Compliance with Leave Tree and Downed Wood Forest Practices Act Regulations

Oregon Department of Forestry
Forest Practices Monitoring Section
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Table of Contents

Table of Tables

Table of Figures

Summary

Compliance with Oregon Revised Statute (ORS) 527.676 was assessed on 37 randomly selected Coast Range units harvested in the years 2003 and 2004. This statute requires two leave trees and two downed logs be retained per acre for units over 25 acres in size and supporting less than a specified density (basal area) of trees after harvest. Compliance for the leave tree portion of ORS 527.676 was 97% (± 6%) and 97% (± 5%) for downed log requirements. In a subset of units where detailed data was collected, landowners and operators were observed to typically exceed the minimum density requirements set forth in ORS 527.676: leave tree densities averaged 7.6 per acre (range 3.5-12.5 per acre; n=6) and downed wood averaged 17.1 per acre (range 1.6 – 54.2 per acre; n=8).

We were unable to determine compliance with the leave tree portion of the statute for three units (8% of the total sample). In all three cases, we were unable to count the number of leave trees because they were located outside of the unit boundary, as indicated on a notification map, and adjacent to a similar stand of trees. Thus we could not determine where the leave tree area ended and the adjacent stand started. Examination of maps submitted with notifications indicates that this problem was likely not limited to the units that received field surveys for this project.

We collected data to describe the conditions and distribution of leave trees and downed logs retained to meet FPA compliance on a subset of harvest units. Most leave trees retained were young, vigorous trees. In this study we found that very few snags were present in the clearcut units we surveyed. We observed that when streams were present, leave trees were often retained within the riparian management area (RMA). We observed that most of the downed log cover in the units we sampled was moderately decayed and on the verge of being too decayed to qualify towards the downed log requirement. Sample sizes for this portion of the study were too small to make inferences to a larger geographic scale or to evaluate possible effects to wildlife species. However, possible issues and areas for future study are discussed.

Recommendations are given in this report for possible changes to improve ODF's ability to evaluate compliance, and thus be able to enforce the portion of the statute regarding retention of leave trees. This includes possible rule development to provide clarification as to exactly where and how long leave trees are to be retained. Recommendations are also given for changes to the Oregon Department of Forestry (ODF) Guidance document, development of tools to map and track leave tree locations, and voluntary measures to encourage retention of high-value wildlife leave trees.

Introduction

Oregon has about 27.5 million acres of forestland, of which approximately 40 percent (11 million acres) is privately owned by both large corporate (6 million acres) and small family landowners (5 million acres). The Oregon Forest Practices Act (FPA) regulates timber harvesting practices and other forest operations on all non-federal forestlands in Oregon. The Oregon Department of Forestry (ODF) administers the FPA. The FPA requires that wood in the form of standing live or dead trees and downed logs be retained during some forest harvest operations for the purpose of contributing to overall maintenance of wildlife, nutrient cycling, moisture retention and other resource benefits of retained wood. Little information is available regarding how regulatory requirements are being met or if they are effective in contributing to the ecological values they are intended to support. In addition, perceptions vary among public, practitioners, and scientists with regard to exactly what is being left, whether compliance is being achieved, and whether the retained structures are providing the intended resource benefit. Therefore, we initiated an effort to evaluate compliance with statutory requirements for leave trees and downed logs. A pilot study was conducted in 2002 to determine feasibility and to test field methods (ODF 2006a). A full examination of compliance with Forest Practices Act regulations regarding leave tree and downed logs in the Coast Range of Oregon was conducted in 2004 and 2005. This report summarizes our findings of a of the study on compliance with Forest Practices Act regulations regarding leave tree and downed logs (Oregon Revised Statutes (ORS) ORS 527.676) in the Coast Range of Oregon.

Importance of Green Trees, Snags, and Downed Logs

A wide variety of wildlife species are dependent on trees, snags and downed logs for survival and reproduction. In the Pacific Northwest, 69 vertebrate species use cavities in dead or live trees and 47 species respond positively to amounts of downed wood (Bunnell et al. 2002). Snags are especially important for cavity-using species of wildlife including cavity-nesting birds, flying squirrels, and most species of bats (Bunnell et al. 2002, Hayes 2003). Almost 80% of nests of weak excavators (those that require well-decayed wood to excavate nests) are found in dead trees (Bunnell et al. 2002). Live trees retained during harvest provide immediate and future structural diversity in the harvest unit. Species richness and abundance of some species has been documented to be greater in young stands with "legacy" structures (live trees, snags, and downed logs) from previous older stands than in young stands with few to no legacy structures (Zarnowitz and Manuwal 1985, Hansen et al. 1995, Chambers et al. 1999). Live trees that are hollow, partially dead, or have defects such as broken or forked tops or mistletoe infections have been documented to provide important breeding and resting habitat for species of wildlife such as Vaux's swift, black bears, red tree voles, and American marten (Bull et al. 1997, Bunnell et al 2002). Snags created by topping live trees are also known to be a valuable resource to cavity-nesting birds. In a study looking at bird use of created snags in western Oregon, Hane et al. (2012) found that created snags were used for nesting by a variety of bird species and that nest survival rates in created snags were similar to those observed in unmanaged stands (Hane et al. 2012).

Live trees and dead wood are also critical components of long-term productivity of both forest and stream ecosystems and play an important role in ecosystem processes. Dead wood in forests influences basic ecosystem processes such as soil productivity and development, nutrient immobilization and mineralization, and nitrogen fixation (Rose et al. 2001). Dead wood is well documented as a major source of humus and soil organic matter, which acts to improve

soil development. Up to 68% of forest soil is derived from decaying wood and loss of soil organic matter has been demonstrated to be closely linked to loss in soil productivity (Rose et al. 2001). Litter fall from live trees provides a substantial short-term but continual source of nutrients to forest soils whereas dead wood acts as a long-term source of nutrients (dead wood absorbs and stores nutrients then releases them over time as decay processes progress (Rose et al. 2001)). Dead wood typically contains from <1 to 4% of the nitrogen and from 4 to 11% of the phosphorus in westside forests (Rose et al. 2001). Dead wood has also been noted as an important component in carbon storage (Harmon 2001). Downed logs also store water, act as nurse-logs for shrubs and regenerating seedlings, and act to reduce soil erosion (Rose et al. 2001).

Dead wood, especially large downed logs are an essential component in stream ecosystems (Naiman et al. 2002). Large downed wood in stream ecosystems plays critical roles in sediment retention, pool formation, and particulate organic matter (e.g., leaves, twigs, needles) storage, which in turn influences nutrient transport and productivity of both invertebrates and fish (Naiman et al. 2002).

Forest Practices Act Statutes for Leave Tree and Downed Wood Retention (ORS 527.676)

The Oregon Department of Forestry administers Forest Practices Act provisions that require retaining standing trees (hereafter referred to as leave trees) and downed logs for wildlife in some clearcuts (type II and type III harvest units, ORS 527.620(9) and (10), respectively). The purpose is to contribute to the overall maintenance of wildlife, nutrient cycling, moisture retention and other benefits of retained wood. Leave tree and downed log retention regulations become applicable when the harvested area is equal to or greater than 25 acres in size and less than a specified density or basal area of trees are left after harvest (Table 1).

Table 1: Thresholds in basal area and number of trees per acre below which leave trees and downed logs are required to be retained.

Site Index	Basal Area (square feet per acre)	Tree Density (number per acre)
I, II, III	33	50
IV & V	20	30
VI	10	15

If leave tree and downed log regulations are triggered, ORS 527.676 requires retention of two snags or green trees and two downed logs per acre harvested. Snags and green trees must be at least 30.0 feet tall and at least 11.0 inches diameter at breast height (DBH) and each downed log must be at least 6.0 feet long and contain a total volume of at least 10.0 cubic feet of volume. At least half the green trees and snags and half of the downed logs left on the unit must be conifers. In most cases (except Oregon Plan for Salmon and Watersheds provisions below), the operator has full discretion as to which trees, snags, and logs to retain. Retained leave trees and down wood, however must meet minimum size requirements, be left within the unit, and must be of a density across the unit to meet the two per acre requirement (i.e., a total of 50 leave trees and downed logs must be left within a 25 acre unit, but they can occur anywhere within the unit boundary).

Alternate plans are allowed to meet the provisions of ORS 527.676, including, but not limited to, waivers for the following:

1. Waiver of the 50% coniferous requirement for sites being intensively managed for hardwood production.
2. Retention of leave trees may be waived if equal or greater number of trees retained in another operation would achieve better overall benefits to wildlife.

ODF Administration of ORS 527.676

ODF published guidance regarding leave tree and downed wood retention regulations to provide additional information for Stewardship Foresters on administration of the statute (ORS 527.676 Guidance, ODF 1998b).

ODF asserts that it is the intent of Forest Practices Act regulations for retaining green trees, snags and downed logs to "build some within-stand structural diversity into future rotations, which may provide habitat for a variety of wildlife species and help maintain site productivity" (ODF, Forest Practices Rule Guidance as stated for ORS 527.676, hereafter referred to as ORS 527.676 Guidance). Either green trees or snags may be retained to meet the leave tree portion of the statute. Throughout the statute, leave trees are described as snags or green trees, appearing to give emphasis to the benefits of both types of retained wood. In the ODF guidance document, it indicates that a mixture of dead and live wildlife trees is preferable so that "dead tree habitat is provided over the rotation." Snags of all decay classes can count towards FPA requirements as long as the dbh and height criteria are met. Retained leave trees and downed logs are to be retained until "they are replaced in the unit over time".

Compliance with leave tree and downed wood retention requirements does not require a written plan. However, if a written plan is required due to other statutory or administrative rules, it is suggested that the location of leave trees be indicated on the map submitted with the written plan (ODF, Forest Practices Rule Guidance as stated for OAR 629-605-170). Location of downed wood does not need to be included on the map submitted with the written plans.

The guidance for ORS 527.676 indicates that heavily decayed logs cannot count towards the downed log requirement. Logs which are too decayed to count towards FPA requirements are described as those in which bark is absent, twigs are absent, log shape is oval, wood texture consists of small, soft, blocky pieces, wood color is light brown to reddish brown; and invading roots are present in the heartwood. In other words, the log is well rotten and cannot hold its shape. A general guideline is provided that if the log would break apart if pulled by a choker[1], it should not be counted towards the downed log requirements.

