



GNSS AND LOCATION TECHNOLOGIES FOR LOGGING SAFETY

Cooperative agreement 5 U01 OH010841

Rob Keefe, Ph.D.

Associate Prof. of Forest Operations
Director and Forest Manager
University of Idaho Experimental Forest

OUTLINE

- Introduction
- Safety benefits of location-sharing in forestry
 - Avoidance*
 - Detection*
 - Response*
- Perceptions of location-sharing
- Discussion





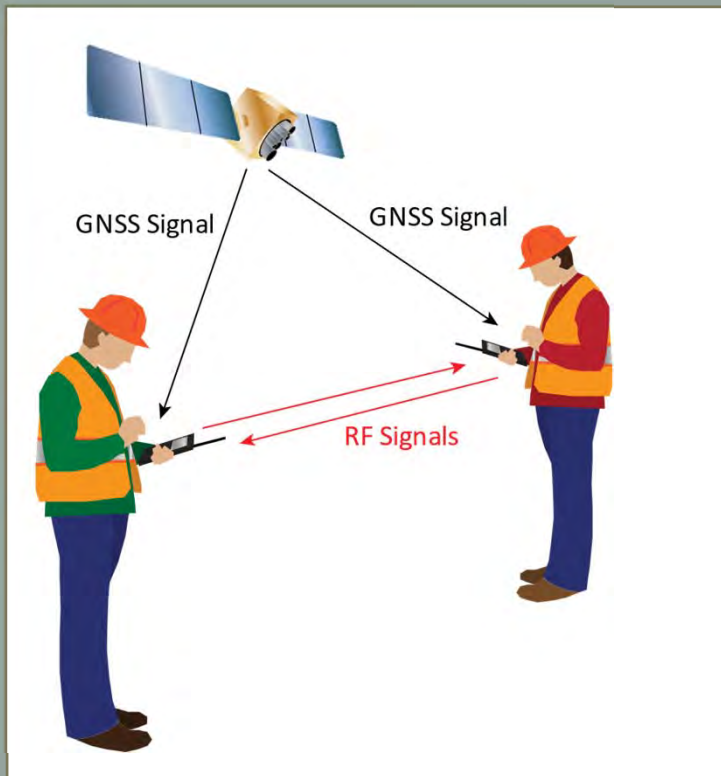




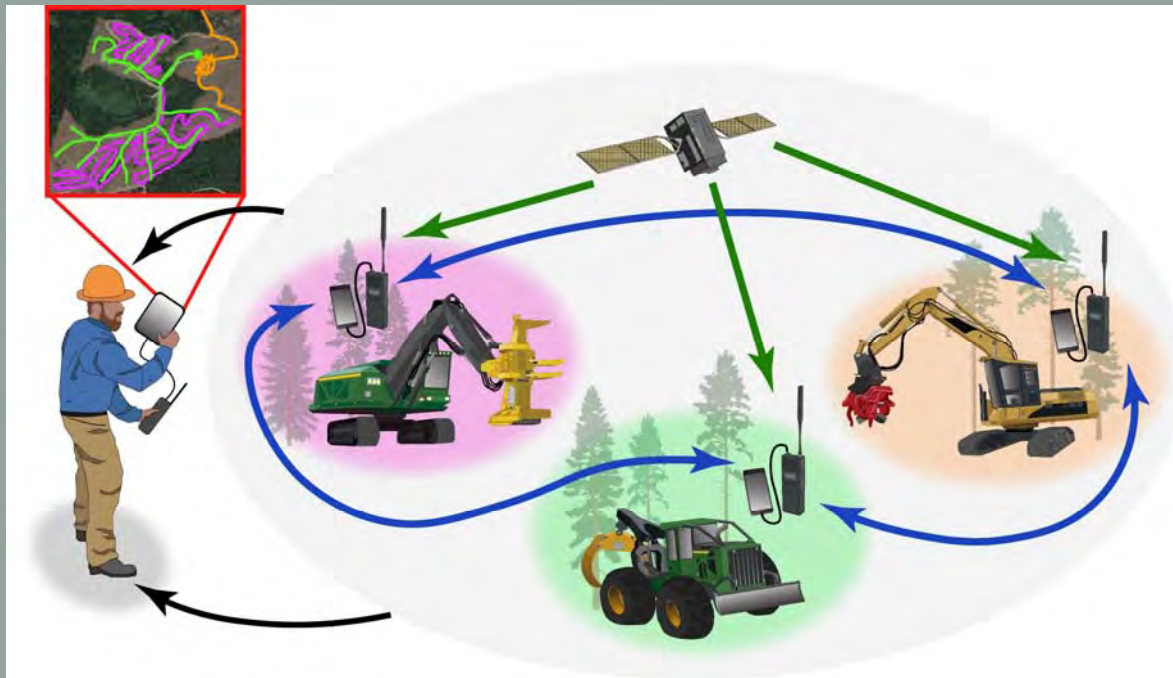




INCREASING SITUATIONAL AWARENESS



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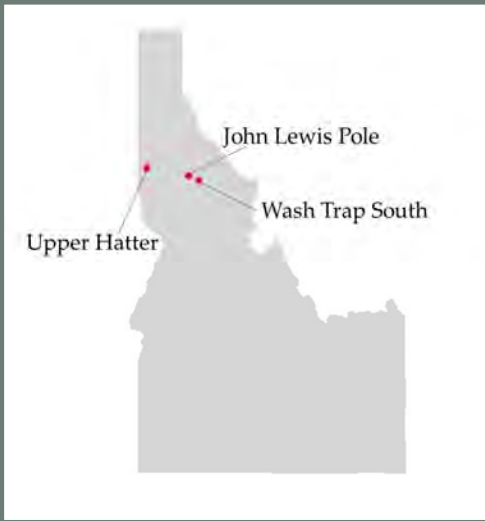
Keefe, R.F., Wempe, A.M., Becker, R.M., Zimbelman, E.G., Nagler, E.G., Gilbert, S.M. and C. Caudill. Positioning methods and the use of location and activity data in forests. *Forests*

