Available online at www.sciencedirect.com
SCIENCE DIRECT®
ELSEVIER
Journal of Ethnopharmacology 100 (2005) 118–123
Journal of ETHNO-PHARMACOLOGY
www.elsevier.com/locate/jethpharm

Perspective paper

Country development does not presuppose the loss of forest resources for traditional medicine use

E.J. Buenz *

Complementary and Integrative Medicine Program, Mayo Clinic College of Medicine, 200 First Street NW, Rochester, MN 55905, USA

Received 11 April 2005; received in revised form 4 May 2005; accepted 4 May 2005
Available online 17 June 2005

Abstract

There are challenges in using ethnobotany as a research technique. Foremost, there is a generational loss of traditional medicine knowledge and a loss of plant resources as raw material for medicinal use. These losses are frequently attributed to the development and modernization of cultures. However, recent work has reported that the loss of languages, a classic marker of traditional knowledge, does not correlate with the relative development status of a country. By analyzing datasets regarding the relative development status of countries and land use patterns, I show that the loss of natural resources for traditional medicine use does not correlate with the relative development status of a country. This work implies that with proper governance, it is possible for countries to develop while preserving the natural resources utilized in traditional medicine.

Keywords: Plant; Traditional medicine; Biodiversity; Development

1. Introduction

Ethnobotanical-driven discovery of novel pharmacologic agents highlights the potential of leveraging collected indigenous knowledge as a research tool (Heinrich, 2000, 2003). However, there are two principle challenges in the application of ethnobotany as a research tool. First, relevant information gathering must race against the generational loss of traditional knowledge (Lee et al., 2001); this struggle to accrue ever-vanishing information is particularly true regarding medicinal knowledge of plants (Cox, 2000). Second, there is the widely accepted, yet unproven, belief that as countries develop, fewer plant resources are available to pursue traditional activities (Cox and Banack, 1991).

Often, modernization of cultures is taken to be synonymous with economic development. It has been suggested that younger generations tempted by the allure of modernization are not interested in learning traditional skills (Lee et al., 2001). Thus, as older members of the community die, the knowledge these elders possess is lost. While recent work has identified methods, such as the mining of historic herbal texts (Buenz et al., 2004, 2005), to resurrect some of this lost knowledge, many of the assumed underlying mechanisms regarding the loss of traditional knowledge are still unproven.

There is little doubt that pieces of traditional knowledge are lost every day. For example, Prostratin, the novel HIV treatment extracted from *Homalanthus nutans* (Gustafson et al., 1992), was originally identified as an anti-viral through ethnobotanical work in Samoa (Cox, 1993). Since then, the individuals with the traditional knowledge that ultimately led to the identification of *H. nutans* as an HIV therapeutic have passed away. Thus, an individual working on the same project today would be highly unlikely to identify *H. nutans* as a potential HIV therapeutic. Additionally, the rate at which this traditional knowledge loss is occurring globally has yet to be confirmed.

Typically, the loss of language is taken as a correlate of the loss of traditional knowledge. This assumption is reasonable since language appears to be at the core of culture

Abbreviations: HDI, human development index; HIV, human immunodeficiency virus; NASA, national aeronautics and space administration

* Tel.: +1 507 284 3759; fax: +1 507 284 1086.
E-mail address: buenz.eric@mayo.edu.

0378-8741/$ – see front matter © 2005 Elsevier Ireland Ltd. All rights reserved.
doi:10.1016/j.jep.2005.05.005

(McSherry, 1999), provides a unique context for understanding traditional skills (Hampton, 2002), and the literature using the language provides an inimitable understanding of the culture (Yapita, 1981; Porter, 1990). Unfortunately, the loss of language is occurring at an astonishing rate (Abrams and Strogatz, 2003) and likely 90% of languages will be extinct within this generation (Krauss, 1992).

Generally it is assumed that as countries develop the Gross Domestic Product and the Human Development Index (HDI) increase. Interestingly, recent work has shown that the number of languages spoken in a country does not correlate with Gross Domestic Product (Sutherland, 2003). While this observation lacks examination of the loss of language as a function of time, it implies that as countries develop they do not necessarily lose languages. Yet, this language loss is intrinsically difficult to quantify in relation to countries, since frequently country borders do not correlate with cultural, and thus language, boundaries. Nonetheless, the loss of language is occurring at a rapid rate and this loss has implications for traditional medicine knowledge.

