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Proposed BMPs for Invasive Plant Mitigation during Timber Harvesting Operations

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Abstract

The invasion and spread of invasive plants is a major problem in forested ecosystems. Invasive plants can displace existing vegetation and in some cases take over the site. With the displacement of native vegetation come major ecosystem changes that may jeopardize ecological processes and functions as well as habitat for wildlife. The disturbance caused during timber harvesting processes creates conditions that encourage the establishment and spread of invasive plants. The machinery and traffic movement within a job site may introduce and spread seeds, roots, and plant parts from one job site to another. In this report, we address the timber harvesting processes and the disturbance that is created; explain how seeds, roots, and other parts of invasive plants can be spread; address the opportunity costs involved and those responsible; and propose voluntary BMPs for invasive plant mitigation during timber harvesting operations.

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INTRODUCTION

Invasive species are one of the greatest threats to the health of forests, rangelands, aquatic and riparian systems, and urban forests. They have impacted forest fire frequency and intensity, forest tree establishment and growth, and altered native species distributions and wildlife habitat. Transport of these invasive species by human global trade and by forest operations has increased the establishment and spread. Forest land managers and decisionmakers must find ways to mitigate the establishment and spread of these species. In 2006, the Invasive Species Strategic Program Area (SPA) of the U.S. Forest Service solicited feedback through a formal external peer review to prioritize research efforts toward mitigating the spread of numerous invasive species (Dix and Britton 2010). The results from this review identify invasive species research and priorities that the Forest Service will use for the next 20 years. One of the priorities that surfaced from this review was an increased emphasis on managing invasive species and ecosystems that have been altered by them. Accordingly, in this report, we address the timber harvesting processes and the disturbance that is created; explain how seeds, roots, and other parts of invasive plants can be spread; and propose voluntary BMPs for invasive plant mitigation during timber harvesting operations. Our focus is limited to the invasive plant species that could be impacted by and during the timber harvesting operations.

BEST MANAGEMENT PRACTICES (BMPs)

Best Management Practices (BMPs) are practical proactive approaches, either mandatory or voluntary, that can be used during forest management operations to accomplish objectives related to soil protection, riparian/buffer zone protection, structural retention, invasive plant species mitigation, aesthetics, wildlife and biodiversity, water quality, recreation, and other goals. BMPs to mitigate the introduction and spread of invasive plant species are available for urban forests (Allison et al. 2009, Boos 2009), forage seed (SASK Forage Council 2010), storm water management (U.S. Environmental Protection Agency [n.d.], Lake County Stormwater Commission 2004), highway rights-of-way and mowing (Anonymous 2006, Campbell 2008, New Hampshire Department of Transportation 2010), plant nurseries (Hamilton County Soil and Water Conservation District [n.d.], Smith and Lopes 2009), aquatic environments (Aquatic Ecosystem Restoration Foundation 2005, 2009), and forest management activities in general (Gagnon 2009, Iowa Department of Natural Resources [n.d.], Smallidge and Goff 1998, Wisconsin Council on Forestry 2009). BMPs and related guidelines have been proposed for forestry operations (Invasive Plant Council of B.C. 2007, Kearns and Chapin 2008, Stringer et al. [n.d.]). Limited work has been done on BMPs for invasive plants for harvesting operations (LeDoux 2011).

BMPs have proven to effectively limit the spread of other organisms during timber harvesting operations. For example, BMPs such as vehicle and equipment washing, roadside sanitation, temporary road closures, and vehicle exclusion have proven to limit the spread of *Phytophthora laterallis*, a pathogen that causes a deadly root rot on Port-Orford-cedar (*Chamaecyparis lawsoniana*) (Betlejewski et al. 2003). Evaluations of a vehicle washing treatment showed large reductions in inoculum on vehicles following washing (Goheen et al. 2000) and after roadside sanitation treatment (Marshall and Goheen 2000). The effectiveness of these sanitation systems can easily be used as a model for developing BMPs for invasive plant mitigation.