LOCATION SHARING DEVICES

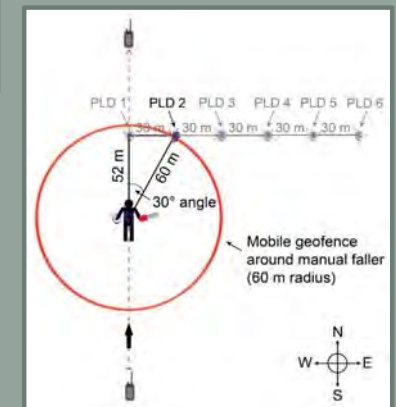
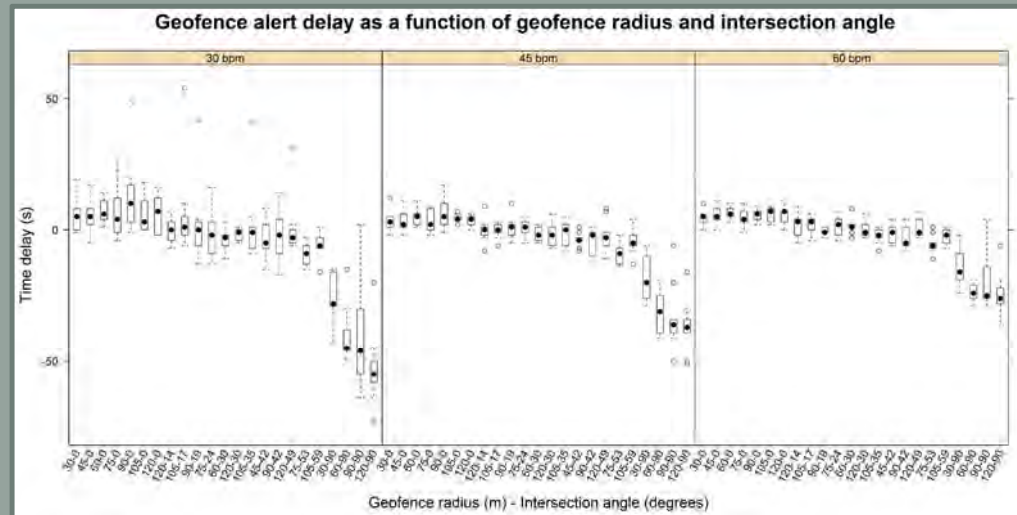
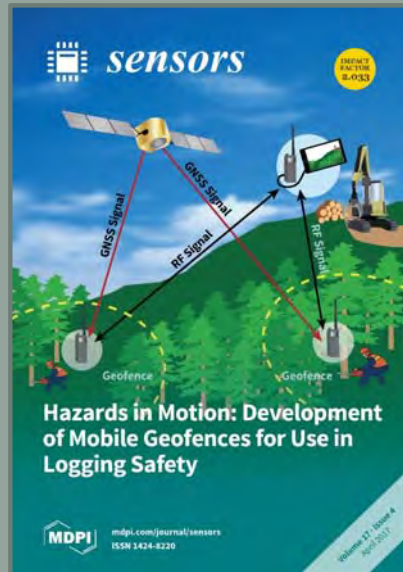


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AVOIDANCE: GEOFENCES



AVOIDANCE: GEOFENCES



Article

Hazards in Motion: Development of Mobile Geofences for Use in Logging Safety


Eloise G. Zimbelman *, Robert F. Keefe, Eva K. Strand, Crystal A. Kolden and Ann M. Wempe

AVOIDANCE: GEOFENCES



Article

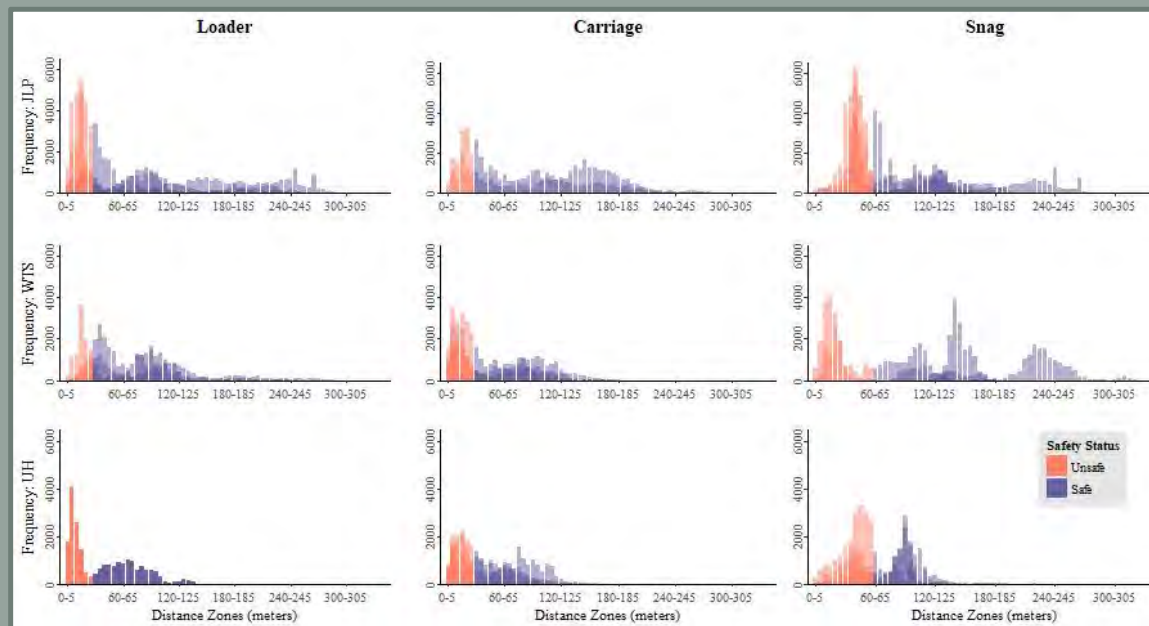
Characterizing Rigging Crew Proximity to Hazards on Cable Logging Operations Using GNSS-RF: Effect of GNSS Positioning Error on Worker Safety Status

