Profile of Eric F. Lambin

A world without forests would challenge life on earth. Forests maintain biodiversity, influence the climate, and regulate the water cycle, says Eric Lambin, a professor of earth sciences at Stanford University and a recently elected member of the National Academy of Sciences. However, as the world's population swells, forest loss accelerates. To feed the world's growing population, it will be necessary to clear an estimated 2.7–4.9 million hectares of cropland per year, even while expanding urban centers shrink the available land by 1.6–3.3 million hectares per year (1).

Deforestation seems like such an overwhelming problem that most people have given up trying to measure it, says Lambin, who divides his time between Stanford University in Palo Alto, CA, and the Université Catholique de Louvain in Belgium. But through decades of research, Lambin has shown that land use change is indeed quantifiable, thanks to the emergence of satellites that capture sweeping images of Earth. Overlaying those satellite images with socioeconomic data from specific locales can reveal the source and spread of land use change: a so-called people-to-pixels approach.

Lambin adopted that approach as a young doctoral student in sub-Saharan Africa in the mid-1980s and has expanded it throughout his career. In his Inaugural Article, he highlights how linking remote sensing and trade data can track land use changes occurring far from the source of the problem. For instance, says Lambin, the rise of biofuels has prompted farmers to divert crops such as corn or soybeans from food to fuel markets. Because the demand for the food crop remains, the change leads to changes elsewhere in the world, a cascade effect that eventually reaches the edge of the forest. "Proponents of biofuels say these effects are impossible to quantify so let's ignore them altogether," Lambin says. But what others see as too complicated, Lambin sees as a puzzle worth solving.

Rebellious Start

Lambin was born in 1962 in Brussels, Belgium, and his parents were both academics. His father taught strategic marketing at a business school, and his mother was a historian. When Lambin was young, his family moved to the Belgian countryside, where he spent his childhood playing the saxophone, reading classics, and playing outdoors. "We always had horses," recalls Lambin, who remains active in dressage.

Despite his parents' influence, Lambin was not interested in education. "I was quite a rebellious teenager," Lambin recalls. "I disliked authority and hated being told what to do." When Lambin graduated from high school in the early 1980s, he packed his bags and headed to Ireland. "I had no clear idea of when I would return," he says.

Eric F. Lambin.

By mid-September of that summer, Lambin realized university would start soon, and he high-tailed it home. Freed of any expectations, Lambin excelled in school. Still unsure what to study, he majored in geography because he thought it would help him travel. It turned out to be a prescient choice.

When he graduated from university in 1985, his professor, Jules Wilmet, asked him to conduct fieldwork in the African Sahel—an opportunity that appealed to Lambin's wanderlust. Satellites had just begun to roam the skies, and Wilmet wanted to see how much land use information could be extracted from the images. Those early satellites laid the seed for a field known as remote sensing, which entails drawing conclusions about physical properties of the land from a distance. So Lambin headed to Burkina Faso.

Satellite images of the country revealed clear patterns of land use, Lambin says. Those patterns were assumed to be related to physical properties of the land, such as variations in geology, soil type, or climate. But when Lambin overlaid the satellite images with appropriate maps, the patterns did not match up. A clear pattern only emerged when he overlaid the images with maps of the scores of tribal groups in the region. Each tribe, Lambin says, displayed a unique ethnic footprint in the landscape (2).

Intrigued, Lambin bought a motorbike and began traveling to area villages to figure out what land use decisions created those patterns. Working much like an anthropologist, Lambin befriended village elders and conducted lengthy interviews with tribal families to understand their day to day lives. Gradually, he earned the villagers' trust. "I was always receiving gifts," he says. "I would spend a few days with them and then, when I left, I would have live chickens [for the evening's dinner] hanging off my motorbike." Through 3 years of interviews and chicken dinners, Lambin realized that the pattern of each tribal group varied depending on the balance of livestock to cultivation, access to fuel, and irrigation practices.

On the verge of finishing his dissertation, Lambin made one last trip to Burkina Faso in 1987. He would not return for another 2.5 decades. While there, Blaise Compaoré seized power in a coup d'état, and Lambin, the only Caucasian male in the region, was mistaken for a spy and arrested. "I was kicked out of the country," Lambin says. Luckily, his research was complete, and Lambin defended his thesis the next year.

Remote Sensing Pioneer

In search of work, Lambin recalled his chance encounter with Alan Strahler at a conference in West Africa 1 year before. Strahler, a geographer at Boston University in Massachusetts, was a remote sensing pioneer. At that time, he was working with the National Aeronautics and Space Administration to create tools to interpret the information to be relayed by the soon to be launched satellite known as Moderate Resolution Imaging Spectroradiometer (MODIS), which remains in orbit today. Specifically, Strahler's team was tasked with creating algorithms that could estimate surface temperatures, moisture, net primary productivity, and reflectance from MODIS images.

Strahler was so revered in the field that Lambin was too nervous to talk to him at the conference. Luckily for Lambin, Strahler's plane was delayed, and the men struck up a conversation in the airport. Strahler was so taken with the people-to-pixels approach that he invited Lambin to give a seminar at Boston University after

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Land use variations in the highlands of Vietnam. Courtesy of Patrick Meyfroidt.

he finished his doctorate. "I'm not sure he really meant it, but the day I finished, I wrote him and told him, 'I'm coming,'" Lambin says. Soon after, he was hired as a geography professor at Boston University and left his people-to-pixels research to work with Strahler on methods for processing MODIS images.

