FACTS, INFERENCES, AND SHAMELESS SPECULATIONS

J. P. Myers

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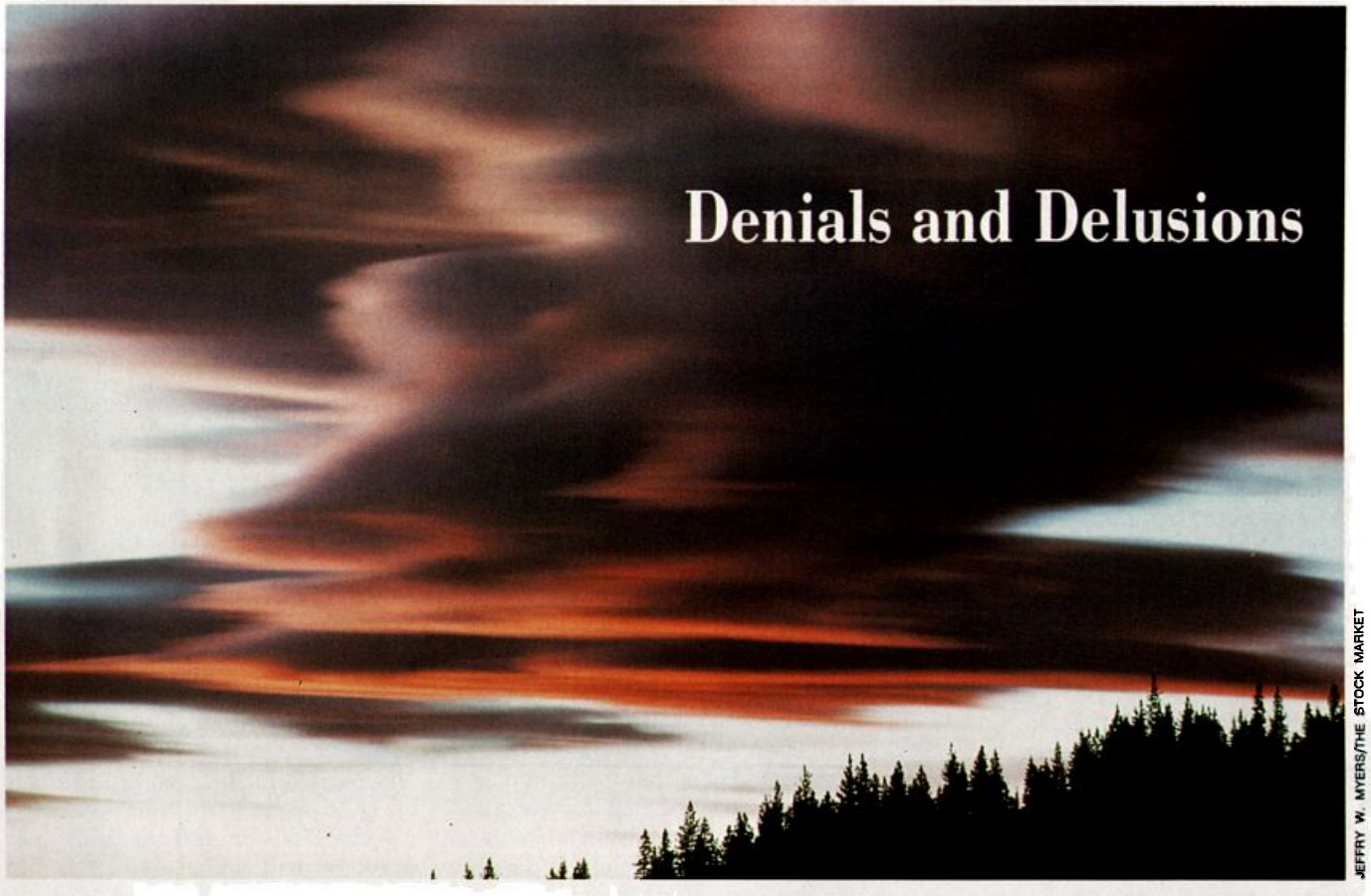

JEFFRY W. MYERS/THE STOCK MARKET

HISTORY, FICTION, AND SCIENCE are full of denials, some heroic, many tragic. "Cigarettes are harmless." "Asbestos is no problem." "That bump, Captain Hazelwood? It must have been a log, or perhaps a large sea otter. Perchance a beer can tossed overboard by a thoughtless tourist in Prince William Sound." Julian Simon on Malthus. Neville Chamberlain. "Guns don't kill people. People kill people." "Migrating continents? Surely, you jest." "I am not a crook." "We don't trade arms for hostages."

The rules of science make denial easy. Something new is not accepted until all other explanations have been

heaped on the trash pile of hypotheses rejected. Skepticism reigns. Reasonable doubt prevails. This is healthy because it protects against falsehoods, false leads, and crackpot ideas, not to mention just plain crackpots. But it also, ironically, can render science and all of its innovations a truly conservative force in public policy, especially so on environmental matters where the complex links of causality can be so wonderfully, excrutiatingly indirect.

