WHITE PAPER

USDA Forest Service | Pacific Northwest Region | Umatilla National Forest

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Density Management Field Exercise

David C. Powell; Forest Silviculturist
Umatilla National Forest; Pendleton, OR

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Objective. This exercise demonstrates that stand density index (SDI) is easily obtained from variable-radius sample data collected in the field. A variable-radius sample is sometimes referred to as 'plotless cruising' because it does not require establishment of a circular, fixed-area plot. This procedure uses a basal area factor (glass prism, angle gauge, Relaskop, etc.) to select sample trees; diameter of each sample tree is then used to calculate basal area per tree, along with number of trees per acre represented by each sample tree. A field exercise illustrates this procedure.

1. Locate a plot center, and designate it by using a temporary stake and flagging.
2. Decide which basal area factor will be used for the inventory: select one that will yield an average of 4-8 tally trees per sample point.
3. Is a tree in the plot? Swing the prism (or similar instrument) in a circle, beginning from true north (just by convention; starting direction does not affect results), and sample all trees that are obviously "in" for the instrument being used.
4. For borderline trees, defined as those not obviously in or out when viewed with the instrument, use this process to determine if they should be tallied or not.
   a. First, use table 1 to obtain a plot radius factor (PRF) for the prism factor you are using (example: 1.944 for a BAF of 20).
   b. Measure breast-height diameter of borderline tree (example: 20.3 inches dbh).
   c. Multiply dbh by PRF to determine a horizontal limiting distance (example: 20.3" × 1.944 = 39.5 feet horizontal limiting distance).
   d. Measure distance from plot center (at 4½ feet above ground) to center of tree bole (side of bole, not face, at 4½ feet above ground); this measurement is slope distance (example: 39.1 feet).
   e. Measure slope percent from plot center (at 4½ feet above ground) to side of the tree (at 4½ feet above ground) (example: 20 percent).

f. Obtain a correction factor from table 2 for slope percent value you measured (example: 1.02 for 20% slope).

g. Multiply measured slope distance by a correction factor to convert slope distance to horizontal distance (example: 39.1 feet × 1.02 = 39.9 feet calculated horizontal distance).

h. Compare calculated horizontal distance with horizontal limiting distance value

- If calculated horizontal distance is greater than horizontal limiting distance, the tree is out and would not be tallied.
- If calculated horizontal distance is less than horizontal limiting distance, the tree is in and would be tallied.
- Example: 39.9 feet is calculated horizontal distance for a 20.3" dbh tree growing on a 20% slope; horizontal limiting distance value is 39.5 feet, so this tree is out because calculated distance exceeds limiting distance.

5. What is the tree species? For all sample trees, record species on plot form (col. 2).

6. What is the dbh? For all sample trees, measure their diameter with a diameter tape (round off to nearest whole inch), and record dbh on plot form (col. 3).

7. How much **basal area, per acre,** does each sample tree represent (col. 4)?
[Hint: basal area factor recorded on top of your plot form will provide this value.]

8. How much **basal area, per tree,** does each sample tree have, as based on its diameter? For all sample trees, record their basal area on plot form (col. 5).
[Hint: look up a basal area value for each sample tree, by dbh, in table 3.]

9. How many **trees, per acre,** does each sample tree represent?
[Hint: this is calculated by taking BA per acre values (col. 4) and dividing them by BA per tree values (col. 5).]

10. What is the plot's total BA per acre value? Use your calculator to sum the BA per acre values (col. 4) (or, you could multiply total number of sample trees (from col. 1) by a plot's basal area factor (top of form)). Record this result on the total line.

11. What is the plot's total Trees per acre value? Use your calculator to sum the Trees per acre values (column 6), and then record this result on the total line.

12. Calculate a quadratic mean diameter. Here's how to do this: calculate the square root of a plot's total BA per acre divided by a plot's total Trees per acre (TPA), and multiply this result by 13.54.

    QMD Equation: $\sqrt{\text{Plot BA/Plot TPA}} \times 13.54$

13. Calculate a stand density index. Here's how to do this: divide a plot's QMD by 10 and raise this result to a power, and then multiply this result by a plot's total Trees per acre value. The power value is a slope factor that varies by tree species; slope factors for 7 Blue Mountains tree species are provided in table 4.

    SDI Equation: Plot TPA $\times$ $(\text{QMD}/10)^{\text{slope}}$

    Question: Why is a plot's QMD divided by 10 when calculating SDI?

Table 1: Plot radius factors.

