Determining the Implementation Costs of Best Management Practices on Family Forests in the Northern Forest

Principal Investigator: René Germain
Affiliation/Institution: SUNY-ESF
Email: rhgermai@esf.edu
Address: 1 Forestry Drive, Syracuse, NY 13210
Completion date: January, 2016

BMP costs ranged from $0 to $62/ac, based on results from eight case studies and a survey of 112 loggers. The case studies showed a reduction in harvest productivity due to BMPs from 0 to 9%, while the high level of BMP requirements described in the survey produced 20% loss in productivity, on average. Crew size, equipment mix, and specific BMP requirements influence impacts of BMPs on logging operations.

Funding support for this project was provided by the Northeastern States Research Cooperative (NSRC), a partnership of Northern Forest states (New Hampshire, Vermont, Maine, and New York), in coordination with the USDA Forest Service.
http://www.nsrcforest.org

Project Summary

Forestry best management practices to protect water quality (BMPs) effectively reduce erosion and sediment transport during and immediately following forest harvest operations. BMPs help maintain healthy aquatic habitats, clean drinking water supplies, and reusable skid trails and forest roads. The costs of implementing BMPs are typically incurred by loggers in the form of equipment and labor costs. Additional costs may be incurred where BMPs extend harvest operations and reduce system productivity.

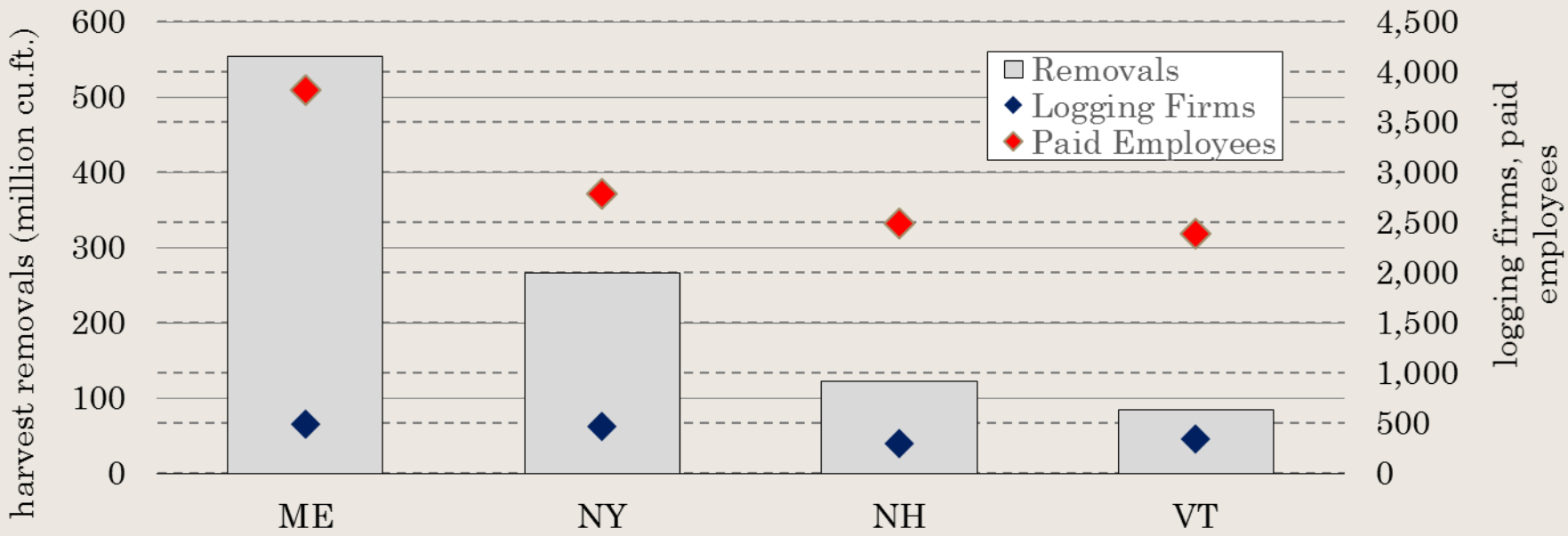
Two distinct methods were used to better understand how BMPs impact logging operations throughout the Northeast U.S. First, shift-level production and activity data were collected and analyzed in combination with machine rate calculations to determine the amounts of time spent on BMPs and the associated costs for eight harvest operations conducted throughout the region. Second, a survey of logging business owners and crew supervisors was conducted to assess how BMP requirements affected logging productivity using a paired timber sale approach. Survey respondents were asked to estimate the number of days required to complete a hypothetical harvest with and without BMPs and to indicate the minimum contract rates they were willing to accept for each.

