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THE GEOGRAPHY OF CONSERVATION ECOLOGY RESEARCH IN SOUTHEAST ASIA: CURRENT BIASES AND FUTURE OPPORTUNITIES

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"I always tell my local graduate students to leave after getting their M.Sc. Only then can they learn from the best and build a network of contacts for conservation." Navjot S. Sodhi (1962–2011)

ABSTRACT. — Conservation ecology research in Southeast Asia is relatively depauperate compared to temperate countries and other tropical regions despite this region's rich and highly threatened biota. By reviewing 20 years of papers published in four major conservation-science journals and three ecology journals with conservation interests, we assessed the geographical bias in total research activity and in-country research activity within Southeast Asia, and we elucidated the scale of international collaborations. We found research activity to be biased toward the Sundaland region, particularly Borneo and Sumatra. The majority of studies were led by researchers based outside of Southeast Asia (67.4%) and outside of the country of research (72.4%). Singapore had the highest proportion of its studies led by scientists based in the country of research (80.8%), while Myanmar (0%) and Cambodia (9.1%) had the lowest. Of the studies led by foreign scientists, only 36.2% involved collaborators within the focal country of research. The total number of studies was moderately positively correlated with country area and the total number of threatened amphibians, birds, and mammals across countries. The proportion of papers led by local scientists was strongly positively correlated with human development index (HDI) but not population size. The alignment of research with need (as expressed by numbers of endangered species) could be seen as a positive result, but it also means that research is lagging in the emerging hotspots of deforestation, e.g., Laos, Cambodia, and Indonesian Papua. To improve conservation science in Southeast Asia, the scientific community must increase research in the region's understudied countries as well as increase the number of Southeast Asians engaged in conservation research. We encourage major funding institutions to target additional funds for work in understudied countries and regions and to give special consideration to research that involves local counterparts. Researchers from universities in wealthier countries can also help less wealthy Southeast Asian countries to build research capacity by participating in the training of young Southeast Asian scientists.

KEY WORDS. — capacity building, collaboration, human development index, human population, research priorities

INTRODUCTION

Southeast Asia, defined here as the region consisting of Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Singapore, Thailand, Timor-Leste, and Vietnam, harbours an exceptionally diverse and highly endemic biota (Sodhi et al., 2004, 2010; Sodhi & Brook, 2006). However, the region's rich biodiversity—much of it yet undescribed (Giam et al., 2010, 2012)—is threatened by extensive and rapid deforestation (Achard et al., 2002; Giam et al., in press; Hansen et al., 2008; Miettinen et al., 2011a, 2011b), expansion of industrial agriculture (Koh & Wilcove, 2008; Koh et al., 2011), illegal hunting and wildlife trade (Chapron et al., 2008; Nijman, 2010), and climate change (Bickford et al., 2010; Corlett, 2011).

To conserve ecosystems and species, conservation scientists aim to understand the scope and distribution of different threats and elucidate how these threats may affect ecosystem structure, functioning, and species communities. Conservation science contributes to land-use and species management policies from local (e.g., management in and around protected

areas [Linkie et al., 2008, 2010]) to national (e.g., national land-use zoning; gazettement/degazettement of protected areas [Giam et al., 2011]) to international-global (e.g., REDD/REDD+ [Ghazoul et al., 2010; Phelps et al., 2011]) spatial scales. Southeast Asia, which consists of 87 ecoregions with distinct habitat types and biotic communities (Olson et al., 2001), is biogeographically diverse. Therefore, the response to a particular stressor in one region may not be representative of the other regions. In addition to its environmental complexity, the region consists of 11 countries with distinct customs, institutions, types of governance, and development trajectories, thus necessitating different approaches for conservation. It is therefore useful to assess current biases in the distribution of research activity in Southeast Asia so as to identify knowledge gaps and prioritise future work.

