Chad Oliver

Fire and the Nuclear Forest

By Richard Conniff

In the fall of 2004 in the rotunda of Marsh Hall on the Yale campus, a forester from Alaska gave a talk about the worst fire season in his state's history. Driven by record-breaking temperatures and drought, intense fires had raged across 6.5 million acres of forest, easily triple what Alaska expected even in a bad year. Despite the latest fire-fighting technology, the fires burned too big and too hot to control. At one point, a change of wind direction blanketed the city of Fairbanks in smoke, reducing visibility at times to a quarter-mile. Air quality was rated very unhealthy or hazardous for 10 days straight, forcing people to stay indoors or even evacuate the city. NASA later reported that the smoke plume had worsened air quality as far away as Houston.

In the audience that day at Yale was an associate professor from the National Agricultural University of Ukraine named Sergiy Zibtsev, who was visiting from Kiev as a Fulbright scholar. As the speaker's photos played across the screen, he contemplated the catastrophic scale of the fires and wondered, "What if it happened at Chernobyl?"

A 50-year-old Scotch pine plantation five miles from the Chernobyl nuclear power plant. The stand has been devastated by insects and is now at an extremely high risk for fire.

Zibtsev, a tall, almost ectoplasmically thin 46-year-old, with a slight stoop and thick hair just starting to go gray, knew the forests around the Chernobyl Nuclear Power Plant as well as anyone. Kiev, where he teaches at the Institute of Forestry and Landscape Architecture, is a two-hour drive to the south. Starting in 1993, he'd spent five summers working four hours a day in the so-called exclusion zone, a fenced-off area of almost 650,000 acres around the power plant. The human population there had been hastily evacuated after the April 26, 1986, explosion at nuclear reactor number four. What

remained behind, apart from the empty cities of Chernobyl and Pripyat, were grassland and forest, largely Scotch pine, with some birch, aspen and oak mixed in, now abandoned and unmanaged. Or, as Zibtsev put it, "completely nature without people, just wind and forest."

It was, and remains, in some ways an inviting forest. "Usually in the Ukraine you never meet wildlife, because of the pressure from hunting," said Zibtsev, on a return visit to Yale this past February. He cradled an imaginary rifle in two hands, by way of explanation. But wolves have come in from Russia, he said, and there are now moose, red deer, wild boar, lynx and beavers. Endangered Przewalski horses and European buffalo have been released there.

People leave the animals alone because Chernobyl is, of course, also a deeply scary forest. The accident at the nuclear power plant released roughly 100 times the amount of radioactive material produced by the atomic bomb at Hiroshima. Much of that radioactive material got trapped by the surrounding forest, helping to limit the geographic spread of the disaster. But it remains there still, in the leaves, needles and bark of the trees and in the upper layer of soil, largely in the form of cesium-137 and, to a lesser extent, strontium-90. Plutonium-239 also contaminates the area nearest the plant, including a 3,700-acre stand now known as the Red Forest, because the needles on the Scotch pine died, turned a rusty brown and dropped off soon after the accident. (Much of the original Red Forest was buried on the site. More radiation-resistant aspen and birch grow there now.)

Like any other forest, the exclusion zone is vulnerable to fires set off by lightning strikes or by the handful of farmers who have crept back to their old homes. The worst such fire, in 1992, burned through 12,500 acres of forest crown, but in an area with relatively low radiation. The plume from another fire, in 2003, reached Kiev, which has a population of 2.7 million people. The exclusion zone has a firefighting force equipped to deal with the problem, at least in theory. But as Zibtsev listened to what had happened in Alaska in 2004 and thought about the increasing tendency of extreme weather conditions to occur in unexpected places, he realized that people in the Ukraine had no idea how to prevent or control a catastrophic forest fire. Moreover, the radioactive potential of such a fire could be equal, as an article in the January/February issue of the *Journal of Forestry* put it, "to a series of new explosions."

Zibtsev went home to spread the word. But in his absence, the Ukraine had gone through the most tumultuous period in its post-Soviet history. The attempted assassination of presidential candidate Viktor Yushchenko, by dioxin poisoning, had made headlines worldwide. Then a series of mass protests and acts of civil disobedience, dubbed the Orange Revolution, had forced a closely monitored election runoff. (During one meeting in New Haven to discuss the dramatic events, someone draped an orange scarf around Zibtsev's neck. He treasured it, until it eventually vanished. "You know, for revolutions somebody always have to pay," he remarked, in a characteristically droll e-mail, "and scarf in general is not bad solution, in compare with October 1917.") Finally, Yushchenko took office as president, promising a program of economic and anti-corruption reforms.

Chernobyl was largely out of sight, out of mind. "They don't have time for this," Zibtsev conceded. "After a fire, they'll give us money. But then it may be too late. The important thing is to get the attention. We already have lots of meetings," he said. Then, with a hometown-Cassandra shrug, he added, "They don't believe me." What he needed was an expert, traditionally defined as "an s.o.b. with a briefcase from out of town."