Ann M. Wempe ⁺ and Robert F. Keefe 

AVOIDANCE: GEOFENCES



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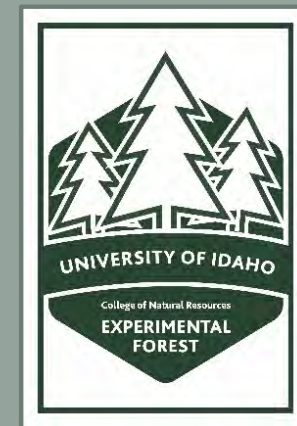
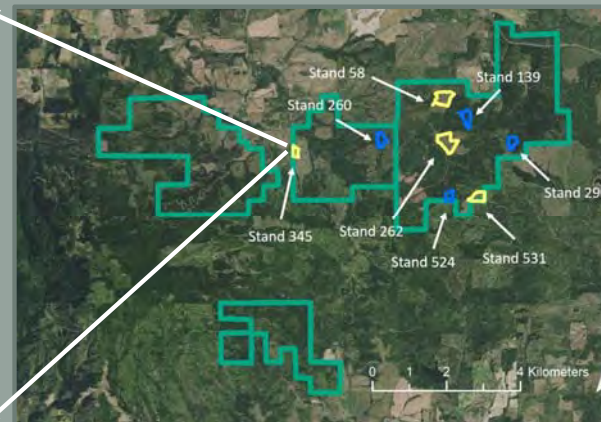
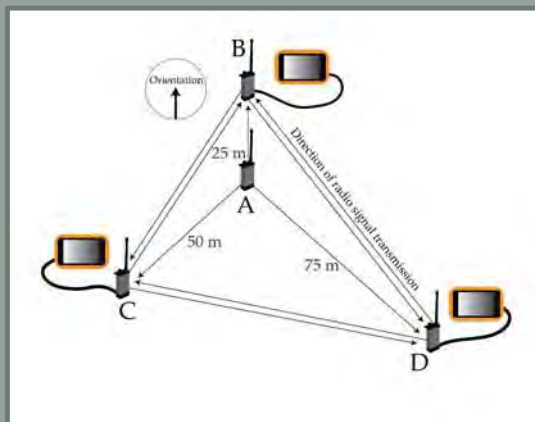


Article

Characterizing Rigging Crew Proximity to Hazards on Cable Logging Operations Using GNSS-RF: Effect of GNSS Positioning Error on Worker Safety Status

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Article

Characterizing Rigging Crew Proximity to Hazards on Cable Logging Operations Using GNSS-RF: Effect of GNSS Positioning Error on Worker Safety Status

Ann M. Wempe* and Robert F. Keefe

Table 1. Controlled experiment: University of Idaho Experimental Forest stand characteristics and sampling conditions.

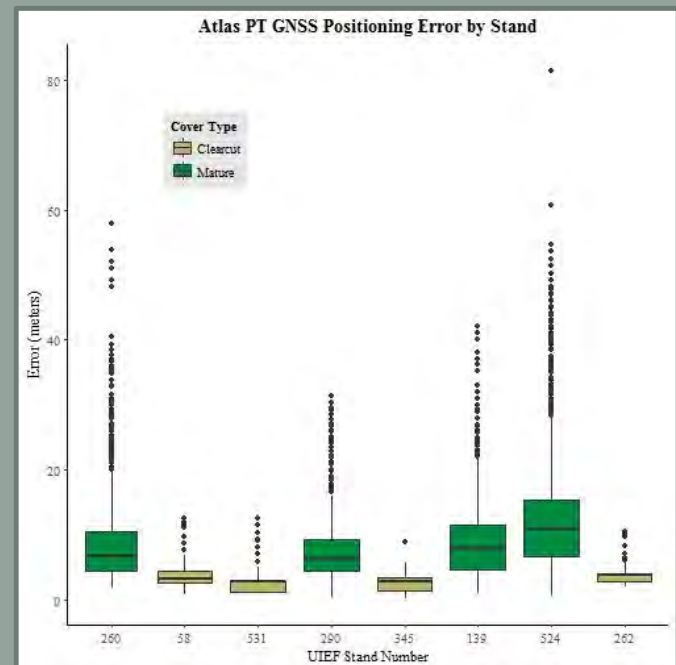
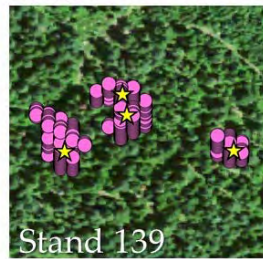
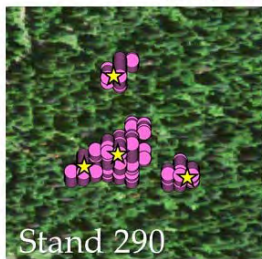
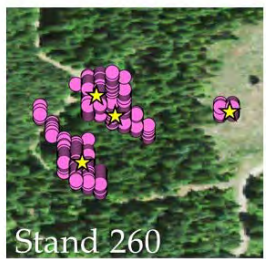
Stand	Cover	Mean Height (m)	Mean DBH (cm)	Azimuth (°)	Slope (%)	Date	Mean Satellites	Mean PDOP
260	Mature	23.52	33	95	37	10/12/16	7	1.6
58	Clearcut	NA	NA	352	18	10/17/16	8	1.3
531	Clearcut	NA	NA	165	35	10/19/16	8	1.4
290	Mature	14.6	25	35	5	10/19/16	7	1.5
345	Clearcut	NA	NA	130	8	10/24/16	10	1.3
139	Mature	16.7	31	347	43	10/24/16	6	1.6
524	Mature	17.3	31	27	14	11/10/16	6	1.7
262	Clearcut	NA	NA	205	2	11/17/16	8	1.2