Southeast Asia is a developing region. With the exception of Singapore and Brunei, all countries are categorised by the World Bank as developing countries (i.e., low-income, lower-middle-income, and upper-middle income economies). Financial resources for conservation research are therefore inadequate as research funds are channelled toward work that is likely to contribute to economic development (Sodhi & Liow, 2000). The capacity for rigorous scientific research is also low. Only three universities in Southeast Asia (National University of Singapore [40th], Nanyang Technological University [169th], Mahidol University [351–400th]) are ranked among the top 400 universities globally in the 2011 edition of The Times Higher Education World University Rankings (http://www.timeshighereducation.co.uk/world-university-rankings/). Consequently, conservation science originating from Southeast Asia is relatively depauperate compared to temperate countries (Sodhi & Liow, 2000) and other tropical regions (Sodhi et al., 2007). International collaborations represent a likely pathway toward building research capacity and improving the overall quality of research (see Stocks et al., 2008 for a review of the issue). For example, collaborations with well-funded and well-equipped institutions from developed countries may allow Southeast Asian researchers and students to learn advanced analytical methods and conceptual approaches (Galvez et al., 2000) that may not be readily accessible owing to the lack of funding and technical knowledge. To encourage further collaborative research, it is of interest to elucidate the scale of international collaborations in Southeast Asian conservation ecology research.

Here, by reviewing 20 years of conservation ecology research in four major conservation-science journals (*Biodiversity and Conservation*, *Biological Conservation*, *Conservation Biology*, and *Conservation Letters* [from 2008]) and three ecology journals with conservation foci (*Biotropica*, *Ecological Applications*, and *Journal of Applied Ecology*), we address the following questions: (1) What is the geographical distribution of conservation research in Southeast Asia? (2) What proportion of research papers is led by scientists based in Southeast Asia? (3) What proportion of papers led by scientists based outside the focal country of research involves at least one in-country collaborator? (4) Are patterns in the distribution of conservation research and collaborations correlated with socioeconomic or environmental variables? Finally, we examine our findings to identify geographical gaps as well as future priorities in conservation research in Southeast Asia.

METHODS

Dataset. — We targeted published research articles that dealt specifically with inland (terrestrial and freshwater) conservation ecology in Southeast Asia from 1991 to 2010. We collated a candidate list of studies from four major conservation ecology journals (*Biodiversity and Conservation*, *Biological Conservation*, *Conservation Biology*, *Conservation Letters*) by performing a search on the ISI Web of Science database using the query: TS=(Indochin* OR Sunda* OR Wallacea* OR South-east Asia* OR southeast Asia* OR Brunei* OR Cambodia* OR Indonesia* OR Borneo* OR Sumatra* OR Kalimantan* OR Java* OR Sulawesi* OR Irian Jaya* OR Papua* OR Lao* OR Malaysia* OR Myanmar* OR Burma* OR Philippines* OR Singapore* OR Thailand* OR Timor* OR Vietnam*) AND SO=("Biodiversity and Conservation" OR "Biological Conservation" OR "Conservation Biology" OR "Conservation Letters"). To this list we added studies from three other major ecology journals that publish conservation-oriented research (*Biotropica*, *Ecological Applications*, *Journal of Applied Ecology*) using a modified search query with conservation as a subject: TS=(Indochin* OR Sunda* OR Wallacea* OR South-east Asia* OR southeast Asia* OR Brunei* OR Cambodia* OR Indonesia* OR Borneo* OR Sumatra* OR Kalimantan* OR Java* OR Sulawesi* OR Irian Jaya* OR Papua* OR Lao* OR Malaysia* OR Myanmar* OR Burma* OR Philippines* OR Singapore* OR Thailand* OR Timor* OR Vietnam*) AND TS=conserve* AND SO=("Biotropica" OR "Ecological Applications" OR "Journal of Applied Ecology"). We read each paper in the candidate list and removed those that had been erroneously retrieved by the search algorithm (e.g., studies in locations other than Southeast Asia). We also excluded regional or global-scale studies that used data from Southeast Asia but did not address conservation issues pertinently at a country or sub-country level. We acknowledge that our dataset of studies is not exhaustive; many Southeast Asian scientists may be conducting meaningful conservation research and publishing their findings in local journals that are not easily accessible to the scientific community. However, by focusing on highly-cited and well-known international conservation journals, we are able to elucidate patterns in studies that are most likely to influence conservation policy and disbursement of conservation funding by both international and national organisations.

