Ecological Knowledge is Lost in Wealthier Communities and Countries

SARAH E. PILGRIM, LEANNE C. CULLEN, DAVID J. SMITH, AND JULES PRETTY*

Department of Biological Sciences, University of Essex, Colchester CO4 3SQ, UK

Received April 10, 2007. Revised manuscript received November 29, 2007. Accepted December 4, 2007.

Accumulated knowledge about nature is an important part of people's capacity to manage and conserve the environment. But this ecological knowledge is now being increasingly lost. There have been few cross-cultural and quantitative studies to describe the phenomenon of its loss. Here we show a strong inverse correlation between ecological knowledge and income levels in and among India, Indonesia, and the UK ($n = 1095$ interviews). Knowledge acquisition and subsequent saturation occurs at an early age in the most resource-dependent communities, but not in the UK, where knowledge levels are low and acquisition is slow. Knowledge variance within communities increases in association with ecological knowledge decline and a scale of progressive knowledge loss was revealed with the most rapid rates of loss in industrialized regions. Various studies have described the mutually exclusive relationship between economic growth and environmental conservation; however this is the first to consider the association between economic growth and social capacity to manage the environment. Understanding ecological knowledge loss is important to understanding the declining capacities of communities undergoing economic development to manage their natural resources and the future of ecosystem diversity in the light of current patterns of economic growth.

Introduction

Accumulated knowledge about nature, termed traditional ecological knowledge (TEK), local ecological knowledge (LEK), indigenous knowledge (IK), ecoliteracy, or more generally ecological knowledge, is an important part of people's capacity to manage and conserve both wild and agricultural systems over extended periods. It is acquired through frequent interaction with the local environment driven by a need to pursue daily subsistence strategies for food and economic provision. This knowledge is transferred between generations through observations and narratives as a key survival tool. It tends to be socially embedded, often contributing to cultural traditions, identities, beliefs, and worldviews. It differs from modern knowledge by being dynamic, adaptive, and locally derived, thus coevolving with the ecosystem upon which it is based (*2–7*).

Ecological knowledge has substantial environmental, human, and economic value, as it codes for and contributes to a wide range of ecosystem goods and services, including current and future pharmaceutical uses, agricultural diversity in terms of both crops and livestock, and wild harvest opportunities for food, medicine, and fuel. Crucial to all of these is the conservation of the ecosystems upon which local knowledge systems, and the management practices derived from them, are based. Though these may not necessarily be conscious conservation efforts, nor is it true that a traditional community will always be successful, it is clear that many societies have evolved social norms and traditional practices that have ensured the continuity of resource stocks over sustained periods (*8–11*).

However, as traditional communities become less reliant on local resources and begin to adopt modern lifestyles, so ecological knowledge is being lost, either as it is supplanted by modern knowledge or is no longer transmitted (*2, 3, 12, 13*). A number of processes have been identified as causes of this decline, and include urbanization, modernization of public services including education systems, and globalization of trade and belief systems (*3, 5, 6, 14–22*). Therefore with a departure from cultural traditions and movement toward market-based lifestyles, combined with a growing disconnection from the land, local intrinsic concern and knowledge of resources is becoming diluted and devoid of purpose, causing local management systems to come under threat. This may in turn lead to overexploitation and ecosystem collapse as financial incentives prevail (*12, 23, 24*).

Therefore the lack of ecological knowledge today can be considered a constraint on the conservation of biodiversity, particularly where state management approaches are distinct from the concerns and capacities of local people (*12, 25, 26*). All of these changes are synonymous with the growth of the formal economy within today's developing countries. Economic growth can be defined as "*an increase in the production and consumption of goods and services. It occurs when the product of population times per capita is increasing. It is generally gauged by measures of national income such as gross domestic product (GDP) and gross national product (GNP)*" (*27*). For the purposes of this research, income has been used as a proxy for wealth (or economic status).

There are a growing number of studies into ecological knowledge within countries. As a result, there are known to be localized differences in the knowledge levels of men and women, of old and young, of groups engaged in ecosystem management and those not, and of those with different amounts of time resident at one place (*14, 28–32*). Very few, however, have been cross-cultural, large-scale, and over a wide geographic spread (*10*). In addition, most have lacked the necessary quantitative data across whole communities to describe the widespread phenomenon of knowledge loss. Here, we question the extent to which economic growth is a key driver of knowledge loss, whether small-scale economic development within a community can be just as detrimental to ecological knowledge as large-scale regional development, whether the age at which knowledge is acquired differs with level of resource dependence, and how wealth corresponds with knowledge distribution within a community (e.g., the difference between the most and least wealthy residents).

The definition of ecological knowledge has been widely contested in the literature. In 1999, Berkes described four levels of ecological knowledge (*33*): (1) the names of living (e.g., plants, animals) and physical (e.g., soils, water, weather) components of ecosystems; (2) the functions and uses of each component; (3) the land and resource management systems and the social institutions that govern them; and (4)

* Corresponding author e-mail: jpretty@essex.ac.uk; tel.: +44-1206-873323.

