生物多样性研究丛书

保护生物学

Conservation Biology

蒋志刚　马克平　韩兴国　主编

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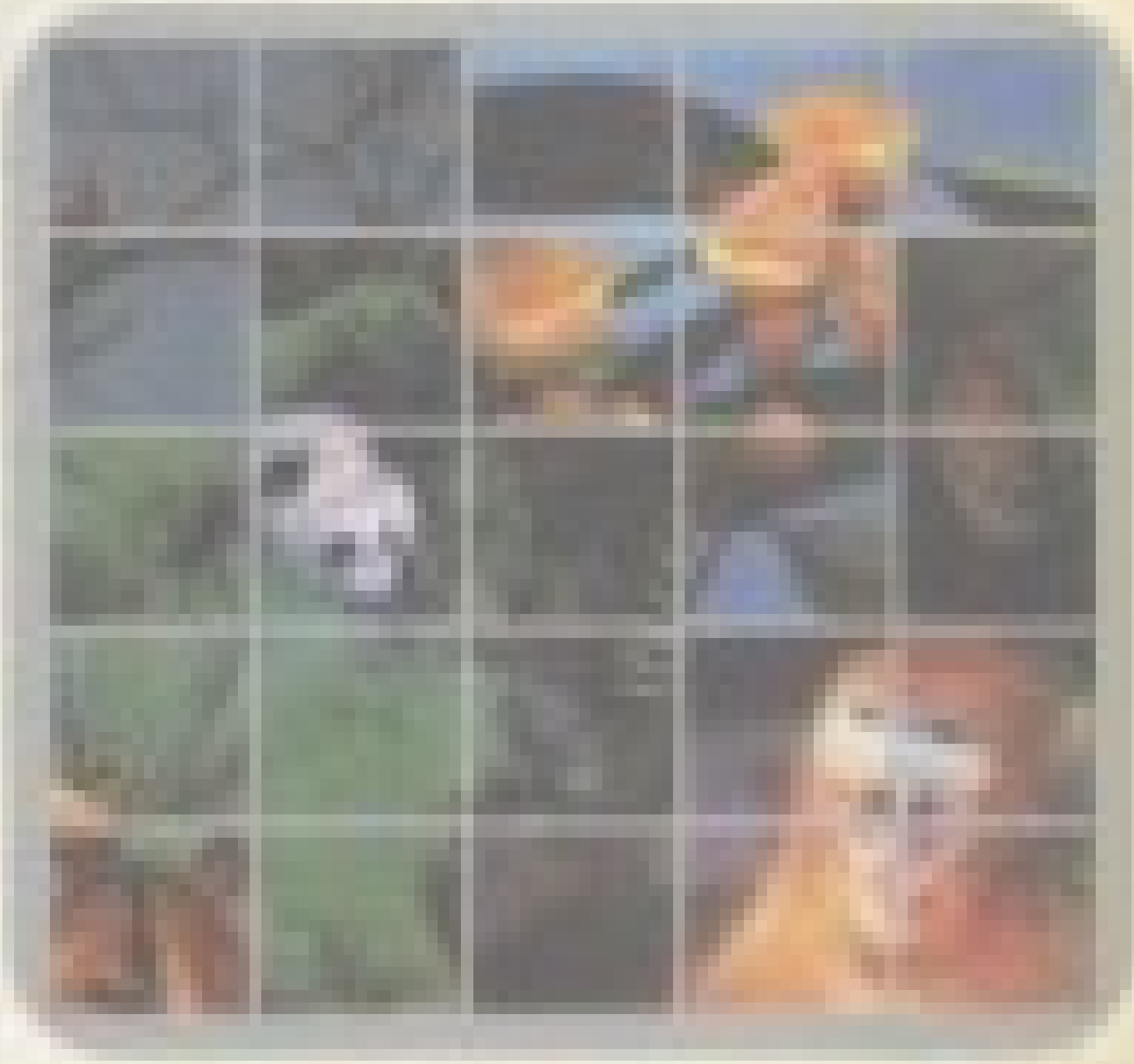

