PRESIDENTIAL ADDRESS

Land, Life, and Environmental Change in Mountains

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One of the greatest challenges facing mountain scholars is to separate environmental change caused by human activities from change that would have occurred without human interference. Linking cause and effect is especially difficult in mountain regions where physical processes can operate at ferocious rates and ecosystems are sensitive to rapid degradation by climate change and resource development. In addition, highland inhabitants are more vulnerable to natural hazards and political-economic marginalization than populations elsewhere. This address focuses on the Nanga Parbat massif in the Himalaya Range of Pakistan, Garhwal Himalaya of northwest India, and Manaslu-Ganesh Himal of central Nepal. I have highlighted three special insights that geographers offer to increase understanding of human impacts on the stability of mountain landscapes. First, the mixed methods and theories we employ—quantitative and qualitative, postpositivist science and social theory, muddy-boots fieldwork linked with GIScience—together position geographers to resolve the debate over human-triggered changes in the physical landscape in mountains and explain the frequent disconnect between mountain science, policymaking, and resource management. Second, academic scholars and policymakers have come to realize that most problems require training, experience, and expertise in understanding physical and human systems. Third, modern techniques of measuring rates of geomorphic change help place the human factor in perspective and explain spatial variability of natural hazards. Forecasting environmental change remains elusive in “the perfect landscape” of mountains. Key Words: environmental change, Himalaya, Karakoram, mountains.

研究山区的学者所面临的最大挑战之一是如何区分人类活动所致的环境变化以及在无人干扰之下所产生的类似变化。原因和结果之分析是一项极为困难的任务，尤其是在山区地区进行此分析。这是因为山区地区的物理过程之运作有着惊人的速度，以及该地区的生态系统对于气候变化和资源开发所造成的迅速退化也特别的敏感。此外，高原居民比起别处的人口更容易受到自然灾害和政治与经济边缘化的影响。这份就职演说把焦点放在喜马拉雅山脉之区块。该区块在于巴基斯坦的喀喇昆仑山脉之区块，西北印度的吉拉喜玛雅山以及尼泊尔中部的马纳斯卢峰和甘尼许玛。我揭露了三个地理学家所能提供的突出见解，以增加我们对人类影响之山地景观之稳定性的了解。首先，我们使用的混合方法和理论—定量与定性，后实证主义之科学和社会理论，泥泞靴子野外工作和地理信息科学联系在一起—有助于定位地理学家来解决人类诱发之山地景观改变之争端并解释为何山区科学，政策以及资源管理往往出现脱节的状况。第二，学者和决策者已逐渐意识到大部分问题需要训练，经验和专业知识来了解自然和人类之系统。第三，测量地貌变化之速度的现代技术有助于深入地了解人类因素和解释灾害的空间变异性。要在这个“完美”的山地景观预测环境变化仍然是一项难以实现的任务。关键词：环境变化，喜马拉雅，喀喇昆仑，山。

Uno de los mayores retos al que se enfrentan los expertos en montañas es separar los cambios ambientales causados por las actividades humanas de los cambios que hubiesen ocurrido sin la interferencia del hombre. La relación entre causa y efecto es especialmente difícil en las regiones montañosas, en donde los procesos físicos pueden desencadenarse a una tasa feroz, y los ecosistemas son sensibles a la degradación rápida provocada por los cambios climáticos y el desarrollo de recursos. Además, los habitantes de las tierras altas son más vulnerables a los peligros naturales y a la marginalización político-económica que los habitantes de otros lugares. Este artículo se concentra en el macizo Nanga Parbat de la Cordillera de los Himalaya de Pakistán, el Garhwal Himalaya del noroeste de India y las montañas nevadas de Manaslu-Ganesh del centro de Nepal. He recalcado tres perspectivas especiales que los geógrafos ofrecen para aumentar la comprensión de los impactos humanos en la estabilidad de los paisajes.
Mountains Sustain Humanity

It is difficult to conceive of landscapes where opportunities for geographic understanding are as great, and as urgently needed, as in mountains of the world. Mountains of diverse origin, climate, and cultures cover approximately 24 percent of the land surface on Earth (Figure 1). Twenty percent of the population in the world resides in mountains or at the edge of mountains. Many mountain landscapes are unstable because of biophysical and socioeconomic factors, experiencing change that defies understanding and prediction. Complex feedbacks affect mountains. For instance, uplift drives climate change, and highlands are also especially susceptible to the consequences of climate change (e.g., melting glaciers, degradation of alpine permafrost, shifting ecosystems, soil erosion, etc.). The physical and human environment changes rapidly over short distances; horizontal and vertical boundaries are the first to be affected by environmental changes (Owens and Slaymaker 2004).