FOREST OPERATIONS PROCESSES

Invasive native and nonnative plant and other species are a major threat to forested ecosystems and the general balance of nature. However, it is beyond the scope of this paper to go into any detail on individual species, threats, or consequences of any one invasion or invader or their spread. Our intent is to present state-of-the-art voluntary BMPs that may mitigate the spread of invasive plant species associated with logging and forest operations that create the type of disturbance suitable for invasion or spread of certain plants. We focus on the types of disturbance associated with logging and forest operations only

as opposed to disturbance caused by recreational activities, movement of wood products, or other types of events. Forest operations such as road and skid trail construction, removal of trees during harvest, landing construction, skidding of logs, and movement of machinery in and out of different operating sites create conditions and opportunities for invasive plants to invade or spread within a site or from site to site. The construction of roads, skid trails, landings, along with the skidding of logs, creates soil disturbance where mineral soil is exposed, creating conditions favorable for invaders. Moving equipment from one logging site to another or moving equipment that has operated in areas that have invasive plants established within a single logging chance provides a vehicle where seeds or other plant parts can be transported into areas without invaders. Currently, there are no mandatory BMPs for logging and forest operations that are designed to mitigate the spread or invasion of invasive plants. Table 1 defines the timber harvesting operations (processes) that create disturbance that can lead to invasions.

The construction of haul roads generally results in major disturbance where trees are removed from the road prism right of way, creating openings that allow sunlight to reach the forest floor. The actual construction process necessarily involves the displacement and movement of soil, rocks, grubbed out root wads, and other vegetation. Generally, cut and fill methods are used to construct roads of adequate standards that log trucks can safely negotiate during the log hauling process. This means substantial quantities of soil must not only be disturbed but also moved. Some of the soil from the cut portion is used in the fill section. In some cases, the excess cut volume must be hauled to some other location and deposited. Additionally, gravel or other crushed stone products may be trucked into the site to serve as the running surface of the road. The traffic and equipment involved in the road building process may move seeds and plant parts in and out of the construction site. The construction of landings and log decking areas also creates major disturbance. Similar to road construction, landing development requires displacement and movement of soil as well as plants and plant parts. The surfacing materials used at landing and log decking areas may be moved in from off site. The constant traffic of log trucks, log skidding equipment, and logs being moved in and out of the landing creates major disturbance to the site. The physical process of moving equipment from one job site to another not only can create disturbance, but also can contaminate the machines. Operating within a single site where portions of the job site are infected and then moving to uninfected areas may aggravate the situation further. Collectively, the site disturbance and movement of seeds and plant parts by the processes defined in Table 1 may not only contribute to conditions where invaders can get started but also may transport those invaders into uninfected areas.

Table 1.—Timber harvesting operations that create disturbance

1.	Haul road/skid trail construction
2.	Landing construction and related log extraction activities
3.	Trucking and log hauling
4.	Moving equipment from job to job
5.	Moving logs/stems from infected areas to uninfected areas

An invasive species inspection by the landowner and/or by the logger would document the circumstances and both parties would sign and date that report. Loggers protect themselves by disclosing what they see to landowners, and this information could become part of the contract. Here we provide proposed voluntary scientific guidelines on what loggers and landowners could do to mitigate invasion or spread during harvesting operations (Fig. 1). Additional Targeted Invasive Plant Solutions (T.I.P.S.) for forestry operations are summarized in Table 2.