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总　序

各种各样的生物资源是地球上人类赖以生存的基础。然而，由于人类活动的加剧，引起了全球环境的迅速恶化。最大限度地保护生物多样性已成为国际社会关注的热点。在1992年6月举行的联合国环境与发展大会上，包括中国在内的153个国家在《生物多样性公约》上签了字，从而使保护生物多样性成为世界范围内的联合行动。中国作为世界上生物多样性特别丰富的国家之一，不仅积极开展了生物多样性的保护活动，而且还最早制订了国家级生物多样性保护行动计划。

作为中国自然科学研究中心的中国科学院一直积极致力于生物多样性的研究工作。在国家科委、国家基金委等单位的支持下，经过四十多年的考察与研究，在许多课题和研究项目上取得了可喜的成绩，还先后组织编写了《中国植物志》、《中国动物志》、《中国孢子植物志》、《中国植被》、《中国高等植物图鉴》、《中国植物红皮书》(第一卷)等书，并增建和扩建了有关的研究设施如标本馆、植物园、定位研究站等，为中国生物多样性保护与持续利用提供了大量的资料和措施。为了加强生物多样性研究工作，在原生物多样性工作组的基础上，于1992年3月成立了中国科学院生物多样性委员会，统一协调生物多样性研究工作，并与国内外有关机构开展了各种形式的合作。

目前，中国科学院已有相当一批专家正在开展生物多样性方面的研究，从基因、物种、生态系统和景观四个水平上研究生物多样性的现状、受威胁或濒危的原因以

及保护与恢复的对策，并积极建设全国性的生物多样性信息系统，以期为中国的生物多样性保护与持续利用提供理论依据。

为了推动生物多样性研究工作，及时反映这方面的研究成果，促进跨世纪人才的培养，在继续编译《生物多样性译丛》的基础上，我们组织撰写了《生物多样性研究丛书》。这套丛书将集中介绍中国科学院生物多样性研究的最新成果和有关的基本原理与研究方法。由于生物多样性研究是综合性和实践性很强的新兴领域，编写这样的丛书也是我们的初步尝试，希望得到有关专家的积极支持，共同培育这棵刚刚破土而出的新苗。

许智宏

1996 年 9 月

序

人类文明即将进入一个新纪元。回顾过去的200年，人类展开科技的双翅飞上天空，潜入大海，足迹几乎遍布地球的每一个角落。但在阵阵凯歌声中，人们发现了不和谐的杂音，这就是人类生存环境恶化的警报。这警报声逐年增大，引起了人们的警觉。面临着生态系统退化、人口急剧膨胀、物种大量灭绝等一系列严峻的问题，面对着我们只有一个地球的现实，人们不禁对过去利用和征服自然的方式提出了疑问，我们应当如何利用自然才能保证千秋万代的生存环境和发展潜力？人类社会的发展像一柄利剑，既可能损伤自然又可能危及人类自身的生存。然而，人类的存在与发展又是历史的必然。

人们在困惑中思索，1985年，一群学者和自然保护工作者在美国圣地亚哥发起、成立了保护生物学会，而后又创办了《保护生物学》杂志。这些人勇敢地开展了保护珍稀物种和生物多样性的理论与实践研究，这标志着保护生物学的开始。

一个新学科的发展是需要时间的。保护生物学的形成和成熟是在1992年联合国环境与发展大会以后，此时，各国政府开始将生物多样性研究和保护纳入议事日程。人们在更高的层次上，以更宽阔的视野开展了有效的保护生物学研究。从研究旗舰种的迁地保护开始，注重栖息地保护、生态系统保护以及生物多样性丰富的“热点地区”的研究和保护实践。这其中不仅涉及到生物学理论，并且综合了古地理、古生态、人文科学、法学方面的理论和实践。

