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PROJECTS

Site 1) China – Anthropogenic change the emergence of SARS; Community understanding of health issues (Zhang/Daszak) – We have access to two long-term study sites in China in two regions: First in Guangdong province, where EHA’s earlier work highlighted bats as a source of SARS-like Coronaviruses that likely gave rise to the human SARS CoV. Here we will continue our collaboration with Dr Shuyi Zhang’s group at East China Normal University (ECNU), where we are hosts of a joint institute for Research on Zoonoses of Wildlife (see letter of support from Dr Zhang). We will specifically investigate the expansion of trade in wildlife, obtaining data on the volume and diversity of wildlife in 7 target wildlife markets in Guangdong, the largest wildlife market in Southern China. This market is in the city of Guangzhou and is a wholesaler of live animals. It is the market from which one of the first SARS human clusters of cases were found. CCM has been granted unprecedented access to this wildlife market to sample wildlife for diseases and trace back the origin of SARS.

We have also begun a wildlife surveillance program in these ‘wet markets to examine the presence and diversity of pathogens within these wildlife. Our proven ability to work in China, and our strong links with the joint institute place us in an ideal position to do this work. We are one of the few U.S. institutions that have permission to work in these ‘wet markets’.

Site 2) Mexico – The epidemiology of West Nile virus and avian influenza (Aguirre, Suzan) – With a population of 103.3 million in 2005, Mexico is the second-most populous country in Latin America after Brazil. Yet, Mexico has an enormous range of natural environments and climate regions, which supports a high diversity of wildlife. There is significant pressure from development on the regions that support this biodiversity, and the recent introduction of West Nile virus was also proposed as a new threat. However, there has been surprisingly little evidence of major impacts of West Nile virus on biodiversity in Mexico, and outbreaks in humans or horses have been relatively small. EcoHealth Alliance Vice President for Programs, Alonso Aguirre is holder of both a US and Mexican passport and has developed a significant research portfolio on infectious disease ecology in Mexico. This work includes surveillance for highly pathogenic H5N1 avian influenza in migratory birds, the biodiversity of rodent reservoirs for Lyme disease, hantavirus and plague, and the rapid spread of West Nile virus across the country.

To expand the capacity for disease detection in Mexico, EcoHealth Alliance has supported the creation of the first Conservation Medicine Laboratory and Biosecurity Level-3 Facility specifically for wildlife in Latin America. This laboratory has first-class equipment to identify emerging infectious agents potentially pathogenic to humans on site (i.e. West Nile virus, avian influenza, sylvatic plague, tularemia, chronic wasting disease). In 2005, this laboratory obtained full certification as a reference laboratory from USDA Veterinary Laboratory Services, Ames, Iowa and the Institute for International Cooperation in Animal Biologics on High Pathogenic Avian Influenza Diagnostics and many other international certifications. Our lab leader has passed the International Training Course on Animal Exotic Disease Diagnostics at the USDA-USDHS Plum Island Animal Disease Center, New York, to work with emerging exotic pathogens to North America. Our work in Mexico will continue to focus on systematically sampling wildlife species at sites where rapid changes are increasing the risk of disease emergence (especially the south of Mexico). We will exchange technology with our EcoHealth Alliance Local Conservation Partners,

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just like we already have done with many North American institutions, so we can find new pathogens and identify diseases in the process of emergence.

Site 3) Brazil – Zoonotic disease dynamics in a fragmented landscape (Cullen) -TBD

Site 4) Bangladesh – Measuring disease dynamics in wildlife, and their contact with people (Luby/Epstein) – Bangladesh has one of the highest population densities in the world, and the connection with remnant biodiversity of wildlife is increasingly pressured. In Bangladesh, we have been collaborating for two years with the ICDDR,B, in Dhaka on the emergence of Nipah virus, which has caused five outbreaks in the country. EcoHealth Alliance has been studying Nipah virus in Malaysia (where it first emerged in 1999, killing more than 100 people) for the last five years under an NIH award. This award has now been renewed for a further 5 years, to focus entirely on Nipah virus Bangladesh. Our work has shown that it emerged from fruit bats, spilling over into pig farms and affecting people who work on these farms. Unlike the Malaysian outbreak, the Bangladesh strain of Nipah virus has moved directly from bats to people, and has set up chains of transmission between people – a critical point in the process of becoming a pandemic. In Bangladesh, we are investigating the interactions of people and bats to assess whether demographic factors are involved in emergence. We are also collecting masses of data from a long-term study of bat Nipah virus serology, with the goal of developing a predictive mathematical model of NiV emergence. This research project site provides a practical way to bring together the human behavioral risk of infection with the wildlife reservoir dynamics affecting risk of spillover.

Site 5) Urban Diseases: Ecology of rat-borne pathogens in Baltimore (Glass) – For the past 4 years, Dr Greg Glass of Johns Hopkins has been conducting an NSF/NIH Ecology of Infectious Diseases-funded program on disease ecology in urban rats in Baltimore. This work involves repeated trapping, sampling and behavioral observational studies on Norway rats in Baltimore. Dr Glass's group has shown that there is a population of likely in excess of 50,000 rats in Baltimore, and more than half of them have antibodies to Seoul virus, a Hantavirus known to be pathogenic in people, as well as other zoonoses⁸¹. Work on the social and behavioral dynamics of rats in relation to their pathogen exposure has led to a series of papers on this system⁸² and field and laboratory work is continuing. This project provides a unique opportunity for new approaches to examining the interactions among economics, sociology, demography and disease emergence in an important urban site.

