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ASIAN ECOLOGY: PRESSING PROBLEMS AND RESEARCH CHALLENGES

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Introduction

Unprecedented economic developments in Asia in recent decades have made it a new center of the world economic growth (see Appendix 1 for the division of Asian regions and constituent countries). With more than a half of the world's population and a economic growth rate of 2 to 3 times the global average, a variety of ecological and environmental problems in Asia, including air pollution, water shortage and contamination, soil erosion, desertification, and resource depletion, also have become increasingly pervasive and severe. Asian countries vary considerably in natural environment, ecological conditions, economy, and political regimes. Although the quality of life varies greatly among the nations, it tends to be correlated with the quality of the environment in general.

With its huge human population and enormous biological resources, Asia's ecological conditions will continue to be crucial to the overall quality of the global environment. Many of the global ecological connections may be perceived in terms of biodiversity and biogeochemical cycles. As the largest continent in the world, Asia is a major source of global biodiversity. The transportation of greenhouse gases and air pollutants show no respect for the boundaries between nations or even those between continents. According to estimates in 1991, 25% of world emissions of the greenhouse gas CO_2 came from the Asia-Pacific region, and if this trend continues, the projected contribution from this region may go up to 36% in 2025 and over 50% by the end of the 21st century (JEC 2000, World Bank 2000). In some cases, such global linkages are quite acute and spectacular. For example, the gigantic dust storm generated in northern China in April 2001 traveled over the Pacific Ocean to North America and then over the Atlantic Ocean! A similar one repeated within less than a year in March 2002.

It seems clear that more than anytime before do ecologist need to become more "global" in their research activities and perspectives because of the inevitably increasing global connectivity in ecology, economy, culture, and politics. Many ecological studies can benefit from a global perspective. This is especially true for human-dominated ecological systems (e.g., urban ecology and agricultural ecology) where cultural and economic differences not only contribute to, but also constitute, the solutions to the problems, and for broad-scale environmental problems (e.g., regional and global ecology) which operate interactively in a global context.

This paper provides a brief overview of some of the pressing environmental problems in Asia as well as challenges in ecological research. In addition, information on various research institutions and organizations in a number of Asian countries is provided, which is hopefully useful for stimulating more international ecological collaborations in these areas.

State of the environment: Living Planet Index and Ecological Footprint

The state of the environment, in terms of biodiversity and ecosystem services, has declined throughout the world with the ever-increasing human population and activities. This trend has been widely documented using various methods and measures. Two simple synoptic indices, Living Planet Index (LPI) and Ecological Footprint (EF), are helpful for acquiring an overall picture of the general environmental conditions at the regional and global scales. LPI is a measure of the natural wealth of the Earth's forest, freshwater, and oceanic/costal ecosystems (WWF/UNEP 2000). LPI is calculated as the average of three indices that monitor population changes of animal species in forest, freshwater and marine ecosystems, respectively (i.e., forest species population index, freshwater species population index, and marine species population index). Each ecosystem index indicates the average population trend for a sample of animal species, and its value at the reference year (1970) is set to zero. The forest index includes 319 species, the freshwater index 194 species, and the marine index 217 species (WWF/UNEP 2000). The three indices showed an average decline of about 12%, 50%, and 35% from 1970 to 1999, respectively, while LPI decreased by about 33% for the same period (Fig. 1). The regional-level analysis suggests that LPI for Asia has declined faster than the global average (WWF/UNEP 2000).

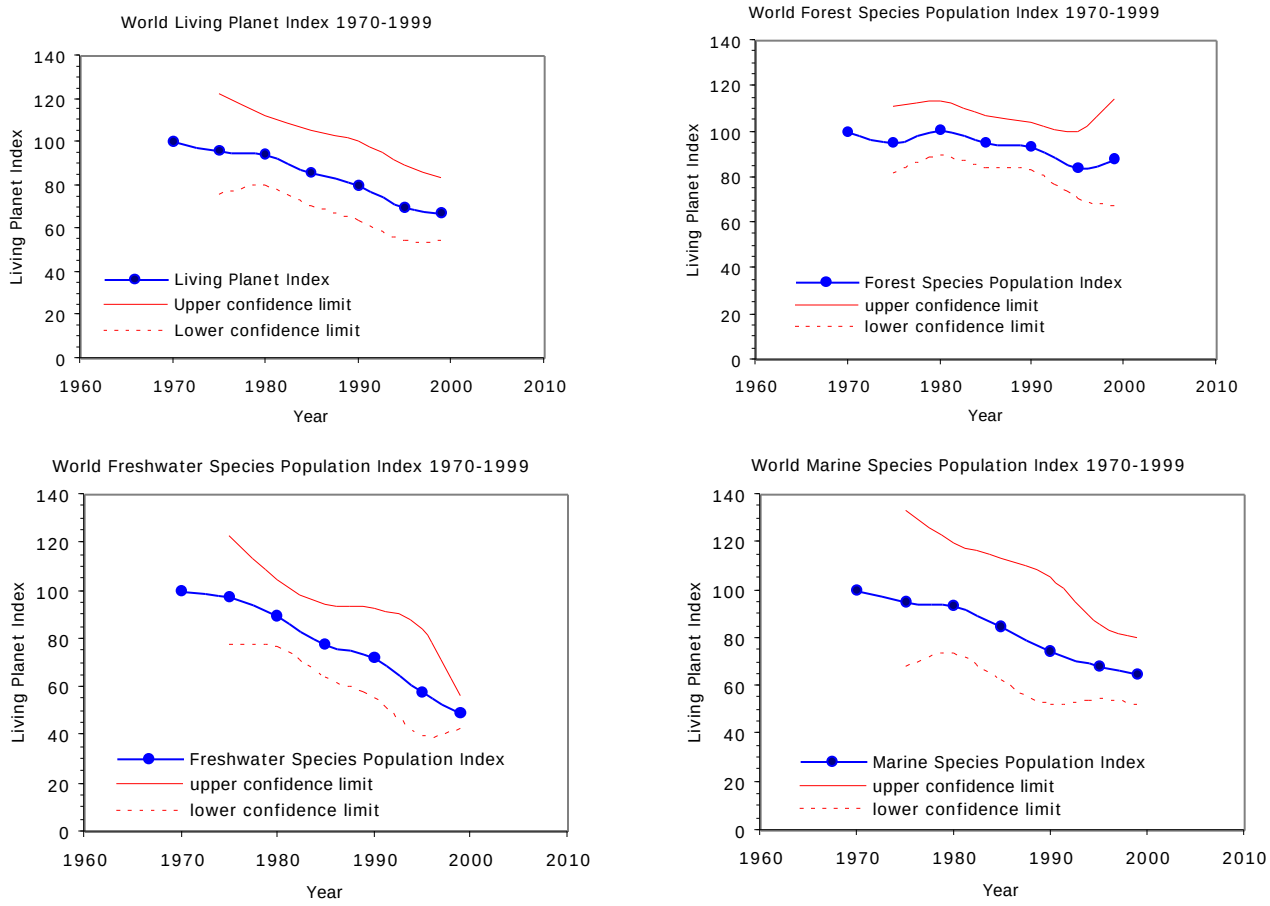

Fig. 1. Living planet index (LPI), a measure of the natural wealth of the Earth's forest, freshwater, and oceanic/costal ecosystems, shows a declining trend in environmental conditions at the global scale (Data from WWF/UNEP 2000).

