

WE MAY NEVER KNOW FOR SURE

Coastal trees are dying and the cause may be acid fog

There are disturbing signs in Isle au Haut's forest and they have implications for much of the Maine coast. Some red spruce stands are showing a yellowing and early loss of needles and a thinning of tree crowns. They are probably dying. The damage is similar to that occurring in the conifer and broad-leaved forests of central and eastern Europe, where air pollutants and acid rain have caused massive tree mortality.

Dr. Richard Jagels of the University of Maine at Orono believes that acid fog might be one factor affecting the island forest, six miles off Stonington. He has measured fog pH levels as low as 2.90, the acid equivalent of table vinegar. The coastal fog, he was surprised to find, was as acidic as cloud water collected at the top of 4,237-foot Sugarloaf Mountain and at high-elevation peaks in New York's Adirondack Mountains and Vermont's Green Mountains, both regions hit hard by acid deposition.

Jagels theorizes that the source of the acid fog may be the dirty gases originating in motor vehicle exhausts or industry smokestacks in Boston and

New York. Swept along on the wind up the Maine coast, the acidic pollutants are picked up by rain or fog and fall back to earth.

Jagels, associate professor of forest biology, stressed that his research is in the early stages. He won't know for several years how quickly the symptoms of decline are progressing or how serious the situation is. He said he may never know definitively if acid fog is the major cause. But already, Acadia National Park officials are concerned. Isle au Haut is the wilderness outpost of the park, and the demise of the island forest, for whatever reason, would affect recreational values, as well as wildlife.

Jagels' findings prompted Acadia officials to look at a few areas of the park on the mainland that also appeared in decline. They found one stand with symptoms similar to those on Isle au Haut and in Europe, Jagels said.

Previously, researchers had documented ozone injury to Acadia's white pine. (Ozone is toxic to vegetation, and its formation in the lower atmo-

sphere is enhanced by nitrogen oxide emissions from vehicle tailpipes and industries.)

Jagels said in an interview that what is happening on Isle au Haut, even in a worse case situation, does not suggest anything about interior Maine's low- or high-elevation forests, that spend much of their time in highly acid cloud water. Air pollution affecting inland mountain forests is more likely blown in from the Midwest than from coastal cities to the south. Island forests must be treated as a separate problem, Jagels said.

No one was more amazed than Jagels at finding the red spruce damage on Isle au Haut. It was not a suspect place. In fact, he picked the island for research because he assumed the forest was healthy and would be a good reference site to compare to a declining high-altitude stand.

Jagels was specifically curious about the importance of fog at the different locales. Fog generally is very acidic at high elevations, averaging around 3.5, whereas "normal" rainwater averages around 5.6 to

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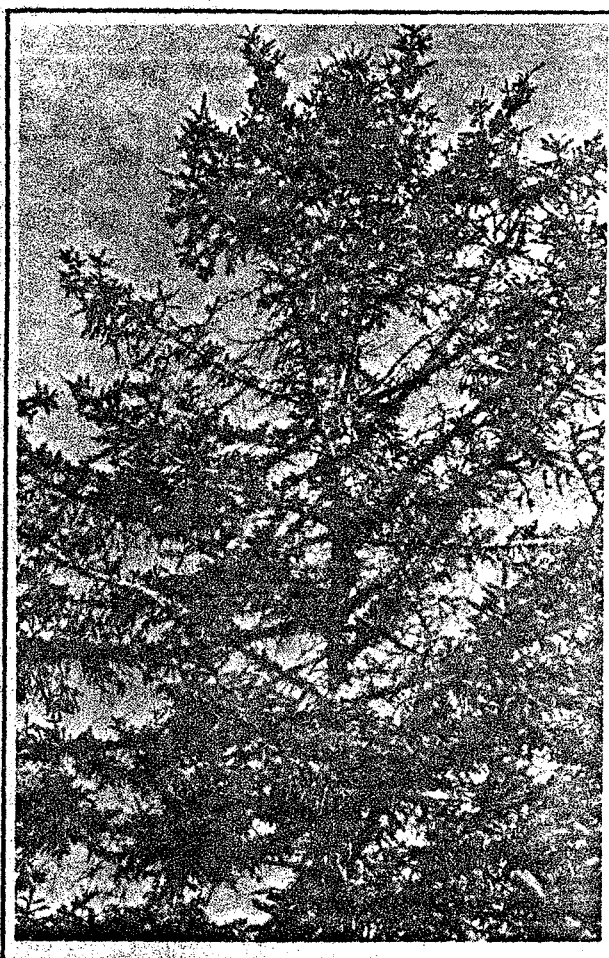
5.7 on the pH scale. (Acidity, as measured on the pH scale of 0 to 7, is greatest at the lowest end of the scale.) Jagels thought that island fogs were mostly generated off the open ocean surface and therefore would be less acidic.