Instead of overlaying successive maps and identifying changes in the landscape, Lambin wanted to relate the changes to specific properties of the land over time, such as vegetation activity and surface moisture. Finding and measuring those properties, he says, required creating and testing complicated algorithms—the gritty work that defined his 3 years at Boston University (3).

As the years passed, those methods laid the groundwork necessary to observe detailed changes to the landscape over time. In particular, it had been assumed previously that land surfaces undergoing change followed a slow but linear switch from, say, forest to field. However, Lambin's work made clear that the process is much less linear and that land surfaces are strongly affected by subtle surface modifications and remain in constant flux (4, 5).

In 1993, Lambin relocated to the Institute for Remote Sensing Applications at the Joint Research Centre in Ispra, Italy. Data in hand, he wanted to decipher the importance of those minute fluctuations. Therefore, he began observing dynamic landscapes, such as biodiversity hotspots and regions undergoing frequent burning. This work allowed him to test long-held ecological principles that had, until then, been difficult to verify. For instance, a Danish researcher by the name of Jon Fjeldsa had collected extensive data on birds in East Africa and suspected that biodiversity tends to crop up in more stable environments. "He could never test that," Lambin says. However, Lambin was able to validate his theory by overlaying the biodiversity data over remote sensing data (6). "He was absolutely right," Lambin says, "and thrilled with the results."

Merging Pixels and People

In 1995, Lambin returned to Belgium and took up a teaching position at his alma mater, the Université Catholique de Louvain—a move that marked his gradual return to people-to-pixels research. In 1997, Lambin published a review paper that described how information from remote sensing was being used to predict future land changes (7). However, creating a comprehensive picture of such change, Lambin realized, required pairing the information derived from the pixels in satellite images with actual information from the ground.

Lambin's efforts to bridge those two disparate communities—remote sensing scientists and human ecologists—led him to the Land Use Land Cover Change Project (LUCC), a consortium of land use change scientists from around the world. The primary goal of LUCC was to monitor incremental fluctuations in land surfaces from across the globe and aggregate that information to create land use change projections. Lambin chaired LUCC from 1999 to 2005.

Lambin's involvement with LUCC prompted him to pursue a suite of Africa-based case studies, each one looking at a different region and the primary drivers of land use change. Basically, says Lambin, he scattered his doctoral students around the globe. "Each student used the same framework—some fieldwork, some modeling, some remote sensing surveys—to look at a suite of different issues. In Cameroon, we looked at deforestation (8, 9). In central Africa, we looked at forest fires (10). In the Sahel, we looked at desertification (11, 12)," he says.

After he had enough case studies, Lambin aggregated the information to extrapolate global patterns of land use change (13–17). "We could study each little village or province forever," Lambin says. "We need to ask: What did we learn here? What do we know today that we didn't know 5 or 10 years ago?" In 2001, he published a paper debunking eight misconceptions about land use change (18). Contrary to prevailing wisdom, Lambin notes that deforestation arises from changing institutions and economic conditions—not just population growth. Even without humans, rangelands are highly dynamic systems. Letting such misconceptions stand leads to policies that can cause more harm than good, he says.

More recently, Lambin was approached by disease ecologists researching the spread of two vector-borne diseases—malaria and dengue—in northern Thailand (19). The project added a layer of complexity to Lambin's work. He now had to extend his land use analyses to disease vectors, chiefly mosquitoes. The study made clear that dengue had increased because of the rise in tree crops, expanding urban areas, and presence of artificial containers that serve as the vectors' breeding grounds. Meanwhile, malaria had decreased because of deforestation and subsequent losses in mosquito habitat.

As his research into this new area has expanded, it has become clear that land use changes are a key driver behind the spread of vector-borne diseases, because those changes govern the level of contact between people and the vector. Combating the spread of vector-borne diseases then becomes a matter of figuring out where the vector and people congregate and reducing those periods of overlap (20). Lambin and a consortium of scientists have extended this work to the study of rodent- and tick-borne diseases in Europe (21) and foot and mouth disease in southern Africa (22).

Predicting Success

For his Inaugural Article, Lambin returns to the pressing issue of deforestation by highlighting seven countries that have managed to transition over to reforestation (1). Lambin says he wanted to take a look at the good news and show readers that deforestation is not an intractable problem. "I thought, 'Let's take each of

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these countries, study them under great depth, and understand under what conditions they were able to turn things around,'" he says (23).

However, the real goal, he says, is to get people thinking about deforestation on a global scale. One country's decision to increase forest cover will invariably shift the burden of producing crops elsewhere (24, 25), and therefore, nations must collectively prioritize which land areas are most important for a healthy world, regardless of political boundaries, he says. Policymakers must also consider the many ways in which globalization alters land use practices. Now, Lambin and his research team are trying to determine where along the supply chain to intervene to promote truly sustainable land use practices for globally traded commodities.

In the past decade, Lambin has also begun to take his message to the masses. He authored his first popular science book, *The Middle Path: Avoiding Environmental Catastrophe* (26), in 2003. In it, he addresses whether we should be optimistic or pessimistic about the health of the planet. "My synthesis shows that we can be rather optimistic provided we change course dramatically," he says.

In his second book, *An Ecology of Happiness* (27), published in French in 2009 (an English translation is expected out this year), Lambin's goal is to reach out to those people who are reluctant to modify their consumption behavior. In that book, Lambin highlights the intrinsic benefits of immersing in nature, such as improved health and personal wellbeing, to support the idea that saving nature actually makes us happier. The basic message of the book, he says, is "don't save nature just for the environment or the butterflies. Do it also because nature makes you happy."

Sujata Gupta, *Freelance Science Writer*

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