AVOIDANCE: GEOFENCES

CLEARCUT



MATURE



AVOIDANCE: GEOFENCES

RESEARCH ARTICLE

Real-time positioning in logging: Effects of forest stand characteristics, topography, and line-of-sight obstructions on GNSS-RF transponder accuracy and radio signal propagation

Eloise G. Zimbelman^{*,}, Robert F. Keefe[™]

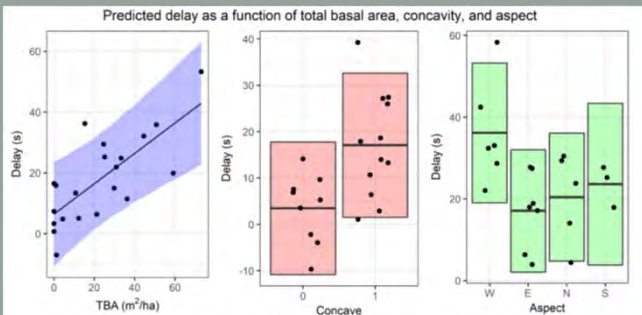


Fig 3. Mixed effects model predictions for geofence intersection alert delay. Predicted delay as a function of the three model variables (TBA, concave, and aspect). Predictions for each variable were made using the mean of the other predictors. 95% confidence intervals computed using the bootstrap are shown as colored bands. Points on each plot represent partial residuals.

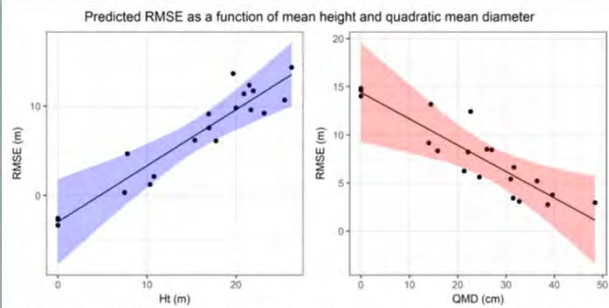
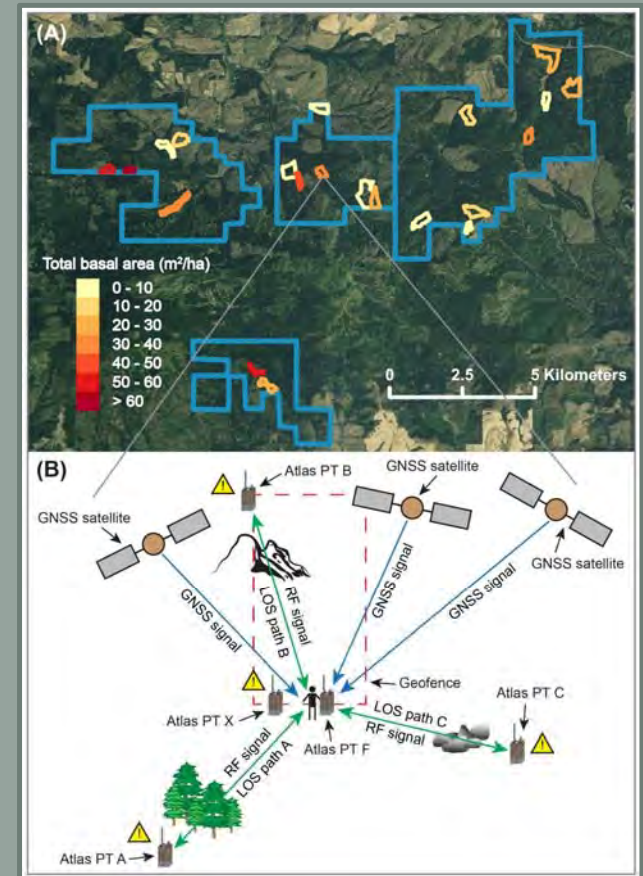


Fig 4. Mixed effects model predictions for PT RMSE. Predicted RMSE as a function of the two model variables (Ht and QMD). Predictions for each variable were made using the mean of the other predictor. 95% confidence intervals computed using the bootstrap are shown as colored bands. Points on each plot represent partial residuals.