In general, trees and snags required to be left for protection of other resources (e.g., wetlands, specified resource site buffers), cannot be counted towards leave tree requirements for ORS 527.676. However, green trees occurring within some riparian management areas (RMA's) can double-count towards these leave tree requirements (ODF 2006b).

[1] Choker - A short length of wire rope or chain that forms a noose around the end of a log to be skidded or yarded.

Oregon Plan for Salmon and Watersheds Recommendations

The Oregon Plan for Salmon and Watersheds (ODF 1998a) recommends that leave trees be left in riparian areas to provide added benefit to fish. In support of the Oregon Plan for Salmon and Watersheds, ODF may require up to 25% of leave trees be retained near fish bearing or domestic use streams within the unit (ORS 527.676.3.c). The Oregon Plan for Salmon and Watersheds also has voluntary measures that recommends that leave trees be voluntarily located along streams (Type N, D, or F) and that the conifer component be increased from 50% to 75% (ODF 1998a).

Monitoring Need

Compliance monitoring for leave tree and downed wood regulations was identified as a top priority in the Forest Practices Monitoring Strategic Plan (ODF 2002). In particular, the strategic plan identified the following questions:

- Question 32—"What are compliance rates with retention of leave trees and downed logs?"
- Question 39—"Do the leave trees and downed log requirements provide for wildlife habitats as intended?"
- Question 40—"What are the implications of preferentially retaining leave trees along streams in support of the Oregon Salmon Plan?"

Study Objectives

The primary objective of this study was to answer Question 32 from the Strategic Plan (ODF 2002) by evaluating rates of compliance with FPA laws for retention of leave trees and downed wood (ORS 527.676). As a first step at addressing Questions 39 and 40, the characteristics and distribution of leave trees and downed logs being retained were also investigated. Thus we utilized a methodology that focused on evaluating compliance, but also involved collecting detailed data to evaluate characteristics of leave trees and downed logs on a subset of units.

Specific objectives are as follows:

1. **Compliance**: Determine rates of compliance with ORS 527.676, leave tree and downed log requirements.
2. **Characterization**: Describe characteristics of leave trees and downed logs retained to meet FPA compliance.
    a. Provide information on the size, density, distribution, and characteristics of leave trees retained in harvest units.
    b. Provide information on the size, density, distribution, and characteristics of downed logs retained in harvest units.
    c. For units with leave trees retained in RMAs, describe the characteristics of those streams (e.g., stream class) and proportion of leave trees retained in the RMA.

Study Area and Methods

We assessed compliance rates on forestlands in the Coast Range georegion. We focused this project on lands owned or managed by private companies, individuals, or local governments (e.g., county or city). State Forests lands were not included because these lands are managed under Oregon Board of Forestry approved forest management plans with greater leave tree and downed log retention requirements than those imposed by the Forest Practices Act. In addition, at the time this study was being developed the State Forests program was conducting similar monitoring which included an examination of how leave tree and downed wood standards set in State Forest management plans were being implemented. This study has since been completed and results can be found in Hayes (2010). Results from Hayes (2010) suggest that quantities of leave trees, snags, and downed wood exceed amounts required by the Forest Practices Act.

Because the FPA statute lists separate requirements for leave trees and downed logs, it is important to be able to identify trees left standing but that have blown down since completion of harvest so they are appropriately counted as leave trees and not as downed logs. To maximize our opportunity to separate blown down leave trees from retained downed logs, we only considered harvest operations completed within the preceding calendar year for sampling.

Selection of Study Sites

We randomly selected harvest units using our database that tracks harvest operations on forestlands in Oregon, the Forest Activity Computerized Tracking System (FACTS). Specifically, queries of the FACTS database were conducted to determine which notifications matched the following criteria:

- Operations planned for the preceding calendar year
- Planned operation includes a clearcut (Activity code = 1b)
- Size of operation $\geq$ 25 acres
- Landowner Class = local government, private non-industrial, private industrial, or private/other
- Location: Township & Range combinations that occur within the Coast Range georegion (unit locations were later double-checked against maps containing the exact location of georegion boundaries to confirm if they were within the Coast Range georegion)

The pool of possible study sites was partitioned into two landowner classes: industrial and non-industrial. The industrial landowner class included notifications from private industrial landowners; the non-industrial class included notifications from private non-industrial, private-other, and local government landowners. Within each of the two landowner classes, each notification was assigned a random number and the list of notifications sorted in ascending order by random number. The first 30 sites in 2004 and the first 40 sites in 2005 (those with the smallest assigned random numbers) in each class were targeted for field surveys. Attempts were made to survey an equal number of sites in each landowner class, however this proved to be difficult as many non-industrial units did not actually meet the qualifications for survey (see Appendix A). Sites were surveyed in order by random number; however, some sites were surveyed out of order due to logistical reasons. A few of the selected sites were ultimately not surveyed because they were skipped for logistical reasons and then not surveyed before the end of the survey season. This occurrence was rare and we do not feel that it affected the study results.

Prior to field sampling, basic information was collected to screen out units that did not meet criteria for sampling. In order to be sampled, the following criteria had to be met:

- The harvest operation was completed
- At least 25 contiguous acres was harvested
- Permission from the landowner to access property and conduct sampling was granted

After selecting a random pool of potential harvest units, interviews were conducted with Stewardship Foresters or landowners to confirm that the harvest operation qualified for our study and to request copies of notifications, written plans, and maps. In addition, we requested permission to sample each harvest unit from landowners; if permission was denied, we could not conduct our surveys. We considered denial of permission if either 1) we received outright denial, or 2) a landowner was initially contacted (either directly or by messages) but did not return our phone calls asking for permission. Multiple messages were left with a landowner before we considered permission denied.

Although notifications contained information on the size of each unit, this value represented the "planned" harvest acreage and may not match the actual acres harvested. It was important to determine the size of the area harvested because the number of leave trees and downed logs required to be retained to meet FPA compliance are based on actual acres harvested. We determined the actual acres harvested for each unit by collecting a series of Global Positioning System (GPS) points to electronically map the extent of the harvested area. As many GPS points were collected along the cut-line as needed to recreate the shape of the harvested area. Coordinates were entered into ArcView (geographic information system software), a polygon of the harvested boundary was digitized, and the harvested acreage of each unit was calculated.

FPA Leave Tree and Downed Wood Compliance

A unit was determined to be compliant with FPA requirements if it contained enough qualifying[2] leave trees and downed logs to meet the two per acre requirement. Thus a unit would be non-compliant with ORS 527.676 if any of the following were observed:

1. less than two leave trees of adequate size were retained per acre harvested
2. less than two downed logs of adequate size were retained per acre harvested
3. The requirement for 50% retention of conifers was not met (less than one conifer leave tree and one conifer downed log was retained per acre harvested

We calculated confidence intervals for our estimates of overall compliance. Ninety-five percent confidence intervals for compliance rates (with a finite population correction factor) were calculated for compliance rates using the following equation (from Steel et al. 1997):

$$p \pm t_{(0.05)} \sqrt{\frac{pq}{n} * \frac{N-n}{N-1}}$$

Where p = proportion compliant
q = 1 – p
n = sample size
N = Population Size
t = Student's t statistic

[2] Throughout this report, the term "qualifying" relates to leave trees or downed logs that met the minimum size standards to count towards the requirements in the FPA.

We included the finite population correction in our calculations because the number of potential study sites was known. A value of 1800 was used for N; this value represents the total number of planned clearcut harvest operations ≥ 25 acres in size located in the Coast Range georegion for the 2003 and 2004 calendar years.

Leave Trees

FPA resource compliance was evaluated by conducting a tally of qualifying leave trees within each unit. The number of leave trees needed for the unit to be compliant was determined prior to field sampling based on the size of the harvest area calculated using ArcView. A qualifying leave tree was defined as a standing tree, live or dead, that was at least 11.0 inches diameter at breast height (dbh) and at least 30.0 feet tall. Dead trees of any decay class could count towards the leave tree requirement as long as the dbh and height criteria were met.

We included qualifying leave trees that were retained at time of harvest but that subsequently blew down prior to field sampling. Blown down leave trees were identified using the following criteria:

- Crown of the tree is still live or contains dead needles
- The root mass is exposed and the soil appears to be freshly disturbed (few to no plants growing on the exposed soil, or if present limited to small herbaceous plants or seedlings of shrubs or ferns)
- Tree appears to have recently snapped partway up the length. Although the standing portion may be less than 30 feet tall, the remaining portion of the crown is in the vicinity and is long enough that the total length of the tree used to be ≥ 30 feet tall. The break appears to have been recent, based on the relative color of the wood at the point of break

We tallied qualifying leave trees until we determined that the unit was compliant or until all leave trees within the unit had been accounted for, which ever occurred first. In the case of compliant units, field sampling of leave trees was terminated once it was determined that the unit was compliant. If enough trees were accounted for to meet the two-per-acre requirement, but over 50% of them were hardwoods, we continued to tally coniferous trees until the entire unit was sampled or until enough conifers were counted to meet the 50% conifer requirement. All qualifying leave trees tallied were marked with paint to avoid double-counting. Maps were hand-drawn in the field to indicate the location of leave trees and the relative size of leave tree areas.

We counted qualifying leave trees within Riparian Management Areas RMAs only if necessary as the FPA regulations become more complicated with regard to which trees, if any, within RMAs can count towards leave tree regulations. In general, the following strategies were used within a RMA:

- *Small Non-fish Streams:* Live and dead leave trees meeting size requirements were tallied
- *Small Fish-bearing, Medium and Large Non-fish, and all Domestic Water Streams*: Live trees meeting size requirements but no snags were tallied
- *Medium and Large Fish-bearing Streams:* Only trees retained above those needed to meet the riparian management area active management target were tallied. A program

developed for use with hand-held data recorders for collecting data in medium and large fish-bearing streams was used. This program used an algorithm to assign each tree measured as counting towards the basal area active management target, as a leave tree, or both as a RMA and as a leave tree

Details on the exact methodologies used to sample leave trees within RMA's can found in ODF 2006b.