Although numerous factors are responsible for environmental and ecological degradation throughout the world, the rapid increase in human population is the most important root cause. Ecological footprint has been used to assess human pressures on the natural environment at spatial scales from individual humans, cities, nations, to the entire globe (e.g. Wackernagel and Rees 1996, Folke et al. 1997, 1998, Luck et al. 2001). EF is usually calculated in terms of the area of biologically productive land or sea required to produce food, materials and energy or, in the case of energy, to absorb the corresponding CO_2 emissions for a given population. The ecological footprint of an individual is the sum of six separate components: the area of cropland required to produce the crops which that individual consumes, the area of grazing land required to produce the animal products, the area of forest required to produce the wood and paper, the area of sea required to produce the marine fish and seafood, the area of land required to accommodate housing and infrastructure, and the area of forest that would be required to absorb the CO_2 emissions resulting from that individual's energy consumption. In 1996 the global average of per capita ecological footprint was 2.85

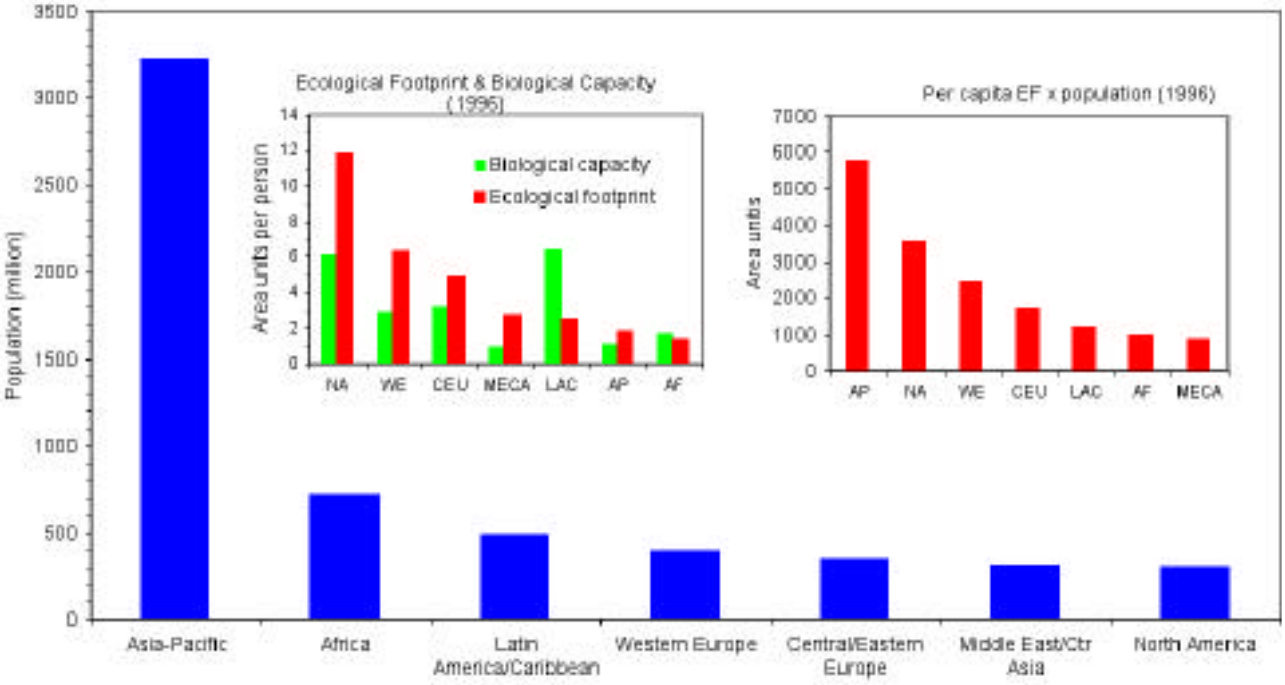

Fig. 2. Population sizes of the different regions of the world and their ecological footprints (EFs). EF is a measure of human pressures on the environment in terms of the area of biologically productive land or sea required to produce food, materials and energy or to absorb CO_2 emissions for a given population (Data from WWF/UNEP 2000).

hectares of biologically productive space with world average productivity (i.e., EF area units), and the footprint of an average consumer in the industrialized world was about 4 times that in the lower income countries. The global ecological footprint has increased from about 9 billion area units in 1961 to 17 billion area units in 1997, and it increased by 50% between 1970 and 1997, a rise of about 1.5% per year (WWF/UNEP 2000). Although the per capita EF of Asia is relatively small as compared to North America, its huge population size makes its regional-scale EF (per capita EF times the population of the region) much larger than that of North America (Fig. 2). The EFs of individual countries in Asia vary greatly, and have far exceeded the existing biological capacity in most countries (Fig. 3).

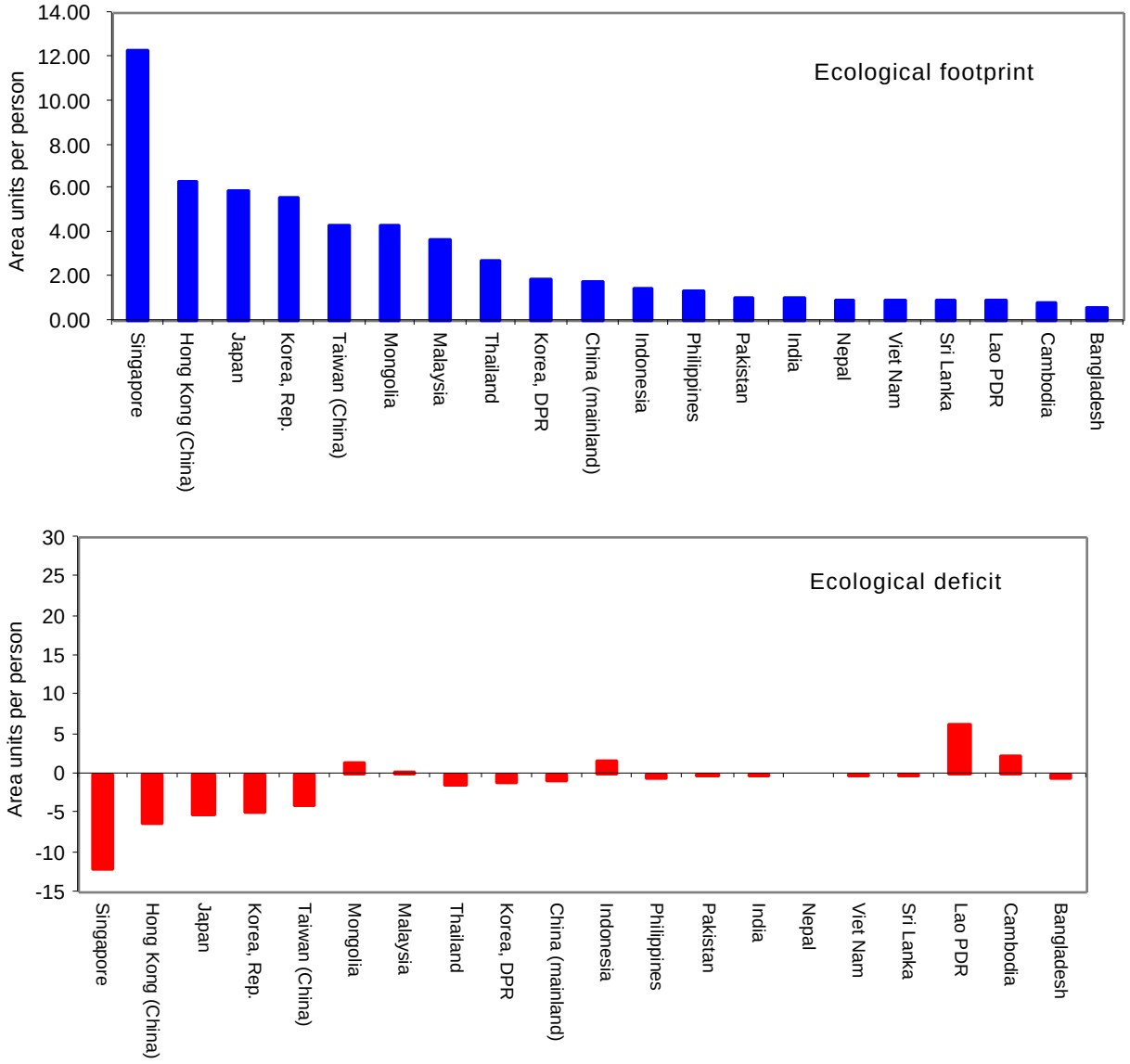

Fig. 3. Variations in ecological footprint and ecological deficit among Asian countries (Data from WWF/UNEP 2000). Ecological deficit is defined as the difference between ecological footprint and existing biological capacity.