10.1021/es070837v CCC: $40.75

Published on Web 01/08/2008

the worldviews and cosmologies that guide the ethics of people in the system. To enable cross-cultural comparisons to be made, in this study we analyze the first two levels of ecological knowledge (the names of living components of ecosystems and the functions and uses of each component) within communities from India, Indonesia, and the UK (similar to the concept of Functional Environmental Literacy defined by Stables (*34*) and Stables and Bishop (*35*)). This study does not look at respondents' knowledge of large-scale dynamic processes, such as climate change or habitat degradation, since worldviews and environmental understandings often differ between regions and cultures (similar to the concept of Cultural Environmental Literacy defined by Stables (*34*) and Stables and Bishop (*35*)). Therefore it has been necessary to adopt a definition that only looks at part of the ecological knowledge issue for the purposes of this research, but that examines it in detail. Thus these results do not necessarily reflect the situation for other aspects of ecological knowledge; they do however reflect people's ability to play a part in the management of their own local ecosystems.

Experimental Section

Study Site Selection. Study sites were chosen for having cultural-segregation, for having differing levels of economic development and resource dependence, and for having different socio−political frameworks and resource management institutions. In the UK, the study sites included four villages in rural Lincolnshire, four urban wards in outer south London, and three coastal towns of north Essex. These were chosen to represent rural, urban, and coastal regions of the UK with differing levels of economic development and divided into smaller areas for subsampling. In India, five villages in Virudhunagar district, Tamil Nadu, were selected for their range of dryland resource-management institutions and capacities (in collaboration with the local nongovernmental organization SPEECH, the Society for People's Education and Economic Change). Here, local market pressures have reduced land dependence, but natural resources are still relied upon particularly when severe environmental conditions prevail. In Indonesia, six villages were selected in Wakatobi Marine National Park, southeast Sulawesi, to include cultural diversity and a range of local resource dependence levels reflecting variation in household income (Lahoa, Sampela, and Mantigola are Bajo reef communities previously sea nomads; Kasuwari, Ollo, and Buranga are Orang Pulo coastal communities previously agri-dependents). This region of Indonesia was selected as a site where economic growth is in its early stages and the pressures of marketization and modernization have only recently emerged. By making intra- as well as intersite comparisons, we examine the impact that economic growth has had on ecological knowledge at all these sites.

Ethnobotanical Interviews. We used ethnobotanical surveys with photographic flashcards (*30, 36, 37*), combined with semistructured interviews, for gathering social and economic data. In other work (*6, 38*), we have found a strong positive correlation between knowledge of plants with that of animals and birds, so here we only focus on identification of plants (level 1) and their functions and uses (level 2), based on the assumption that these are indicators of overall ecological knowledge.

Up to 50 species were chosen for inclusion at each site based on abundance at the study site, having an affinity for a variety of local habitats, and having ecological requirements that fit the environmental conditions of the region (for instance, drought and high temperature tolerance in India). Between 2 and 4 local experts (known locally for their in-depth botanical knowledge) were consulted per site. Each was asked if the species shown to them could be found locally, and if they knew of any local names and uses. Plant species that were identified as being absent from study sites were eliminated.

During interviews, respondents were asked whether they recognized the species shown to them, to name the species, and to list any uses for it. Names matching those given by local experts were taken to be correct and alternative names were recorded on site. Local experts were later consulted to assess if alternative names given were incorrect or simply less common vernacular names. In addition, demographic data were collected for each respondent including age, gender, village of residence, and livelihood. An economic survey was carried out at the Indonesia study site to measure primary household income, which comprised a household survey for which semiquantitative interviews were used. During this survey, 10% of all households from the 6 Indonesian villages were sampled at random.

All interview protocols were piloted locally prior to formal interviewing. A total of 1095 people were interviewed using the ethnobotanical surveys across the three sites (India $n = 192$; Indonesia $n = 192$; UK $n = 711$). In addition, another 144 respondents were randomly chosen for inclusion in the economic survey carried out at the Indonesia study site. Interviews were conducted during July−August 2003 (India), April 2004−December 2005 (UK) and July−September 2005 (Indonesia).

Sampling Strategy. Stratified cluster sampling was used at each site for the ethnobotanical surveys. Initially, cluster sampling was used to select the villages or wards within each locality, and then stratified sampling was used within villages/wards to ensure that all subpopulations were fairly represented (men, women; age groups 15–19, 20–29, 30–49, and 50+ years). Where possible, 10% of each village subpopulation was sampled. However where this was not viable due to large actual population sizes or actual population sizes being unknown, the minimum number of respondents required for statistical testing were interviewed according to Roscoe (*39*) (30 per subpopulation).

Quotas were met through purposive sampling techniques including door-knocking, visiting local groups, public libraries, and high streets, and chain referrals commonly used in this field of research (whereby respondents were asked to give the names of several other local people who may be willing to participate, names from this list were then chosen at random) (*4, 40, 41*). No two respondents interviewed were from the same household. Economic surveys carried out at the Indonesia study site targeted the heads of households or their spouses and were fully randomized. Local translators were used at both the India and Indonesia study sites.