It has also been suggested that the loss of plant resources for use in traditional systems is a factor in reducing traditional knowledge transfer from older to younger generations. This loss of forest resources is obvious; examples include the 30% decline in the Mediterranean forest cover since the 1950s (Mace, 2005) and the 0.6–0.8% decrease in forest cover in tropical biomes per year (FAO, 2001). Furthermore, this loss is visually striking, as demonstrated by the deforestation of the Amazon basin in Brazil over 30 years (Fig. 1). This loss of forest resources has a direct impact on traditional medicine use: traditional healers have to travel greater distances than previously to find plants for traditional medicine use (Balick and Cox, 1997).

Regardless of the mechanism of traditional knowledge loss, this knowledge loss has negative implications for the identification of new drugs through ethnobotany. However, the loss of plant material is important as well, since without the plants used by traditional medicine healers, there is little reason to pursue medicinal ethnobotany. In turn, determining the driving forces behind this loss of plant resources provides a unique window to begin modeling the loss of resources for traditional medicine and establishing mechanisms for resource preservation.

Typically, the ecosystems supported by natural forest cover provide the raw materials for traditional medicine. Here I present an analysis showing no correlation between the loss of natural forest cover and the relative development status of a country. Additionally, I report positive yearly increases in forest cover occur more frequently in developed countries than less developed countries. While this analysis is blind to the species composition (beyond the classification as natural forest cover), it does demonstrate that the conventional assumption wherein economic development results in decreased availability of plant resources for traditional medicine use may not be true. This work also suggests that proper development through good governance may allow preservation of resources useful for traditional medicine.

2. Methodology

2.1. Overview

Datasets regarding relative development status and land use patterns were analyzed. The Human Development Index (HDI) from 2001 was used as a marker for relative development status of a country. These analyses established relationships between the relative development status of the countries and land use patterns.

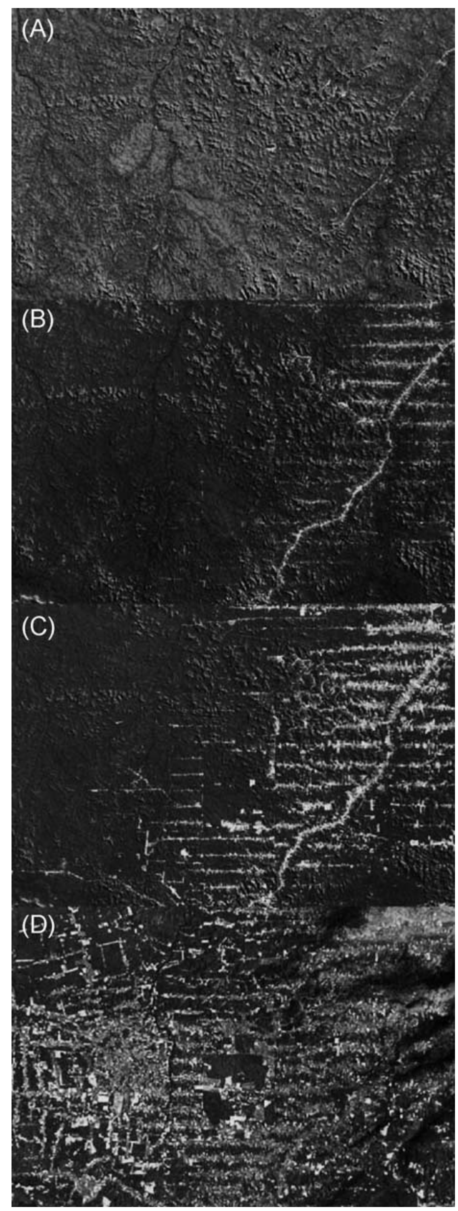

Fig. 1. Satellite imagery illustrating a time course of deforestation of the Amazon basin in Rondonia, Brazil (latitude 10.2°; longitude 63.5°): (A) 19 June 1975; (B) 1 August 1986; (C) 22 June 1992; (D) 7 February 2001.

2.2. Satellite imagery

Satellite imagery from the National Aeronautics and Space Administration (NASA) was accessed through World Wind (NASA, 2004). The NASA SVS Image Server was used to locate images at the indicated dates and locations. Images were navigated through the World Wind browser and screen captured.

2.3. Procurement of datasets

Datasets were identified through the United Nations Environmental Program GEO Data Portal (Leslie, 2005; UNEP, 2005). Table 1 lists all datasets and provides a description of each resource. Table 2 lists countries used in the analysis: countries lacking a statistic for a certain characteristic were excluded from only that analysis. The percent of land under natural cover was calculated for each country by dividing the area of natural cover by the country size.

