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Effects of Pathogen Decontamination on the Strength of Climbing Rope and Harness Equipment

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Cover photo—A caver prepares to survey a cave, Grant County, WV.
—Photo courtesy of Ed Devine

Effects of Pathogen Decontamination on the Strength of Climbing Rope and Harness Equipment

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Acknowledgments

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A caver completing a 120-foot drop, Bland County, VA. —*Photo courtesy of Ed Devine*

Contents

Abstract

Decontaminating caving gear is important for reducing the spread of pathogens such as the fungus that causes white-nose syndrome in bats. The U.S. Department of Agriculture, Forest Service, National Technology and Development Program (NTDP), evaluated the effect of the current decontamination protocol on the strength of popular models of ropes and harnesses. The decontamination procedure had minimal effects on the strength of ropes or harnesses that NTDP tested.

A little brown bat with white-nose syndrome, WIndsor County, VT. — *Photo courtesy of Marvin Moriarty, U.S. Fish and Wildlife Service*

Introduction

White-nose syndrome is a fungal disease that has devastated hibernating bat populations in the United States and Canada. To reduce the risk of human-assisted transmission of *Pseudogymnoascus destructans* (Pd), the fungus that causes this disease, cavers and bat researchers may be required to decontaminate ropes and harnesses between caves or research sites. The strength of ropes and harnesses is critical to the safety of the users, so it is important to know how decontamination affects equipment strength (figure 1).

Although there are several applications and products with demonstrated efficacy against Pd, one of the preferred methods is submersion in hot water (hotter than 55 °C for 20 minutes). The U.S. Department of Agriculture, Forest Service, National Technology and Development Program (NTDP), tested the effects of this method, as prescribed in the current "National White-Nose Syndrome Decontamination Protocol—Version 4.12.2016," on the strength of selected ropes and harnesses. Test results indicated that treated rope samples had about 0.2 percent to 2.0 percent less strength than untreated ropes. Tests showed that all of the treated ropes had actual breaking strengths well above the minimum breaking strength advertised by the rope manufacturer. All harnesses (treated and untreated) passed the 3,372 pound-force (lbf) test (European Standard EN 12277). There was no evidence that the decontamination procedure affected the performance of the harnesses.

Figure 1—A caver using climbing rope and harness equipment, Grant County, WV.

Equipment Tested

Funding and time constraints made it impossible for NTDP to test every type of rope or harness available to cavers. We consulted with the project proposer and a leading caving supply shop to determine some of the most common equipment used by cavers. NTDP purchased the following models of rope and harnesses for testing:

Ropes

- PMI Pit Max 11-millimeter rope
- PMI EZ Bend Sport 11-millimeter rope
- PMI EZ Bend Sport 10-millimeter rope

Harnesses

- PMI Pit Viper
- Petzl Fractio
- On Rope 1 Goliath Frog

NTDP purchased spools of the 3 models of rope, cut 10 rope samples into 12-foot-long segments (30 rope samples total), and attached a printed label with an identifying number on both ends of each rope sample. We purchased 10 harnesses of each model (30 harnesses total), inscribed the identification number on a tag, and sewed the tag to the end of one of the adjustment straps.

For the evaluation, we left five samples of each type of rope and harness untreated. We used these as controls to determine the baseline breaking strength of the equipment. We treated five samples of each type of equipment using one of the standard protocols for decontaminating caving equipment according to section V of the "National White-Nose Syndrome Decontamination Protocol—Version 04.12.2016" (WNS Decontamination Team, Disease Management Working Group 2016). Based on this protocol, cavers can decontaminate their equipment by submerging it in hot water (equal to or hotter than 55 °C) for at least 20 minutes, and then allowing it to dry.

Pretest Treatment of the Test Samples

NTDP used an ANOVA W-22 waterbath to heat the water to 55 °C (figure 2). When the water reached this temperature, we placed the samples in the waterbath and used two stainless steel bars to hold the samples under water. We set the metal cover on the waterbath and allowed the samples to soak for at least 20 minutes. We then removed the samples from the waterbath, placed them on a rack, and allowed them to air dry overnight (figure 3). NTDP personnel replaced the water in the waterbath with fresh tapwater after treating each batch of the same rope or harness type. This prevented contaminating the next batch of samples with any chemicals that may have leached out of the previous samples. We subjected each sample to the decontamination procedure 30 times.

