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Introducing Chinese Beetles to Control Tamarisk

Introduction:

Salt cedar, also called tamarisk, is a woody plant native to the eastern Mediterranean where it thrives in a hot, dry climate and on salty water. Salt cedar was introduced into the American Southwest in the 19th century to control soil erosion, and it now covers more than 500,000 acres in seventeen western states. It is considered a pest because it crowds out native plants such as cottonwood trees. Along stream banks in the arid Southwest the cottonwood/willow association historically provided habitat for a rich variety of animals, including the willow fly catcher, which was put on the endangered species list in 1995.

The US Fish and Wildlife Service is now attempting to control salt cedar and protect and recover willow fly catcher populations. The Catch 22 is, now that the willow fly catcher has lost most of its cottonwood willow habitat, the birds use salt cedar for nesting. There are one hundred-fifty pairs of willow fly catchers remaining in Arizona, and 90 percent of them nest in salt cedar. So removing salt cedar without replacing them with appropriate plants would leave the flycatchers without a home. FWS scientists are now conducting experiments with Chinese leaf-eating beetles to see if they might be safe to release into the wild. If they decide they are, they plan to let them loose in the hope that they will slow the advance of salt cedar in the Southwest.

Simply removing salt cedar does not mean that the native plant associations will come back. Livestock grazing and water management have changed the hydrology in much of the Southwest to such an extent that even if all the salt cedar somehow disappeared, native plants would face drier, saltier, more heavily grazed land than it was one hundred years ago. We spoke with Professor Robert Ohmart about the plan to introduce exotic beetles to control salt cedar.

ER: Professor Ohmart, what is your job?

RO: I've been a professor of biology at Arizona State University for thirty years. When I started working on the lower Colorado River in 1972, one of the most dominant plant communities was the exotic plant salt cedar, and it's become more dominant as time has gone on.

ER: Where does salt cedar come from?

RO: Salt cedar came from the Mediterranean region, probably near Israel. Someone brought it over here in the 1800s, no one's exactly sure who or when. It was brought in as an ornamental and as a soil stabilizer. Salt cedar is an excellent soil stabilizer. As we have removed the water from the rivers here in the Southwest, stands of salt cedar will move into the river basin itself and begin to trap sediment.

ER: Why are cottonwoods dying back and salt cedar expanding?

RO: We have created, not intentionally, but we have created excellent ecological conditions for the establishment and naturalization of this species

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here in North America. Once a river is impounded, in stream flow below the dam is reduced. This lowers the water table below the dam, which in turn selects against shallow-rooted trees and plants, which here in the Southwest and along the Colorado River, is the cottonwood-willow association.

Also, when we put in a dam the reservoir is for flood control, power generation, and irrigation storage. Here in the Southwest there are high ambient temperatures along the Colorado River, where 120 degrees Fahrenheit is not unusual and relative humidities of 10 to 15 percent are common. So if a dam has a large shallow reservoir, and most of them do, although Lake Mead is more or less in a fjord, the reservoirs are large evaporation sources. Even Lake Mead evaporates almost three quarters of a million acre feet of water a year. That evaporation increases water salinity; and the Colorado River is already a fairly saline river because it flows over old ocean deposits.

So impounding the water increases the salt content of the river by evaporation. Then, when the water is distributed to agricultural areas, the first thing they do along the Colorado River is they put up a berm around the field and flush it with water two or three times to leech the salts out of the soil. That salty water is diverted back into the river. So below the dam we're putting salty water back into a reduced stream flow.

Water management activities tilt the ecological balance in favor of salt cedar, the exotic, and against our native plants. We're increasing salinity in the soils, we're increasing salinity in the water, and we're also lowering the water table. All of these favor the salt cedar and work against the native plants.

ER: Don't the cottonwoods and willows need a flood now and then to regenerate?

RO: The main thing dams have done is they have stopped floods, and you're right, cottonwoods and willows evolved under natural flooding conditions. Their nursery bars are the sands that are deposited after a flood. These sandbars are where the seeds stop, germinate, where the seedlings establish and get their roots into the water table and follow it down as it slowly drops back to what the river level would be.

ER: Is the impetus for trying to control salt cedar that it's crowding out native plants?

RO: No, I think the impetus is that we've got a plant here that's using water, and water managers like to have all the water there is in the stream. Even native species such as cottonwoods and willows were targeted years ago by the Bureau of Reclamation and the Army Corps of Engineers and other water management agencies for removal.

In fact, along the Pecos River in New Mexico there have been 50,000 acres or more that have been kept salt cedar free for water salvage. Cottonwoods, willows, and even salt cedar have their roots in the capillary fringe of the water table, and water managers don't want them there. It seems like to an engineer, that if they get rid of those trees they'd get rid of that wicking of water out of the stream.

ER: It seems like the shade trees provide would make up for the water they use.

RO: Data has been brought forward to that effect. Riparian trees shade the soil, they shade the water, they also

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create a boundary layer, which prevents the wind from sweeping away the evaporated moisture. And incidentally, they are about the only safe place for people with bees to house their animals during the periods when pesticides are in use.

