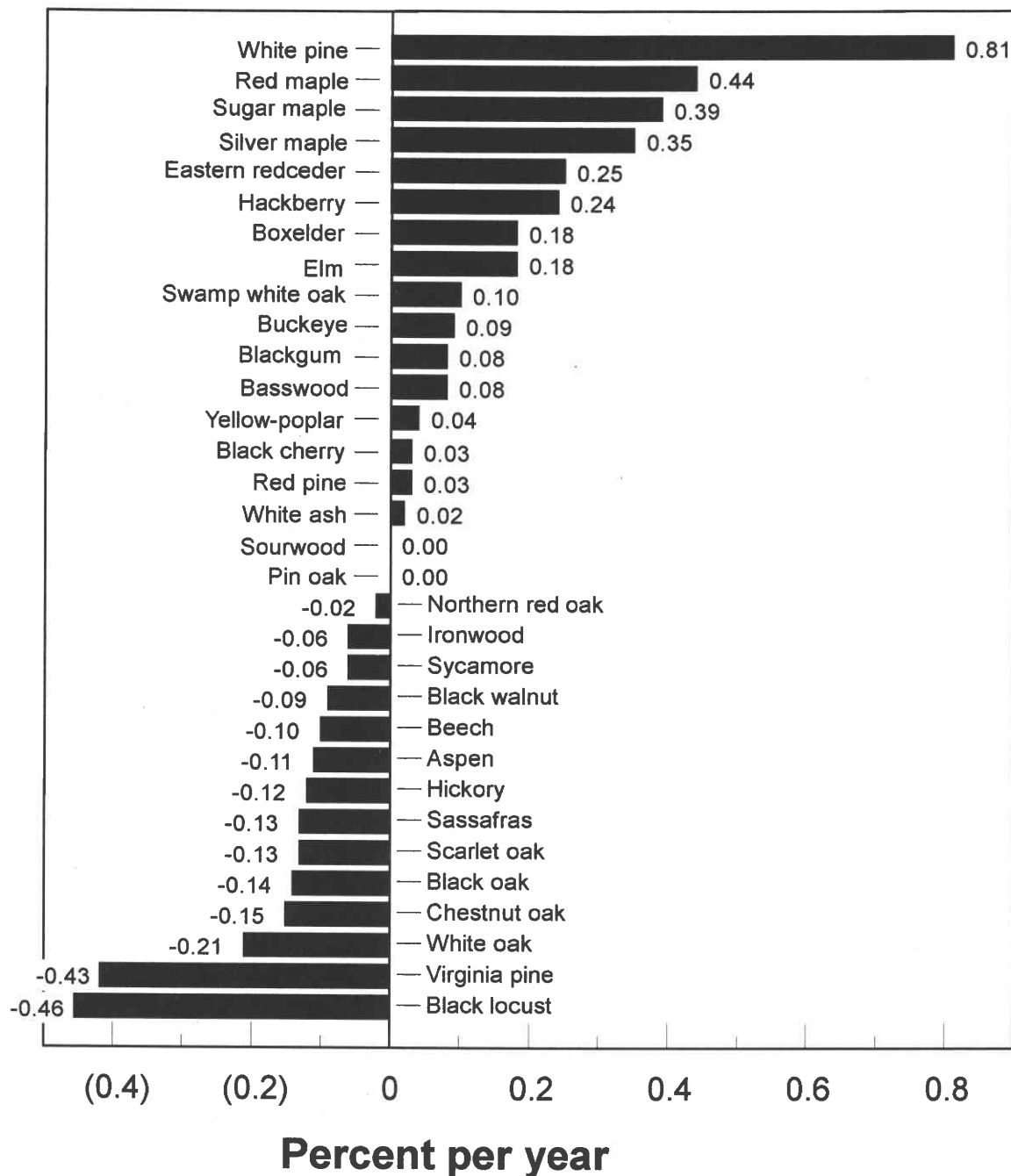


Figure 4. Average annual change in the relative stocking of some common forest tree species in Ohio, 1979-1991.

