14 Biotechnology and Biological Diversity

MASAO KAWAI
Tokyo 105, Japan

Introduction 434
1 Biological Diversity in the Tropics 435
2 Humans and Nature in Tropical Regions 436
3 Current Situation Concerning the Conservation and Utilization of Tropical Forests 437
4 Useful Products Found in Tropical Forests 437
5 Research Facilities and Organizations in Tropical Areas 438
6 International Trends Related to the Conservation and Utilization of Biological Resources 439
7 Present State and Potential of Biotechnology for the Conservation and Utilization of Tropical Forests 440
8 Summary and Proposals 441
  8.1 The Need to Conserve Species as a Global Environmental Problem 441
  8.2 Sustainable Utilization of Genetic Resources 442
  8.3 The Promotion of Cooperation between Developing and Industrialized Countries Concerning Genetic Resources 442
  8.4 Necessary Framework 443
Introduction

The diversity of organisms which inhabit tropical regions is much greater than that of other geographical regions, and this diversity is particularly remarkable in tropical forests. However, tropical forests are decreasing rapidly due to various kinds of economic activity such as commercial logging and development, so there is now concern that valuable biological and genetic resources are being lost and that the global environment is deteriorating.

The conservation and restoration of tropical forests is being demanded by the world community. Yet tropical forests are valuable resources for the countries which possess them, so it is not possible to only consider a conservation–protection option. It is necessary therefore to achieve some sort of compatibility or balance between the conservation and utilization of tropical forests.

This chapter examines, from a global point of view, various aspects of tropical forests, such as biological diversity, the present state of the forests, movements afoot to protect the forests, and the activities of research organizations. Furthermore, after investigating measures to achieve compatibility between the conservation and utilization of tropical forests, as well as the potential for biotechnology to contribute to these measures, long-term policy proposals are made within a framework of international cooperation.

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List of Contributors

(Numbers in the parentheses mean section number(s) to which the contributor made his contribution.)

Fukui, Katsuyoshi (4, 6)
National Museum of Ethnology

Harada, Hiroshi (7)
Institute of Biological Sciences, University of Tsukuba

Inoue, Tamiji (1, 6)
Center for Ecological Research, Kyoto University

Ishikawa, Fujio (7, 8)
Japan Bioindustry Association

Izawa, Kousei (5)
Faculty of Education, Miyagi University of Education

Kakeya, Makoto (4, 5)
Center for African Area Studies, Kyoto University

Kanoh, Takayoshi (5)
Primate Research Institute, Kyoto University

Kawai, Masao (5, 8)
Japan Monkey Center

Komagata, Kazuo (4, 6)
Faculty of Agriculture, Tokyo University of Agriculture

Koshimizu, Koichi (4)
Faculty of Agriculture, Kyoto University

Maeda, Hidekatsu (4, 7)
National Institute of Bioscience and Human-Technology (MITI)

Matsumoto, Tadao (3)
College of Arts and Sciences, University of Tokyo

Miyachi, Shigetoh (4, 5, 7)
Marine Biotechnology Institute Co. Ltd.

Ogino, Kazuhiro (1, 5, 8)
College of Agriculture, Ehime University

Ohigashi, Hajime (4)
Faculty of Agriculture, Kyoto University

Ohswara, Hideyuki (5, 6)
Primate Research Institute, Kyoto University

Tabata, Mamoru (4, 7)
Faculty of Pharmaceutical Sciences, Kyoto University

Takaya, Yoshikazu (2)
Center for Southeast Asian Studies, Kyoto University

Takemura, Osamu (7)
Primate Research Institute, Kyoto University

Yamada, Isamu (3, 5)
Center for Southeast Asian Studies, Kyoto University

Yamamoto, Norio (4, 5, 6)
National Museum of Ethnology
1 Biological Diversity in the Tropics

Biological diversity was attained through the process of the evolution of organisms. Its understanding therefore must be based upon the basic theory of evolution. Historically, it has been thought that species are independent units and that different species would not merge with each other (genealogical tree). Recently, however, it has been found at the DNA level that there is an exchange of genes even among species which are genealogically separate, and that this is the mechanism by which new species are formed (genealogical network). According to Darwin's Theory of Natural Selection, the driving force for evolution is intra- and inter-species competition; however, recently the importance of coexistence among different organisms has become clear. It has been found that tree growth depends upon the symbiotic relationships between the tree and ectotrophic mycorrhiza which provide nutrient salts and insects that carry pollen. In this way it can be seen that a species is not an independent unit, and that symbiosis is important for the continued existence of the species. Therefore, biological diversity must be conserved based upon the premise that the entire ecosystem is a system in which such symbiotic relationships are involved.