For every study that met our criteria, we recorded the focal location(s) as well as the institutional affiliation(s) of the first author and corresponding author. Locations are countries with a continuous land mass (Brunei, Cambodia, Laos, Myanmar, Philippines, Singapore, Thailand, Vietnam) and sub-country units for archipelagic countries Malaysia (Peninsular Malaysia and East Malaysia) and Indonesia (Java,

Kalimantan, Lesser Sundas, Sulawesi, Sumatra, Indonesian Papua). We excluded East Timor from our study as it became a sovereign country only in 2002 after being annexed by Indonesia from 1976 to 1999. We noted whether a study was led by researchers based in the focal country of research, in another country in Southeast Asia, or outside of Southeast Asia; the first and corresponding authors were considered as lead researchers. We further assigned studies led by foreign-based researchers to three categories: studies that involved (1) at least one scientist based in Southeast Asia, (2) at least one scientist based in focal country of research, and (3) only foreign-based researchers.

We also collated data for potential correlates of the distribution of conservation research and international collaboration: (1) total land area, (2) population size (data.worldbank.org), (3) human development index (HDI) (http://hdr.undp.org/en/statistics/), and (4) the number of amphibian, bird, and mammal species that are globally threatened and occur within a given country (www.iucnredlist.org). The HDI summarises a country's human development from three dimensions: life expectancy, access to knowledge, and per capita wealth (United Nations Development Programme, 2010). For population size and HDI, we averaged the values over five time slices from 1990 to 2010.

Analysis. — We hypothesize that the total number of studies across countries correlates positively with size of the country and the total number of threatened species. We also expect the total number of studies per capita to correlate with HDI. Further, we predict that the proportion of studies led by local scientists in each country correlates with human development index and population size. Stocks et al. (2008) found a correlation between the same variables but for a global dataset of studies published in *Biotropica* and *Journal of Tropical Ecology*. They suggested that a larger population size likely contributes more in-country scientists for research. We predict that HDI correlates positively with the proportion as well as per capita number of studies led by in-country scientists because Southeast Asian consists mainly of developing countries whose research productivity may be limited by the lack of financial resources and research capacity. We also expect HDI to correlate with the proportion of foreign-led studies in each country that involve at least one local scientist. Here the correlation may be either positive or negative. On the one hand, countries with higher HDI are likely to have better funding and better skilled researchers and, therefore, are more likely to attract collaborators from foreign countries. This results in a positive correlation between HDI and the proportion of foreign-led studies that involves a local co-author. On the other hand, countries with a lower HDI may have regulations that mandate foreign researchers to work with a local counterpart in order to facilitate information exchange and capacity building.

Nonparametric Spearman's rank order correlations were used to examine these bivariate relationships owing to the non-normality of variables. The effect size (Spearman's ρ) was used to assess the strength of correlations: weak (ρ = 0.2–0.5); moderate (ρ = 0.5–0.8) and strong (ρ > 0.8) (Ferguson, 2009). We chose not to perform null hypothesis significance testing (NHST) owing to the low power of correctly detecting a correlation when the sample size is small (Zar, 2010). We employed a Monte-Carlo bootstrap test to determine the *P*-value of each correlation (9999 iterations; Davison & Hinkley, 1997) but did not set a cut-off *P*-value for significance. One-tailed *P*-values were computed when we have a priori expectation of the correlation slope. All analyses were performed in R 2.13.1 (R Development Core Team, 2011).

RESULTS

We collated 301 studies that focused on conservation issues in Southeast Asia from 1991 to 2010. Research that focused on Malaysia and Indonesia constituted 68% of all studies (N = 206). A large number of these studies were conducted or dealt with conservation questions related to Borneo. Indonesian Borneo (Kalimantan), followed by Malaysian Borneo (Sabah and Sarawak), had the largest number of studies across all regions in Southeast Asia (N = 61 and 51, respectively) (Fig. 1). There were relatively few studies conducted in the Indochinese region. Laos and Brunei had the fewest studies (N = 11 each), followed closely by Myanmar and Indonesian Papua (N = 12 each), and Cambodia (N = 16).