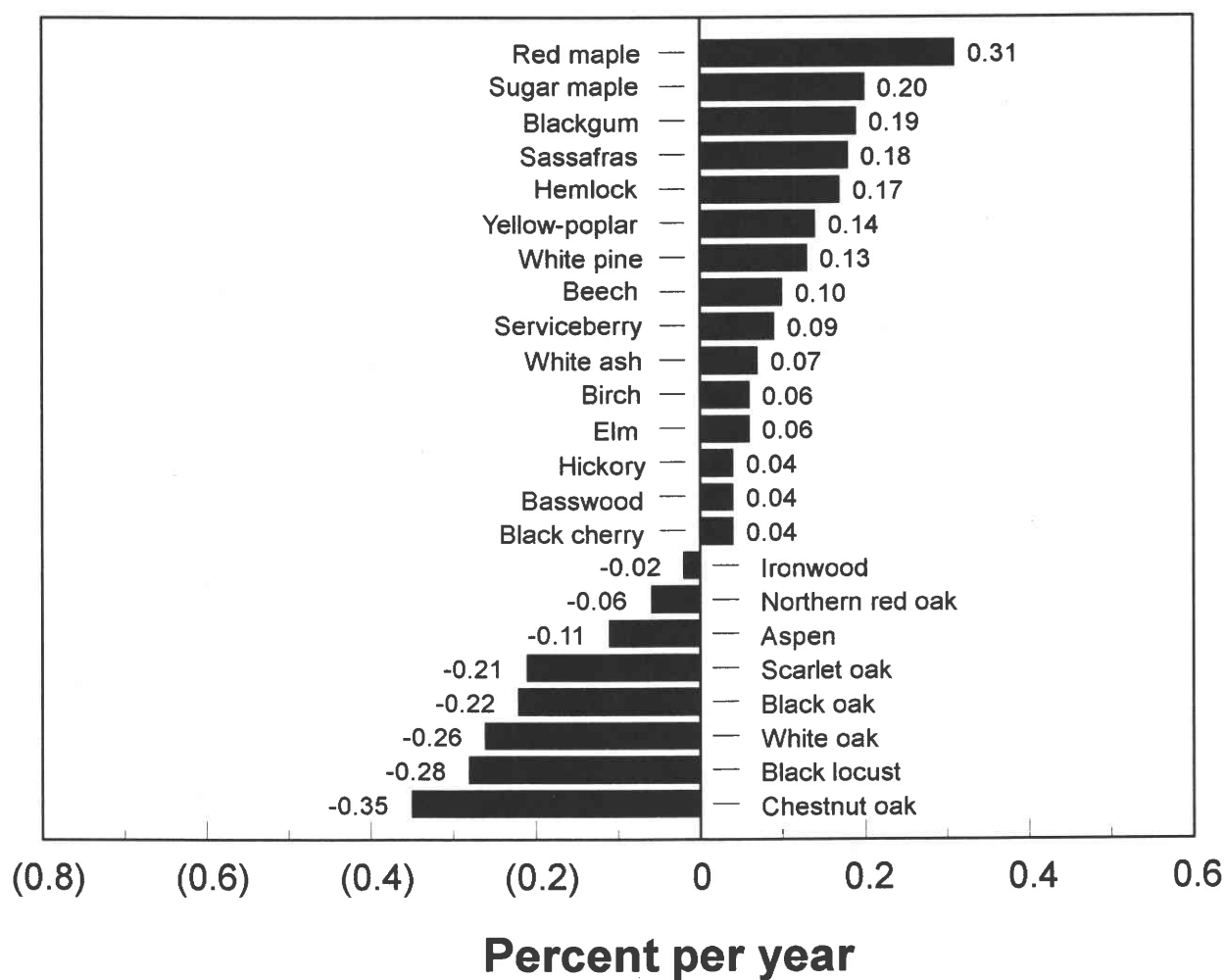


Figure 5. Average annual change in the relative stocking of some common forest tree species in Pennsylvania, 1978-1989.

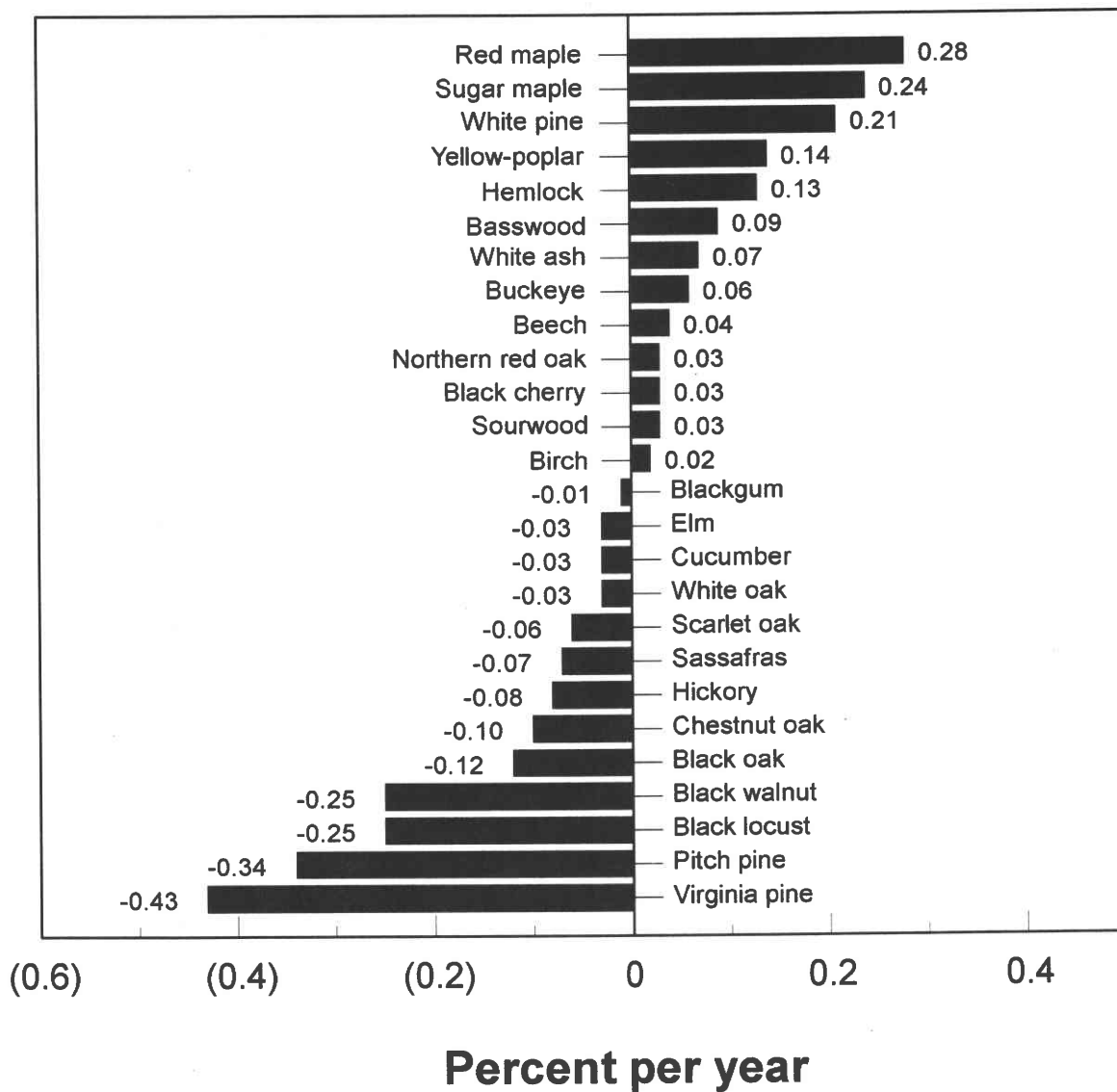


Figure 6. Average annual change in the relative stocking of some common forest tree species in West Virginia, 1975-1989.

