ditions at the Elsberry, Missouri nursery such success was the exception rather than the rule. Field plantings of Ozark cedar have resulted in uniformly-poor survival. Failure to respond from transplanting is apparently due to foliar transpiration beyond the ability of the reduced root system to supply necessary moisture. All planting experiences have supported this hypothesis.

The species is apparently not winter hardy much north of the northern limit of its natural range near the Arkansas-Missouri line.

While reports of growth rate are at variance and data are available for only a few years after planting, apparently the Ozark white cedar lags somewhat behind the eastern red cedar in this respect. Even where some initial survival was obtained, Ozark cedar gave no indications of being adapted to the eroded soils where eastern red cedar will become established. On better soils, such as Iona silt loam and Wabash clay loam, Ozark cedar has been established successfully.

It is believed that the inherent weaknesses, mentioned above, are sufficient to dismiss the further use of this plant for conservation plantings in the Upper Mississippi region.

Ecological Forestry in Central New England[1]

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It is generally recognized that, in theory at least, silvicultural treatments should follow nature as far as possible. In practice, however, this maxim often has been forgotten or otherwise violated. In this paper is presented the case for the application of ecology to forest practices in a specific region.

DESPITE nearly forty years of educational effort, forestry in central New England still suffers from the prevalent belief that scientific culture is expensive,—a belief closely associated with failure to appreciate the essential biological basis of the forest and the vast power of nature to assist man in his efforts to grow trees. For the most part, forestry has taken the form of costly plantings and intensive protection measures against fire, insects, and disease. The favoring of artificial stands, usually established on worn-out, abandoned farm land, has been responsible for needless expenditures and unsatisfactory results.

As our knowledge of the forests has increased we have come to realize that the more we correlate our forest practices with the natural factors operative in the forest the less expensive and hazardous forestry becomes. The purpose of this paper is to demonstrate that in central New England, forest ecology, and more specifically forest succession, is the key to profitable forest management. Ecological terms are used not in their strictest sense but more or less loosely, as the forester understands and uses them.

A consideration of the forest history of a region is requisite to any discussion of either the biological or economic aspects of forest management. The climatic climax in central New England is predominantly a hardwood-hemlock association. In the forests present at the time of the first white settlers, this was an important cover type. Secondary successions originated chiefly as a result of fire, either caused by lightning or Indians, and periodic hurricanes or heavy gales.

In many places, however, due to local site conditions, cover types other than this climatic climax attained permanency. Examples of such physiographic climaxes in central New England include pure white pine stands on certain light, sandy soils and pitch pine and scrub oaks on the pine barrens.

The impact of civilization has greatly changed the original forest composition. Destructive logging, fire, grazing, and farm abandonment have all initiated secondary successions that have given us forests which bear little resemblance to the original. Many aspen, paper birch, and pitch pine stands owe their existence to repeated fires. The clearing of between fifty and eighty percent of the land for farms and the abandonment of this land during the past century gave rise to the large acreage of "old field" white pine, a temporary type which, in turn, has been followed by mixed hardwood associations. At the present

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time new successions are being initiated on the thousands of acres devastated by the 1938 hurricane, and the problems of controlling forest composition by silvicultural treatments has attained new prominence in central New England.

Many problems confront the forester in this region. Biotically, due to nearly two centuries of misuse, the present forests contain a large proportion of trees of inferior form or species. From an economic standpoint there is little merchantable timber left to carry forest expenses and maintain forest industries. The forest land is parcelled out between many owners, each class of which has often disregarded nature in attempting to change the forest composition over to suit its own individual economic needs. As a result, large areas not only lack mature timber but also are stocked with species unsuited to the sites on which they grow. Truly, the present forests of central New England are neither in a satisfactory economic nor biologic condition. It is becoming increasingly clear that the costly and wasteful practices of the past should be discontinued in favor of silvicultural practices that will lead to a more profitable forest composition and form. From an ecological viewpoint the forester has the choice of adopting practices which lead toward artificial types, toward temporary natural types, or toward near-climax natural types.

The term "artificial types" includes all forest stands containing transoceanic exotics, native species growing outside of their natural range, and native species in stands of unnatural composition or on unnatural sites. In central New England the propagation of artificial types has, at times, been much favored. Among other examples may be mentioned the growing of Scotch pine, European larch and Norway spruce from Europe; white spruce from the northern forest; pure stands of red pine; and pure white pine on rich, heavy soils.

As a whole, these artificial types have not been successful. Older trees are often of poor form, and growth is likely to decline sharply in later life. Very few artificial stands have been profitably brought to maturity. Furthermore, these types are especially susceptible to damage—from insects and other animals, from disease, and from the elements. Examples are numerous: Norway spruce is severely attacked by the white pine weevil; exotic larch plantations on the Harvard Forest are being severely damaged by the porcupine and squirrel; the European pine shoot moth and the Tympanis canker are severe on red pine planted south of its natural range; crookedness in Scotch pine has been attributed to frost damage; weeviling in white pine appears to be more severe on heavy soils than on light soils, where pure stands naturally occur.