The cottonwood-willow association is the most productive wildlife habitat in North American. There are more breeding species of birds and greater densities of birds in the cottonwood-willow association than any other, and that's not surprising when one looks at insect data for the cottonwood-willow association. Studies done many years ago demonstrate that the most insect rich forest in the world is the *Salicaceae* family of plants, which includes both the cottonwoods and the willows.

Salt cedar (Tamarix sp.)

ER: Do they need year round water?

RO: If you look at the distribution of the cottonwood-willows in the West, you see that they are strictly stream or riparian species; they can only live where there's either a permanent stream or a stream that's intermittent enough to almost assume permanency.

So as we de-water streams, as we impound streams and get into a water management mode, we're essentially trying to wring every drop of water from the stream that we possibly can. Here in the Southwest we have really done a number on most of our large rivers through water management. For example, the Gila has been de-watered, the Rio Grande is de-watered, parts of the Colorado River are essentially de-watered once you get past the international boundary of Mexico and the United States.

ER: How much do you mean by de-watered? Fifty percent?

RO: De-watered 100 percent.

ER: How does salt cedar alter the habitat for itself?

RO: It has salt glands in its leaves so it can draw saline water out of the soil, extrude sodium chloride through its salt glands into the leaves, which will drop back to the ground. That in turn increases the salinity of the soil to the point where cottonwoods and willows couldn't grow there even if they were introduced.

In addition, damming the rivers means the flood cycle has been broken, so there's no leeching of salts out of the soil and on down the river, which would occur if there were a natural flooding regime.

So the salt cedar has not only gained the ecological edge, but is also increasing that ecological edge for itself by the bringing up of water and salts, extruding the salts.

And, of course, it's a deciduous tree, so the leaves all fall off in wintertime. After about fifteen years of litter accumulation, especially here in the Southwest, the area is ripe for fire.

Our native species generally are not very well adapted to fires, especially riparian species. In general cottonwoods die immediately when they get near a fire, and willows will re-sprout maybe two or three times before they finally fade out of the picture. But salt cedar will re-sprout from the root crown, and a few months after a fire, four-to-six-foot new stems are coming out of the root crown. Of course, the above-ground plant material is all killed. But salt cedar is fire adapted, and it is helped by this burning process. Again, if there were a normal flood regime, that leaf litter would be swept away from time to time.

We do have a few salt cedar stands that are on rivers that are not dammed, and when these stands gain a height of twenty-five to thirty feet, they become excellent nesting habitat for black-wing doves and other species including the willow fly catcher.

ER: So once salt cedar is in, it's still going to stay unless somebody digs it out?

RO: Well, that may not be totally true, and I draw upon an example of a court case I was involved in southeastern Utah in an area called Grand Gulch. It's a natural recreation area, and cattle were taken out of there about twenty-four years ago. When I was in Grand Gulch hiking the last time, I noticed that the salt cedar are really in poor condition or dying. Now that livestock have been kept out of the system for twenty-four years, it's beginning to upgrade, it's beginning to build new soils, build new habitat. Natural flooding is leeching salts out of the soil and it's beginning to tip the ecological balance back toward native trees and shrubs. Cottonwoods and willows abound in there, and there's now a stream channel which carries water, it's no longer entrenched to bedrock.

So by removing domestic livestock, we're tipping the ecological balance back toward favoring native species. I'm not about to say that if we got rid of all the dams and stopped some of the more damaging water management practices that we would reverse the trend and eliminate salt cedar. I don't think we will. I think there will be places where salt cedar will always occur, but it wouldn't be nearly as abundant as it is today because of groundwater pumping and water management activities that are stressing riparian areas here in the West.

But if we go back to this initial premise for the introduction of exotic insects, which is that once we control salt cedar the native plants will come back, that's simply a myth. The native trees are not going to come back if the soil is too saline and is no longer suitable, if we don't have any floods any more. People are blowing smoke if they think that's going to occur.

ER: What about the plan to introduce beetles to eat the plants?

The three major stressors on riparian habitats here in Arizona are dams and water management; groundwater pumping; and cattle grazing.

RO: I question the wisdom of bringing in exotic insects to try to control an exotic plant. We've had many instances of plants and animals being either accidentally or purposefully released into the United States. In fact, exotic plants are probably going to be one of the biggest conservation problems we will have in the next fifty years because they're displacing so many native species. And yet we're willing to make this experiment. In experimental cages people will say, salt cedar is all the bugs eat. But once they are released and are out on their own and salt cedar becomes unhealthy, they're going to eat something or they're going starve to death. Maybe they'll starve to death. I don't know. But we can't know until we release them. The proponents of this idea are now claiming that they're only going to reduce the health of the trees, the beetles are not going to actually kill them. But a healthy salt cedar habitat is more productive to wildlife than an unhealthy habitat, simply because of the insect abundance that are found in there.

When I was called and asked what I thought about the introduction of these bugs to help control salt cedar, the first question I asked was, What's going to replace salt cedar? The naive response was, it'll be replaced with native cottonwoods and willows.

ER: I don't suppose there's a quick and dirty way to control salt cedar?