Pressing environmental problems in Asia

High population density

Asia has more than half of the nearly 6 billion world population. The problems of fast population growth and high population density are pervasive across Asia, and invariably associated with the problem of shortage of arable land (Fig. 4). The average population density of the Asia-Pacific region reached 90 persons/km^2 in the early 1990s, while its average availability of arable land was only about 15% (FAO 1996, UNEP 2000). South Asia had the highest average population den-

sity (186 persons/km^2) and the highest proportion of arable land (39%), and the lowest extent of forest cover (less than 20%). Southeast Asia, with a population density of 104 persons/km^2, has more than 50% of its land forested and about 18% cultivated. East Asia's population density was 120 persons/km^2, with only 9% of its area available as arable land. China may be the richest country in Asia in terms of the absolute amounts of natural resources, but is among the poorest on the per capita basis. For example, the per capita arable land of China is only 0.086 ha, one-fourth the world average (0.344 ha); each Chinese has 0.133 ha of forested land, only 11.3% of the world average (JEC 2000).

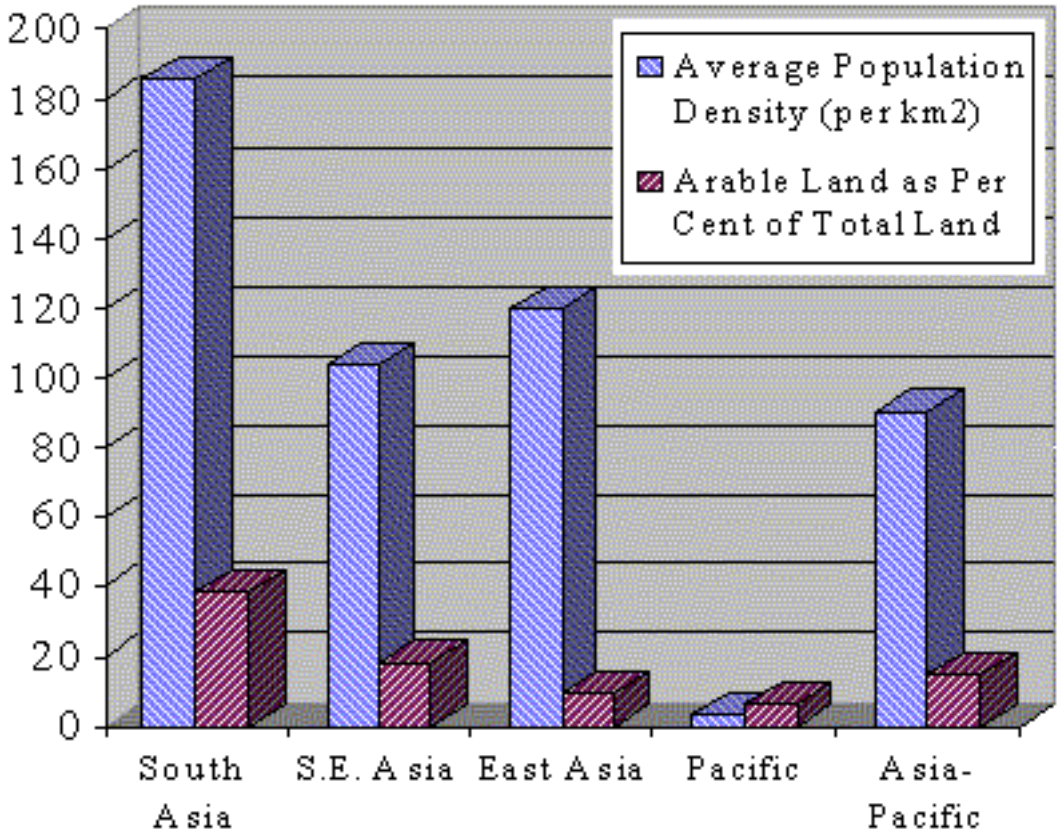

Fig. 4. Population density and arable land in Asia-Pacific region in 1992 (UNEP www.eapap.unep.org).

The driving forces for the different environmental problems in Asia (as well as in the rest of the world) are fundamentally related to human population growth which increases the use of natural resources and production of wastes. Rapid population growth in Asia has contributed to the destruction of natural habits, wide-spread land conversion, and increased intensities of land use, further resulting in a series of problems of ecosystem degradation including desertification, salinization and alkalization, water-logging, and air and water pollution.

Land degradation

Human survival and prosperity are dependent ultimately on the productivity of the lands on which populations reside. However, human abuses of the land have resulted in desertification, which is land degradation in arid, semi-arid and dry sub-humid regions and may lead to the perma-

nent loss of land productivity (Wu 2001). Desertification has affected more than one hundred countries spreading across six continents, and most of the desertified lands are found in Asia and Africa (Table 1).

Table 1. Desertification in different regions of the world (from Thomas 1995).

Region	Total dryland area (10^3 km^2)	Desertified area (10^3 km^2)		
		Light and moderate	Strong and extreme	Total area of desertified land
Asia	16718	3267	437	3704
Africa	12860	2453	740	3193
Europe	2997	946	49	995
Australasia	6633	860	16	876
North America	7324	722	71	793
South America	5160	728	63	791
Total	51692	8976	1376	10352

About 15 million acres (more than 6 million hectares), an area equal to the size of the state of West Virginia, become desertified annually. Of the world's rangelands, 73% are at least moderately desertified, and 47% of the world's rain-fed croplands are at least moderately desertified (Asia and Africa most serious). Almost 30% of irrigated cropland is moderately desertified, of which Asia has the highest proportion. The Asia-Pacific region accounts for more than 70% of the world's agricultural population but only 30% of the world's agricultural land. Production increases in the last decades have been achieved at considerable costs to the resource base and largely by means of heavy external inputs: irrigation, seeds, fertilizers, pesticides, etc. (FAO 1996). In many regions of Asia, the loss of vegetation cover and soil erosion due to water and wind are seriously altering the structure and function of natural ecosystems. 16% of Asia's agricultural land are considered severely degraded (loss of 50% of its production potential). In India alone, 38.5% of its 32.77 million hectares of agricultural land has been affected by severe water erosion. China, with one-fifth of the world population, has more than 358,800 km^2 of desertified lands; over 96% of these areas (345,046 km^2, including potential desertifying and desertified areas) is found in northern China (Zhu 1989, Wu and Loucks 1992). This large-scale land degradation in northwestern China may have been a major factor for the rapid increase in the frequency and scope of the horrifying dust-storms in recent decades, which blacked out the city of Beijing and dimmed the sky of the western states of USA.

The two major types of land degradation in Asia-Pacific are water erosion (523.4 million ha, 61%) and wind erosion (238.6 million ha, 28%), together accounting for nearly 90% of the degraded lands (UNEP www.eapap.unep.org). Although both human activities and climate variations contribute to desertification, overcultivation, overgrazing, urbanization, fuelwood collection, and salinization are the primary causes. In the Asia-Pacific region 310 million hectares (37%) of degraded lands was caused by vegetation removal, 280 million hectares (33%) by overgrazing, 212 million hectares (25%) by agricultural activities, 46 million hectares (5%) by overexploitation, and 1 million hectares (<1%) by industrial activities (Oldeman 1994, UNEP/ISRIC 1990, UNEP 2000).

Efforts of land rehabilitation have been made in Asia. For example, China has achieved remarkable progress in controlling soil erosion through the implementation of water and soil conser-

vation measures since the early 1980s. About 22% of China's desertified land was rehabilitated or treated to stop further deterioration in the past few decades (UNEP 2000). Watershed management programmes have been implemented extensively in India to combat the problem of soil erosion, and over 30,000 hectares of shifting and semi-stable sand dunes have been treated with shelter belts and strip cropping (UNEP 2000).

Urbanization

Urbanization has profoundly transformed the natural landscapes everywhere throughout the world, inevitably exerting pervasive effects on the structure and function of ecosystems. According to United Nations, the world urban population was only a few percent of the global population in 1800's, but increased to nearly 30% in 1950 and reached 50% in 2000. Nearly 40% of the population of the Asia-Pacific region is urban, and the region owns 13 of the 25 largest cities of the world. It has been estimated that by 2015 about 903 million people in Asia will live in cities with more than one million population (WRI/UNEP/UNDP/WB 1996, 1998). While the world urban population is projected to rise to 60% by 2025, nearly half of this is to reside in the Asia-Pacific region. Undoubtedly, urbanization in Asia will continue to have significant impacts on the environment as well as on economic, social and political processes at local, regional and global scales (e.g., ESCAP 1993, Ness and Low 2000).