Funnell and Price (2003) have noted over the last forty years that mountain studies have moved dramatically from the pursuit of a few dedicated individuals to a process involving global agencies. The 1992 Earth Summit in Rio de Janeiro was instrumental in moving mountains up in the global environmental agenda (Bandyopadhyay and Perveen 2004). A small, informal group of mountain scholars, known as the Mountain Agenda collective, succeeded in adding Chapter 13 to the global plan of action for sustainable development that was adopted at the Rio Summit, better known as Agenda-21. This led to the United Nations declaring 2002 as the International Year of Mountains. It is clear from the work launched during the 1992 Earth Summit (e.g., United Nations 1992; Messerli and Ives 1997), the International Year of Mountains in 2002 (e.g., Price, Jansky, and Iatsenia 2004), the Millennium Ecosystem Assessment (Korner and Ohsawa 2005), and work of the International Centre for Integrated Mountain Development (e.g., Gyamtsho 2006; ICIMOD 2006) that mountain ecosystems are especially fragile and degrading rapidly, although the cause may differ from one mountain region to another.

The beauty, inspiration, dramatic history of exploration, sacred significance, and abundant recreational opportunities afforded by mountains have long been celebrated in a rich published literature and thriving tourism industry (Zurick 1992; Blake 2002, 2005; Zurick and Pacheco 2006). The place identity of mountains remains strong in many cultures, those indigenous to mountain regions and beyond (McDonald 2002; Macfarlane 2003). As expressed by The Mountain Institute (2006, 1): “Mountains sustain humanity. Our emotions about mountains are complex. We are comforted by their presence and inspired by their beckoning spirit. We admire them. We fear them. We aspire to them.” One expects spectacular physical landscapes in the high Himalaya, but the greater impression was left on me by the imprint of Buddhism on the landscape in the form of prayer flags, prayer wheels, chortens, gompas, monasteries, and the camaraderie and general demeanor of the Sherpa who served as guides on our expeditions. Mountain geography is so successful as a meeting place for human and physical geographers because of the transcendent significance of mountains to land and life, whether as sacred place or site to study geomorphology, landscape ecology, and glaciology.

Agricultural terraces in Asian mountains were first brought to my attention in remarkable classroom lectures by UCLA geography professor Joe Spencer, but one has to trek through the Lesser Himalaya during the monsoon season to fully appreciate the hydraulic engineering and enhanced landscape stability of...
terraces (Figure 2). The system of agricultural terraces, in place for centuries if not millennia in the Middle Mountains of Nepal, transmits 1,500 to 2,500 mm of rainfall down hillslopes during the monsoon season, and retains moisture sufficient to irrigate crops. The portion entering steep streams turns millstones and prayer wheels. In khet terraces constructed with a berm (or bund) on the outer edge to retain water, surplus runoff moves downslope from one ramped terrace to the next, and this occurs over hundreds and sometimes thousands of meters of local relief without triggering irreparable erosion. At higher elevations, rain-fed bari terraces, without a berm and sloping outward, experience rates of erosion two orders of magnitude higher than khet terraces. This creates a demand for labor to repair the terraces in winter after crops are harvested and labor becomes available (Johnson, Olson, and Manandhar 1982; Wu and Thornes 1995).