Figure 2—The National Technology and Development Program (NTDP) applied the decontamination protocol to half of the test equipment samples. NTDP soaked the samples in a 55 °C waterbath for 20 minutes or longer.

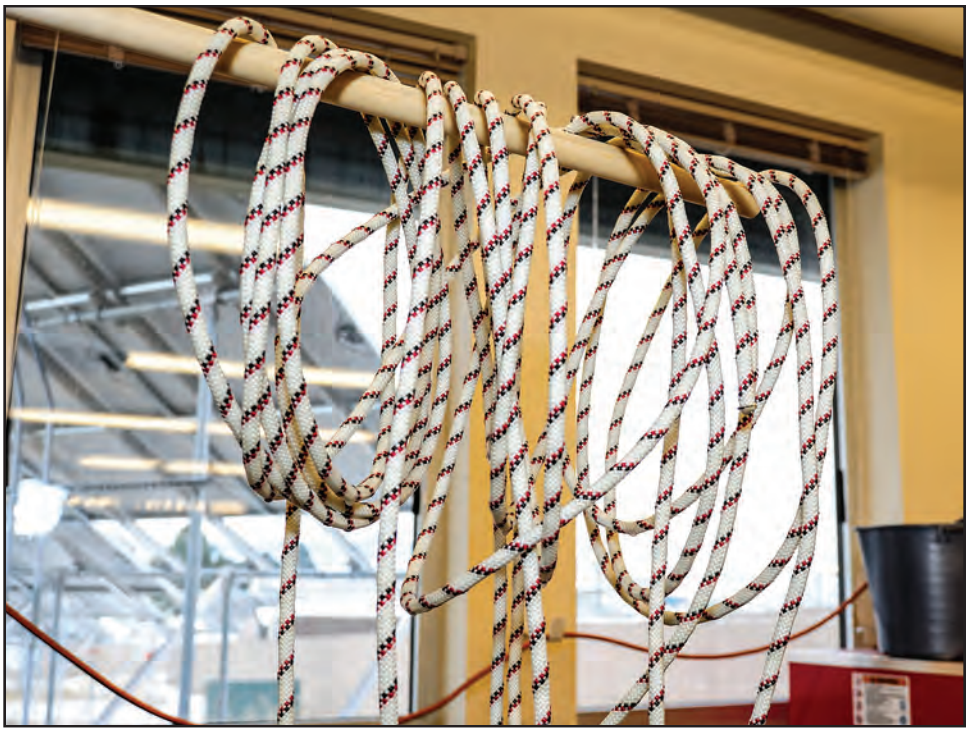

Figure 3—The National Technology and Development Program allowed the treated samples to air dry overnight.

Rope Testing

NTDP sent the rope samples to Holloway Houston, Inc., for strength testing. They recorded rope strength and elongation data as a test machine pulled the rope samples (figures 4 and 5). The machine pulled each sample until it broke. Holloway Houston, Inc., tested in accordance with the requirements of the minimum breaking strength test of Cordage Institute CI–1801 (2007: Section 9.2).

