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# Condensed Transcript

# "Road Ecology: Our Giant on the Land"

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## Introduction

What I would like to share with you today are some thoughts about *road ecology*. We have spread an enormous net over the land of North America - almost five million miles of public roads. A quarter of a billion vehicles use that net. Most of the net was put out before its day, before the rise of modern ecology. It's an engineering marvel. It's an economic success story. It has provided unprecedented human mobility. It has stretched the boundary of social interactions, greatly facilitated the movement of goods across the country. In effect, it's at the core of today's society and economy.

This network of roads is superimposed on mountains and valleys, rivers, plains. It teams with natural flows - that is, ground water, surface water - and it flows across the land. Wind carries seeds and spores and soil. Wildlife forage, and then they disburse. Sometimes they migrate as do fish. In effect, nature's never-ending flows, horizontal flows, and movements across the land mold the land mosaic and produce the patterns to provide diversity.

These two giants, the net and the land, are in an uneasy embrace. The road system ties the land together for us. It divides nature into pieces. And therein lies the opportunity for us.

Nature is degrading roads; roads are degrading nature. Both of these factors are costly to society. These are increasingly receiving public attention, and this translates into the need for political action. Meanwhile, traffic is increasing at a greater rate than almost all the other statistics you can name. So, there's a greater call for new knowledge and skills. Just in time, the science of road ecology perhaps is meshing, is jelling, bulging with useful applications. Its roots are in vegetation, stream ecology, wildlife ecology, chemistry, hydrology, and more. Yet the new catalysts are intelligible. The new kid on the block that helps to bring this together is landscape ecology.

For the last 20 years I've been analyzing the landscape - a large heterogeneous area, lots of flows, patterns, changes over time, as if you turned a kaleidoscope. Now, add a highway. Landscape ecologists really didn't even notice the road system, even though in most landscapes

it's the most prominent feature out there. And yet, we didn't study it. It's the least ecologically known feature. Now that, in itself, is a challenge for scientists like me; that's a challenge. So I spent 20 years or so studying that landscape as an object and understanding - analyzing – it, just as if it were a human body or a cell that has an anatomy, a structure, in which things flow through it. It works, it has a functioning, and it changes over time.

**The Green Book and VMT**

The *Green Book* [AASHTO Green Book, *A Policy on Geometric Design of Highways and Streets, 2001*]: I'd never seen it. And I see many of us in the room have never seen it before, and it's absolutely fundamental to the design of roads and everything having to do with roads. I mean, it is absolutely critical - every cul-de-sac and every housing development follows that *Green Book*, almost. Although you're allowed to deviate - as I understand it, you're allowed to deviate from it if you can justify now that you have something better. Another component I want to bring up is "VMT." Six years ago I had never heard the word "VMT." VMT means "vehicle miles traveled," and it's absolutely central to transportation planning. It's the most common phrase among transportation planners in my experience. VMT. It's very important.

So, my point here is that we ecologists and people outside the transportation field are faced with things that mean nothing to us. We have to learn. We have to be open to learn. If we are open to learn, there's a lot there, and maybe we can begin to communicate. So, taking that step is very important.

**Wildlife**

So, you have a population going along with some variability and doing fairly well, it's a large population, low extinction probability. Then you put in - we put in - a road, and the obvious thing is that you remove some habitat. That's what habitat loss is - not very interesting conceptually; it is important to the animals, however. The second item is reduced habitat quality. Now, the thing we mostly focus on here is the edge effect next to a road; the microclimate gets in and drives out the edge, and there are studies on these various places. So, there's a road part of that, and there's a traffic part of that. The third aspect of decreasing a population size is road kill, or mortality. The fourth aspect of decreasing this population is the barrier effect, reducing the connectivity that I started out with that animals and species move across the landscape. There are good ecologists that argue that animals must move; that's controversial, but that's a possibility. Finally, you're left with the small populations with a higher probability of local extinctions that are disappearing locally. So that's the overall picture here, and I just want to emphasize that in decreasing population sizes of animals, there are four processes going on, or one can boil them down to four major processes, all of which are important.

Now, let me shift to the other aspect of wildlife, and this has to do with the traffic - traffic disturbance. We did a logistic regression analysis trying to figure out whether traffic volume and the distance from the road is important relative to the size of the clearing, how far the clearing is from the next clearing, and what the adjacent habitat to each clearing is, whether it is a built area or forest. So, what we found out, basically, was that traffic - that the highway and traffic - was significant. In other words, none of the animals is breeding regularly within a few hundred meters of the highway with a traffic volume of 8,000 to 15,000 vehicles per day, for a 24-hour commuter day. But what it says is, if you're interested in songbirds, and you're spending money

to design nature reserves for them, then don't put them [the reserves] near busy highways. Don't put them very close at all, or don't put the highways near the nature reserves.

**Vegetation and Water**

Now, vegetation and water, this is something familiar to all transportation folks. Water flows downhill, and we put ditches in to catch [the water], and on slopes, you know, the cut bank on the upslope, water oozes out there. It oozes out, and it goes down into the ditch, and on the upside goes down through a culvert and down toward a stream. Well now, what does that do? Well, it does a number of interesting things relative to the stream. One thing it does is it takes ground water, turns it into surface water, and heats it up. So the water going into the stream is warmer. Now cold water fish like trout and salmon don't like that so much. Another thing it does is that when it comes out of the culvert it may form a channel and erode some material down to the stream and flatten out the stream bottom; it may not, it may. Another thing it may do is carry nutrients down into the stream and cause various consequences.