Take acid rain (I wish someone would). We have been hearing about the environmental effects of acid raid for more than a decade. It took a while to unravel the causes of acid rain ("Power plants don't make acid rain. Hydrogen ions make rain acid."). Now they are not debated. The next denial to fall was acid rain's impact on streams, lakes, and their biota. A series of elegant experimental studies by David Schindler at the University of Guelph (*Science* 239:149–157) nailed the tail on that particular donkey. But in the process, a decade plus wore on in which the denials effectively blocked significant policy advances. And all the time reasonable doubt kept the stopcocks open into our watersheds, similar debates raged over acid rain and forests.

This has proven far more difficult to resolve. Do the experiment. Enclose a few branches. Expose them to pH levels comparable to what falls out of the sky. By gum (by poplar, by oak and by chestnut), the branches don't wilt. They show nothing comparable to the forest dieback that is sweeping through West Germany and rumbling into the Great Smoky Mountains of North Carolina. Red Spruce in the Northeast has a problem but most other trees are not affected directly. Acid rain has a much more immediate and undeniable impact on gravestones, church gargoyles, and BMWs. Just ask the car dealers in Jacksonville, Florida, whose newly-arrived shipments of German lust-objects were pitted by a passing bout of acid precipitation. If you want to organize a grass-roots campaign against acid rain, the message seemed to be, get mailing lists from Jaguar, Mercedes, and BMW, but leave out the foresters. The utility industry, whose smokestacks belch the key ingredients for acid rain, exploited this uncertainty mercilessly, knowing full well that owners of BMWs needed to run their expresso machines when they weren't experiencing their cars and hence were at the industry's mercy. All the while, the ions fell.

New work by a West German ecologist, Ernst-Detlef Schulze, has disentangled the roots in this particular forest (*Science* 244:776–783). Acid rain does not kill trees, directly. Insects kill trees. Blight kills trees. Drought kills trees. All standard agents of tree death and nothing damning acid rain, until you look at why a particular tree died from insects, blight, or drought.

The causal chain actually starts in the soils: aluminum remains bound within the soil at medium to high pH

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levels. But lower the pH with a liberal dose of acid precipitation and you will see this formidable cation freed into solution where it competes with other cations for portals into the trees' roots. The trees wind up starved for nutrients essential to their growth—magnesium and calcium especially, and their foliage winds up deficient in these and other elements like potassium, iron, and manganese. The result is a massive chemical imbalance in the forest ecosystem.

That in itself, however, doesn't kill the trees. You ought to note in passing, incidentally, that aluminum is also implicated in the etiology of Alzheimer's disease. Implicated—not demonstrably, causally linked. Epidemiologists stop short of that. I know their hesitation will give you comfort as you imbibe from municipal water supplies fed by watersheds within regions affected by acid raid.

So poor nutrition alone doesn't kill trees. Another link is necessary and it comes from the various forms of nitrogen that drizzle down along with hydrogen ions in the polluted rain. These nitrogenous wastes are part and parcel of the processes that generate acid rain. Trees, ironically, interpret them as chemical signals that conditions are good for growing. The problem is that attempted growth in a chemical setting imbalanced by aluminum turns out to stunt the trees even more than the simple absence of proper nutrients. Yet even this does not kill trees.

Weakened by the effort to grow in nutrient-poor conditions, trees become much less resistant to disease and other problems. Finally, they die, killed not by acid rain directly but by traditional agents of tree death: blight, insects, drought. The Death Certificate would not read "acid rain" any more than would the Oiling Certificate of Prince William Sound read "Exxon." Blight and Captain Hazelwood get the blame.

What does this mean for birds? No, baby warblers are not writhing in nests under the painful duress of coal-fired plant water-torture. But even if less direct, the impacts are no less substantial. In the short-term they come from that massive chemical imbalance in the ecosystem I mentioned above. When hit hard by acid rain, aquatic systems clearly have impoverished and altered food chains. Less food means lower reproduction and higher mortality for birds. In forests, the chemical imbalance changes nutritional conditions, not just of trees but of the insects that feed on trees' leaves and the birds that consume the insects. P. J. Drent and J. W. Woldendorp, for example, report egg-shell thinning in great tits in the Netherlands that they attribute (*Nature* 339:431) speculatively to reduced calcium levels in what the tits eat. Acid rain means more aluminum in the soil which means less calcium in the leaves and the caterpillars and the oviducts of egg-laying birds.

In the long-run, if forest death continues, at best the result of acid rain will be good for a few years of woodpecker reproduction. Dead snags will no longer be the limiting factor for hole-nesting birds. The price of cured firewood will fall. Perhaps some inventive souls bent on species transplantation programs will bring Black-backed Woodpeckers to North Carolina, gladdening the hearts of at least a few state listers. But massive forest

dieback (today about a third of West German trees show heavy damage) does not bode well for eastern forest passerines.