Overall, costs ranged from $0/ac to $62/ac and depended on the specific BMP requirements, machine costs, level of mechanization, and crew size. The results of this study will inform loggers, extension specialists, cost-share programs, and, importantly, practicing foresters who represent landowners and mills.

Background and Justification

- Logging businesses of the Northern Forest states are . . .
  - a critical link in the wood supply chain.
  - positive contributors to local, state, & regional economies.
  - a means for achieving landowner objectives.

- 779 logging firms, 3,843 employees, harvested over 1 billion cu.ft. (2014)



Data: US Census Bureau. 2014. County Business Patterns. Retrieved from http://www.census.gov/programs-surveys/cbp.html
USDA Forest Service. 2014. Forest inventory and analysis. Retrieved from: http://apps.fs.fed.us/fia/fido/index.html

Background and Justification

- The business of logging is . . .
  - Capital intensive
  - Vulnerable to market/price fluctuations
  - Sometimes profitable, sometimes not [1]

- BMPs are . . .
  - Encouraged under the Clean Water Act
  - Proven to be effective [2]
  - Often voluntary
  - Being implemented at high rates nationally (91%) [3]

[1] Germain, R., S. Bick, M.C. Kelly, J. Benjamin, and W. Farrand. 2016. A case study of three high-performing contract loggers with distinct harvest systems : Are they thriving, striving or just surviving? *Forest Products Journal*. 66(1/2): 97-105.

[2] Cristan, R., W.M. Aust, M.C. Bolding, S.M. Barrett, J.F. Munsell, and E. Schilling. 2016. Effectiveness of forestry best management practices in the United States: Literature review. *Forest Ecology and Management*. 360:133–151.

[3] National Association of State Foresters [NASF]. 2015. *Protecting water quality through state forestry best management practices*. Available online at: www.stateforesters.org. 8 p.

Background and Justification

- BMP Costs Literature:
  - $26/ac in 2014 dollars in US south [4]
  - $12 - $75/ac in 2014 dollars in Virginia [5]
  - 52% of survey respondents reported logging cost increases of 1 – 9% due to BMPs in Minnesota [6]

- Limitations in the literature:
  - No studies done in Northeast
  - Methods often rely exclusively on surveys (no ground truthing)
  - Focus has been on effects of BMPs on increasing costs, no attention to effects on reduced productivity

[4] Lickwar P, Hickman C, Cubbage FW. 1992. Costs of protecting water quality during harvesting on private forestlands in the southeast. *Southern Journal of Applied Forestry*. 16(1):13–20.

[5] Shaffer RM, Hanley HL, Worrell EG, Aust WM. 1998. Forestry BMP implementation costs for Virginia. *Forest Products Journal*. 48(9):27–29.

[6] Blinn CR, Alden A, Ellefson PV. 2001. Timber harvester perceptions of costs and benefits from applying water quality BMPs in North-central USA. *Journal of Forest Engineering* 12(1): 39-51.