RO: There is a herbicide that is 95 percent or more effective in killing salt cedar. This gives us an ability to control salt cedar in areas where we want to control it, and leave it alone in areas where we're not going to be able to bring back native plants.

ER: Is there a more natural way to tilt the balance back towards native plants?

RO: There are some experiments going on now over on the Bosque del Apache in New Mexico, which is a federal wildlife refuge. They have a relatively unlimited water supply over there, and managers are flooding some

areas where there is salt cedar, leeching the salts out of the ground, eliminating the salt cedar with root plowing and other methods, and actually getting cottonwoods and willows established. But on the Colorado River no water manager is going to give you the water to do these kinds of things. The Bosque del Apache refuge has water rights and they were having some success by flooding during the right months. It's expensive but it's probably well worth it if we can get some more patches of cottonwood-willow association back along our rivers and streams.

ER: The salt cedar provides habitat for birds doesn't it?

RO: Yes. One of the stumbling blocks that the insect control proponents have run into is that we've got endangered species living in salt cedar habitat. In the Southwest and here in Arizona we have willow flycatchers living in mature salt cedar habitat at the mouth of a salt river where it enters Lake Roosevelt. The trees are tall, dense, and mature, and the flycatchers find them suitable for nesting and carrying out their annual reproductive cycle. And so you wind up with a flycatcher that is in dire trouble unless we address the habitat issues.

We have data from the Colorado River that salt cedar stands can support between eighteen and twenty-five bird species, depending on the locality and the stature of the salt cedar.

Unfortunately once salt cedar burns it's reduced back to zero vertical foliage volume, and when it's done that it's virtually back to bare soil and you have to wait another twenty-five years for it to come back to the vertical height that it had and the foliage volumes that it had prior to fire.

So introducing exotic insects has got all kinds of problems. if I were smart enough to predict what the bug would do, or the bugs, and they succeed, I still wouldn't support bringing them in, again, because salt cedar is better habitat for the birds than bare soil.

ER: Seems like they should restore some habitat for the flycatcher before they take out the salt cedar.

RO: They have done that, but unfortunately some of it has burned down. Now, some of our reservoirs have deltas where the river comes in, the water is slowed and you get soil deposition and high water tables. In that situation you get new cottonwoods and willows coming in because it's perfect habitat for them. But once we fill those reservoirs, we drown out those trees and the flycatcher then no longer has a place to live.

And we've got problems with domestic livestock grazing on our streams. Cattle do not allow the regeneration of cottonwood-willow habitats; they change the entire hydrology of the steam.

ER: This information is in an environmental risk project you worked on wasn't it?

RO: Right. I served on the Risk Assessment Technical Committee, which drew up the guidelines on the ecosystem risks in the state of Arizona.

ER: They gave you the task of documenting environmental problems in the landscape, but avoided any effort to fix them.

RO: Our governor at that time had no love for endangered species or environmental issues. But the EPA had some money to give each state for environmental risk assessments, and its a rare politician that will turn money away.

What was more surprising to me was that he selected well-known people who had impeccable integrity and put them on this committee. They

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Cottonwood and willow stands have an open structure and provide habitat for many species.

Salt cedar forms dense thickets and supports fewer species.

came from all walks of life: there were scientists, user groups, academics, and they put us together and let us pound this report out with no one trying to interfere. Then when we finished our project, it was like it was the devil, and all of a sudden we had these user groups pouring in and wanting to postpone the finalization of the document.

ER: What are the main findings of the ACERP report?

RO: The three major stressors we have on riparian habitats here in Arizona are dams and water management; groundwater pumping; and cattle grazing. What are we going to do? Who's going to go out and remove these dams? I'm not advocating it now, but I think eventually we will have to take some of them out. What are we going to do about groundwater pumping? Our legislature has disassociated surface water and groundwater rights, which is about as dumb as one can do, but that's not untypical of many laws in many states.

Then the third stressor is domestic livestock grazing, which is ubiquitous in Arizona. That's probably the only environmental stressor we can change with any certainty, and since much of Arizona is public land, grazing represents a large segment of the state of Arizona. There are law suits going on now on these issues, but our report really brought the cattle growers out and screaming when it came up for draft review.

ER: Reports like this are usually meticulous and authoritative and gather dust after they are published.

RO: They've essentially done that, although it will be rediscovered. It's not forgotten by everyone, but it certainly has been forgotten by the politicians.

ER: There's a before and after picture in the report of a section of the San Pedro River after cattle were excluded from it. It went from barren ground to lush forest in six years.

RO: Right. In 1987 the BLM did some land trades and wound up with both of those old Spanish land grants. And on the first of January 1987 the cattle were all taken off the river. In that picture you're looking at about seven and a half years of cottonwood-willow regeneration. Many people look at that slide and say that's impossible.

ER: Was it replanted?

RO: No. It's natural regeneration. It's just that there are no dams on the San Pedro. It is the last — and you'll laugh at this — major river in Arizona that does not have an impoundment on it. It doesn't look major to most people when you come from any other part of the country, but for us down here it's a major river.

So people look at that picture and say, This is impossible. But on the Colorado River we were getting ten vertical feet of growth on cottonwoods and willows on an annual basis. People don't like to hear me say it, but they're really the weeds of riparian areas. But those trees on the San Pedro

are around fifty feet tall. That's all natural stuff that came in once the cows were gone.