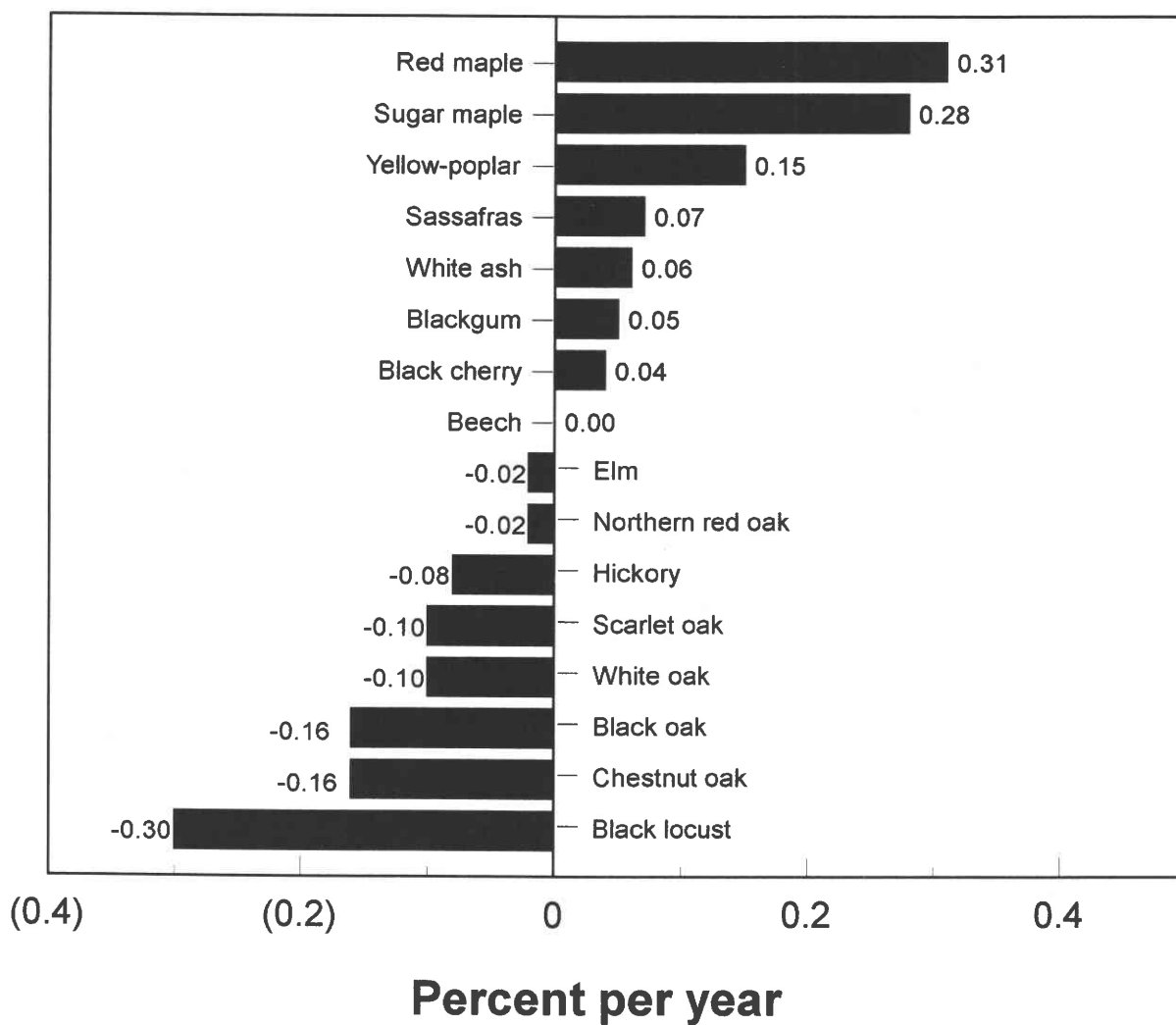


Figure 7. Average annual change in the relative stocking of forest tree species common in the five-state area.

TRACKING TRENDS AND SPOTTING PROBLEMS

Since each inventory plot represents a proportional share of the forest area in a county, appropriate weights can be assigned to plot data to derive average trends in relative stocking for individual species in each county. County averages can then be mapped to provide a closer look at where a species is gaining or losing ground. Maps showing county trends for three of the area's top gainers (red maple, sugar maple, and yellow-poplar) and three of its losers (black locust, chestnut oak, and black oak) are presented here (Figures 8-13).

Using county averages to gauge trends in relative stocking has its limitations. Some county averages, especially those for sparsely forested counties, are based on very few ground plots and may be subject to high sampling errors. Locations of individual ground plots have been digitized, so trends for each plot also can be mapped. These maps provide a more specific view of spatial shifts in relative stocking (Figures 14-15).

Together, maps showing trends for counties and individual plots can be used to detect areas where species are gaining or losing ground and, thus, help us locate potential problems in tree health. For example, figure 12 shows that chestnut oak has been losing ground in several of the region's counties. Figure 14 tells us that declines were especially noticeable in Pennsylvania where chestnut oak occurred on one-third of the remeasured plots and was losing ground on two-thirds of them. Bedford County in south-central Pennsylvania epitomizes the worst case. Here, change in the relative stocking of chestnut oak averaged -0.86 percent per year. Dead trees and stumps recorded on Bedford County plots provide clear evidence of why. For a first-hand view of the situation, take a ride on the Pennsylvania turnpike and check out the landscape around Everett, Pennsylvania. Some good news here is that most of the oak stands that were devastated by gypsy moth, drought, cutting, and other agents during the 1980's have regenerated to a more diverse mix of species such as maple, birch, cherry, ash, and yellow-poplar that are less susceptible to the gypsy moth (Gansner et al. in press).