Downed Logs

FPA resource compliance with downed log retention requirements was evaluated by conducting a tally of qualifying downed logs within each unit. Number of downed logs needed for the unit to be compliant was determined prior to field sampling based on the size of the unit. A qualifying downed log was defined as a log that was at least 6.0 feet long and contained at least 10 cubic feet of volume. Individual downed logs with at least 20 cubic feet of volume were tallied as two logs, as described in the FPA (ORS 527.676). Only sound logs were tallied. We used criteria as written in ODF Forest Practice Rule Guidance (ODF 1998b) to determine if a log was sound enough to count towards downed log criteria. Specifically, the guidance states that if "the log can be moved by a choker" without being significantly broken up, it can count towards downed log regulations. Thus for moderately decayed logs, we counted only those that were intact and with solid centers, such that they would likely remain intact if they were "moved by a choker."

Downed logs were accounted for in an opportunistic fashion. If downed logs were clumped, we began counting logs in clumps to maximize efficiency. Neatly stacked log decks or logs within unburned "burn piles" were avoided as we assumed these logs may be removed from the site or burned. We did not count logs on landings as these logs cannot be used to count towards downed log regulations (ODF 1998b). If downed logs were scattered, logs were sampled by traversing the unit in a series of loosely defined transects. RMA's were not be surveyed for downed logs because logs within RMA's cannot be counted towards downed log requirements.

Flagging was used to mark areas sampled for downed logs and to serve as a reference point so that the same area was not double-sampled and so that portions of the unit were not missed. In addition, all sampled logs that were large enough to count towards FPA requirements were marked with paint to avoid double-counting individual logs.

Maps were hand-drawn in the field to indicate the approximate areas surveyed for downed logs. These maps serve to give a rough estimate of the proportion of the unit that had to be surveyed before compliance was determined. Detailed methods used to survey downed logs are described in ODF 2006b.

Leave Tree and Downed Log Characterization

Approximately every fourth unit in each landowner class received a more detailed survey (characterization survey) to describe the distribution and characteristics of qualifying leave trees and downed logs retained to meet FPA compliance.

Leave Trees

A full cruise of standing leave trees (≥ 11 inch dbh and ≥ 30 feet tall) was conducted and detailed data was collected to characterize each tree and to indicate its location within the unit. All qualifying leave trees had the following data recorded:

- Species (code for species name, unknown conifer, or unknown hardwood)
- Diameter at breast height (± 0.1 inch)
- Decay class (see Figure 1A)
- Distance from channel (if in a RMA; in classes, 0-20 feet from the stream, between 20 feet from the stream to the RMA edge, outside of the RMA)
- Height (in classes [< 30 ft., 30-50 ft., 50-100 ft, > 100 ft])
- Windthrow since harvest (yes/no)
- Location in unit (in the following classes: on unit edge, in a clump of trees, scattered, in RMA [plus stream type])

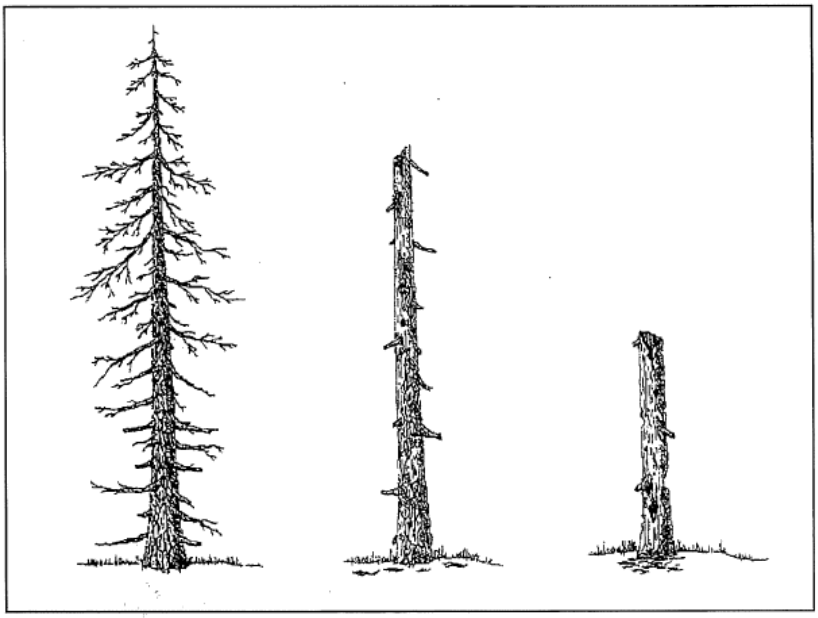
We recorded the location of individual sampled leave trees or boundaries of leave clumps using a GPS receiver so that long-term retention can be evaluated as part of a follow-up study.

Downed Logs

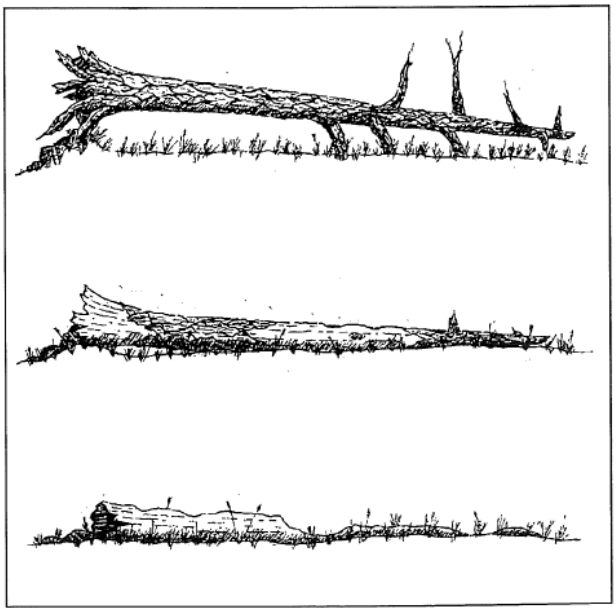
In order to obtain a random and representative sample of downed logs, characterization of downed logs was evaluated using a line-intercept sampling methodology. We surveyed four line transects per unit; each transect was 328 feet (100 meters) long (horizontal distance). Transects were randomly located by selecting a random starting point from a grid with 328 foot spacing placed over a map of the unit and by selecting a random azimuth. If percent slope exceeded 15%, the transect length was corrected for slope. A hip chain and compass were used to lay out each transect and all logs crossed by the transect that were at least 6 inch diameter at point of intersection were measured.

The following data were collected for each downed log crossed by a transect:

- Species
- Diameter at point of intercept (+/- 0.1 inch)
- Small-end Diameter (± 0.1 inch)
- Large-end Diameter (not including root wad, if present) (± 0.1 inch)
- Length of log (± 0.1 foot)
- Decay class (see Figure 1B)
- Piece angle (degrees from horizontal, only recorded if angle > 15%)
- Number qualifying (0, 1, or 2; # to count towards FPA requirements); (qualifying log = sound conifer logs > 6 feet long and > 10 cubic feet volume)



a: Decay classes of snags. Decay class 1 (left) snags are recently dead with most of their branches and bark and little decay. Decay class 2 (center) snags have been dead for at least several years with loss of some branches and bark and some decay. Decay class 3 (right) snags are trees dead for a long time with little to no bark or branches, broken tops, and extensive decay.



b: Decay classes of downed logs. Decay class 1 (top) are recently fallen trees that retain their bark and branches and have little decay. Decay class 2 (center) are logs in contact with the ground with some loss of bark and branches with some decay. Decay class 3 (bottom) logs are logs that have begun decomposing into the forest floor, are not intact, are extensively decayed, and lack both bark and limbs.

Figure 1: Pictorial example of decay classes of snags and logs from Parks et al. 1997.

Density of qualifying logs per acre was estimated using the following expansion equation (DeVries 1973, Waddell 2002):

$$Pieces\ \ per\ acre = 43{,}560 * \frac{\pi}{2L} * \left(\frac{1}{l_i * Cos_{piece\ angle}}\right)$$

Where:

L = transect length in feet (horizontal distance)
l_i = piece length in feet
Piece angle = angle of the log (measured in degrees), if angle < 15°, then Piece Angle = 0

Percent cover of qualifying logs was estimated using the following equation (adapted from Waddell 2002):

$$Percent\ Cover = 2.08 * \pi * \frac{Ds_i + Dl_i}{L}$$

Where: Ds_i= Log diameter (in) at small end of individual log *i*
Dl_i = Log diameter (in) at large end of individual log *i*
L = Transect length (ft)

Volume (cubic feet per acre) of qualifying logs was estimated using the following equation (from Waddell 2002):

$$Volume = \frac{\pi}{2L} * \frac{V_{ft}}{l_i} * 43560$$

Where

L = transect length in feet (horizontal distance)
l_i = piece length in feet of individual log *i*
V_{ft} = Volume (cubic feet) of individual log *i* as determined by

$$Vft = \frac{(\pi / 8)\left(D_S^2 + D_L^2\right) * l_i}{144}$$

And where D_S = Diameter (in) of log at the small end of individual log *i*
D_L = Diameter (in) of log at the large end of individual log *i*
l_i = piece length in feet of individual log *i*

All of the above equations were used to calculate ***Per Log*** estimates; in other words the pieces per acre and percent cover that each individual log contributes to the stand-level estimates. In order to determine estimates for each transect, values are summed for all logs sampled on each transect.