Basal Area Factor (BAF)	Plot Radius Factor
10	2.750
20	1.944
30	1.588
40	1.375
60	1.123
75	1.004
80	0.972

Sources/Notes: Plot radius factors were taken from Dilworth and Bell (1978), and various other sources.

Table 2: Slope correction factors.

Slope Percent	Correction Factor
0 – 9	1.00
10 – 17	1.01
18 – 22	1.02
23 – 26	1.03
27 – 30	1.04
31 – 33	1.05
34 – 36	1.06
37 – 39	1.07
40 – 42	1.08
43 – 44	1.09
45 – 47	1.10
48 – 49	1.11
50 – 51	1.12
52 – 53	1.13
54 – 55	1.14
56 – 57	1.15
58 – 59	1.16
60 – 61	1.17

Sources/Notes: Taken from various sources; many inventory or sampling references provide slope correction information in detailed, 1-percent increments.

Table 3: Basal area; and plot radius distances (feet and tenths), for various basal area factors (BAF), from plot center to center of tree (not face) at dbh and for 0% slope.

DBH (Inches)	Basal Area (Square Feet)	Plot Radius: BAF 10 (Feet)	Plot Radius: BAF 20 (Feet)	Plot Radius: BAF 30 (Feet)	Plot Radius: BAF 40 (Feet)
1	0.01				
2	0.02				
3	0.05				
4	0.09				
5	0.14	13.8	9.7	7.9	6.9
6	0.20	16.5	11.7	9.5	8.3
7	0.27	19.3	13.6	11.1	9.6
8	0.35	22.0	15.6	12.7	11.0
9	0.44	24.8	17.5	14.3	12.4
10	0.55	27.5	19.4	15.9	13.8
11	0.66	30.3	21.4	17.5	15.1
12	0.79	33.0	23.3	19.1	16.5
13	0.92	35.8	25.3	20.6	17.9
14	1.07	38.5	27.2	22.2	19.3
15	1.23	41.3	29.2	23.8	20.6
16	1.40	44.0	31.1	25.4	22.0
17	1.58	46.8	33.1	27.0	23.4
18	1.77	49.5	35.0	28.6	24.8
19	1.97	52.3	36.9	30.2	26.1
20	2.18	55.0	38.9	31.8	27.5
21	2.41	57.8	40.8	33.3	28.9
22	2.64	60.5	42.8	34.9	30.3
23	2.89	63.3	44.7	36.5	31.6
24	3.14	66.0	46.7	38.1	33.0
25	3.41	68.8	48.6	39.7	34.4
26	3.69	71.5	50.6	41.3	35.8
27	3.98	74.3	52.5	42.9	37.1
28	4.28	77.0	54.4	44.5	38.5
29	4.59	79.8	56.4	46.0	39.9
30	4.91	82.5	58.3	47.6	41.3
32	5.59	88.0	62.2	50.8	44.0
34	6.31	93.5	66.1	54.0	46.8
36	7.07	99.0	70.0	57.2	49.5

Sources/Notes: Basal area per tree values (col. 2) were calculated by using an equation shown in item #5 on bottom of page 6. No plot radius values are provided for DBHs less than 5" because it is assumed that when double-sampling, break-point DBH would be set at 5" and trees < 5" would not be tallied on a variable-radius plot. Plot radii are calculated to center of a tree stem, not to the face of a tree. Plot radius values (R) were calculated by using this equation: $R = (DBH/12) \times \sqrt{200/BAF}$

Table 4: Slope factors for stand density index equation (item 13), by tree species.

Tree Species	Slope Factor
Ponderosa pine	1.77
Douglas-fir	1.51
Western larch	1.73
Lodgepole pine	1.74
Engelmann spruce	1.73
Grand fir	1.73
Subalpine fir	1.73

Sources/Notes: Taken from Cochran et al. (1994).

EXAMPLE PLOT (Basal area factor = 20)

Tree Number	Species	Diameter (Inches)	BA per acre	BA per tree	Trees per acre	SDI (Dsum)
1	Ponderosa pine	22	20	2.6	7.7	31.1
2	Ponderosa pine	27	20	4.0	5.0	29.0
3	Western larch	18	20	1.8	11.1	30.7
4	Douglas-fir	29	20	4.6	4.3	21.7
5	Western larch	12	20	0.8	25.0	34.3
6	Douglas-fir	8	20	0.3	66.7	47.6
7	Western larch	14	20	1.1	18.2	32.5
8	Ponderosa pine	9	20	0.4	50.0	41.5
9	Ponderosa pine	15	20	1.2	16.7	34.2
10	Douglas-fir	16	20	1.4	14.3	29.0
TOTAL		TOTAL	200		219.0	331.6