Runoff from snow melt, glacier melt, and rain in mountains generates 32 percent of global runoff, water that is used for drinking and hygiene, irrigation agriculture, hydropower, and other services by half of the population on Earth (Meybeck, Green, and Vorosmarty 2001). In Wyoming, only 15 percent of the state experiences a water surplus—all of which occurs in mountains—and runoff from the mountainous highlands supplies water to the remaining 85 percent of the state that is situated in water-deficit lowlands (Ostresh, Marston, and Hudson 1990). Water resource development in the Himalaya and Karakoram varies from local-scale technology to large-scale dams to generate hydropower for distant markets (Ives 2006). Mountains provide a significant portion of other resources: crops and pasture, forests (for fuel, construction, fodder), and minerals (Messerli and Ives 1997). Mountains also constitute storehouses of biological and cultural diversity.
Figure 2. Khet terraces in the Garhwal Himalaya. Source: Author photo, March 2003.

(United Nations 1992; Bandyopadhyay and Perveen 2004; Korner and Ohsawa 2005). The Indian Himalaya alone provides habitat for more than 1,748 plant species of known medicinal value (Samant, Dhar, and Palni 1998).

Whereas mountains do sustain humanity, they are also recognized as one of the most rugged and challenging places on Earth to pursue a sustainable livelihood (B. C. Bishop 1990; Stevens 1993; Zurick and Karan 1999). Consider the vulnerability of society as a function of exposure, sensitivity, and resilience to natural hazards (Turner et al. 2003). Mountain peoples are exposed to slope failures, snow and ice avalanches, glacier and landslide outburst floods, earthquakes, wildfires, extreme climatic events, and other environmental calamities. Mountain inhabitants are subject to place sensitivity, but also to social sensitivity, finding themselves isolated as well as politically and economically marginalized more than populations elsewhere (Zurick and Karan 1999; Korner and Ohsawa 2005). The consequences for this in the Himalaya and Karakoram are observed in the widespread poverty, poor access to education and health care, and inadequate community infrastructure. Residents in the Himalaya and Karakoram lack the full capacity to adapt to hazards because of the limited access to technology, capital, and government. Mountains are often sites for political borders and access might be restricted through narrow corridors, so it is not surprising that they become the refuge for displaced groups (Zurick and Karan 1999; Korner and Ohsawa 2005). Concerns over environmental degradation, sustainability, and vulnerability have been replaced in some mountain regions by concerns for security and economic globalization. For example, the war in Afghanistan and Pakistan and the Maoist insurgency in Nepal are only the most recent vestiges of “conflict at the top of the world” (Margolis 2002).
The interaction between mountains and their inhabitants deserves special attention from geographers and other mountain scholars and is the main focus of this address. The theories, knowledge, and techniques of geography yield special insights into environment–society interactions in mountains (Figure 3). We seek to understand the spatial distribution of earth surface phenomena (biophysical and social), the links between these phenomena, the resources and hazards for humans created by these distributions, human impacts on these distributions, and the meaning of places to people and societies. This address focuses on these themes in the Nanga Parbat massif in the Himalaya Range of Pakistan, Garhwal Himalaya of northwest India, and Manaslu-Ganesh Himal of central Nepal (Figure 4). The Himalaya, Karakoram, and Tibetan Plateau comprise the highest and greatest mountain mass on Earth and one of the best natural labs to study mountain systems (Owen 2004). For a wonderful cartographic and photographic portrayal of the Himalaya, readers are referred to the award-winning Illustrated Atlas of the Himalaya by Zurick and Pacheco (2006).

A Grand Challenge for Mountain Geographers

One of the greatest challenges facing mountain scholars is to separate environmental change caused by human activities from change that would have occurred without human interference. If we cannot make this distinction, we will fail to bridge the gap among science, policymaking, and resource management. Linking cause and effect is especially difficult in mountain regions where physical processes can operate at ferocious rates and ecosystems are sensitive to rapid degradation by climate change, resource development, and land use and land cover change.