With funding from the university's Land and Water Resources Bureau last year, Jagels became "a six-months' expert" collecting fog and rainwater on Isle au Haut, plus three other Down East coastal sites — Damariscove Island off Boothbay Harbor; Roque Island off Roque Bluff; and Mt. Desert Rock, about 25 miles off the coast from Schoodic Point. Roque Island is also forested. Damariscove and Mt. Desert are essentially barren, and they were chosen as comparisons to see if the presence of a forest had any influence on the level of activity.

Jagels found that fog was more acidic at the southwestern sites of Isle au Haut and Damariscove Island and less acidic at the northeasterly sites farther away from large metropolitan areas. Immediately, he scrapped the idea of using Isle au Haut as a reference site for research on mountain forest decline. Also dropped was testing on the upwind and downwind sides of the forest to see if the trees were trapping particles from the fog as it passed through the canopy.

Since 1985 was a relatively dry year, the number of coastal fogs was limited. But the ones sampled were highly acidic, any number with a pH of 4.6 or lower. The Isle au Haut fogs averaged 3.26 on the pH scale, and one fog dipped down to 2.90. Damariscove Island's fogs averaged 3.83, and the single worst one was 2.98. Roque Island averaged 3.91 and never got below the 3.32 mark. Mt. Desert Rock averaged 4.06 and never got below 3.39. Jagels said that the collector on Sugarloaf Mountain recorded the lowest minimum of all sampling stations, 2.80, but the average pH of the fog there was 3.78.

Jagels said the minimum pHs may be more important than the averages "because if those very acidic fogs happen at a critical time like leaf-out, they can have greater biological impact."



This red spruce shows the early thinning of tree crowns on Isle au Haut. The cause could be acid fog.

Because of the high acid levels, Jagels decided he had made an "erroneous assumption" that fogs affecting islands were generated entirely off the sea surface. He now believes it is more likely they are influenced by weather systems moving along the East Coast and carrying the pollutant "precursors" that cause acid rain and fog.

Isle au Haut, six miles long and three miles wide,

has a forested ridge running down its back, and its highest point is 543-foot Mt. Champlain. Mature spruce dominates, and there is some pine, fir, and hardwoods. As Jagels and his research associate collected fog and rain water, they noticed that some of the spruce looked sick. "The symptoms of yellowing and needle loss became more noticeable in the fall," Jagels said in an interview, "and it looked to me much more like what's happening in central and eastern Europe than what's happening in the high-elevation forests in the eastern U.S."

He explained that the damaged forests of Europe show a thinning of the older foliage and chlorosis, or a yellowing of the needles or leaves. As the condition of the coniferous tree worsens, he said, needles are left only at the tips of the branches and on a small crown. "The tree slowly dies," he said. Ultimately, the woods stand naked, depleted of foliage. Dead branches litter the forest floor, and other trees, weakened from acidic effects, are uprooted by winds and have stunted and deformed root systems. Earthscan, a London-based news service of the United Nations, says more than 16 million acres of forest in nine European countries have been damaged by acid rain. In West Germany alone, more than half the nation's forest have been affected by *Waldsterben*, or "forest death." In total, 11 species in the different counties have been affected: Norway spruce, white fir, Scotch pine, European larch, European beech, silver birch, European ash, European alder, common maple, and two species of oak. Foresters there believe that the combined effects of a number of pollutants, particularly the nitric acids from vehicle exhausts, are working simultaneously or sequentially to induce tree damage. Europe does not yet mandate automobile sulphur dioxide or nitrogen oxide emissions controls, but West Germany is experimenting with lower vehicle speeds and will require cars sold after 1986 to have catalytic converters and use unleaded gasoline.