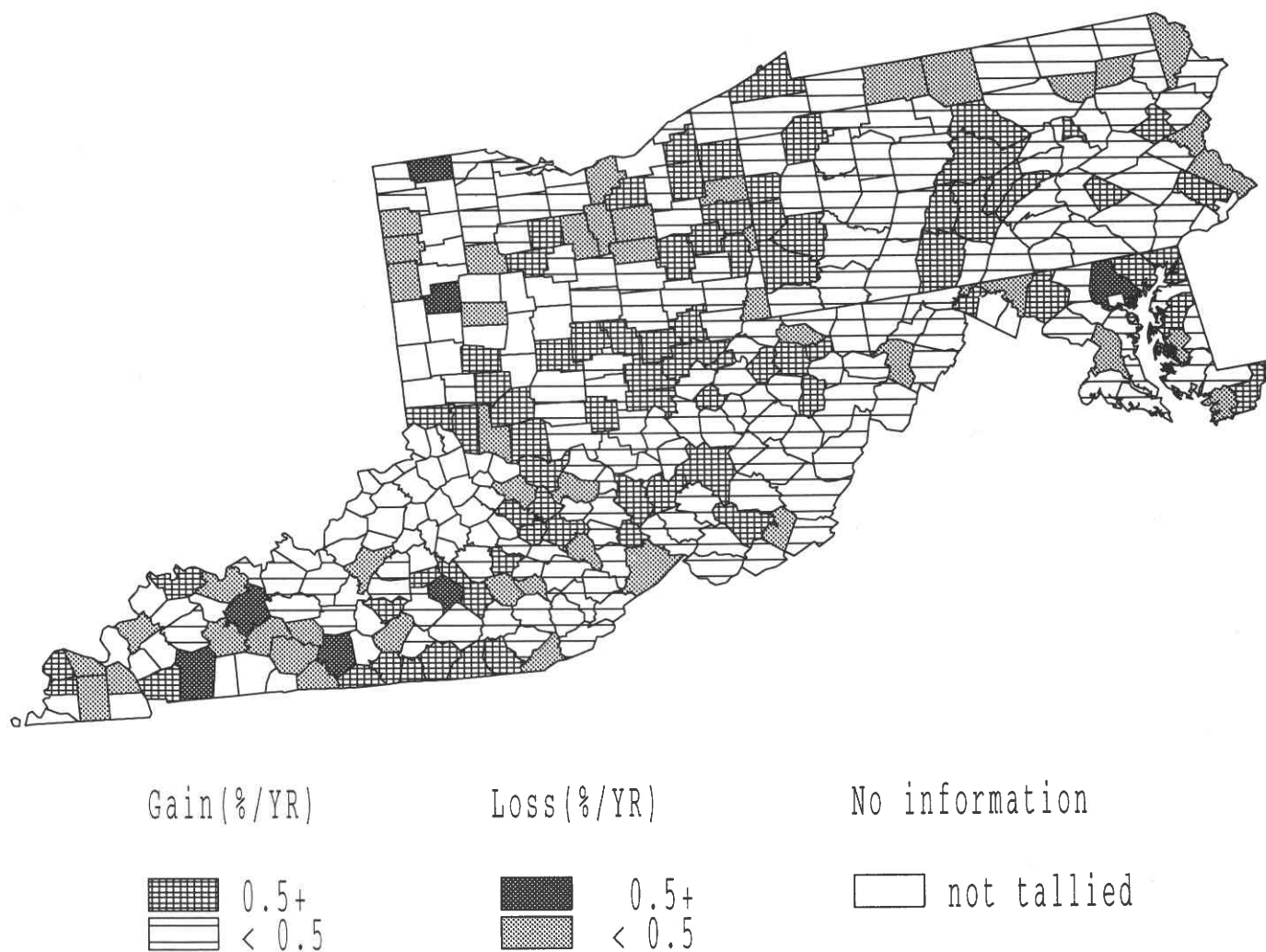
For a completely different scenario, take a look at sugar maple. Figures 9 and 15 indicate that this species recorded large gains in relative stocking in all five states. But the maps also show that while sugar maple was performing well regionwide, it was losing ground in some places such as the Allegheny Plateau in Elk, Forest, McKean, and Warren Counties, in northwestern Pennsylvania. Annual change in the relative stocking of sugar maple in these four counties averaged -0.12. The reasons for this change are not apparent.

IMPLICATIONS

The procedure used here to track shifts in relative stocking can be used for virtually any species anywhere. Results provide an extensive look at where each species is gaining or losing ground and, thus, a means for locating current and potential problems in tree health.

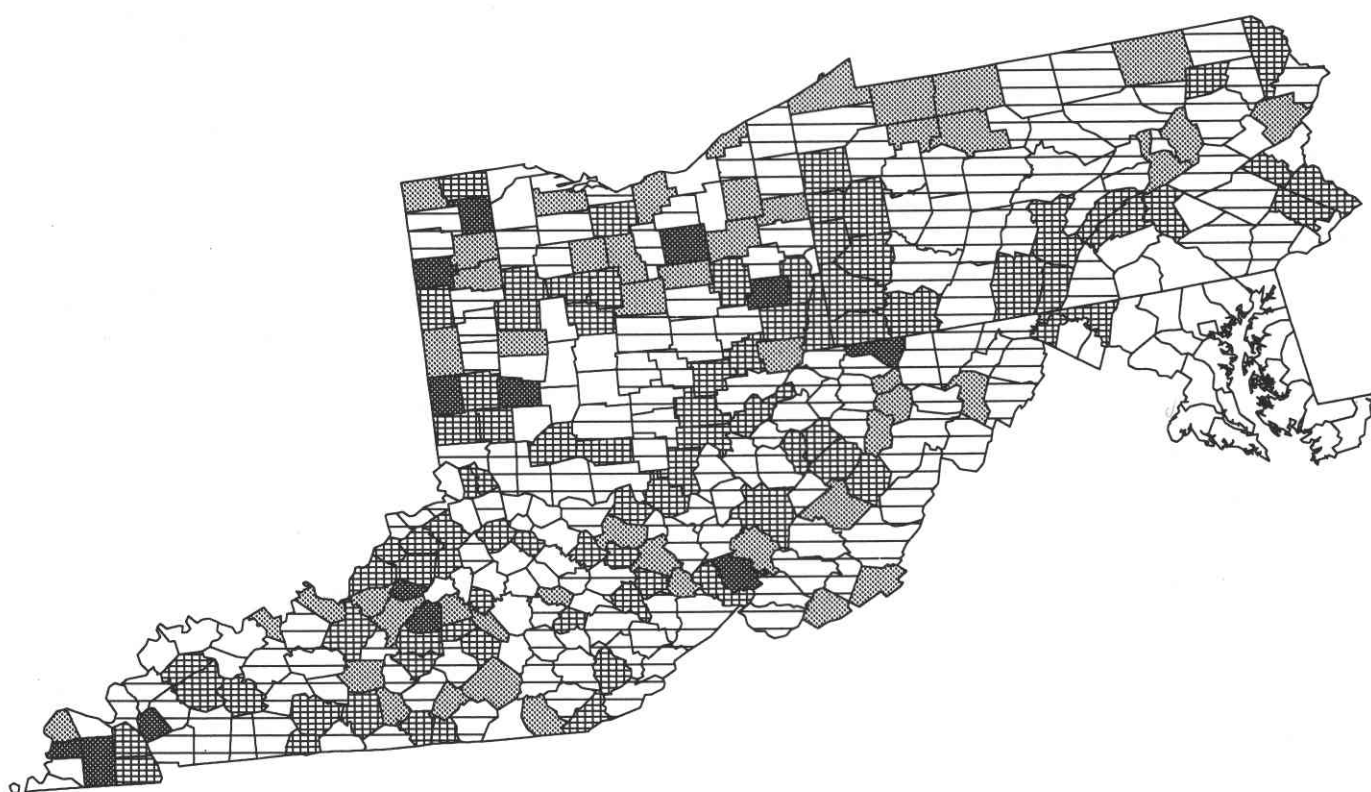
Findings of our analysis raise more questions than they answer. Will red maple continue its rapid gains in relative stocking and, if so, how will that affect the integrity of the region's forested ecosystems? Will oaks continue to lose ground or will they overcome the effects of gypsy moth and other stress that hit them hard during the last couple of decades? Why is sugar maple making significant gains regionwide but losing ground on the Allegheny Plateau of Pennsylvania--is it pear thrips, drought, overstocking, a combination of these factors, or none of the above? Many are hypothesizing that sugar maple just does not do well in dense maturing stands. Will black locust continue to disappear from the scene as overall stocking continues to improve? Is white pine on the verge of regaining the status it once held? What is happening to the hard pines? And what about hickory, especially in Kentucky, Ohio, and West Virginia?