Three quantifiable measures of ecological knowledge were generated from this methodology: (i) mean % identification of local plant species, (ii) mean number of uses known for local plant species, and (iii) knowledge variance (the difference in knowledge between the most and least knowledgeable members of a community, measured by coefficient of variance of % identification). SPSS 12.0 was used for database construction, data handling, and statistical analysis. As a result of the data being non-normally distributed, nonparametric statistical tests were used. All associations were tested for using Spearman's rank and age differences in knowledge were tested for using Kruskall Wallis (comparing country differences) and Mann–Whitney-U (comparing differences in knowledge between adults (over 20 years) and young people (under 20 years)).

Results

Intracountry Differences in Wealth (Indonesia). Although no difference in % identification was detected among the Indonesian villages, there was a strong inverse correlation between income and number of uses known for local plants

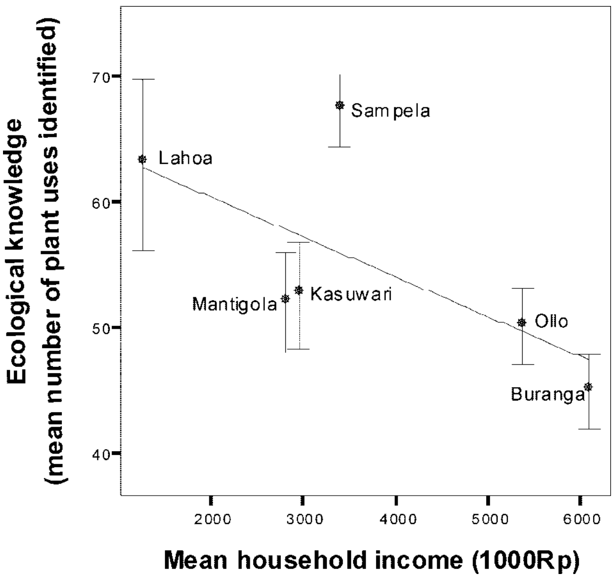

FIGURE 1. Mean ecological knowledge (plant use identification) related to mean income for six resource-dependent villages, Indonesia (±2 SE, $n = 192$).

(wealthy villages knowing on average 18 fewer species uses) ($R_s = -0.211$, $p < 0.01$, $n = 192$) (Figure 1). This indicates that as household income and external purchasing power increases, so there is an associated loss in resource dependence and its supporting knowledge of local uses. Residents of the outlier village, Sampela, had higher knowledge levels than expected for its level of income. This may be a consequence of the conservation organization, Operation Wallacea, having a social science field base within the village which employs some local villagers, thus altering their economic status seasonally.

Intercountry Differences in Wealth (UK, India, and Indonesia). In comparing communities from the UK, India, and Indonesia, levels of ecological knowledge (in terms of % identification) were found to be inversely correlated to Gross Domestic Product (GDP) and Human Development Index (HDI) ($R_s = -0.471$, $p < 0.001$, $n = 1095$) (Figure 2). Residents in the UK, with an HDI score of 0.94 and a mean per capita GDP of U.S. $26,150, had the lowest levels of plant identification (on average 24%), whereas those living in marginal areas of Indonesia, with an HDI of 0.55 and GDP of U.S. $2143, had the highest identification (71%). The Indian communities were intermediate with an HDI of 0.65 and a plant identification score of 46%.

Due to high variation in human development levels across India and Indonesia, the regional score for Tamil Nadu was used and the Indonesia HDI score was adjusted to compensate for the high proportion of indigenous groups resident at the study site. Marginal tribes are rarely included in population demographics in Indonesia despite suffering below average life expectancies, literacy levels, and economic status (Majors, personal communication, August 14, 2005). Therefore southeast Sulawesi HDI was recalculated compensating for reduced Bajo life expectancy, literacy, and GDP (HDI was reduced from a regional value of 0.64 to 0.57) (*42–44*).

Knowledge Variance within Communities. The knowledge variance within a community (measured by coefficient of variance) between the most and least knowledgeable individuals was lower in the less wealthy communities with sustained resource dependence, such as Indonesia (20% variance, 71% identification), and higher in the UK (58% variance, 24% identification) (Figure 3). India, again, had an intermediate level of knowledge variance coinciding with its intermediate knowledge levels (27% variance, 46% identi-