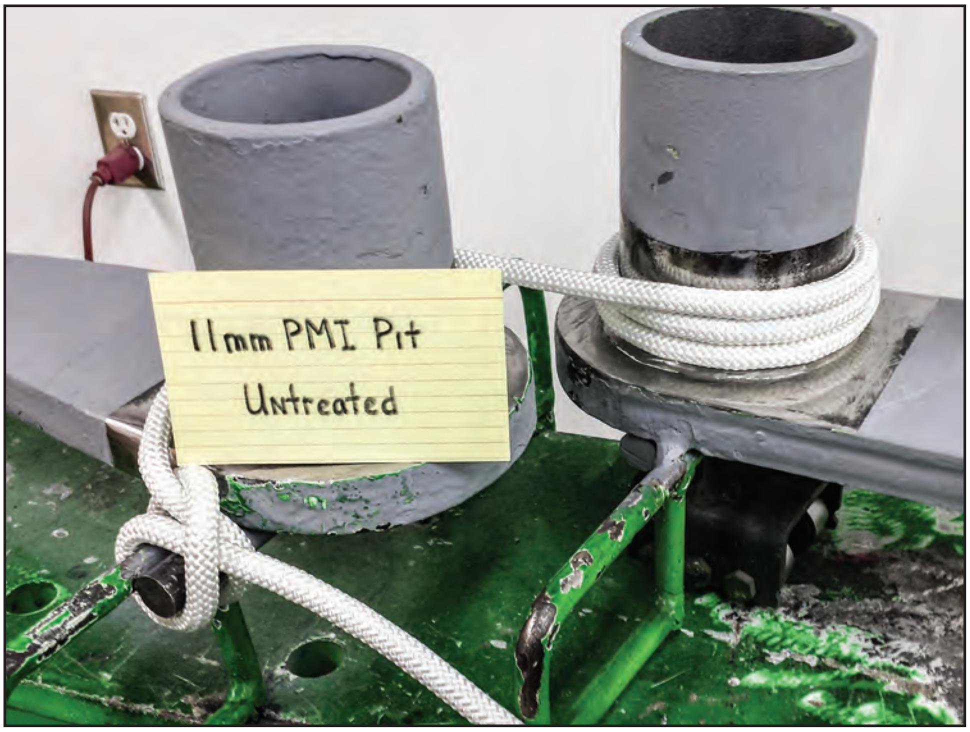

Figure 4—Holloway Houston, Inc., pull-tested rope samples until the samples broke.

Certificate Of Test

Performed By:

Holloway Houston Inc.

HHI #	USFS 020816-1-11mm-11EZ06	WLL	0	Lbf
Customer	US FOREST SERVICE - MISSOULA M	Factor (*)	1.00	
Description	11mm EZ BEND TREATED	Test Load	0	Lbf
Description2		Max Load	7105	Lbf
Test Type	BREAK IAW CI 1801-07	Max Displacement	34.896	Inches
Serial #		Hold Time	0.39	Minutes
Part #				
P.O. #	VBL WESLEY THROOP			
Dwg #				

This certifies the item(s) described has been loaded to the specified test load. Load measuring instruments are accurate +/- 1% of reading as specified by ASTM E4. Certificates on file. Upon conclusion of testing no obvious defects were noted.

Disclaimer: No other tests, inspections, or certifications have been made or implied on this document. The owner and/or end-user is responsible for the use and suitability for any task.

Tested By: Dave Richards Witnessed By:

Report Printed: 2/10/2016
Test Equipment: 20k Load cell SN 98025-2
DasyLab ID#:

Report Time: 8:37:31 AM

Figure 5—A certificate of test for a treated 11-millimeter EZ Bend rope sample. The red line and y-axis values indicate pound-force (lbf) applied to the rope. The green line and y-axis values indicate the amount of stretch or displacement of the rope in inches.

Harness Testing

NTDP sent the harnesses to BlueWater Ropes for testing. They conducted harness tests in accordance with European Standard EN 12277:2007. They fitted each harness to a specially-designed, rigid test dummy (figure 6) and attached the dummy to a test machine. The machine applied a load of 3,372 lbf to the dummy and harness (Section 5.2.6.3 of EN 12277). The standard indicates that a harness fails if any of the following occurs during testing:

- The webbing tears
- Parts of the harness breaks
- The test dummy releases from the harness
- Load bearing buckles or adjusting devices slip more than 20 millimeters during the test

As a secondary test, we asked BlueWater Ropes to test the harnesses to failure. BlueWater Ropes could not test to failure. They retested harnesses using the same criteria as earlier tests, but they applied increasing weight loads to a maximum of about 5,000 lbf, the limits of their testing machine.

Figure 6—A dummy and test apparatus setup ready for a harness pull test.

Rope Test Results

In general, testing showed that the average breaking strength of the treated rope samples was slightly less than the average breaking strength of the untreated samples for all rope types tested. Even the lowest recorded breaking strengths for the treated samples were well above the manufacturer's advertised minimum breaking strengths. Appendix A provides results of the rope testing.

PMI Pit Max 11-millimeter rope has an advertised minimum breaking strength of 6,430 lbf. The tested breaking strength of the five untreated samples ranged from 6,892 lbf to 7,218 lbf, and averaged 7,100 lbf. The tested breaking strength of the treated samples ranged from 7,042 lbf to 7,237 lbf, and averaged 7,089 lbf. Treated samples had about a 0.16 percent lower average maximum strength compared to untreated samples.

PMI EZ Bend 11-millimeter rope has an advertised minimum breaking strength of 6,542 lbf. The tested breaking strength of the five untreated samples ranged from 7,055 lbf to 7,293 lbf, and averaged 7,145 lbf. The tested breaking strength of the treated samples ranged from 6,948 to 7,130 lbf, and averaged 7,026 lbf. Treated samples had about a 1.67 percent lower average maximum strength compared to untreated samples.