Rapid urbanization in most developing countries in Asia since the 1990s has been accompanied by a proliferation of slums and dysfunctional neighborhoods with high health risks. For example, it was reported that only 8 of the 3,119 towns and cities in India had full wastewater collection and treatment facilities and 209 have partial treatment facilities (ESCAP 1993, UNEP 2000). High rates of urbanization and industrialization have increased the demands for land, water, and energy, and resulted in expanding transportation networks that constitute a key accelerating factor in economic growth as well as environmental degradation. For example, urbanization and economic growth in many Asian countries frequently result in air and water pollution, loss of productive agricultural land, loss and fragmentation of species habitats, over-extraction of groundwater resources, and deforestation as a consequence of increased demand for construction timber (UNEP 2000). It is important to realize that the ecological influences of cities go far beyond the space they occupy. Their ecological footprints can be enormous because of their huge demands for energy, food and other resources, and the regional and global impacts of their wastes and emissions to soil, air and water (UNEP 1999, Luck et al. 2001).

Loss of biodiversity

It is estimated that 12.5 million species exist , of which 1.7 million have been identified (WCMC 1992). The moist tropical forests account for only 8% of the world's land surface, but probably hold more than 90% of the world's species. Asia is one of the richest regions in biodiversity, along with Africa, the Pacific, and Latin America (UNEP 1999). In particular, China, Indonesia, Thailand, India, Malaysia, and Papua New Guinea host a huge number of species of fish, amphibians, reptiles, birds, and mammals (Table 2). Unfortunately, Asia is also a region where the loss of biodiversity has been dramatic in past decades (Fig. 5).

The underlying causes of the loss of biodiversity in Asia are mainly population growth, land use and land cover change, unsustainable exploitation of natural resources, the introduction of non-native species, international trade (particularly timber), and environmental pollution including improper use of agrochemicals (UNEP 1999, 2000). For example, two-thirds of Asian wildlife habitats

have been destroyed with the most acute losses in the Indian sub-continent, China, Vietnam and Thailand (Braatz 1992). Air and water pollution stress ecosystems and reduce populations of sensitive species, especially in coastal zones and wetlands (UNEP 1999).

Environmental pollution

Atmospheric pollution is a wide-spread problem in Asia (JEC 2000, Lelieveld et al. 2001). The Asian-Pacific region has experienced significant growth in atmospheric pollution due to the heavy use of coal and high sulfur fuels, traffic growth and forest fires (UNEP 1999). In West Asian regions, air pollution is only a problem in relatively large cities, but exacerbated by the high temperatures and levels of sunlight. While SO_2 emissions in Western, Central and Eastern Europe fell by 50% between 1985 and 1994 in line with the Convention on Long Range Transboundary Air Pollution protocols (Berge 1997), they continue to increase in Asia and will likely far exceed those in North America and Europe combined in future (Fig. 6). The most serious air pollution problems often occur in urban areas. A survey by the World Health Organization (WHO) and United Nations Environment Program found that the levels of suspended particulate matter (SPM) in 10 of the 11 cities they examined were 2 times higher than WHO's guidelines – dangerous to human health. Problems of SO_2, lead and SPM pollution are serious in many cities of Asia-Pacific (Table 3). There is little doubt that air pollution will continue to increase in major Asian cities such as Beijing, Tokyo, Seoul, Taipei, Jakarta, and Bangkok in the early 21st century.

Other serious environmental problems in Asian cities include water pollution, solid waste accumulation and disposal (including toxic and hazardous wastes), and noise (UNEP 1999). Non-source pollutions are a pervasive problem in most of the developing countries in

Table 2. The total number of known species in selected countries of the Asia-Pacific region (IUCN 1994, UNEP www.eapap.unep.org).

Country	Amphibians	Birds	Fish	Mammals	Reptiles
China	263	1244	686	394	340
Indonesia	270	1531	N/A	436	511
Thailand	107	915	>600	265	298
Australia	205	751	216	252	748
India	197	1219	N/A	316	389
Malaysia	158	736	449	286	268
Papua New Guinea	197	708	282	214	280
Lao PDR	37	651	244	172	66
Pakistan	17	671	156	151	172
Japan	52	583	186	132	66
Bangladesh	19	684	N/A	109	119
Cambodia	28	429	>215	123	82
Afghanistan	6	460	84	123	103
Bhutan	24	543	N/A	99	19

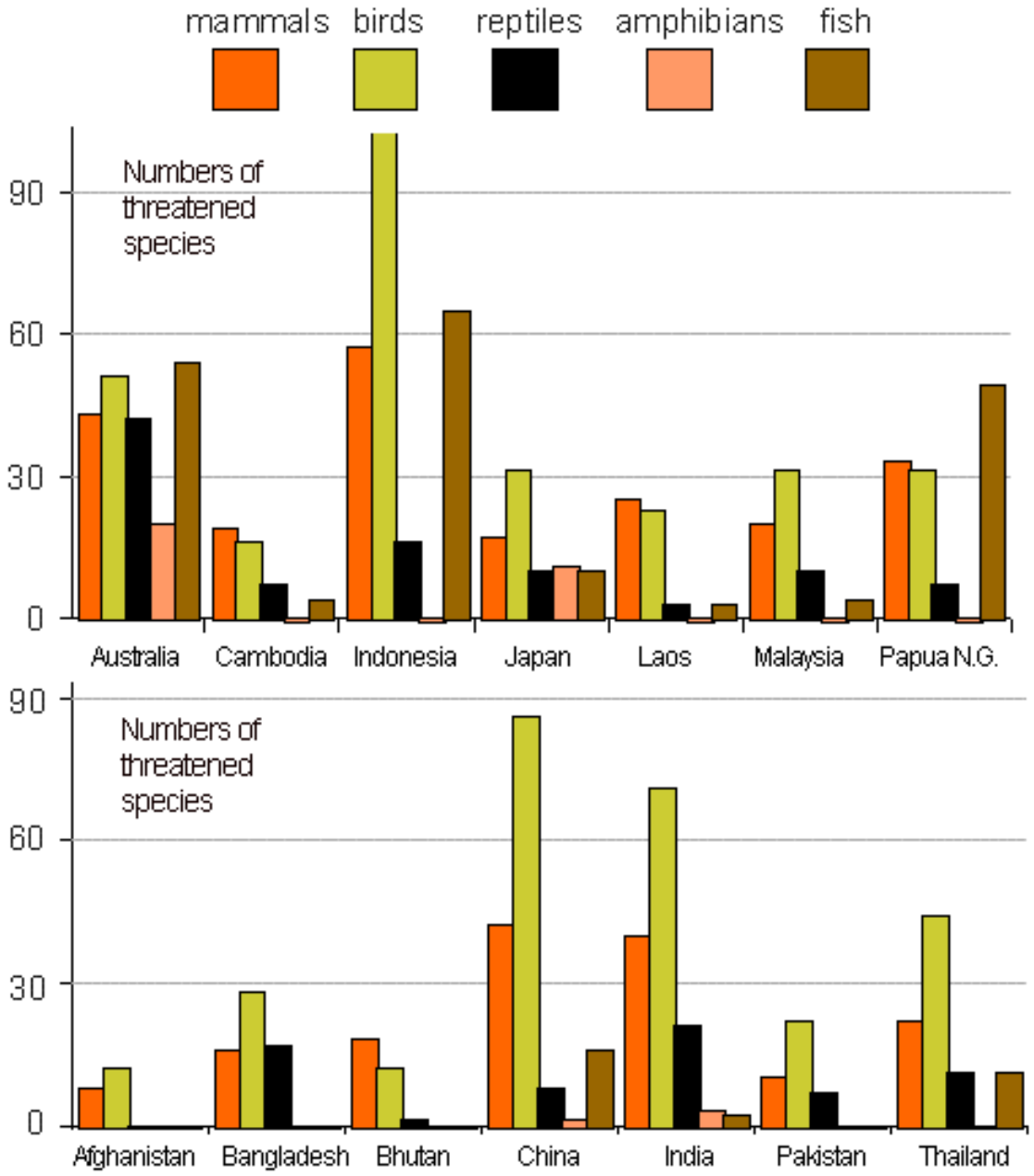

Fig. 5. The number of threatened species by group in selected countries of the Asia-Pacific region (IUCN 1994, UNEP www.eapap.unep.org). The number of threatened species includes all species that are classified by the World Conservation Union as endangered, vulnerable, rare, and indeterminate, but excludes introduced species and those that are known to be extinct or whose status is insufficiently known.