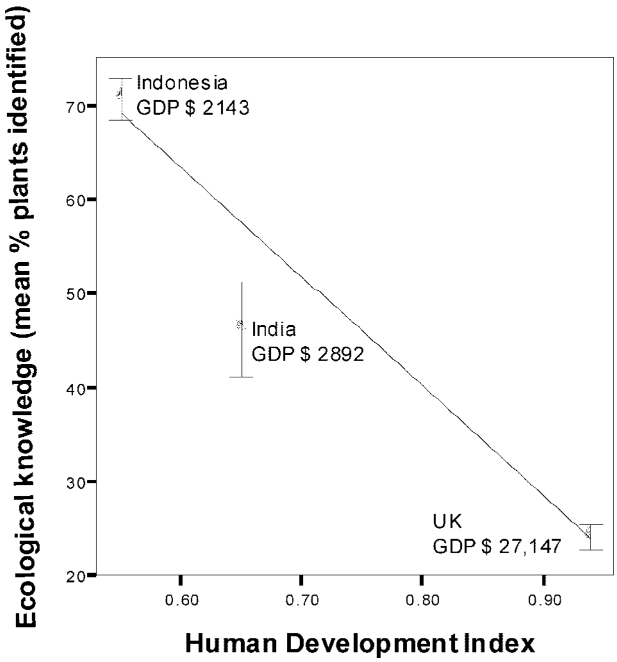

FIGURE 2. Mean ecological knowledge (plant name identification) in three countries and relationship with Human Development Index and per capita GDP (±2 SE, $n = 1095$) (GDP U.S. dollar estimates derived from purchasing power parity (PPP)).

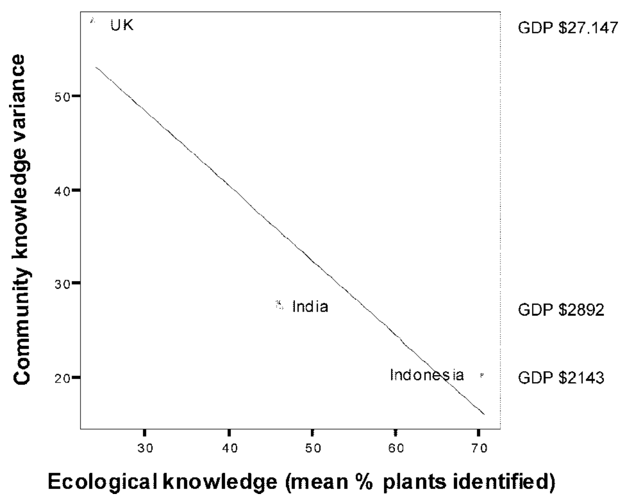

FIGURE 3. Mean ecological knowledge (plant name identification) in relation to variance in community knowledge across three countries (mean ± 2 SE, $n = 1095$) (GDP U.S. dollar estimates derived from purchasing power parity (PPP)).

fication). Therefore a negative association exists between knowledge variance and knowledge level ($R_s = -0.471$, $p < 0.001$, $n = 1095$).

Differences in Age of Acquisition. The difference between old and young people's knowledge of local species names significantly differed among sites ($H = 14.478$, df = 2, $p < 0.01$, $n = 1095$). In the UK, older people were able to identify many more local species than younger people ($U = 16920.500$, $p < 0.001$, $n = 711$) (Figure 4). In India and Indonesia, however, there were no significant differences observed between age groups, and knowledge saturation (whereby young people hold the same level of knowledge as their elders) occurs earlier. The age of knowledge saturation increased from the ages of 30 (Indonesia) and 50 (India) to the age of 70 in the UK. Thus a scale of progressive knowledge loss with age was detected (*31*); from rapid loss of both primary (names)

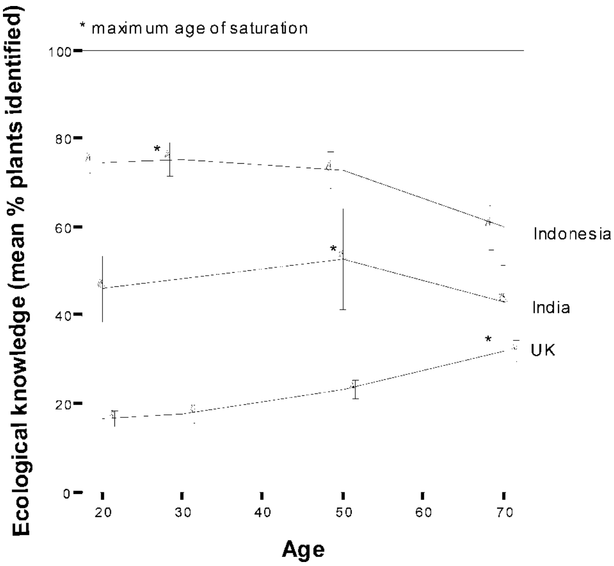

FIGURE 4. Relationship between age and mean ecological knowledge (plant name identification) including the age of knowledge saturation in three countries (mean ± 2 SE, n = 1095).

and secondary (uses) knowledge in the UK (names, U = 16920.500, $p < 0.001$, $n = 711$; uses, $U = 26748.500$, $p < 0.001$, $n = 711$), to a gradual loss of secondary (uses) knowledge in India (U = 36.000, $p < 0.05$, n = 192), to no significant knowledge loss with age at the Indonesia study site. Table 1 shows the four most identified plant species at each site and their uses.

Discussion

We found that level of resource dependence and frequency of environmental interaction dictated by community wealth are key to ecological knowledge gain in low income communities. Where a community has become industrialized and largely independent of local environmental goods and services, knowledge of species names and functions on the whole is low, difference in knowledge level between old and young are large, and variance between experts and nonexperts is great. In resource-dependent low-income communities, ecological knowledge was found to be higher, with lower variance between experts and nonexperts and rate of knowledge acquisition rapid from a young age. This suggests that as communities become wealthier, knowledge becomes concentrated in fewer people with a sustained personal interest (e.g., those who study the environment). However, where communities are resource-dependent, their knowledge of species names and uses is likely to be shared among all community members engaged in daily tasks to meet family needs.