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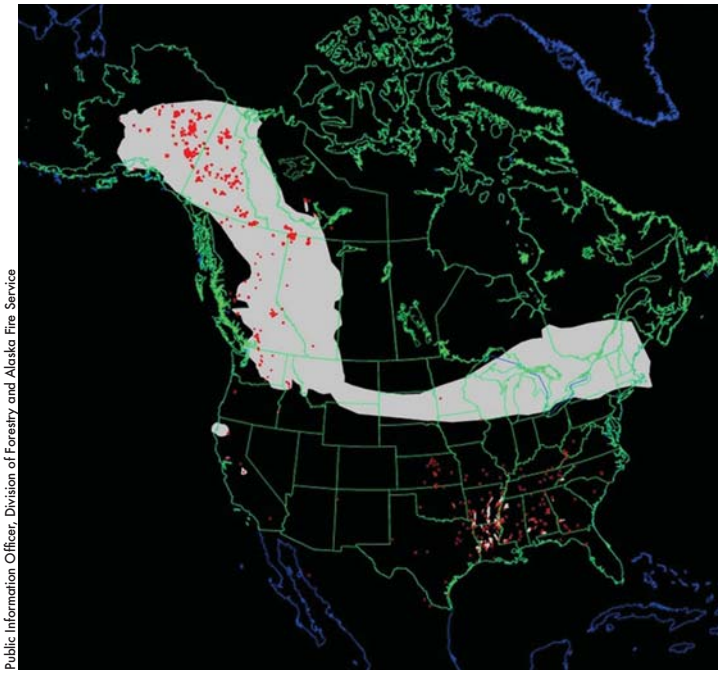
Zibtsev had come to Yale at the invitation of Chad Oliver '70, Ph.D. '75, a mild, thoughtful figure with a soft Tennessee accent, watery blue eyes and a trim salt-and-pepper beard who carries the formidable title of Pinchot Professor of Forestry and Environmental Studies at F&ES. He also carries a briefcase or, at least, a laptop bag. Oliver is an expert on forest dynamics, particularly as influenced by human actions. His father owned a



Public Information Officer, Division of Forestry and Alaska Fire Service

In August 2004, smoke from fires originating in Alaska, the Yukon Territory and the Pacific Northwest made its way to the East Coast. There is concern that radioactive smoke from forest fires in the Chernobyl exclusion zone could have catastrophic consequences for the 2.7 million inhabitants of Kiev.

forest management company in the Southeast, and from high-school age on, "when there was a fire, we all went out and fought it." As a college student, he also worked a summer as a firefighter in the forests of the Northwest. He went on to earn his Ph.D. from F&ES in 1975. Later, he joined the faculty at the University of Washington and served as an advisor to the U.S. Forest Service and other land management agencies around the world. Then, in 2002, he returned to F&ES as part of a concerted effort by the school to broaden its international reach. He now heads Yale's Global Institute of Sustainable Forestry.

At Zibtsev's invitation, Oliver made his first trip to the Ukraine in the summer of 2005, and what he saw in the exclusion zone was disconcertingly familiar. Until 1986, the state forestry agency had managed the forest intensively for timber, typically leaving no more than 12 cubic meters of dead wood, a couple of stems, per acre. Locals also picked over the fuel wood, berries, mushrooms and game. Then the forest had been abandoned for 20 years, with no plans for increased management any time in the future. "So the trees were extremely crowded, which leads to trees dying and the buildup of fuel for fire," Oliver recalled recently. On a laptop, he showed a photograph of a stick forest of skinny, unstable conifers, some of them already broken and tilted. The soil was also sandy, prone to drying out quickly in a drought. "And when it dries out, you have a real mess on your hands."

Igor Kostin/Sygma/Corbis

Much of the radioactive material produced by the Chernobyl accident contaminates a 3,700-acre stand now known as the Red Forest, because the needles on the Scotch pine died, turned a rusty brown and dropped off soon after the accident.

In the early 1980s, Oliver had seen a similar buildup of fuel wood in the American West and helped predict the catastrophic forest fires that later ravaged the forests there. The causes of that buildup were, of course, completely different: A misguided federal policy of suppressing all fires through much of the 20th century had turned the forests into a fuel dump. Even when the danger became alarmingly evident, actually doing something to fix it proved difficult, in part, says Oliver, because environmentalists objected to almost any logging.

When the inevitable conflagration finally came, said Oliver, "the main thing it showed us was that our concern about and our ability to predict catastrophic fires are not like Chicken Little saying the sky is falling. These catastrophic fires really do occur, and once they occur it's too late to try to put them out. You have to be proactive. It just confirmed our worst fears."