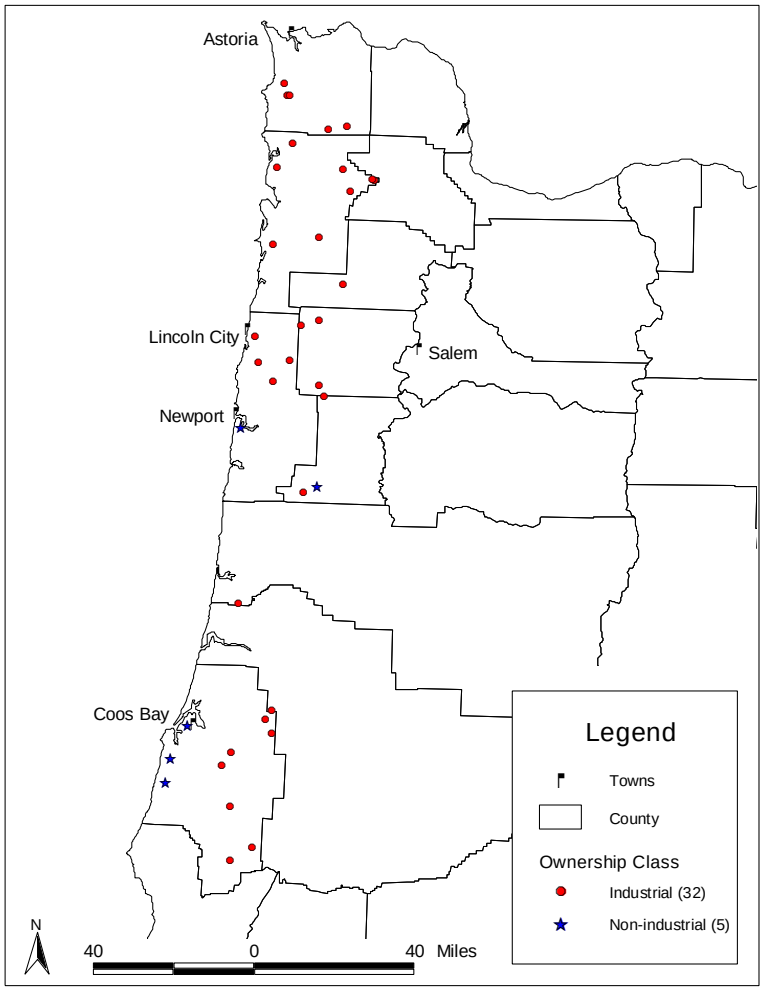
Results

Leave Tree and Downed Log Compliance

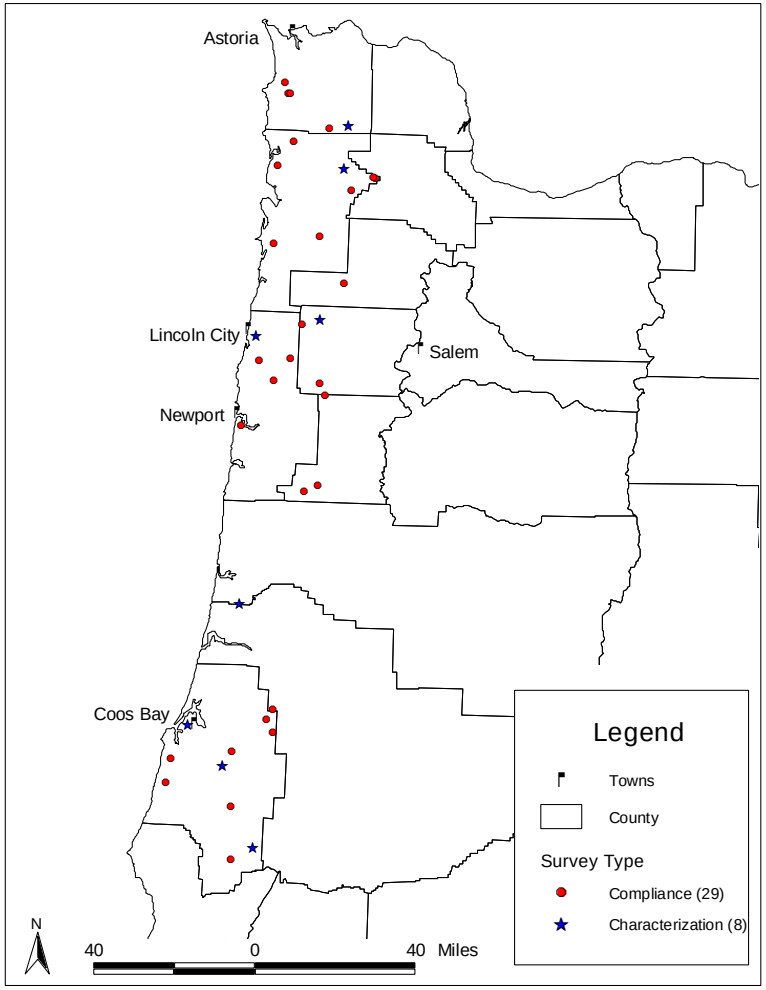
We evaluated compliance rates for leave trees and downed logs as required by ORS 527.676 on 16 units in 2004 and 21 units in 2005. Units were well distributed throughout the Coast Range (Figure 2). Thirty-two units were on industrial lands and five were on non-industrial lands.

Leave Trees

Compliance for the leave tree portion of FPA regulations was 97% (33 of 34 units were compliant). The 95% confidence interval for this estimate ranges from 91% to 100%; thus we are 95% certain that the true rate of compliance with ORS 527.676 was between 91% and 100%. The single non-compliant unit deficient by 0.3 trees per acre, or 25 leave trees for the 83 acre unit. We were unable to evaluate compliance for the leave tree portion of the FPA for three units. All three had leave tree areas indicated on unit maps submitted with notifications; however, the leave tree areas were not clearly defined and were outside of the unit boundary (Figure 3B). The retained leave trees were located on the edge of the unit and were of a similar age, size, and species composition to an adjacent stand of trees. Thus, in these situations we were unable to determine where the leave tree area ended and the adjacent stand of timber began.

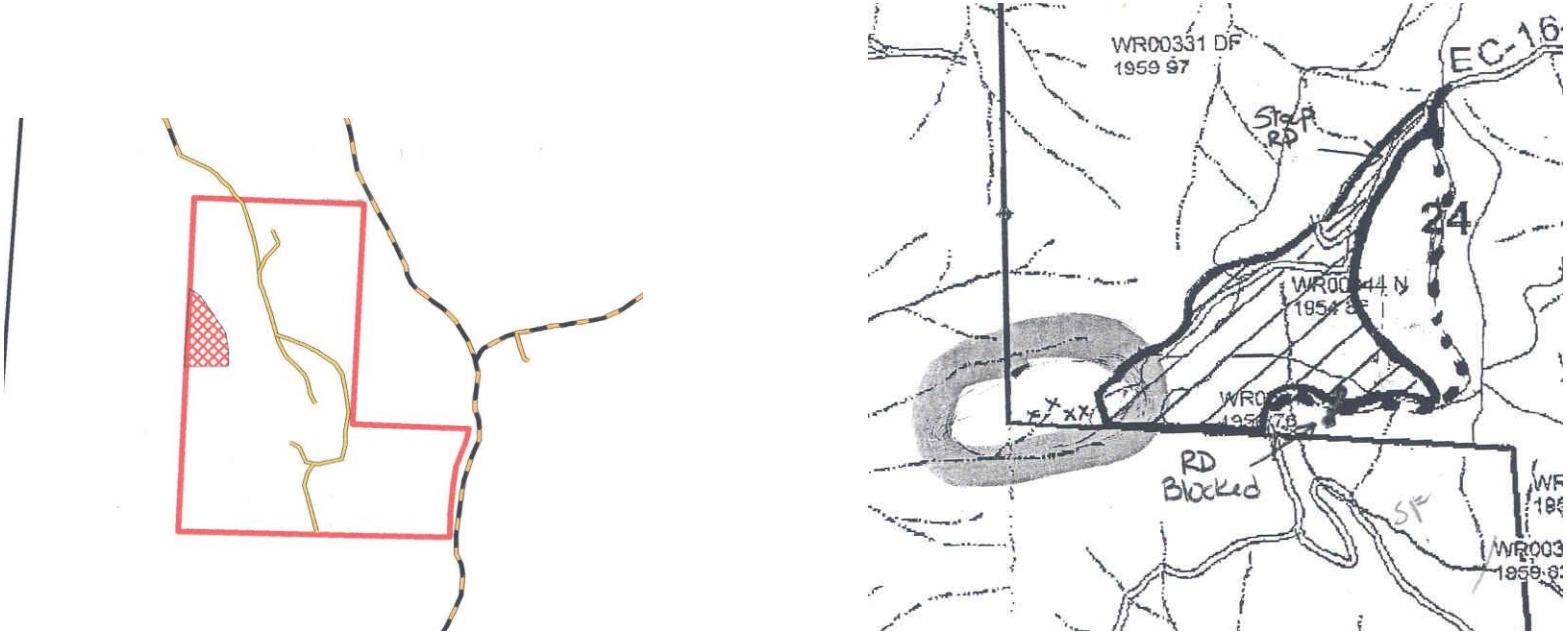


A



B

Figure 2: Location of study sites with regard to ownership class (A) and survey type (B); (sample sizes are in parentheses).



A B

Figure 3: Examples of situations where leave trees were A) clearly located within the unit boundary [trees=hatched polygon] and B) outside of the unit boundary [trees="x's" circled to west of unit].

Downed Logs

Compliance for the downed log portion of FPA regulations was 97% (36 of 37 units were compliant). The 95% confidence interval for this estimate ranges from 92% to 100%. The single non-compliant unit did not contain enough downed logs and was deficient by 0.5 logs per acre (44 logs for the 88 acre unit). The same harvest unit deficient in number of leave trees was also deficient for downed logs.

Leave Tree and Downed Log Characterization

Eight units (seven industrial and one non-industrial) were evaluated to provide information on the characteristics of leave trees and downed logs retained in harvest units. Downed logs were sampled on all eight units whereas leave trees were sampled on only six units. We were unable to survey leave trees for two units due to issues with locating leave trees as discussed above. Results are given below, however sample sizes are too small to be used to infer that means and ranges given below are representative at a larger scale.

Leave Trees

A mix of coniferous and hardwood trees were retained to meet leave tree requirements (Table 2). Douglas-fir and red alder were the most frequently retained species, making up ≥ 50% of the trees retained. Other tree species frequently observed were western hemlock and big-leaf maple.

Density of qualifying leave trees ranged from 3.5 to 12.5 trees per acre (Table 3). Mean dbh of qualifying leave trees was consistent across all six units sampled and ranged from 17 to 20 inches. Most leave trees were < 100 ft. tall.

A small proportion of the leave trees retained were snags (Table 4). Snags made up < 5% of the leave trees on five units; 11% of the leave trees were dead on one unit. Density of snags ranged from 0.04 to 0.37 snags per acre. Most (≥ 50%) of the snags were recently dead (decay class 1).

Table 2: Relative abundance of species of qualifying leave trees measured in characterization surveys (values are percent of trees of each species or species class within a site).