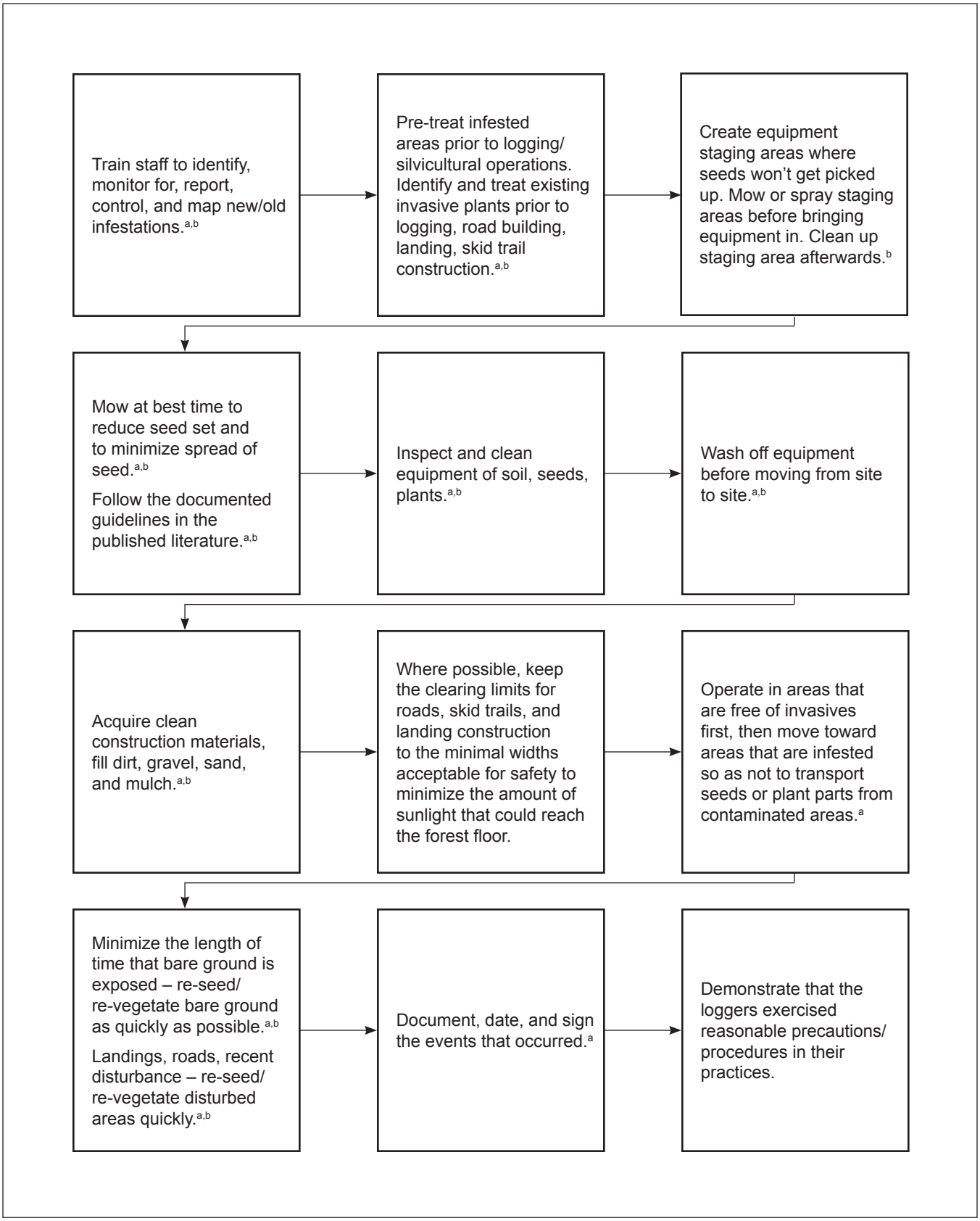

Figure 1.—Flow diagram of proposed voluntary BMPs for invasive species mitigation during harvest operations ([a]Invasive Plant Council of BC 2007, [b]Kearns and Chapin 2008, LeDoux 2011).

Table 2.—Targeted Invasive Plant Solutions for forestry operations (Invasive Plant Council of BC 2007)