On Camel's Hump in Vermont and other East Coast mountain areas where there has been a spruce dieback, Jagels said it's the youngest foliage that



At a later stage, the spruce has lost almost all of its crown. It is a symptom characteristic of Central European forests ravaged by acid rain and other pollution.

has been killed first and turns brown. So far, only conifers have been seriously affected — white, loblolly, shortleaf, pitch and slash pines; red spruce; and balsam and Fraser firs. But acid rain, in combination with heavy metal deposition, is the prime suspect in a new sugar maple decline in the Northeast.

Jagels said he hasn't observed the affected Isle au Haut spruce for an entire year yet. But his associate recently reported that the needles continue to be as yellow as they were in the winter, and there is no evidence of regreening. With new research funding, Jagels is proceeding to set up a biomonitoring program to concentrate on certain trees not only to determine the volume of needle loss but the anatomical changes as well. The invisible, internal symptoms of slow growth and declining productivity occur long before the tree shows visible signs of breaking down.

Jagels said one leading theory is that acid fog penetrates the needles through the stomates and weakens the cell membranes, allowing pollutants, such as ozone, to leach out critical nutrients, magnesium, potassium, and calcium. If the trees are on granitic rocks or acidic soils, they don't have soil nutrients that might replace the leached out elements, and there is more rapid decline, he said.

"Most of us feel that we may never actually have a definitive answer in terms of whether air pollution is directly affecting forests — that is a definitive answer that would be satisfactory to the scientist," Jagels said. "It's my guess we will develop more and more correlative data and that at some point we'll be able to say that it's more likely one thing than another." (See sidebar.) Emerging evidence from the forest decline worldwide gives credence to many scientists' belief that the causes are multiple and include acidic pollution, nutrient deficiencies, climatic changes, pests, and diseases.

Jagels favors applying air emissions controls to protect the forests, "but if we jump the gun and apply the wrong control because we want to take action today then we will be much worse off politically for getting the right controls at a later time. We may have enough information already about lake systems to apply controls for sulfur dioxide emissions to save fish populations. But if we're going to talk just about forests, I think it's way too early to say. We're talking about a different kind of mechanism going on in a water system than might be occurring either directly in the tree canopy or in the soils system."

Some 600 lakes and ponds in the Adirondacks and eight high-altitude ponds in Maine are among the eastern water bodies that have been acidified to some degree, triggering fish declines.

Jagels will drop the Mt. Desert Rock fog collections this summer and add a collector at Cape Elizabeth, which has "very high ozone levels," he said. Cape Elizabeth has some spruce stands. He doesn't see any signs of decline there, "but the soils are entirely different. They are deep, well-drained,

and sandy — much better soil than on Isle au Haut." It could take more time for symptoms to be visible, he said.

Meanwhile, Acadia National Park officials are waiting for results from the National Laboratory at Oak Ridge on several hundred trees examined for acid rain impact. Carroll Schell, chief of resource management at Acadia, said 720 trees of six different species were cored to determine if growth is waning because of air pollution. He said, "We're not doing enough about acid deposition here. We

have concentrated heavily on ozone damage. I can show you plenty of ozone-affected trees. They are a dime a dozen. But acid rain, that's a lot more complex."

Schell said he has seen the spruce needle yellowing at Acadia, "but the park is not in a position to articulate what we suspect the exact cause is."

by Phyllis Austin

(Phyllis Austin is an Alicia Patterson Foundation Fellow for 1986.)

Congress is finally acting

Strong Congressional support for acid rain controls appears to have broken the six-year legislative stalemate on emissions reductions. A new coalition of Democrats and Republicans has achieved subcommittee approval of a bill to begin reducing the pollution that causes acid rain, and by June the full Energy and Commerce Committee will start debating the issues.

Although some leading environmental organizations feel encouraged that a breakthrough has been made, they are quick to point out that the legislation is not as protective as they would have liked. The bill would require highly polluting industrial facilities to meet emissions rates already widely achieved at other plants using readily available control equipment.

Specifically, the compromise would create a program for reducing sulfur dioxide and nitrogen oxide emissions from electric utilities that burn fossil fuels.

By 1997 the controls would bring sulfur dioxide pollutants down by nine million tons below the 1980 levels. A more stringent bill introduced by Senator Robert Stafford (R-Vermont) would cut sulfur emissions by another three million tons.

Both Stafford's Senate bill and the House bill would reduce nitrogen oxides, also a precursor of acid rain, and ozone pollution through tighter controls on motor vehicle and industrial sources.

