Physiography did not appear to have a great influence on mortality risk, but the difference in annual oak mortality volume between affected and unaffected areas was greatest on mesic landforms (table 10). As with the analyses of losses by forest type, SI, and SI/age, oak decline losses were greatest when they occurred on more favorable sites (more mesic landforms).

No decline was detected on hydric landforms, and only a small amount of oak forest type was found there. Oak mortality was high on unaffected hydric sites, but dead trees did not display evidence of prolonged dieback.

**Density**—Decline is a stress-mediated condition. If intertree competition is an important contributor to decline etiology, one would expect affected areas to have higher initial (1977) basal area and total volume than unaffected areas. In general, basal area and volume were higher on affected than on unaffected areas (table 1). However, prediction of decline incidence and severity from basal area or volume has limited value because these stand characteristics depend on many factors, including stand age, site quality, and previous treatment. An association between decline vulnerability and stand density might be indirectly revealed by examining density characteristics within age and SI categories. Of the factors included in this work, age class would be expected to have the greatest effect on density (table 7). In most age classes, there were only slight differences in initial basal area and total volume between affected and unaffected areas. The differences were substantial only for the < 40-year age class. This result is probably attributable to decline occurring in a residual overstory component from an older age class. While intertree competition may well contribute to occurrence of decline in individual trees, we conclude from these data that stand basal area is not a useful predictor of where decline will occur. However, stand density cannot be dismissed as a factor until its influence has been isolated from those of other closely associated variables.

## Conclusion

In the Mountain and Northern Piedmont Survey Units in Virginia, oak decline was the leading cause of mortality between 1977 and 1986. Our best estimate is that annual losses due to oak decline averaged between 7.4 and 13.8 million cubic feet during the period. Bechtold and others (1987) reported that hardwood mortality increased in Virginia as a whole by 59 percent since the previous statewide inventory, and that two-thirds of that increase occurred in the Mountain Units. Our results show that oak decline is a primary cause for that increase.

There seems little doubt that drought in the early and middle 1980's predisposed the oaks to decline. In the last few years, rainfall has been adequate, and that is comforting. We believe, however, that it would be foolish for forest managers and forest policymakers to ignore the implications of these findings. There have been droughts in the past in western Virginia, and there will be droughts in the future. When they occur, heavy losses of maturing oaks can be anticipated.

Oak stands on National Forests were particularly prone to damage, probably because stands there are older, overall, than other publicly and privately owned stands. Bechtold and others (1987) reported that public lands supported a large proportion of the upland hardwood stands where growth is slow and risk of mortality is high. The present management direction for National Forests in the South appears to be toward longer rotations and less frequent timber harvests. While this direction may be reasonable given recent public comment on National Forest Land Management Plans, it should be recognized that it will lead to very large losses of oak timber in the long run.

Since this inventory, gypsy moths have overspread most of the Northern Mountain and Northern Piedmont Survey Units in Virginia. Area of defoliation has increased more than a hundredfold from 5,200 acres in 1985 (USDA Forest Service 1986) to 594,000 acres in 1990 (USDA Forest Service, In press). Gypsy moths attack oaks preferentially (McManus and others 1989), and defoliation predisposes oaks to decline. The probability of mortality is especially high for oaks that are defoliated after decline has begun (Herrick and Gansner 1987). Thus, losses of oaks in the study area are likely to continue and even increase.

Our results give no clear indication of how forest managers should respond to oak decline. Certainly, oaks are valuable for timber, and they may be even more valuable for wildlife. Specific research should be conducted to determine whether oak regeneration occurs beneath declining trees. We do know, however, that decline can cause major reductions in the quantity and quality of acorns produced by affected trees (Gysel 1957; Oak and others 1989). We also know that reproducing red oaks on good sites requires considerable care and skill (Loftis 1990). In the absence of specific information, it may be reasonable to assume that without management intervention, oak decline and gypsy moth defoliation will reduce the proportion of oak in the hardwood stands of western Virginia. We think that forest managers should address that probability.