Asia in which agriculture is the primary industry. For example, India alone uses 55,000 metric tons of pesticides a year, of which 25% end up in the sea, and the increased use of pesticides has resulted in contamination of shell and finfish (UNEP 2000). The "red tides", caused by blooms of particular plankton species, deplete oxygen levels resulting in mass deaths of aquatic organisms, and cause

paralytic shellfish poisoning that poses human health risks. Red tides have recently become a major environmental and economic problem in several coastal areas of Philippines, China, and other Asian countries (UNEP 2000).

Table 3. Air quality in 11 megacities of the Asia-Pacific region (UNEP www.eapap.unep.org).

City	SO	SPM	Lead	CO
Bangkok	L	H	M	L
Beijing	H	H	L	L
Bombay	L	H	L	L
Calcutta	L	H	L	L
Delhi	L	H	L	L
Jakarta	L	H	M	M
Karachi	L	H	H	L
Manila	L	H	M	L
Seoul	H	H	L	L
Shanghai	M	H	L	L
Tokyo	L	L	L	L

Challenges for ecological research

Given the several pressing environmental problems, Asian ecology faces a number of grand challenges. In the following, we discuss several major challenges that seem most urgent and important to Asian ecology in the coming decades. Of course, some of these challenges are not just unique to Asia; they are indeed relevant to ecological research across the world. Also, they are inherently interrelated to one another, and it is difficult to assess which one is more crucial. Thus, the sequence of the challenges, as listed below, does not necessarily reflect the order of urgency or importance.

1. Crisis-oriented ecology as a research priority

We use the term, "crisis-oriented" ecology, to refer to research that directly and rigorously tackles pressing environmental problems based on ecological theory, principles, and methodologies. In the history of ecology, many studies once were motivated primarily by the curiosity of the investigators, rather than real-world problems or societal needs. These "good and old days" seem to have long passed. While there always are a great number of intellectually or academically intriguing, but realistically moot questions ecologists can pursue, it is high time for us, as scientists and citizens, to assume the imperative responsibility of helping resolve real-world problems and improve the environment. Indeed, maybe because of the exceptionally high population and already seriously deteriorated ecosystems in this region, Asian ecologists seem acutely aware of this, and the emphasis of their research seems to indicate such consciousness.

However, it remains a grand challenge to prioritize "crisis-oriented" ecological studies on the research agenda in many Asian countries because of: (1) the inertia of the traditional perception that basic research is superior, (2) limited funding sources with many competing interests, and (3) attrac-

tions of internationally "trendy" or "politicized" research topics. In fact, the dichotomy between basic and applied research may be misleading, at least, in ecology simply because neither of them can be worthwhile without relevance to the other. Explicitly setting crisis-oriented ecological research as a priority is only to give more emphasis on the most urgent and important problems, not to undermine the significance of basic research. Several fields may be considered as crisis-oriented: for example, conservation biology, restoration ecology, ecosystem management, ecological and environmental toxicology, agroecosystem ecology, and urban ecology.

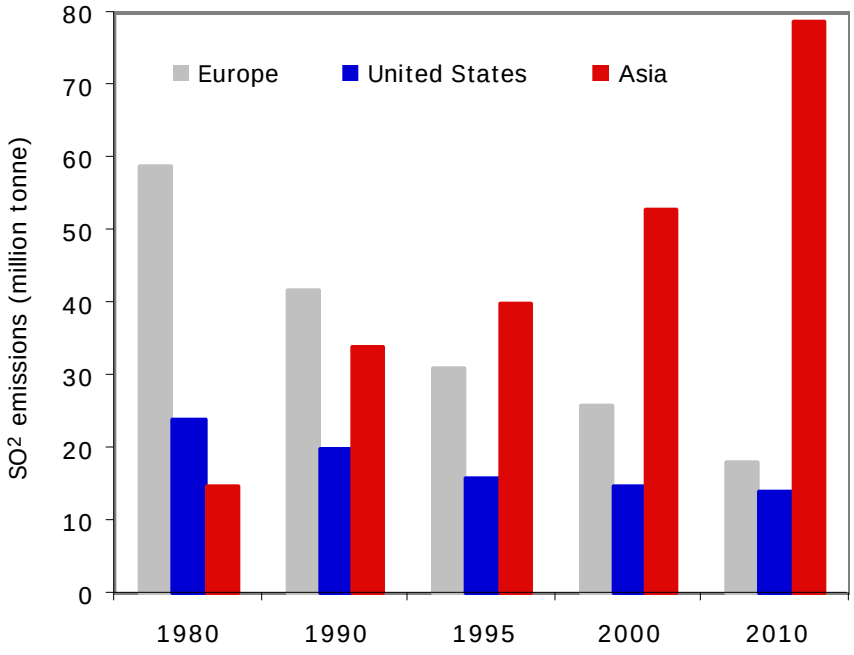

Fig. 6. Comparison of SO_2 emissions from Asia, Europe, and the United States in different decades (data from Worldwatch Institute 1998).

2. Integrating research with applications

In order to effectively integrate research with applications, ecologists are challenged to deal with real-world problems, to work directly with resource managers, planners, and policy makers, to communicate across disciplinary boundaries, and to go beyond the "research-publication sequence" to follow through the "research-application cycle". Given the variety of political and economic conditions in Asia, such integration may take different forms and be carried out at different scales.

3. Large-scale ecology

Most environmental problems, such as biodiversity loss, land degradation, pollution, urbanization, and global climate change, must be dealt with on multiple and broad scales in time and space. Arguably, landscapes and regions based on biogeographical units and bioclimatic conditions may represent scales at which many of the pressing environmental problems can be tackled most effectively. Dealing with large-scale ecological phenomena requires theory, methods, and technologies (e.g., GIS and remote sensing) to acquire, analyze, and synthesize information on spatial heterogeneity of biodiversity and ecological processes across a range of scales. In particular, landscape and regional ecology, which is among the weakest areas in Asian ecology, ought to play a much more important role. In general, to achieve any long-term success in biodiversity conservation, ecological restoration, or environmental management, the landscape and regional context must be explicitly considered.

4. Interdisciplinary and holistic ecological research

Holistic research methods that emphasize the nonlinear interactions, emergent properties, and integrity of systems are quite familiar to many scientists in Asian countries (especially China and Korea). However, such approaches have to go beyond the current more or less philosophical frameworks based on doctrines such as "yin-yang", "five-element", and "feng-shui", and substantiate them with rigorous scientific methods. Also, interdisciplinarity is or should be a hallmark of crisis-oriented and large-scale ecology. To effectively study and resolve the pressing environmental problems in Asia, successful integration among different disciplines in earth sciences and between natural and social sciences is imperative. Such integration requires holistic approaches as well as collaborations among scientists, practitioners, and policy-makers.

5. Education and training

Comprehensive and integrative university curricula and professional training programs (within and outside academic institutions) need to be established and strengthened. These curricula and training programs should emphasize the interdisciplinarity and holistic nature of environmental and ecological problems. They also need to highlight the unique ecological and socioeconomic characteristics of Asian ecosystems, and accommodate the diverse needs of students and professionals who have different interests and backgrounds. In addition, through outreach programs and other means, effective communication with the public and decision makers needs to be considered explicitly part of the ecological program at both the university and national levels.