PMI EZ Bend 10-millimeter rope has an advertised minimum breaking strength of 5,710 lbf. The tested breaking strength of the five untreated samples ranged from 6,509 lbf to 6,641 lbf, and averaged 6,568 lbf. The tested breaking strength of the treated specimens ranged from 6,610 lbf to 6,509 lbf, and averaged 6,556 lbf. Treated samples had about a 0.19 percent lower average maximum strength compared to untreated samples.

Harness Test Results

None of the harnesses (treated or untreated) failed with an applied load of 3,372 lbf (per the EN 12277 standard). At this load, the testing facility did not report any tearing of webbing, damage to seams, or failure of any harness components. They also did not observe any test dummies released from the harness, and load bearing buckles or adjusting devices did not slip more than 20 millimeters. They recorded a maximum slip of 7 millimeters. When the testing facility increased the maximum load (up to 5,000 lbf), they observed damage to a portion of the harnesses. Furthermore, the test dummy released from over half of the Petzl Fractio harnesses. Appendix B provides results from the harness testing.

PMI Pit Viper harnesses passed the EN 12277 standard test. The amount of slip at load bearing buckles or adjusting devices ranged from 0 to 7 millimeters. None of the test dummies released from harnesses during the maximum load (up to 5,000 lbf) test. However, the test facility recorded some seam failures on three of the decontaminated (treated) harnesses during the maximum load test. They did not observe any failures on the untreated harnesses.

Petzl Fractio harnesses passed the EN 12277 standard test. The amount of slip at load bearing buckles or adjusting devices ranged from 0 to 6 millimeters. The test facility recorded slightly more slipping on the untreated harness. Six test dummies released from the harnesses (four from untreated and two from treated harnesses) during the maximum load (up to 5,000 lbf) test. The testing facility did not observe any seam failures, but they did note torn webbing and D-ring failures on all but two of the treated harnesses during the maximum load test (figure 7).

On Rope 1 Goliath Frog harnesses passed the EN 12277 standard test. The amount of slip at load bearing buckles or adjusting devices ranged from 0 to 4 millimeters. The test facility recorded more slipping on the treated harnesses. None of the test dummies released from harnesses during the maximum load (up to 5,000 lbf) test. The test facility did observe some seam failures (right leg loop) on three of the untreated harnesses during the maximum load test (figure 8). They did not note any failures on the treated harnesses.

Figure 7—Some webbing failures occurred during the 5,000 pound-force test.

Figure 8—Some seam failures occurred during the 5,000 pound-force test.

Conclusions

In general, decontamination of ropes and harnesses selected for this testing had minimal effects on the strength of this equipment. All rope samples passed the minimum breaking strength test of Cordage Institute CI–1801 (2007: Section 9.2).

The rope samples that NTDP subjected to the submersion in hot water procedure only had 0.2 percent to 2.0 percent less strength than untreated ropes.

All the decontaminated harnesses passed the European Standard EN 12277 test at the required 3,372 lbf load. Our results did not provide any evidence that the decontamination procedure affected the performance of the harnesses. With the maximum applied load (5,000 lbf), the On Rope 1 Goliath Frog harness sustained the least amount of damage during testing, and the Petzl Fractio was the only harness to release the dummy.

NTDP acknowledges that the conclusions from these test results may not apply to other brands or models of ropes and harnesses. However, the ropes and harnesses that we did test did not show any major degradation or loss of strength due to the decontamination process.

References

Cordage Institute. 2007. Rope standard CI–1801—Low stretch/static kernmantle safety rope. Available at <http://www.ropecord.com/cart/cartpubs.asp>.

WNS Decontamination Team, Disease Management Working Group. 2016. National white-nose syndrome decontamination protocol—version 04.12.2016. Available at <https://www.whitenosesyndrome.org/sites/default/files/resource/national_wns_decon_protocol_04.12.2016.pdf>.

Appendix A–Testing Rope Breaking Strength

Holloway Houston, Inc., tested rope samples for breaking strength. They used the following rope number identification: the first two digits denoted the rope diameter in millimeters, the letters denoted the rope model, and the last two digits denoted the sample number. The U.S. Department of Agriculture, Forest Service, National Technology and Development Program (NTDP), soaked treated ropes (five samples of each rope model) in a 55 °C hot waterbath for at least 20 minutes and air dried them according to the National White-Nose Syndrome Decontamination Protocol—Version 04.12.2016 (WNS Decontamination Team, Disease Management Working Group 2016). NTDP repeated this decontamination procedure 30 times for each treated sample. Tables A–1 through A–3 show rope breaking strength results.