自80年代后期，我开始与中科院的汪松、陈灵芝等几位专家一起关注和推动中国的生物多样性保护研究工作。经过各个方面的努力，特别是在国家自然科学基金委员会有关同志的支持下，由我主持了自然科学基金重大项目“中国主要濒危植物保护生物学研究”(执行期为1993～1997年)。在研究工作中，我们感到迫切需要编写一本适合于中国情况的保护生物学专著。经过中国科学院生物多样性委员会组织一批以年轻人为主体的生物学和生态学工作者的积极努力，编写出了具有鲜明中国特色的中国第一本《保护生物学》专著。这是一本集学科系统性与区域特色于一身的好书，给我留下了深刻的印象。通过本书，读者可以了解保护生物学的基本框架、发展简史、基本概念、基本原理和若干选于中国的研究和保护实例。毫无疑问，本书的出版对于保护生物学的研究和普及，对于中国保护生物学的发展以及中国生物多样性的保护和持续利用都会起到较大的推动作用。作为本领域从事多年研究工作的老同志，我愿意为大家推荐这本书，并对蒋志刚、马克平等诸位年轻同仁为本书的及时出版所付出的艰辛劳动表示衷心的感谢。

中国科学院院士　洪德元

1997年8月30日

前　言

保护生物学是一门具有地域特点的学科。在全球宏观环境的大背景下，保护生物学与区域性的社会、经济、自然状况密切相关。首先，社会结构对于一个国家的自然保护有着深刻的影响，离开社会形态去探讨自然保护显然是不可能的；其次，一个地区的经济发展水平在某种程度上决定着文化教育水平和环境保护意识，以及实施自然保护的能力。中国是生物多样性极其丰富的国家，从巍峨的喜马拉雅山、高耸的青藏高原到沟壑纵横的黄土高原、广袤无垠的戈壁沙滩，以及众多的人口、古老的文明，这一切决定了我国保护生物学研究对象的基本特征。半个世纪以来，特别是最近15年来，我们在自然保护特别是野生动物保护方面做了大量的工作，因此有必要总结其中的经验教训，以逐步形成有中国特色的保护生物学理论体系。

以生物多样性及其保护为主线，本书分为概论、生物多样性层次（第2章至第4章）、生物多样性演化（第5章至第8章）、生物多样性保护（第9章至第14章）以及中国生物多样性保护实例（第15章至第21章）五大部分内容。分别探讨了保护生物学与生物多样性、生物多样性危机的关系，以及保护生物学的起源、特征和发展；介绍了生物多样性的三个层次，即遗传多样性、物种多样性和生态系统多样性；阐述了物种形成和物种灭绝的机理、生物多样性的演化历程和影响其演化的内外因素；第9章至第14章包括了物种濒危等级划分、物种保护原理、国家公园和自然保护区的设计与管理，以及物

种迁地保护方法和措施，并介绍了生物安全以及与自然环境保护有关的法律与公约；最后几章介绍了一些保护生物学研究热点和濒危动物保护实例。

本书由蒋志刚、马克平写第 1 章和第 4 章，蒋志刚写第 5 章和第 12 章，葛颂写第 2 章，贺金生、马克平写第 3 章，黄大卫写第 6 章，陶毅、王祖望写第 7 章，王印政写第 8 章，袁德成写第 9 章，李义明、李欣海、李典谟写第 10 章，李迪强、蒋志刚、王祖望写第 11 章，钱迎倩写第 13 章，范志勇、宋延龄写第 14 章和第 17 章，吴春花、宿兵、张亚平写第 15 章，张先锋写第 16 章，刘宏茂、许再富、马信祥、陶国达和殷寿华写第 18 章，马世来、韩联宪、兰道英、季维智、Richard B. Harris 和 William V. Bleisch 写第 19 章，Richard Corlett 写了第 20 章（李迪强译，蒋志刚校），蒋志刚和彭镜毅共同完成了第 21 章。各章作者完成初稿后，由中国科学院生物多样性委员会邀请了陈灵芝、洪德元、李典谟、钱迎倩和王祖望 5 位先生对书稿作了审定。刘岩参加了本书的最后清稿工作。在中国科学院生物多样性委员会和浙江科学技术出版社的鼎力资助下，在中国科学院有关领导和同事们的支持下，经过一年的努力，国内第一本《保护生物学》专著终于与读者见面了。