6. International collaborations

International collaborations are critical for meeting any of the above challenges in Asian ecology because: (1) The majority of the recent advances in ecological theory and applications have been made outside Asia, (2) As compared to the western world, most Asian countries have a relatively small number of ecologists with respect to their huge population sizes and they are often inadequately trained, (3) Many of the pressing environmental problems in Asia go beyond individual countries and even the continent, and (4) Ecological research in most Asian nations, especially those developing countries, are seriously limited by funding sources.

There already exist several rather visible international collaborative networks that involve many countries and regions in Asia, such as MAB (Man and Biosphere), ILTER (International Long-Term Ecological Research network), and GCTE (Global Climate and Terrestrial Ecosystems) of IGBP (International Geosphere and Biosphere Programme). Also, in recent decades there have been an increasing number of international collaborative research projects, concentrating on the tropical and subtropical regions of Asia. However, more international collaborations at different levels and in different forms are needed, which include ad hoc and periodic international training programs and workshops for students and researchers, and collaborative research projects at the levels of individual investigators, institutions, nations, and international organizations.

With the increasing "globalization" of ecological problems and ecologists' search for understanding and solutions, it is likely that more ecological scientists want to be engaged in international collaborations in Asia. This paper, in a way, is intended to be a stimulus for promoting further research collaborations between ecologists in Asia and the rest of the world. Finding out the needed information on potential collaborative institutions or researchers in some Asian countries can still be difficult, although the situation is improving thanks to the advances in information technology. We have compiled a number of research institutions in Asian countries, with brief introductions and web addresses, which hopefully will be useful to those who are interested in ecological studies in Asia (Appendix 2).

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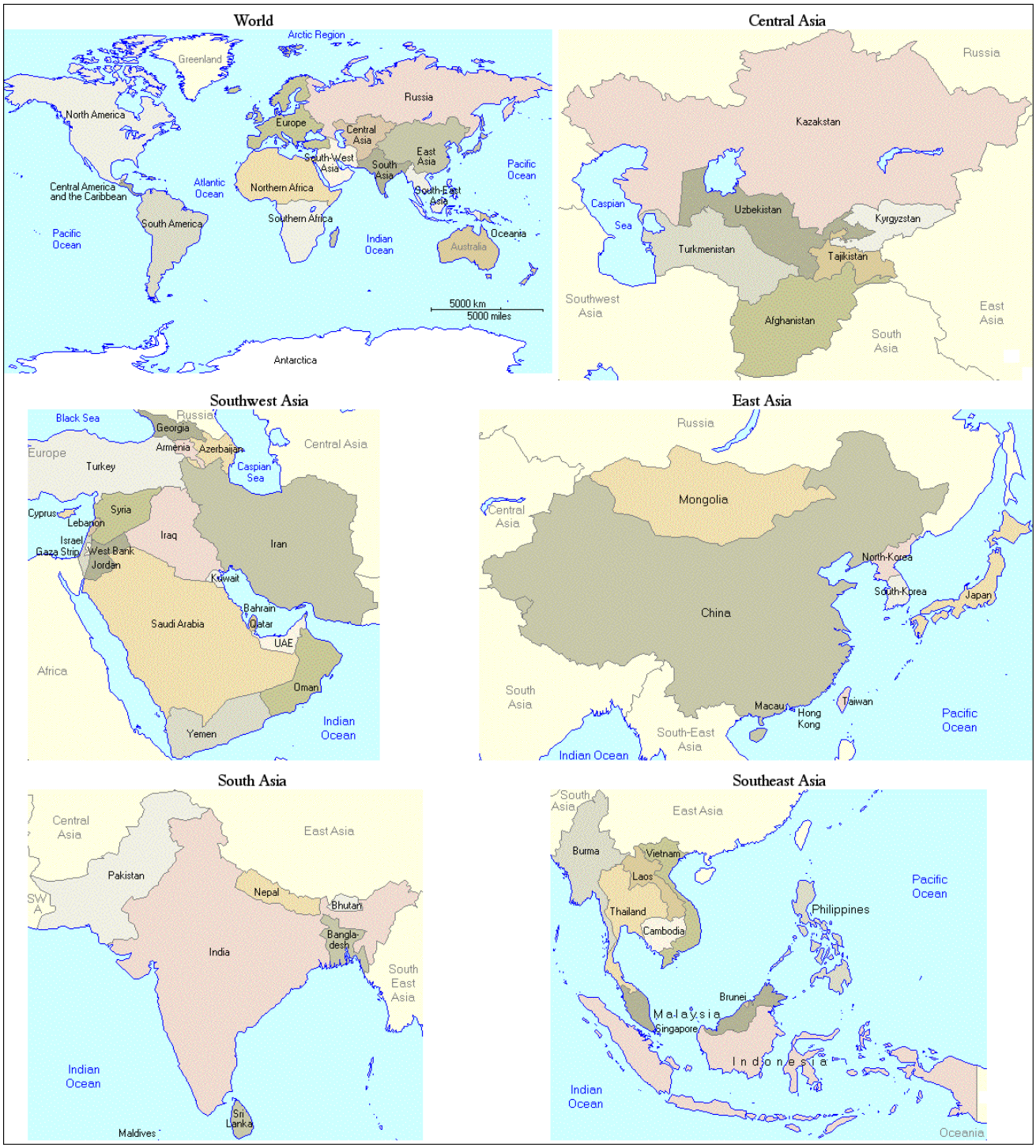
Appendix 1a. Asian regions and constituent countries (see maps in Appendix 1b).

Asia-Pacific	China, South Korea, North Korea, Mongolia, Japan, Afghanistan, Bangladesh, Bhutan, India, Iran, Nepal, Pakistan, Sri Lanka, Cambodia, Lao PDR, Myramar, Thailand, Viet Nam, Indonesia, Malayasia, Philippines, Singapore, Fiji, Papua New Guinea, Soloman Islands, Australia, New Zealand
East Asia	China, South Korea, North Korea, Mongolia, Japan
South Asia	Afghanistan, Bangladesh, Bhutan, India, Iran, Nepal, Pakistan, Sri Lanka
Southeast Asia	Cambodia, Lao PDR, Myramar, Thailand, Viet Nam, Indonesia, Malayasia, Philippines, Singapore
Pacific	Fiji, Papua New Guinea, Soloman Islands, Australia, New Zealand

Appendix 1b. Maps of Asian regions.



Appendix 2. Some research institutions and organizations in Asia that may be of interest to ecologists.

Country	Institution/Organization /Web Address	Description
China	Chinese Academy of Sciences (CAS) Headquarters: Beijing, China www.casbic.ac.cn/English.htm www.cashq.ac.cn/	CAS was founded in Beijing on 1st November 1949 on the basis of the former Central Academy of Sciences and Beiping Academy of Sciences. It is China's supreme academic institution and comprehensive research and development center in natural sciences and technologies. The Academy consists of 5 academic divisions, 108 scientific research institutes, and over 500 science and technology enterprises.
China	China's Top 100 Universities www.cashq.ac.cn/column/human/gx/index.asp	This web site, hosted by Chinese Academy of Sciences, lists nearly 100 top universities in China within which a variety of research/education programs in ecology and environmental sciences operate. Each university has its own web site with both Chinese and English versions.
China	Chinese Academy of Agricultural Sciences (CAAS) Headquarters: Beijing, China www.caas.net.cn/ www.caas.net.cn/engforcaas/index.htm	CAAS was established in 1957, and is China's national agricultural research organization, administered by the Ministry of Agriculture. CAAS's strategic task is to serve for nation-wide agricultural and rural development and to empower farmers with science and technology. CAAS has about 10,000 staff members and 38 research institutes located in 17 provinces and regions across China.
China	Chinese Academy of Forestry (CAF) Wanshou Shan Beijing 100091, China www.caf.ac.cn/newcaf/english/main.htm www.forestry.ac.cn/	CAF was founded on October 27, 1958, based in part on the Forest Cultivation Experimental Farm of the Ministry of Agriculture and Forestry established in 1912. The academy has 9 research institutes, 4 experimental centers and 3 research and development centers, which are located in 10 provinces of China, with over 1,600 scientists and technicians. The programs at CAF range from basic to applied research and from science to technology.
China	Chinese Ecosystem Research Network (CERN) Headquarters: Beijing, China www.cern.ac.cn/index.jsp www.ilternet.edu/networks/china/	CERN, established in 1988 to foster long-term ecological research activities in China, currently consists of about 30 field research sites, including agriculture, forest, grassland, and wetland ecosystems. It administers five research focus centers (hydrology, soil, atmosphere, biology, and aquatic ecosystems) and one synthesis center. CERN is essentially the "Chinese LTER network".
China	Chinese Academy of Fishery Science (CAFS) Headquarters: Beijing, China www.lib.noaa.gov/china/headquaters.htm	CAFS, administered by the Chinese Ministry of Agriculture, is a leading research institution in marine and freshwater research in China. Founded in 1978, CAFS has 21 related research institutions spreading across China, with a total of 1,590 scientists.
China	Chinese Biodiversity Information System (CBIS) http://cbis.brim.ac.cn/cbise/ http://cbis.brim.ac.cn/index.html	CBIS contains data sources including specimen collections, botanical gardens, natural reserves, field ecosystem research stations, seed banks, geneplasm banks and research groups.
China	Taiwan long term Ecological Research Network (TERN)	TERN was established in 1992 with main sponsorship from the Taiwan National Science Council (NSC) and cooperation with universities and the Taiwan Forestry Re-