Furthermore, the cost of production of artificial types is high. Planting costs between $15 and $30 per acre; necessary weedings to free the planted trees come to nearly half again as much; and, in many cases, expensive protection measures will be necessary to prevent damage by insects and diseases. These charges must be carried for at least several decades before any substantial revenue is received to offset them.

While it is not denied that eventually, after sufficient knowledge is acquired, artificial types may be shown to produce crops of satisfactory quality and quantity at maturity, practices leading toward the production of such crops cannot now be recommended, due to the general lack of previous success, the high risk inherent in their production and the unavoidable high costs involved.

Natural forest types may be roughly separated into two divisions, depending largely upon the place of the type in natural forest successions. These divisions are: (1) temporary types, and (2) near-climax types. Temporary types, or types that occur early in the successional series of the forest, include pioneer stands on denuded areas and their immediate successors. "Old field" white pine, aspen, gray birch-red maple, and paper birch are all temporary forest types.

These temporary forest types are of a short-lived nature. There is a constant invasion of the longer-lived or more exacting species. Consequently it is difficult to maintain such a type for very long, and practically impossible to maintain it generation ofter generation. Our pure white pine stands which came into existence on abandoned farm lands cannot be economically reproduced on most soils.

Silvicultural treatments aimed at the perpetuation of temporary types usually involve extreme exposure of the site, such as that resulting from clear cutting; and this exposure is a threefold evil: first, it results in site deterioration; second, it increases the abundance of inferior species in the ensuing stand at the expense of the more desirable ones, thus necessitating repeated expensive weedings in order to obtain satisfactory stands; and, third, it exposes hardwoods to excessive frost damage and pine to severe attack by the white pine weevil.

Considering the difficult and expensive silvicultural treatments necessary to perpetuate these temporary types, the evils of extreme site exposure and the consequent lowered cash value of the resulting stands, it would appear that forest practices designed to maintain these types will generally be unprofitable.

The second division of natural forest types mentioned above consists of the more stable associations that occur in the later stages of forest succession. These generally are made up of a mixture of both tolerant hardwoods and conifers. In actual practice, the theoretical climax composition will not be aimed at by the silviculturist, but, rather, the composition will be modified in order to reduce disease and insect attack to a minimum and to produce the highest economic returns consistent with the maintenance of these more stable types. Red and white oak, hard and soft maple, beech, yellow and black birch, white ash, hemlock, and red spruce are among the common components of near climatic climax types in the region.

Once established, these types are maintained by relatively light cuttings. Such practices are advantageous in that site deterioration is prevented, unwanted weed species are restricted, and the generally resulting quick establishment of acceptable species reduces weeding and other expenses to a minimum.

In general, the forester has the maximum control over the forest composition when the near-climax types exist and are maintained. Through varying the intensity and frequency of the cutting operations, he is able to hasten the trend toward or to maintain a given composition. In central New England, through a knowledge of successional trends and modifications to be expected due to local conditions, it is possible to control, within certain limits, the proportion of the various species in the final stand.

From an economic standpoint, near-climax types are by far the most desirable. The cost of production is low. Whereas a red pine plantation costs around $20 to $30 an acre to establish, and "old field" pine stands cannot be reproduced for less than an equal amount, if at all, a mixed hardwood selection forest of near-climax species may be maintained without any extra charge for reproduction. Near climax types generally are less subject to attack by disease and insects. Due to the protection afforded reproduction, frost damage is slight as compared to temporary types; and, due to the variety of species and age-classes within the stands, loss from windthrow is likewise lessened. This variety of species and age-classes assures maximum protection against market changes and makes possible a variety of products and an annual rather than periodic income.

At the present time in central New England it is exceedingly risky to make large investments per acre in silviculture. Severe hurricanes such as those of 1815 and 1938 are frequent enough that wholesale windthrow must periodically be expected. Ice storms must similarly be taken into account: one severe storm around fifty years ago deformed to a greater or lesser degree nearly every older stem in the vicinity of the Harvard Forest. Furthermore, the choice of species to favor is obscured by unstable markets. Present wood-using industries are based largely on the temporary "old field" white pine type, and many of these can be expected to lose importance or even disappear in the future. With few permanent wood-using industries and with the competition from other parts of the country, the preferences of the future market for local timber products are and for some time will remain obscure.

In central New England it is therefore evident that both from a biological and an economic viewpoint we must point silvicultural practice in the direction of the low cost production of late successional natural forest types. Only by studying and following the ecological relationships of the forests of the region can we progress in this direction and finally achieve profitable forest management.