Missoula Technology and Development Center

Shaping Solutions for the Forest Service

During severe fire seasons, Missoulians have been able to watch fire retardant drops near town. The Missoula Technology and Development Center sets and maintains the standards for all retardants used for wildland firefighting (Scott Peryam photo).

For the past half century, the Forest Service's Technology and Development program has provided practical solutions to problems identified by USDA Forest Service employees and cooperators. The solutions help the Forest Service do its work more efficiently and more safely.

Two centers, one in Missoula, MT, and the other in San Dimas, CA, provide solutions. Each year, they work on 80 to 150 projects. Most projects are completed within 18 months to 3 years.

The current projects at Missoula include:

- Evaluating improved versions of the emergency fire shelter
- Testing fire retardants
- Developing a water pump that can be used by people with disabilities
- Developing a Web-based catalog of trail bridge designs

Such variety requires many different talents. The skills of the center's 50 employees include engineering, forestry, machine tool operation, metal fabrication, drafting, computer systems management, contract administration, publication design, helicopter rappelling, smokejumping, explosives, recreation management, sociology, global positioning systems, equipment design, textile design, contracting, editing, photography, finance, Web design, safety, statistics, chemical analysis, reforestation, and video production.

Although the centers are funded specifically to solve problems for the Forest Service, the solutions have been widely adopted by other agencies and by private groups in the United States and abroad.

Inside

Photos Within the Fire
p. 2

History
p. 3, 4

Success Stories
p. 5, 6, 7, 8

Stopping Pepper Spray
p. 9

Patenting Successes
p. 10

Saving Money
p. 11

How to Find Us
p. 12

Camera Cooler's Job is No Picnic

There's no better way to learn about fire than to see inside. But photographers and cameras can't handle the heat.

Photographer Jim Kautz figured a way around that problem when he developed a camera box that allows a video camera to survive the heat of a wildland fire. Boxes based on his design have been used in the United States, Canada, and Australia.

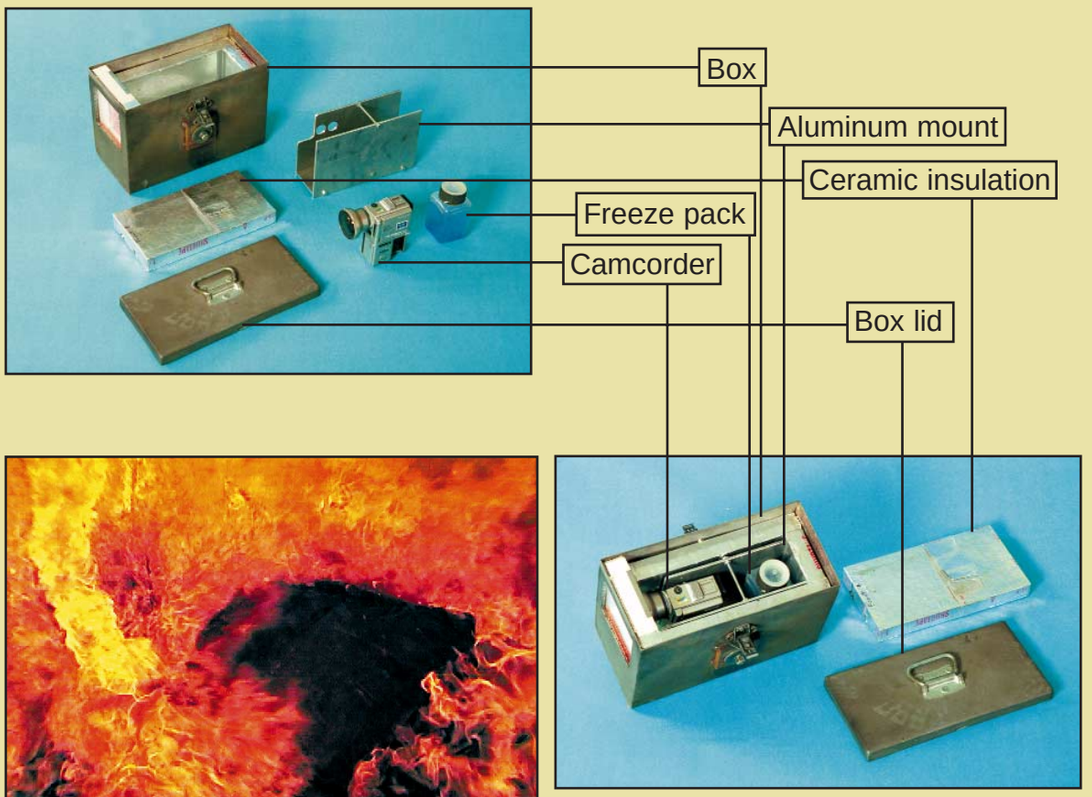
Essentially, the camera box is a metal picnic cooler with a special glass window. The window has two layers of glass: an outer layer that can withstand temperatures of up to 2,500 degrees and an inner layer that allows visible light to pass, while reflecting heat.

An assistant retrieves an insulated camera box after the experimental fire.

Ceramic insulation protects the camera from the heat of the fire. An ice pack protects the camera from the heat it generates as it runs.