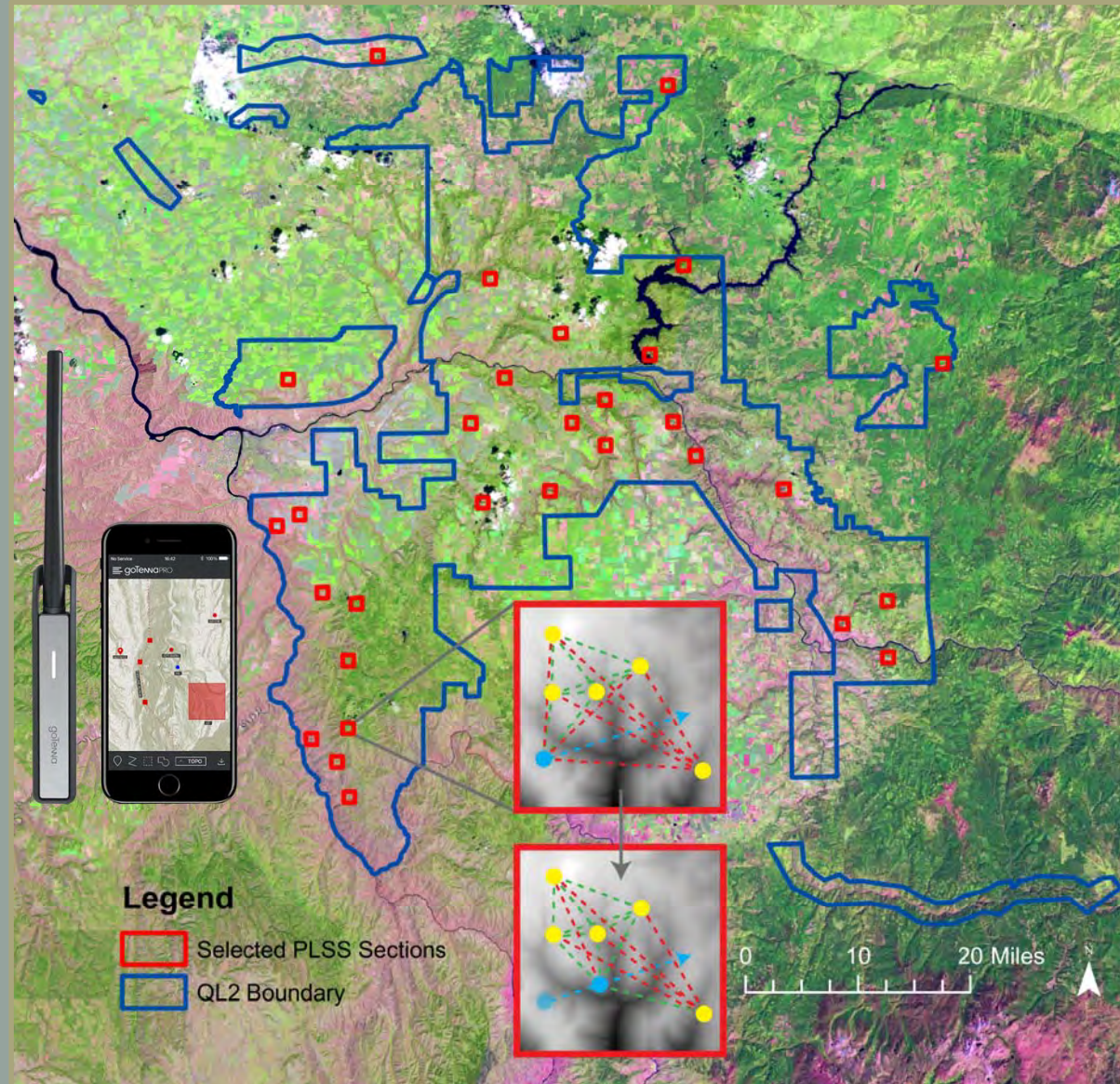
AVOIDANCE

Evaluating connectivity of smartphone-based mesh networks in irregular, forested terrain

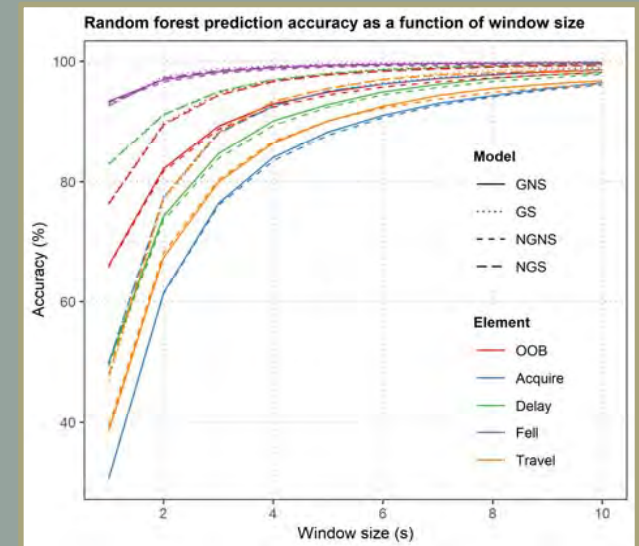
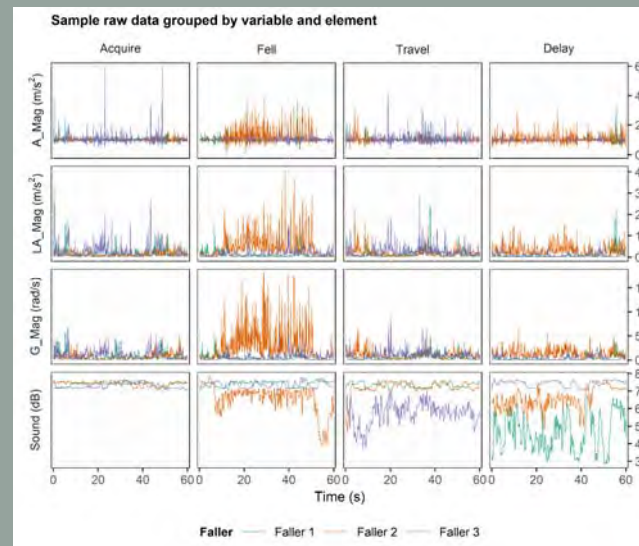
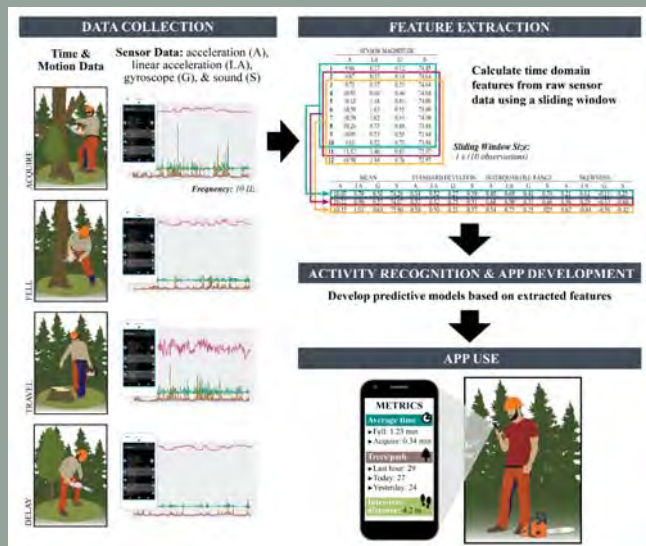
-30 Public Land Survey System (PLSS) sections: 1 mi² (260 ha)