2.4. Statistical analysis

Correlation values were determined by calculating the Pearson Product Moment Correlation in SigmaStat (Systat: Richmond, CA, USA). Scatter plots were created in SigmaPlot (Systat: Richmond, CA, USA).

3. Results

3.1. Relative development status does not correlate with percent of land under natural cover

To determine if the relative development status of a country correlated with the percent of land under natural forest cover, a correlation analysis between the HDI and the percent of land under natural cover was performed. Surprisingly, there was not a significant correlation ($p = 0.15$) between the relative development status of a country and the percent of land under natural cover (Fig. 2). Additionally, this lack of correlation was confirmed through performing a correlation analysis between Gross Domestic Product per capita and percent of land under natural cover ($p = 0.60$; data not shown). These data suggest that developed countries, defined by HDI, do not have less natural forest cover compared to less developed countries.

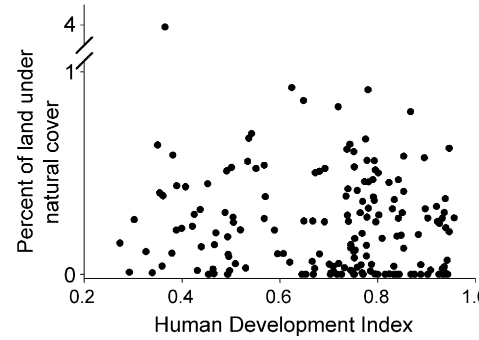

Fig. 2. Scatter plot of relative country development status and percent of land under natural cover. There is no relation ($p = 0.15$) between the development status of a country and the percent of land under natural cover.

3.2. Developed countries have altered land use patterns

To determine how the relative development status of a country relates to other markers of forest use, I examined the percent of land under permanent pasture for the latest available year, meat production per capita, and percent change of forest cover per year relative to the HDI. Fig. 3A illustrates the significant ($p = 0.004$) decrease in the land under permanent pasture as countries become more developed ($\rho = -0.218$). Additionally, Fig. 3B shows that the more developed countries have a significantly ($p = 1.6 \times 10^{-13}$) greater production of meat per capita compared to less developed countries ($\rho = 0.523$). These results suggest an altered land use pattern wherein developed countries are able to more effectively utilize the permanent pasture thus resulting in greater meat production per capita.

Table 1
Name, description, year(s) used, and organizations supplying datasets for analysis

Name of dataset	Description	Year(s) used	Reference
Human Development Index (HDI)	Combination of three categories for human development: life expectancy at birth, adult literacy and school enrollment, and Gross Domestic Product per capita.	2001	UNDP (2004)
Area of land under natural cover	Lands with primarily indigenous tree cover of more than 10% and an area of more than 0.5 ha.	2001	FAO (2004)
Percent of land under permanent pasture	Land used 5 years or more for herbaceous forage crops.	2002	FAO (2004)
Percent change of forest cover	The net change in forests including expansion of forest plantations and natural forests. Stands of trees established primarily for agricultural production are excluded.	1990–2000	FAO (2004)
Meat production per capita	Meat, both domestic and wild, from animals slaughtered in country regardless of origin.	2000	FAO (2004)
Country size	Total land area of country.	2003	CIA (2004)