		Coniferous Tree Species (%)				Hardwood Tree Species (%)			
Unit ID	n[1]	Douglas-Fir	Western Hemlock	Other Conifer Species[2]	Total Conifer	Red Alder	Big-leaf Maple	Other Hardwood Species[2]	Total Hardwood
I08	177	37	3	10	50	8	42	0	50
I16	702	89	5	<1	94	2	0	4	6
I102	535	13	38	10	61	38	0	<1	39
I105	286	11	19	7	37[3]	57	3	3	63
I113	915	83	8	2	92	7	0	<1	8
N111	154	1	18	15	34[3]	66	0	0	66
All Sites Combined	2803	56	14	5	76	20	3	1	24

[1] n = total number of trees surveyed

[2] Other Conifer Species included grand fir, noble fir, Sitka spruce, western redcedar and unidentifiable conifers; Other Hardwood Species included cascara, cherry, willow, and chinquapin.

[3] Although total % coniferous was < 50%, these units were in compliance because ≥ 1 conifer tree per acre was retained.

Table 3: Characterization of qualifying leave trees (contains data only for trees ≥ 11 in. dbh and ≥ 30 feet tall).

Unit ID	N[1]	Density (#/acre)	Mean dbh (sd)	Height Class (% of total trees in each class)		
				30-50 ft.	50-100 ft.	> 100 ft.
I08	177	3.5	19.4 (7.0)	73	26	1
I16	702	7.5	16.8 (4.4)	12	84	4
I102	535	10.5	18.6 (8.6)	3	81	18
I105	286	7.3	17.9 (6.7)	6	70	24
I113	915	12.5	19.6 (5.4)	<1	13	86
N111	152	4.2	19.5 (6.5)	7	49	44
			Estimates across all units (n=6)			
		7.58 (3.49 sd)	18.63 (1.11)	9	53	38

[1] n = total number of trees surveyed

Table 4: Percent of qualifying leave trees that were snags; percent of snags in each decay class.

Unit ID	n[1]	% snags	# snags/ acre	Decay Class (% of total snags in each class)		
				1	2	3
I08	19	11	0.37	53	47	0
I16	4	1	0.04	100	0	0
I102	10	2	0.20	30	50	20
I105	3	1	0.08	67	33	0
I113	6	<1	0.29	50	33	17
N111	6	4	0.10	100	0	0
			Estimates across all units (n=6)			
		3	0.18	58	35	6

[1] n = total number of snags per unit.

Rates of windthrow within approximately one year of harvest were low; most units had no windthrow or had < 1% of the leave trees blown over. Two units had 4% and 7% of their leave trees blown over.

Most of our data on distribution of leave trees is anecdotal and based on maps hand-drawn in the field and from field observations. However, some patterns were observed (see Appendix B). In general, when fish-bearing RMA's were present, most leave trees appeared to have been retained within the RMA's. This was especially apparent for units with small fish bearing RMA's where trees retained in the RMA can be double-counted as wildlife leave trees. Leave trees were also frequently retained along small non-fish bearing streams; of all the units with small non-fish bearing streams, only one did not have any trees retained along the stream. When leave trees were retained in the upland portion of the unit, most were left in one or more large clumps. We also observed leave trees scattered throughout the upland portion of some units. Seven units had 10 to 50% and one unit had > 50% of the leave trees scattered.

Downed Logs

Nearly all downed logs sampled on line intercept surveys were coniferous and most were unidentifiable to species (Table 5). These unidentifiable conifer logs were typically large-diameter legacy logs, most likely from a previously-harvested mature or old-growth stand.

Most logs sampled were of moderate decay (Figure 4). The lack of decay class 3 logs was an artifact of the definition of a "qualifying log." Highly decayed logs that are too unsound to be "moved by a choker" cannot be counted towards the downed log requirement. Most decay class 3 logs sampled were too decayed to qualify towards the leave requirement" (Figure 4). Few qualifying logs of class 1 were observed; all were relatively small (< 20 inch diameter at large end) and most were relatively short (< 40 feet long).

Estimates of mean density of downed logs ranged from <2 to 54 logs per acre (Table 6). Confidence intervals were large and usually encompassed the value of two logs per acre necessary to determine compliance. This result supports our findings in the pilot study (ODF 2006a) which suggested that line-intercept techniques are not an appropriate sampling technique to determine if a unit is compliant. For example, the estimate for mean density of logs for unit I13 suggest that this unit was non-compliant when in fact that unit was determined to be compliant by a tally of qualifying downed logs in the unit. Estimates of mean percent cover of qualifying downed logs ranged from close to zero to 3% cover (Table 6). Mean volume per unit ranged from a low of 23 ft^3/acre to a high of 1908 ft^3/acre; most units contained > 400 ft^3/acre (Table 6).

Table 5: Relative abundance of species of qualifying downed logs measured in characterization surveys (values are % of trees of each species or species class within a site).

Unit ID	n[1]	Douglas-Fir	Western Hemlock	Noble Fir	Unknown Conifer[2]	Total Conifers	Total Hardwoods[3]
I08	10	20	10	0	70	100	0
I13	1	0	0	0	100	100	0
I16	21	5	0	0	95	100	0
I102	6	33	33	0	33	100	0
I105	7	0	0	0	86	86	14
I109	5	0	20	20	40	100	0
I113	7	29	0	0	71	100	0
N111	2	0	0	0	100	100	0
Mean % of All Units Combined		11	8	5	74	98	2

[1] n = total number of qualifying downed logs surveyed over all 4 transects
[2] Unidentifiable conifers. Typically large-diameter, highly decayed logs with no bark remaining.
[3] Species = red alder; no other species observed for qualifying downed logs.

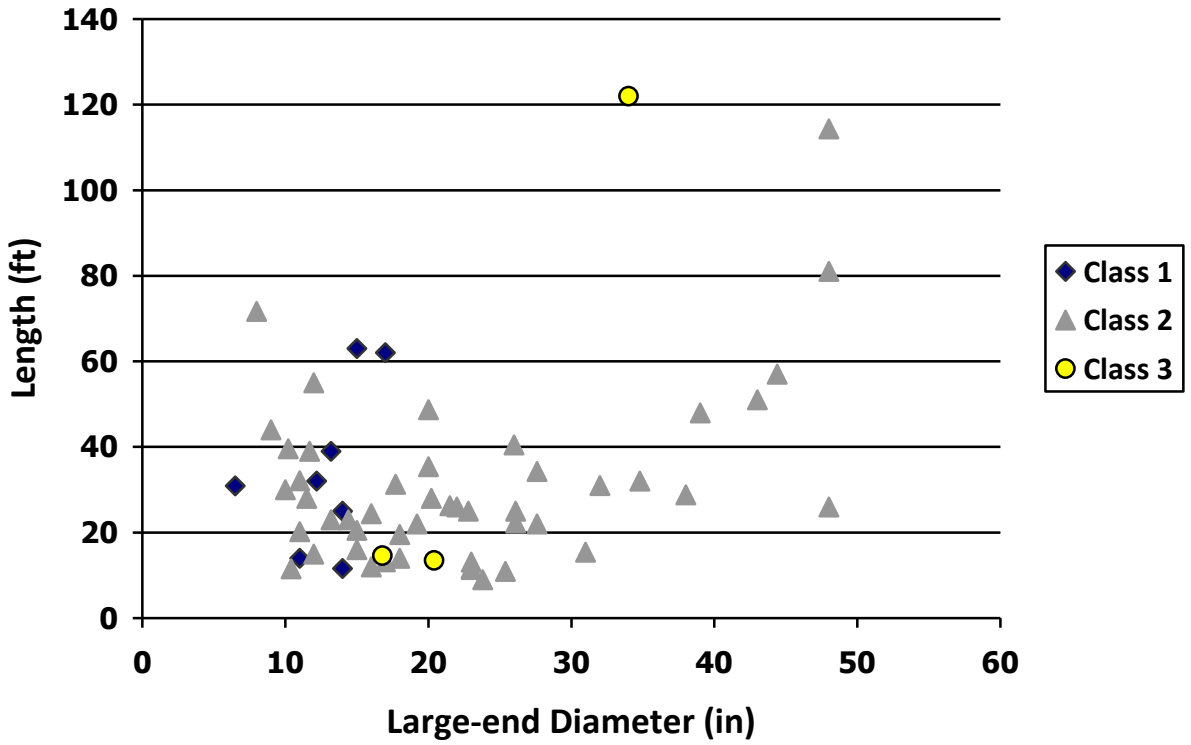


Figure 4: Large-end Diameter, length, and decay class for qualifying downed logs surveyed during characterization surveys (all sites combined, n=57 logs).

Table 6: Density, Percent Cover, and Volume estimates of qualifying downed logs from line transect surveys.

	Density (#/ acre)		Percent Cover		Volume (ft^3/acre)	
Unit	Average (sd)	95% Confidence Interval	Average (sd)	95% Confidence Interval	Average (sd)	95% Confidence Interval
I08	26.56 (14.86)	2.91 to 50.21	2.25 (2.03)	0 to 5.48	1719 (1750)	0 to 4503
I13	1.62 (3.25)	0 to 6.79	0.09 (0.17)	0 to 0.36	23 (45)	0 to 94
I16	54.19 (31.59)	3.94 to 104.45	3.33 (1.76)	0.54 to 6.13	1908 (1497)	0 to 4290
I102	12.33 (17.08)	0 to 39.51	0.84 (0.97)	0 to 2.38	429 (569)	0 to 1333
I105	16.00 (14.47)	0 to 39.03	1.58 (1.12)	0 to 3.36	1317 (921)	0 to 2782
I109	7.59 (10.39)	0 to 24.12	0.81 (0.98)	0 to 2.37	528 (780)	0 to 1768
I113	13.81 (19.17)	0 to 6.79	1.27 (1.79)	0 to 4.12	762 (1119)	0 to 2542
N111	4.04 (5.09)	0 to 12.5	0.25 (0.29)	0 to 0.71	92 (109)	0 to 265
			Estimates across all units (n=8)			
	17.07 (16.87)	2.96 to 31.17	1.30 (1.08)	0.40 to 2.20	849 (721)	0 to 1702

Discussion

Compliance Rates & Characteristics of Leave Trees and Downed Logs

Landowners and operators achieved high rates of compliance when implementing forest practices to retain leave trees and downed logs in harvest type 2 or type 3 units. Compliance for the leave tree portion of ORS 527.676 was 97% (± 6%), and compliance for the downed log portion was 97% (± 5%). In addition, landowners and operators typically exceeded the minimum requirements set forth in ORS 527.676. In units with a 100% cruise of leave trees, density of leave trees ranged from 3.5 to 12.5 per acre. Although we did not conduct a 100% cruise on all 37 units evaluated, this pattern appeared to be consistent for most of the units surveyed. In only a few cases did we count nearly all the leave trees present before meeting the two per acre requirement. Leave trees retained were also typically larger and taller than the minimum standards set forth in ORS 527.676. Average dbh of leave trees ranged from 17 to 20 inches and were generally 30 - 100 ft. tall, whereas ORS 527.676 specifies that green trees and snags must be at least 11 inches dbh and 30 feet in height. For downed wood, most units contained more than five qualifying logs per acre and >400 cubic feet acre, whereas the minimum requirements specified in the FPA are to retain only two downed logs each comprise of at least 10 cubic feet gross volume (thus minimum volume would be 20 cubic feet per acre).