T.I.P.S. for Forestry Operations	
Operation	Targeted invasive plant solutions
General	These practices are always applicable, regardless of the operation, and are not limited to specific operations listed here. 1. Determine priority invasive plant species within your operating area. 2. Stay informed through collaborations with regional experts and assist staff and contractors to identify and minimize spread of invasive plant species within your operating area. 3. Carry out regular detection surveys and record the locations of invasive plants in your operating area. 4. Keep equipment out of areas infested by invasive plants and keep equipment yards and storage areas free of invasive plants. 5. Regularly inspect the undercarriages of vehicles and remove any plant material found. 6. Dispose of plant material at the site of the infestation (if no flowers are present), or bag the plant material and dispose of it (locally) in the garbage (if flowers are present). 7. Wash plant seeds and propagules from personal gear, equipment, vehicles, and machinery at designated cleaning stations before leaving infested sites and before entering uninfested sites. Ensure soil that is being moved does not contain invasive plant seeds or propagules. 8. Minimize unnecessary soil disturbance during road, landing, skid trail, and site preparation. Ensure soil that is being moved does not contain invasive plant seeds or propagules. 9. Re-vegetate disturbed areas as soon after disturbance as possible using an appropriate combination of scarification, seeding, fertilizing, and mulching. Ensure that seed used to re-vegetate will meet site objectives. Use Canada Common #1 Forage Mixture or better. 10. Treat infestations of invasive plants prior to disturbance (pre-treatment). 11. Monitor treatment sites for several years to ensure efficacy. Re-treat as necessary to ensure spread does not continue. 12. Avoid moving equipment from an infested area to an uninfested one.* 13. Avoid repeated entries into a site with invasive species.* 14. Schedule harvest to occur during a time of year when invasive species are less likely to spread.* 15. Consider using helicopter logging or cable systems to lower the risk of spread of invasive species compared to ground based logging systems.*
Silviculture & Reconnaissance Surveys	16. Consult the Invasive Alien Plant Program (IAPP) Application database to determine locations of high-risk infestations. 17. Incorporate IAPP spatial data into planning maps (www.nric.ca/). 18. Incorporate detection surveys into existing survey procedures. 19. When you encounter an invasive plant: record the species, date of observation, location (UTM coordinates), and estimated area of infestation (ha or m^2). IAPP field cards are available for use. Provide this information to the regional invasive plant committee coordinator or MFR invasive plant specialist, or enter the data independently.
Road Building & Maintenance	20. Inspect gravel pits and material sources for invasive plants, and remove invasive plant seeds and materials prior to use. 21. Where possible, begin work in un-infested areas and move toward infested areas. 22. Promptly re-vegetate disturbed areas along roadsides, landings, and cleaned culverts. 23. All machinery and equipment capable of carrying invasive plant propagules should be cleaned prior to moving on and off site. 24. Grade roads in directions that do not encourage spread of seeds away from known, priority invasive plant sites.
Harvesting & Site Preparation	25. Re-vegetate all harvested openings by re-establishing an appropriate stand of trees following the stocking standards prescribed in the Forest Stewardship Plan. 26. Minimize disturbance and the duration of time the site is left un-vegetated. Consider seeding if there is a delay in re-vegetation. 27. All machinery and equipment capable of carrying invasive plant propagules should be cleaned prior to moving on and off site.

*T.I.P.S. 12-15 were added by the authors.

COSTS AND RESPONSIBILITIES

The costs involved in taking the necessary precautions to minimize the spread or invasion of invasive plants can be substantial and in some cases prohibitive. Additionally, there is the issue of who should pay such costs. Ideally, the costs of mitigation should be subtracted from the gross value of the timber being harvested just like all the other harvesting, transportation expenses, and other BMP costs considered in determining stumpage values. In this case, the landowner bears the costs. In other scenarios, the federal government, states, tribes, or other organizations could bear or share the costs involved. In some cases, the government may bear the cost in the form of a subsidy payment to the landowner to reimburse any net loss of profit to the landowner or parties involved. In this section, we use data from LeDoux (2006), LeDoux and Whitman (2006), and LeDoux and Wilkerson (2006) to illustrate the potential opportunity costs involved and how they might be handled during the stumpage appraisal process. The net profit loss can also be used to define the level of subsidy required to reimburse the landowner. In extreme cases where invasives would take over the entire site and displace the existing or potential new stand, it can be argued that the opportunity costs are those represented by the future value of the timber on those sites if invasives had not been allowed to take over. If we use opportunity cost data for example stands from the above references, the total dollar value loss per acre could range from $2,043 to $3,050 per acre for a yellow-poplar stand or a mixed hardwood stand, respectively.

It may cost from $100 to $1,200 per job to clean harvesting machines with pressure equipment before moving from site to site. The equipment needs to be cleaned only if the site it operated in was infected; if the site was not infected, a thorough pressure cleaning is not needed. Cleaning costs involved in mitigating the spread of invasives need to be prorated subject to the volume and acreage being harvested. For example, pressure cleaning costs in the range of $100 to $200 per job results in per cord costs of about $0.11 to $0.23 on a 40-acre tract when volume removals average about 2,000 cubic feet per acre. The net prorated cost per unit produced can vary widely depending on the acreage and volume per acre being harvested. The values in Table 3 can be used to illustrate the impact of alternative cleaning costs, volume removals per acre, and acreage harvested on costs per unit produced. For example, low to medium costs per job in the range of $200 to $300 can result in cost per unit produced of $0.03 to $0.31 per cord when the acres harvested range from 40 to 100 with volume removals of 2,200 to 6,600 cubic feet per acre, respectively. By contrast, medium cost per job of $300 may result in cost per unit produced of $2.45/cord when the acres harvested are 5 with volume removals of 2,200 cubic feet per acre. High cost per job of $1,200 can result in cost per unit that ranges from $36.00 to $1.80 per cord when the acres harvested are 5 and 100 with volume removals of 600 cubic feet per acre. High cost per job of $1,200 can result in unit cost of $0.16/cord when the acreage is 100 and the volume removed per acre is 6,600 cubic feet per acre. Clearly, the prorated cost per unit produced can vary widely