The take-home message is twofold. One is there are various heavy metals and other things coming from both road and roadside sources, and vehicular sources. The second thing that's interesting, to me at least, is that there are quite a few of these things [metals, etc.] coming from each of these sources. If you want to look for a magic bullet to solve ground water pollutions from storm water, there isn't one. It's going to take an action at a whole range, at least from the source control point of view, take an action on a whole range of activities there. For the bulk of those pollutants, or pollutant constituents, their ecological effects are only measurable for meters to tens of meters out from the highway. In other words, there are some exceptions, but by and large, those chemicals aren't things that are affecting long distances, like traffic noise or traffic disturbance effects.

So then, ask yourself, "What's the effect on the streams in the landscape?" What the various articles in the *Journal of American Planning Association* and elsewhere conclude is that in the 0 to 10 percent hard surface zone, the streams are in good shape, relatively speaking, and then in the 10 to 25 zone, they're impacted, they're degraded. So that's putting the hydrology, the water flows, in with the housing and so on, but using hard surface as your common communication tool or element. Those are the things that in state after state we should be looking for. Those are the rare species in our roadsides. We should be doing something about that. Few states perhaps are; many states aren't.

Here's something interesting - a man went out to a car wash, and for three months he collected the water coming out of the car wash. He filtered out all seeds, and he put all the seeds on soil and grew all the plants that came up. This is what he found out. He found out that most of the plants were from the city and the surrounding cropland. He found some plants also from the native community, the wooded communities there, both herbaceous plants and woody plants. But over 20 species of plants came from afar - that is, they weren't known in that urban region and, therefore, came from somewhere else.

There's a lot of talk about transportation and exotic species, a lot of finger pointing. Our Federal Highway Administration has a wonderful book on native and exotic plants, what you can plant in North Carolina and what you can't, what you should, shouldn't, and so forth. I should say that

there's not a lot of evidence that exotic plants are actually going from roadsides into nature reserves or from roadsides into ranchland, pastureland, or cropland. It must happen. I can't find the literature for it. And so, some research needs to be done there.

**Road-Effect Zone**

Now, the primary thing I want to do is to get the landscape ecologists and the engineers talking. So, the *road effect zone* is focused in that direction. What we call the *road-effect zone* is the zone in which ecological effects go out. It's how far a statistically significant effect can be measured. The zone is very uneven; it's an asymmetrical, highly convoluted boundary. Landscape ecologists, watershed biologists, conservation biologists and others who take real broad views say, "You've got to consider the whole landscape." The highway engineer does a real careful, meticulous, elegant job in a narrow zone next to the road. How are you going to get these two perspectives together? I mean, for society. This [road-effect zone], to me, is a quantitative way of getting them together. The road-effect zone is the minimum effect that has to be considered in highway planning, road planning, upgrading projects, and other project maintenance.

We took this concept and applied it to the whole United States. We asked the question, "How much of the United States area is ecologically affected by the four million miles of public roads? One hundredth of them - that is, about 40,000 - are interstate highways. About one-tenth of them belong to the U.S. Forest Service, although the Forest Service readily admits it doesn't know exactly how many roads it has. These people keep putting in roads illegally. So, what's the total effect of the four million miles of public roads?

Then we said, "What's the total land area effected ecologically for each of those?" When you add them together, you get about 20 percent, or about one-fifth, of the total U.S. area is directly affected ecologically by our road system. That's the first estimate anybody every made. It's rough. Hopefully, somebody will do it and do it a lot better. The article I published lists a whole lot of things that may reduce or increase [that number]. My interpretation is that the number's going to increase, almost inevitably.

**The Book – *Road Ecology: Science and Solutions***

The book is the final thing I want to mention. [*Road Ecology: Science and Solutions*] will be out in seven months or so, and I'm just one of several folks spearheading it, along with my colleague, Dan Sperling, in California. This is a synthesis of ecologists and transportation experts. It's a wonderful experience. I can't express it any other way than that. I learned so much, they learned so much. Some of us started into this project feeling that roads are basically bad, although they do provide some social and economic benefits. Some of us went into this project thinking that roads are really good, although they have some environmental problems. That's a really different way of coming at it, and to be able to work together and hopefully affect one-fifth of our nation is kind of neat.

The book contains some road stuff and traffic planning at the beginning, some wildlife and vegetation aspects and mitigation in the middle, and some water and chemical effects on the ecosystem at the end. I skipped over wind and atmospheric effects. I'm happy to talk about wind, air pollutants, and greenhouse gases. There are so many reports on that subject that are

really good, and it's changing so fast that we're not really dealing with that in this book. We have a very cursory section there. Then the exciting stuff is tying the land together with the road network.

Just to emphasize: there's a research opportunity here. There's a big research opportunity. I gave a talk some years ago, and I used this image to try to think of some theories that might be useful in road ecology, and I kept coming back to spatial models as a way to begin to develop theory. Some of these models, like network theory, are well worked out in transportation literature, I mean huge amounts of literature about the traveling salesman, probably, looking at this thing that he's got to deliver to 13 cities, and thinking, What's the optimum route? Or, I've got some goods I've got to transport, I need some redundancy or stability in my system in case there's a strike or a breakdown of rail or something. And how do you get circuitry in your routes? It's a big body of literature; it's fascinating, wonderful literature. I enjoy it.