Difficulties in Determining Compliance

During the course of this study, we discovered that compliance with ORS 527.676 was difficult to evaluate. The main causes for this were due to vague boundaries on unit maps submitted with notifications and a lack of knowledge as to the extent of leave tree areas, in particular when leave tree areas were indistinguishable from adjacent stands.

Although operators have full discretion as to the location of leave trees and downed logs, they are intended to be retained within the unit. Thus, a clear unit boundary drawn on a map that is submitted with the notification is critical to determining compliance with leave tree and downed log regulations specified in ORS 527.676. During our study site selection process, we observed that the types of maps submitted with notifications varied in their format and that many did not include a clear harvest unit boundary. To quantify our observations, we evaluated the unit maps submitted with notifications (see Appendix C). We found that 12% of the unit maps submitted with notifications did not contain a unit map that would be adequate for evaluating compliance with ORS 527.676. This appeared to occur more frequently for non-industrial landowners: 31% of non-industrial notification maps did not have the unit boundary clearly marked whereas only 6% of industrial maps did not clearly indicate unit boundaries. In addition, even when clear unit boundary maps were available, often the leave trees were located outside of the unit boundary. When leave trees are located outside of the mapped unit boundary, it can be difficult to impossible to determine the extent of the leave tree area. This is especially true when the leave trees are adjacent to a stand of timber of similar age and species composition. In these cases, it can be impossible to tell where the leave tree area ends and the adjacent stand starts. In fact, we were unable to evaluate compliance for the leave tree portion of the statute for three units for this reason. This effectively meant that we were unable to evaluate compliance for 8% of our study sites. Examination of maps submitted with notifications indicates that this problem was likely not limited to the units that received field surveys for this project. Of the 31 unit maps which indicated location of leave trees, 21% noted the location of leave trees outside of the unit boundary. Thus, unless the leave tree areas were clearly marked in the field, able to be determined based on a stand type break or

other identifying features, it is possible that we would be unable to evaluate compliance on these units as well.

Issues with vague unit maps and unidentifiable leave trees may indicate that long-term accounting of leave trees will be difficult. Leave trees and downed logs are meant to be retained to provide structure into the next rotation, therefore it is important that landowners and Stewardship Foresters have the ability to monitor the long term retention of leave trees and downed logs. Because downed logs typically have little economic value, there is likely little potential for downed logs being removed from a stand prior to the next rotation. However, because most leave trees are live, they do have economic value and thus there is potential for those trees to be harvested, intentionally or unintentionally, before the rotation is complete. This would be most likely for leave trees retained in large clumps at the edge of another mature stand of timber or roads. During conversations with Stewardship Foresters while conducting this study, this issue was brought up as a problem that has already been observed in the field.

Patterns of Retention: Possible Issues for Future Study

This study focused primarily on regulatory compliance and was not intended to be an implementation or effectiveness monitoring study. However we did observe some patterns with regard to the type and location of leave trees and downed logs being retained. Although our sample sizes were too small to make large-scale inferences, the patterns observed may point to implementation or habitat effectiveness issues that may warrant additional monitoring in the future.

Leave Trees

Most of the leave trees retained to meet FPA compliance were young, vigorous trees. Few of the qualifying leave trees were large relic or decadent trees or snags. If existing leave trees are harvested at the next rotation and a new cohort of young trees retained to meet Forest Practices Act requirements, we can expect that the leave trees will continue to be small-diameter and mostly live. In particular, we noted that only a small proportion of the leave trees retained to meet compliance with the statute were snags. Linden and Roloff (2013) looked at patterns of retained structures in clearcut harvest units in Oregon, Washington, and California. They found that snags and legacy trees were relatively uncommon (but not completely absent) on the units they sampled. Similar to our observed density of snags (less than 0.5 per acre), Linden and Roloff (2013) observed scattered snags to be relatively uncommon (0.04 to 0.08/acre). Snags have long been identified as key components for wildlife in forested ecosystems (Bull et al. 1997, Bunnell et al. 2002). Twenty-five to thirty percent of the vertebrates in Pacific Northwest forests use cavities in snags for reproduction or foraging and 22 "species at risk" in Oregon are associated with cavities in forested habitats (Bunnell et al. 1999). This pattern of retention across private lands may have negative implications for meeting the intent of the FPA regulations to contribute to overall maintenance of wildlife because small-diameter live trees do not provide the same quality wildlife habitat as do larger-diameter live trees or snags.

We observed that when streams were present, leave trees were often retained within the RMA. This pattern of leave tree retention may lead to improvements to aquatic habitat, especially for salmonids and stream-associated amphibians. Retention of leave trees within the RMA is a strategy recommended in the Oregon Plan for Salmon and Watersheds. Retention of leave trees within the RMA may benefit riparian-associated wildlife that are known to prefer closed-

canopy forest or that have been documented to increase in abundance with increasing width of stream buffers. Examples include some amphibians (e.g., tailed frogs and torrent salamanders, clouded salamanders), riparian-associated mammals (e.g., marsh shrew, Trowbridge's shrew, shrew-mole), and songbirds (e.g., Pacific-slope flycatcher, brown creeper) (Hagar 1999, Vesely and McComb 2001, Sarr et al. 2005). However, retention of most to all of the leave trees within the RMA, especially if this is the standard practice over large landscapes, may have unintended negative consequences to upland-associated wildlife. For example, in studies comparing wildlife communities between riparian and upland areas, many species were found to be positively associated with upland habitats (McGarigal and McComb 1992, McComb et al. 1993a, McComb et al. 1993b).

Downed Logs

We observed that most of the downed logs we sampled were legacy wood that was large diameter and in mid- to late-stages of decay (Figure 4). Many logs were on the verge of being too decayed to qualify towards the downed log requirement. We did not observe any trees being purposely felled to meet the downed log requirement. Within the next couple of rotations, many of the residual logs that can be used to meet FPA requirements may no longer be sound enough to count and landowners may need to fell trees to meet the requirements. Because small-diameter logs decay much faster than do large-diameter logs, logs felled in one rotation may be too decayed to meet FPA requirements by the time the next rotation occurs. In this scenario, landowners may be faced with needing to fell many trees for downed wood at each harvest rotation. Implications for wildlife will be that downed log cover may remain low and be comprised of mostly small-diameter logs. This scenario is supported by research elsewhere. In Fennoscandia, cumulative reductions in downed wood volume over time with intensive forestry was demonstrated. Dead wood comprised 30-40% of the total wood volume in unmanaged stands, declined to 20% after one rotation, and further to about 1% after several rotations of intensive forestry (Angelstam 1997). In a modeling study examining future downed wood dynamics in Oregon, Kennedy et al. (2010) observed that downed woody debris volume, especially for large logs, is likely to decline over time on private lands in Oregon that are managed to standards set in the Forest Practices Act.

Opportunities

Our findings demonstrate encouraging rates of compliance with the FPA related to leaving snags and downed logs in harvest type 2 or type 3 units, as well as identifying areas of possible compliance and resource issues. These issues effect the administration and implementation of the FPA regulations relevant to leave trees and downed logs in harvest units and warrant further discussion within the Department.

Clarity of requirements associated with ORS 527.676

One of the primary results of this study was that compliance with ORS 527.676 can be difficult to evaluate. This is due partly due to a lack of clarity as to where leave trees and downed logs need to be retained relative to the unit. It is also related to a lack of clarity in the notification process as to how the location of leave trees is to be conveyed to the State Forester). The main issue is that it is not always clear where leave trees are located and whether they are located within or outside the boundary of the unit map that is submitted with the notification, thus it can be difficult to impossible to determine if compliance with ORS 527.676 was met. ORS 527.676 does not specifically state that leave trees are to be retained within the unit boundary. However it is implied as ORS 527.676 is specific to individual harvest units and because ORS 527.676(3)(b) indicates that an alternate plan is required if the landowner chooses to retain the leave trees in a different harvest unit. ODF staff interpret the statute to mean that leave trees and downed logs are to be retained within the harvest unit boundary.

The duration of time that leave trees and downed logs need to be maintained in the unit before they are available for future harvest or removed is also vague. ORS 527.676 does not contain any statements as to the required longevity of leave trees and downed logs. Although the exact timeline is unclear, it appears that leave trees are intended to be retained for an extended period of time. Through our conversations with Stewardship Foresters, it is apparent that the general rule of thumb is that leave trees retained to meet compliance with ORS 527.676 are to be retained until the regenerating trees in the harvest unit are large enough to replace the leave trees (are at least 11 inches dbh and 30 feet tall). However, this is not clearly indicated in the statute or in FPA guidance documents. It is also unclear if the same trees retained at the time of harvest are to be retained throughout the rotation or if they can be "swapped" for other leave trees. Through conversations with Stewardship Foresters and landowners, it was identified that in some cases, leave trees are harvested and "replacement" trees retained elsewhere. It is unclear if this practice would meet compliance with ORS 527.676 if the replacement trees are adjacent to the original harvest unit. ODF asserts that the practice of harvesting leave trees and replacing them with leave trees elsewhere on the property (i.e., not adjacent to the original harvest unit) would not meet the requirements of ORS 527.676 as the replacement trees are not associated with the original unit. This practice would only be allowed with an approved Plan for Alternate practices as described in ORS 527.676 (3)(b)(B).