Table 3.—Low, medium, and high job cost, volume removal, and acreage impacts on $/cord produced

	$/job	Volume Removed (ft^3/acre)	Acres	$/$ft^3$	$/cord
Low	200.00	6,600	100	0.0003	0.03
Medium	300.00	2,200	40	0.0034	0.31
Medium	300.00	2,200	5	0.0273	2.45
High	1,200.00	6,600	100	0.0018	0.16
High	1,200.00	600	100	0.0200	1.80
High	1,200.00	600	5	0.4000	36.00

depending on the size of the tract being harvested and the total volume being extracted. These costs would ideally be considered while determining the stumpage value or bidding price for a potential job along with all other costs of owning and operating harvesting equipment. Most loggers embed all such costs in their bid prices. It is not unusual for timber buyers to define tract size desired in their advertising searches for available timber that might be for sale. For example, an advertisement may read as follows: (WANTED TO BUY, Standing Timber, Pine and Hardwood, 25 acres+, phone number). The arrows in Figures 2 to 6 point to areas on machines that accumulate soil and other debris and that need to be cleaned. Major areas are tires, wheels, tracks, rollers, track shoes, radiator grids/screens, blades, grapple and articulating unions, trailers, knuckles, cutting head pivot points, and sprockets, along with the steps into and out of the cab. This is not an exhaustive list but shows the areas that are most likely to come in contact with the ground and most likely to accumulate debris.

Figure 2.—Skidder transporting a load of logs, photo courtesy of Tigercat. Arrows point to areas on machine that accumulate soil and other debris and that need to be cleaned.

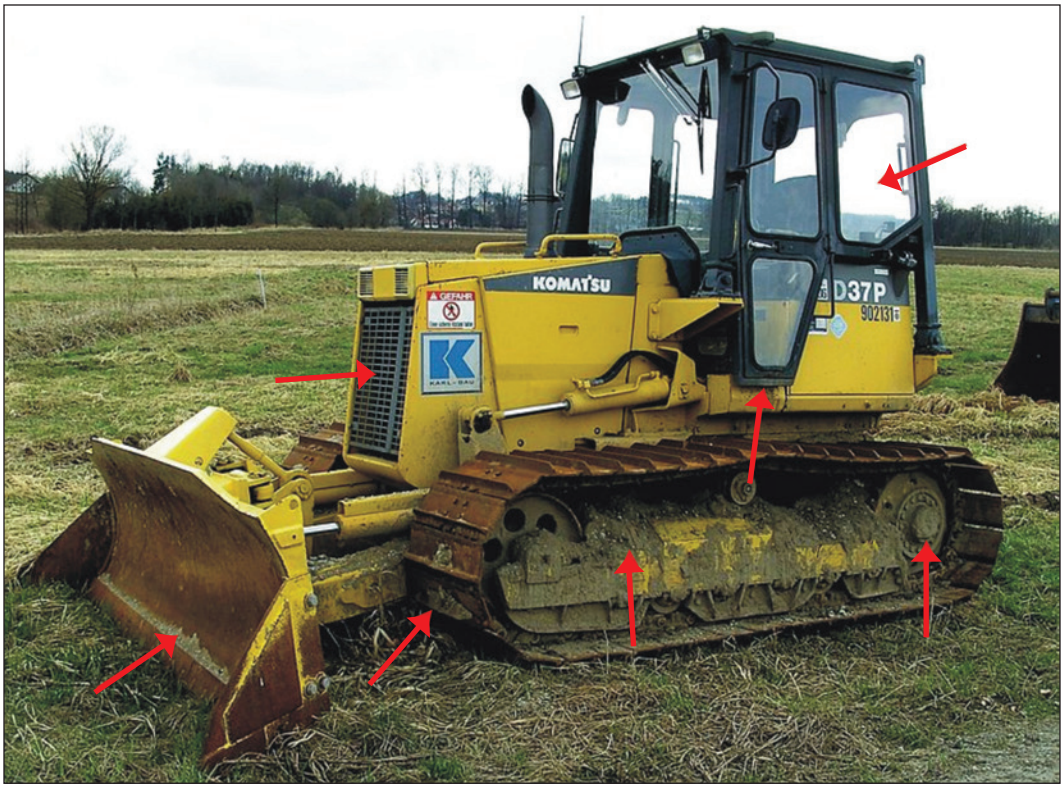

Figure 3.—Crawler dozer, photo courtesy of Komatsu. Arrows point to areas on machine that accumulate soil and other debris and that need to be cleaned.