保护生物学在当前还是一门全新的学科，其理论和方法有待完善、提高。我们期待与同行交流，以便共同提高。我们正处在世纪之交，既面临着经济发展的机遇，又肩负着环境保护的重任。我们这一代人肩负的重担，到下一世纪将转移到正在成长的青年一代肩上，他们将成为中国自然保护的中坚。我们有必要将知识传给他们。怀着对祖国的一片赤子之心，我们在繁忙的工作之余，编著了这一本《保护生物学》，献给绿色、和平的未来。

蒋志刚

1997 年 8 月 2 日

Summary

Biological diversity or biodiversity is the complexity of living organisms, as well as all relevant ecological processes. Biodiversity is the fundamental feature of all life systems. The diversity exists at a variety of biological levels such as genes, cells, tissues, organs, populations, species, communities, ecosystems and landscapes. Most of biodiversity studies have been carried out on the three levels genetic diversity (genediversity), species diversity and ecosystem diversity.

Genetic diversity includes all genetic information materials and carried by living organisms on the Earth; however, under specific circumstances, genetic diversity only denotes the genetic varieties within species. Heredity is a conservative process, but the mutation of genetic materials, which includes the change of chromosome number and structure, or the sequence of nucleotides, will increase genetic diversity. The genetic diversity may be expressed at the levels of cells, organs, physiological mechanisms and morphology.

Measurement of genetic diversity has been developed from the Research of chromosomes, the research on morphological variation, the disclosure of diversity at the molecular level with enzyme electrophoresis, to the determination of sequence of deoxyribonucleic acid (DNA). Research on genetic diversity can Reveals history of life evolution and be helps the conservation of species resources.

Species diversity is the phenotype of biological diversity expressed at the species level. The research on species diversity is much earlier, more extensive and with methods better developed than These on genetic diversity and ecosystem diversity. Depending on scales of different researches, there are two meanings for species diversity, that is, regional species diversity and community species diversity. Measurements of regional species diversity mainly include species richness, species-area relationship and the ratio of endemic species.

There are about 13 to 14 million of species on the Earth, but only 1.75 million have been scientifically described. So far we still know little about insects, lower invertebrates, and fungi. Species are not distributed evenly on Earth, and 12 megabiodiversity countries host 60% to 70% or even more species of the entire world. From the viewpoint of regions, the 18 generally recognized hot-spots of biodiversity host 20% of world plant species, and contain high ratio of endemic species, nevertheless, life species in these regions are also more severely threatened. Because of different geography and history, those countries with high ratio of endemic species will play an important role in the conservation of species diversity.

China is one of the countries with megabiodiversity and higher ratio of endemic species. However, endemic taxa are not evenly distributed. There are three endemic centers for endemic vascular plants in China, 14 key regions with terrestrial biodiversity of international

significance. They are of great significance in the conservation of species diversity in China.

Ecosystem diversity denotes the diversity of habitats, communities and ecological processes within the biosphere. The habitat diversity is the basis for the formation of community diversity and even the entire biological diversity. Community diversity is the diversity of composition, structure and dynamics (succession and fluctuation). Ecological process is the interaction or interrelationship among components and between those components and their environments, reflected mainly by energy flow, material cycling and information transference.

Ecosystem is a natural functional unit. The distribution of ecosystems is mainly affected by water and temperature condition. There are many ways to classify ecosystems, but the widely used one, nowadays, is based on the scale, that is, when at a large scale, classification will be based on the characteristics of habitats, and otherwise when at a middle or small scale, the classification will focus on the vegetation. The ecosystem diversity is also an important criteria for the determination of key region of biological diversity.