The high degree of biological diversity of tropical forests is also evident from the fact that while tropical forests only account for about 3% of the Earth's surface area, they contain more than 50% of the species. In order to comprehend the biological diversity of the tropics, it is necessary to consider the natural history of the Earth. The last Ice Age, which reached its peak 20,000 years ago, brought about a dry period in the tropics which resulted in the shrinkage and disruption of the tropical forests. Many organisms most likely became extinct during this period of upheaval. However, it must also be realized that the differentiation of species was accelerated by the dislocations which occurred. This drying out was particularly severe in the tropical regions of Africa and Central and South America. In Southeast Asia, the connection of land masses due to the drop in sea level at this time is the reason why the biological diversity of the area is not advanced even though the region is presently made up of islands.

Several theories have been proposed to explain the biological diversity of tropical forests. When discussing the conservation of biological diversity, it is important to consider the hypothesis of disturbance. Tropical forests undergo spatial disturbances of different magnitudes (forest fires, falling trees), as well as temporal disturbances which may occur over periods of anywhere from 4 years to hundreds of years. It has been observed that forests which experience a suitable degree of disturbance exhibit a high level of biological diversity. Humans have been living in tropical forests for thousands of years without causing a decrease in the biological diversity of the forests. This is because the scale and frequen-
The destruction of tropical forests in the last several decades due to modern civilization has resulted in more disruption than which occurred during the last Ice Age. What is urgently needed is the establishment of protected areas of tropical forests where human impact can be kept to a minimum. Modern ecology is not yet at a level where it can show standards to establish protected areas. However, knowledge concerning groups of islands does offer some standards related to the extent of protected areas, the diversity of the habitats, and the species diversity which the protected areas can maintain. Using this information, a system must be set up with which to create protected areas and monitor biological diversity. It is possible to use methods such as dynamic planning techniques and adaptive management techniques for this purpose.

2 Humans and Nature in Tropical Regions

Tropical regions are diverse. Therefore, in order to accurately discuss tropical regions, they must be classified according to the special features of each particular region. It is not enough to base this classification of the regions only upon ecology, but rather, one should include social and cultural aspects as well because they are also related to the conservation and use of biological resources.

The islands of Southeast Asia can be assumed to consist of a single tropical zone in terms of the social, cultural and ecological classification alluded to above. The ecological characteristics of insular Southeast Asia then is one of an archipelago of tropical rain forests.

The people of this insular tropical rain forest region traditionally lived by harvesting forest products and practicing slash and burn agriculture. The harvesting and transporta-
the 21st century. That is because the indigenous people in the inner world have respect for the gods of the forest, and live in harmony with all the living creatures. The risk-taking vitality is also a valuable asset.

3 Current Situation Concerning the Conservation and Utilization of Tropical Forests

Tropical rain forests are not simple forests, but rather are very diverse. In Southeast Asia there are mangrove forests situated along the seashore in lowland marshy areas, peat swamp forests, and moist fresh water forests. In lowland areas, mixed Dipterocarpaceae forests occupy a large portion of the entire forest area up to about 1500 meters above sea level, while above this are montane forests and subalpine forest zones. The geographical conditions of each are different and the types of trees which grow are diverse, so a high degree of knowledge about tropical forests is needed when discussing them. All of these forests have been disturbed to some degree by humans. In order to conserve genetic resources under these sorts of circumstances, the natural characteristics of tropical regions, as well as the human involvement and biological features must be understood from a long-term point of view. There are a multitude of different insects in tropical rain forest ecosystems which are fundamentally dependent on plants for their survival. However, at the present time, a mere 10% of the insects have been taxonomically classified. Very little is known about their ecology and behavior. Among the diverse array of insects which inhabit tropical forests, those which consume wood-fiber (xylophagy) and detritus play a significant role in the recycling of materials in the ecosystem. These insects function as the degraders of dead plant material, and they have intimate symbiotic relationships with microorganisms such as bacteria, fungi, and protozoa. The role played by termites is especially important, since they contribute greatly to the recycling of carbon and nitrogen. Better policies for the conservation and utilization of tropical forests can be brought forth by deepening our understanding of the interactions among the plants, animals and microorganisms in this kind of ecosystem.