Table 2
List of countries used in the correlation analyses

Afghanistan	Dominica	Liberia	St. Kitts
Albania	Dominican Rep.	Libya	Saint Lucia
Algeria	Ecuador	Liechtenstein	St. Vincent
Andorra	Egypt	Lithuania	Samoa
Angola	El Salvador	Luxembourg	San Marino
Antigua	Equatorial Guinea	Macedonia	Saudi Arabia
Argentina	Eritrea	Madagascar	Senegal
Armenia	Estonia	Malawi	Serbia
Australia	Ethiopia	Malaysia	Seychelles
Austria	Fiji	Maldives	Sierra Leone
Azerbaijan	Finland	Mali	Singapore
Bahamas	France	Malta	Slovakia
Bahrain	Gabon	Marshall Islands	Slovenia
Bangladesh	Gambia	Mauritania	Solomon Islands
Barbados	Georgia	Mauritius	Somalia
Belarus	Germany	Mexico	South Africa
Belgium	Ghana	Micronesia	Spain
Belize	Greece	Rep. of Moldova	Sri Lanka
Benin	Grenada	Monaco	Sudan
Bhutan	Guatemala	Mongolia	Suriname
Bolivia	Guinea	Morocco	Swaziland
Bosnia	Guinea-Bissau	Mozambique	Sweden
Botswana	Guyana	Myanmar	Switzerland
Brazil	Haiti	Namibia	Syria
Brunei	Honduras	Nauru	Tajikistan
Bulgaria	Hungary	Nepal	Tanzania
Burkina Faso	Iceland	Netherlands	Thailand
Burundi	India	New Zealand	Timor-Leste
Cambodia	Indonesia	Nicaragua	Togo
Cameroon	Iran	Niger	Tonga
Canada	Iraq	Nigeria	Trinidad
Cape Verde	Ireland	Norway	Tunisia
C.A.R.	Israel	Palestine	Turkey
Chad	Italy	Oman	Turkmenistan
Chile	Jamaica	Pakistan	Tuvalu
China	Japan	Palau	Uganda
Colombia	Jordan	Panama	Ukraine
Comoros	Kazakhstan	P.N.E	U.A.E.
Congo	Kenya	Paraguay	United Kingdom
D Rep Congo	Kiribati	Peru	United States
Costa Rica	Dem. Rep Korea.	Philippines	Uruguay
Côte d'lvoire	Korea, Rep. of	Poland	Uzbekistan
Croatia	Kuwait	Portugal	Vanuatu
Cuba	Kyrgyzstan	Qatar	Venezuela
Cyprus	Laos	Romania	Viet Nam
Czech Rep.	Latvia	Russia	Yemen
Denmark	Lebanon	Rwanda	Zambia
Djibouti	Lesotho	Sao Tome	Zimbabwe

Finally, to examine how the relative development status of a country correlates to reforestation, I examined reforestation rates in relation to the HDI (Fig. 4). Interestingly, developed countries have a significantly ($p = 1.0 \times 10^{-7}$) greater percent of land returning to forest cover per year compared to less developed countries ($\rho = 0.394$). This correlation suggests that more developed countries are better able to conduct reforestation efforts.

Together, these data suggest that developed countries experience a redistribution of land use, and that more developed countries are more likely than less developed countries to increase forested area.

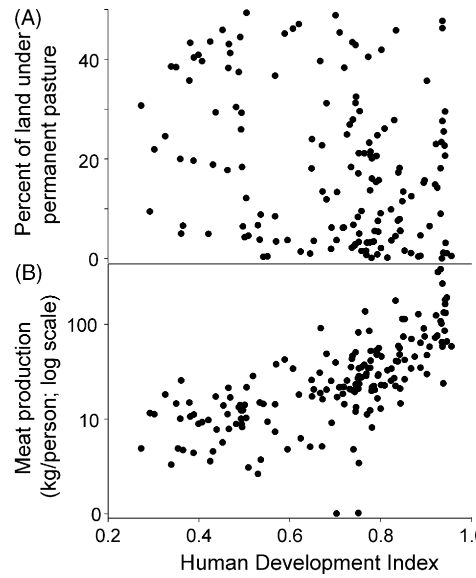

Fig. 3. Scatter plots illustrating land use patterns and relative country development status. (A) More developed countries have less land under permanent pasture ($p = 0.004$); (B) more developed countries produce more meat per capita compared to less developed countries ($p = 1.6 \times 10^{-13}$).

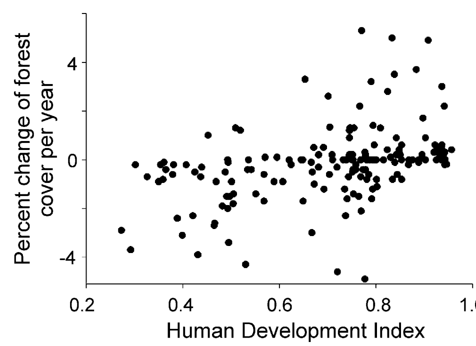

Fig. 4. Scatter plot illustrating percent of land reforested from 1990 to 2000. More developed countries have a greater percentage of land becoming forest cover compared to less developed countries ($p = 1.0 \times 10^{-7}$).