But how to convince Ukrainian officials of that? And how to do it with the requisite urgency – and yet not raise the sort of alarm that might jeopardize Kiev's political and economic revival? It is, said Oliver, a delicate challenge: "If there is the possibility for radioactive smoke to float over a city and for the people to breathe it, then the viability of foreign investment in Kiev immediately goes down. And if it really does happen, you're in for a health disaster." (Dmytro Melnychuk, rector of the National Agricultural University, put the problem far more starkly in a letter last year to F&ES Dean Gus Speth: "In the event of a catastrophic fire of over 50,000 hectares in the Chernobyl zone, radioactive smoke will cause millions of dollars in health and economic loss to Kiev and other parts of the Ukraine. Such a fire is currently likely. …")

On the other hand, the tools for managing forests to prevent catastrophic fires are already available. In addition to his expertise, what Oliver brought to the task was a remarkable computer program, the Landscape Management System (LMS), which he began to develop in the late 1980s as a way to think through the competing values in managing a piece of land. At the time, the major conflict in the Pacific Northwest was about logging versus protection of endangered spotted owls. But LMS allows policy makers to look at any stand in any forest and ask "What if …?"

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One day last February, in a fluorescent-lit corner of Greeley Memorial Lab, Zibtsev and a team of LMS mavens put a 7,900-stand sample of Chernobyl forest through its paces. It was the sort of room where lots of people work briefly, then go away, leaving the blackboards and glass partitions covered with diagrams and scratchings that look like a cross between a Cy Twombly painting and a football playbook. They might have represented the dynamics of a forest anywhere from Florida to Alaska. Here and there, a legible term leapt out – "remote sensing" or "Holdridge Life Zones" or, somewhat cryptically, "Michelle 17."

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Dmytro Melnychuk

Jim McCarter, a software development coordinator for the University of Washington, worked at his keyboard, and every now and then, after a whirring of hard drives, he announced the results of an alternative management scheme. Sometimes the analysis came up as a series of graphs representing relative fire risk. In a high-risk scenario, 60 percent of the trees in a stand would be destroyed. The goal was to get to the low-risk scenario, where less than 25 percent of trees would die in a fire. At times, LMS served up a visualization of a tree stand, then showed how a particular management strategy would make it look in five, or 25, years. The visualizations, said McCarter, were a useful tool for helping laypeople and policy makers see forests grow before their eyes – at a rate of 50 years in 20 seconds.

LMS could help to show Chernobyl firefighters the scale of the problem they face as the forest changes. Asked about fire risk now, said Zibtsev, they tend to say, "'No problem. We can control any fire. We have helicopters and trucks. …'"

"It's the confident attitude of the action agency," said Oliver. "To do this kind of thing, you need a can-do attitude." But catastrophic fires have an alarming power to remind people of human limitations, often when it's too late. "The U.S. Forest Service, they don't have that attitude anymore," said Oliver, and McCarter added, "They sort of had that drummed out of them." At Chernobyl, much of the firefighting equipment Oliver saw in 2005 and on a return visit in 2006 was outdated or poorly maintained. The tires on the fire trucks were bald and the 808 miles of forest roads were untended, often with trees growing up in the middle. A USFS team of fire management experts who visited in 2006 found that the use of lookout towers and reconnaissance helicopters was "very effective" in detecting fires. But the city of Kiev would be far better off if firefighters had access to real-time satellite data for spotting fires and monitoring smoke plumes.

Fires in the exclusion zone tend now to stay close to the ground, where the hazard is relatively contained. There's usually not enough underbrush or other ladder fuels to carry the flames to the treetops. But that's changing as the forest matures and as insects and disease flourish in crowded stands of Scotch pine. On his laptop, Zibtsev produced an aerial photo of a forest stand pockmarked with purple blemishes. "These are forest patches with root rot from fungus," he said. As dead trees begin to fall there and saplings grow up in the new openings, it creates a fuel ladder. "When ground fire hits, it could leap up into the crowns."

With LMS, it becomes practical to keep track of these pockets, along with a daunting assortment of other variables, and to manage them to minimize the risk. It might make sense, for instance, to cut down a stand and create a firebreak. Likewise, the software can point out when all stands in a cluster will reach their fire peak at the same time, enabling foresters to create a break ahead of time and make a crown fire drop down to the ground. "You want to break it up, you want to change fire behavior," said Ann Camp '90, a senior lecturer and research scientist in stand dynamics and forest health at F&ES who has worked on forest fires in the dry landscapes of the American West. "It will still be burning, but you have a chance to fight it. When it's in the crown, you can't do much of anything, unless you have airplanes."

"You need to have a constant dynamic, a mosaic of structures," said Oliver. "As one stand changes and grows to a new structure, you create another stand that has the old structure. The secret is to put the forests in a condition so that fires don't get started or don't have enough fuel to develop in a catastrophic manner."

