Fire
Tech Tips

United States Department of Agriculture
Forest Service
Technology & Development Program
May 2008
5100 0851–2323–MTDC

The Heli-Claw: A New Way To Transport Mulch for Erosion Control

Tim Lynch, Project Leader

After large wildland fires, Burned Area Emergency Response (BAER) teams determine which areas may be most susceptible to erosion and prescribe treatments. Since the early 1990s, more and more acres have been treated with mulch to reduce erosion.

Helimulching, also called "hay bombing" or "bale bombing," is one of the most common treatments used. A cargo net filled with wheat, barley, or rice straw is attached to the remotely controlled hook of a helicopter longline (a 100-foot cable for this cargo). The net is emptied in flight.

When the helicopter returns to the loading site, ground support crews:

- Lay out empty nets
- Fill them with straw bales (figure 1)
- Cut and remove twine from the bales
- Close the nets

Figure 1—Loading cargo nets used for helimulching.

Highlights...

- After wildfires, helicopters distribute mulch on severely burned lands to reduce erosion.
- Using the standard process, mulch is loaded into nets that are opened remotely by the helicopter pilot.
- After a load of mulch has been delivered, the helicopter has to hover while the empty net is removed from the longline and a full net is attached.
- The Missoula Technology and Development Center has developed a device, known as the heli-claw, that allows a helicopter pilot to pick up a load of mulch quickly without requiring the help of crewmembers working underneath the helicopter.

- Attach hardware on three corners of the net to the longline's remotely controlled hook.
- Attach the fourth corner of the net to a fixed point on the longline near the hook.

Helicopters often hover for up to 60 seconds while the ground support crew detaches empty nets and attaches full nets. The longlines must be at least 100 feet long to minimize rotor wash on the ground support crew. The San Dimas Technology and Development Center's tech tip "Helimulching—Equipment and Techniques" (0757–1305–SDTDC) discusses the current best practices and provides technical guidance for aerial mulching projects.

For additional information, contact: *Tim Lynch, project leader; USDA Forest Service, MTDC; 5785 Hwy. 10 West; Missoula, MT 59808–9361. Phone: 406–329–3958; fax: 406–329–3719; e-mail: tlynch@fs.fed.us*

On a large erosion control project, three or more helicopters take turns working at a single site. Each helicopter generally needs at least five to six ground support crewmembers who load, attach, and detach nets.

As helicopters arrive and depart, some ground support crewmembers lay out empty nets, load nets, strip twine, and close nets. They work beside other crewmembers who attach and detach the nets.

Tractors or other motorized farm equipment may be used to pick up and load straw bales into nets, adding another potential hazard to an already busy worksite. The process of removing empty nets and attaching loaded nets (figure 2) is fast paced, labor intensive, and exposes crewmembers to the hazards of working beneath hovering helicopters.

Figure 2—Attaching a loaded cargo net to the remotely controlled hook of a helicopter longline.

The Interagency Incident Business Management Handbook classifies working beneath a hovering helicopter as hazardous duty. Airborne dust and straw particles also pose potential health hazards for crews working at loading sites.

Another potential hazard is that the straw bales do not always release smoothly when the net is opened. Pilots sometimes receive uncomfortable jolts.

High-speed video taken while straw was being dropped shows the cause of jolts. When the pilot releases the hook on the longline, bales of straw sometimes begin to fall, get caught in a fold of the net, and break up. When bales get caught, they may generate peak loads that are much higher than the weight of the bales.

Without further testing, it is not possible to determine whether the peak loads exceed the maximum load ratings for equipment used with a given helicopter.

After analyzing the use of nets to distribute straw for erosion control, project leaders and engineers from the Missoula Technology and Development Center (MTDC) began designing a device that would allow a helicopter to pick up and drop straw or wood shreddings. They based their early designs on the widely used hydraulic helicopter logging grapples.

MTDC employees designed and fabricated a prototype for testing, dubbing the new device the "heli-claw."