The majority of studies were led by scientists affiliated with an institution outside of Southeast Asia; only 32.6% of the studies (N = 98) were led by scientists based in Southeast Asia (Table 1). Of these 98 studies, 83 were led by an author based in the country of research. Most (N = 10) of the other 15 studies were led by an author based in Singapore. Singapore had the highest proportion of its studies led by scientists based in the country of research (80.8%; 21 out of 26 studies), followed distantly by Malaysia (22.8%; 18 out of 79 studies). Myanmar (0%, 0 out of 12 studies) and Cambodia (9.1%, 1 out of 11 studies) had the

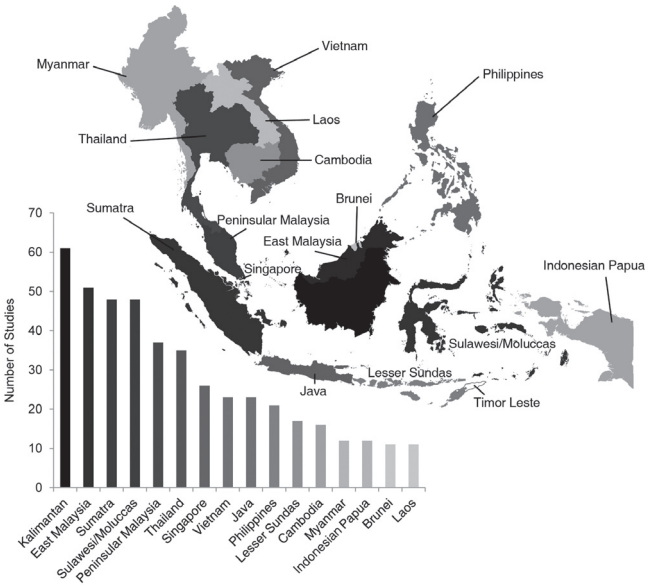

Fig. 1. Total number of studies across various regions/countries in Southeast Asia. (Note: Timor Leste is included to complete the map but excluded from analyses).

Table 1. The total number of studies on each country. SEA-led: Number of studies led by researchers from Southeast Asia. Local-led: Number of studies led by scientists in focal country of study. Also listed are the number of collaborations involving co-authors based in the country of study for foreign-led studies.

Country	Total	SEA-led	Local-led	Non SEA-led (Collaborations)	Non Local-led (Collaborations)
Brunei	11	4	2	7 (0)	9 (0)
Cambodia	16	4	1	12 (7)	15 (7)
Indonesia	150	37	25	113 (42)	125 (48)
Laos	11	4	1	7 (3)	10 (3)
Malaysia	79	33	18	46 (15)	61 (21)
Myanmar	12	4	0	8 (4)	12 (4)
Philippines	21	6	2	15 (8)	19 (10)
Singapore	26	22	21	4 (1)	5 (2)
Thailand	36	15	10	21 (3)	26 (3)
Vietnam	23	7	2	16 (2)	22 (4)
All studies	301	98	83	203 (66)	218 (79)

lowest proportion of their studies led by scientists affiliated with institutions within their respective countries (Table 1). Of the studies led by scientists based outside of Southeast Asia, most of them were led by British (N = 55; 27.0%) or American authors (N = 54; 26.4%) (based on affiliations of corresponding authors).

Only a minority of studies led by scientists based outside Southeast Asia involved collaborators based in Southeast Asia (40.3%; 82 out of 203 studies). Fewer still involved collaborators based in the focal country of research (66 out of 203 studies [32.5%] led by non-Southeast Asian researchers, and 79 out of 218 studies [36.2%] led by researchers outside of country of research, including other Southeast Asian countries) (Table 1). In the latter group, the proportion of collaborative studies was highest in Philippines: 10 out of 19 studies led by non-Southeast Asian researchers in the Philippines involved collaborators based in that country. On the other hand, studies in Brunei and Thailand were less likely to involve local counterparts: none of nine studies led by researchers based outside of Brunei involved Bruneian co-authors while only three of 26 studies in Thailand involved co-authors based in Thailand (Table 1).

The total number of studies was moderately correlated with the total number of threatened amphibians, birds, and mammals across countries (Spearman's $\rho = 0.58$, one-tailed $P = 0.037$) (Fig. 2a) and country area ($\rho = 0.50$, one-tailed $P = 0.07$) (Fig. 2b). Per capita total number of studies was moderately correlated with HDI (Spearman's $\rho = 0.58$, one-tailed $P = 0.039$) (Fig. 2c). HDI was also moderately correlated with the per capita number of studies led by local scientists ($\rho = 0.78$, one-tailed $P = 0.004$) (Fig. 2d) .The proportion of papers led by local scientists was strongly positively correlated with HDI (Spearman's $\rho = 0.93$, one-tailed $P = 0.0002$) (Fig. 2e) but not population size ($\rho = -0.24$, one-tailed $P = 0.75$). We did not detect a correlation between the proportion of foreign-led studies that involved at least one local scientist and HDI across countries ($\rho = -0.12$, two-tailed $P = 0.73$).