Information on shifts in relative stocking can provide a symptomatic guide to recognizing problems of forest health. It definitely gives us a better understanding of the complex workings of a dynamic ecosystem. This information can help us make better decisions about the management and use of our precious forest resource.

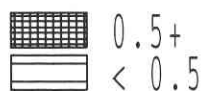


Regional average = 0.31

Figure 8. Average annual change in the relative stocking of red maple, by county.



Gain(%/YR)



Loss(%/YR)



No information

not tallied

Regional average = 0.28

Figure 9. Average annual change in the relative stocking of sugar maple, by county.

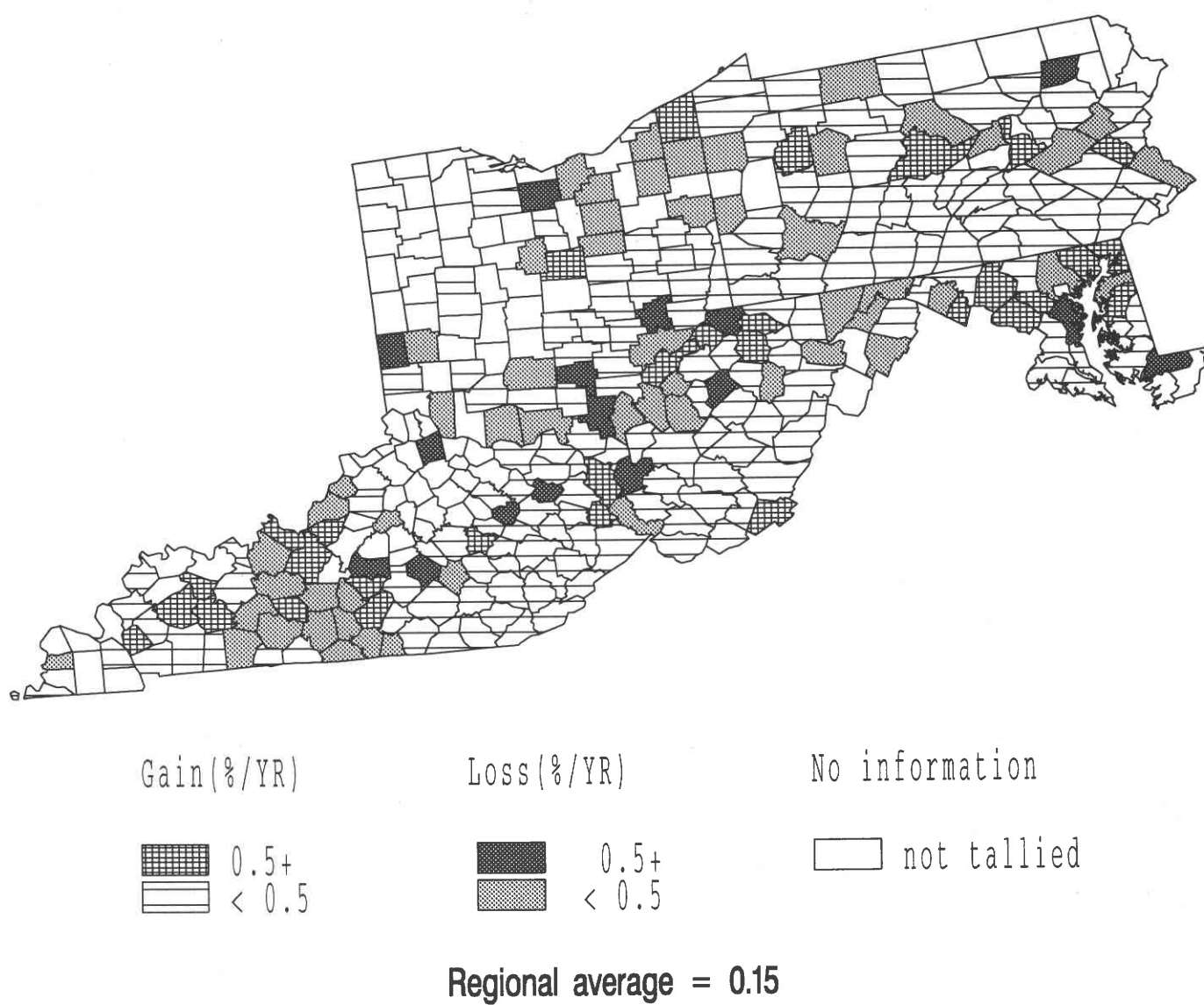
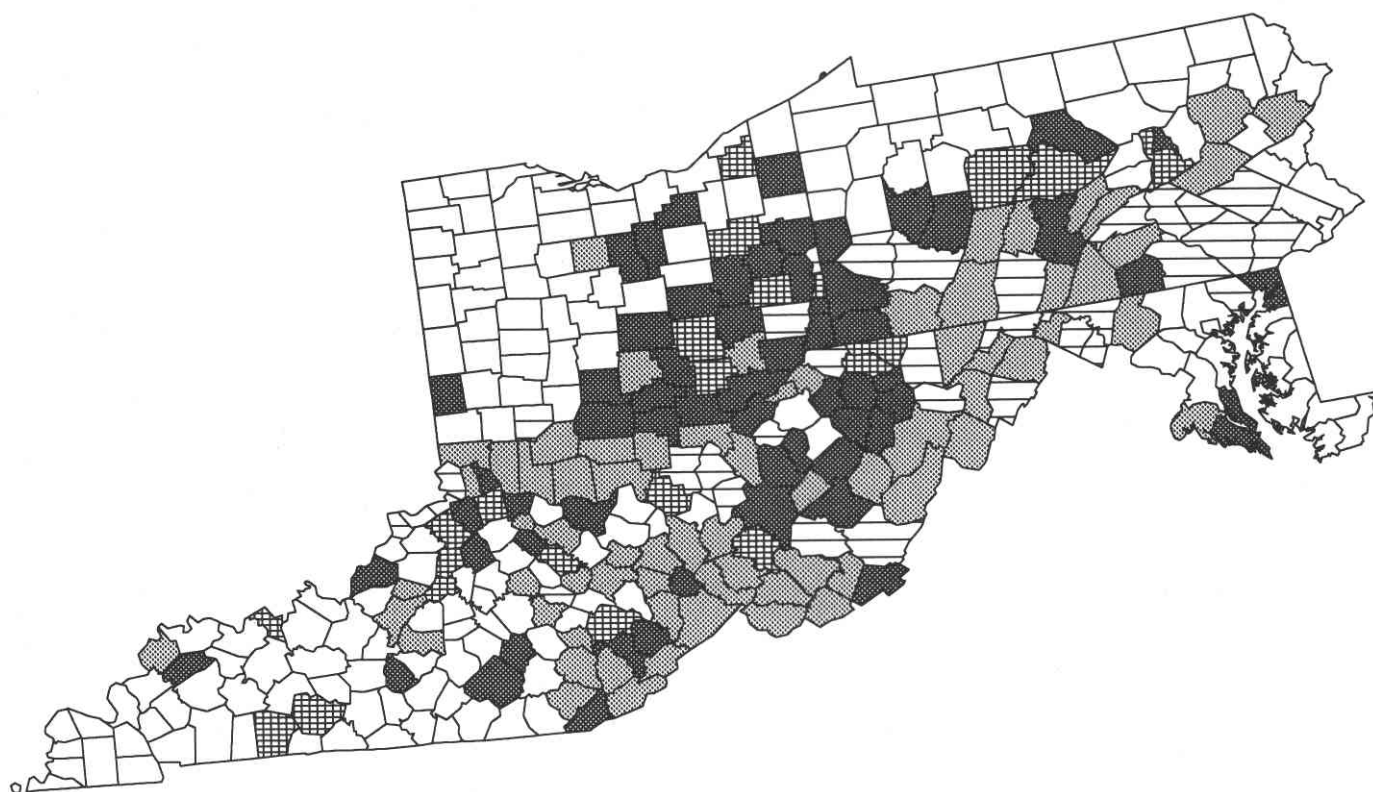


