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Are Spotted Owls Doing Better?

Introduction:

The northern spotted owl was put on the endangered species list in 1990 over the bitter protests of the timber industry. The spotted owl litigation forced a reluctant Forest Service to make serious efforts to protect owl habitat, and logging on public lands in the Cascades, Sierras and Coast Ranges has been reduced by 80 percent.

Conservationists used the spotted owl at least partly as a proxy to protect the old growth forests that the owl requires. This strategy was successful in the short term, it has given the owls some breathing room, but it has a serious weakness; that is, spotted owls are not necessarily dependent on old growth forests. It is only a matter of time before the timber industry uses this argument to try to open up logging in old growth areas.

Less than 10 percent of old growth forests remain in the West and they must continue to be protected. Using the northern spotted owl to protect old growth was an effective tactic to stall the timber industry, but economic pressure to mow them down will certainly increase. We must use the time we have gained to find a more direct way to protect and rebuild the scattered remnants of our region's once thriving forest ecosystem. We spoke with Alan Franklin, a conservation biologist, about the current status of spotted owls.

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ER: Professor Franklin, what is your training?

AF: I received my Ph.D. at Colorado State University and I currently work as a Research Associate at Colorado State University; I'm also an adjunct Assistant Professor at Humboldt State University and the University of Minnesota.

I'm on the recovery team for the Mexican spotted owl. I co-lead the most recent meta-analysis of population trends for the northern spotted owl, with Ken Burnam, Gary White, Bob Anthony, Eric Forsman, and many other people. I'm also leading another meta-analysis to determine population trends in the California spotted owl population in the Sierra Nevada Mountains of California. In 1985, Pat Ward, Rocky Gutierrez and I started a demographics study in northern California on northern spotted owls, which is ongoing.

There was a lot of litigation around the northern spotted owl. Management plans were dropped and revised, new plans were developed, so it is a complicated issue. Steven Yaffee in his book *The Wisdom of the Spotted Owl*, gives a good overview of the controversies in Oregon and Washington[1].

In 1985, prior to the owl being put on the endangered species list, there were basically five demography studies for the northern spotted owl and much of that data was used for the listing decision. There were some ugly politics around the listing and decisions were changed at upper echelons; but the northern spotted owl finally was listed in 1990, largely as a result of lawsuits brought by environmental organizations.

There were lessons that could have been learned from the northern spotted owl listing that were not learned in the Southwest and that's one of the reasons why the Mexican spotted owl was listed. However, for the California spotted owl I think they have learned from the previous two listings and are

taking a more careful approach in developing a management plan for the Sierra Nevada, but many people might disagree with me on that.

ER: What's new with your research on the spotted owl?

AF: We just recently published a monograph on the effects of climate and habitat quality on spotted owls, and found some things that surprised us[2]. One is that even if habitat pretty much stays the same, we might expect episodes of population decline just due to inclement weather. For example, cold wet springs appeared to have a negative impact on the population.

The other surprise was that an owl's survival is keyed towards amounts of interior mature and old growth forest, but also keyed toward the amount of edge with other seral stages in a territory. *[Seral stages are other ages and mixes of trees. Ed]* Also, reproductive success is highly correlated with the amount of edge with earlier seral stages. Our understanding had been that the more old growth the better, and we're finding out that may not be the case in our area. We found that spotted owls have fairly low reproduction in areas with a lot of old growth. The mosaics of interior older forest mixed with other seral stages promoted both high survival and high reproduction.

ER: Were these oak or conifer woods?

AF: That's a key point because this is a different kind of forest than in the northern part of the owls' range. This study area is in mixed conifer/ hardwood forests. They're very productive forests for wildlife because of that hardwood component. So at least in this study area, good quality owl territories have a mix of interior older forest and other types of vegetational stages.


Alan Franklin

ER: Why is that mix of woods good for owls?

AF: One of the spotted owl's primary prey species in our area is the dusky-footed wood rat, and these animals can reach high populations in these early seral stages. We think the edges between older forests and other vegetation types may be good foraging areas for the owls.

Then in terms of survival, the interior forest provides better protection against the owls' predators; and it's a better thermal environment for them as well.

ER: And better nesting opportunities.

AF: That too, although closer to the coast owls will nest in clumps of debris, mistletoe clumps, and old stick nests. In our study area, which is more inland, they do nest in structures that are more associated with older forests, like big broken-top trees that have these chimneys and side cavities to them. So yes, old growth probably does offer them more nesting opportunities, but the edge in there seems to be important. We're planning some experiments to see whether edges do in fact provide more prey and whether the owls are actually taking prey out of these ecotones rather than in the interior forests.

ER: The follow-up would be to see if prey availability correlates with nesting success.

AF: Yes, exactly. We already see a pretty strong correlation between production of young and the presence of edges in the territory.

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ER: Why do you think wet weather would harm owls in the wild?

AF: We found that these cold wet springs and rainy winters seem to negatively impact both adult survival and recruitment of young into the population. We also found an interaction between habitat quality and weather: birds in high-quality habitat didn't suffer nearly as much as birds that were in poorer quality habitat.