Table A–1—PMI Pit Max 11-millimeter rope test (advertised breaking strength of 6,430 pound-force).

Rope number	Maximum tested strength (pound-force)
Untreated	
11PIT01	7,218
11PIT02	7,036
11PIT03	6,892
11PIT04	7,180
11PIT05	7,174
Treated	
11PIT06	7,080
11PIT07	7,237
11PIT08	7,017
11PIT09	7,042
11PIT10	7,067

Table A–2—PMI EZ Bend 11-millimeter rope test (advertised breaking strength of 6,542 pound-force).

Rope number	Maximum tested strength (pound-force)
Untreated	
11EZ01	7,055
11EZ02	7,061
11EZ03	7,186
11EZ04	7,293
11EZ05	7,130
Treated	
11EZ06	7,105
11EZ07	6,948
11EZ08	6,973
11EZ09	7,130
11EZ10	6,973

Table A–3—PMI EZ Bend 10-millimeter rope test (advertised breaking strength of 5,710 pound-force).

Rope number	Maximum tested strength (pound-force)
Untreated	
10EZ01	6,553
10EZ02	6,509
10EZ03	6,641
10EZ04	6,553
10EZ05	6,584
Treated	
10EZ06	6,515
10EZ07	6,572
10EZ08	6,572
10EZ09	6,509
10EZ10	6,610

Appendix B–Testing Harness Failure

BlueWater Ropes tested harnesses for several failure criteria. The testing facility applied 3,372 pound-force (lbf) (per the EN 12277 standard) to the dummy and harness setup for slippage tests. Slippage test results are the number of millimeters the straps slipped at various locations on the harness (for example, left leg, right leg, and waist). The testing facility applied increasing lbf (up to a maximum of 5,000 lbf) to the dummy and harness for harness failure tests. Harness failure test results are the number of lbf at failure and the failure mode(s). BlueWater Ropes used the following harness number identification: the letters denoted the type of harness and the numerical digits denoted the sample number. The U.S. Department of Agriculture, Forest Service, National Technology and Development Program (NTDP), soaked treated harnesses (five samples of each harness model) in a 55 °C hot waterbath for at least 20 minutes and air dried them according to the "National White-Nose Syndrome Decontamination Protocol—Version 04.12.2016" (WNS Decontamination Team, Disease Management Working Group 2016). NTDP repeated this decontamination procedure 30 times for each harness. Tables B–1 through B–6 show harness slippage and failure test results.

Table B–1—PMI Pit Viper harness slippage test.

Harness number	Harness location slip distance		
	Left leg (millimeters)	Right leg (millimeters)	Waist (millimeters)
Untreated			
PV01	0	5	0
PV02	0	5	3
PV03	4	4	0
PV04	5	0	0
PV05	6	7	0
Treated			
PV06	0	0	0
PV07	0	0	6
PV08	3	4	0
PV09	0	4	0
PV10	1	4	0

Table B–2—PMI Pit Viper harness failure test. The tester noted seam rips in sheath as specified in the "Other" column, but stated the rips did not compromise the integrity of the harness.

Harness number	Maximum applied force (pound-force)	Failure mode					
		Excess slippage	Seam failure	Webbing failure	Buckle failure	Dummy released	Other
Untreated							
PV01	4,834	No	No	No	No	No	None
PV02	4,929	No	No	No	No	No	Right leg loop seam rip in sheath
PV03	4,829	No	No	No	No	No	None
PV04	4,847	No	No	No	No	No	None
PV05	4,856	No	No	No	No	No	Right leg loop seam rip in sheath, left leg rip in sheath seam
Treated							
PV06	4,909	No	Yes, left leg loop, at 4,902 pound-force	No	No	No	Left leg loop seam rip in sheath, right leg rip in sheath seam
PV07	4,890	No	No	No	No	No	None
PV08	4,935	No	Yes, right leg loop, at 3,372 pound-force	No	No	No	None
PV09	4,912	No	No	No	No	No	None
PV10	4,923	No	Yes, right leg loop at 4,923 pound-force	No	No	No	None

Table B–3—Petzl Fractio harness slippage test.