-Selected based on LiDAR-derived rumple index (ratio between surface area and projected area)

- Exclude sections with rumple indices > 1.2 (limited accessibility) and sections that aren't within 10% of 260 ha
- Ranges from 1.00286–1.199872, divide into 5 categories and randomly select 6 sections from each



DETECTION: ACTIVITY RECOGNITION

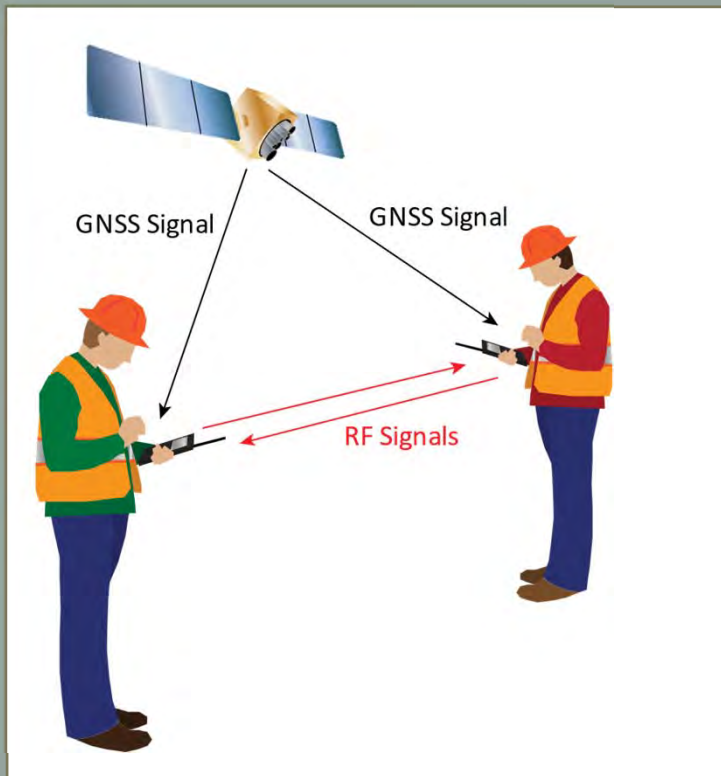


Use of smartphone sensors to quantify the productive cycle elements of hand fallers on industrial cable logging operations

Robert F. Keefe , Eloise G. Zimbelman and Ann M. Wempe

Department of Forest, Rangeland and Fire Sciences, University of Idaho, Moscow, ID, USA

RESPONSE



CONTRACTOR PERSPECTIVES



The faller could definitely see where the other guy that's working with him is, knows how far away he is.

People could notice that he's been sitting in the same spot for 15 minutes and the dot hasn't moved. We need to get over there and check on him.

The [yarder] operator a lot of times can't see his hookers down on the ground in the bottom of the strips. So yeah, I do think [GPS] could be beneficial in some areas. Particularly the line skidding operations.

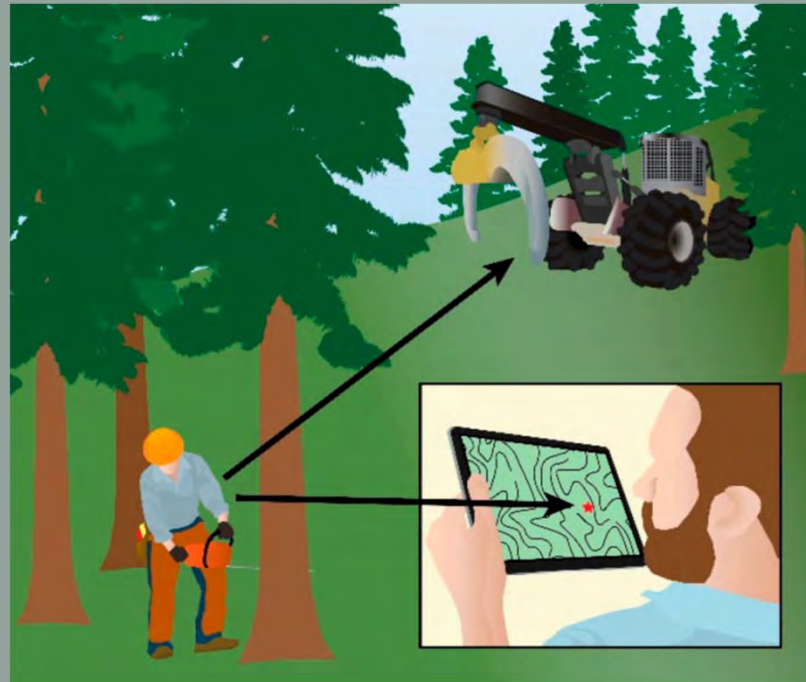
I'm sure there's been times that a buncher has fell timber a little closer to the skidder than what should be happening.

Article

Human Factors Affecting Logging Injury Incidents in Idaho and the Potential for Real-Time Location-Sharing Technology to Improve Safety

Soren M. Newman ^{1,*}, Robert F. Keefe ², Randall H. Brooks ², Emily Q. Ahonen ³ and Ann M. Wempe ²

CONTRACTOR PERSPECTIVES



Article

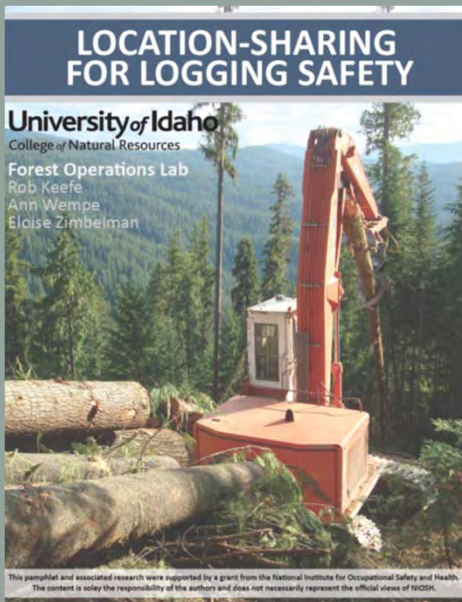
Intent to Adopt Location Sharing for Logging Safety Applications

Ann M. Wempe ¹, Robert F. Keefe ^{1,*}, Soren M. Newman ² and Travis B. Paveglio ³

CONTRACTOR PERSPECTIVES

LOCATION-SHARING FOR LOGGING SAFETY

University of Idaho
College of Natural Resources
Forest Operations Lab
Rob Keefe
Ann Wempe
Eloise Zimbelman



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WHAT IS LOCATION-SHARING?