We're theorizing that in periods of good weather birds are going to move into these secondary habitats, and then when you get a bad spell of weather, cold, wet springs, those owls would be the first to go, and so you're going to see a population decline then. Good quality habitat buffers the individuals from bad weather. It's like being in a good house versus a bad house. When you get a cold winter, you're much less likely to survive in a bad house than you would in a good house.

ER: But in the wintertime they're dealing with snow and ice.

AF: In our area snow is not nearly as much of a problem as precipitation. We're in more of a temperate maritime climate. That's not to say we don't get snow, we do, but rainfall is the predominant form of precipitation.

If you've ever been in the woods during a heavy rainfall you might have noticed that there's a lot of white noise. There is research that shows that wood rats are less likely to move around in bad weather. But noise also affects the owl's ability to pinpoint prey, because they locate their prey initially at least by sound. Those make interesting stories but whether that's true or not we don't know. We'd like to do some experiments with captive owls looking at that. All we know is that we see a strong correlation between bad weather and declines in survival and reproduction.

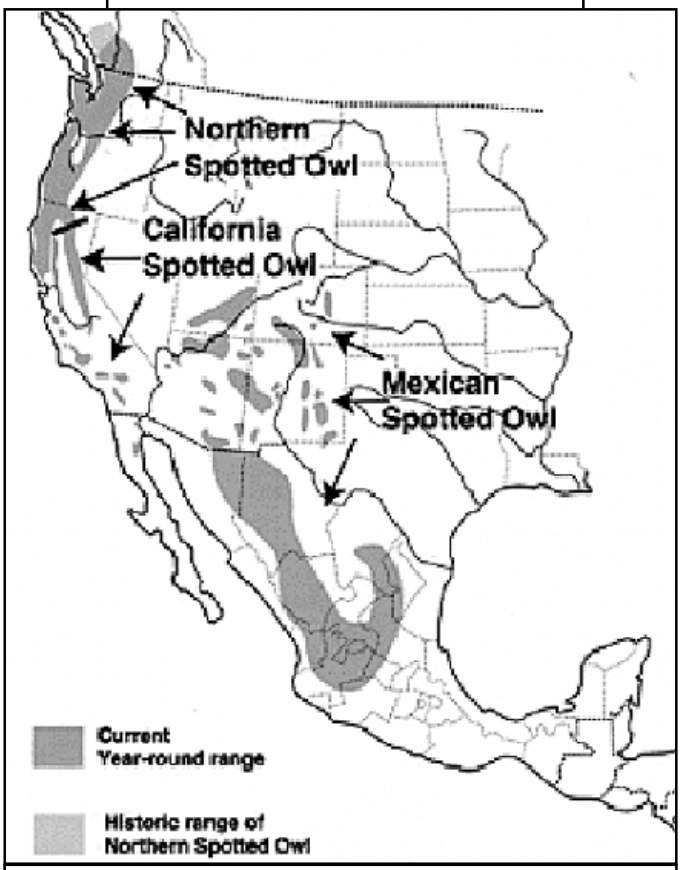
The key thing is that it's cold and wet during the early spring, and we think that's when the birds are on that energetic edge when they're starting to reproduce. They're breeding and they're energetically stressed to begin with, and then you hit them with less food.

ER: Are barred owls moving into spotted owls' territory?

AF: Yes. There's evidence that they displace spotted owls, and there's evidence that they kill spotted owls. When I've seen encounters between barred and spotted owls, usually it's the spotted owl that backs off. And barred owls are coming into our study area. They are down near Lake Tahoe now, they've come in well into California. We've had them in California since we started this study, but never on our study area, and now in the last two years we have breeding barred owls in our study area. So they are getting a foothold; and we have found hybrids on our study area.

ER: Where are they coming in from?

AF: They apparently came across Canada and down through Washington. They were first detected in Washington, and then moved down through Oregon and then into northern California. Some people think that because more forested areas have appeared in the Great Plains that barred owls are using those as a stepping-stone to move across from the East. Some people don't quite buy that idea; it's hard to say whether it's human induced or not. For example, we're seeing a lot more eastern birds on the front range of Colorado, we're seeing an influx of what used to be strictly eastern birds.



Spotted owl populations in the West have declined because the old growth forests they live in have been decimated.

ER: What is good spotted owl habitat in northern California?

AF: If you can think of a block of old mature forest with these convoluted intrusions of younger trees in it, at least in northern California, that's our understanding of what good quality habitat is, habitat that promotes high reproduction and high survival. We're on the cusp of understanding that.

ER: Are the spotted owls doing better or worse since going on the endangered species list?

AF: We're finding that the trends in northern spotted owl populations are variable: they are declining more rapidly in some areas than others. In the meta-analysis we did in 1993, we found a declining rate of adult female survival over the range of the owl, and that wasn't good news.

ER: In northern California?

AF: No, that was over the entire range. That was looking at all the studies across Washington, Oregon, and California. That was not good news because that indicated that the rate of decline of the population was accelerating. But in 1998 that trend in adult female survival started climbing back up. We're still finding individual populations that are declining, but we have concerns about whether we're estimating the trends correctly or not. We have some serious concerns about how we estimate those trends, and we've been working to better develop those. The reason for that is there's a bias in juvenile survival, which is one of the components used to estimate rates of population trend.