The cameras have allowed researchers to measure exactly how long it takes the flame front of a fire to pass in different fuel types. Without video footage, that time is difficult to determine.

Specially insulated camera boxes allowed video cameras to record conditions within this experimental fire in the Northwest Territories.



These photos show the conditions fire shelters could be exposed to if they were deployed in timber. Shelters just 12 feet outside the timber survived the experimental fire.

Born of Fire: Forest Service Technology and Development

During the late 1940s, Forest Service employees at the Aerial Fire Depot in Missoula, MT, began working on ways to use aircraft more effectively for fighting fires in remote areas.

When regular aircraft patrols detected a forest fire, smokejumpers and cargo were dropped to the fire. The success of these techniques led to the establishment of the Missoula Aerial Equipment Development Center in 1953.

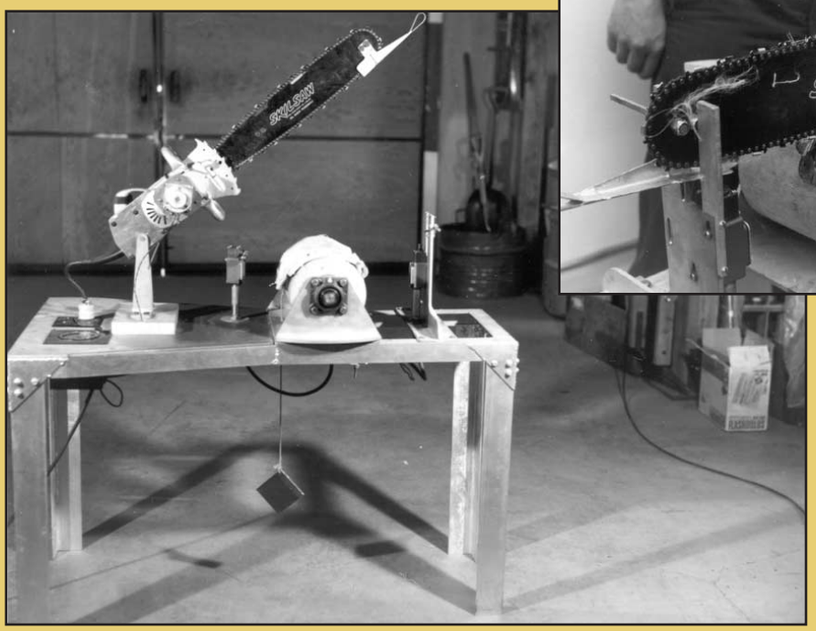
Center employees worked in a variety of locations in Missoula before offices were moved to Fort Missoula during the 1960s. Meanwhile, fire equipment was also being developed by a center in California. The centers soon were solving other nationally important natural resource problems for the Forest Service. In 1987 the names of both centers were changed from "Equipment Development Centers" to "Technology and Development Centers" in recognition of their expanded role.

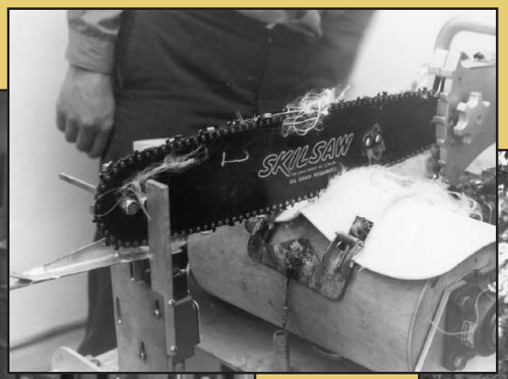
Both centers were scheduled for new facilities during the 1960s. The Forest Service purchased land near the Missoula airport for the new facility in Missoula.

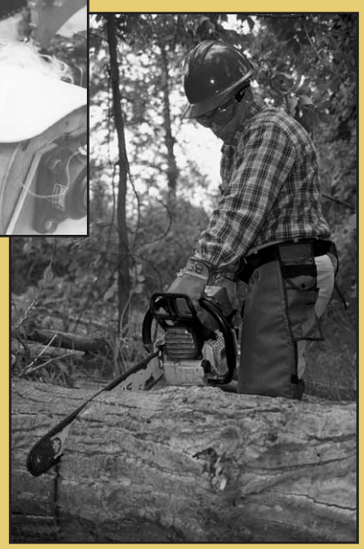
The San Dimas, CA, center moved into its new facility in 1965, but the Missoula facility was not funded. Plans for a new facility were redrafted several times during the past three decades, but funding for construction wasn't available until 2000.

Beginning in March 2002, the Missoula center began moving from seven buildings around Missoula to its new facility near the airport. The facility includes offices, a chemistry laboratory for analyzing fire retardants, a photo studio, a video editing studio, a textile fabrication shop, an electronics shop, a machine shop, and a large meeting room for training. The center enters the 21st century with all its employees under a single roof, better able to solve problems for the Forest Service.

Gyroscopes kept this prototype cargo carrier upright, even when someone tried to pull it over. The goal was to find a way to transport ore from backcountry mines on trails rather than roads. The electronic controllers available during the 1960s did not respond quickly enough when the carrier hit large rocks. Once the carrier was part of the way over, the gyroscope threw it to the ground. The project was abandoned. With modern electronics, these carriers would be more likely to succeed.