Unlike in the UK, ecological knowledge accumulation (of the names and functions of ecosystem components) appears to be rapid at a young age in India and Indonesia, probably resulting from high dependence on local marine and terrestrial resources. However, some of this knowledge is most likely forgotten with age. As communities become wealthier and increasingly engage with external economies by trading goods and services, so knowledge saturation appears to be delayed, due to decreased interaction with natural resources. This is combined with the declining value given to the intergenerational transfer of experiential knowledge in modern societies. Mean community knowledge levels and variance are likely to provide a better indicator of community management capacity since they are more likely to be indicative of the ability of a community to act collectively, rather than the expert knowledge of healers and shamans focused on in many previous studies (*4, 45–47*). Thus ecological knowledge decline (in terms of species names and uses) is associated with increasing disconnection and livelihood independence from agricultural and wild systems as a consequence of modern economic growth.

This data cannot on its own confirm Pyle's (*19*) hypothesized "Extinction of Experience", as we do not know prior levels of ecological knowledge at earlier times. It is, however, suggestive that as people become wealthier and more dependent on purchasing imported market provisions, so this particular level of ecological knowledge is no longer required on a daily basis to survive. At the same time, there may be less knowledge transmission between generations, or simply substitution for other forms of knowledge, particularly among younger generations as a result of the introduction of formal schooling, in which ecology as a science has been downgraded, and urban jobs. Local ecological knowledge is likely to be substituted by modern environmental knowledge about global warming, energy saving techniques, and organic foods for example. This global knowledge is, of course, essential but should not replace that of our local ecosystems (*6, 36, 37, 48*).

As almost half of the world's population is now urbanized (*49*), and almost all future population growth is set to occur in urban regions rather than rural, there are concerns about the future of ecological knowledge. This is particularly important in the light of progressive loss associated with modern patterns of economic growth and the departure from traditional lifestyles shown here. These changes and differences in ecological knowledge have important implications if the world's many valuable ecosystem goods and services are to be retained (*12, 50*), and if the terrestrial and marine habitats from which they derive are to receive public support for their protection and long-term sustainable management (*12, 47, 51*). After all, the levels of ecological knowledge studied here (names of living components of ecosystems and the functions and uses of each component) provide an indication of a community's connectivity and willingness to care for the local environment, since naming things with which we are familiar is human instinct and we are unlikely to care about that which we do not know (*52*).

Many marginal communities have managed their systems and resources effectively throughout history. As a result, they hold knowledge of how wildlife behave, reproduce, aggregate, and migrate. Where wildlife reproduction is predictable in time and space, users and managers can assess the levels of resource removal or harvest that can be permitted while sustaining population viability (*53*). Thus local management techniques based on this information can be sustainable and locally self-enforcing if everyone is under pressure to conform to customary norms and behavior thought to be in the best interests of the community (*54*).

As knowledge of local ecosystems decreases and uncertainty increases, management centers more on externally derived insurance functions, as comanagement shifts more toward the realms of the state. Future management prospects without local ecological knowledge would therefore rely on external theory and state institutions alone which have, so far, been inadequate and often unsuccessful (*1, 55*). Despite this, as shown here, certain levels of ecological knowledge, and management techniques derived from them, are being rapidly discarded or made redundant as people adopt contemporary exploitative methods and management techniques. Thus in resource-dependent communities, where ecological knowledge is high and variance between the most and least knowledgeable is low, a high capacity for self-management still exists. Our findings, however, suggest this may now be under threat.

TABLE 1. Names and Uses of the Four Most Identified Plant Species at Each Study Site Including Percent Identification at Each Site

country	plant name	local uses	% identification
UK	daisy *Bellis perennis*	none given	83
	english bluebell *Hyacinthoides nonscripta*	none given	78
	meadow buttercup *Ranunculus acris*	none given	70
	milk thistle *Silybum marianum*	none given	62
India	divi-divi *Caesalpinia coriaria*	food – human and livestock, construction, cosmetic, medicinal	100
	buffel grass *Cenchrus ciliaris*	food – livestock, construction, medicinal	96
	egyptian grass *Dactyloctenium aegyptium*	food – livestock, medicinal	96
	bristly foxtail *Setaria verticillata*	food – livestock, medicinal, ornamental, religious	96
Indonesia	banana *Musa acuminata*	food – human, economic, religious	100
	papaya *Carica papaya*	food – human, economic, medicinal	99
	chili *Capsicum annum*	food – human, economic, medicinal	99
	coconut *Cocos nucifera*	food – human, economic, religious	98

Conservation of the world's ecosystem goods and services is vital to human and economic health, but ecological knowledge decline at the rates detected in this study threaten to constrain future conservation efforts globally. The recent Millennium Ecosystem Assessment highlighted the considerable value of the world's marine and terrestrial ecosystem services (*12*). Conserving biodiversity worldwide has been estimated to cost U.S. $300 billion (*56*). However virtually all large-scale damage to the global environment is caused by economic activities (*57*). Yet despite widespread belief that economic growth is unlimited, the loss of environmental goods and services will almost certainly act to limit economic growth in the future (*58*). The consumption of environmental goods and services by the economy is inevitable as is the production of wastes and pollutants. This acts to limit species diversity, ecosystem health, and goods and services, in turn limiting capacity for future development and economic growth. The mutually exclusive relationship between economic growth and future conservation has been well-described in recent years (*27, 58–60*).

