AUTHOR COMMENTARIES - 2009

May 2009

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Arturo Sanchez-Azofeifa

Featured Scientist from *Essential Science Indicators*SM

Late last year, the work of Dr. G. Arturo Sanchez-Azofeifa entered the top 1% in the field of Environment & Ecology in Essential Science Indicators *from* Thomson Reuters*. His current record in the overall database includes 38 papers cited 633 times between January 1, 1998 and December 31, 2008.*

Dr. Sanchez-Azofeifa is Director and Professor of the Center for Earth Observation Sciences (CEOS), a Professor at the Earth and Atmospheric Sciences Department, and a Principal Investigator of the TROPI-DRY Collaborative Research Network at the University of Alberta.

In the interview below, ScienceWatch.com *correspondent Gary Taubes talks with Dr. Sanchez-Azofeifa about his highly cited work.*

SW: As a civil engineer by training, how did you get involved in deforestation and climate change research?

In the early 1990s, I came to the US on a Fulbright scholarship to do a masters and Ph.D. in hydrology at the University of New Hampshire. At the time, I had the opportunity to work with a very good group at the university that was working on deforestation in the Amazon basin, using remote sensing. While working on my dissertation, I met such people as Paul Ehrlich, Kamal Bawa, and Robert Harris, and they are the ones who actually pulled me into this line of work over the years, and we've continued working together in this area. A lot of my work has been derived from interactions and discussions with them.

SW: What was your first approach to studying deforestation?

Looking at the effects of parks on deforestation. Basically Kamal and I asked ourselves in 1998 whether national parks were effective or not in preventing deforestation, and I think we published probably one of the first papers in Conservation Biology about those issues. We looked at a very important park in Costa Rica and we used remote sensing to look at how deforestation and fragmentation were occurring in the vicinity of the park.

SW: Could you explain what fragmentation is?

Taking a huge portion of forest and cutting it into little pieces. When you look at the Amazon now, you see what you often see in the American Midwest, small patches of forest in the middle of vast fields. That's what we call fragmentation. My work in Costa Rica over the years has been along those lines, and we did the first inventory of deforestation and fragmentation in the region and we've continued working on this, publishing a lot of papers that have had impacts on policy, environmental services, water resources, etc.

SW: One of your most-cited papers in our database is the 2006 *Nature* article, "Widespread amphibian extinctions from epidemic disease driven by global warming." Would you walk our readers through this paper and its findings?

The paper was motivated by the work of Alan Pounds, the first author. There was a lot of discussion at the time about whether climate change was affecting cloud forests, which are forests at the top of mountains; not alpine forests, but forests affected by the constant movement of clouds.

The best way to understand this is to look at the Monteverde cloud forests, which is where Pound works. We met through the Tropical Science Center in Costa Rica. There were some theories floating around for years talking about the effect of deforestation on local climates and that this could explain the disappearances of frogs, for instance. I remember talking to Alan about this and we were thinking that there must be something else involved.

My work in the team was to provide all the deforestation analysis based on satellite analysis that went into the model, which ultimately demonstrated that deforestation was, in fact, not a factor in the disappearance of frogs in Monteverde. That led, in turn, to the whole theory of climate change and how changes in micro-temperature during the day and night affected the disappearance of frogs. We had evidence from other sites, as well, so that story became more significant.

Figure 1: +details

Figure 2:

Figure 3:

SW: Why do you think that paper has been so highly cited?

I think there are two reasons. One is the time it was released—January 12th 2006. I remember being at my house when *Nature* released that paper. It seemed like two minutes later when the phone started ringing, and it kept ringing for hours. This story was all over the place—it was in 278 newspapers in a week. It turns out this was when the Intergovernmental Panel on Climate Change (IPCC) was preparing to release its 2007 report, its fourth assessment on climate change, and the IPCC report actually cited our paper as demonstrating one of the effects of climate change. In practice it was very unique. We actually demonstrated that the frogs had been killed by pathogens, but what was happening was that the pathogen was moving into higher elevations because of the temperature change. Some people say that climate change is the trigger for the bullet that is killing the frog. So I think that opened the door.