Location-sharing devices can determine where they are from groups of satellites in the Global Navigation Satellite System (GNSS), such as the United States' Global Positioning System (GPS). They can then share their position with other mobile devices through cellular networks, satellite data communication, or radio transmission.

Finding Your Location

Satellites communicate via microwaves, which travel to Earth at the speed of light. Positioning devices receive these signals and determine the amount of time the signals traveled. With speed and time, a device can calculate its distance from the satellite's position. Knowing distances from multiple satellites allows the device to tell you where on the Earth's surface you are located.

Sharing Your Location

Your location can be shared with others through a radio frequency (RF) transmission and then mapped on a mobile device, such as a tablet or smartphone, so others can see where you are. GNSS-RF communication does not require cellular networks or an internet connection, so these location-sharing devices can be used off the grid in remote areas, making them useful for forestry applications.

For more information contact: Rob Keefe
robk@uidaho.edu • (208) 885-0749
University of Idaho

LOCATION-SHARING & LOGGING SAFETY

Where is everyone?

Loggers could use location-sharing technology with a mobile device, like a smartphone or tablet, to see the real-time locations of workers or equipment on a harvest map. Location sharing can help increase situational awareness of where everyone is in case of emergency.

When do people need help?

Many location-sharing devices allow users to send alerts when they need help, or devices may be able to send an automatic warning under certain conditions, such as when someone has not moved in a long time and may be hurt.

When are people near hazards?

Some devices are able to use virtual boundaries known as geofences to mark dangerous areas on logging operations and send alerts when someone has moved into a geofenced area. For example, workers could receive a warning when they approach within two tree lengths of a hand faller, or when a member of the rigging crew is underneath the skyline carriage. The accuracy of geofences in forested environments varies widely among available devices and technology, so use of proximity alerts for these kinds of safety applications should be used with caution. The most important safety benefit of location sharing is usually just being able to see the approximate, current positions of fellow crew members and equipment.

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LOCATION-SHARING DEVICES

	Beartooth	Mesh goTenna	Sonnat	Garmin Rino 750	Ravenon Atlas PT	TrellisWare Ghost	Garmin InReach SE*	SPOT Gen3*
Requires mobile device	✓	✓	✓	✓	✓	✓	✓	✓
SOS	✓	✓	✓	✓	✓	✓	✓	✓
Texts	✓	✓	✓	✓	✓	✓	✓	✓
Voice	✓	✓	✓	✓	✓	✓	✓	✓
Images	✓	✓	✓	✓	✓	✓	✓	✓
Videos	✓	✓	✓	✓	✓	✓	✓	✓
Position update	manual	manual	30 sec	manual	1 sec	2-3 sec	2-10 min	2.5 min-1 hr
Geofencing	✓	✓	✓	✓	✓	✓	✓	✓
Mesh networking	✓	✓	✓	✓	✓	✓	✓	✓
Battery life	4 days	24 hrs	24 hrs	14-18 hrs	24 hrs	9 hrs	75-100 hrs	10+ days
Range**	1 mi (400) 50 mi (Sat)	3-8 mi (Mesh) 15-18 mi (Sat)	0.5-4 mi	20 mi	30 mi	20 mi (Mesh) 18 mi (Sat)	global	global
Price	~\$250-2	~\$80-2 ~\$400-10	~\$180-2 ~\$300-10	~\$50	~\$1,800	~\$4,200	~\$400 + monthly subscription	~\$170 + service plan

*satellite based communication
**advertised ranges - actual ranges will vary

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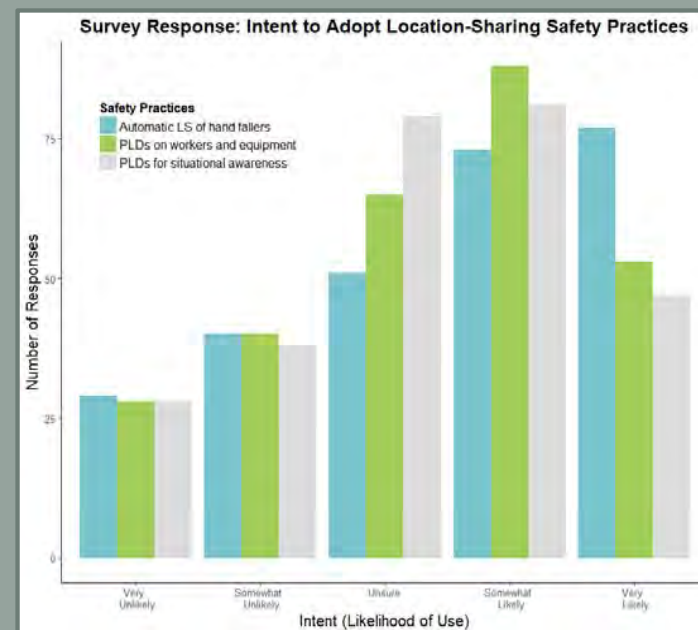
Article