Methods

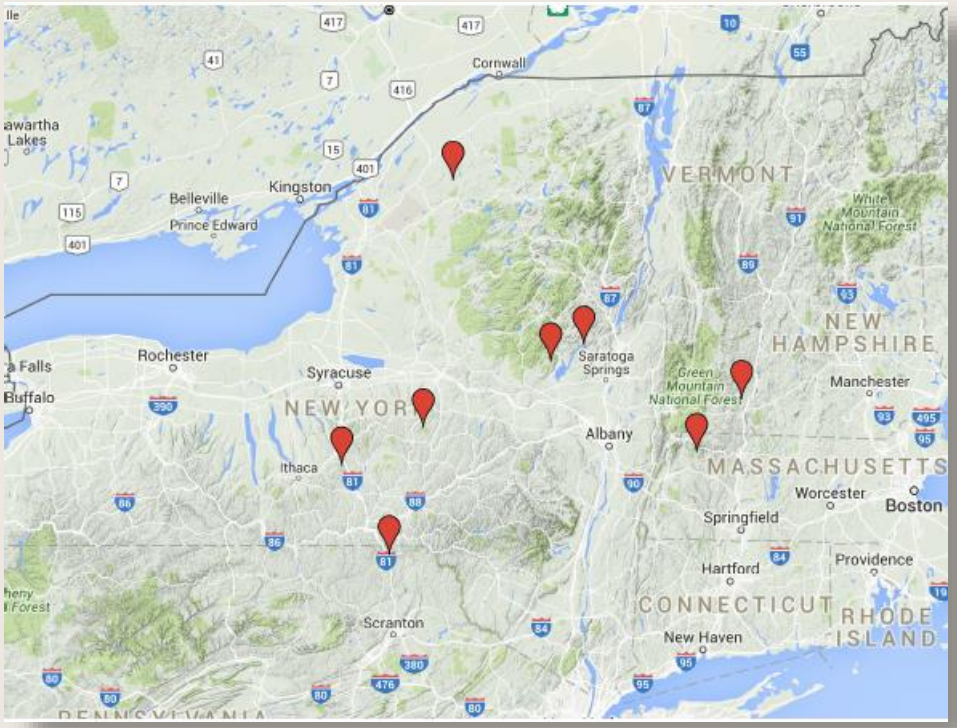
Objective: Assess impacts of BMPs on logging productivity and costs for harvest operations typical of Northeast USA

Method 1: Series of case studies using time study methods.

Method 2: Logger survey - willingness to accept contract rates for a timber sale with and without BMP requirements

Method 1: Case Studies

- 8 logging crews participated.
- Each was recommended by one or more foresters or other industry professionals.
- Each had at least one crew member who completed a logger training certification program.
- Study sites in NY, VT, PA & MA



Method 1: Case Studies

- Loggers record daily production, activities, and delays (including BMPs) throughout an entire harvest.
- Machine data (purchase price, make, model, year, etc.) collected.
- Data used to calculate logging costs following Miyata (1980) and productivity.

DAILY PRODUCTION

General Information

Date	_____	Operator	_____
Property/Unit	_____	Start time	_____
Weather: sunny cloudy rainy		End time	_____
Temperature (°F)	_____	Break time	_____

Terrain (circle one for each)

Slope:	*gentle (0-9%)*	*moderate (10-20%)*	*steep (>20%)*
Rockiness:	*mild*	*moderate*	*very rocky*
Wetness:	*dry*	*somewhat wet*	*very wet*

Chainsaw

Total # of sale trees	_____	*trees*
Avg. diameter at stump (in)	_____	*inches*
Total # of logs bucked	_____	*logs*
Time on chainsaw (nearest ¼ hour)	_____	*hours*

Skidder

Total hitches/turns	_____	*hitches*
Avg. skid distance	_____	*feet*
Time skidding (nearest ¼ hour)	_____	*hours*
Fuel consumed	_____	*gallons*
Total volume skidded:	_____	*bdft (sawtimber)*
	_____	*cords (firewood, pulp)*
	_____	*tons (pulp, biomass)*

Slasher/Loader

Total logs bucked and decked	_____	*logs*
Time spent bucking and decking (nearest ¼ hour)	_____	*hours*
Total truck loads loaded	_____	*loads*
Time spent loading (nearest ¼ hour)	_____	*hours*

Delays (greater than 10 minutes)