Unfortunately for the San Pedro it's now threatened because of groundwater pumping. We are mining more groundwater than is available for the river, and so the mean-based flow for the last twenty years has declined and continues to do so. So the San Pedro may die from de-watering.

ER: What can be realistically done about cattle grazing?

RO: Well, there's been a number of approaches that have been suggested. One is to fence off the river. And of course, many people are against that. They think there are too many fences on public lands as it is. Also if we fence them off and cattle get in there, then it becomes a trap and keeps them in.

The other option is to exclude domestic livestock grazing from public lands. Of course that is totally untenable to any rancher. With the subsidies they get from the federal government, they break even or maybe make a little money. But it's a lifestyle that's deeply entrenched in the West; people are in love with this way of living.

Today we're seeing people who have made their money elsewhere, like lawyers and doctors who want to buy a ranch and run a few head of cattle. Most of them are drugstore cowboys but they're still getting the subsidies from the government; they're still running cattle on public lands.

Most of the Western senators and political elite are related to or some way or another involved in ranching. Sandra Day O'Connor is one of the chief justices and her brother owns one of the largest ranches in Arizona; Bruce Babbitt's family is one of the largest sheep ranching families, although they are phasing out of it. Influential senators from the West are fighting tooth and nail to preserve this lifestyle and to preserve domestic livestock on public lands.

Probably what is going to break their resistance is endangered species. There's been almost 700 miles of river now in Arizona and New Mexico that are no longer going to be grazed because of the Endangered Species Act.

Literature Cited:

The Arizona Comparative Environmental Risk Project (ACERP) can be found at http://earthvision.asu.edu/acerp

Market-Based Pollution Reduction Schemes

Introduction:

The U.S. tradable permit system for sulphur dioxide emissions is an institutional innovation invented by resource economists, promoted by environmental interests, and implemented by the government as a constructed market to reduce air pollution. Sulfur dioxide, the chief culprit in acid rain, is produced primarily by coal burning electrical power plants. To reduce overall sulphur dioxide emissions, EPA allocates a limited number of allowances to companies. Each allowance's current market value is about $200: and it permits the owner to emit one ton of sulphur dioxide into the air. Utilities that reduce their emissions more than required, may sell their excess allowances to those utilities for whom reductions are expensive. The result is a government mandated reduction in air pollution, with the industry deciding how it will comply.

We spoke with Jay Coggins about pollution trading markets, how they have worked thus far and how they might be applied to global scale air pollution such as green house gases.

ER: Dr. Coggins, what is your training?

JC: I received my Ph.D. in agricultural and applied economics at the University of Minnesota in 1989. Since then I've been on the faculty at Montana State University, the University of Wisconsin at Madison, and now I'm back at Minnesota where I'm an environmental economist in the Department of Applied Economics.

ER: How do pollution permits work?

JC: Imagine a city where there are two electricity generating plants. They both burn coal and so they both emit sulphur dioxide. Suppose that they pollute a total of 250 tons of sulphur dioxide. One plant pollutes more than the other and it also incurs higher

costs to cut back. So perhaps the dirty firm currently pollutes 150 tons out of that 250, and the cleaner firm is just 100. The clean firm can cut back more cheaply than could the dirty firm.

Let's imagine two alternatives for the EPA or a regional air quality agency to achieve an improved level of environmental quality. The city council says emissions of 250 is too much. We want to cut back on emissions by 40 percent to a total of 150 tons.

Consider two alternatives. One is something that seems reasonable and fair. That is just to tell both of these plants that they must cut back by 40 percent. So the plant that was at 150 goes down to 90, the plant that was at 100 goes to 60. That's the first alternative, proportional reduction.

The second alternative is to give the two plants a total of 150 permits and then tell them, You can buy and sell as much as you want of these permits between each other, but at the end of the day you better have as many permits as your emissions.

The punch line is, in this permit trading scheme whichever plant can cut back the cheapest will do most of the cutting back, and it can afford to sell its permits then to the other firm and save costs overall. The firm with the high costs would rather buy these permits than cut back because cutting back is expensive for it. So this wedge between the cost of abatement for the two firms creates an opportunity for gains to trade.

With little numerical examples it's easy to show, with abatement cost curves that have the right shape and so on, that you can save money with permit trading. And the key is that the firms that can cut back cheaply do most of the cutting back, and that saves money overall.

ER: Is there some equity consideration involved in this? Why is this preferable to a command and control approach?

JC: There's a couple questions there. Why is it better? It's better because of the efficiency advantages. Overall, reaching a given target, like 150 tons in our example, or in the Clean Air Act, 8.95 million tons of sulphur dioxide annually in the country, you can reach a given standard more cheaply with permit trading. That's the basic logic of that story I just told.

> We're not talking about letting a market decide that there should be 8.95 million tons of sulphur dioxide. That's a political decision.