Harness number	Harness location slip distance			
	Left leg (millimeters)	Right leg (millimeters)	Upper waist (millimeters)	Lower waist (millimeters)
Untreated				
FRC01	6	4	0	0
FRC02	5	6	0	0
FRC03	3	6	0	1
FRC04	4	5	0	4
FRC05	4	5	0	1
Treated				
FRC06	4	5	0	0
FRC07	No data	No data	No data	No data
FRC08	2	4	1	0
FRC09	3	5	0	2
FRC10	0	0	0	0

Table B–4—Petzl Fractio harness failure test.

Harness number	Maximum applied force (pound-force)	Failure mode					
		Excess slippage	Seam failure	Webbing failure	Buckle failure	Dummy released	Other
Untreated							
FRC01	4,722	No	No	No	No	No	None
FRC02	4,547	No	No	Right leg webbing tore three-quarters of the way across	No	Yes	Left D-ring fail
FRC03	4,602	No	No	Left leg webbing tore at buckle	No	Yes	Right D-ring fail
FRC04	4,348	No	No	No	No	Yes	Right D-ring fail
FRC05	4,215	No	No	Right leg webbing tore slightly and melted some at buckle	No	Yes	Left D-ring fail
Treated							
FRC06	4,739	No	No	No	No	No	None
FRC07	No data	No data	No data	No data	No data	No data	No data
FRC08	4,739	No	No	Right leg webbing tore slightly and melted at buckle	No	Yes	Left D-ring fail
FRC09	4,761	No	No	Left leg webbing tore some at buckle	No	Yes	Right D-ring fail
FRC10	4,700	No	No	Right leg webbing tore slightly at buckle	No	No	None

Table B–5—On Rope 1 Goliath Frog harness slippage test.

Harness number	Harness location slip distance		
	Left leg (millimeters)	**Right leg** (millimeters)	**Waist** (millimeters)
Untreated			
FROG01*	0	0	0
FROG02	0	0	0
FROG03	0	0	0
FROG04	0	0	0
FROG05	3	0	0
Treated			
FROG06	0	2	0
FROG07	3	2	2
FROG08	0	0	0
FROG09	0	0	0
FROG10	4	2	3

*Right gear loop bottom span was broken before testing.

Table B–6—On Rope 1 Goliath Frog harness failure test.

Harness number	Maximum applied force (pound-force)	Failure mode					
		Excess slippage	Seam failure	Webbing failure	Buckle failure	Dummy released	Other
Untreated							
FROG01	4,949	No	No	No	No	No	None
FROG02	4,841	No	Right leg loop rip	No	No	No	None
FROG03	4,866	No	No	No	No	No	None
FROG04	4,894	No	Right leg loop rip	No	No	No	None
FROG05	4,896	No	Right leg loop rip	No	No	No	None
Treated							
FROG06	4,934	No	No	No	No	No	None
FROG07	4,881	No	No	No	No	No	None
FROG08	4,939	No	No	No	No	No	None
FROG09	4,921	No	No	No	No	No	None
FROG10	4,825	No	No	No	No	No	None

About the Authors

Wesley Throop (retired) was a project engineer at the National Technology and Development Program from 1999 to 2016. He previously worked at the Idaho National Laboratory's Advanced Test Reactor and on shipboard weapon-handling systems at the Puget Sound Naval Shipyard.

Gary Kees joined the National Technology and Development Program in 2002 as a project leader. He works in the Reforestation and Nursery, Forest Health, Facilities, Fire, and Global Positioning System (GPS) Programs. His current projects involve all-terrain vehicle and backpack sprayers, nursery equipment, and GPS accuracy testing. Kees, who has a degree in mechanical engineering from the University of Idaho, worked for 10 years as a mechanical and structural engineer, project manager, and engineering group leader for Monsanto Co., in Soda Springs, ID.

Library Card

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Keywords: caving, climbing harness, climbing rope, decontaminate, decontamination, EN 12277:2007, hot waterbath, white-nose syndrome

Contact Information

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Search NTDP <http://www.fs.fed.us/eng/pubs>

Forest Service and Bureau of Land Management employees can search NTDP documents, CDs, DVDs, and videos on their internal computer networks at:

Search MTDC <http://fsweb.mtdc.wo.fs.fed.us/search/>

Search SDTDC <http://fsweb.sdtdc.wo.fs.fed.us/>

—Photo courtesy of Marvin Moriarty, U.S. Fish and Wildlife Service

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