Intent to Adopt Location Sharing for Logging Safety Applications

Ann M. Wempe¹, Robert F. Keefe^{1,*}, Soren M. Newman² and Travis B. Paveglio³

CONTRACTOR PERSPECTIVES

		Response Percentage (%)		
		No	Unsure	Yes
Previous use of LS devices				
Emergency receivers (n=271)		91.5	1.8	6.6
2-way radios (n=270)		79.3	1.1	19.6
Smartphone receivers (n=271)		87.8	1.1	11.1
Improvement to safety by device				
Emergency receivers (n=263)		16.0	20.5	63.5
2-way radios (n=269)		8.6	12.6	78.8
Smartphone receivers (n=272)		14.0	14.0	72.1
Improvement to safety by feature				
Hazardous area alerts (n=277)		11.9	11.2	76.9
Automatic updates to coworkers (n=275)		13.1	14.2	72.7
Automatic updates to supervisors (n=271)		47.2	18.8	33.9
Help button to coworkers (n=275)		7.3	9.5	83.3
Help button to supervisors (n=274)		24.1	13.5	62.4
Help button to emergency services (n=276)		8.3	12.7	79.0
Messaging (n=273)		12.8	15.0	72.2
Privacy concerns associated with LS				
Coworkers (n=276)		72.5	8.7	18.8
Supervisors (n=273)		56.0	11.4	32.6
Smartphone ownership (n=279)		27.6	NA	72.4



Article

Intent to Adopt Location Sharing for Logging Safety Applications

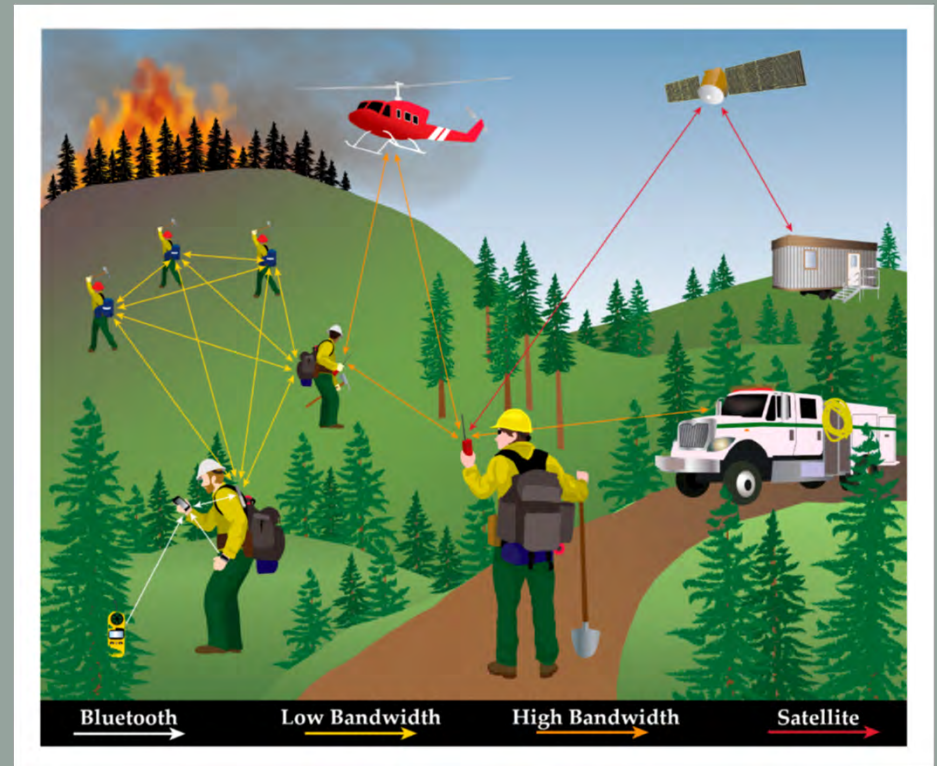
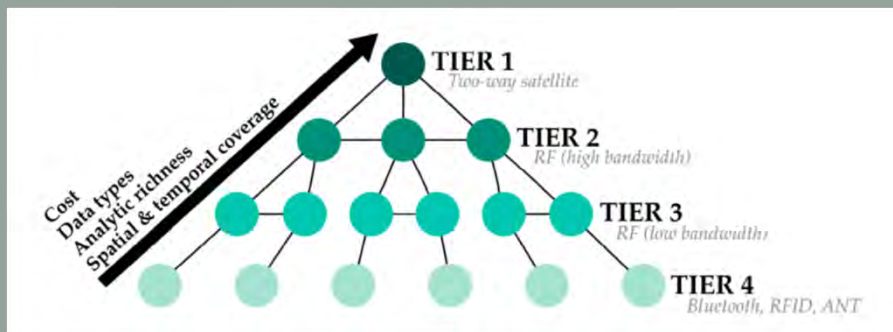
Ann M. Wempe ¹, Robert F. Keefe ^{1,*}, Soren M. Newman ² and Travis B. Paveglio ³

DISCUSSION

1. Accuracy, data rates, device size, etc. depend on application (prevention, detection, response)
2. GPS/GNSS-based solutions for *prevention* should be used for broad situational awareness and not for detailed proximity alerts in the woods
3. Good support among loggers for technology-based solutions to improve safety. We have a very positive, continuing dialog among researchers and contractors
4. Integration of location and activity data into digital health may be useful for increasing SA to improve safety in rural occupations
5. Commercially available mesh RF and satellite devices are useful solutions for different applications— Both are evolving quickly



DISCUSSION



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QUESTIONS?

Rob Keefe, Ph.D.

Associate Professor of Forest Operations

Director and Forest Manager, UI Experimental Forest

Moscow, ID, 83844-3322

robk@uidaho.edu

(208) 310-0269



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*Reducing logging fatality and non-fatal trauma incidence rates with new real-time operational
GPS-RF communications and safety procedures.***

***Contributors include, among others, Eloise Zimbelman, Ann Wempe, Soren Newman, Jan Eitel, Travis
Paveglio, Emily Nagler, Eva Strand, Crystal Kolden, and Randall Brooks***