Plot QMD = $\sqrt{\text{Plot BA/Plot TPA}} \times 13.54$; $\sqrt{200/219} \times 13.54$; $.9556 \times 13.54 =$ **12.9"**

Plot SDI = Plot TPA $\times$ (Plot QMD/10)$^{\text{slope}}$; $219 \times (12.9/10)^{1.77}$; $219 \times 1.29^{1.77}$;
$219 \times 1.57 =$ **343.7** (when using the PP slope factor of 1.77)
321.7 (when using the DF slope factor of 1.51)
340.2 (when using the WL slope factor of 1.73)

Note: SDI(Dsum) column shows SDI calculated by individual sample tree (slope factors were specific to each species), and then summed for an entire plot.

SDI FIELD EXERCISE PLOT FORM

Plot number ____________ Basal Area Factor (BAF) ___________

1 Tree Number	2 Species	3 Diameter (Inches)	4 BA per acre	5 BA per tree	6 Trees per acre
		TOTAL			

COLUMN DESCRIPTIONS

1. Number sample (tally) trees sequentially
2. Tree species
3. Tree diameter (record to nearest whole inch)
4. Basal area (BA) per acre (each tally tree is same amount of BA/acre as BAF value)
5. BA per tree (calculate as Pi × $(DBH/24)^2$, or look it up in table 3)
6. Trees per acre (TPA) = BA per acre (column 4) ÷ BA per tree (column 5)

Plot QMD = $\sqrt{\text{Total BA}/\text{Total TPA}} \times 13.54$; Plot QMD = ___________

Plot SDI = Total TPA × $(\text{Plot QMD}/10)^{slope}$; Plot SDI = ___________

Appendix 1: Double Sampling (Stand Exam) Considerations

A stand examination generally uses what is referred to as a double sample – larger trees are sampled by using a variable-radius plot, and smaller trees are sampled on a fixed-area plot. A 'break-point' diameter is specified in an exam's sample design to designate a tree size separating the two plots – a break-point diameter of 5" means that all trees greater than or equal to 5" dbh will be tallied on a variable-radius plot, and all trees less than 5" dbh will be tallied on a fixed-area plot.

So, what happens if a 5.2" dbh tree is within the radius of a fixed-area plot, such as a 1/100th-acre plot, but it is too far away from the plot center to be tallied by the prism being used for variable-radius sampling – should this tree be recorded?
Answer: since this tree is greater than the 5-inch break-point dbh, the only way it can be tallied is to be 'in' on the variable-radius plot, so whether it occurs inside or outside the fixed-area plot is irrelevant.
Remember: only trees less than a break-point dbh can be tallied on a fixed-area plot, so trees larger than a break-point dbh are really invisible (ignored) when completing the fixed-area portion of a double sample.

This example demonstrates that when designing and completing a field exam involving a double sample, three primary decisions must be made –

1) Which basal area factor will be selected to sample larger trees?
2) Which fixed-area plot size will be selected to sample smaller trees?
3) Which break-point diameter will be used to separate small from large trees?

Variable-radius sampling makes the plot radius a function of tree diameter, so individual sample trees are selected with a probability proportional to their basal area. Or to put it another way – the plot radius varies according to the dbh of each tree. Table 3 provides plot radius values for four commonly used basal area factors (BAF). It clearly shows that a radius associated with a large-diameter tree is greater than a radius for a small-diameter tree when scanning down any individual BAF column.

A variable-radius sample could be completed by measuring a tree's dbh and its distance from plot center, and then use limiting distance values in table 3 (by BAF) to determine if a tree is 'in' or 'out'. Although this approach certainly works, it is much slower than using a prism, angle gauge, relaskop, or similar instrument to determine if a tree should be tallied on a variable-radius plot. For this reason, the measurement approach described here is only used for borderline trees when it is not clear if they are in or out by using a sampling instrument (prism, etc.).

During a variable-radius sample, borderline trees of diameter D[1] are tallied if they occur within the plot radius R shown in table 3:

For any given D and BAF, measured R > limiting R (table 3) = OUT (tree not tallied)

For any given D and BAF, measured R < limiting R (table 3) = IN (tree is tallied)

[1] Most tatum aids used for stand examinations and other double sampling activities will be much more specific than what is shown in table 3 of this white paper – tree size will be shown in both inches and tenths, and a range of diameters included will span a wider gamut.

Expansion Factor

An expansion factor associated with each sample tree estimates number of trees per acre, or basal area per acre, that a sample tree represents. This factor is referred to as an *expansion factor* because rarely (if ever) is an entire acre included in a sample (for fixed-area sampling), and the concept of a fixed-plot size does not pertain to variable-radius sampling anyway.