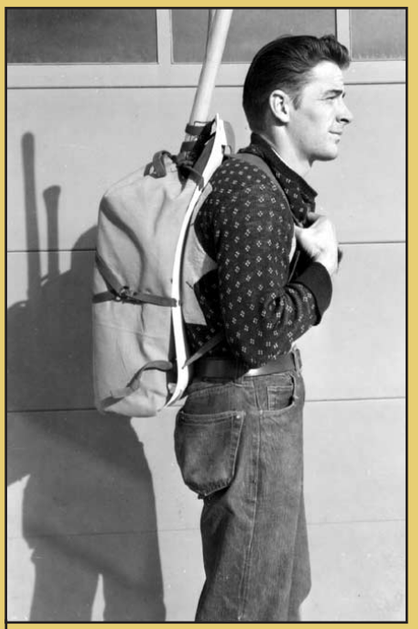
Kevlar fabric in chain saw chaps protects users from injuries. The chaps were developed during the 1960s. Testing devices make sure that the chaps continue to work even as chain saws are improved.

The Early Days

Herb Harris, the first director of the Missoula Technology and Development Center, in the bed of a Dodge Power Wagon modified for firefighting.

This modified chain saw is one of many tools the center has evaluated for building fireline. Although the tools were fast, they threw rocks and posed other safety hazards.

The top photo shows testing during the 1950s that eventually led to development of the fire shelter carried by firefighters today. All but one of these designs have a fatal flaw: the firefighter is standing up. The photo below shows a firefighter lying down inside a fire shelter. Assuming that an area has been cleared of fuel, temperatures at the surface of the ground will be much lower than temperatures even a foot above the ground when a fire passes over. The fire shelter has saved the lives of several hundred firefighters since it was developed in the 1960s. The center is evaluating improved versions of the fire shelter and should have a new shelter for firefighters during the 2003 fire season.



Contoured fiberglass pack boards replaced wooden models, making the task of carrying fire packs a little easier.

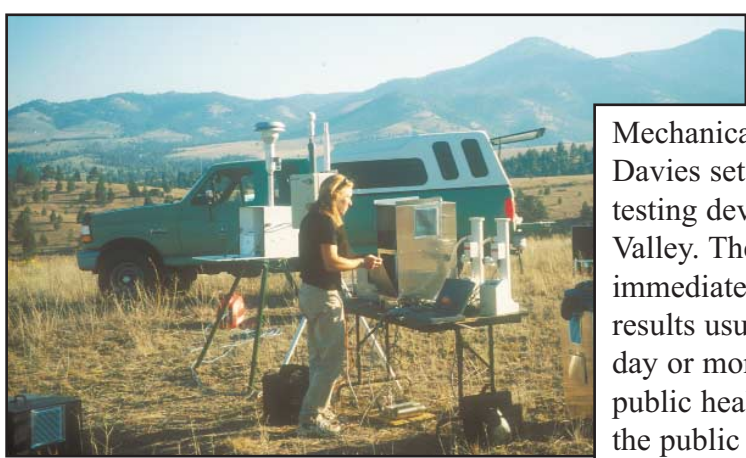
These early snow machines were tested by the center during the 1960s and early 1970s.

Problems Solved by the Missoula Technology and Development Center

Although these photographs show boat ramps, parachutes, all-terrain vehicles, and similar devices, the products the center produces are often prototypes. Mechanical drawings, specifications, reports, videos, Web sites, and CDs allow others to reproduce the center's successes. Each year, the center distributes more than 100,000 copies of its reports, videos, CDs, and technical drawings.

Traditional skills, such as felling trees with a crosscut saw, are lost as experienced Forest Service employees retire. The center helps maintain these skills by producing videos, publishing reports, and preparing training materials.

Firefighters rappel from helicopters using equipment developed by the center. The use of rappelling has been growing in recent years.



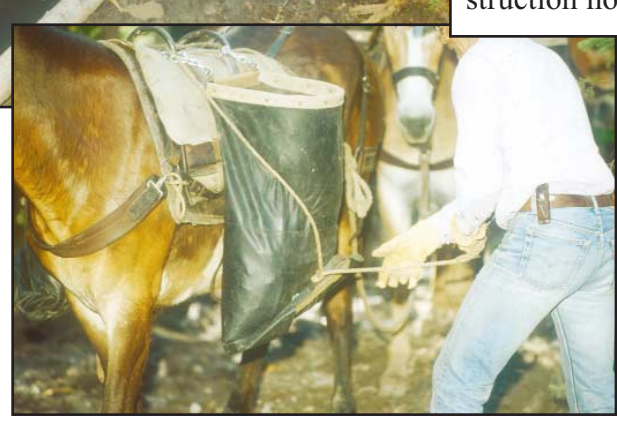
Mechanical engineer Mary Ann Davies sets up portable air quality testing devices in the Bitterroot Valley. These devices give results immediately. With standard devices, results usually aren't available for a day or more. With the new devices, public health officials could notify the public the moment air quality deteriorates.