During the middle and late 1970s, a rising tide of scientific literature and media attention was devoted to a perceived crisis in the Himalaya, linking deforestation in the Himalaya to flooding and slope failures locally and far downstream in the Ganges River plain and delta. One of the more influential articles in the popular literature was authored by Kerasote (1987) in Audubon and titled, “Is Nepal Going Bald?” To investigate the link among deforestation, flooding, and slope failures, I was invited to join two scientific expeditions to the central Nepal Himalaya, hiking a total of 430 km in the Langtang-Jugal and Manaslu-Ganesh himals. We traveled between elevations of 1,000 and 5,000 meters in the Middle Mountains and Greater Himalaya physiographic regions. I presumed that deforestation would accelerate flooding and slope failures, as conventional thinking dictated and as it does in the Coast Range and Cascades of the Pacific Northwest where I had received my graduate training. In short, our research in the Middle Mountains (Lesser Himalaya) of central Nepal revealed that forest cover had no influence on the patterns of monsoon flooding (Marston, Kleinman, and Miller 1996). We were equally astonished to learn that slope failures occurred at a lower frequency in disturbed (deforested) lands than in land where the forest cover was intact (Marston, Miller, and Devkota 1998). The cause, form, and frequency of slope failures did vary by physiographic region and slope aspect, but was not influenced by deforestation. The primary control on slope failures was exerted by geologic and geomorphic factors, more than by land use and land cover. This finding has been subsequently confirmed by the majority of researchers (e.g., Shroder 1998; Dhakal, Amada, and Aniya 2000; Ives 2006). Humans do accelerate slope failures through road building, especially when the roads are situated in midslope locations instead of along ridge tops (Marston, Miller, and Devkota 1998; Barnard et al. 2001). Roads in eastern Sikkim and western Garhwal have caused an average of two major landslides for every kilometer constructed. Road building in Nepal has produced up to 9,000 cubic meters of landslide per kilometer, and it has been estimated that, on average, each kilometer of road...
Figure 4. Location of three study areas discussed in the article. Source: MODIS imagery draped over Space Shuttle digital elevation model (DEM), courtesy of Bill Bowen, February 2005.

constructed will eventually trigger 1,000 tons of land lost from slope failures (Deoja 1994; Zurick and Karan 1999).

The lesson was learned that “place matters,” a lesson that is fundamental to geography, but one that is sometimes assimilated only after long and difficult labors in the field. One must take care to avoid bias from having received academic training and experience in a limited number of locales (Schumm 1991). It simply was not possible to translate our understanding of the effects of deforestation in the Pacific Rim to the steep slopes and thin soils of the tectonically active, monsoon-affected central Nepal Himalaya. The value of “muddy boots” geography became apparent: Go to the field, measure, and learn for yourself! Andrew Marcus (personal communication 2007) stated: “Fieldwork generates some deep emotions for the world around you. It also generates deep learning . . . you and your students ask more challenging questions when confronted by the immensity of the world around them.”

Our studies of monsoon flooding and slope failures in the central Nepal Himalaya were hampered by the absence of a globally robust theory for understanding mountain hydrology and geomorphology. On reflecting about this state of affairs, Phillips (2007) authored a benchmark article titled “The Perfect Landscape.” He proposed a new way of thinking about landscape evolution, one that in fact explains why geomorphologists have not been able to develop a general, widely accepted model of landscape evolution. Phillips pointed out that landscapes are controlled by a combination of global factors (i.e., independent of time and place, governed by the laws of physics and chemistry) and local factors. Each landscape has an inherited history—from
biophysical and human influences—that will almost certainly vary from place to place. The historical legacy of local disturbances leads to increased divergence, whereas global controls lead to convergence. The key, therefore, is to increase the generality of our models, concepts, and research and to reduce the number of variables and factors considered, rather than seek deterministic models to describe landscapes in all of their complexity. The “perfect landscape,” a term adapted from the book *The Perfect Storm* (Junger 1997), is one where an improbable (hard-to-predict) convergence of global and local factors create a rather unique (or unusual) set of interacting landforms. Phillips (2007, 160) wrote:

> The probability of existence of any landscape or earth surface system at a particular place and time is negligibly small; all landscapes are perfect. Recognition of the perfection of landscapes leads one away from a worldview holding that landforms and landscapes are inevitable outcomes of deterministic laws, such that only one outcome is possible for a given set of laws and initial conditions.