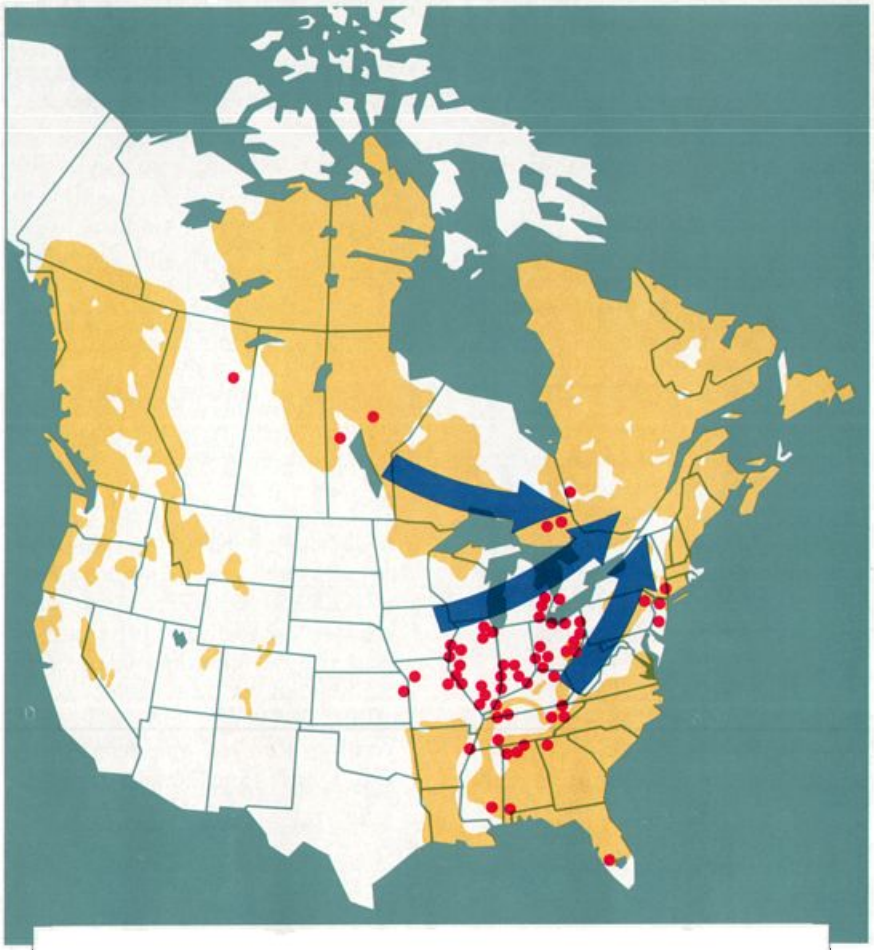
So much for causality and dead forests. What of denial and science? It took considerable time and ingenuity to unravel the causal pathways that link acid rain with forest death. This prolonged the resolution of acid rain policy by making arguments plausible that proof just wasn't there. In fact, it wasn't—with absolute certainty. And thus in the face of uncertain cause, on the one hand, and plausible arguments about economic cost, lost jobs, and other unpleasant political outcomes on the other (not to mention political pressures), policy procrastination was inevitable.

Think about the imbalance: the necessary internal skepticisms of science pitted against the advocacy of predictive politics (I am permitted one oxymoron per column). If the science is uncertain, then hold back. That is the rule. But for matters in the social and political arena, denial is more what you wish on your enemy or employ in self-delusion, than a constraint you place on yourself. The net result is an opportunity for abuse.

Waiting until all the data are in on issues like acid rain, stratospheric ozone depletion, and climate change may place an intolerable burden on our planet.

No, the answer to this is not less rigor in science. Instead it is threefold. First, scientists need a better grounding in "mediarology," as Steve Schneider puts it in his new global warming book, and to become more effective at stating the facts and dealing with scientific uncertainties in the context of public policy debates. We must also work to make the public more comfortable in facing uncertainty. Waiting until all the data are in on issues like acid rain, stratospheric ozone depletion, and climate change may place an intolerable burden on our planet. We might have that luxury were these impacts reversible and without inertia. But they are not. By the time that denial becomes irrefutably deniable, we will be over the edge of the cliff, flailing away with denials of Newton and gravity.

And finally, predictably, there is the issue of research. There must be more of it. Not mindless fillips that regale the backwaters of science with more dotted i's and crossed t's. Not the play that diddles and twiddles with small points, here and there. No, if one of the scientists' messages is that responsible people face big issues by investing in revelations of truth—with more research—then the work has to be just as big as the problems. If science wants to play in this particular corral, then scientists had better be damned sure their six-shooters are loaded.



LOCATION OF MAJOR SOURCES OF SO_2 EMISSIONS IN NORTH AMERICA AND PREVAILING WIND PATTERNS

○ Areas having SO_2 emissions greater than 100,000 tons per year.

□ Areas most sensitive to acid precipitation.

Prevailing wind patterns.

This map clearly illustrates why efforts to control acid rain are concentrated in the east. Most major North American sources of SO_2 emissions are located within this area, which is quite sensitive to acid precipitation. In addition, prevailing winds transport pollution into this general area.

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