Center personnel conduct a pull test for the Federal Aviation Administration during the 1980s. This test shows that the center's anchor for parachute static lines can safely handle anticipated loads. Nearly every smokejumper aircraft used by the Forest Service has been equipped with modifications designed by the center.

Problems Solved

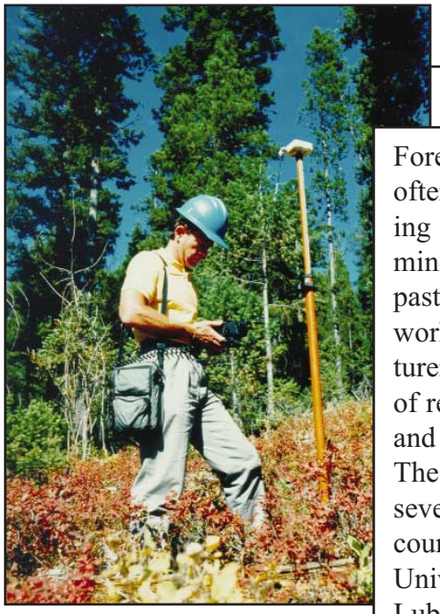
Forest Service smokejumpers have softer landings and can get closer to their target using a new parachute developed by the center in cooperation with a parachute design firm. The parachute is the first round chute that can fly backward. It has been so successful that it has also been adopted by the U.S. Army.

Physiologist Dr. Brian Sharkey measures the extra work required for a firefighter to breathe while wearing a respirator at the University of Montana's Human Performance Laboratory. Among the results of Sharkey's studies for the center over the past three decades have been the step and pack tests that measure the fitness of firefighters. Now, Sharkey and his colleagues at the university are studying the effects of the arduous duties of firefighting on immune function and fatigue.

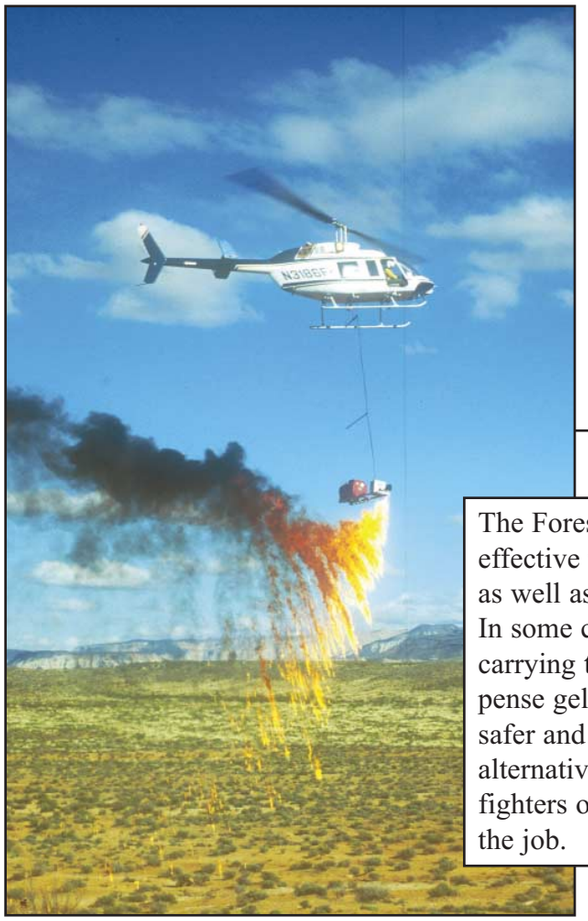


Special panniers make it easier to carry and dump gravel during trail construction in the backcountry. Trail construction is also aided by drawings of equipment for pack stock, a series of videos, and a trail construction notebook published by the center.

All chemical products (such as retardants, foams, and gels) for wildland firefighting must be proven safe and effective before the Forest Service qualifies them for use. This wind tunnel test of the effectiveness of fire retardant is one of many tests the center conducts on each product.



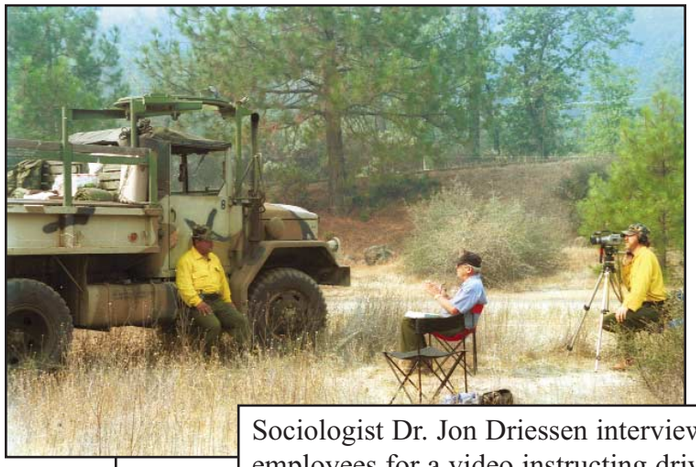
Forest Service employees often rely on global positioning system receivers to determine their location. Over the past 20 years, the center has worked closely with manufacturers to improve the accuracy of receivers under tree cover and in mountainous terrain. The center tests receivers at several carefully surveyed test courses, including one at the University of Montana's Lubrecht Experimental Forest 30 miles east of Missoula.