ER: What is the current population trend?

AF: It's a fairly small decline, it's around 5 percent a year, but there's a lot of uncertainty around that estimate. We feel fairly comfortable that it's a small decline and it's something we want to be careful about. We don't want to make a mistake and say it's not declining when in fact it is.

Spotted owl populations are declining about 5 percent per year, but there is a lot of uncertainty about that estimate.

ER: What is the total number of spotted owls?

AF: That's usually one of the first questions people ask, and that's a difficult question to answer because the number continually changes as people find new sites and some sites are abandoned by the owls. It's not like you can just go out and census them.

There are published estimates of 10,000 to 15,000 birds, but I always take that number with a big grain of salt.

In the big picture I think the number is less important than the trends. Northern spotted owls are pretty much confined to the Pacific Northwest. The emphasis has been not on trying to count how many owls are out there, but what direction the population is going in.

ER: How effective has been the Clinton forest plan for the spotted owl?

AF: My gut feeling, from my work on my own area, is that it was successful in that it gave the owls some breathing room. It slowed things down, and I think that was valuable. I think it's been underutilized though, because people have backed off on public lands from doing much of anything, and I'm not convinced that that's the right tack.

One of the problems is that these publicly owned forests have been under fire suppression for the last eighty years, so they're not the same forests they were eighty years ago. In our study area fire used to be a fairly strong disturbance with low to medium-intensity burns every fifteen to twenty-five years.

Anecdotally, we've seen that owls can hang in there when fairly substantial fires go through an area, but usually these have been a low to medium burns where the overstory was

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left intact, the understory was pretty much slicked off, and the mid-story was mildly impacted. We found that the owls not only survived but they also reproduced fairly well after this kind of fire. So the owls can coexist with fire, and we know that the landscape used to burn on fairly regular intervals.

But what do you do? You can't just light a match and walk away because the fires are going to be much more severe now because of the build-up of undergrowth.

ER: The Yellowstone and Los Alamos fires showed us that.

AF: Right. And so the quandary now is that there has to be some management in these areas, and I'm not sure what. Other people have pretty strong opinions on what to do. How these management efforts are going to affect the owl we don't know, but some other people are going to do some experiments to see how thinning affects birds.

ER: Is fire suppression putting more conifers into the woods or are they just denser?

AF: The woods are getting denser. In the seventeen years I have worked on this particular area, seedlings that were once three feet high are now twenty-five feet high. And the fires that have hit our territories have pretty much just removed the understory.

ER: You said that there were lessons not learned when they were planning to save spotted owls in Arizona and New Mexico. What are those lessons?

AF: First of all, to adjust our management to the science of the times. We're always working with the best available science, so we're always learning from one year to the next. People want definitive answers, and that isn't always possible in science because many times we either support what we found before or we start refuting what we found before.

In the cases you asked about I don't think the Forest Service changed their management to deal with the problem effectively. They went back to some of those older management schemes: Well, we'll just plop a circle down on the ground around an owl territory and call it good. They didn't satisfy the Fish and Wildlife Service that they were going to manage effectively for Mexican spotted owls, so it got listed. That's what happened with the northern spotted owl too. The management agencies didn't respond well to the science of the times or communicate effectively with the Fish and Wildlife Service, so they got listed.

I think the Sierra Nevada was different. They established a science team, they looked at several different scenarios, and they were conservative in the management plan that they chose. They were more conservative protecting not just spotted owls but protecting systems and ecosystems and watersheds. They were more conservative in saying, If we learn something different, then we can adjust our management, but for right now we're going to try to protect what we can. So I think they are on the right track in the Sierra. I think that's the way it ought to be done in a lot of cases, because it is public land, it's owned by the people of the United States.

Our understanding had been that the more old growth the better, and we're finding out that may not be the case in our area (northern California).

ER: The judge in Seattle who presided over the spotted owl litigation was scathing in his criticism of the Forest Service.

AF: He passed down some good decisions on the spotted owl that I thought were honest, but I believe that some form of logging and maintenance of spotted owl populations is doable.

I also am fairly conservative in terms of doing what's best for wildlife species because I always have these nagging doubts in the back of my mind. I always think of the passenger pigeon and the Carolina parakeet. These were abundant species that went out with a bang. It's always in the back of my mind that if we make a mistake we can lose a species quickly.

ER: The northern spotted owl was on that path I think.

AF: I think so too. Although you see interesting cases like the private lands in California, at least in the redwoods, where these forests have been harvested fairly heavily and they have fairly substantial spotted owl populations on their lands. But these are very productive lands, they are in a more benign climate, and also, redwood grows quickly. A sixty year-old redwood is the size of a mature Douglas fir, and many of these early seral stages produce an abundance of prey that the owl uses.

This is the kind of information you need to understand to manage both owls and logging. We need to understand what is affecting the owls, and if it's a positive or a negative effect. Whether the owl populations are declining or not is interesting, but we can't deal with the future unless we understand the mechanisms behind the declines.