When someone writes a paper on this subject, the first thing their introduction has to do is frame the work inside a body of knowledge, and ours is a very important paper in this respect. When people want to say that climate change has an impact on biodiversity, then Pounds *et al.* is the first paper they cite. When the disbelievers write their papers, they use Pounds *et al.* to define their own theories. And once we had a couple of replies in *Nature* and another reply in another journal, the whole thing snowballed. The key element—and it's important to stress this—is that the paper was used by the IPCC as among the first evidence of the effect of climate change in Latin America, a topic on which we have very little information.

SW: What do you consider the most challenging aspect of studying the effect of climate change on deforestation?

I think it is always difficult to work with remote sensing on a site that's always covered with clouds. Those are optical satellites, after all. If you have clouds, you cannot see the forest and so you have trouble developing algorithms that the modeling team can use to get accurate rates of deforestation. That, to me, is now the most challenging, although over the years it's not actually the most difficult thing we've ever done.

SW: OK, so what was the most difficult?

Ever? Oh, man. There's a paper by Phillips from the Royal Academy of Science in England, published in one of the top journals, in which he talks about the 10 fingerprints of global change in the tropics—hunting, fragmentation, things like that (Lewis SL, *et al*., "Fingerprinting the impacts of global change on tropical forests," *Phil Trans. Roy. Soc. London B-Biol. Sci.* 359[1443]: 437-62, 29 March 2004). And one he mentions is the increase in the extent of lianas—these woody vines that climb around and between trees. Lianas are parasites that extend all the way to the top of the tree. The question is, if lianas are so important for global change, which Phillips and others have documented, and if the extent of lianas is increasing in the tropics and is strongly related to the increase in CO_2, could we detect the lianas from space using satellite data?

So I developed a program of research with postdocs, students, etc., trying to answer that question. I went from the question of how the leaves of the lianas reflect light compared to the leaf of a tree. I tried to extrapolate from there to the canopy and from there to the landscape. I used construction cranes in Panama, in the middle of forests, to understand those processes. To me, this is the most difficult thing I've ever done. And one thing I can say so far is that we cannot detect the extent of lianas in tropical rain forests from satellites, but we can do it in tropical dry forests.

You caught me right now addressing the reviews of that paper. One referee said we quote ourselves too much and we have to explain to the editor that we have to do that because nobody else is doing this work. It seems to me that for a long time researchers working on forests did not make the connection that lianas are important or that they are even part of a tropical ecosystem. It is like they do not exist. The only thing researchers saw was the tree. In some cases, lianas may constitute 70% of the structure of the forest. There is a tree in Panama, for example, with 27 species of lianas in one single crown. Sometimes the lianas become so heavy that they kill the tree.

SW: It seems like you've become fascinated with lianas in and of themselves.

I have. Lianas just grow. They don't have to put any energy into generating trunks and branches. The energy all goes to leaves and growing. It's really interesting, and I think this is opening up a whole new line of research. People are now starting to write proposals on this. People have worked on the ecology of lianas for many years but not this linkage between the ecology of lianas on a tree and the observation of the presence of the life form in a crown of a tree using satellites. So, yes, this to me is one of the most difficult things to do and we're still struggling with that.

"I think it is always difficult to work with remote sensing on a site that's always covered with clouds."

SW: Another of your highly cited papers is the 2001 *Ecological Applications* paper, "Countryside biogeography: Use of human-dominated habitats by the avifauna of southern Costa Rica," (11[1]: 1-13, February 2001). Would you please talk a little about this paper and its significance for the field?

This paper is with Gretchen Baily and Paul Ehrlich and it was published in *Ecological Applications* in part because we introduced this concept of countryside biogeography. That's the seminal paper in which we presented the concept and demonstrated the principle of it, and people can then use it to help develop this field of study. And that's why this paper is so highly cited.