The equity consideration is a different matter, and in the end that comes down to the decision about who gets the permit in the beginning. So deciding how to allocate those 150 permits among the two firms has everything to do with the equity effects of permit trading. You could give all 150 permits to one of the firms. Of course, that firm has a huge advantage. Or you could divide them in such a way that after trading the two firms incur about the same amount of overall costs, where costs are two parts now: the cost of actually cutting back pollution using a scrubber or other technology, and the cost of buying and selling permits. In the case of the sulphur dioxide programs there will doubtless be winners and losers depending on the way that you write the formulas for handing out these 8.95 million sulphur dioxide allowances each year.

So the equity concerns are affected by the permit market, but largely that has to do with the administrative decision of how to allocate the permits. We're expressly not talking about letting a market decide that there should be 8.95 million tons of sulphur dioxide. That's a political decision. It's a political decision in my example, and it's really a political decision in the sulphur dioxide permit trading scheme. Given that overall target, economists say, generally, using permits to get to the target will be good.

ER: Where did the idea come from?

JC: Economists came up with the basic insight about thirty years ago. In a 1968 book by Dales he asked the question, Why don't we let people trade the right to pollute? Then in the early 1970s some other economists took up this idea and proved some mathematical theorems showing that trading pollution rights can reduce costs. In economics, mathematical support for a basic insight is pretty important. So most economists were converted to the idea, and environmental economists especially thought trading permits would be effective.

There is quite a bit of literature in the intervening years saying, maybe a permit trading scheme isn't so good if

the affected industry is regulated or if there's a monopoly. So it's not uniformly true that the economics literature on this question says permit trading is effective, but it's certainly the main theme.

But there was a lot of frustration for a long time that this idea, which seemed so promising, was ignored by policy makers. Then in 1990 the right group of people occupied some key policy posts, and President Bush had some other people advising him who thought this was worth a try.

ER: I thought permit trading predated that.

JC: Well, there had been some attempts to make permit trading work, and none of them ever really took off. The sulphur dioxide market is the first one that succeeded, first of all at the national level with lots of traders; and second, in the sense that there have been many trades. Some others were air pollution in Southern California and water pollution in Wisconsin. There have been other examples, but almost no trades had ever occurred. An exception to that is the trading scheme for the phase-down of lead in gasoline in the late 1970s and early 1980s, which involved active trading among refineries. As far as I know lead is the one example from before 1990 that worked well.

ER: Why is this not a free market approach?

JC: When we think of a free market we typically think of a market that arose spontaneously because buyers and sellers both felt a need for each other. So there is a market for sport utility vehicles because Detroit deduced that buyers would like such vehicles, and car buyers figured out that they liked them. That didn't take any government agency anywhere helping direct either the buyers or the sellers. That's a truly free market, or about as close as we can get, given that there are taxes and so on that affect the market.

But pollution is by its nature an externality, and there really isn't a market for externalities. This is why it takes the government passing a law that says, Thou shalt buy and sell permits. Or, to put it a little less strongly, Thou shalt have enough permits, and by the way, we suggest that you trade them with each other.

ER: What do you mean by externality?

JC: In economics by an externality we mean some effect that takes place outside of market transactions. So for example if I'm burning coal and selling electricity to everybody in my service area, I'm also, just by happenstance, sending some sulphur dioxide out into the air. The people who enjoy fishing in the lakes near me might find suddenly there are no fish any more, as the lake goes acidic due to my sulphur dioxide emissions. There's no way for them to hold me accountable, absent some law. That's the sense in which it's an externality, as a part of the transaction in which I produce electricity and sell it to my customers, I'm not required to count the damage that I'm causing with my pollution unless the government tells me to. Externalities are real, but figuring out what to do about them, sensible policy making that deals with them is complicated problem. But the effects are real.

ER: How would you describe industry's resistance to this idea.

JC: In the beginning, let's say 1980, U.S. coal-burning power plants, which were then responsible for about 70 percent of the sulphur dioxide emissions in the country, polluted 19 million tons of sulphur dioxide per year. Under the law at that time some of them had scrubbers so there was some abatement going on. They were incurring a small cost as an industry to reduce sulphur dioxide emissions, but not much, and the cost was borne mostly by new sources. Just by way of comparison, when Mount Pinatubo erupted in the Philippines in 1992, it spit out 20 million tons of sulphur dioxide in a matter of a few days.

The point I'm making is that if you're the owner or the operator of a utility and you're facing a new law that says you must reduce your sulphur dioxide emissions as an industry by more than half, to about 9 million tons per year, it's hard to see that as a gift from society. The new law requires that you incur billions of dollars of cost, hundreds of millions per year, that could have been avoided if the government hadn't told you to cut back by 10 million tons per year.

> The environment is cleaner than it would be if the permit trading schemes hadn't been agreed to.

ER: Did the industry get concessions during the negotiation?

JC: There was a quid pro quo during the negotiations over this sulphur dioxide title of the Clean Air Act amendments in 1990. Environmental groups were pushing for 14 or more million tons of reduction. That would be from 19 million tons annually down to 5. Industry wanted to reduce emissions by about 5 million tons. They were that far apart when negotiations started.