Figure 10. Average annual change in the relative stocking of yellow-poplar, by county.



Gain(%/YR)



Loss(%/YR)

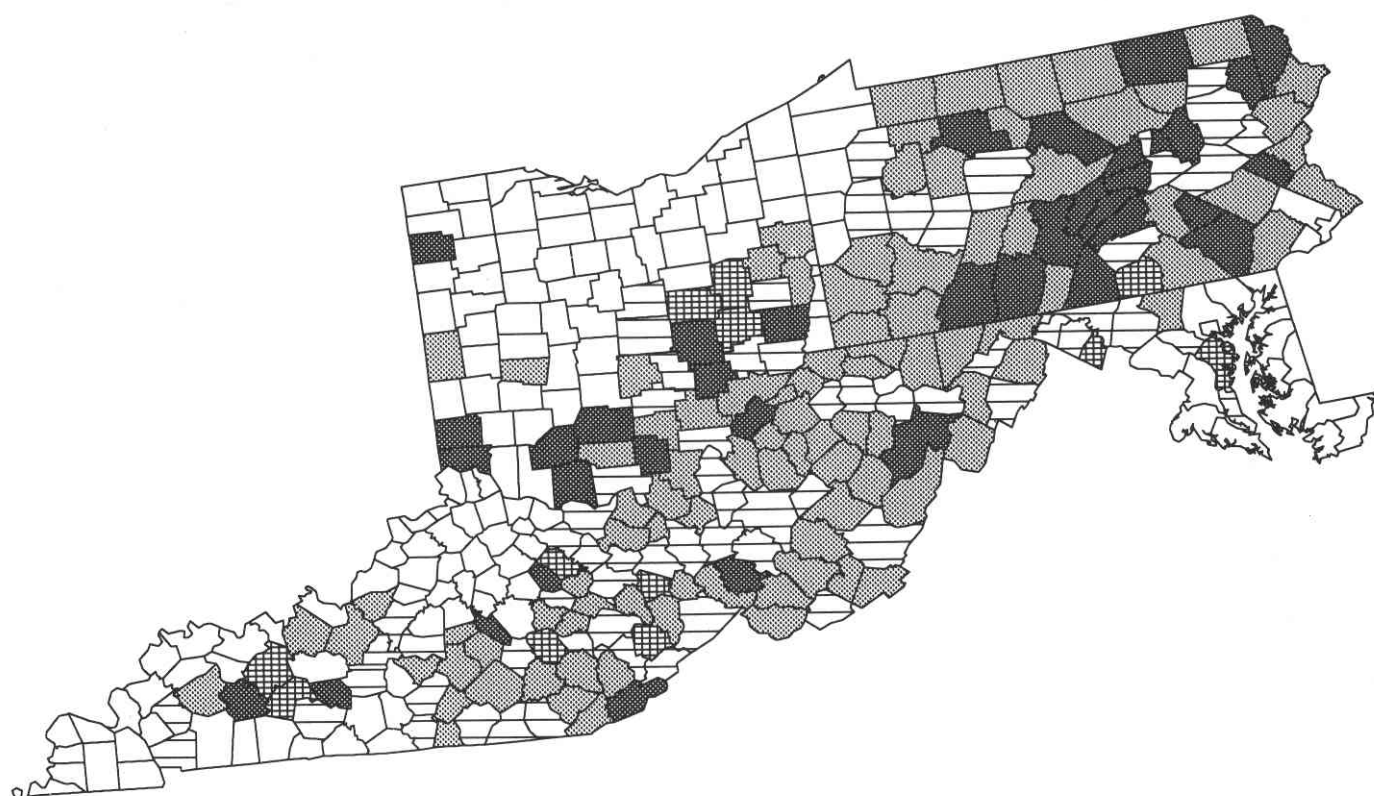


No information

not tallied

Regional average = -0.30

Figure 11. Average annual change in the relative stocking of black locust, by county.