ER: At least in the Pacific Northwest the northern spotted owl was a proxy for old growth. We were trying to save what's left of the old growth forests and used the spotted owl because it needs old growth forests. Was that a good idea?

AF: I never liked the fact that the spotted owl was used as a political football, but I think in the long run it was good for spotted owl populations. At least in northern California we're finding out that, yes, spotted owls are old growth dependent, but they aren't strictly old growth dependent, they may depend on other seral stages in their environment to maintain healthy populations. It's not just an owl equals old growth issue, it's owl equals old growth plus some other things as well. So old growth is still important to the owl, but in a less simplistic context.

There are good reasons to be concerned about mature and old growth forests, the spotted owl is one of them, but that's missing the big picture. I think people like Jerry Franklin and Chris Maser have outlined why old growth forests are important and worthy of saving in themselves[3].

We are learning that on dynamic landscapes in our area it probably wasn't solid mature and old growth forests, there were other seral stages, there were clear areas in there because fires occurred, because landslides and windthrows occurred.

Carl Skinner has done some work in northern California, where he saw that there were a lot more natural openings in forests prior to fire suppression than there are now and that these openings have slowly closed up after fire suppression.

ER: That caused a stir when that insight was published.

AF: Yes. It's not as simple as we'd like to think. Just setting aside old growth without reintroducing the dynamic processes will be a mistake.

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Biosolids: Making Use of Human and Industrial Wastes

Introduction:

King County in western Washington is home to Seattle, Bellevue and numerous smaller towns, and the 1.4 million citizens of King County generate 300 tons of treated sewer waste every day. Until the 1960s we dumped raw sewage into Lake Washington and Puget Sound. Today King County/Metro is committed to 100 percent capture and reuse of our sewage wastes. Federal law prohibits ocean dumping of treated sewage waste, landfilling is expensive, incineration is even more expensive and generates air pollution to boot, so Metro composts 10 percent of its biosolids and sells the rest as fertilizer.

Aside from culturally ingrained fear of human wastes, there are real considerations of disease and the potential concentration of industrial pollution in treated biosolids. The Cornell Waste Management Group has raised these and other technical concerns with the biosolids industry and government regulators. We spoke with Chuck Henry about King County's waste treatment system.

ER: Professor Henry, what is your training?

CH: I have a bachelor's degree in Civil Engineering, a master's degree in Environmental Engineering, and my Ph.D. is in Soils and Waste Management. I have been a professor since

1990; I'm presently a Research Associate Professor at the University of Washington, Seattle.

ER: What are biosolids?

CH: Biosolids are the residuals from wastewater treatment that takes the solids out of the wastewater stream. Our urban wastewater stream has contributors from industrial, commercial, and residential sources.

ER: Does storm water go into that system?

CH: Ideally none does, but in the past when we first put sewer systems together they were usually combined systems. The West Point treatment plant here in Seattle has a significant amount of storm-related inflows but the Renton plant, which is a newer system, does not.

ER: What proportion of our wastewater stream is industrial?

CH: People tend to think that their own waste is relatively clean and industries are high polluters. When you have a combined system that puts both of those waste streams together, it raises peoples' perception of high contamination. Back in the early days of waste treatment, before the 1980s, we simply combined the wastewater flows and treated it all. Since then we have realized that metals are not what we want in our biosolids and our wastewater stream, so we have worked hard to eliminate those sources.

A big effort has been put into industrial pretreatment of the waste stream. That means that an industry is only allowed to have a certain concentration of a particular contaminant, lead or chromium for example, in their wastewater stream. They have to treat it before it goes into the system.

That may sound like we're trusting them, but the people who regulate the industry at the county level, if they see any increase in metals coming into the wastewater treatment plant, they can trace it upstream through the system, identify the source, and that contributor will get fined. This has proved to be an effective check against industries that dump, and it's decreased the industrial contribution to the wastewater stream tremendously.

Interestingly, industry is not the biggest source of heavy metal contamination. Back in the early eighties, the biggest contribution was our water system itself because the water was slightly acidic and the acidic water leached metals out of pipes and put them in our drinking water system. That was one of the biggest contributions of metals, and when Seattle limed its water system, the metals levels in our wastewater went down dramatically.

A variety of actions decreased the metals levels; industrial pretreatment had a significant impact, but it was of the same order of magnitude as some other corrective measures taken at that time.

The main areas where biosolids are applied are wheat fields and hop fields and rangeland in eastern Washington. Basically that is done by flinging the material evenly over the surface of the land so that it's incorporated into the soil.

ER: How much biosolids does Seattle generate?

CH: About 300 tons of wet material leaves King County wastewater treatment plants every day; that's 20 percent solids. King County has a fairly multifaceted program; its goal is 100 percent utilization. The majority of our biosolids goes to agricultural uses east of the mountains, wheat fields and hop fields; a portion goes to forestry within the Mountains-to-Sound Greenway.

ER: Do the users pay for this fertilizer?