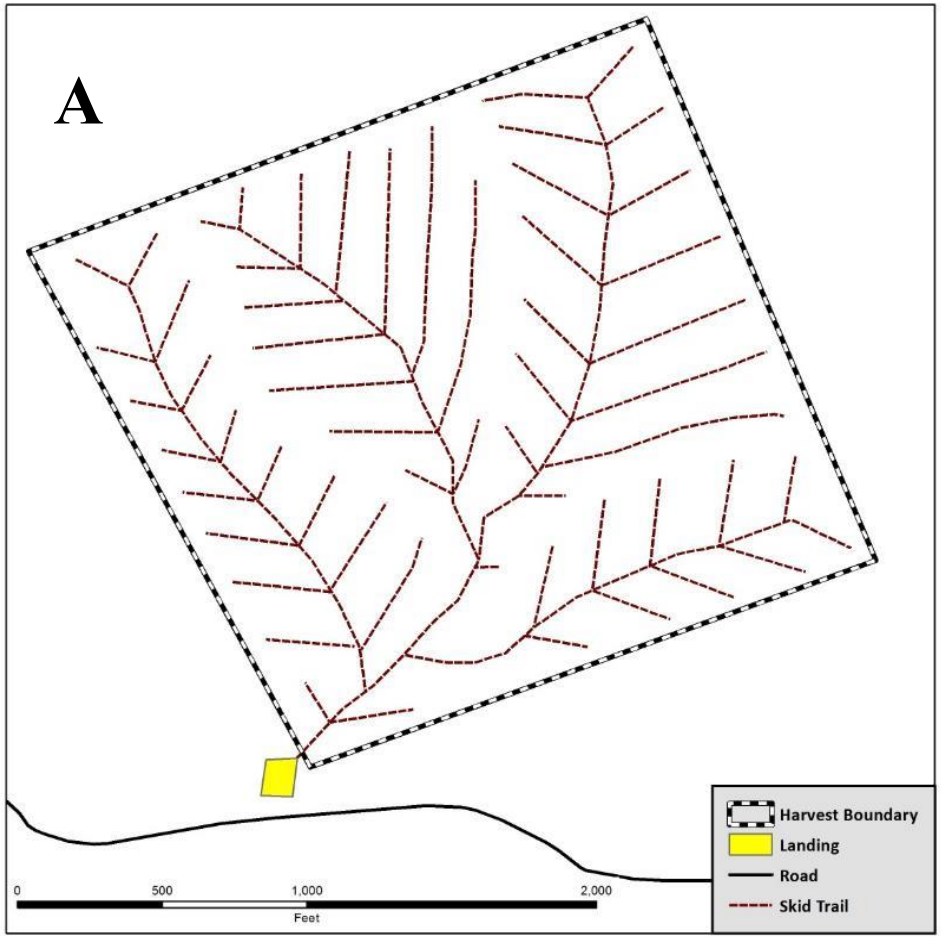
Minutes	Type* (circle one)	Description of Delay
	Maintenance Mechanical Personal BMP Other	

Method 2: Logger Survey

- Administered at 10 logger workshops / training courses throughout New York, Vermont, and Maine.
- Also, administered at the NYLT / Watershed Agricultural Council Forestry booth at the 2014 NYS Woodsmen's Field Days event in Booneville, NY.
- 123 surveys were completed, but 10 were discarded as grossly incomplete, leaving 113 for analysis.
- Basic questions regarding:
  - Years experience
  - Typical crew size
  - Typical equipment mix
  - % of annual production based on contract work vs. purchased stumpage

Method 2: Logger Survey

Loggers asked to consider Harvest A and answer the two questions below



Harvest A information

- 100 acres
- marked for crown thinning
- northern hardwoods (maple/birch)
- 150 MBF (1,300 tons) of sawtimber
- 400 cords (1,200 tons) of low-grade (pulp, chips, firewood)
- 20 miles from your home/office to site
- average tree diameter = 18 inches
- average skid distance = 1500 feet