At Chernobyl, the variables include all of the ordinary considerations in managing a conventional forest. Experience in the Ukraine suggests, for instance, that fire risk decreases dramatically when hardwoods like birch and aspen make up more than 30 percent of the trees in a stand. As in any forest, thinning out weaker trees would also make for healthier stands, enabling the remaining trees to become thicker and more stable.

But as Oliver, Zibtsev and the others chatted around the computer, the conversation veered into unorthodox territory, like the tendency of plutonium to vaporize at a temperature of 400 degrees Celsius and cesium at 700 degrees Celsius. "That's not an extreme data point," said Camp. "In a landscape-scale fire, 400 degrees is a normal temperature." The radioactive decay rate of these substances also figured largely in the conversation. Cesium-137 has a half-life of just 30 years, meaning that fire management needs to focus mainly on what happens in this century. But with plutonium, which takes 24,000 years to lose half its radioactivity, the challenge will be to minimize fire risk effectively forever.

Why not just cut down the forest, prevent all fires and be done with it? During the five summers Zibtsev worked in the Chernobyl forest, his job was to

collect soil samples and tree parts to track the circulation of cesium, as the radioactivity cycled back and forth between the trees and the soil. "The idea of management there is to not allow the forest to die," he said, "because when it dies, the cesium migrates into the ground water," contaminating the drinking supply. Like other workers in the exclusion zone, Zibtsev wore special clothing, including radioactivity tags. Afterward, doctors pronounced him clean and in good health. But he added, "Who knows? That's the problem with radiation. No threshold. Radiation can impact at low doses or high doses. Nobody can predict." The one thing everyone accepts is that they don't want people drinking water contaminated with radiation.

Another complication is that the wood is basically worthless, meaning that there is no self-sustaining source of income for cutting trees to create firebreaks or for thinning. Some of the less-contaminated tree trunks can serve as props in underground mines. But most may have to be stacked at the site and left to rot. In dry weather, it might be necessary to hose down the stacks periodically as a fire precaution.

"It would be nice to have a shredder," Ann Camp suggested.

"But you don't want to breathe the dust," said Chad Oliver. Material that's harmless on the skin can be deadly in the lungs.

At that point, after a flurry of activity from the LMS software, McCarter turned around and offered yet another risk-reduction strategy on his computer screen: "Every stand is thinned to 250 trees per acre, and for stands where that still doesn't decrease the fire risk, you convert to hardwood. Just flip it off, and let birch regrow." On the screen, the graphs showed three-quarters of the forest at high risk at the start, with as many as 800 trees per acre in neglected stands, and three-quarters at low risk at the end.

Would it work on the ground? To get to that point, LMS will eventually need data on all 40,000 tree stands around Chernobyl. Because there is currently no information on dead and down trees, foresters will also need to visit sample areas throughout the forest and run transects, recording every twig on a series of 50- or 100-meter lines. After that, according to Oliver, it will become relatively easy to investigate different management strategies, with LMS showing how much a given strategy will reduce fire risk and at what cost and then directing people exactly where to go to take action on the ground.

The real objective for now, said Zibtsev, is simply to "open up the situation" so people have a way to think about – and visualize – the possibilities. "We have a lot of information, a lot of scientific monitoring. But we have no tools to do analytic work [using] this information. That is why LMS is useful. It's not just an impression, but scientific calculation. My task is to use the simulation to attract the attention of donors, the international community and people responsible for fire issues and radioactive safety." The next step will be a conference in Kiev this summer among stakeholders and experts to persuade people, said Zibtsev, "that a continuous investment in reducing the hazard would be much better than the alternative." George Chopivsky, Yale College Class of 1969, has agreed to fund the conference.

Forest management in the exclusion zone currently costs about $2.2 million annually. No one knows yet how much more it will take to update the basic fire management plan and to undertake the sort of detailed projection of forest structure and health that's really needed, incorporating questions like biodiversity and radionuclide emissions. Tony Brunello, a member of of the U.S. Forest Service team that visited the site last year, estimated that establishing a satellite receiving station, which would also provide flood warning and other services for the entire country, might cost up to $1 million. In any case, Brunello suggested, the cost is small relative to what's at stake.

"Everybody is looking at the sarcophagus of the power plant at Chernobyl. And hardly anybody is thinking about the forests," said Brunello. Construction has begun on a "New Safe Confinement" to replace the deteriorating 300,000-ton concrete-and-steel tomb placed over reactor number four in the immediate aftermath of the accident. That project, including surrounding infrastructure, will cost upwards of $900 million. But forest management, now largely forgotten, is the "low-hanging fruit" in the effort to prevent further disasters. A little money there, said Brunello, "would go much further than all the millions we are now pouring into Chernobyl. Nobody's paying attention, and somebody needs to pay attention to this." ■