CH: The users pay for the fertilizer value, but biosolids management is a net cost to the agency. There is a fairly high cost for treatment, there's a cost for transportation, and then there's a cost for application. In general the agency will pay the cost, but then the farmers or the forest managers (Weyerhaeuser or the state Department of Natural Resources) will pay the agency for the fertilizer value, around two dollars a wet ton.

ER: Can you outline the process of making biosolids?

CH: Primary treatment is basically sedimentation. The wastewater comes into a quiet pool called the clarifier, and the solids that are heavier than water will settle out; that takes about 50 percent of the solids out. The suspended and dissolved solids won't settle out quickly, so there's a reactor in which microbes use the waste as an energy source, and then that flows into a second quiet pool, a secondary

clarifier, where those microbes settle out, and that becomes raw biosolids as well. Those two biosolids streams are combined and go to a digester.

A digester is basically a big biological cooking pot that's kept at 37 degrees Celsius, a temperature that maximizes microbial activity. *[37 degrees C is 98.6 degrees Fahrenheit Ed.]* The microbes in there digest more of the organic material. *[Organic material is anything that was once alive. Ed.]*

It takes fifteen to thirty days for the materials to decompose in the digester, depending on the treatment plant. There is about a 50 percent reduction of organics in the digester because as the organic matter is digested in an anaerobic process, gases like methane and carbon dioxide are given off. *[Anaerobic means without oxygen. Ed.]*

ER: So half of it is broken down?

CH: Yes. This digester creates energy from treatment of the biosolids and some of that energy goes to heat facilities at the treatment plant, like the digester, and some of it is sold and converted into electricity. The waste gas is not vented to the atmosphere, it's used.

At the digester stage the waste is still fairly liquid, and the treated biosolids are put through a process that squeezes some of the water out. At the West Point treatment plant that's done through a centrifuge where the water is spun out. In Renton it goes through a filter press where the biosolids are funneled onto a belt where the water goes through the filter and the solids stay on top. At that point, it's about 20 percent solids and it's ready for use.

After the water is pulled out, the biosolids are loaded into trucks, which carry about 30 tons each. If it's being used in the forest, then it goes to forest land either with Weyerhaeuser in their Snoqualmie tree farm; or with the state Department of Natural Resources lands, also in the Mountains-to-Sound Greenway; or even to the University's experimental forest.

We have management restrictions for biosolids that say, If you put biosolids in a site, don't let the public access the site for a year; if you grow a crop on it, don't grow a crop where it touches the soil for over a year; that gives additional time for the continued die-off of pathogens.

It's applied by a special vehicle that basically throws it into the forest, applied at a rate such that the trees can assimilate the nitrogen.

ER: What are the agricultural uses?

CH: The main areas where biosolids are applied are wheat fields and hop fields and rangeland in eastern Washington. Basically, that's done by flinging the material evenly over the surface of the land so that it's incorporated into the soil.

ER: What about the odor?

CH: One of my Ph.D. students did a thesis on odor evaluation and control of odor for biosolids. The initial smell after application is the somewhat medicinal smell of ammonia, and then later on you get some of the sulfur compounds coming out. Methylbisulfide is probably one of the main ones, and it is in concentrations that the nose can perceive, but it's not at concentrations that are a health concern.

So odors do occur, and there's ways that we can decrease them. The work my Ph.D. student did was to combine the biosolids with wood ash, which is quite effective, it's like activated charcoal. There are other mechanisms that potentially can be used to reduce odors as well.

ER: How long does it take for biosolids to quit smelling when you apply them to the woods or a farm?

CH: Well, there's the initial ammonia odor, and that's the intense one, and then there's a residual odor that depends on climatic conditions primarily. If you apply it and it dries quickly, then the odors are eliminated; if you apply it and it freezes, odors are eliminated. If the biosolids go through cycles of heat and rain, then the odors rise and fall. A sequence of rain and heat provides ideal conditions for maintaining anaerobic conditions and you have prolonged odor.

A good way to reduce the evolution of odor is to immediately incorporate it into the soil, because the odor compounds are then absorbed into the soil complex. There are some places where you can apply it and not worry about the odor, because it's in a couple hundred thousand acres of woods or even wheat fields. But it behooves a wheat farmer to incorporate it into his soil as soon as he can so as not to lose the nutrients and not to lose the water.

So there are some benefits that are conducive to biosolids management that make sense from both directions; those are common-sense management techniques.

ER: Biosolids can be a tough sell.

CH: Yes. Our society is fecal phobic, and for some good reasons, because back in the not too distant past this was one way diseases were transmitted: if people drank contaminated water, they got sick. And when the Clean Water Act was passed, the EPA marketed the concept that waste was toxic, and so our society grew up thinking that if it was waste then it was dangerous. This is one of the problems we have with recycling: the perception that every waste is dangerous, regardless of what you do with it.

As scientists we know that there are many things that can be used if they are managed properly, and that can give a net benefit to the environment. If we mismanage almost anything, then it could potentially have health or environmental consequences. If you mismanage a car, you could kill people pretty quickly. If you mismanage nitrogen fertilizer that comes out of a bag, you can kill all your plants in your yard, and if your kid ate the fertilizer, he'd die. People don't have a negative perception about these products, but we have been taught anything associated with fecal wastes is dangerous.

