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MEETING REPORT: THE BEIJING INTERNATIONAL SYMPOSIUM ON BIOLOGICAL INVASIONS, 6－11 JUNE 2004

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Scientists and policy-makers are now well aware of the ecological and societal problems associated with the introduction of species by humans across natural barriers to dispersal. Some introduced species spread abundantly in their new habitats and have negative effects on existing species, both agricultural and natural. Such introduced, invasive species can alter fire, nutrient, and hydrological regimes and have large economic costs.

In many parts of the world, this awareness has come rather late: commerce and travel have already carried large numbers of plants, animals, and microbes between many regions. In contrast, China's relative self-remove from global trade during much of the second half of the 20th century may have earned it a partial reprieve from invasions from abroad and reduced the number of invasions from China to elsewhere. If so, there could be a new wave of species invasions between China and North America impending. China's trade with the U.S. increased by 460% from 1992 to 2002, according to the U.S. Department of Commerce. This may be the critical moment to apply the lessons learned from invasions across other oceans and forestall new invasions across the Pacific. We need to match growth in trade with growth in the science and policy needed to prevent and control introductions.

To this end, some 100 scientists and representatives of governmental and non-governmental organisations from eight countries gathered on June 6－11 for the Beijing International Symposium on Biological Invasions, subtitled "Species Exchanges Between Eastern Asia and North America: Threats to Environment and Economy". The Institute of Botany of the Chinese Academy of Sciences and the Sino-Ecologists Club Overseas organized the meeting, under the leadership of Xinguo Han and Ming Dong for the Institute and Shili Miao for the Club. The National Science Foundation of China, the U.S. Geological Survey, and the Asian Ecology Section of the Ecological Society of America provided additional support. Shili Miao and Jianhui Huang coordinated the program and logistics, and the Beijing Botanical Garden provided the venue, appropriately stocked with introduced plants from around the world, presumably non-invasive ones.

There were two keynote addresses. Harold Mooney (Stanford, USA) highlighted the need for scientists to develop quantitative tools that managers can use to analyze the extent and the impacts of invasions. Richard Mack (Washington State, USA) noted that the phylogenetic, latitudinal, and climatic similarities between China and the U.S. may predispose introductions from one to the other to bloom into invasions. The 37 other talks and the posters focused on current patterns of invasion in eastern Asia, the theory of invasions, techniques to manage invasions, and policies to prevent them.

About 230－380 plants, 20 insects, 9 terrestrial vertebrates, and 7 fishes have been identified as introduced, invasive species in China (Weiguo Sang, Institute of Botany, China; Bo Li, Fudan, China). Costs of invasive species to agriculture, industry, the environment, and health in China amount to US $2.5 billion per year, which is only 2% as much as in the U.S. but a similar percentage of gross national product (Haigen Xu, Nanjing Institute of Environmental Science, China). Despite its much smaller area, Japan has about as many invasive plants as China (Takashi Enomoto, Okayama, Japan); riparian habitats are one type that is highly invaded in Japan (Isumi Washitani, Tokyo, Japan). South Korea has a smaller number of invasive plants (Eun Ju Lee, Seoul National, South Korea).

Introduced, invasive plants in China are concentrated in the southeast, where development is also most extensive. Invasion is associated with transportation density (Bo Li, Fudan, China), much as road density correlates with degree of invasion into natural areas in the U.S. (Hong Jiang, Conservation Biology Institute, USA). Some remote western regions such as the Hengduan Mountains are almost free of introduced plants (David Boufford, Harvard, USA). A disproportionately high number of invasive plants spread vegetatively, and more of those with critical impacts in China are native to North America than to any other continent (Ming Dong, Institute of Botany, China). Species of *Artemisia*, *Mikania* and *Eupatorium* in the family Asteraceae are among the most invasive terrestrial plants (Weiguo Sang, Institute of Botany, China; Xingjun Yu, Wuhan, China; Xueying

Zhuang, South China Agricultural, China). The Asteraceae and the Poaceae are the two plant families with the most invasive species in China.

Notable invasions from China to the U.S. include those of the climbing fern *Lygodium microphyllum* (Yegang Wu, South Florida Water Management District, USA) and huge carp (*Hypophthalmichthys molitrix* and *nobilis*; Duane Chapman, US Geological Survey, USA) that leap out of the Mississippi and Missouri rivers and may injure boaters. Most marine introductions to the Pacific Coast of North America have come from eastern Asia (Anson Hines, Smithsonian Environmental Research Center, USA). Some crabs and fish valued for food in Asia are among the invasive introductions, creating a conflict of values between gourmands and managers (Weiyin Wong, Brown, USA). One impact of introduced aquatic plants can be to change water chemistry and reduce the fitness of amphibians (Bernd Blossey, Cornell, USA). In general, high diversity is not necessarily beneficial when due to introduced species (Dov Sax, California at Santa Barbara, USA).

Factors likely to influence invasion include disturbance, habitat and community structure, and perhaps simply competitive superiority. Disturbance is a key factor in invasion in some of the temperate forests that characterize both northern China and the eastern U.S., although different forest types can differ in invasibility independent of disturbance (Jessica Gurevitch, Stony Brook, USA). In wetlands, different types of disturbance can favor invasion by different introduced species (Young Choi, Purdue at Calumet, USA). Although wide dispersal is commonly seen as promoting invasion, stochastic spatial simulation and pair approximation modeling suggest that increasing the clustering of habitat types in a landscape can allow a short-distance disperser to invade and exclude a long-distance disperser (David Hiebler, Maine, USA). Communities may gradually become less and less invasible after disturbance, since experiments on the assembly dynamics of artificial communities suggest that they become more resistant to invasion over time (Richard Law, York, UK).