SW: So what exactly do you mean by the term "countryside biogeography?"

The understanding of effects of fragmentation in the landscape, considering the matrix of the landscape. For many years, fragmentation and the effects of fragmentation on biodiversity considered just forest and non-forest, which is effectively everything that's not a tree. In this paper with Gretchen and Paul, we moved away from that concept and looked beyond forest and non-forest.

We were looking at what the landscape looks like; what happens when you have coffee plantations? What about if it's sugar cane? What if it is half sugar cane, half coffee? What if you have a forest that is surrounded by a coffee plantation, and the coffee plantation has trees that can be used by birds as a stepping stone? That is the kind of research that this paper opened and I think that's why it's so highly cited.

SW: Where do you see your research going in five to ten years?

I think that it will go in several main lines. We are going to continue working on the issue of lianas: how can we map their presence and absence in tropical dry forests? That's where we're finding more significant differences between the lianas themselves and their host trees. The second will be dealing with the role of climate change phenology; that is, the change of seasons, from winter to spring to summer to fall in dry forest environments. We have ways to quantify that transition dynamic using satellites. We have long-term remote-sensing time series and it's interesting to see how those processes have been captured over the last 30 years, and if there are any trends, and where those trends are more noticeable.

The third one is an area that has not been explored in depth by anyone, which is the role of endophytes in the response to climate change. Endophytes are fungi that live inside the leaf. They're important when you consider the theory of how a leaf reflects light and then extrapolate this to the canopy and then to the landscape. Most satellites have sensors that look in the near-infrared, and the way that a leaf reflects light is in the near-infrared. When you take a cross-section of a leaf and look at it with a microscope, you'll find that in the middle of the leaf there's the spongy mesophyll. It actually looks like a sponge. Light goes through the epidermis of the leaf and reflects inside the spongy spaces of this spongy mesophyll. The theory says that the way a leaf reflects light in the near infrared is related to the amount of empty space inside the leaf. Now guess where the endophytes go—inside those empty spaces.

What we want to know is the relative contribution of those fungi to light reflectance and how they use that light. And we are finding some phenomenal things. For example, in one single leaf you can find up to 10 or even 16 different species of endophytes. One plant may have over 120 species of endophytes. And nobody has ever looked at this. So we're starting to develop a line of research to understand the role of endophytes on the spectral reflection of light from leaves.

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Arturo Sanchez-Azofeifa's current most-cited paper in *Essential Science Indicators*, with 191 cites:

Pounds JA, *et al*., "Widespread amphibian extinctions from epidemic disease driven by global warming," *Nature* 439(7073): 161-7, 12 January 2006. Source: *Essential Science Indicators* from Thomson Reuters.

KEYWORDS: GLOBAL WARMING, CLIMATE CHANGE, DEFORESTATION, REMOTE SENSING, NATIONAL PARKS, CLOUD FORESTS, MONTEVERDE CLOUD FORESTS, MICROTEMPERATURE, FROGS, SATELLITE ANALYSIS, LIANAS, CARBON DIOXIDE, COUNTRYSIDE BIOGEOGRAPHY, ENDOPHYTES.

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Figures and descriptions:

Figure 1:

Figure 1:
Arturo Sanchez-Azofeifa using an UNISEC field spectrometer to measure canopy reflectance of liana-infested trees in Panama. View larger image (allow time to load). Close new browser window to return to this page.

Figure 2:

Figure 2:
Canopy crane managed by the Smithsonian Tropical Research Institute (STRI) at the Parque Natural Metropolitano, Panama City, Panama. The crane allows for easy access to the top of the canopy of this tropical dry forest to study and sample liana leaves optical properties and their relationship to remote sensing observations. Panama City is observed in the background. View larger image (allow time to load). Close new browser window to return to this page.

Figure 3:

Figure 3:
Tropical dry forest during the rainy season infested with lianas. Panderios Conservation Areas, Minas Gerais, Brazil. View larger image (allow time to load). Close new browser window to return to this page.

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