Gain(%/YR)

 0.5+
 < 0.5

Loss(%/YR)

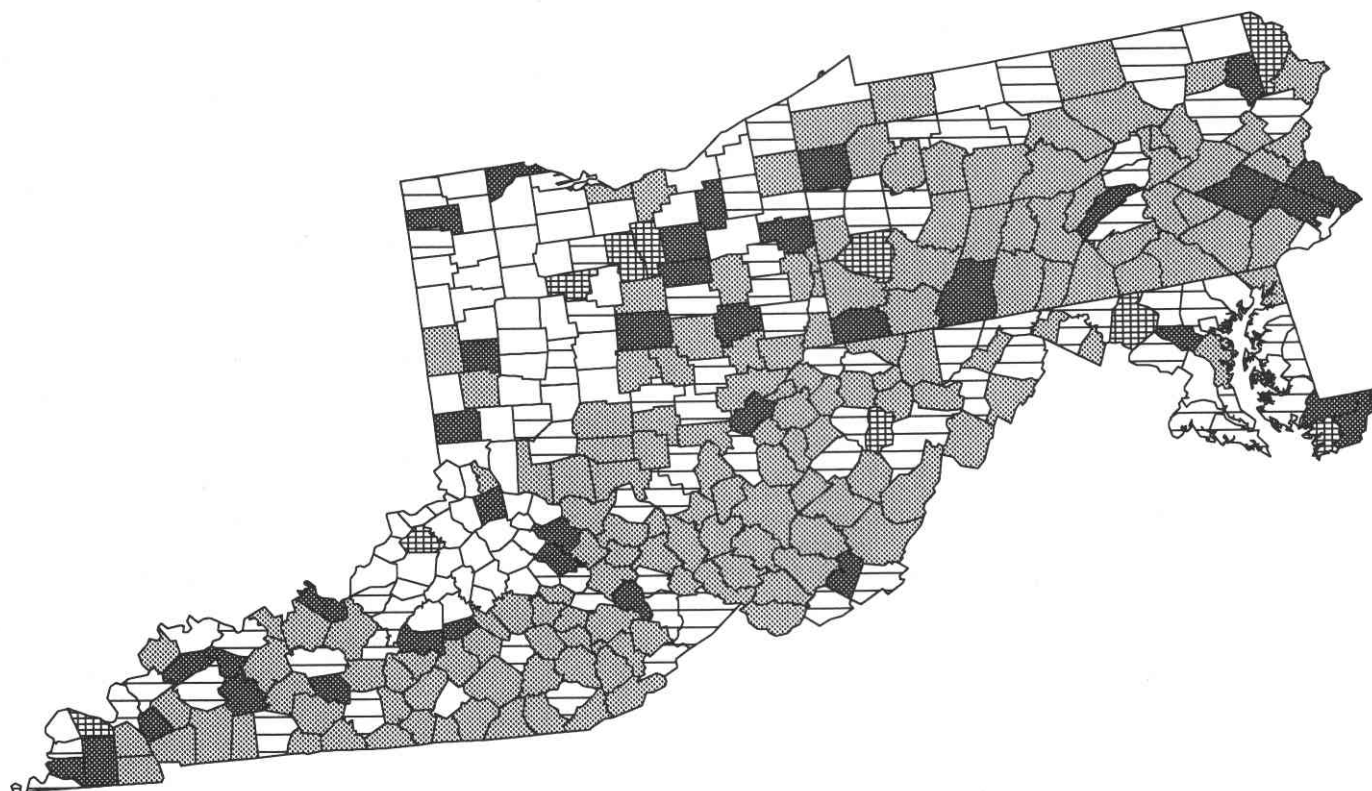
 0.5+
 < 0.5

No information

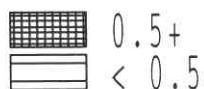
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Regional average = -0.16

Figure 12. Average annual change in the relative stocking of chestnut oak, by county.



Gain(%/YR)



Loss(%/YR)



No information

 not tallied

Regional average = -0.16

Figure 13. Average annual change in the relative stocking of black oak, by county.