Some introduced species may invade simply because they are more fit than any natives (Peter Alpert, Massachusetts at Amherst, USA). One example in China may be the eastern North American salt marsh grass *Spartina alterniflora*, which combines high tolerance of anoxia and salinity with prolific seed production and dense clonal growth (Irv Mendelssohn, Louisiana State, USA). Experience in the western U.S. suggests that *S. alterniflora* may be impossible to control once widespread (Heather Davis, California at Davis, USA). In other cases, introduced species may wield "novel weapons", such as allelochemicals, against which natives have not evolved a defense (Ragan Callaway, Montana, USA).

Selection for horticultural traits such as a dense canopy may also increase invasiveness of plants (Kaoru Kitajima, Florida, USA). On the other hand, there appear to be ways to genetically engineer male- and female-sterile genotypes of economically useful plants that still bear normally sized fruit but have no potential to spread (Yi Li, Connecticut, USA).

To manage invasions, it may be useful to incorporate both ecological and economic factors into risk analyses of potential introductions and of benefits of controlling existing ones (David Lodge, Notre Dame, USA). In some cases, current distribution can used to infer invasion (Wei Fong, Long Island University). However, explanations of plant invasions do not necessarily stand up as predictions of future ones, due to base set effects, statistical shrinkage, and other statistical hazards (Mark Williamson, York, UK). Around Toyko, regenerating native forest may be the single best step towards controlling invasion (Shin-ichi Suzuki, Center for International Studies in Ecology, Japan). The introduced parasitic plant Cuscuta campestris has been used to control introduced trees in China, an example of fighting one invasive with another (Mingguang Li, Sun Yatsen, China).

On the policy level, both the U.S. and China could use tighter regulation of intentional introductions, such as by permitting import only of "white-listed", non-invasive species and by raising funds for the prevention of invasions through fees to species importers (Peter Jenkins, International Center for Technology Assessment, USA). The U.S. may be slightly ahead of China in regulation of unintentional marine introductions (Bin Wang, State Oceanic Administration, China), but Japan may forge ahead of both countries if it adopts a pending Invasive Alien Species Act (Toshikazu Mito, Ministry of the Environment, Japan). Meanwhile, a good existing model for preventing invasions into little-invaded areas is the plant

biosecurity system in Western Australia (Shashi Sharma, Dept. of Agriculture, Australia).

A major purpose of the symposium was to foster cooperation between eastern Asian and North American managers and researchers. Opportunities for comparative studies include comparisons between source and introduced populations of species in North America and Asia (Qinfeng Guo, U.S. Geological Survey, USA). Dispersal behavior of Asian long-horned beetles (*Anoplophora glabripennis*) in their native China is being used to develop techniques to attract and kill introduced beetles in the U.S. (Michael Smith, Agricultural Research Service). Some North American species of the herb *Solidago* have invaded the temperate deciduous forests at both ends of Eurasia from the temperate deciduous forest of North America (Liang Jin, Fudan, China). These parallel invasions have not yet been compared. Recent extensive invasion of the shrub *Lantana camara* in the Himalayas (R.Kohli, Panjab, India) could be compared to its much older invasion in Hawaii. The wetland and aquatic plants *Spartina alterniflora* and *anglica* (Fuchen Shi, Nankai, China; Qing Wang, Fudan, China), *Eichhornia crassipes* (Yonghong Xie, Wuhan, China), and *Alternanthera philoxeroides* (Kaiyang Xu, South China Institute of Botany, China; Xiaoyun Pang, Fudan, China) have been the subject of intensive biological control efforts in both China and North America and provide a chance to compare the successes and pitfalls of biological control of the same species on different continents (Jianqing Ding, Cornell, USA).

Practical sharing of information and even natural enemies between China and the U.S. has already begun. The Sino-American Laboratory jointly operated by the Chinese Academy of Sciences and the U.S. Department of Agriculture's Agricultural Research Service is working on biological control and potential swaps of control agents (Robert Pemberton, Agricultural Research Service, USA). The U.S. Geological Survey's Eros Data Center and the Chinese State Bureau of Surveying and Mapping are cooperating on a spatial database of invasions and their ecological correlates, using models based on the genetic algorithm for rules of production (GARP) or on classification and regression trees (CARP) to infer potential distributions of introduced species (Thomas Albright, U.S. Geological Survey, USA). China's web-based Chinese Species Information System includes invasive species (Yan Xie, Institute of Zoology, China) and has a U.S. counterpart in an invasive species information node facilitated by the new National Institute of Invasive Species Science (William Gregg, U.S. Geological Survey, USA). Asian and North American participants discussed further planning for a Global Invasive Species Information Network with regional hubs (Annie Simpson, U.S. Geological Survey), and specifically for an Invasive Alien Species Network of Eastern Asia and North America. Another useful model for invasion databases is the Invasive Plant Atlas of New England, which enlists volunteers to detect new introductions (Les Mehrhoff, Connecticut, USA).

A set of papers drawn from the symposium is scheduled for publication as a special issue of the journal *Biological Invasions* in 2005. In the meantime, a PDF copy of the abstracts is available from Shili Miao at smiao@sino-eco.org.

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