Although early removal is less of an issue for downed logs because of their minimal economic value as compared to live trees, downed logs also need to be retained over time and not removed as firewood or during a fuels reduction project. With the growing interest in removing nonmerchantable woody biomass as an alternative fuel source, ensuring compliance with downed wood requirements may become more of an issue in the future.

The absence of clear language compromises ODF's ability to enforce ORS 527.676. It would be difficult to enforce the statute where the leave trees were retained outside of the unit boundary or harvested prior to the end of the rotation. Because the above two issues are critical to the administration of this statue, especially with regards to enforcement, rule development may be appropriate. Changes to guidance are not likely to be effective in this case because statements included in guidance documents alone cannot be used for enforcement purposes.

The Board of Forestry has exclusive authority to develop Forest Practices rules. Forest Practices rules could be formulated to clarify both of the above aspects of ORS 527.676. Development of rules would be intended to accomplish the following:

1. improve the clarity of ORS 525-676 with regards to acceptable:
    a. locations for retention of leave trees and downed logs
    b. minimum periods of retention for leave trees and downed logs to meet the statute and whether leave trees retained at time of harvest can be "swapped" for different leave trees at any time during the unit rotation length.
2. improve the enforceability of ORS 527.676

Tracking Leave Trees to Ensure Compliance with ORS 527.676

Identifying leave trees

Because leave trees and downed logs are intended to be retained for an extended period of time, it is important to be able to track those structures over time. This is especially true for leave trees. Leave trees are not currently required to be marked or mapped, making it sometimes difficult to determine the location of leave trees for enforcement purposes. This is especially true if leave trees are retained along the edge of the harvest unit, adjacent to a similar-aged stand of trees. In this case, determining if enough leave trees were retained to meet compliance can be difficult or impossible. As noted above, a first step to resolving this problem is resolving acceptable locations of leave trees relative to unit boundaries and how leave tree locations are identified on notification maps. Clear identification of the extent of leave tree areas on a map or marking of leave trees in the field would also assist the Stewardship Foresters in their ability to determine compliance.

Clarification of guidance for OAR 629-605-0150 (rules on the notification process)

Forest Practices Act rules regarding the notification process indicate, "the notification shall include a map to scale, or aerial photograph that is corrected for distortion, on which the boundary of the operation is clearly marked." The definition of a "unit" in OAR 629-600-0100, states, "unit means an operation area submitted on a notification of operation that is identified on a map and that has a single contiguous boundary." Despite this, the guidance for OAR 629-605-0150 describes an acceptable map as, "a map to scale or an aerial photo that is corrected for distortion which shows the location of each unit in enough detail to guide the SF to the unit in the field, and to allow the SF or other personnel to determine the proximity of the planned operation." The emphasis in FPA guidance is on having the map indicate the location of the unit and no mention is made of the need for a clear unit boundary. In addition to the Forest Practices rules, the results of this study identify issues and concerns relevant to the need for having maps submitted with notifications that have the boundary clearly marked. This issue could be addressed through guidance indicating that a clear harvest unit boundary *'must'* be indicated on the map submitted with the notification.

Tracking Leave Trees Over Time

The development of a leave tree tracking system may simplify the compliance checking process for ODF Stewardship Foresters. There is currently no consistent mechanism to allow the Stewardship Forester to document and track location of leave trees to ensure that existing leave trees are not included within the cut line of a new unit or aren't otherwise harvested early. The utility of the current system is further limited by notification record retention lengths (7 years). Tracking of leave tree locations could be facilitated through a Geographic Information System (GIS). VANTAGE, the spatial program used by ODF Stewardship Foresters, does not currently contain a feature which allows for mapping of leave trees but this could be added. VANTAGE, or the new FERNS program currently in development, could be enhanced with the capability to use symbology to indicate the location of individual trees as well as adding polygons to identify the boundary of leave tree clumps.

This is but one option for tracking leave trees over time and puts the burden of tracking upon the Department. Other options could require the inclusion of leave tree provisions within Stewardship Agreements, conservation easements, or other methods of tracking leave trees external to the Department.

Exploration of Voluntary Incentives

We recommend that incentives be explored to encourage the retention of large-diameter live trees and snags. As previously identified, these structures are especially important to many wildlife species and were found to be limited in the harvest units that we sampled in this study. One example of a potential incentive is to allow landowners to have some of their leave trees be shorter than the required 30 feet in height if they are sound, large-diameter snags or if they wish to actively create snags by topping with machinery. Another example is allowing a credit towards the two-per-acre requirement for each large-diameter snag or live tree retained—the amount of the credit could increase with increasing diameter of the structures retained. Because the Forest Practices Act leave tree and downed log regulations are in statute, it is unclear whether there is flexibility to develop voluntary incentives without input from the Legislature. Thus, although desirable, this concept needs further exploration.

Additional Monitoring Needed

Expand to Other Georegions

This study was designed to be repeated over multiple georegions (ODF 2006b). Additional georegions need to be evaluated to determine if compliance rates observed in this study are consistent across geogregions. We recommend that priority be given to future sampling in the Interior and the Eastern Oregon georegions. Because there are more non-industrial landowners in the Interior georegion than in the Coast Range, sampling there may provide a better indication of compliance rates for non-industrial landowners. Sampling in the Eastern Oregon georegion is important to determine what, if any, implications fuels reduction strategies may have on compliance rates.

Long-term Retention of Leave Trees

Because we only evaluated compliance within one year of harvest, we were unable to consider longer-term compliance with regard to long-term retention of leave trees. There is also a need to determine if and how often leave trees are harvested before the original harvest unit becomes mature. We collected GPS data and hand-drew maps of leave tree locations and leave tree clumps as part of this project. Thus, these sites could be re-visited in the future. In

addition, it may be possible to re-visit a subset of units harvested in the past to determine if leave trees are still present. This second strategy would have to rely on the presence of unit maps with leave tree locations indicated on them or on information recorded by Stewardship Foresters regarding the location of leave trees observed during field visits.

Adjacency (beyond a single unit) Monitoring

Another aspect that we did not consider is compliance with ORS 527.676(4). This portion of the regulation indicates that if a harvest unit occurs adjacent to a prior Type 2 or Type 3 harvest unit and if the total contiguous acreage exceeds 25 acres, retention of leave trees and downed logs is required. For this study we only included individual harvest units which exceeded 25 acres in size. Compliance was not evaluated for the situation where two small adjacent units exceed 25 total acres to determine if the leave tree statue is being implemented.

Effectiveness Monitoring

Although our study collected data on characterization of leave trees and downed logs for a subset of harvest units, sample sizes were too low to make inferences regarding wildlife habitat. The following monitoring questions from the Forest Practices Monitoring Strategic Plan (ODF 2002) need a more complete and rigorous implementation and effectiveness monitoring study to evaluate them:

- Question 39—"Do the leave trees and downed log requirements provide for wildlife habitats as intended?"
- Question 40—"What are the implications of preferentially retaining leave trees along streams in support of the Oregon Salmon Plan?"

Recent research studies have been conducted which partially address Question 39. Arnett et al. (2010), Hane et al. (2012), Kroll et al. (2012a) evaluated wildlife use of created snags in clearcut harvest units in Oregon. Although these snags were shorter than the 30 foot minimum required by the FPA, the results are still applicable. Linden et al. (2012) and Linden and Roloff (2013) looked at retention patterns and wildlife use in clearcut harvest units in Washington, Oregon and California. Their studies focused largely on green leave trees and snags. This study's scope was limited in Oregon to a single watershed and a single landowner, thus results may not be representative of overall patterns of structural retention in Oregon. NCASI recently initiated a new project that is looking at wildlife use of retained structures in a rigorous, experimental study (Verschuyl, et al. 2012). The NCASI study is looking at how the quantity and distribution of retained green trees and snags influences wildlife. This study has multiple participating landowners and sites in both the Coast and Cascade Ranges. Because of this, as well as the experimental nature of the study, the NCASI study should provide high-quality data and results applicable to a broader geographic scope. The NCASI study will partially address ODF Monitoring questions # 39 and # 40. Although existing research by outside parties has partially addressed the question of the effectiveness of retained structures, there are still knowledge gaps. In particular, the effectiveness of retention of downed logs has not been addressed. In addition, the effectiveness of the leave tree and downed log statute in "contributing to the overall maintenance of wildlife" has not yet been examined at a larger, landscape-scale. Kroll et al. (2012b) also identifies research needs with regards to snag retention in relation to forest management on private lands. Among their suggestions are the need for studies that are broader in scope, both spatially and temporally; the need for additional research on the landscape context of retained snags to wildlife (e.g., in blocks of

private lands versus checker-board private/public and young/older forest landscapes); and the relative contribution of snags in riparian buffers versus in upslope retention areas.

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Appendix A: Reasons for units being dropped from initial pool of potential study sites

The initial pool of potential harvest units randomly selected from the FACTS database included 70 industrial and 70 non-industrial units. Of those units, 20 industrial and 56 non-industrial units were dropped from the initial pool (Table A1). Of units that were dropped from the initial pool of study sites, most were due to changes in planned operations from those submitted in notifications. 32% were not harvested and 37% harvested < 25 acres, thus the leave tree and downed wood regulations were not triggered. Only 6% (5 units) had to be dropped due to lack of permission. For two of those units, the landowner was contacted and told about the project, following which the landowner stated that they did not want to participate in the study. The other three units were all owned by the same owner who was initially contacted and told about the study, but the landowner stated that they would look up information on their units and get back to ODF staff. Multiple attempts were made to re-contact the landowner but we were unable to contact them and they did not return our calls. We interpreted this as the landowner not wishing to participate in the study.

Table A1: Units dropped from the initial pool of randomly selected study sites and reasons for their omission. Values represent the number of units (except where specified, % values represent the % of total units within a landowner class that were dropped for each reason).