Flight tests in 2007 (*http://www.fs.fed.us/t-d/pubs/videos/flash/08512C01/*, Username: t-d, Password: t-d) showed that the heli-claw functioned as envisioned. When the heli-claw is suspended on a 100-foot longline beneath a helicopter (figure 3), the helicopter pilot can independently pick up, transport, and drop up to a ton of straw or similar material.

Figure 3—The loaded heli-claw in flight.

Because recent experiments have shown that shredded wood fiber can be an effective mulch for erosion control, the heli-claw was designed to pick up shredded wood fiber as well as straw.

The heli-claw's hydraulically powered set of steel "jaws" are designed to penetrate piles of straw or shredded wood. The jaws (figure 4) compress the load so it can be lifted and transported. The teeth along each jaw are spaced to keep the mulch from falling out when the load is lifted. A central steel frame provides an attachment point for the helicopter's longline and serves as a hinge point for the jaws. The steel frame also serves as a reservoir for hydraulic fluid and as a cooling system.

Figure 4—The heli-claw "parked" on the ground.

The heli-claw's hydraulics are powered by a 6.5-horsepower Honda gasoline motor. Each 10-foot-long jaw is attached to a hydraulic ram that opens and closes the heli-claw. A mechanical hydraulic flow divider ensures that the two jaws open and close in unison.

The individual "teeth" on each jaw (12 on one jaw and 11 on the other) are made from hardened ¼-inch steel plate. Each tooth is attached to the jaw with just two bolts, allowing a damaged tooth to be replaced in a few minutes. When the heli-claw is closed, the teeth on one jaw fit between the teeth of the opposite jaw.

Because the teeth are easy to remove and interchangeable, their spacing can be altered as needed to penetrate piles of mulch or other materials, such as brush or slash. If a helicopter's performance or other conditions call for lighter loads, one or more teeth on either end of the jaw can be removed quickly in the field, allowing the heli-claw to take a smaller bite when picking up the mulch.

A lightweight plastic mesh covers the curved frame sections near the teeth. The mesh prevents mulch from spilling out as the jaws close and helps keep the load compressed and secure in flight.

After the pilot lowers the open heli-claw on a pile of mulch, it takes less than 10 seconds to close the jaws and begin lifting the load. The heli-claw penetrates piles of straw more quickly than piles of shredded wood. Some mulch will fall away when the loaded heli-claw is lifted. Once the load is compressed and the helicopter is in forward flight (figure 5), very little falls out.

Figure 5—A closeup of the loaded heli-claw in flight.

A removable Lexan plastic vertical stabilizer/rudder prevents the heli-claw from spinning in flight and keeps the heli-claw aligned with the helicopter. A continuous electrical contact swivel connects the lower end of the longline to the heli-claw, preventing the longline from twisting.

During flight tests, the heli-claw was evaluated at speeds from 30 to 80 knots when the heli-claw was:

- Open and empty
- Closed and empty
- Closed and loaded

In forward flight, the heli-claw is very stable, whether it is loaded or not. The heli-claw remains stable at speeds up to 80 knots even while opening or closing.

A three-wire electrical line is mated to the helicopter's steel longline. The electrical line, which connects the heli-claw's 28-volt electronic control system with the helicopter's control system, is attached with a nine-pin "pigtail" that plugs into a nine-pin female receptacle on the underside of the helicopter.

The three-wire/nine-pin configuration is the same configuration used by the Bambi Bucket Torrentula system (*http://www.fs.fed.us/fire/niicd/docs/avionics/FSOASA16.pdf*). The pilot uses a three-position switch mounted on the helicopter's collective (one of the helicopter's main controls) to open and close the heli-claw.

The heli-claw's jaws can be adjusted anywhere between fully open (jaws 10 feet apart) and fully closed. To keep the heli-claw stable on the ground, it needs to be fully open (figure 6) during takeoffs and landings.

Figure 6—The heli-claw open in flight.

Helicopters must be equiped with an onboard load cell to display the weight of the loaded heli-claw. If necessary, a pilot can dump a portion of a load to keep it within the allowable weight limit.