With the fragility, heterogeneity, and dynamic physical geography endemic to many highland environments, mountain locations conform to Phillips’s construct of perfect landscapes.

**Many Ways of “Knowing” in Mountain Geography**

Simultaneous with my field research in Nepal, research efforts by Jack Ives, Bruno Messerli, and a legion of students led to publication of a series of articles and two noteworthy books that present a theory of Himalayan environmental degradation (HED; Ives and Messerli 1989; Ives 2006). The theory of HED was presented as a series of interlinked propositions based on the casual observations and conventional thinking of many. Ives and Messerli were not proponents of the theory, but rather used it as a starting point to call for data collection and analyses to confirm or reject it. Ives (2006) presents the most succinct outline of the theory of HED as eight points; it is presented here in simplified form as a flowchart (Figure 5). Ives and Messerli (1989) and Ives (2006) have shown that the theory of HED could not be supported when one actually collected field and remotely sensed data to test the hypotheses. In particular, the link between deforestation and floods and slope failures could not be supported, confirming our studies in the Langtang-Jugal and Manaslu-Ganesh himals. The review by Kasperson, Kasperson, and Turner (1995) also confirmed that no reported impending collapse of the human–environment system existed in the Middle Mountains of Nepal.

Research by social theorists has revealed how effective response to environmental change in mountains is confounded by power politics and failure to fully regard the differential impacts by gender and social class. If the theory of HED has been invalidated, one must ask why forest management practices have not been modified. Blaikie and Muldavin (2004) wondered why coercive restrictions still exist on agriculture and forestry in the Himalaya of India and China; why not more local control, as has happened in Nepal? Thompson, Warburton, and Hatley (2007) suggested that we shift our attention away from uncertain nature and focus instead on institutions. Blaikie and Muldavin asserted that those in the national political arena of India and China have ignored what science has to say to maintain the power of the central government. Furthermore, they claimed, the notion that floods and sediment damage can be reduced through upstream land use policies can be used as leverage when governments apply for foreign aid. Thus, government attention has not been shifted from the theory of HED in India and China to the more real and pressing social issues of warfare and insurgency, poverty, education, medical problems, infrastructure, and water supplies. Ives (2006) agreed that attention has been diverted from the problems of unequal access to resources, mistreatment of mountain minorities, and political fragmentation.

Understanding of environment–society relations in the Himalaya has been gained from postpositivists and
social theorists alike. We learned to ask different questions; dialogue is possible, but we must be willing to talk with one another (Harrison et al. 2004; Murphy 2006). Many ways exist of “knowing” in geography; no one has a lock on the truth. The methods and modes of presentation differ between biophysical and humanistic geography. Multiple geographies exist, however, and we improve understanding of mountains when we consult and collaborate. Writing in *To Interpret the Earth: Ten Ways to be Wrong*, Schumm (1991) delivered an effective message that is relevant to the debate over the theory of HED. Most postpositivists recognize potential pitfalls in linking cause and effect. Science might not always “get it right” the first time, but the studies linking deforestation, flooding, and slope failures demonstrate that science is a self-correcting process over time. Gober (1990) identified the key for geography to fulfill its goal of searching for synthesis at the nexus of the natural sciences, the social sciences, and the humanities:

In order to achieve this goal, however, we must leave the isolated intellectual realms into which we have retreated, dampen the fires of criticism that have polarized us, rethink the way graduate education is structured, foster new networks of communication, and develop a disciplinary culture that values both specialized analytical research and broader integrative research. (Gober 1990, 1)

**Ferocious Rates of Uplift and Denudation in the Himalaya and Karakoram**

One of the questions in mountain geography that will not go away is how fast are the Himalaya rising and denuding? The question begs controversy as new dating techniques have yielded astounding results and spawned new theories to explain the geodynamics of the Indian–Asian collision. Advances in numerical dating of episodes of deformation and denudation create exciting opportunities to more closely document the timing of uplift and denudation in the Himalaya and Karakoram.

**Figure 6.** Nanga Parbat massif, Pakistan, looking southward directly up Raikot Valley, with Indus River in foreground. *Source: Landsat 7 imagery draped over Space Shuttle digital elevation model (DEM), courtesy of Bill Bowen, February 2005.*
of landscape forming events in high mountain areas. Answering this question will help place human impacts into context.