In the end, the quid pro quo was this: industry agreed to a far more stringent cap than they wanted, reduce emissions by more than half, by 10 million tons. That's what the industry gave up. The environmental groups who wanted to see 14 million tons didn't get what they wanted, but they still got a stringent cap on sulphur dioxide emissions. In return, the industry got this permit trading scheme. If it weren't for the permit trading scheme, I don't think there is any way politically we would have such a large reduction in sulphur dioxide emissions.

The environment is cleaner than it would be if the permit trading schemes hadn't been agreed to. So I believe that some of the people who say permit trading is ethically wrong fail to appreciate the fact that the environment is cleaner than it would have been without it.

ER: But EDF was one of the prime movers behind this negotiation.

JC: Well, of course, groups of environmental activists differ widely on many things, among them in how much they appreciate market-based approaches to environmental improvement. Let me read a passage from a recent article in the *Journal of Economic Perspectives* by a Harvard economist named Robert Stavins. He says, "In 1990 the Environmental Defense Fund was able to make powerful arguments for tradable permits on the grounds that the use of a cost-effective instrument would make it politically feasible to achieve greater reductions in sulphur dioxide emissions than would otherwise be possible." He goes on to say, "Market-based instruments are most likely to be politically acceptable if they can achieve environmental improvements that otherwise are not politically or economically feasible."

Market-based instruments are most likely to be politically acceptable if they can achieve environmental improvements that otherwise are not politically or economically feasible.

EDF was making this argument I've just been making: we get more environmental improvements if we're willing to buy into this market-based approach than if we don't.

The EDF attorney, Joseph Goffman, was involved with drafting the sulphur dioxide title in the 1990 Clean Air Act Amendment. There was also an economist who was a senior staff economist on the Council of Economic Advisors, named Robert Hahn, who became a prominent proponent of permit trading.

ER: In the last few years there's also been a movement towards market-based incentives instead of command and control for wildlife and nature conservation.

JC: I think there are many forces we all should be trying to harness as we try to make air and water cleaner and as we try to preserve species and habitat. One of those forces, and I think an effective one in many cases, is the profit motive. It drives an awful lot of important changes that occur in our economy and in our society; it can do great harm and it can do great good.

I think carefully crafted incentive-based environmental regulations that do harness the profit motive in a positive way can get us a long ways towards the environment and the world that we all want. But if we do it poorly we can do great harm.

ER: Are there international considerations with sulphur dioxide?

JC: Well, the permit trading that has taken place so far under the Clean Air Act, Title IV, only concerns sulphur dioxide emissions in the United States. It's more than just the Midwest, it definitely involves southern states and the Northeast in a complicated interregional way. But aside from the effect on Southeast Canada, it has almost no effect internationally. Sulphur dioxide is a fairly localized pollutant, not as much as, say, smog, but a great deal more localized than greenhouse gases.

So it's very plausible to me that if China could put in place a permit trading scheme as they priva-

tize their economy, they could clean up their ever worsening acid rain problem more cheaply than by any command and control scheme that they devise. They haven't done that, but they could.

A different point, but one that I could say is related to equity in some sense, is this interregional point. After all, because the sulphur dioxide market is national, it's entirely possible, likely, one could even say, that there is a coal-burning plant somewhere in New Hampshire that recently switched to low sulphur coal, thereby freeing up some of its sulphur dioxide allowances, which it can sell on the open market at something over $200 each, maybe to a plant that American Electric Power owns in southern Ohio. AEP turns around and burns a little more coal than they would have otherwise if they hadn't bought these permits, and they emit sulphur dioxide that lands in New Hampshire. So there is some danger about hot spots: places, especially in the Northeast, where there will still be deposition of sulphur dioxide that creates environmental harm.

It's important to keep in mind that all of the force of the earlier versions of the Clean Air Act are still in place. The state implementation plans which lay out in a detailed way what states will do if ambient sulphur dioxide levels are still high, are still in place. So federal law under the previous statute gives states the right, and case law appears to be upholding this.

There is still a way to guard against hot spots to some degree, but the law itself (Title IV of the 1990 Clean Air Act) doesn't prevent this New Hampshire-to-Ohio trade in my example, which would not cure the problem in New Hampshire unless we were careful. I don't think it can be denied that the U.S. sulphur dioxide trading program has brought an incredible amount of attention to the idea because there have been so many trades.

According to the most recent calculations that I know of, the annual savings in constant 1995 dollars due to permit trading just in sulphur dioxide, have been around two or three hundred million dollars per year. This law is working. Almost 8 million allowances traded hands in 1997, and 9.5 million in 1998 according to the EPA. The price of permits is lower than expected. Low sulphur coal prices are lower than expected, rail rates to get low sulphur coal from Wyoming and Montana to the central part of the country are lower than expected. I think the idea has been shown to work, and that's why people in European countries are paying attention and trying to figure out how they could do this. I think that's all to the good because I think permit trading can save a lot of money and allow us to get a cleaner environment than we would otherwise have.

ER: You mentioned applying this concept to greenhouse gases. Is this the way we're going to go with greenhouse gases?

JC: The differences between greenhouse gas control internationally and sulphur dioxide control in the United States are so great that one could legitimately question whether carbon dioxide greenhouse gas global trading programs could ever work.