Ecosystem diversity is generally measured at two levels, that is, communities and ecosystems. As communities being kernel parts of ecosystems, the measurement of community diversity is often used as of ecosystem diversity. Though some ecosystem diversity indexes have been put forward, none of them have got widely accepted it is worthy of every attempt.

Ecosystem is also a dynamic function unit Those changes mainly include: the long-term change of physical environment, the genetic change as a result of natural selection. Monitoring of ecosystems is based right on those changes, but more attention is paid to the third one. Two ways of monitoring are recommended: (1) using sampling quadrate to monitor the change of composition, structure and major ecological processes of ecosystem; (2) using remote sensing (RS) and geographical information system (GIS) to monitor the change of area and distribution pattern of different ecosystems.

With the increasing human population and aggravating economic activities, mankind is exerting more and more influences on biological diversity. The most concerned one is the fragmentation of habitats or landscapes. Influences of habitat fragmentation include: (1) the energy budgets in fragmented habitats are significantly different from in those landscapes all covered with dense vegetation; (2) fragmented habitats suffer more from the winds; (3) fragmentation will affect the hydrological cycling of ecosystems; and (4) fragmentation will affect the ratio of species migration and extinction.

The relationship between biological diversity and ecosystem function is one of the core fields for ecosystem diversity research. What role do taxa play in the maintenance of structures and functions of ecosystems and whether different species or taxa are interchangeable regarding their function. Chapter 4 will give you a discussion on these topics after an introduction to the role of life species in ecosystems, keystone species and functional groups.

Comprehensiveness is the most significant characteristic in biological diversity research. The following two aspects can refer to the comprehensiveness, first, the comprehensiveness of all those levels from gene to landscape and even to the biosphere. The protection of endan-

gered species is not only limited to protect individuals at the species level, but already extends to discover mechanisms of species endangerment at levels of genes, cells and populations, to consider protection measures at levels of habitats or ecosystems. The second aspect is the comprehensiveness of different taxa and disciplines involved. For example, researches on the mechanism of maintenance of ecosystem diversity not only consider effects of ecological environment on system stability, but also pay more attention to effects of interactions among different taxa on system stability.

Biodiversity varies spatiotemporally, that is, growing out of nil and changing from simple to complex. The evolution of biodiversity has occurred at all of its levels, that is, closely related with both intrinsic mechanism of living organisms and changes of geosphere, hydrosphere and atmosphere.

Evolution of life is affected by such macroscopic factors as vicissitudes between ocean and land, the separation of Gawana and Laurasia, the drift of plates, and the vicissitudes of paleo-climate. During the evolution of biodiversity, the most astonishing event is nothing more than massive extinction of life species. What caused the massive extinction? Does it happen periodically? Regarding to the disappearance of dinosaurs, there are a variety of opinions, but no unanimous conclusion can be drawn from them. The event which happened in Quaternary more seriously affected the distribution of modern life species. During that era, because of the cold weather, glacial periods appeared on the Earth several times. The growth and retreat of pole glacier and alpine glacier modified habitats and the distribution of wildlife, and created conditions for species migration and new species formation. The Quaternary glacier also influenced the ecological environment of China, resulting in changes of vegetation among mixed coniferous deciduous forest, coniferous forest, grassland in alternation. Changes of vegetation caused fauna succession. The collision between the Indo-subcontinent Plate and the Eurasia Plate brought about the uplifting of Qinghai-Tibet Plateau. The raised plateau blocked warm and humid airflow and affected the air circulation in the north hemisphere.