Caine (2004) has reviewed the extreme variability in rates of denudation for mountain regions. For the entire Himalayan system, Galy and France-Lanord (2001) reported denudation rates of 2.1 meters per 1,000 years for the Ganges River drainage and 2.9 meters per 1,000 years for the Brahmaputra drainage. Rates of sediment yield climb to astonishing values of 5 to 20 meters per 1,000 years for smaller, high-relief watersheds. Incision rates for the Indus River where it borders the Nanga Parbat massif vary from 2 to 12 meters per 1,000 years (Burbank et al. 1996). Rates of incision for tributary valleys around Nanga Parbat are 22 ± 11 meters per 1,000 years (Shroder and Bishop 2000; Cornwell, Norsby, and Marston 2003). Zeitler et al. (2001) proposed that the river incision that produced the deep Indus River gorge would weaken the crust, attracting advective heat flow in the crust, which in turn triggers rapid uplift (Owen 2004). A steepened thermal gradient would also be created in the massif that would further weaken the crust. This process constitutes a positive feedback and has been termed a tectonic aneurism. Indeed, the local relief and rates of erosion reported for the Nanga Parbat massif are both among the highest ever measured on the planet (Figure 6). In summarizing the literatures, Ives (2006) reported rates of uplift for the Himalaya ranging from 0.5 to 20 meters per 1,000 years.

I was also part of a team that explored the links between uplift and erosion in the Garhwal Himalaya.

Figure 7. Cross-valley topographic profile, derived from 40 to 60 meter digital elevation model (DEM). Source: Prepared by Ben Holland, NSF-REU student in July 2003, using ArcMap 3D Analyst. Yellow denotes Main Central Thrust (MCT) zone.
of northwest India (Catlos et al. 2007). Conventional thinking was that this region had been tectonically inactive since the early Miocene (22 million years BP), but severe earthquakes in the Garhwal during the 1990s led us to question this assumption. The Main Central Thrust (MCT), identified as a dominant crustal-thickening mechanism in the Himalaya, is responsible for post-Miocene deformation and produces extreme relief when concurrent with rapid river incision and mass movement. Advances in numerical dating of episodes of deformation and denudation create exciting opportunities to more closely document the timing of landscape-forming events in high mountain areas. Using monazite geochronology, Catlos found that significant deformation had occurred within the MCT shear zone between 1 and 4 million years BP. I examined the geomorphic signature of MCT activity. Slope failures were more frequent near major thrust faults that define the borders of the MCT, a finding confirmed by Saha, Gupta, and Arora (2002). As in the central Nepal Himalaya, slope failures in the Garhwal were affected more by proximity to geologic factors (rock type and proximity to major thrust) and river erosion than to land use and land cover. The longitudinal profile of rivers crossing the MCT exhibited a knick point or steepening, a finding confirmed elsewhere in the Himalaya by Seeber and Gornitz (1983) and Hodges et al. (2004). Topographic profiles were created for several valley sections in the Garhwal from the 40 to 60 meter digital elevation models (DEMs). Cross-valley topographic profiles are decidedly more convex in and near the MCT zone (Figures 7 and 8). Finally, cosmogenic isotope dating was used to date strath terraces along the Bhagirathi, Alaknanda, and Maldakini rivers in the Garhwal Himalaya. Rates of incision were calculated at 3.6 to 11 meters per 1,000 years, comparable to the rate of 4 meters per 1,000 years reported by Barnard et al. (2001) for the Alaknanda drainage.