When the fuel and hydraulic reservoirs are full, the heli-claw weighs about 900 pounds, including the longline, swivel, and accessory hardware. The heli-claw was designed to pick up 2,000 pounds of straw or shredded wood. The maximum loaded weight is about 3,000 pounds, the approximate weight limit for Bell 205-type helicopters (helicopter performance charts and the density altitude at the site will dictate the allowable loads).

This project's goal was to build a device that would weigh 500 pounds or less and lift 100 cubic feet or 2,000 pounds of material. Because the all-steel prototype was deliberately overengineered, it weighs almost twice as much as desired.

Future steel prototypes could be redesigned to save 100 to 200 pounds. If aluminum, plastic, and other lightweight materials were used for some components, the weight could be reduced even more.

The heli-claw reduces the time helicopters need to hover while loading mulch. A helicopter pilot cannot safely perform an emergency landing (autorotation) unless the helicopter is in forward flight and is high enough above the ground. A pilot using the heli-claw will spend less time hovering close to the ground, reducing this risk. The heli-claw and longline can be jettisoned by the pilot if an emergency arises during flight.

The heli-claw reduces the need for employees to work beneath hovering helicopters, eliminating risk to them. Because fewer ground support crewmembers will be needed for the heli-claw, distributing mulch for erosion control should cost less with the heli-claw than when nets are used.

A video of the initial heli-claw flight test is available on the T&D Internet site at: *http://www.fs.fed.us/t-d/pubs/videos/flash/08512C01/* (Username: t-d, Password: t-d). Field tests using the heli-claw to deliver mulch for erosion control have not yet been conducted.

Mechanical drawings of the heli-claw prototype should be available by late fall.

Acknowledgments

The stimulus for development of the heli-claw was a T&D project proposal submitted by Willy Acton, now the zone aviation officer for the Nez Perce and Clearwater National Forests. The heli-claw is based on an original concept proposed by Tim Lynch. Mechanical engineer Matt Pagel developed the initial design, constructed a scale-test model, and performed tine force/penetration tests on straw and shredded wood. MTDC mechanical engineer Keith Windell refined the heli-claw design and developed mechanical drawings. MTDC fabrication shop technician Chuck Harding constructed and modified the prototype heli-claw.

About the Author

Tim Lynch has been a project leader at MTDC since 2001, working with a number of projects in the fire and aviation program. His wildland fire career includes experience as an engine supervisor, crew supervisor, smokejumper, and helicopter rappeller.

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Lynch, Tim. 2008. The heli-claw: a new way to transport mulch for erosion control. Tech Tip 0851–2323–MTDC. Missoula, MT: U.S. Department of Agriculture Forest Service, Missoula Technology and Development Center. 6 p.

After wildland fires, mulch may be spread on the most severely burned areas to control erosion. Now, the mulch is loaded into a cargo net attached to a 100-foot longline underneath a helicopter. After each load of mulch is delivered, the helicopter has to hover while the empty net is removed from the longline and a full net is attached. The pilot and everyone under the helicopter are at risk while the helicopter is hovering near the ground. The Missoula Technology and Development Center has developed a device, known as the heli-claw, to carry loads of mulch. The heli-claw has hydraulically operated jaws that can carry up to a ton of mulch. The helicopter pilot has to hover for no longer than 10 seconds while picking up a load of mulch. In addition, crewmembers do not have to work underneath the hovering helicopter. A prototype of the heli-claw performed well during flight tests, but field tests using the heli-claw to deliver mulch for erosion control have not yet been conducted.

Keywords: BAER, biomass, erosion control, heli-claw, helicopter, mulch, safety at work, shredded wood, straw

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USDA Forest Service
Missoula Technology and Development Center
5785 Hwy. 10 West
Missoula, MT 59808–9361
Phone: 406–329–3978
Fax: 406–329–3719
E-mail: *wo_mtdc_pubs@fs.fed.us*

For additional information about the heli-claw, contact Tim Lynch at MTDC:

Phone: 406–329–3958
Fax: 406–329–3719
E-mail: *tlynch@fs.fed.us*

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