An expansion factor controls how information collected for a single sample tree will be **expanded** to a whole-acre basis. A total number of trees per acre, or total square feet of basal area, in a stand is estimated by summing expansion factors for all sampled trees – if 3 seedlings are tallied on a 1/300th acre plot, then their information (size, damage levels, growth rates, etc.) is assumed to represent 900 similar trees per acre (i.e., 3 sample trees × 300 trees/acre (expansion factor for 1/300th acre plot) = 900 trees per acre).

Note that for quick-plot stand examinations, timber cruises, and other types of rapid forest surveys, group tallying is often used. For group tallying, a number of sample (tally) trees may be grouped by 2-inch diameter classes (or any other grouping scheme relevant to an inventory's objectives, like 4-inch dbh classes, 10-foot height classes, 4-foot-tall seedlings, and so forth), and the expansion factor would then pertain to all trees included in a group. If 6 trees are tallied in a 14-inch diameter class, and if a basal area factor of 10 was used for variable-radius sampling, then the expansion factor for a 14-inch class would be 60 (10 ft^2/tree × 6 tally trees = 60 ft^2).

Sampling Considerations

When designing a double sample (stand exam, etc.), these points could be considered:

1. *Choose a basal area factor (BAF) by considering sampling objectives*. As a rule of thumb, you'll want to pick a BAF that provides you with an average of 4 to 8 tally trees per plot (Dilworth and Bell 1978), but 6 to 8 is actually better for many sampling objectives. Extensive experience has shown that this number of sample trees will tend to adequately characterize your stand's conditions, including variations in its species composition and stocking levels.

   Keep this in mind: you cannot change BAF from one plot to another – if your stand exam will have 10 plots, then the same BAF must be used for all 10 plots. In other words, you can't use a BAF 10 for point 1 because it yields 7 tally trees, but then switch to a BAF 20 for point 2 because staying with a BAF 10 would result in 14 tally trees! Once you pick a BAF, you're stuck with it for an entire exam.

   Historically, there was a period when examiners attempted to use what was called a "constant tally rule" – vary BAF from point to point in order to get a constant number of tally trees (i.e., hold 'number of tally trees' constant instead of holding BAF constant). It was quickly found, however, that this approach interjected sampling bias, and it was difficult to correct for the bias later when processing an exam. Therefore, a constant-tally approach was abandoned, and we now use a constant-BAF approach (Wensel et al. 1980).

Occasionally, you might want to go back to point 1 and start over if it becomes clear that your BAF selection was a particularly poor choice (i.e., you are only averaging 2 tally trees per plot). Note that *starting over would only occur for a situation where too few tally trees were being recorded*; recording too many tally trees is inefficient and results in extra work and effort (and better statistics), but too many sample trees would not be a reason to redo an exam.

2. *Choose a BAF by considering stand conditions*. If you're sampling a relatively open stand (relatively low basal area), it would typically be necessary to use a low BAF (10 or 20) in order to average 4-8 variable-radius tally trees per plot. However, if a stand has a lot of brush, a large plot radius associated with a low BAF may make it difficult to see trees clearly enough to determine if they are in or out (a 36" dbh tree has a radius of 99 feet for BAF 10 (table 3), so it may be difficult to see its stem clearly in a brushy stand). In this situation, a compromise may be in order – pick a larger BAF and accept fewer sample trees per plot.

3. *Choose a BAF by considering previous sampling experience on your unit*. Chances are good that previous stand exams have been completed on your unit. If you're unsure which BAF might be most appropriate for a stand, try to use historical exams for similar situations (similar forest types, stocking levels, etc.) to help pick a BAF for your stand. If historical exams have been loaded into FSVeg, then it would be fairly easy to access their sample designs and determine which BAF and fixed-area plot size was used. And if historical exams are available in FSVeg-Spatial, you could compare how an historical exam compares with your current stand when viewed on the same background imagery such as NAIP. But, this strategy doesn't tend to work well if an historical exam occurs in an area where vegetation conditions have changed significantly since field sampling occurred (such as a severe fire) – in this instance, imagery probably portrays much different conditions than were sampled by the historical exam.

4. *Consider using a similar sampling objective (4 to 8 tally trees) for a fixed-area plot*. When planning for a stand examination, distribution and abundance of regeneration can sometimes be more difficult to predict than an expected number of variable-radius sample trees. Even so, try to select a fixed-area plot size that will yield an average of 4 to 8 tally trees for seedling-sapling size classes.