4. Discussion and conclusions

Generally, it is assumed that as countries develop the cultures they contain modernize. In this assumption it is also implied that this modernization results in cultural assimilation, and a resounding loss of traditional knowledge. In turn, this modernization concomitantly results in a loss of traditional medicine knowledge describing the use of plants as medicines. As over 100 plant extracts have resulted in pharmaceuticals (Stepp, 2004), the loss of traditional medicine knowledge describing the use of plants and the loss of plant resources represent significant potential obstacles to future drug discovery processes. Counterintuitively, extrapolation of recent work reporting no correlation between Gross Domestic Product and number of languages (Sutherland, 2003) draws the conclusion that development of a country does not correlate with a classic marker of traditional knowledge loss: the loss of languages. In this work, I additionally concur that a country's relative development status does not correlate with the percent of land under natural forest cover —a resource typically providing the raw materials for traditional medicine use.

This lack of correlation is surprising since the loss of natural resources, such as the loss of forest cover illustrated in Fig. 1, is commonly considered a cost of economic development. There are two explanations for this unexpected result. First, these data may signify the two variables are unrelated and that development does not have a bearing on the loss of plant resources for traditional medicine use. Alternately, the interpretation of these data may advocate that certain countries are better able to manage development without natural resource exploitation. Anecdotal evidence suggests the second hypothesis is correct: countries under proper governance are better able to manage natural resources as they develop. This interpretation is exciting for the use of natural products in drug discovery since it proposes there are mechanisms to preserve the natural resources used in traditional medicine regardless of a country's relative development status.

To explain these first series of data and the relationships, I examined the association between land use and forestation rates with country development. The correlation between the land under permanent pasture, meat production per capita, and percent of forestation rate per year with the HDI indicates that the more developed countries have less land tied to permanent pasture and more land returning to a forested state. These results support the second interpretation of data regarding natural cover and development, as countries develop they are better able to manage natural resources and conduct reforestation efforts. Yet it has been shown that as countries move to more high-intensity farming methods, there is a reduction in biodiversity (Bignal and McCracken, 1996). Thus, while it is not implied that these reforestation efforts are exclusively returning the land to natural forest cover, there are efforts to re-establish native species for traditional medicine use. For example, the People's Republic of China is one of the world's fastest developing countries (Thun, 2004; Zhang et al., 2004) and recent case studies report projects to replant native species for traditional medicine use in deforested areas (Yang, 2005).

Notably, the datasets analyzed did not address the biodiversity of the examined areas, which is an important factor regarding the availability of resources for traditional medicine. By the Living Planet Index, a marker of global biodiversity, biodiversity has decreased 37% from 1970 to 2000 (WWF, 2004) and the implications of this loss are far-reaching (Hanski, 2005). This loss in biodiversity is particularly relevant since the use of plants in traditional medicine is a marriage between cultural and biological diversity, ultimately, loss of one factor will concurrently lead to a loss of the other factor. While the reasons for the loss of the biological and cultural diversity may differ (Sutherland, 2003), this interdependency between culture and ecosystem is nonetheless critical to interpret these results correctly. It is challenging to identify the loss of culture or biological diversity as the etiologic agent of this biodiversity loss.

Ultimately, these data and the interpretations are exciting for the field of ethnobotany. These data suggest that while there are daily losses of both languages and plant sources for traditional medicine, the loss of resources are not inextricably tied to development. Rather, these data suggest that with proper governance as countries develop, the countries may be able to preserve their natural resources. Since loss of raw material for traditional medicine use has been identified as a principle challenge for ethnobotany, the opportunity to manage this challenge through proper governance is exciting.

Acknowledgments

I am indebted to Drs. Moses Rodriguez, Charles Howe, and Brent Bauer, Mayo Clinic College of Medicine, Rochester, MN, USA for their support of this project. I thank David Schnepple, Mayo Clinic College of Medicine, Rochester, MN, USA and Kris MacPherson, St. Olaf College, Northfield, MN, USA for their critical review of the manuscript and identification of case studies. Much of the biodiversity discussion was drawn from an excellent article by Dr. Ilkka Hanski (Hanski, 2005).

References

Abrams, D.M., Strogatz, S.H., 2003. Linguistics: modelling the dynamics of language death. Nature 424, 900.

Balick, M., Cox, P.A., 1997. Plants, People, and Culture: The Science of Ethnobotany. Scientific American Library, New York.

Bignal, E., McCracken, D., 1996. Low-intensity farming systems in the conservation of the countryside. Journal of Applied Ecology 33, 413–424.

Buenz, E.J., Johnson, H.E., Beekman, E.M., Motley, T.J., Bauer, B.A., 2005. Bioprospecting rumphius's ambonese herbal: volume I. Journal of Ethnopharmacology 96, 57–70.