BMP Requirements

None

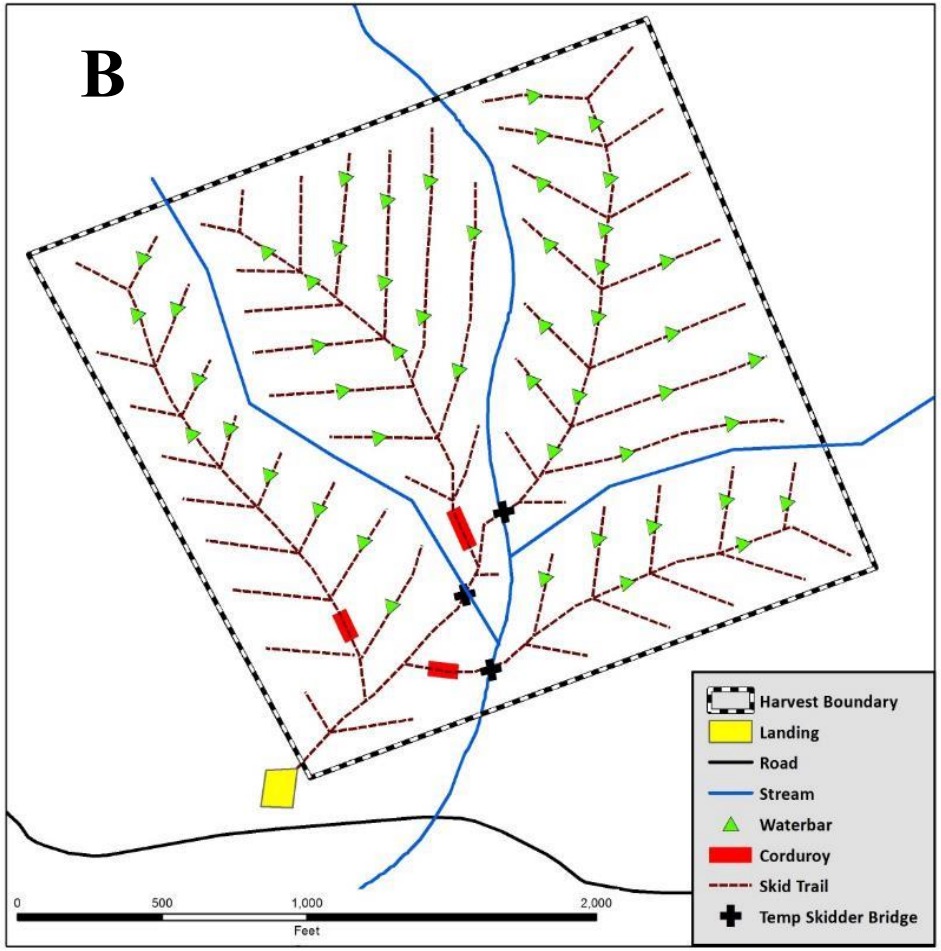
1. How many days would it take you and your typical crew to complete this harvest? _____ days

2. What is the minimum contract rate you would be willing to accept for this job?

_____ $/MBF
_____ $/ton
_____ $/cord

Method 2: Logger Survey

Loggers asked to consider Harvest B (w/ BMPs) and answer the same two questions. Differences between the two sets of questions indicate the expected impact on productivity and the amounts loggers need to be compensated.



Harvest B information

- Same as Harvest A (no change)

BMP Requirements

- 3 stream crossings: 20-foot temp skidder bridge, install and remove at closeout
- seed and mulch 25-ft back from crossings at closeout
- re-shape stream banks at crossings
- 3 wet sections of skid trail require corduroy (total = 150 ft)
- 50 waterbars to be installed

1. How many days would it take you and your typical crew to complete this harvest? _____ days

2. What is the minimum contract rate you would be willing to accept for this job?

_____ $/MBF
_____ $/ton
_____ $/cord

Results: Case Study

Case study analysis based on data from:

- 8 harvests
- 249 workdays
- 3991 worker hours
- Variety of harvest systems

Results: Case Study

	harvest 1	harvest 2	harvest 3	harvest 4	harvest 5	harvest 6	harvest 7	harvest 8
equipment mix	chainsaw	chainsaw	chainsaw	chainsaw	chainsaws	f. buncher	harvester	chainsaws
	cable skid	grapple skid	grapple skid	cable skid	forwarder	grapple skid	forwarder	grapple skid
	dozer	slash/load	slash/load	slash/load		slash/load		cable skid
				dozer		truck/trailer		slash/load
crew size	1	1	1	2	1 to 5	3	2	3 to 5
treatment	thin / TSI	shelterwood	thin	thin	thin	shelterwood	clearcut / thin	shelterwood
acres (approx.)	20	70	90	30	40	200	25	110
avg skid dist. (ft)	625	1,678	1,374	1,262	1,700	356	800	2668
landings (moves)	3	1	2	1	1	3	1	1
avg tree diam. (in)	12.5	14.9	17.4	13.9	22.6	16	12	17
total volume (ft^3)	7,603	43,934	43,220	13,334	25,833	76,512	52,360	56,525
total cost ($)	$10,440	$24,577	$26,958	$12,220	$38,362	$90,985	$21,191	$43,585
daily cost ($/day)	$475	$1,024	$509	$764	$852	$1,716	$1,766	$1,503
days to complete	22	24	53	16	45	48	12	29
ft^3/hr	52	184	116	115	70	183	668	245
$/$ft^3$	$1.37	$0.56	$0.62	$0.92	$1.44	$1.19	$0.40	$0.77

Harvests varied in crew size, equipment mix, harvest size, productivity and costs

Results: Case Study

Delay factors were calculated for the various delay types (i.e. maintenance, mechanical breakdown, personal, other, BMP) for each harvest as follows:

$$DF_i = \frac{\sum D_{10i}}{\sum PMH}$$

Where,

DF_i = delay factor for delay category i
D_{10i} = delay > 10 min for category i
PMH = productive machine hours

Results: Case Study

	delay factor (%)				
Harvest	D_{10} maint	D_{10} mech	D_{10} pers	D_{10} BMP	D_{10} other
1	2.3	2.8	0	14.3	**32.0**
2	0.9	0	0	**3.8**	0.5
3	**3.6**	2.4	0	0.6	2.8
4	0.4	0	0.3	1.8	**7.7**
5	4.6	3.1	0	1.5	**9.9**
6	**7.8**	7.2	0.3	3.8	6.1
7	**5.3**	4.2	0	0	1.5
8	0.5	**9.1**	0	0.5	3.1
Mean	3.18	3.60	0.08	3.29	**7.95**
(SD)	(2.64)	(3.20)	(0.14)	(4.68)	**(10.23)**

BMP delay factors ranged from 0% to 14.3%, with a mean of 3.29%. However, BMPs resulted in the greatest delay factor for only one of the eight harvests, while Maintenance and Other delays were greatest for 3 harvests each.

Results: Case Study

	Harvest									
	1	2	3	4	5	6	7	8	Mean	SD
BMP Hrs/acre	0.60	0.12	0.02	0.08	0.32	0.66	0	0.04	0.2	0.22
reduction in productivity due to BMPs (%)	9.4	3.6	0.5	0	1.2	0	0	0	1.8	3.29

BMPs impacted productivity of harvests 1, 2, and 3 because these were each conducted by a single logger who single-handedly carried out each element of the harvest. Therefore, any time spent on BMPs extended harvest time.

In contrast, Harvest 6 spent considerable amount of time on BMP implementation, however the larger crew size (3) allowed for one logger to operate a slasher/loader and implement BMPs in the same amount of time required of the fellerbuncher and grapple skidder operators to complete their work. Therefore, Harvest 6 productivity was not affected by BMPs.

Results: Case Study

	Harvest									
	1	2	3	4	5	6	7	8	Mean	SD
total BMP cost ($)	827	888	146	243	824	2,424	0	257	700.97	778.60
% of delay-free cost	10.7	4.2	0.5	2.2	2.4	2.9	0	0.6	2.9	3.44
$/ft^3	0.11	0.02	0.003	0.02	0.03	0.03	0	0.01	0.027	0.0355
$/ac	36	13	2	6	27	43	0	3	16.30	16.82

BMP costs were calculated by multiplying the machine rate of the machine that was used to implement the BMPs ($/hr) by the number of hours spent on BMPs.

If it was determined that BMPs extended the harvest, additional daily overhead costs were added to the total BMP costs.