The Clinton administration has done some analysis comparing compliance costs if we do or if we don't have permit trading schemes for carbon, and up to tens or hundreds of billions of dollars are saved annually if we have permit trading to achieve any given level of carbon emissions.

But, one has to think of some of the impediments. First of all, with sulphur dioxide it's easy to look at the important sources and measure emissions from them. One of the reasons this law works is because it has an entire separate section dealing with monitoring of sulphur dioxide emissions. It requires every stack to have a continuous emissions monitor in the stack, and this provision has been very effective.

The same thing would be impossible with carbon. Carbon is coming out of lawnmowers, automobiles; greenhouse gases are coming out of livestock; there are too many sources of greenhouse gases to possibly measure with the same level of accuracy. The second question is, How do you enforce commitments that people make under these permit trades when the traders are likely to be sovereign states, some of whom we don't have any particular reason to trust on this question? Another aspect

> Until we come up with some dramatically improved technologies for producing energy ... I don't think we can reduce carbon emissions to the level that people want without changing our way of life pretty dramatically.

of that question is who would be the traders? Would it be corporations within countries or would it be countries themselves?

I don't know that this means we shouldn't try to develop and implement a permit trading scheme for greenhouse gases, but I think there is certainly an order of magnitude difference in the difficulty that we face making that scheme work compared to the sulphur dioxide scheme. Economists seem to be of two minds on the feasibility question. I'm one of several hundred economists who signed a letter calling for the exploration of market-based schemes to control greenhouse gas emissions globally. In principle I'm for it, but I think consensus is far from clear on just how we would do it and how likely it would be to work.

ER: The permit trading system defused some of the political resistance to sulphur controls. Can that happen with greenhouse gases?

JC: Yes, I think there is some of the same impetus. But I think U.S. industries are still hoping that they'll be able to avoid the strongest measures that are being talked about. At some point during the sulphur dioxide negotiations it became clear to the power industry that they were not going to escape regulation. From that point on their goal was finding a way to keep the monetary damage as low as possible.

I think currently American firms are still hoping that they're going to dodge the greenhouse gas, global warming bullet to the greatest degree possible. And so they may not have decided yet what they're willing to do.

ER: Carbon emissions are probably less elastic in that people are going to want energy no matter the cost. These unanticipated improvements in the marketplace for low sulphur coal, we can't really expect that again with carbon.

JC: That's right, but I think there's some truth in the following statement: levels of most pollutants can be reduced if we pay enough money. That's certainly true with sulphur dioxide. If we're willing to buy enough scrubbers and deal with the solid waste that results from a scrubber, we can reduce sulphur dioxide emissions by quite a bit without changing how much electricity we use. We might pay a little more for electricity, but we don't have to change our way of life. But until we come up with some dramatically improved technologies for producing energy, whether it's wind or solar or geothermal, I don't think we can reduce carbon emissions to the level that people want without changing our way of life pretty dramatically.

All those sport utility vehicles you see out there would probably have to go. There are many things about our transportation sector that would have to change. Mind you, if we pumped three trillion dollars into research and development on carbon-free energy sources, we'd probably come up with that breakthrough more quickly.

ER: Where did three trillion come from?

JC: I just made it up. We spend a minuscule fraction of that on research and development in renewable energy sources. If we put half of our gross domestic product into it, we'd get there sooner. But I don't see the political will to do that either. Three trillion was significant of nothing other than it would be a significant fraction of our gross domestic product.

The annual savings due to permit trading in sulphur dioxide have been around two or three hundred million dollars per year.

Tropical Forestry Initiative: Progress and Setbacks

Introduction:

The first interview in *Environmental Review* (Volume 1 Number 1 1994) was with Carl Leopold about the Tropical Forestry Initiative, an effort to grow native hardwoods in a reforestation project in Costa Rica. In 1994 TFI had made a good start: it had aquired 60 hectares of a played out farm pasture on a steep hillside, it had started up a nursery of native trees for replanting, and had planted the first year's seedlings. Over the intervening years they have worked with local farmers to demonstrate the value of planting native trees, they have increased the size of their demonstration plot to 140 hectares (345 acres). They use American students as interns as well as a small staff to collect basic information on the growth of the trees and recovery of the ecosystem, looking at soils, insects, birds and other animals that use the forest.

Recently TFI's field station burned to the ground, destroying all of the caretaker family's possessions and the equipment and living areas for the interns. Fortunately no one was hurt and the nursery was undamaged. We caught up with Carl in Ithaca, New York and talked about progress and setbacks at TFI's station.

ER: Carl, can you remind us of TFI's mission?

CL: We perceived there was a need for learning how to restore the natural wet forests that belong in Costa Rica. So we started out in 1993 with establishing a nursery for native tree species from the surrounding area. Our intent was that we would grow native trees and then put them out in mixed stands in pastures. The pastures themselves represented an interesting problem because in that part of Costa Rica they are on steep land, and the soils are badly depleted.

ER: Soil erosion is spectacular in the high country of Costa Rica.

Our fastest growing native trees are putting on as much as three meters in height per year. That's equivalent to exotic trees that were brought in just because they're fast growers…

CL: Yes, and soil erosion was particularly evident after the Caesar hurricane two years ago. From the hilltops around our farm you can look down on the neighboring pastures and see pockmarks where the land has slid downhill; not just in a few places, but systemically on the pastures on steep land.