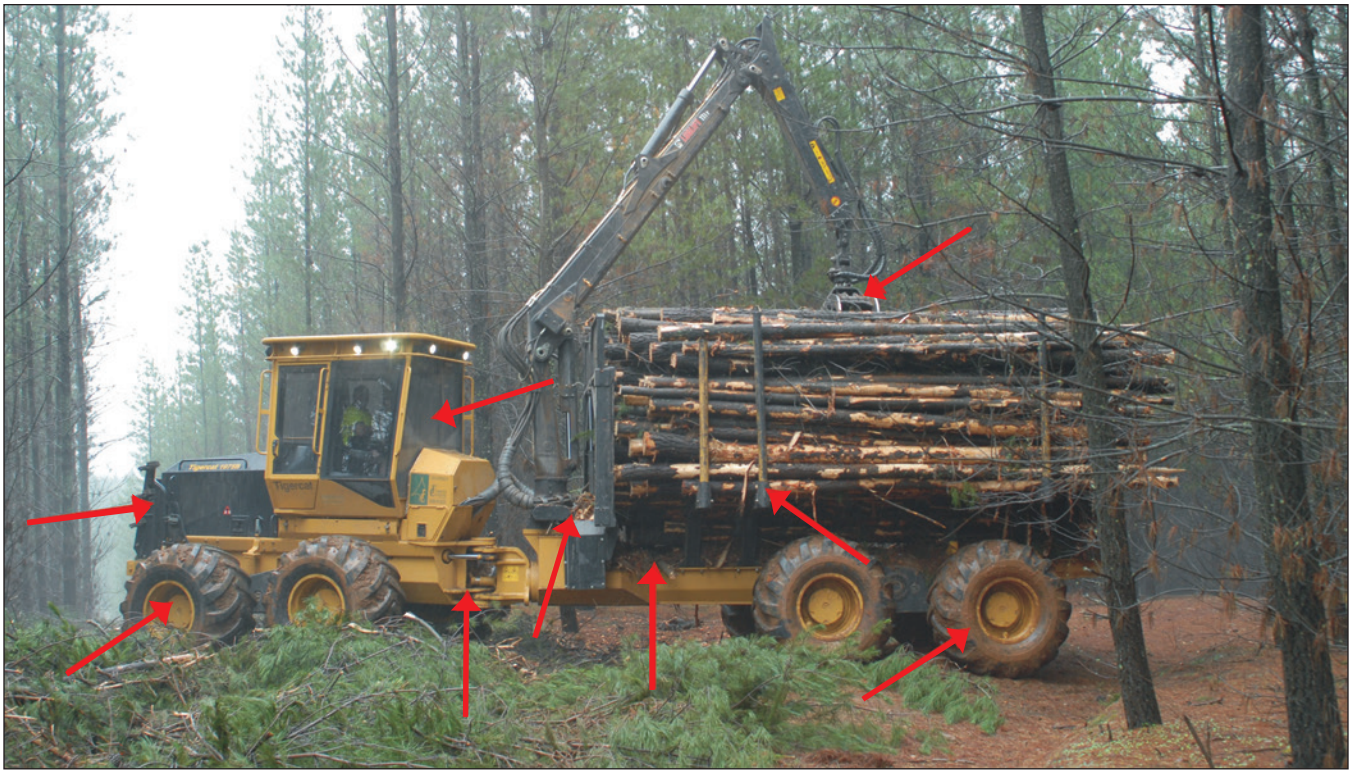

Figure 4.—Forwarder transporting a load of logs, photo courtesy of Tigercat. Arrows point to areas on machine that accumulate soil and other debris and that need to be cleaned.

Figure 5.—Log truck, photo courtesy of Forestry Equipment Sales in Minnesota. Arrows point to areas on machine that accumulate soil and other debris and that need to be cleaned.