The Forest Service needs effective ways to start fires as well as to put them out. In some cases, helicopters carrying torches that dispense gelled gasoline are safer and quicker than the alternative of having firefighters on the ground do the job.

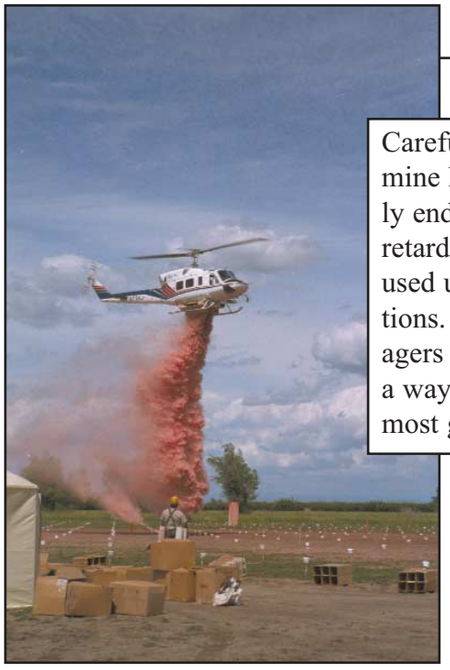
Operators on all-terrain vehicles can maintain lanes and trails using accessories developed by the center.

This prototype machine injected steam into the soil at Forest Service nurseries, killing disease organisms. The machine was developed to reduce the need for fumigation with ethyl bromide. Although the prototype worked, it would need a larger boiler to be practical.

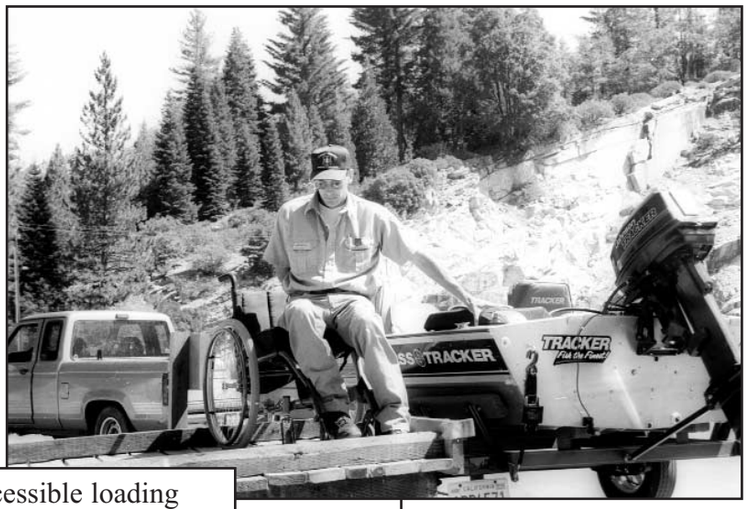


Sociologist Dr. Jon Driessen interviews experienced employees for a video instructing drivers who transport firefighters to wildland fires. Over the past three decades, Driessen, a University of Montana professor, and his graduate students have conducted studies that formed the basis for training programs to help Forest Service employees adapt to a changing workplace.

Problems Solved

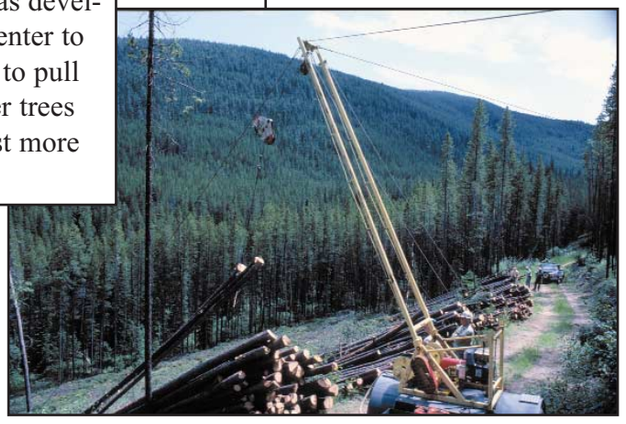


Carefully conducted tests determine how much retardant actually ends up on the fuels when retardant delivery systems are used under a variety of conditions. These tests allow fire managers to order retardant drops in a way that's likely to do the most good for the least cost.

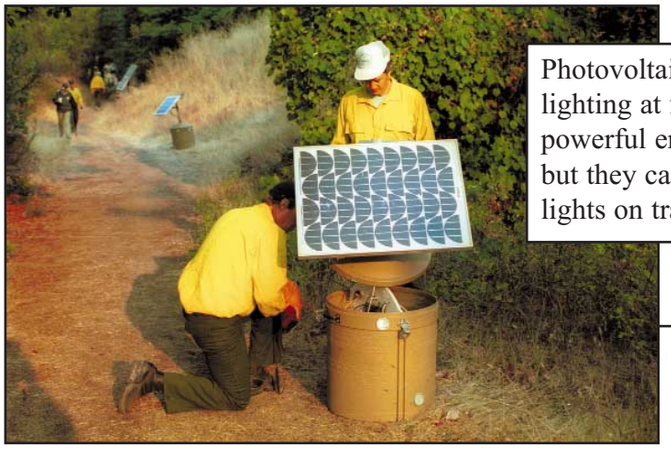


Accessible loading platforms make it easier for people with limited mobility to get in and out of boats. Once boaters have boarded, the boat is backed to the water for launching. This platform and drawings were developed by the center.