But the prevailing view as exemplified by Kuznet's curve indicates that environmental threats posed by society are low before economic growth, high during early growth, and then decrease again once the economy is wealthy enough to invest in conservation programs (*58*). However, this is contradicted by the widespread failure of many state management efforts to sustain local resources. Although wealthy nations may have the financial resources to invest in conservation efforts, their failures are most likely a consequence of paucity in ecological understanding combined with low local support (*25, 51, 53, 61*). The direct environmental consequences of further economic growth upon biodiversity conservation have been well described, however the social repercussions of future growth on the capacity of communities to manage their local environments have not yet been considered.

Our study reveals that ecological knowledge, a primary factor responsible for successful resource management (*25, 62, 63*), declines in association with economic growth (through hybridization and lack of transfer). Although the connection between ecological knowledge and management capacity has previously been made, as has the connection between knowledge decline and economic growth of a region, the link between loss of management capacity and economic growth has not previously been discussed. Therefore, in addition to the depletion of goods and services, the capacity of local communities to manage what environmental assets remain will decline in the future in association with economic growth. Hence time and money could be spared if the knowledge, experiences, and capacities of local peoples were protected and used in resource management efforts today (*64*).

Acknowledgments

We are very grateful to the following for help and support during field work: Z. Harris of Croydon library, C. Hudson of West Wickham library, Bromley library staff, Old Wilsonian's Association and Gainsborough library staff; M. Hailes, C. Hailes, and P. Hailes of Kexby, Lincolnshire; the Society for People's Education and Economic Change (SPEECH), Madurai, Tamil Nadu, India, particularly J. Devavaram, A. Erskine, and A. Thangham; Operation Wallacea, Wakatobi, Indonesia, particularly J. Clifton and C. Majors. This research was supported by the UK's Natural Environment Research Council (NER/S/A/2002/10365).

Literature Cited

(1) Olsson, P.; Folke, C. Local ecological knowledge and institutional dynamics for ecosystem management: A study of Lake Racken watershed, Sweden. *Ecosystems* **2001**, *4*, 85–104.

(2) Berkes, F.; Colding, J.; Folke, C. Rediscovery of traditional ecological knowledge as adaptive management. *Ecol. Appl.* **2000**, *10*, 1251–1262.

(3) Gadgil, M.; Seshagiri Rao, P. R.; Utkarsh, G.; Pramod, P.; Chhatre, A. and members of the People's Biodiversity Initiative. New meanings for old knowledge: The people's biodiversity registers program. *Ecol. Appl.* **2000**, *10*, 1307–1317.

(4) Davis, A.; Wagner, J. R. Who knows? On the importance of identifying "experts" when researching local ecological knowledge. *Human Ecol.* **2003**, *31*, 463–489.

(5) Pilgrim, S. E.; Cullen, L.; Smith, D.; Pretty, J. Hidden harvest or hidden revenue? The effect of economic development pressures on local resource use in a remote region of southeast Sulawesi, Indonesia. *Indian J. Traditional Knowledge* **2007**, *6*, 150–159.

(6) Pilgrim, S. E.; Smith, D.; Pretty, J. A cross-regional assessment of the factors affecting ecoliteracy: Implications for policy and practice. *Ecol. Appl.* **2007**, *17*, 1742–1751.

(7) Pretty, J. *The earth only endures*; Earthscan: London, 2007.

(8) Gadgil, M. Biodiversity and India's degraded lands. *Ambio* **1993**, *22*, 167–172.

(9) Murdoch, J.; Clark, J. Sustainable knowledge. *Geoforum* **1994**, *25*, 115–132.

(10) Sillitoe, P. The development of indigenous knowledge: A new applied anthropology. *Current Anth.* **1998**, *39*, 223–252.

(11) Gilchrist, G.; Mallory, M.; Merkel, F. Can local ecological knowledge contribute to wildlife management? Case studies of migratory knowledge. *Ecol. Soc.* **2005**, *10* (20);Available from-http://www.ecologyandsociety.org/vol10/iss1/art20/.

(12) MEA. *Current state and trends, Vol. 1: Ecosystems and well-being*; Millennium Ecosystem Assessment; Island Press: London, 2005.