Figure 6.—Cut-to-length processor, photo courtesy of Tigercat. Arrows point to areas on machine that accumulate soil and other debris and that need to be cleaned.

CONSIDERATIONS FOR MANAGERS

The voluntary BMPs in this document are general and state of the art. They are grounded in scientific principles but may not be substantiated in rigorous studies in the literature. As such, they should be viewed and used as a starting place for developing more rigorous BMPs for invasive species mitigation. However, a logger would be prudent to follow these guidelines and share this information with the landowner to further mitigate any actions taken against the logger by the landowner to account for any introduction or spread of invasive plants or conditions that are created by the logging operation. The logger would be wise to survey, document, and inform the landowner of any invasive plant infestations or communities of invasive plants within the proposed harvest tract before any harvesting operations. The logger would also be wise to follow these voluntary BMPs, document their activities, and disclose them to the landowner. This approach would inform the landowner, establish a record of prior conditions, and serve as a record of the precautions the logger took to practice in a reasonable manner to not aggravate the situation.

The T.I.P.S. shown in Table 2 are categorized by operation as general, silvicultural and reconnaissance surveys, road building and maintenance, and harvesting and site preparation. Some of the proposed BMPs for invasive plant mitigation in this document are borrowed from Table 2 and from Anonymous (2002). We arranged the BMPs in a decisionmaking flow diagram that follows processes in the order they would actually be performed on the job.

By necessity, the removal of trees during a harvest is generally based on some silvicultural prescription. Although scheduled openings in the forest canopy are desirable to accomplish objectives such as freeing up or establishing regeneration, accelerating residual tree growth, and creating succession habitat for select species of wildlife, they also create an opportunity for invasive plants to get established. The removal of trees during a harvest creates conditions where more sunlight is reaching the forest floor, creating conditions favorable for invaders to get established or spread. A major void exists in the scientific literature on the optimal residual tree spacing required to mitigate the challenge of the additional sunlight reaching the forest floor. Silviculture guidelines are needed that accomplish the above objectives yet mitigate the establishment of invasive plants. Although we do not propose BMPs to mitigate additional sunlight reaching the forest floor, we believe that the cumulative effect of following these BMPs would to some degree mitigate the challenge of invasives getting started and/or spreading during timber harvesting operations.

PERIODIC MAINTENANCE AND INVASIVE SPECIES MITIGATION

Daily maintenance on equipment, cleaning mud off tracks, wheels, etc. according to the equipment manufacturers' recommendations goes a long way toward mitigating the spread of invasives within a tract. Fifteen to twenty minutes of daily or every other day maintenance can accomplish this. This additional periodic maintenance will pay dividends in productivity in having machines that are operating and not breaking down, offsetting any costs of cleaning the equipment. Scheduled maintenance cleanings result in higher productivity that offsets any cleaning costs. These are not full blown pressure cleanings such as those required when moving from one infected site to another. A three-person crew with a loader, skidder, dozer, and some chainsaws will take 15 to 20 minutes to accomplish this cleaning such as at the end of the shift. It is not recommended or desirable to clean after each hitch or load. Religious cleaning of equipment results in optimal maintenance as recommended by factory representatives or users manuals. Fewer breakdowns due to cleaning offset cleaning costs due to increased productivity. This approach concentrates seeds, propagules, plant parts, etc. at the landing where they can be more easily treated or otherwise disposed of. The crew is already on the job so there is really no additional cost here.

In this report we propose voluntary BMPs that can be used to mitigate the introduction and spread of invasive plants during timber harvesting operations. We illustrate the impact of harvest tract attributes on the cost per unit produced on a given operation. We address who should be responsible for the costs and we argue that the costs should be subtracted from the value of the timber along with all other costs involved. Preharvest and postharvest surveys should be the responsibility of the landowner. It may not be necessary to use all of the BMPs all of the time. For example, for a given tract that is free of invasives except for an area in a bottom where a landing is to be located, it may be necessary only to pretreat the landing area before any operations. Although we propose voluntary BMPs and address cost and responsibility issues, we do not provide all the answers needed to totally mitigate the introduction and spread of invasive plants during timber harvesting operations. Clearly, more work needs to be done and additional guidelines must be developed and implemented.

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KEY WORDS: timber harvesting processes, BMPs, invasive plants, ecological functions, wildlife habitat, opportunity costs

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