Life species extinction and replacement occurs incessantly. The formation of new species increases biological diversity. However, there are heated debates on the concept of species in scientific circus. In the chapter of "Species and their formation", those concepts of species put forward by those Essentialists, Nominalists, Darwinists and biologists are discussed, respectively. The debates on the nature of species seemed to be originated from the emphases of different schools and thus resulted in the contending of different ideas. Since the birth of Modern Synthetic Evolution Theory, the biological species concept has been considered as most valuable one by evolutionary biologists. However, the evolution of a species from its ancestors cannot be always discrete and distinguishable event. The discontinuity in distribution, morphology, and reproductivity is also an important characteristic of species. The reproductive isolation is prerequisite for sympatric speciation and geographical isolation is also a possible cause. Human activities are major reason for modern species extinction and have directed the evolution of biological diversity.

With so many life species living on the Earth, to protect biological diversity, one of emergent tasks is to make an inventory of those species and to determine the list of identified species, and the range of their distribution in a specific region. Inventorying is the basis for biodiversity monitoring and research of conservation biology, and the prerequisite for conserving and sustainable utilizing biotic resources. Many globe-, region- and nation-wide inventories have already been implemented. Categorizing endangered species can simply and clearly demonstrate the status of endangered species and provide foundation for the implementation of species protection. The categorization of endangered species is generally based on their population size, their population characteristics, their range distribution, their habitat area and quality, causes of their endangerment. The categorization of species endangerment of the International Union of Conservation of Nature, the World Conservation Union (IUCN) contain eight levels, including extinction (EX), extinct in the wild (EW), critically endangered (CR), endangered (EN), vulnerable (VU), lower risk (LR), data deficient (DD), and not evaluated (NE). The Conservation on International Trade in Endangered Species of Wild Flora and Fauna (CITES) decided the conditions of sign-off for the trade certification according to the degree of species endangerment. Because of the limited manpower, and material resources for the protection of biological diversity, in order to use those resources effectively, it is necessary to determine an order of priority for species protection. Generally, the priority is given to on the measurement of species diversity with emphasis on the endemism, keystone flora and fauna, and then set protection priority to determine which region should be protected first.

Scientists usually divide populations of endangered species into small populations and declining populations. Small population refers to those with extremely low number of individuals, which may extinct soon. Small populations hold special meaning for the protection of biological diversity. Declining population denotes those with large but decreasing number of individuals because of the pressures from destruction of habitats and hunting, but there is no clear line between the two terms. A population is a declining one when its size is diminishing. If no immediate measures are taken, the declining population will be destined to be a small population. Hence, declining populations and small populations are two different phases of endangered species only with different number of individuals. With the computer simulation technology, population viability analysis (PVA), which calculates the living probability of a population, can determine the surviving time of a small population. For different life species in different ecological environments, their smallest viable population sizes are different, thus, there is no common size of smallest viable population. Nevertheless there are quite developed methods for the analysis of small population viability, however, the analysis of declining population viability is still premature. Crested ibis is a critical small population. PVA of Crested ibis is introduced in Chapter 10.

It is undoubtedly an optimal choice to protect an endangered species in its original habitat. However, when the wild population of an endangered species is close to extinction and its habitat does not exist anymore, *ex-situ* conservation will provide last choice for its protec-

tion. In fact, many life species, such as Przewalcki's Horse, Arabian Oryx, and Pere David's Deer still living up to now, are right protected by *ex-situ* conservation. *Ex-situ* conservation includes the transfer of endangered species to both other habitats and artificial environment. The aim of the management of those populations is to or restore their wild populations. North American Black-footed ferret is a successful example. In *ex-situ* conservation environment, the development of individual behavior is easily neglected, so attention should be paid to the influences of imprinting and parental care on behavior development of juveniles. Special attention should be paid to training the captively bred individuals to learn to identify natural enemies and preys. Modern zoological parks, aquariums and botanical gardens have the responsibility to conserve, to breed, and to exhibit animals and plants, however, problems still exist such as small populations, heterozygosity and artificial selection in zoos, aquariums and botanical gardens. Large seed banks and gene banks have preserved a huge amount of genetic resources. Global actions are involved in present life species conservation, and the Conservation Breeding Specialist Group (CBSG) of the Species Surviving Commission (SSC) of IUCN has contributed much to the coordination and implementation of global off site conservation.