Site 6) US Seabird mortality study - SeaNET (Ellis) – The Seabird Ecological Assessment Network (SEANET) is a collaborative effort that was initiated by the Tufts Center for Conservation Medicine and the Lloyd Center for Environmental Studies in 2002. Seabirds are among the most conspicuous organisms in marine ecosystems and are frequently used as indicators of marine oil pollution and other threats. Numerous threats contribute to seabird mortality including disease, fisheries operations, organic pollutants, heavy metals, offshore development, and oil pollution. These risks also threaten coastal and marine environments used by humans for recreation and ecological services. The overarching goal of SEANET is to pinpoint some of the most detrimental threats to marine bird populations, target specific conservation measures to alleviate those threats, and educate the public about conservation of the larger marine ecosystem. At our sites along the East Coast of the USA, we have instigated over 3,000 individual surveys covering over 2,700 miles of the Atlantic coastline. Over 1,000 carcasses of

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more than 100 different species were encountered by volunteers, who then submit fresh carcasses for necropsy. Such necropsies yield basic biological information on these species, but also give important perspective on parasites, disease and environmental contaminants. Results revealing numerous causes of death have generated several ongoing research projects, presentation and publications, and have contributed to important management decisions. The student exchange projects will involve a mixture of fieldwork and data analysis of the large necropsy and testing datasets.

Site 7) Urban to Rural Ecology of West Nile virus in the USA (Kilpatrick/Goldberg) – West Nile virus (WNV) was introduced into North America in 1999, and has caused repeated large-scale human epidemics in North America since it was first detected in 1999. It has caused over 20,000 reported cases, 770 deaths and an estimated 215,000 illnesses over up to 2006, and is now the dominant vector-borne disease in North America. EcoHealth Alliance has been studying WNV in New York and the greater Washington DC region since 2003. We have set up field sites along a gradient of urbanization in the mid-Atlantic and have used this approach to identify the key vector in WNV transmission to humans, the key avian host for amplification, to show that late summer shifts in mosquito feeding from a preferred avian host (American robins) to humans are a key factor in driving the intense epidemics of WNV across North America. Most recently we have shown that seven of twenty species of native North American birds are suffering regional impacts due to WNV. Similarly, RCN Core participant Dr. Tony Goldberg is PI of a newly funded NSF/NIH Ecology of Infectious Diseases project to study the dynamics of viral transmission in suburban Chicago, in a persistent “hot spot” of arboviral amplification and human disease. This project is a continuation of a longer-term research program on West Nile virus in Chicago, funded by NSF since 2004.

Site 8) Human-primate zoonoses and disease emergence in Uganda – Since 2004, Dr. Tony Goldberg has led (in collaboration with Dr Innocent Rwego) the Kibale EcoHealth Project, an epidemiological and ecological study focused on human/animal health and zoonotic disease transmission in the region of Kibale National Park, western Uganda. Kibale is a protected tropical forest known for its exceptional biodiversity and richness of primate species. The project focuses on humans, primates, and livestock in disturbed forests outside the national park. These areas are “hot spots” for human-wildlife-domestic animal interaction within a region that is itself a “hot spot” for zoonotic disease emergence due to its fast rate of population growth, high human disease burden (e.g. malaria, AIDS), and exceptional diversity of animal disease reservoirs. The project investigates how anthropogenic disturbance to primate habitats (e.g. deforestation, forest fragmentation, encroachment) alters among non-human primates (monkeys and apes), humans, and domestic animals.

Major findings to date include 1) increased rates of bacterial transmission between humans and chimpanzees in the context of research and tourism; 2) enhanced rates of gastrointestinal microbial transmission between humans and gorillas in the context of habitat overlap and encroachment; 3) a strong effect of forest fragmentation on rates of enteric bacterial transmission among humans, livestock, and wild primates; and 4) the presence in endangered monkeys of novel and potentially zoonotic viruses in areas where these primates interact at high rates with immunocompromised people. The Kibale EcoHealth Project offers opportunities for students to gain experience in diverse areas, such as wildlife ecology, landscape ecology, primatology, veterinary medicine, and health geography.

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Site 9) National Wildlife Health Center – disease outbreak investigation

The National Wildlife Health Center is the federal agency with a responsibility for disease outbreak investigation in wildlife on federal lands, in federally protected species, and on migratory species in the USA. The NWHC is also one of the founding members of EcoHealth Alliance's Consortium for Conservation Medicine. The NWHC conducts hundreds of large-scale (mortality greater than 1000 individuals) disease outbreak investigations each year and publishes reports, papers and the wildlife disease equivalent of the Morbidity and Mortality Weekly Reports – the NWHC Quarterly wildlife mortality reports in the *Journal of Wildlife Diseases*. This research project will involve taking part in wildlife disease outbreak investigations, from the fieldwork, sampling, testing, necropsy and analysis of epizootiological data. It will be facilitated by Scott Wright, Branch Chief for the Disease Investigation Branch of NWHC.

Project 10) Socio-economic, demographic and global environmental drivers of EIDs (Finnoff/Jerde/Levy/Daszak/Kilpatrick) –

EcoHealth Alliance has spent the last 6 years developing a large database of every disease classified as emerging in the human population from 1940-2004 (over 450 pathogens, based on the initial list of emerging pathogens published previously, expanded to include information on the temporal and spatial origin of every emerging pathogen, on the factors that caused it to emerge, and on the pathogen's and hosts' biology. This database was used to demonstrate a significant rise in the number of EIDs over time, corrected for reporting bias, and a novel way to predict areas most likely to produce the next emerging disease, in our recent *Nature* paper. We have also been filing FoIA requests for data on every animal imported into the USA since 2000 (1.6 billion animals), and have been analyzing the risk of disease introduction. Our preliminary analyses were recently published in *Science*. These databases provide a good opportunity for students with good analytical skills to produce publishable work.

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