Costs ranged from $0/ft^3 to $0.11/ft^3 and from $0/ac to $43/ac

Results: Logger Survey

Descriptive statistics

Factor	(%)	Med	Min	Max
Years in logging (*n* = 112)		25	1	47
Typical crew size (*n* = 109)		2	1	10
% of annual volume from contract work* (*n* = 103)		50	0	100
Role in company = owner or crew supervisor (*n* = 111)	92			
Typical equipment mix (*n*=111)				
Fully mechanized system	53			
Cut-to-length system (subset of fully mechanized)	17			
Conventional hand-felling system	67			
Dozer included	63			
Chipper included	24			

* vs purchased stumpage

Results: Logger Survey

Harvest A (no BMP)

Harvest A variable	Med	Range	*n*
Days to complete	32.5	5 - 178	106
Min. sawtimber rate ($/MBF)	160	100 - 250	93
Min. low-grade rate ($/ton)	22	5 - 50	72
Min. low-grade rate ($/cord)	55	5 - 110	51
Daily revenue ($/day)	1,409	44 - 9,300	100

Results: Logger Survey

Harvest B (with BMPs)

Harvest B variable	Med	Range	*n*
Days to complete	46.5	6 - 225	99
Min. sawtimber rate ($/MBF)	186	120 - 350	92
Min. low-grade rate ($/ton)	27	5 - 50	70
Min. low-grade rate ($/cord)	65	5 - 113	51
Daily revenue ($/day)	1,260	32 - 8,525	94

Results: Logger Survey

Difference between A & B

Variable	Med	Range	*n*
Days to complete	6.0	0 - 70	97
Min. sawtimber rate ($/MBF)	20	0 - 75	86
Min. low-grade rate ($/ton)	3	0 - 20	70
Min. low-grade rate ($/cord)	6.5	0 - 85	50
Daily revenue ($/day)	-100	-1,864 - 429	93
Daily revenue change (%)	-8.3	-56.6 - 31.3	94

* vs purchased stumpage

Implications and applications in the Northern Forest region

- BMPs requirements vary from site to site, and thus BMP costs will vary (from $0/ac to $62/ac).
- Loggers are encouraged to monitor the time and resources they spend on BMPs. This will help them better anticipate BMP costs for future harvests.
- Loggers are often squeezed between landowners and mills, and end up incurring costs. Loggers should be empowered to negotiate stumpage and contract rates based on BMP requirements.
- Fair compensation for BMPs will deter loggers from cutting corners. This is important especially where BMPs are voluntary.
- Effects of BMPs on productivity are greatest for single-logger operations.
- Subcontracting close-out operations with a dozer owner/operator could be a viable option for some business owners.

Future directions

- The use of on-board computing technology will improve the resolution of time and activity data collected during harvest operations. Future research should look at time spent on BMPs over multiple harvests by the same crews over the course of a year or longer. On-board computing technologies will allow for this level of data collection.

List of products

Publications:

- Kelly, M.C., Germain, R.H. and S. Bick. *In revision.* Impacts of best management practices on logging costs and productivity in the Northeast USA. Journal of Forestry.
- Kelly, M.C. and R.H. Germain. *In revision*. Is it efficient to single-handedly run a multi-machine harvesting operation? A case study from the Northeast United States. International Journal of Forest Engineering
- Kelly, M.C. 2015. Logging operations of the Northeast United States: Assessing harvest costs, productivities, delays, management strategies, and impacts of best management practices. State University of New York College of Environmental Science and Forestry, PhD Dissertation. 202 p.

Presentations/posters

- Kelly, M.C. and R.H. Germain. 2016. Impacts of best management practices to protect water quality on logging costs and productivity. Society of American Foresters National Convention. Madison, WI, November. (presentation)
- Kelly, M.C. and R.H. Germain. 2016. Impacts of best management practices to protect water quality on logging costs and productivity. International Symposium of Society and Research Management. Houghton, MI, June 23. (presentation)
- Kelly, M.C. and R.H. Germain. 2015. Impacts of best management practices on logging productivity in the Northeast US. New York Society of American Foresters Annual Meeting. Syracuse, NY, January 22. (Presentation and poster)
- Kelly, M.C. and R.H. Germain. 2014. Impact of best management practices on logging costs and productivity in the Northeast. Symposium on Forestry Best Management Practices Effectiveness in the Eastern U.S. Blacksburg, VA, May 12-15. (Poster)