Since 1970's, gene engineering technologies such as DNA recombination, cell fusion, gene conversion have emerged, and now, we can transfer them to the genetic material of other organisms to produce human desired features. Till the end of 1995, American government has approved more than 10 agricultural products of gene engineering to market, and totally 311 genetically modified living organisms approved by Europe Union were released to environment from 1991 to 1994. Five years later (from 1991), the total sale of biotechnological products amounted to 6 billion in American markets. However, DNA gene recombination may be harmful to environment, such as crops with conversed genes may turn into weeds, thus bring about negative effects on the protection and sustainable utilization of biological diversity, likewise to human beings' health, and debates on moralities may be triggered when human genes are involved in conversion. Therefore, relevant agencies began to pay attention to those happenings. Biotechnology depends on biodiversity to provide genes, and it can also preserve the genetic resources for biodiversity and may produce new varieties and species. Because of these potential dangers, biotechnology risk assessment of should be strengthened.

Mankind has now already stepped into a civilized society and all countries have drafted laws to regulate people's activities of using natural resources, in order to protect the environment on which human beings depend and utilize biotic resources sustainably. For protecting the common environment of human beings, all countries are now seeking international cooperation to confine nations' actions, to coordinate actions for environmental protection and to ensure rational development of global environmental resources, and a series of international conventions have been formulated, such as Biodiversity Convention, the Convention on International Trade of Endangered Wild Flora and Fauna and the Convention on the Protection of Migratory Species. At the same time, many nations also have settled down some bilateral

or multi lateral treaties. Based on the principles of coordination between social economic development and environment protection, and respect for nation's sovereignty public ocean, outer space and the south pole can be managed the international society. Since the beginning of 1980's, the legislation on environment has developed rapidly in China. The principal law for environment protection in China is "The Law of Environment Protection of People's Republic of China", which was issued in 1989. Besides, China has also formulated some specific laws for controlling environment pollution, for the protection of oceanic and terrestrial living organisms, for the construction and management of nature reserves, and for the protection of wildlife species.

Nature reserves are set up to protect life species and their habitats, However, the existing. Existing nature reserves have not covered all areas with high biodiversity and of potential protection value. Using geographic information system (GIS) technology, Scott et al. analyzed the spatial information of relevant biological diversity to find lacuna areas of biodiversity protection. This technology is called GAP method. Nature reserves also have the responsibility to protect nature value other than biological diversity. So, the construction of nature reserves needs to consider ecosystem typicalness, fragility, species rarity, destruction degree by pollution, attraction of natural beauties and potential economic and scientific values. Generally, there are conflicts between Conservation and economic development, then it is necessary to make decision in line with local conditions whether to build one reserve with larger area, or several ones with smaller area. On the other hand, habitat corridors should be designed to link nature reserves to provide passages for the migration of wildlife. The effectiveness of habitat corridors depends on their width, and different species need significant different width of corridors. Nature reserves can be divided into kernel protection zones, buffer zones, and scientific experimental zones. To carry out eco-tourism in the experimental zone of nature reserves is a way to obtain revenue for the maintarinarie of natural reserve. However, the tourism management of nature reserves should match the goal of biodiversity protection, do best to abate the negative impacts resulting from tourism and allocate the earning rationally. Much relevant work has been carried out internationally. After the construction of nature reserves, their management should be based on the biological principles, and their ecological evaluation and management assessment should be implemented periodically.

The development of non-destructive DNA sampling technology greatly simplified procedures of DNA determination, and made it possible to identify the parenty in wild population, thus could more truly reflect genetic background of all kinds of life species and provide important genetic data and basis for the decision-making of conservation strategy. In the meantime, scientific research and the sense of protection can really go well with each other, that is, research will not be harmful to its objects any more. Using this technology in research on molecular evolution of some precious and endangered animals and conservation genetics will be helpful to reveal the evolution history of life species or populations, their evolution potential and future destination, and to inquire into the causes of species endangerment. Experts