

Introduction

Conservation of diversity in forest ecosystems

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The symposium from which the papers in this issue derive was organized to foster an awareness among forest managers of the issues surrounding biological diversity. Forest geneticists have been calling for conservation of diversity for many years (Anonymous, 1975). Since they were geneticists, they naturally called this gene conservation. Forest geneticists often sold gene conservation from a practical viewpoint. Genes were needed in breeding, as raw material for selection, and to maintain viable populations of commercial species. That argument is as valid as ever, but over time we have come to publicly acknowledge that the problem is broader than the need to bank genes for future use in breeding. Research and experience have made us aware of many more aspects of diversity and its uses. Diversity has assumed a value in its own right as people turn to nature for recreation and solace. The existence of wildness keeps our everyday world from becoming one large cage.

In contrast to the geneticists, who tended to focus within populations, ecologists looked at conservation as if they were suspended from a satellite. They warned that the insults we are imposing on ecosystems threaten their very existence — the basic geoclimatic cycles that support life on earth. Unfortunately, many ecologists neglected to consider how important genetic diversity among and within populations of species was to functioning of ecosystems. Variability within a population may be important to many biotic interactions — interactions between herbivores and hosts, or to the partitioning of resources among competing plants, and even to species survival in fluctuating environments. Foresters have certainly appreciated the value of some aspects of diversity among populations. For example, ignoring variability among populations of a commercially important species such as ponderosa pine (*Pinus ponderosa*) by planting seed collected at 2000 m to sites at 1000 m may cost 50% of volume growth in only 50 years (Conkle and Westfall, 1984). By moving a low-elevation population to a high elevation, a forester would run the risk of losing the entire crop. But much of what we know is not being applied consistently on the ground, and we are only beginning to appreciate

other aspects of genetic diversity. Adaptational fine-tuning of populations to microenvironmental factors may optimize both timber yields and ecological functions. The organization of genes in individuals and in populations may confer resistance to conditions we cannot anticipate.

We organized the 1988 symposium to address the issues of conservation of diversity in forest ecosystems, with particular reference to genetic diversity. Most of the papers from the symposium are included in this special issue. The issue begins with two papers that discuss threats to diversity. Paul Ehrlich began the symposium with a keynote address on "Conservation, from genes to ecosystems"; here we reprint an earlier article in which he emphasizes the scope of the problems and the urgency for action. Although Ehrlich stresses that the root of the problem stems from human population growth and rampant capital consumption, he urges that trends can be reversed by the manner in which wildlands, especially forests, are managed.

One of the most serious threats to diversity in the next Century may well arise from those specific anthropogenic actions that affect global climate through accumulation of greenhouse gases. Robert Peters summarizes current projections for climate warming and the enormous consequences they would have for plant distributions and species survival. If even a fraction of the projected changes occur, the nature of temperate-forest management will change in a drastic way. We must be prepared for those changes.

Following these two papers on the threats to biodiversity are five papers on ways to approach conservation of forest diversity. With the specter of global climate change imminent, the focus of genetic conservation must shift to integrate ex-situ preservation of germplasm along with in-situ measures. Frank Bonner presents the current status of seed-storage technology. Advances in cryogenic preservation may provide the technological breakthrough in seed storage. Although seeds from many forest tree species can be stored indefinitely, there are many temperate as well as tropical species that cannot be stored for more than a year.

In-situ protection of resources has long been a concern of forest managers, especially forest geneticists. The detrimental effects of dysgenic harvest, artificial regeneration with ill-adapted stock, and inbreeding are well-known and usually avoided. Sometimes, however, the goal of wood production, no matter how conscientiously practiced, counters the goal of protecting natural diversity: species mixes are altered, superior (but novel) genotypes are introduced, and a biased sample of trees are removed. Lawrence Riggs presents a case for maintaining both genetic diversity and its organization on-site and illustrates how existing information can be used to evaluate conservation measures affecting California forests. Drawing on an example in temperate forests, William Gladstone and Thomas Ledig show how intensive forest management can increase yields from the tropics, thus simultaneously providing needed wood fiber and releasing other lands for conservation.

From an institutional perspective, the best strategy for conserving diversity is diversified conservation. The U.S.D.A. Forest Service is approaching the issue in this way, as Hal Salwasser describes, by building a multipronged, coordinated program to manage biodiversity on the National Forests. The Center for Plant Conservation, a consortium of U.S. gardens and arboreta dedicated to conservation, was conceived with the notion of pursuing an integrated conservation strategy. Donald Falk describes the endangerment status of U.S. tree species, and argues for conservation methods that include in-situ and ex-situ components in a balanced program.

Six case studies follow these papers. The first two are examples involving individual taxa, while the last four describe organizational approaches. The absolute dependence of conservation projects on dedicated, long-term funding is illustrated by William Libby's personal account of the Monterey pine (*Pinus radiata*) genetic-conservation project. Early support funded an ambitious program for conserving the germplasm of one of the world's most important softwood species. Lagging financial assistance, however, two decades into the program seriously threatened the security of the in-situ reserves and ex-situ collections; these irreplaceable materials may be lost.

Concern for preservation of old-growth Douglas fir (*Pseudotsuga menziesii*) forests in western Washington led the Washington State Department of Natural Resources to establish a program of gene pool reserves. Boyd Wilson describes the planning, design, and management of this program, apparently the first of its kind in the nation.

The effects of silviculture and tree improvement on genetic diversity are a major concern of forest geneticists. Jay Kitzmiller outlines the sources of these effects, from seed collection to plantation establishment, drawing on the experience of the tree improvement programs of the U.S.D.A. Forest Service in the California region. Tree-improvement programs must monitor and anticipate the effects and seek ways to prevent damage to the genetic resource.

A few institutions and programs now focus specifically on the alarming erosion of genetic diversity in the tropical forests. CAMCORE of North California State University (U.S.A.), described by William Dvorak, provides assistance to forest industries in Mexico and Central America through a genetic-resources cooperative. These industries provide cooperative funds which ensure conservation of germplasm of potential importance to tree-improvement programs. The Oxford Forestry Institute (Great Britain) has similarly directed attention to commercial pines of Mexico and Central America. Robert Barnes and Jeff Burley summarize several decades of the Institute's efforts to integrate conservation objectives into tree-improvement programs. The forestry programs of the Food and Agricultural Organization of the United Nations were instrumental in bringing conservation issues to the attention of forest managers worldwide. Their scope includes both temperate- and tropical-zone forests. Christel Palmberg and J. Esquinas-Alcazar describe the for-

est-conservation programs of the F.A.O. and other international agencies, with special attention to tropical forests.

With this set of papers, we hope to bring attention to the enormity of the problems regarding conservation of diversity, and to the spectrum of opportunities that forest managers now have to influence the fate of that diversity. The world has already lost too much of the biological diversity that it inherited, and threats to diversity, now and in the near future, are much greater than any in the past. We want all forest managers to know that conservation of diversity is possible. It can be accomplished not only by creating reserves and storing germplasm in banks, but also through the many management decisions made every day on the forest.

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