ER: What about the disease potential?

CH: Disease is a real possibility. If you were to eat biosolids then you will have stomach disorders. Through the wastewater treatment process, as wastewater comes into the wastewater treatment plant and biosolids go out, at least 99 percent of the disease-causing organisms are killed. What the regulators have found is that with proper management techniques we can manage biosolids so it will be safe for humans, primarily because human pathogens are adapted to living inside the human body. *[Pathogens are disease-causing organisms: bacteria, viruses, parasites, etc. Ed.]*

ER: The gut, primarily.

CH: Right. Your gut is at body temperature, it's anaerobic, it's got special conditions; and germs, pathogens, are specific to those conditions and they do not survive well out the environment. Some can persist, but in general they don't survive well outside their host's body. So we have management restrictions for biosolids that say, If you put biosolids in a site, don't let the public access the site for a year; if you grow a crop on it, you don't grow a crop where it physically touches the soil for well over a year, and that gives additional time for the continued die-off of pathogens.

If you apply biosolids east of the mountains and you have sun and heat and drying conditions, pathogens in the biosolids will die out in a couple days.

ER: Which pathogens are of most concern?

CH: What diseases are there in Seattle? If anyone in Seattle uses a toilet, that goes into the wastewater treatment system. Many microbes die off in the treatment process and there aren't many left as it becomes biosolids, but some persist. The microbes we use as indicators of contamination are things like fecal coliform bacteria, salmonella bacteria, and some viruses; those are monitored on a regular basis.

Tacoma on the other hand has a digester that raises the temperature to over 50 degrees Celsius, *[122 degrees Fahrenheit]* a temperature that will kill pathogens. This produces a Class A material and eliminates the disease potential with someone contacting the biosolids.

ER: That's more like composting.

CH: Same concept, yes. You can also put lime into the biosolids and raise the pH, and the combined temperature, drying, and high pH will kill pathogens. The active management of pathogens is either you kill them with your biosolids treatment or you use the environment to kill them. If you rely on the environment to kill them, then you make sure you have the management practices in place that remove humans from access to that site.

ER: How are biosolids different from composting?

CH: Composting is in general an aerobic treatment process, and it gets to much higher temperatures. *[Aerobic*

The active management of pathogens is you either kill them with your biosolids treatment or you use the environment to kill them. If you rely on the environment to kill them, then you make sure you have management practices in place that remove humans from access to that site.

means oxygen is present. Ed.] The reason we compost is because when things decompose without oxygen they have unpleasant odors.

One of the things we like to do is change the physical characteristics of the material to make it more user friendly; when we compost we can do that. Composting does a variety of things: it changes the physical and chemical characteristics, it reduces odors, and because of the higher temperatures, composting kills pathogens.

The way that the biosolids are composted from King County is that sawdust is added. Sawdust is added for two reasons. One is that it is a carbon source, which helps assimilate some of the nitrogen and it also absorbs some of the water from the biosolids. At 80 percent water, it goes anaerobic. Sawdust sucks up some water and it adds porosity, meaning that the air can get through to a certain extent and then it can decompose with the microbes that decompose using oxygen.

King County has an effective composting process that they've used for a number of years. The method of composting that King County does is a hybrid: it's done in large piles, so there is an aerobic shell that may be three feet deep, and then you have a core that's still without oxygen, but then it gets turned a few times, and so eventually it all goes through an aerobic process. Then before a pile of composted waste is ready to go to market, analyses are done to make sure that it's free of pathogens.

ER: What proportion of the waste stream gets composted?

CH: It's in the neighborhood of 10 percent. It's called Growco. Have you ever been to the Flower and Garden show in downtown Seattle? Many of the beds in the garden show are planted with Growco. The majority of this Growco is used in landscaping. It's a good material.

ER: Is there any science-based criticism of biosolids?

CH: The Waste Management Group at Cornell University has a variety of concerns about biosolids. In general their concern is that some of the risk assessments that have been done for heavy metals may not be as protective as we think they are. One way of expressing this is the time bomb theory. A lot of the research or a lot of what people have thought in the past was that biosolids have organic matter, organic matter complexes metals, and therefore the metals are not available for plants to take up. The Cornell group points out that organics do decompose and when that happens then metals will be free to enter groundwater, contaminate plants and enter the food chain.

Our society is fecal phobic, and for some good reasons, because in the not too distant past this was one way diseases were transmitted.

That's a simplification, but that's basically where there are differing opinions. Much of the scientific work on biosolids has found that the majority of the metals aren't necessarily organically bound. There are other mechanisms in biosolids that are much stronger binding mechanisms, and when the organics do decompose, then the metals can be transformed into more stable forms that are less bioavailable. This is just one example; I don't want to get into the details.

In addition, the Cornell group doesn't think some of the assumptions used in the EPA's risk assessment model are valid; for instance, the assumptions about how much people eat or what the background soil conditions would potentially be.