(13) Singh, R. K.; Singh, D.; Sureja, A. K. Community knowledge and conservation of indigenous biodiversity: Exploration of hidden wisdom of Monpa tribe. *Indian J. Traditional Knowledge* **2006**, *4*, 513–518.
(14) Nabhan, G. P.; Trimble, S. *The geography of childhood: Why do children need wild places?* Beacon Press: Boston, MA, 1994.
(15) Peat, F. D. *Blackfoot physics: A journey into the native American universe*. Fourth Estate: London, 1996.
(16) Nolan, J. M.; Robbins, M. C. Cultural conservation of medicinal plant use in the Ozarks. *Human Org.* **1999**, *58*, 67–72.
(17) Johnson, J. M. *Design for learning: Values, qualities and processes of enriching school landscapes*; American Society of Landscape Architects: Washington, DC, 2000.
(18) Turner, N. J.; Ignace, M. B.; Ignace, R. Traditional ecological knowledge and wisdom of aboriginal peoples in British Columbia. *Ecol. Appl.* **2000**, *10*, 1275–1287.
(19) Pyle, R. M. The rise and fall of natural history: How a science grew that eclipsed direct experience. *Orion* **2000**, *20*, 17–23.
(20) Hamwey, R. Traditional knowledge and the environment: Statement by the United Nations Environment Programme. In *Protecting and Promoting Traditional Knowledge: Systems, National Experiences and International Dimensions*; Twarog, S., Kapoor, P., Eds.; United Nations: Geneva, 2004; pp 345−346.
(21) Tansey, G. A food system overview. In *Protecting and Promoting Traditional Knowledge: Systems, National Experiences and International Dimensions*; Twarog, S., Kapoor, P., Eds.; United Nations: Geneva, 2004; pp 41–58.
(22) Stocks, A.; McMahan, B.; Taber, P. Beyond the map: Indigenous and colonist impacts and territorial defence in Nicaragua's BOSAWAS Biosphere Reserve. Working paper; Department of Anthropology, Idaho State University: Boise, ID, 2006.
(23) Evans, S. M.; Gill, M. E.; Retraubun, A. S. W.; Abrahamz, J.; Dangeubun, J. Traditional management practices and the conservation of the gastropod (*Trochus nilitocus*) and fish stocks in the Maluku Province (eastern Indonesia). *Fish. Res.* **1997**, *31*, 83–91.
(24) Ghimire, K. B.; Pimbert, M. P. *Social Change and Conservation: Environmental Politics and Impacts of National Parks and Protected Areas*; Earthscan: London, 1997.
(25) Feit, H. A. Self-management and state-management: Forms of knowing and managing northern wildlife. In *Traditional Knowledge and Renewable Resource Management in Northern Regions*; Freeman, M. M. R., Carbyn, L. N., Eds.; Boreal Institute for Northern Studies, and International Union for the Conservation of Nature and Natural Resources: Edmonton, 1988; pp 72−91.
(26) Pretty, J.; Smith, D. J. Social capital in biodiversity conservation and management. *Conserv. Biol.* **2004**, *18*, 631–638.
(27) Czech, B.; Pister, P. Economic growth, fish conservation, and the American fisheries society. *Fisheries* **2005**, *30*, 38–10.
(28) Mellor, M. *Feminism and Ecology*; Polity Press: Cambridge, 1997.
(29) Kahn, P. H., Kellert, S. R., Eds. *Children and Nature: Psychological, Sociocultural, and Evolutionary Investigations*; The MIT Press: Cambridge, MA, 2002.
(30) Nyhus, P. J.; Sumianto, T; Tilson, R. Wildlife knowledge among migrants in southern Sumatra, Indonesia: Implications for conservation. *Environ. Conserv.* **2003**, *30*, 192–199.
(31) Birchenough, A. C. The use of local knowledge to map the distribution of endangered birds on Pacific Islands. In *Proceedings of the 3rd International ENSUS Conference: Promoting Knowledge and Understanding of the Environment*; Evans, S. M., Foster-Smith, J., Eds.; University of Newcastle upon Tyne: UK, 2005; pp 37−45.
(32) Singh, R. K.; Sureja, A. K.; Singh, D. Amta and Amti (*Hibiscus sabdariffa* L.): Cultural and agricultural dynamics of agrobiodiversity conservation. *Indian J. Traditional Knowledge* **2006**, *5*, 151–157.
(33) Berkes, F. *Sacred Ecology*; Taylor and Francis: Philadelphia, PA, 1999.
(34) Stables, A. Environmental literacy: Functional, cultural, critical. The case of the SCAA guidelines. *Environ. Educ. Res.* **1998**, *4*, 155–164.
(35) Stables, A.; Bishop, K. Weak and strong conceptions of environmental literacy: Implications for environmental education. *Environ. Educ. Res.* **2001**, *7*, 89–97.
(36) Balmford, A.; Clegg, L.; Coulson, T.; Taylor, J. Why conservationists should heed Pokémon. *Science* **2002**, *295*, 2367.
(37) Evans, S. M.; Dixon, S.; Heslop, J. *Environmental knowledge: How good is it and where does it come from? Promoting knowledge and understanding of the environment.* ENSUS Third International Conference, University of Newcastle upon Tyne: UK, 2005.