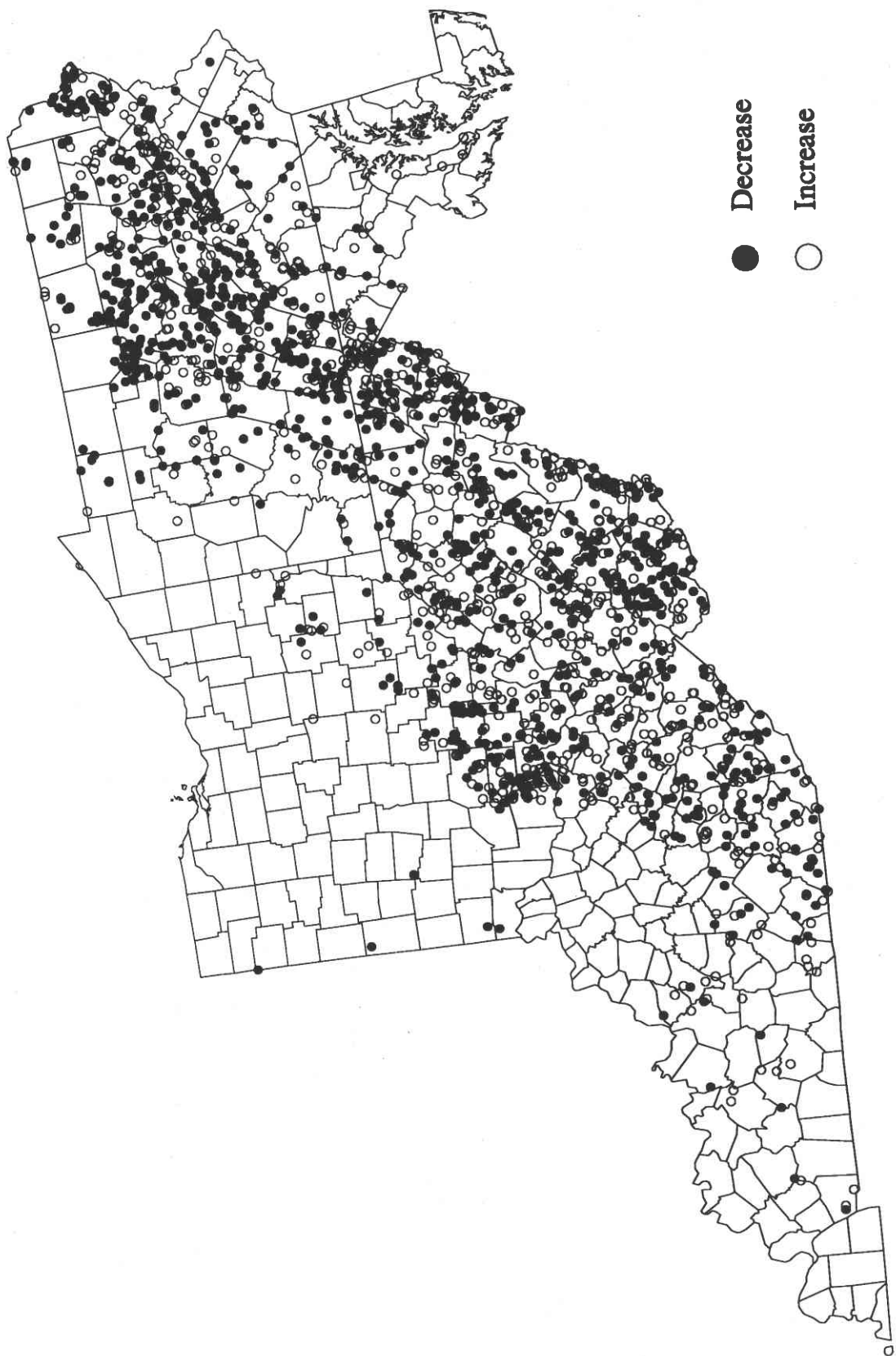


Figure 14. Change in the relative stocking of chestnut oak on plots between inventories.

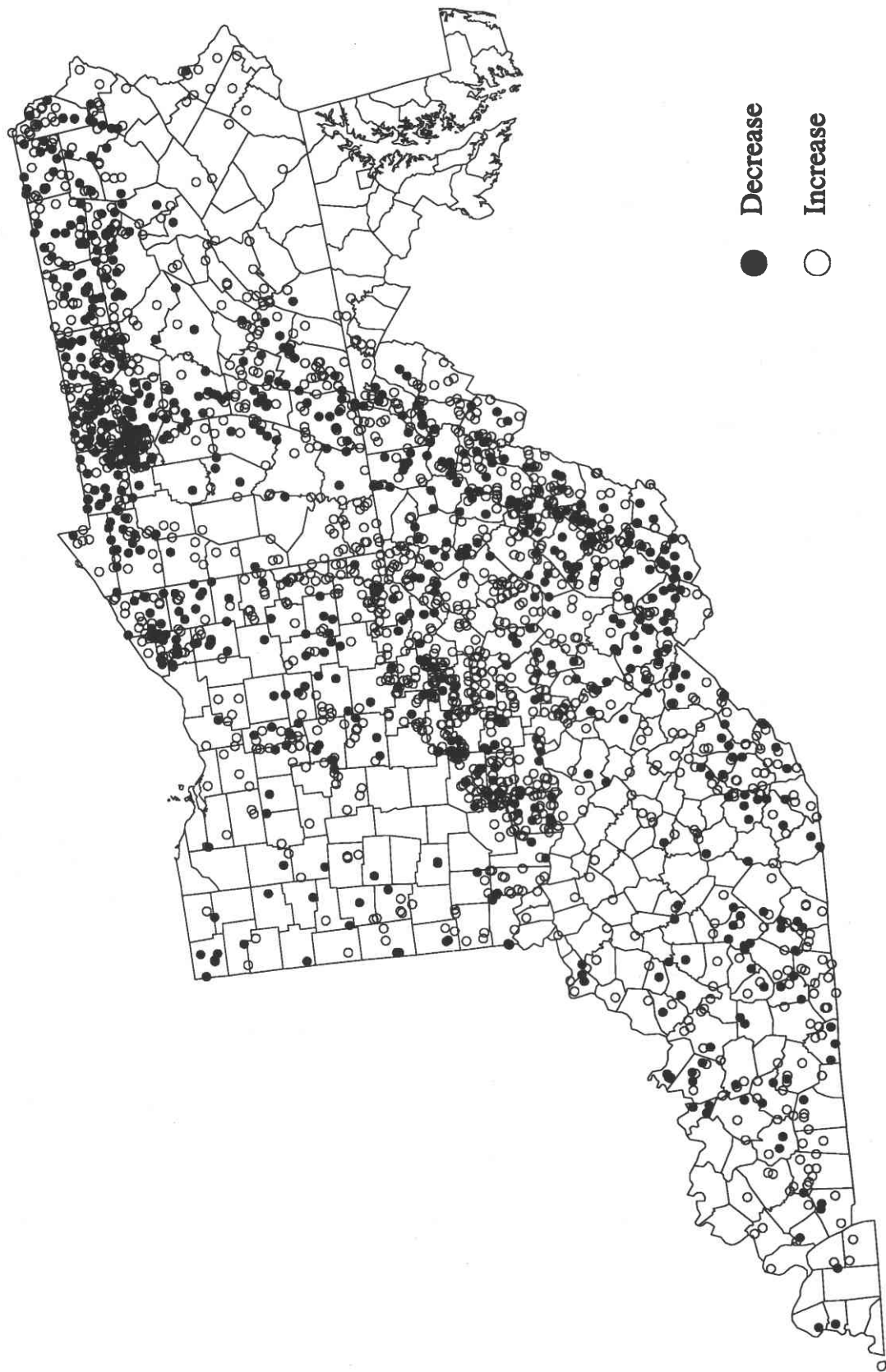


Figure 15. Change in the relative stocking of sugar maple on plots between inventories.

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