The biosolids industry is really bugged by this Cornell work, but my view of the Cornell position is that this is great. When our society stops asking questions, then we're in trouble. I appreciate scientists who differ from me in their interpretation of results because they ask questions to make sure that we are where we say we are. If we closed our minds to different opinions, then we're back in the dark ages.

There are recognized scientists who are working with the Cornell group, and as scientists their ideas should be listened to and respected. And this is an incentive for us to continue to understand what we're talking about. So I would say that what they have done is a service to the biosolids industry.

ER: The mainstream press has ignored biosolids for pretty obvious reasons.

CH: Well, this relates to the fecal phobia: that we're polluting the world with our wastes. You have to differentiate between the science and the taboo.

ER: Why did we quit ocean dumping of biosolids? Was that not wanting to eutrify the ocean?

CH: Well we don't really know what happens in the deep ocean trenches where this material ended up. I think one of the biggest reasons is that we don't know exactly what's happening in the ocean because it's not as easy to monitor as it is on land, but people saw unpleasant things wash up on their beaches, and this is not good.

Dumping into the ocean to my way of thinking is a waste of a valuable resource. One could argue biosolids provide nutrients that can be used by the phytoplankton. Maybe ocean dumping of treated waste wasn't such a bad method as far as the potential environmental consequences, but I don't support it because I like the idea of reuse under good management practices. It's like incineration of biosolids. Why would you want to do that?

Incineration is one of my pet peeves. Most people I think will admit there are beneficial qualities to biosolids. Here you are with a valuable resource, but you spend money and use even more resources to burn it. Then when you're done burning it, you still have residuals that you have to landfill because only about 70 percent of it will burn.

ER: Plus the air pollution from the burning.

CH: Yes, plus the air pollution. But it is done because it's out of sight out of mind. Land filling is probably the next largest land management strategy for biosolids. Land filling again is one of those things where you are burying a resource; the concept is disposal rather than reuse.

Editor's note: The Cornell Waste Management Website is at www.cfe.cornell.edu/wmi

How Much of the Colorado River Delta Remains?

Introduction:

The Colorado River is the fifth largest river in the United States, draining parts of seven states in the Southwest as well as parts of northern Mexico. There are thirteen major dams in the river system and more than 90 percent of the river's water is diverted for agriculture and drinking water. Disputes over water are a permanent feature of public life in the Southwest with some cases reaching the U.S. Supreme Court. However, the natural systems that depended on the river's water have not received as much attention. In 1922 Aldo Leopold camped and canoed through the river's delta and called it "a milk and honey wilderness" but in one generation that delta ecosystem was gone. Until recently we didn't even know how big the original delta ecosystem was or how much life it supported. In a recent paper Karl Flessa and his colleagues used fossil clamshells from the old river estuary to find out how productive the Colorado Delta system was during its heyday[1] . For the last thousand years the river's delta ebbed and flowed with natural changes in the climate and landscape, but in the last seventy years it has been reduced in area by 95 percent and it's productivity declined proportionately. We spoke with Michal Kowalewski, one of the authors, about this clever and important contribution.

ER: Professor Kowalewski, what is your training?

MK: I'm Polish, but most of my academic career happened here in the U.S. I received my master's degree in Geology at the University of Warsaw in Poland, and then I moved to the University of Arizona in Tucson, where I received my Ph.D. in Geosciences.

I am a faculty member at the Virginia Polytechnic Institute in the Department of Geological Sciences. My job title is geobiologist, which is a new name for paleontologist, which recognizes that we integrate geological and biological sciences in our research. Much of my research falls quite nicely under the umbrella of geobiology, like this research in the Colorado River delta.

ER: What's going on in the delta now?

MK: There is a lot of agriculture north of the delta in the Mexicali area. The area around the river mouth is barren and the tidal flats of the lower delta are mostly uninhabited. Farther south there is San Felipe, a relatively small tourist town.

The lower Colorado delta is an extensive macrotidal flat located south of the river mouth along the eastern coast of Baja, California. Except for a few small fishing settlements nothing much happens there. From the west the tidal flats are flanked by piedmont plain covered by sparse desert vegetation. The tidal flat includes supratidal flats (above high water level) that includes salt pans, and intertidal flats (between high and low tide) where remnant populations of shellfish can be found. We work primarily on the intertidal flats of the lower delta.

ER: The Colorado River is pretty much dewatered by the time it gets to the sea. Where does the water go?

MK: The Colorado River has multiple users in both Mexico and the U.S. The dams which control the Colorado River store the water in reservoirs; part of the water goes into agriculture, part goes into municipal systems, and part comes across to Mexico where its used mostly by agriculture.

ER: The delta is greatly reduced in size. How does your work relate to that?

MK: Everyone knew that the marine part of the ecosystem has been badly altered, that many organisms either went extinct or are on the verge of extinction, but this was qualitative and anecdotal information. Our fieldwork has provided some hard numbers and rigorous estimates for what the biological productivity had been in the delta before we messed up the system. Now we know what it was like in the past, we can look at the abundance of organisms now, and we can say with some degree of certainty how much it has changed.