Richard Ayres, chairman of the National Clean Air Coalition, told the House Subcommittee on Health and the Environment that a 12-million-ton reduction in sulfur dioxide emissions is critical because that is the amount necessary for a 50 percent reduction in acid deposition as recommended by the National Academy of Sciences. "Likewise, the 11-year timetable for achieving the full emissions reductions does not reflect the urgency that is called for after years of delay," he said. "If it were shortened by five years, the environment's exposure to sulfur oxides would be reduced by some 50 million tons."

But the subcommittee did not change the tonnage reduction or the timetable, and, in fact, approved an amendment that seriously weakened the "consensus" bill. National Wildlife Federation legislative counsel Janet Hathaway told *Maine Times* that the subcommittee changed the emissions averaging from monthly to yearly. Although that amendment doesn't sound important, she said, the effect was to reduce the sulfur dioxide requirement by one million tons. "That is the very bottom line we are willing to support," Hathaway said.

National Clean Air Coalition spokesman Ayres said, "There is no time to rest. Given the number and quality of congressional, governmental, and scientific analyses of the acid rain problem, Congress already has ample evidence of the problem and the control options."

The new acid rain initiatives follow recent major developments. President Ronald Reagan met with Canada's Prime Minister Brian Mulroney to discuss the endorsement of a five-year, \$5-billion plan to conduct more research — this time a joint effort — into new emissions control technologies. But environmentalists believe that move is a political ploy by the White House to weaken the progress on emissions reductions, since affordable technologies already exist to reduce pollution by 50 percent within the next decade.

And, after two years of study, the National Academy of Sciences established a causal link between sulfur and nitrogen emissions and the subsequent acidification of air, water, and soils. It identifies acid rain as the prime suspect in the

decline of forests. Sierra Club legislative director David Gardiner said, "Previous reports have shown us the smoking gun in the acid rain mystery. This new report gives us the bullets and the fingerprints."

Supporters of acid rain controls not only have the recent Academy report but thousands of other reports with which to try to disarm opponents. More than 3,000 scientific papers have been published in the last 15 years that link the causes of acid rain to manmade air pollution. During that period, the acid level of precipitation has increased up to 30 to 40 times more than normal in the eastern U.S., affecting not just earth resources but buildings and even human health.

Just in the past year, the U.S. Environmental Protection Agency (EPA) reported that more than 4,000 lakes in the eastern and midwestern states are at a crisis stage, with almost no buffering capacity left to cope with acidification. The agency estimated that nearly 1,000 lakes in the East already can't support fish life. However, the EPA's estimates are believed to be low. The survey didn't include lakes smaller than four acres in size, and these thousands of small water bodies are known to be particularly vulnerable to acid damage.

Moreover, the EPA survey used pH levels of 5.0 and 5.5 as the cutoffs to indicate biological damage. But the Canadian Freshwater Institute was reported in *Science* to have found that irreversible damage to a lake's food web occurs at much lower levels of acidity than heretofore believed. For example, at the seemingly high average pH of 5.93, key organisms in the food chain of lake trout failed to reproduce. With a pH of 5.64, thick mats of algae grew over the trout's spawning grounds, and the ecosystem was collapsing at pH 5.59.

A study by scientists from the University of Vermont and the National Aerospace and Scientific Administration reported that damage to Vermont's Green Mountain forests is so severe "it looks like a forest fire." Red spruce have died, nutrient cycling has been disturbed, and root systems have been damaged.

High altitude spruce and fir forests in the southern Appalachians are declining, according to studies by North Carolina State University. Significant increases in symptoms of decline turned up over a single year, and the symptoms are strongly associated with increases in the acidity of precipitation.

Southern yellow pine in the southeastern U.S. has peaked and turned downward after a long upward trend, according to the U.S. Forest Service. And the Canadian Forestry Service reported that significant forest productivity declines may already be underway in the Atlantic and Quebec/Ontario regions of their country.

A report from the Environmental Defense Fund said smelter emissions in the western U.S. are directly related to increases in acid rain over distances beyond 600 miles. The pollution threatens valuable aquatic and timber resources, and recreational areas including national parks, wilderness areas and national forests.

An acid rain control program might pay for itself in reduced damages to building materials alone, said a draft study of the EPA, Brookhaven National Laboratory, and the Army Corps of Engineers. It estimates that damages to U.S. buildings from acid rain run between \$3.5 billion and \$6 billion per year. The report says that acid rain is literally eating away outdoor statues, monuments, historic buildings, concrete, and automobile paint.

(PA)