4 Useful Products Found in Tropical Forests

The range of secondary chemical metabolites of tropical forest plants which diversify in response to the species, ecological and genetic diversity of tropical forests, is also extremely diverse. Furthermore, it has recently been shown that these chemical substances function as chemical signals such as allelopathy(s), pheromones, phytoalexins and other compounds between plants and other plants, plants and animals, and plants and microorganisms. These metabolites influence the natural environment and play an important role in the structure of tropical ecosystems. In other words, tropical forests exist as forests because of their biological diversity, and they are treasure troves containing a majority of the Earth’s resources of genes and physiologically active substances.

The biological resources of tropical forests have been effectively used in a variety of ways, including as primary and secondary products such as materials for everyday use, timber, industrial products, foods, drugs and agricultural chemicals. It should be noted in particular that there have been many discoveries of active drug ingredients that are vital to modern medicine being isolated from tropical plants. Several examples of the success of recent investigative research can be given, such as the isolation of the alkaloid anti-cancer agent vinblastine from the rosy periwinkle, the antiinflammatory compound cortisone, and diosgenin, a substance isolated from Mexican mountain potatoes that is a raw ma-
terial used in the production of contraceptive pills. Artemisin, a compound which exhibits high efficacy against chloroquine-resistant malaria, has been isolated from a traditional folk medicine, and saponin, a substance which kills the snail that is the intermediary host for African schistosomes, has been isolated from an African leguminous plant. Thus, these compounds are helping to improve the health of the local inhabitants. Catechol, obtained from the catechu plant of tropical Asia, has been marketed in approximately 40 countries in Europe and elsewhere for treatment of liver disease.

It must be borne in mind that the biological resources now being used are the direct or indirect cultural heritage of the inhabitants of tropical forests in Southeast Asia, Africa and Central and South America. The slash and burn farming Hanunoo tribe in the Philippines, the hunter-gatherer Efe pygmy tribe in Northeastern Zaire and the slash and burn farming Lese tribe are examples of indigenous people who have been living in harmony with nature, in particular plants, and making use of the abundance of the forests. These “forest people” possess a remarkable amount of knowledge concerning the useful plants and animals of the tropical forest. However, changes in their way of life are occurring along with the wave of development that has been happening, and they are increasingly coming into contact with surrounding cultures. As a result, there is the danger that the valuable traditional knowledge which has been passed down from generation to generation is disappearing along with the tropical forests. In this respect, while the conservation of tropical forests is of course desirable, it is also hoped that biotechnology, which has been developing at a rapid pace in recent years, can be applied to the utilization of tropical forests. In other words, biotechnology should be used for the utilization of tropical forests, starting with basic research using small quantities of living material, to high-level applied research. This work should be carried out by obtaining and conserving the tropical forest of a particular area that is to be used as an experimental research station for biological diversity studies through cooperation with the local inhabitants, and by exploring the forest for the specific living phenomena that are utilized as cultural traditions. Through such endeavors, in the end not only can valuable results be expected related to the development of value-added pharmaceuticals, highly selective agricultural chemicals, and biochemicals, but it is also possible to conserve genetic resources as well as breed and select useful species of organisms. It is not unrealistic to say that these achievements will contribute to improving the lifestyles and economies of the local inhabitants and the conservation of tropical forests.

5 Research Facilities and Organizations in Tropical Areas

The majority of countries located in tropical regions are developing countries, which makes research activities into the “conservation and utilization of biological diversity” economically and politically difficult. These countries recognize the need for conducting this type of research, however, they lack both the funding and human resources required to effectively deal with the situation. While this situation is common to these countries, it should be emphasized that the various countries in Africa, Latin America and Southeast Asia each possess regional and national characteristics which reflect differences with respect to the number of research facilities, the state of their facilities, level of activity, and so on.

Among Southeast Asian countries there is a variety of needs and demands concerning tropical forest resources, ranging from that of Malaysia which is attempting to develop economically by exploiting its forests for timber, to Thailand which has adopted a policy of banning commercial logging in order to protect the environment. There are also differences with respect to the type of research activities being carried out. For example, Malaysia is pressing ahead with research that focuses mainly on forestry, while Thailand is...