Unlike most commercial yarders, the Bitterroot miniyarder is small enough to be hauled behind a pickup truck. It was developed by the center to allow loggers to pull small-diameter trees from the forest more economically.



The center's fabrication shop allows us to produce prototypes of new products.



Photovoltaic cells are being tested for lighting at fire camps. The cells aren't powerful enough to replace generators, but they can quietly charge batteries for lights on trails to sleeping areas.

Simple Solution Stops Pepper Spray

Pepper spray stops bears. That's why Forest Service employees working in bear country carry it.

Pepper spray also stops humans. A 1-second burst of spray directly in someone's face could cause temporary blindness; induce choking, coughing, and nausea; and restrict breathing. If the spray accidentally discharged in a vehicle, the driver would have difficulty stopping safely.

A pressure gauge proved whether containers leaked.

The center was asked to develop a container that could be used to safely carry bear spray.

Mechanical engineer Dick Karsky not only needed to figure out a solution, he needed to figure out a realistic test to show that it actually worked.

Karsky sealed the bear spray canister in a PVC plastic container that would prevent any leakage. A pressure gauge showed that the container held 150 pounds of pressure per square inch for 4 hours without leaking. Karsky had calculated that 150 pounds of pressure could be generated if the canister were heated to 125 degrees, as could easily happen in a vehicle on a summer day.

For the test, Karsky rigged a handle on a threaded rod sealed into the cap. When he twisted the handle, the end of the rod fired the bear spray inside the container. The pressure rose to 60 pounds per square inch. The container didn't leak. The problem was solved.

But Karsky wasn't finished. He knew that the O-rings that sealed the container's caps could fail if they weren't installed properly or cracked with age. He also knew that it would be impossible to open the container if it were sealed at low altitude and taken to high altitude. He recommended that a tire valve be installed on the cap of all PVC containers so they could be tested to prove they held pressure and to relieve pressure when they were taken to different elevations.

Mark Matheny, founder of pepper spray manufacturer UDAP Industries in Bozeman, suggested storing pepper spray in a simple 2-liter Nalgene container. Meanwhile, Dave Dieziger from the Forest Service's Missoula regional office had tested terry cloth pouches. Dieziger found that the terry cloth trapped the pepper oil while allowing the propellant to escape. The pepper oil is not dangerous when it is a liquid.

Karsky combined the approaches. First he tested the Nalgene container. It held just 50 pounds per square inch of pressure before leaking, not enough to contain the aerosol if the container burst. He lined the container with 1½-inch-thick open-cell, fine-pore urethane foam used for furniture padding. Karsky drilled a vent hole into the container's top and placed a 2-inch-thick circular plug of foam under the top.

For testing, he drilled another hole into the top of the container and used a rod to fire the pepper spray. The foam trapped the active ingredient. The problem was solved a second time.

This solution was inexpensive, simple enough for anyone to make, and relatively foolproof. This is the solution that Karsky recommended. Matheny now sells this container as an accessory.

The recommended storage container is a simple Nalgene plastic bottle lined with open-cell furniture foam. The foam traps the active ingredient while allowing the propellant to escape.

Each year, Matheny hears about canisters of bear spray that have leaked or exploded after being left in a hot car. One canister left on a dashboard blew out the windshield.

Matheny has never heard of a problem from anyone who was using the container to store bear spray. Forest Service safety regulations now require that pepper spray be in one of the MTDC-approved containers whenever pepper spray is carried in a vehicle or in a light aircraft. The spray cannot be carried on commercial aircraft.

How T&D Solves Problems

Identify Problems
Forest Service employees submit project proposals.

Rank Problems
National steering committees select the most important projects.

Assign a Project Leader
Project leaders tap resources within the center, the Forest Service, and outside.

Consider Alternative Solutions
Most problems have more than one solution.

Test the Solutions
Compare the potential solutions.

If Everything Else is Equal, Choose the Simplest, Least-Expensive Solution
Simple solutions are usually better than complex solutions that aren't affordable or don't get used.

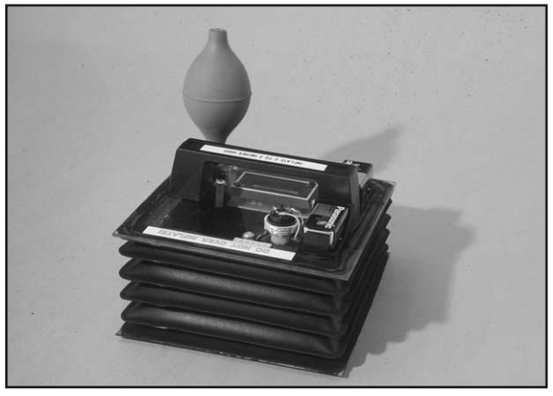
Implement the Solution
Find ways to produce the product, or share the knowledge through field trips, reports, videos, CDs, or Web sites.