DISCUSSION

Conservation ecology research in Southeast Asia is biased towards the insular region consisting of Sumatra, Peninsular Malaysia, East Malaysia, Kalimantan, and Sulawesi/ Moluccas. There are relatively fewer studies conducted in countries in mainland Southeast Asia such as Vietnam, Cambodia, Myanmar, and Laos. However, the number of studies correlates most strongly with the number of threatened amphibians, birds, and mammals across countries. This correlation suggests that more research is being performed in countries with higher conservation need. Indeed, deforestation hotspots within Southeast Asia for 2000–2005 are largely found in Peninsular Malaysia, East Malaysia, Sumatra, and Kalimantan (Hansen et al., 2008), and these are also the hottest regions in terms of conservation research. This alignment of research with need (as expressed by numbers of endangered species) could be seen as a positive result, but it also means that research is lagging in the emerging hotspots of deforestation (i.e., Laos, Cambodia [Hansen et al., 2008], and Indonesian Papua [Miettinen et al., 2011b]). We recommend that greater research effort be expended in these regions to improve species inventories (e.g., Kottelat & Tan, 2011; Iskandar et al., 2011; Clements & Tan, in press; Tan, in press), elucidate existing biodiversity patterns (Catullo et al., 2008), determine threats, identify priority areas for protection, and identify possible tradeoffs between conservation versus development given a range of development scenarios (Koh & Ghazoul, 2010).

In regions where research productivity is currently relatively high, there is still a need to increase the volume and quality of research that is both relevant and pragmatic with respect to wildlife conservation (Meijaard & Sheil, 2007). For example, in Peninsular Malaysia, Sumatra, and Borneo, where large tracts of selectively logged forests are vulnerable to conversion to plantations (Giam et al., 2011), important research questions include (but are not limited to) the following:

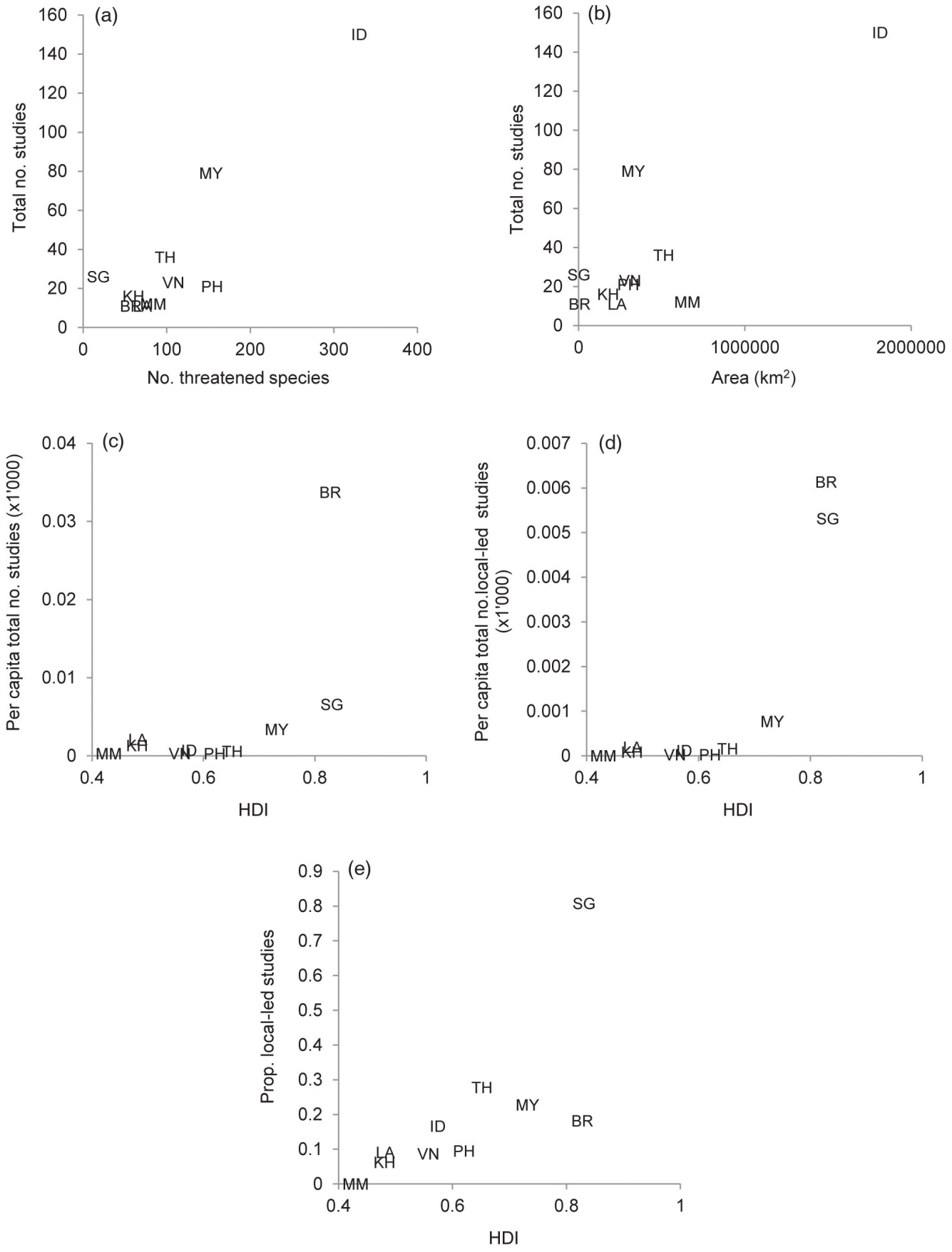

Fig. 2. Relationships between (a) total number of studies and number of threatened species; (b) total number of studies and country area; (c) per capita number of studies and HDI; (d) per capita local-led number of studies and HDI; and (e) proportion of studies led by in-country scientists and HDI. Country abbreviations in parentheses: Brunei (BR), Cambodia (KH), Indonesia (ID), Laos (LA), Malaysia (MY), Myanmar (MM), Philippines (PH), Singapore (SG), Thailand (TH), Vietnam (VN).

1. How do we slow down or halt the conversion of logged forests to plantations while also fulfilling concomitant human development goals?
2. Which tracts of logged/degraded forests are most important for biodiversity, incorporating both current biological value and long-term considerations of succession, habitat area and connectivity?
3. What are the most cost-effective methods to rehabilitate logged/degraded forests to maximise biodiversity and restore ecosystem functioning?
4. What are the impacts of different types of plantation agriculture on understudied taxa, especially aquatic communities and terrestrial macroinvertebrates? How do we minimise or mitigate these impacts?
5. Are logged forests, degraded areas, and abandoned plantations more susceptible to the ecological impacts of exotic/invasive species?

HDI shows a moderate positive correlation with per capita total number of studies across countries. Countries with a higher HDI may have a better educated populace and therefore greater research capacity. In addition, these countries may take a greater interest in conducting conservation research given that their human development needs are already significantly met (Environmental Kuznets Curve; Bradshaw et al., 2010).

Interestingly, in our study the correlation between HDI and per capita number of studies led by in-country scientists is stronger than that of HDI and per capita total number of studies. HDI is also very strongly correlated with the proportion of papers led by in-country scientists. This suggests that the increase in research productivity with HDI is largely driven by research led by in-country scientists. This is not surprising. Foreign-led studies are by definition managed by foreign research teams and primarily funded by organisations in the home countries of those foreign researchers; therefore, foreign researchers may not be limited by the paucity of funding and lack of research capacity in the country of research.

Stocks et al. (2008) argued that a larger human population likely contributes more in-country scientists. However, we did not observe a correlation between population size and the proportion of local-led studies. This suggests that a larger population by itself does not guarantee greater research output by in-country scientists. Lastly, despite the importance of HDI in driving locally-led research, it does not appear to drive the foreign lead researchers to collaborate more with local scientists. As explained above, it is likely that foreign lead researchers are well-equipped to perform research without assistance by local researchers. Another possible reason is that the two hypotheses outlined in the Methods section (countries with lower HDI mandating that foreign researchers collaborate with local researchers to build capacity versus countries with higher HDI having higher research capacity thus attracting greater collaboration) cancel each other out.