	http://wagner.zo.ntu.edu.tw/tern/English/introduction.htm	search Institute (TFRI). The network currently has four sites (Fu-shan Forest, Guan-dau-shi Forest, Nan-jen-shan Forest/Lake, and Ta-ta-chia Forest).
India	Indian Council of Forestry Research & Education (ICFRE) http://www.wii.gov.in/envhome	The major objectives of the Council are to undertake, aid, promote and coordinate forestry education, research and its application.
India	Wildlife Institute of India (WII) P.O. Box 18 Chandrabani Dehra Dun 248 001 India Wii@wii.gov http://envfor.nic.in/icfre/icfre.html	WII's tasks include: Train managers and biologists for protected area management and wildlife research; Conduct and coordinate applied wildlife research and evolve relevant techniques suited to Indian conditions; Create a database for building up a wildlife information system employing modern computerized analytical techniques; and Provide advisory and consultancy services to central and state governments, universities and research institutions, etc.
India	Ashoka Trust for Research in Ecology and the Environment (ATREE) PO Box 2402 HA Farm Post Hebbal Bangalore 560 024, India atree@dte.vsnl.net.in http://www.atree.org/	ATREE is a nonprofit organization working to conserve biodiversity and promote sustainable development. Its mission is to advance protection of the environment, conserve biodiversity and promote sustainable use of resources. The Trust combines public concern over the deteriorating economic and physical environment with a vigorous scientific approach to solving environmental problems. ATREE emphasizes interdisciplinary approaches and combines principles of ecology and economics to undertake and promote scientific, educational, and development activities. These range from basic to applied research combined with action.
India	Bombay Natural History Society (BNHS) Hornbill House Shaheed Bhagat Singh Road Mumbai 400023, India http://www.bnhs.org/	The BNHS is dedicated to nature conservation in the Indian sub-continent, including the preservation and management of all forms of wildlife together with the natural habitats. It is the largest non-government organization (NGO) in the Indian subcontinent engaged in nature conservation research. In the 117 years of its existence, its commitment has been the conservation of India's natural wealth, protection of the environment and sustainable use of natural resources for a balanced and healthy development for future generations.
India	Environmental Information System (ENVIS) ENVIS Centre Wildlife Institute of India P.O. Box #18 Dehra Dun 248 001 India Envis@wii.gov.in www.wii.gov.in/envhome	ENVIS is a network of subject specific nodes located in various institutions throughout the country. The Focal Point of the present 25 ENVIS centres in India is at the Ministry of Environment and Forests, New Delhi, which further serves as the Regional Service Centre (RCS) for INFOTERRA, the global information network of the United Nations Environment Programme (UNEP) to cater environment information needs in the South Asian Sub-region. The primary objective of all ENVIS centres is to collect, collate, store and disseminate environment related information to various user groups, including researchers, policy planners and decision makers.

India	G.B. Pant Institute of Himalayan Environment & Development Kosi-Kotarmal Almora - 263643 India Gbpihed@nda.vsnl.net.in http://envfor.nic.in/gbpihed	Established in 1988 as an autonomous Institute of the Ministry of Environment and Forests, Government of India, G.B. Pant Institute of Himalayan Environment and Development has emerged as a focal agency to advance scientific knowledge, to evolve integrated management strategies, demonstrate their efficacy for the conservation of natural resources and to ensure environmentally sound development in the entire Indian Himalayan Region (IHR).
Japan	Asian Natural Environmental Science Center University of Tokyo 7-3-1 Hongo, Bunkyo-ku Tokyo 113-8654, Japan www.anesc.u-tokyo.ac.jp/english/ default.htm http://www.u-tokyo.ac.jp/eng/gaiyou/shared.html	The Center promotes cooperative studies on sustainable utilization of bioresources in the Asian region. Its activities are coordinated with environmental conservation aimed at preventing the exhaustion of bioresources and environmental destruction now obvious in many are around Asian region. Researchers at the center have responsibilities to develop novel systems for land use based on regional characteristics, and the effective and sustainable utilization of untapped bioresources. The development of novel and low-energy-input systems to increase the quantity of bioresources will be undertaken by the staff of the DBRD using symbiotic and stress-tolerant functions of plants.
Japan	Ecological Society of Japan c/o Center for Ecological Research Kyoto University Hirano, Kamitanakami, Otsu Shiga, 520-2113, Japan esj-cer@ecology.kyoto-u.ac.jp wwwsoc.nii.ac.jp/esj/index-e.html	The Ecological Society of Japan was founded in 1949 to promote research in all aspects of ecology. Membership is open to anyone interested in ecological science.
Japan	The Society of Population Ecology http://meme.biology.tohoku.ac.jp/POPECOL/RP.html	The society of Population Ecology was founded in 1961 for the purpose of promoting and fostering the study of population ecology. Now the activities of both the society and its publication cover broader aspects of population ecology and population biology, in both basic and applied fields. Membership is open to persons interested in population ecology and related fields of the biological sciences.
Japan	Mahale Wildlife Conservation Society http://jinrui.zool.kyoto-u.ac.jp/PAN/mwcs/mwcs.html	The Mahale Wildlife Conservation Society was established in 1994 to promote conservation, research and public education activities related to the wildlife (chimpanzees, in particular) of the Mahale Mountains and other areas of western Tanzania.
Japan	Center for Ecological Research, Kyoto University Kamitanakami Hiranocho Otsu, Shiga, 520-2113, Japan http://ecology.kyoto-u.ac.jp/~gaku/diwpaindex.html	DIVERSITAS was organized by UNESCO, SCOPE and IUBS in 1990 for the conservation and utilization of biodiversity. The four main purposes are (1) study of the ecological function of biodiversity, (2) study of the mechanisms of origin, maintenance and extinction, (3) inventory and monitoring, (4) setting up programs for conservation. DIWPA will cover all these items in the region of Western Pacific and Asia.