Patenting Successful Products

Patents can interest industry in producing products the government develops. That's the philosophy behind patents now held by the Forest Service for products developed at the center.

The philosophy appears to have worked for at least one product, an electronic meter that measures the moistness of the layer of decaying leaves and needles (duff) on the forest floor. When forest managers use fire to thin small trees, they need to know just how moist this layer is. If the layer is too dry, the fire may burn the entire layer, leaving the soil exposed. If the layer is too moist, the fire may smolder and smoke without killing small trees as intended. Without the meter, the only accurate way to determine duff moisture is to weigh samples before and after heating them in an oven.

The duff moisture meter is now being sold by Campbell Scientific, Inc., which negotiated a license to use the patents (Patent No. 5,920,195 and 6,078,181). The center developed the meter in cooperation with scientists at the Forest Service Rocky Mountain Research Station.



This electronic meter measures moisture content instantly, helping fire managers make better decisions.

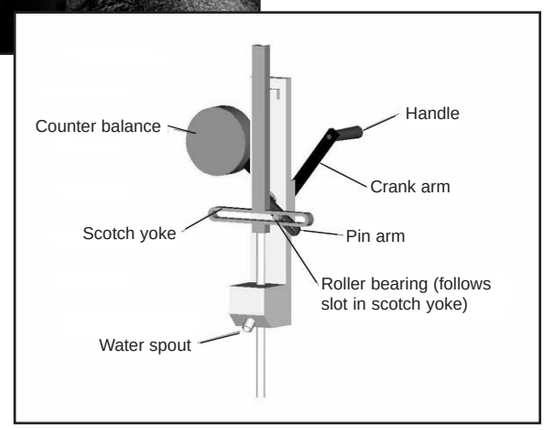
The meter will help fire managers determine whether conditions are right before they decide to ignite a prescribed fire. In addition, the meter will help fire managers predict the behavior of wildland fires.

Other center products with patents include:

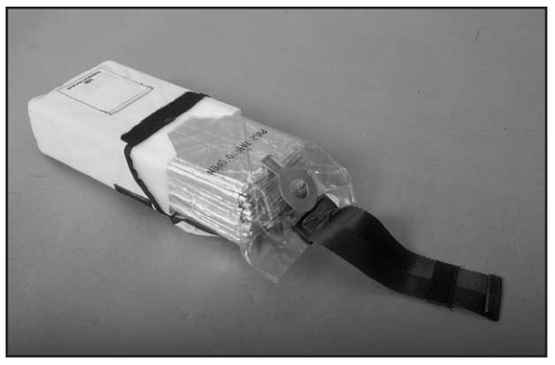
- Insulated camera box to allow a camera to take pictures from within a wildland fire (Patent No. 5,835,806).
- Pull strap that allows firefighters to open the fire shelter container with one gloved hand (Patent No. 5,921,388).
- A device that maintains the brightness of a battery-powered headlamp as the batteries are wearing down (Patent No. 4,949,014).
- A portable water bag system using a nylon duck cover with a replaceable plastic liner to deliver water to firefighters (Patent No. 5,230,566).
- Campground water pump that can be operated by people with disabilities. Just 5 pounds of force is needed to operate the pump (patent to be applied for).

Aside from the few products that have been patented, all of the center's work is freely available for use by the public, private industry, or Government agencies. Once the center has developed a prototype, mass production is done by private contractors.

The center developed nylon fabric water bags with replaceable plastic liners to assure that drinking water was sanitary. The bags are available in different sizes for carrying on a firefighter's back, in a truck, or slung beneath a helicopter.



The design of this water pump will allow it to be used by people with disabilities.



This pull strap allows firefighters to open the fire shelter container and begin removing the shelter with just one gloved hand.

Contracts Save Big Bucks

Buying firefighting equipment through contracts saved taxpayers an estimated $34 million last year compared to the cost of buying the same items in small quantities. The purchases are based on contract specifications established by Forest Service technology and development centers in Missoula, MT, and San Dimas, CA.

Savings add up when you consider how much equipment is needed each season by firefighters in the Forest Service, Bureau of Land Management, National Park Service, Bureau of Indian Affairs, Fish and Wildlife Service, and other agencies.

Last year, agencies ordered 129,455 pairs of the newest model of flame-resistant pants for a savings of almost $9 million. Another $3 million was saved buying 73,221 yellow flame-resistant shirts.

Dennis Davis is in charge of specifications at the center. He specifies the requirements a contractor must meet when mass-producing flame-resistant shirts or other items. Technical drawings show a contractor the exact dimensions of each item.

In many cases, these items would not exist without the Forest Service's technology and development centers. Prototypes of the flame-resistant shirt and pants, fire shelter, and similar items were developed and tested by the technology and development centers. The final specifications allow contractors to produce the items in large quantities for field use.

The General Services Administration provides the specifications when soliciting bids from contractors. Once a contract has been awarded, Davis inspects the "first article" to make sure the product meets the specifications. The contractor has to correct any mistakes in materials or construction before large quantities of the item may be produced for the Forest Service.