These studies blended extensive fieldwork under difficult conditions, meticulous lab analyses for cosmogenic dating, and a variety of geospatial techniques, including digital terrain representation, remote sensing, geostatistics, artificial intelligence, cartography, and visualization (Marcus, Aspinall, and Marston 2004). New technologies in geography have helped overcome the difficulties of access to remote steepland environments. Recent breakthroughs in geospatial analysis have allowed earth scientists to study mountain environments in new ways (M. P. Bishop and Shroder 2004). To advance understanding in studies of the Nanga Parbat massif and Garhwal Himalaya, it was critical that

Figure 8. Bhagirathi River valley illustrates effects of rapid uplift concurrent with rapid river incision in the Garhwal Himalaya. (A) Recent incision has created an inner gorge, (B) convex hill-slope profile, (C) view across Bhagirathi River at junction with small tributary stream; a knick point has been created because of the more rapid incision of the Bhagirathi River. Source: Author photos, March 2003.
I collaborated with geologists and others with expertise far beyond my own. The propensity for collaboration within our discipline and with practitioners from other disciplines serves geographers well for understanding environment–society relationships in mountains. Rather than assert that we have an advantage as geographers, it is perhaps more accurate (and properly humble) to say that geographers offer a body of knowledge, theories, and mix of techniques that foster collaboration. Most mountain scholars recognize that problems and issues in environment–society relations require the expertise of more than one discipline, especially in this age of information explosion. The boundaries between disciplines are becoming blurred. For mountain scholars who want to move beyond empirical studies to develop and implement action plans, opportunities abound. Nongovernmental organizations that deal with mountain issues are growing in number, size, and influence at the same time that new academic journals are appearing. This momentum contributes to the development of national and international centers of mountain research.

Conclusion

One of the greatest challenges facing mountain scholars is to separate environmental change caused by human activities from change that would have occurred without human interference. Linking cause and effect is especially difficult in mountain regions where physical processes can operate at ferocious rates and ecosystems are sensitive to rapid degradation by climate change and resource development. In addition, highland inhabitants are more vulnerable to natural hazards and political-economic marginalization than populations elsewhere.

I have highlighted three special insights that geographers offer to understanding human impacts on mountain landscape stability. First, the mixed methods and theories we employ—quantitative and qualitative, postpositivist science and social theory, muddy-boots fieldwork linked with GIScience—together position geographers to resolve the debate over human-triggered changes of the physical landscape in mountains and explain the frequent disconnect between the findings of mountain science, policymaking, and resource management. My own studies in the central Nepal Himalaya and the many studies conducted by others as a test of the theory of HED underscore the place-dependence of processes and the importance of primary data gathering via fieldwork. The preoccupation on effects of deforestation on landscape stability has diverted attention from the more dramatic impacts of roads and from the more pressing social needs related to political fragmentation, poverty, education, plus access to health care and water supplies.

Second, academic scholars and policymakers have come to realize that most problems require training, experience, and expertise in understanding both physical and human systems. Our propensity for collaboration within our discipline and with practitioners from other disciplines serves geographers well for understanding the human impact in mountains. Geographers have achieved accurate, balanced, and informative synthesis in the mountain studies that test links between resource use and land management, thereby strengthening our discipline’s position as a bridge between the social and natural sciences.

Third, modern techniques of measuring rates of geomorphic change help place the human factor in perspective and explain spatial variability of natural hazards. New technologies in geography have helped overcome the difficulties of access to remote steepland environments. Recent breakthroughs in geospatial analysis have allowed earth scientists to study mountain environments in new and exciting ways and have strengthened our ability to identify linkages between spatial and temporal variability. With respect to the study of mountains, developments in physical geography and geospatial sciences need not distance physical geography from human geography. Forecasting environmental change remains elusive in “the perfect landscape” of mountains.

Most geographers who I know want to be part of something bigger than ourselves and follow a career path that moves beyond understanding and explanation of geographic phenomena to a larger goal of improving the human condition on our planet. The need persists to measure and map biophysical processes, as well as to apply social theory in mountains as part of the greater effort to identify landscapes at risk. If you want to get your arms around the major issues in mountain geography, focus on vulnerability studies, rural sustainability, and land use and land cover change while continuing to measure and model geomorphic change and ecosystem changes. The International Year of Mountains in 2002 spawned widespread initiatives to raise the awareness of the values of mountain regions and build on the motto, “We are all mountain people.” Let us endeavor to use geographic theory, knowledge, and techniques to improve the human condition in the mountains and for all who live downstream.
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References

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