Buenz, E.J., Schnepple, D.J., Bauer, B.A., Elkin, P.L., Riddle, J.M., Motley, T.J., 2004. Techniques: bioprospecting historical herbal texts by hunting for new leads in old tomes. Trends in Pharmacological Sciences 25, 494–498.

CIA, 2004. The World Fact Book. US Government Printing Office, Washington, D.C.

Cox, P.A., 1993. Saving the ethnopharmacological heritage of Samoa. Journal of Ethnopharmacology 38, 181–188.

Cox, P.A., 2000. Will tribal knowledge survive the millennium? Science 287, 44–45.

Cox, P.A., Banack, S.A., 1991. Islands, plants, and polynesians. Dioscorides Press, Portland, OR.

FAO, 2001. Global Forest Resources Assessment 2000: Main Report. Rome, Italy: Food and Agriculture Organization of the United Nations.

FAO, 2004. FAOSTAT. http://apps.fao.org/ (accessed on 24 March 2005).

Gustafson, K.R., Cardellina II, J.H., McMahon, J.B., Gulakowski, R.J., Ishitoya, J., Szallasi, Z., Lewin, N.E., Blumberg, P.M., Weislow, O.S., Beutler, J.A., et al., 1992. A nonpromoting phorbol from the samoan medicinal plant Homalanthus nutans inhibits cell killing by HIV-1. Journal of Medicinal Chemistry 35, 1978–1986.

Hampton, J.A., 2002. Language's role in enabling abstract, logical thought. Behavioral and Brain Sciences 25, 688–682.

Hanski, I., 2005. Landscape fragmentation, biodiverstiy loss and the societal response. EMBO Reports 6, 388–392.

Heinrich, M., 2000. Ethnobotany and its role in drug development. Phytotherapy Research 14, 479–488.

Heinrich, M., 2003. Ethnobotany and natural products: the search for new molecules, new treatments of old diseases or a better understanding of indigenous cultures? Current Topics in Medicinal Chemistry 3, 141–154.

Krauss, M., 1992. The world's languages in crisis. Language 68, 4–10.

Lee, R., Balick, M., Ling, D., Brosi, B., Raynor, W., 2001. Special Report: cultural dynamism and change—an example from the Federated States of Micronesia. Economic Botany 55, 9–13.

Leslie, M., 2005. Planet Earth Checkup. Science 307, 651.

Mace, G., 2005. Biodiversity. In: Carpenter, S., Pingali, P. (Eds.), Conditions and Trends Assessment of the Millennium Ecosystem Assessment. Island Press, Washington, DC.

McSherry, C., 1999. Todas las Voces: indigenous language radio, state culturalism and everyday forms of public sphere formation. Journal of Iberian and Latin American Studies 5, 99–131.

NASA, 2004. World Wind, http://worldwind.arc.nasa.gov/: accessed on March 24 2005.

Porter, A.M., 1990. Krio literature: the most popular literature of sierra leone. In: Granqvist, R. (Ed.), Signs and Signals: Popular Culture in Africa. U of Umeå Press, Umeå, pp. 67–89.

Stepp, J.R., 2004. The role of weeds as sources of pharmaceuticals. Journal of Ethnopharmacology 92, 163–166.

Sutherland, W.J., 2003. Parallel extinction risk and global distribution of languages and species. Nature 423, 276–279.

Thun, E., 2004. Keeping up with the Jones': decentralization, policy imitation, and industrial development in China. World Development 32, 1289–1308.

UNDP, 2004. Human Development Report. http://hdr.undp.org/statistics/ (accessed on 24 March 2005).

UNEP, 2005. GEO Data Portal, http://geodata.grid.unep.ch/: accessed on 24 March 2005.

WWF, 2004. Living Planet Report 2004. Gland, Switzerland: World Wildlife Fund for Nature.

Yang, T., 2005. Studies of the status of the native environment of Western China and its application. Working Paper: Jishou University, Institute of Anthropology and Ethnology, Hunan, China (in Chinese).

Yapita, M., 1981. The aymara alphabet: linguistics for indigenous communities. In: Hardman, M.J. (Ed.), The Aymara Language in Its Social and Cultural Context: A Collection of Essays on Aspects of Aymara Language and Culture. University Press of Florida, Gainesville, pp. 262–270.

Zhang, X., Mount, T., Boisvert, R., 2004. Industrialization, urbanization and land use in China. Journal of Chinese Economic and Business Studies 2, 207–224.