Dennis Davis inspects items to make sure they meet contract specifications.

Savings for firefighters' protective clothing purchased during 2001.

Missoula Technology and Development Center

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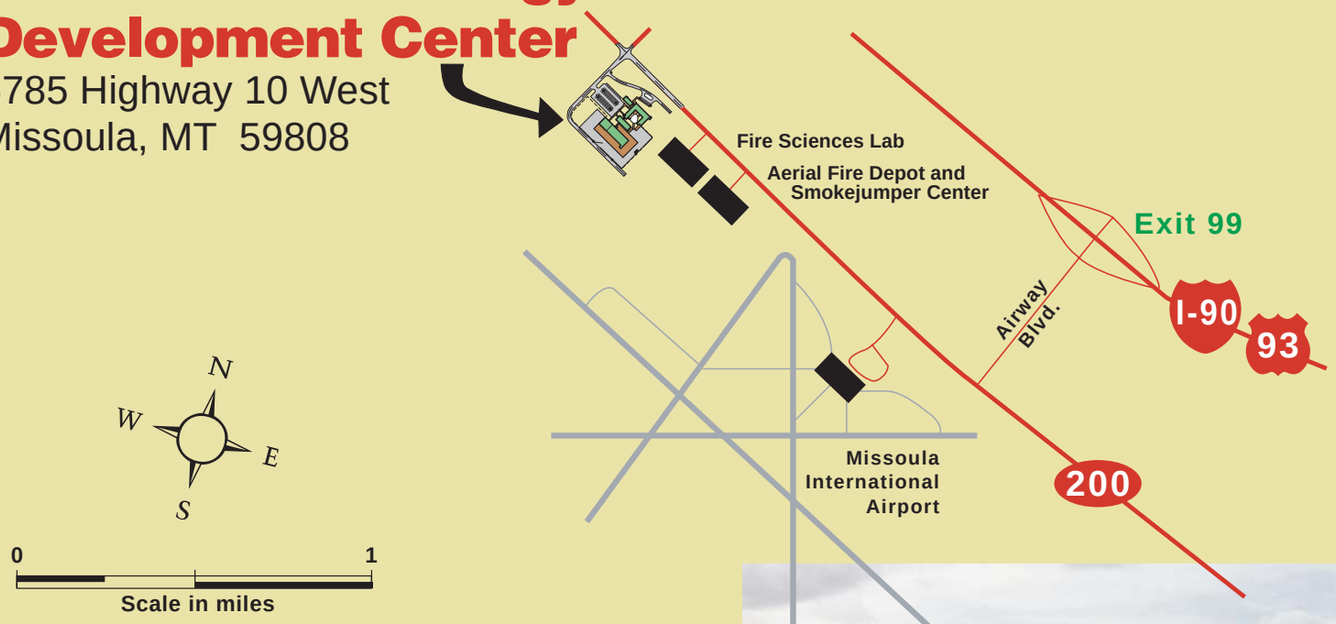

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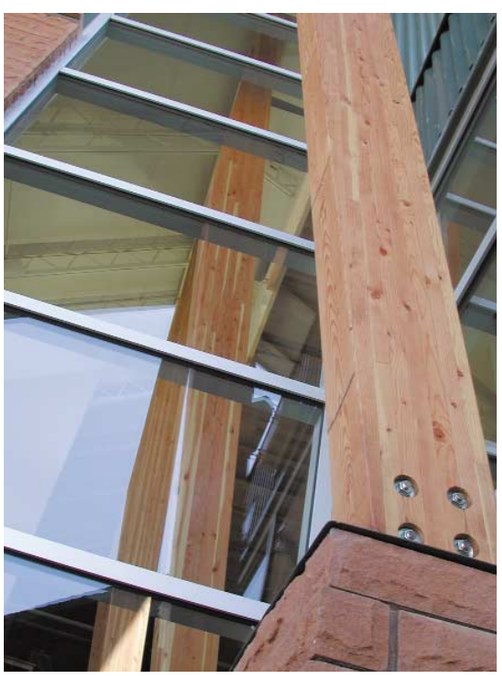
June 2002 0271-2818-MTDC

New Building Conserves Resources and Displays Technology



Our new facility lets us work effectively while it conserves resources and displays new technology. Recirculated groundwater cools the building, which has no traditional air-conditioning units. The system saves energy and eliminates the use of refrigerants that could contribute to global warming. Natural light keeps most areas of the building bright and cheery, even when the energy-saving fluorescent lighting is not turned on.

Switches allow one bulb or all three bulbs to be turned on in each fluorescent light. After working hours, timers automatically turn off all but a few lights. The system allows the number of lights left on to be varied during different conditions.

Urinals that do not require flushing save an estimated 60,000 gallons of water a year. Most of the site's landscaping consists of recently seeded native grasses and plants that won't require irrigation.

Pressed boards made from wheat straw (otherwise a waste product) are used on some walls, balcony rails, and in the reception desk. Sweeping laminated wooden beams reach from the floor more than 30 feet to support the roof, displaying modern uses of forest products.

The facility was built with recycling in mind. The carpets, metal siding, and aluminum door frames and windows will be easy to recycle if the building is no longer useful.

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