It's been known for quite some time that the marine life and associated riparian habitats in the delta have been badly affected by the withdrawal of water, and there are several ecosystems that are affected. Not only the delta, but neighboring terrestrial habitats, riparian habitats with their own vegetation and with a unique shorebird populations are affected.

Also, the marine life near the delta is affected by changes in water and nutrient input. It's intuitively obvious that if you shut down the river, the consequences will be grave but until recently we never had hard numbers that would allow us to ask, What was the density of shellfish in the intertidal environment 100 or 200 years ago?

ER: What was the delta like before we dewatered it?

MK: We had descriptions of the delta by early explorers and from early 20th century, so we know that the ecosystem was richer then. We have records from shrimp and fish yields, but it doesn't go beyond the late 19th or early 20th century. Many of the more rigorous scientific records are only from the second half of the 20th century when the alterations to the Colorado River had already happened, so we don't have a baseline for the times before human alterations to the river.

The geological and paleontological data we collected in the Colorado delta can supplement what conservation biologists and ecologists do, it can provide a temporal dimension or depth to complement their research.

In this case we looked at shellfish. Shellfish were abundant in the Colorado delta in the past and were an important food source for fish, for crustaceans, and for shorebirds for which the Colorado delta was and still is a major wintering ground. All those organisms benefit from the presence of shellfish, so we used shellfish as an indicator or proxy for the overall health of the ecosystem.

ER: How many shellfish were there on the delta?

MK: We estimated the standing population density of shellfish in the delta for the last 1,000 years to be at least fifty specimens per square meter of intertidal flats, whereas today the number is three, twenty times less than our conservative estimates of what it was during the last 1,000 years, prior to the damming of the Colorado River. A twenty-fold drop in productivity occurred in this part of the ecosystem since the 1930s.

Just recently I heard from some Mexican paleontologists working in the delta. They found fossil horizons with mollusks and other shellfish preserved in live position; those shells were 400 to 500 years old, and the mollusk density was over 100 specimens per square meter. We were pleased to see an independent confirmation of our work so soon.

ER: Why was the live position important? How is that different from what you did?

MK: We looked at shells that had been eroded away from tidal flats and deposited in long beach ridges situated along the shoreline. These deposits are a sample or collection of shellfish that inhabited the intertidal flats in the past, but they don't tell you anything about densities. They are not preserved

where they lived but are all piled together in ridges. We dated those specimens to the last 1,000 years, we made some conservative assumptions about the area they must have covered, the turnover of populations, and we came up with an estimate of at least fifty specimens per square meter. This would be the minimum number of animals required to produce that deposit during the given time interval.

This was a completely different approach than finding a horizon where a piece of sea floor was preserved and you could count specimens preserved in their life position. Those types of preservation events are uncommon, and it was fortunate that our colleagues from Mexico found a horizon like that.

ER: Has there been any improvement in the delta?

MK: Water releases to the Colorado delta have been conducted intermittently in the last twenty years as restoration efforts. From 1981 on, various organizations have tried to get the water management agencies to release as much water as possible. So whenever there is enough water, let's say from rainfalls or snowmelt in the Rocky Mountains, they would release as much water as possible to the river and subsequently to the delta, and there are some signs that riparian habitats around the delta are improving, and claims are being made that ecosystems are improving. But we measured the mollusk density at the mouth of the river in 1999 and 2000, and it's still only three specimens per square meter. This is still at least twenty times less than what it was as late as the 19th century.

This work speaks to my job as a geobiologist. Restoration efforts can be evaluated in terms of our estimates of what the ecosystem used to be like. Are restoration and remediation efforts effective? Has the ecosystem recovered to pre-settlement levels?

What was once a productive delta ecosystem is now a barren tide flat with thousands of acres of clam shells.

ER: Can you estimate the former size of the delta?

MK: Yes. I think we have evidence for a much larger delta in the past. The main shellfish in the geological record in those beach regions is a brackish clam, *Mulinia coloradoensis*. This clam doesn't do well in full marine salinity, it requires inputs of fresh water, so whenever you have an active large delta, the populations of brackish species will spread over larger areas. Today *Mulinia* is restricted to remnant populations around the present mouth of the river, which is relatively small. The contact between the sea and the river these days is about twenty square kilometers.

But if you examine the shells accumulated in those old beaches, you find *Mulinia coloradoensis* up to 60 kilometers away from the river, so you can map the extent of freshwater input by looking at *Mulinia*. The farther you go from the delta, the less is the abundance of that particular clam. Historically, brackish clams were present many kilometers away from the mouth of the river, whereas today they are restricted to the mouth of the river. This suggests that the area influenced by the river was huge: hundreds of square kilometers.

ER: What else can the shells tell us?

MK: Mollusk shells are an attractive tool for studying river flow because you can extract oxygen isotope ratios from those shells, and oxygen isotope ratios are sensitive to salinity level. If you have a lot of fresh water coming into the delta, the mollusks, when they secrete their shells, will reflect that isotope signature. That has to do with the fact that the river brings a lot of water that has a light oxygen isotope signature.

ER: That's because of distillation in the atmosphere?

MK: Yes, exactly. During the evaporation process, when clouds form there's isotope fractionation: heavier