Reason for being dropped	Landowner Class		Total (landowner classes combined)
	Industrial	Non-industrial	
Harvest not conducted	9 (45%)	15 (27%)	24 (32%)
< 25 acres harvested	3 (15%)	25 (45%)	28 (37%)
Unit not in Coast Range Georegion	4 (20%)	7 (12%)	11 (14%)
Permission to survey denied[1]	1 (5%)	4 (7%)	5 (6 %)
Other[2]	3 (15%)	5 (9%)	8 (11%)
Total dropped in each landowner class (% of possible study sites dropped [n = 140 possible sites])	20 (29%)	56 (78%)	76 (54%)

[1] Denial of permission included both direct denial as well as indirect denial through unanswered phone calls.
[2] Other reasons for a unit being dropped include: Forest Practices Act regulations are not applicable (e.g., for properties owned by tribes or for activities such as land use changes), unit incorrectly "triggered" for study due to a data entry error in the FACTS database, inability to obtain paperwork from field office, and unit boundary not able to be determined

Appendix B: Distribution of leave trees within each unit

Units are sorted by 1) units with trees in RMA's are listed before units with trees only in the upland, 2) within those units with trees in RMA's, units with LF RMA's are listed first, those with no LF but with MF are second, those with no LF or MF but with a SF are listed next, etc. Within each RMA size class, units are ordered by the percent of the leave trees that were contained within that RMA class. For units with trees only in the upland, units are sorted by the percent of trees in upland clumps. Units in bold had a 100% cruise conducted for leave trees, thus the percentages are exact. For all other units, values were estimated from maps of leave tree locations drawn in the field, thus they are approximate. For RMA columns, cells with blanks indicate that that RMA class was not present for that unit; if the RMA class was present but leave trees were absent or possibly present, the cell will contain a 0% or a ?, respectively.

	Distribution of leave trees between upland and riparian areas		**Relative distribution of upland leave trees**			**Relative distribution of riparian leave trees among stream class**					
Unit ID	**Upland**	**Riparian**	**Clumped**	**Scattered in Interior**	**Scattered along Edge**	**LF**	**MF**	**SF**	**MN**	**SN**	**SU**
I106	40%	60%	100%			100%					
I124	1%	99%		100%		90%	10%				
I105	**0%**	**100%**				**53%**		**47%**			
I111	15%	85%		100%		10%		90%			
I113	**17%**	**83%**	**95%**	**5%**		**8%**	**55%**	**25%**		**12%**	
I110	0%	100%				?	?	85%		15%	
I30	10%	90%		100%			85%	10%		5%	
I112	50%	50%	100%				?	98		2%	
I21	0%	100%						100%			
N108	0%	100%						100%			
N111	**0%**	**100%**						**100%**			
I107	0%	100%						100%			
I1	10%	90%	100%					100%			
I4	70%	30%	40%	30%				100%			
N26	90%	10%	11%	89%				100%			
I27	0%	100%						60%		40%	
I19	10%	90%	100%					20%		80%	

	Distribution of leave trees between upland and riparian areas		Relative distribution of upland leave trees			Relative distribution of riparian leave trees among stream class					
I102	**100%**	**<1%**	**90%**	**10%**				**<1%**			
I26	90%	10%	100%						10%	60%	40%
I108	0%	100%								100%	
I130	0%	**100%**								**100%**	
I3	50%	50%	100%							100%	
I16	**64%**	**36%**	**98%**	**2%**						**100%**	
I24	80%	20%	87%	13%	<1%					100%	
25	95%	4%	99%		1%					100%	
I109	**100%**	**0%[1]**	**100%**							**0%[1]**	
I103	0%	100%									100%
I5	100%	N/A	100%								
I6	100%	N/A	100%								
I13	100%	**N/A**	**100%**								
N129	100%	N/A	100%								
I126	100%	N/A	100%								
I116	100%	N/A	95%	5%							
I134	100%	**N/A**	**94%**		**6%**						
I8	100%	**N/A**	**68%**	**17%**	**15%**						
N114	100%	N/A	20%		80%						

1--Contained one or more SN streams, but no trees were retained there.
? = Stream class present, but did not determine if any leave trees were in RMA. Because only conifers > AMT can count as LT, a survey is necessary to determine if LT are present.

Appendix C: Evaluation of unit maps—Compliance with OAR 629-605-0150

A clear map indicating the location of the unit boundary and the ability to identify this area on the ground is important to determine leave tree and downed log requirements and rates of compliance with ORS 527.676. Therefore, we reviewed notifications and maps for all potential study sites to evaluate whether map(s) had the boundary of the operation unit clearly marked as required by OAR 629-605-0150. Unit maps were determined to be adequate for evaluating leave tree and downed log requirements and rates of compliance with ORS 527.676 if the map included a clear harvest operation boundary (Figure C1, A and B). Unit maps were determined to be inadequate for evaluating compliance if they indicated the general location of the harvest operation but that did not have the actual operation boundary identified (Figure C1, C and D). Some maps submitted with notifications indicated 'planned' locations of leave trees. When this occurred, we noted if the planned locations of leave trees were within or outside of the planned unit boundary. We also assumed that leave tree areas clearly within the mapped unit boundary would also be easy to locate and count in the field whereas leave trees located outside of the mapped unit boundary would be more difficult to identify.

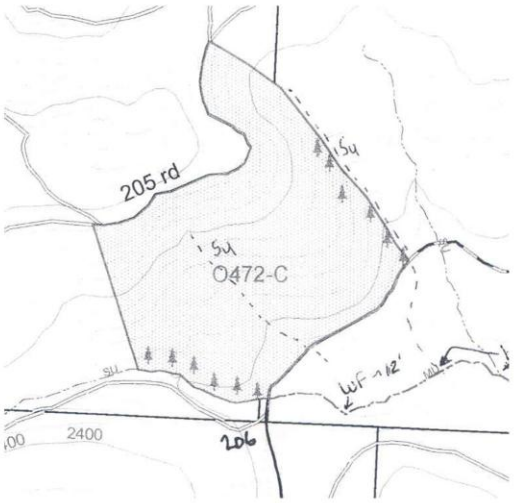
Results

We obtained copies of notifications, unit maps, and other paperwork (e.g., written plans) for 111 of the 140 harvest operations randomly selected for this study from the FACTS database. We only evaluated maps for those units subject to ORS 527.676. This included 64 maps; 48 on industrial and 16 on non-industrial lands. The remaining notifications were either determined not subject to ORS 527.676 or were uncertain because landowners were not contacted to confirm that they had actually operated and that their operation met the 25 acre minimum size needed to trigger ORS 527.676 (see Appendix A).

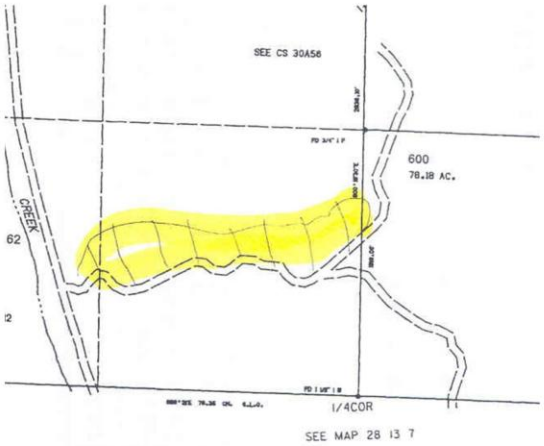
Of the 64 notifications examined, 56 maps (88%) included a map that met the criteria specified in OAR 629-605-0150(7), "boundary of operation clearly marked." Patterns differed between landowner classes; 45 of 48 (94%) industrial unit maps were compliant whereas only 11 of 16 (69%) of non-industrial unit maps were compliant. Noncompliant maps were maps that indicated the general location of the operation but did not include a clear map of the harvest unit boundary. In most cases these maps consisted of a mark on a tax lot map indicating the general location of the harvest operation. The definition of a unit within the FPA states, "Unit means an operation area submitted on a notification that is identified on a map and that has a single continuous boundary. Unit is used to determine compliance with ORS 527.676 (downed log, snag, and live tree retention), ORS 527.740 and 527.550 (harvest type 3 size limitation), and other forest practice rules (OAR 629.600.0100 (78))." Thus a clearly identified unit boundary is important in order to determine compliance with leave tree and downed wood regulations.

Although it is not required, landowners sometimes indicated the location of leave trees on maps with their notifications. Of the 56 compliant maps reviewed (those with clear unit boundaries), 38 indicated location of leave trees on the map submitted with the notification. Location of leave trees on unit maps was more commonly observed for notifications submitted by industrial landowners (80%) than those submitted by non-industrial landowners (18%). Of the unit maps that indicated location of leave trees, leave trees were located outside of the unit boundary on 21% of the maps.

Compliant Unit Maps

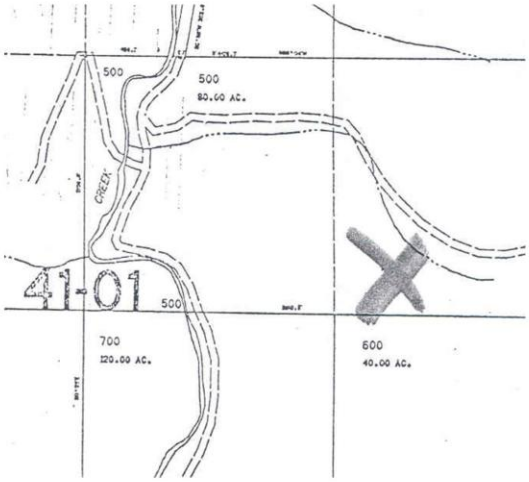


A

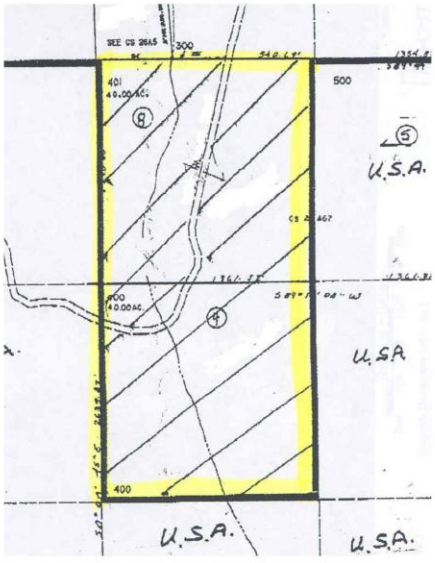


B

Non-compliant Unit Maps



C



D

Figure C1: Examples of Compliant (A & B) and Non-Compliant (C & D) unit maps. Compliant unit maps include a clearly defined harvest unit boundary whereas non-compliant unit maps do not indicate the area intended to be harvested (D indicates notification of an entire taxlot).