Japan	The Environment Preservation Center Sakyo ku, Kyoto 606 8501 Tel. (075) 753 7700 http://ddb.libnet.kulib.kyoto-u.ac.jp	The Environment Preservation Center was established in 1977 as one of the cooperative facilities of the University. The objectives of the Center are to prevent pollution caused by waste from various activities in the University, to carry out research work on technological problems of waste management, and to cooperate in education schemes concerning environment preservation. The Center manages and maintains disposal plants for organic and inorganic liquid wastes.
Japan	National Institute for Environmental Studies (NIES) 16-2 Onogawa, Tsukuba-Shi Ibaraki, 305-0053 Japan http://www.lbri.go.jp/default.htm	NIES has been conducting research focused on the unprecedented problems occurring in our generation. In response to these challenges, NIES has been expanding its research fields from domestic to the Asian region, and to a global scale.
Korea	Environmental Research Institute Cheju National University 1 Ara 1-Dong Cheju City, Cheju-Do 690-756 Republic of Korea Phone: (064) 754-2333	The Institute aims to contribute to the development of environmental science by conducting research on the protection of the natural environment, and the reduction of pollution and the development of its abatement techniques.
Korea	Korea Long-Term Ecological Research (KLTER) http://klter.kookmin.ac.kr/emain.htm	Korea LTER Committee (KLC) was established in 1997. KLTER is still in its early developmental stage.
Mongolia	The Institute for Mongolian Biodiversity and Ecological Studies Academy of Natural Sciences 1900 Benjamin Franklin Parkway Philadelphia, PA 19103 www.acnatsci.org/mongolia/	The mission of the Institute for Mongolian Biodiversity and Ecological Studies is to stimulate and help coordinate biodiversity and ecological research in Mongolia. Its ultimate goal is to develop an understanding of this land's unique ecology while encouraging ecological tourism as part of Mongolia's economic development plan.
Mongolia	Eastern Steppe Biodiversity Project P.O. Box 350 Choibalsan 07, Dornod Tel: (061) 3042 esbp@magicnet.mn http://www.un-mongolia.mn/projects/	The overall objective of the project is the long-term conservation and sustainable use of biodiversity in the Eastern Steppes of Mongolia (Dornod, Sukhbaatar and the southern part of Khentii). In order to assist Mongolia with conservation of this globally important ecosystem, the Global Environment Facility have provided funds through the United Nations Development Programme for implementation of this project, Executed by the Ministry for Nature and the Environment and the United Nations Office of Project Services (started in 1998).

Mongolia	Faculty of Biology National University of Mongolia Ikh surguuliin gudamj 1, Ulaanbaatar 210646, P.O. Box 46/377 Tel: +976-1-323970 Fax: +976-1-320159 Num@num.edu.mn	The Faculty is one of the biggest centers for training and research in the biological sciences. Professors and scientists are active in many fields of study, and more than 10 cooperative research projects are carried out every year within the faculty.
Mongolia	Ministry of the Environment Barsbold Ulambayar Minister of Nature and Environment http://www.pmis.gov.mn/men/english_page.htm	The mission of the Ministry is to create a safe and healthy environment for Mongolia's citizens by maintaining an ecological balance in accordance with the concepts of sustainable development. To create a legal, economic and organizational background for environmental protection and the proper use of natural resources and to coordinate activities of the Government and Non-Governmental Organizations within this framework.
Philippines	Center for Tropical Conservation Studies Zoo and Botanical Garden Silliman University Dumaguete City, Philippines http://www.philngo.com/centrop1.htm	The center's main objective is to study and conserve terrestrial surrounding islands. The major areas of concern are the protection of nature, prevention of desertification, captive breeding of spotted deer, bots, etc. environmental education, committee organizing and capability-building. Their development philosophy is the integration of research and conservation programs through community participation.
Philippines	The Center for Environmental Concerns http://www.psdn.org.ph/cec/cec.htm	Founded in 1989, CEC is a non-government development organization pursuing environmental advocacy through education research, ecosystems management and rehabilitation for grassroots empowerment. The Center provides services which include environmental education curriculum and materials development, training, environmental research, ecosystems management, and maintains an education and information center.
Philippines	Institute for Environment and the Sciences University of Asia and the Pacific Pearl Drive, Ortigas Complex Pasig City, Philippines http://www.philngo.com/institut.htm	As a research and communication arm of the College of Arts and Sciences of the University of Asia and the Pacific, IES conducts various activities and projects on the environment and the natural sciences, in addition to promoting their synergistic interaction with liberal education, business and society, guided by a holistic approach and a Christian view of the universe. It recognizes the important role of the environment and the sciences in the global pursuit of sustainable development.
Russia	Russian Academy of Sciences http://www.ras.ru/	Russia's supreme academic research institution.
Russia	Russian Foundation for Basic Research (RFBR) http://www.rfbr.ru/	RFBR is a self-governing State organization whose primary goal is to support the most promising research initiatives in all fields of fundamental science on the competitive basis, without any departmental restrictions.

Russia	Karelian Research Centre of the Russian Academy of Sciences Pushkiskaya st., Petrozavodsk Russia, 185010 http://www.krc.karelia.ru/index.shtml	Research focuses on the water-ecological resources of the Karelian Republic. The most significant hydro-ecological problems today are related to the effect of natural and man-made climate changes on the water ecosystems of the North; acidification of waterbodies and estimation of their stability, buffer capacity; eutrophication and toxic effects on the hydrobios of the largest European lakes - Onego and Ladoga; effects of sewage on water systems; the status of the White Sea, particularly Karelian coastal zone; wider use of ground waters.
Russia	Forest Research Institute (FRI) 11 Pushkinskaya Petrozavodsk, Karelia, Russia http://www.krc.karelia.ru/structure/fri/index.shtml	FRI is a scientific research institution under immediate scientific and organizational supervision of the Russian Academy of Sciences' General Biology Department. Primary interests include: study of structural and functional organization, biodiversity, dynamics and the bioresource potential of forest ecosystems, elaboration of scientific principles for increasing their total productivity; study of physiological and cytological aspects in woody plants adaptation; study of the soil cover structure and forest soils genesis.
Russia	Northern Fisheries Research Institute 185031, Petrozavodsk, Varkaus, 3 http://petrsu.karelia.ru/psu/Structure/fish_e.html	The Northern Fisheries Research Institute (SevNIIRH) was founded in March of 1931. Its major objective is the investigation of freshwater basins of Karelia for the purpose of the most complete and effective use of their fish resources. The main objective of the research is the improvement of water surface quality control, evaluation of the biological quality of water and of the anthropogenic influence on basins.
Russia	Center for Russian Nature Conservation (CRNC) http://www.russianconservation.org/	CRNC focuses its work on Northern Eurasia, the countries of the former Soviet Union. CRNC supports projects in conservation legislation, land and water conservation, endangered species protection and environmental education. CRNC has three main goals: information dissemination, assistance in project development and fundraising for Eurasian groups, facilitation of professional exchanges.
Singapore	The Biodiversity Group Tel: 874 2969 / 874 6282 dbsngkl@nus.edu.sg http://rmbr.nus.edu.sg/research/research.htm	The Biodiversity Group in the National University of Singapore was set up in 1998 under the auspices of the Raffles Museum of Biodiversity Research. Currently, it consists of some ten academic staff and numerous postgraduate and undergraduate students. The Research is organized into three main sections: Aquatic diversity - which consists of research mainly on freshwater fish and decapod crustaceans, aquatic bugs and beetles. Marine diversity and ecology - corals, mangroves, marine fungi, plankton, polychaetes, decapod crustaceans, fishes, coastal zone management. Terrestrial diversity and ecology - which consists of research mainly on angiosperms, mosses and ferns, fungi, birds and insects.

Singapore	Environmental Technology Institute (ETI) wwweti@eti.org.sg http://wwweti@eti.org.sg	The mission of ETI is to "Position Singapore's Environmental Technology Industry to meet the challenges of evolving markets and to propel the firms to higher levels of competitiveness." Activities include research and development, pilot studies, demos, full scales with private and public sector interest, in addition to capacity building via technology focused training programmes and conferences. Network building at home and abroad.
Singapore	Regional Institute of Environmental Technology (RIET) www.sec.org.sg	This non-profit provides a forum for dialogue on environmental threats and opportunities in Asia; promotes business led strategy responses to Asian environmental difficulties; instigates the development of industrial partnerships between technology providers and publishes reports and periodicals on environmental practices and environmental business information and intelligence.
Singapore	Singapore Environmental Council 21 Lewin Terrace Fort Canning Park, Singapore www.sec.org.sg	The mission of the Singapore Environmental Council is to educate, inspire and assist individuals, business organizations, and environmental groups to care for and protect the environment.
Singapore	Nature Society (Singapore) e-mail: natso@csingnet.com.sg http://mars.post1.com/home/naturesingapore	Non-Government, Non-profit, dedicated to the study, conservation and enjoyment of the natural heritage in Singapore. They work with the public to incite awareness an implement conservation campaigns. They also conduct environmental impact assessments and surveys.