ER: How did your young plantation hold up?

CL: Our planted forests held up very well. We had one slide within our planted area, but considering that we had so much territory already, it's a wonder there weren't more landslides. We feel we've stabilized the land considerably with planting. We were about four years into plantation by the time we had the hurricane.

ER: How big an area are you working now?

CL: We're now up to about 140 hectares. We have been blessed with a supporter who helped us purchase now three more farms.

ER: What about your intern program?

CL: Well, one of the things we would like to accomplish is not only so that the recovery of the natural forests could be achieved, but also as an educational project we were very interested in bringing young people in and getting them acquainted with the problems of tropical forestry and how this technique might be useful in other places.

Nineteen ninety-nine has been the third year of our having interns there. It was the largest class we've ever had, ten people, and two weeks before they were to arrive the house and the building that was to provide shelter for some of the interns burned down. The consequence of the fire was that the North American partners who were able to, all flew off to Costa Rica, cleaned up the mess, disposed of the ruins, and proceeded to rebuild. By the time the interns were due to arrive, we had them essentially completed.

The interns are there right now. Nevertheless, we hadn't any plans at all for having to put the amount of expense into buildings, much less into helping the local family that lived there with restoring their goods and belongings. So the situation is still pretty acute. This fire accident has

been a severe setback, so we really appreciate any contributions that other people might make to help us out.

ER: Is the family still living at the station?

CL: Yes. We have one family that has lived on our property ever since we started. They're very dear friends, innovative local farmers; they've been doing the backbreaking work of growing the trees in the nursery and getting them planted out into the pastures, and then also in maintaining a clearance around each tree. You have to keep the new growth of grasses and weeds away from the trees for about four years before they can really take off. So this problem has rested with the Fallas family.

ER: And they lost their possessions in the fire?

CL: They lost everything, yes. We lost all of our library and our instruments, and so the work that the interns can do has had to be changed substantially to adapt to a much more simple array of tasks. But I have great confidence that the two people that are steering the interns are going to do a good job anyhow.

ER: What are they doing?

CL: The interns are spending the first week in a tour of the various kinds of tropical forests. Costa Rica is blessed with a whole array of different kinds of tropical forests, wet forests and dry forests, montane and high forests, dwarf forests. And so the first week they spend just getting acquainted with this, and then the rest of their time there is spent in a more structured situation, helping with research projects that we have going. Many of them have individual projects surveying either some part of the biota: one of them is surveying the species of ants; another one is studying the herbaceous plants; another one has been following up on my measurements of tree performance, their growth and productivity.

ER: You need this kind of information to know if your reforestation has been successful.

CL: It really represents I think a very interesting opportunity to learn about the restoration and the onset of return of biodiversity. How complex does the forest get to be after how many years?

ER: What do your neighbors think of your project?

CL: We're optimistic that we've making a difference. I think I can say that the local people are impressed with the rapid rate of growth of the native trees that we're putting in. I think we're beginning to receive a little bit of interest on the part of the Costa Rican government, and we're in communication with people in the Organization for Tropical Studies.

So in terms of outreach, I think that we're gaining some visibility, and I hope this can lead to some forward motion in the local people on the land using this technique to bring back some biodiversity instead of growing junk trees.

ER: Was your tree nursery damaged in the fire?

CL: No. The nursery escaped altogether. The nursery is very important to us. We grow 5,000 to 6,000 seedlings a year, and about one-third of those now we're finding the local

A Modest Proposal

The following is excerpted from letters to the editor of *Science* magazine vol 285, 27 August 1999, p 1325

The plant revolution, the genetically transformed crops, and their optimistic scientific background are bringing increasing benefits to companies, farmers, scientists, and maybe the environment. Furthermore, it has been claimed that biotechnologies will contribute to the increase of food availability in developing countries and in reducing poverty, hunger, and diseases. Yet every year in Italy and the rest of Europe, tons of agricultural products and foods are destroyed to keep prices high, and developing countries have never had much benefit from the abundance of food in Western countries. This could be a convincing argument to discuss with the public: We all know how important sentiment is in persuading people that something is good and true.

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people want them and will buy them. We sell them at a less than cost price, and we hope that this is helping to encourage restoration.

ER: How do your native hardwoods compare to the exotics people have been planting?

CL: Our fastest growing native trees are putting on as much as three meters in height per year. That's equivalent to the numbers I've seen published for exotic trees that were brought in just because they're fast growers and produce low quality wood. So instead of growing chips for paper, our native trees are growing as fast as they do but they are producing a much higher quality wood.

The fastest growing native trees are good for lumber, but the intermediate and slower growing trees produce beautiful hardwoods that are good for furniture and fine products, much higher value in the marketplace than wood chips.

For more information about how you can participate in TFI write:

NEXT MONTH

TUBERCULOSIS IN CHILDREN:
Jeffrey Starke

JOBS VERSUS THE ENVIRONMENT?
Eban Goodstein

TREE GROWTH AND GREENHOUSE GASES:
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