(38) Pilgrim, S. E. A Cross-Cultural Study into Local Ecological Knowledge. PhD thesis. University of Essex: UK, 2006.
(39) Roscoe, J. T. *Fundamental Research Statistics for the Behavioural Sciences,* 2nd edition; Holt Rinehart & Winston: New York, 1975.
(40) Huntington, H. P. Using traditional ecological knowledge in science: Methods and applications. *Ecol. Appl.* **2000**, *10*, 1270–1274.
(41) Brodt, S. Learning about tree management in rural central India: A local-global continuum. *Human Org.* **2002**, *61*, 58–67.
(42) Indonesia Human Development Report. *Human development challenges in a democratic, decentralised Indonesia*; United Nations, 2001; Available from www.hdr.undp.org/reports/detail_reports.cfm?view=144.
(43) Tamil Nadu Human Development Report. *Synopsis of Tamil Nadu HDR*; Government of Tamil Nadu, 2003; Available from www.undp.org.in/hdrc/shdr/TN/.
(44) UNDP. *UN Human Development Index Report*; United Nations, 2004; Available from http://hdr.undp.org/reports/global/2003/.
(45) Barrett, B. Herbal knowledge on Nicaragua's Atlantic coast: Consensus within diversity. *J. Comm. Health* **1995**, *20*, 403–421.
(46) Alexiades, M. N. Ethnobotany of the Ese Eja: Plants, health and change in an Amazonian society. Ph.D. thesis. City University of New York: New York, 1999.
(47) Howard-Borjas, P. L. Gender relations in local plant genetic resource management and conservation. In *Encyclopedia for Life Support Systems: Biotechnology*; Doella, H. W., DaSilva, E., Eds.; EOLSS Publishers: Cambridge, 2002.
(48) Skutnabb-Kangas, T. *On biolinguistic diversity: linking language, culture and (traditional) ecological knowledge*; Invited plenary lecture at the interdisciplinary seminar: At the limits of language; Department of Biology and Department of Linguistics and Philosophy, Universidad Autónoma de Madrid and Cosmocaixa: Madrid, 2004.
(49) Sustainable Development International. *World Urban Forum*; 2004; Available from http://www.sustdev.org/index.php?option=com_events&task=view_detail&agid=6&year=2004&month=09&day=13&Itemid=1.
(50) Constanza, R.; d'Arge, R.; de Groot, R.; Farber, S.; Grasso, M.; Hannon, B.; Limburg, K.; Naeem, S.; O'Neil, R. V.; Paruelo, J.; Raskin, R. G.; Sutton, P.; van den Belt, M. The value of the world's ecosystem services and natural capital. *Nature* **1997**, *387*, 253–260.
(51) Lundquist, C. J.; Granek, E. F. Strategies for successful marine conservation: Integrating socioeconomic, political, and scientific factors. *Conserv. Biol.* **2005**, *19*, 1771–1778.
(52) Pyle, R. M. The rise and fall of natural history: How a science grew that eclipsed direct experience. *Orion* **2001**, *20*, 17–23.
(53) Rudd, M. A.; Tupper, M. H.; Folmer, H.; van Kooten, G. C. Policy analysis for tropical marine reserves: Challenges and directions. *Fish Fisheries* **2003**, *4*, 65–85.
(54) Pretty, J. Social capital and the collective management of resources. *Science* **2003**, *302*, 1912–1915.
(55) Alcorn, J. B. Indigenous peoples and conservation. *Conserv. Biol.* **1993**, *7*, 424–426.
(56) Myers, N. A convincing call for conservation. *Science* **2002**, *295*, 447–448.
(57) Nadeau, R. L. *The Wealth of Nature: How Mainstream Economics Has Failed the Environment*; Columbia University Press: New York, 2003.
(58) Czech, B.; Angermeier, P.; Daly, H.; Pister, P.; Hughes, H. Fish conservation, sustainable fisheries, and economic growth: No more fish stories. *Fisheries* **2004**, *29*, 36–37.
(59) Czech, B. Economic growth, ecological economics, and wilderness preservation. *USDA Forest Proc.* **2000**, *2*, 194–200.
(60) Bigford, T.; Hyatt, K.; Dobson, T.; Poage, V.; Reynolds, L.; Czech, B.; Hughes, B.; Meldrim, J.; Angermeier, P. L.; Gray, B.; Whitehead, J.; Hushak, L.; Lupi, F. Economic growth and fish conservation. *Fisheries* **2006**, *31*, 404–409.
(61) Agrawal, A.; Gibson, C. C. Enchantment and disenchantment: The role of community in natural resource conservation. *World Dev.* **1999**, *27*, 629–649.
(62) Drew, J. A. Use of traditional ecological knowledge in marine conservation. *Conserv. Biol.* **2005**, *19*, 1286–1293.
(63) Tyrrell, M. The social reproduction and growth through practice of marine knowledge and skill. Unpublished, 2005.
(64) Veitayaki, J. Traditional marine resource management practices used in the Pacific Islands: an agenda for change. *Ocean Coast. Manage.* **1997**, *37*, 123–136.

ES070837V