Irrespective of the causes, the fact that only 40% of studies led by scientists based outside of Southeast Asia have co-authors based in Southeast Asia strikes us as very unfortunate. Unless a concerted effort is made by foreign researchers to build conservation-science capability within Southeast Asia, the long-term prospects for biodiversity in the region are poor because effective biodiversity conservation requires the participation of local scientists. First, in-country/region scientists are likely to have a better understanding of local culture, values, and politics than foreign-based researchers who spend less time in the country of research; consequently they may be more effective in translating research into actual conservation initiatives by working closely with local communities, NGOs, and the government. Second, in-country researchers and academics are primarily responsible for the training of the next generation of conservation workers in each country. Having a team of capable and well-trained conservation researchers/educators facilitates the transfer of knowledge and ensures that the next generation of scientists, natural resource managers, and policy makers are well-equipped to deal with conservation challenges.

Thus, we see two important needs with respect to conservation science in Southeast Asia: (1) increase the total amount of research in understudied parts of Southeast Asia; and (2) increase the number of Southeast Asians engaged in conservation science research. With respect to the first need, we encourage major funding institutions to target additional funds for work in understudied countries, especially Laos, Cambodia, and Vietnam, and regions such as Indonesian Papua. Moreover, if receipt of those funds is contingent on the researchers having one or more in-country partners, then the second need can be partially addressed as well.

To further address the second need, we encourage researchers from universities in wealthier countries (e.g., Singapore, USA, Great Britain, Australia, Japan, etc.) working in Southeast Asia to identify promising students from less developed countries and hire them as field assistants, and subsequently, lobby for their admission into undergraduate and/or graduate programmes at the researchers' home institutions. The universities must be cognizant that many of these prospective students may lack the educational background and proficiency in English language of their counterparts in richer countries and must therefore be prepared to provide students with additional training and support to bridge educational gaps. Additionally, short-term (1–2 year) fellowships can be set up by governments of wealthier countries, possibly co-funded by participating universities and/or international non-governmental organisations (NGOs), to enable talented undergraduate and graduate students from Southeast Asian developing countries to study and work with experienced researchers. Such fellowships enable students to obtain additional training in conservation science and build linkages with researchers and funding agencies in other countries. Universities can work closely with NGOs that work with or know of highly talented people (e.g., students, research assistants, lecturers) in developing countries to identify suitable candidates for graduate study or fellowships. If prospective students are not able to move abroad for an extended period of time (e.g., owing to family commitments), they should be encouraged to enroll in graduate programmes

at local universities. Foreign researchers can help to mentor locally-based students as co-advisors or committee members for their dissertation research. Such an arrangement would also help build capacity among local scientists who oversee the students' research.

In addition to assistance from wealthier countries to build research capacity, governments and academic institutions in Southeast Asian countries can help to encourage conservation research in several ways. First, academic institutions can provide incentives for local scientists, if not already present, to publish in the major international conservation journals (e.g., introduce rate of publication in international journals as a criterion for academic promotions, bonuses, etc). Second, governments can consider simplifying and expediting research permit applications for projects performed in collaboration with foreign researchers (Sodhi & Liow, 2000). Third, local funding agencies should provide greater support to research that addresses important conservation questions.

We recognise, however, that there are two risks associated with these simple steps. First, diverting funds from one Southeast Asian nation to another ignores the fact that this region as a whole is desperately in need of more conservation-science research. Robbing Peter to pay Paul is hardly a satisfactory solution to the overall problem; hence, we would hope that new sources of funding for Southeast Asia will be obtained to avoid this predicament. Second, to the extent that particular nations raise needless obstacles to conducting research within their borders, funders should be wary of directing money to those countries. In the long term, biodiversity in Southeast Asia will be conserved only if Southeast Asians have the capability to study it and manage it, along with the desire to protect it. But in the short term, at least, we encourage conservation scientists from around the world to consider working in this region in partnership with in-country scientists and students. The need for conservation research is immense, but so too are the rewards.

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