   [Historically, not much consideration was given to selecting a fixed-area plot size because seedlings and saplings were often viewed as unimportant (no merchantable volume), but if you are going to use exam results for modeling purposes (Nearest Neighbor imputation, FVS modeling, etc.), having good information about a stand's regeneration component can be crucially important.]

   For special exams where seedling-sapling size classes are a focus of the inventory (plantation stocking surveys or regeneration exams), consider an approach that would likely yield more tally trees than just 4 to 8. A sample design involving a relatively large fixed-area plot might be ideal for this objective, rather than a double sample including a variable-radius plot, because a more intensive inventory may better address specific questions associated with a regeneration exam (species composition, height growth, damage levels, etc.).

One additional caveat: sometimes, a regeneration survey does not measure big trees, regardless of whether they are sampled with a variable-radius or fixed-area plot. This can be problematic because although big trees (shelterwood seed trees, for example) obviously do not qualify as regeneration, and characterizing reproduction (seedlings and saplings) is an objective of a regeneration survey, presence of big trees can be expected to influence future stand development (by casting shade and as a source of competition), and it would be nice to know something about their characteristics as well (density, size, condition, etc.).

Basal Area Factor. A constant factor for a given critical angle (which is the angle projected from a sample point by any particular instrument used for variable-radius sampling, such as a 10-factor glass prism; all trees wider than the projected angle are tallied) (Dilworth and Bell 1978). Table 1 provides these factors for seven different critical angles. Basal area factor can also be used to refer to the number of square feet of basal area, per acre, represented by each tally tree. If eight trees are tallied at a sample point with a prism having a BAF of 10, then the basal area at this sample point is 80 square feet per acre (Wensel et al. 1980).

Variable-radius plot. In a double-sample approach, a variable-radius plot is one of two plots that share a common point center; a variable-radius plot is used to select sample trees with a probability proportional to tree size. An angle device (prism, angle gauge, relaskop, etc.) is used to project a constant angle by rotating the device around a point center in a full circle; any tree wider than the angle is tallied on this plot.

Fixed-area plot. In a double-sample approach, a fixed-area plot is one of two plots that share a common point center; a fixed-area plot is usually circular in shape and is used to sample trees that cannot be considered for sampling on a variable-radius plot. In a double-sample design, a breakpoint diameter is used to specify which trees will be considered for each of the plot types.

Breakpoint diameter. In a double-sample approach, some trees are considered for sampling on a variable-radius plot, and other trees are considered for sampling on a fixed-area plot. No tree can be tallied on both plot types for a double sample – they are mutually exclusive! For a sample design, a breakpoint diameter is used to establish a size boundary between two plot types – a breakpoint diameter of 5 inches (most common usage) means that only trees of 5 inches and greater dbh would be tallied on a variable-radius plot, and trees less than 5 inches would be tallied only on a fixed-area plot.

REFERENCES

Dilworth, J.R.; Bell, J.F. 1978. Variable probability sampling – variable plot and three-P. Corvallis, OR: O.S.U. Book Stores, Inc. 130 p. isbn:0-88246-030-7.

Wensel, L.C.; Levitan, J.; Barber, K. 1980. Selection of basal area factor in point sampling. Journal of Forestry. 78(2):83-84. doi:10.1093/jof/78.2.83

APPENDIX 2: SILVICULTURE WHITE PAPERS

White papers are internal reports, and they are produced with a consistent formatting and numbering scheme – all papers dealing with Silviculture, for example, are placed in a silviculture series (Silv) and numbered sequentially. Generally, white papers receive only limited review and, in some instances pertaining to highly technical or narrowly focused topics, the papers may receive no technical peer review at all. For papers that receive no review, the viewpoints and perspectives expressed in the paper are those of the author only, and do not necessarily represent agency positions of the Umatilla National Forest or the USDA Forest Service.

Large or important papers, such as two papers discussing active management considerations for dry and moist forests (white papers Silv-4 and Silv-7, respectively), receive extensive review comparable to what would occur for a research station general technical report (but they don't receive blind peer review, a process often used for journal articles).

White papers are designed to address a variety of objectives:

(1) They guide how a methodology, model, or procedure is used by practitioners on the Umatilla National Forest (to ensure consistency from one unit, or project, to another).
(2) Papers are often prepared to address ongoing and recurring needs; some papers have existed for more than 20 years and still receive high use, indicating that the need (or issue) has long standing – an example is white paper #1 describing the Forest's big-tree program, which has operated continuously for 25 years.
(3) Papers are sometimes prepared to address emerging or controversial issues, such as management of moist forests, elk thermal cover, or aspen forest in the Blue Mountains. These papers help establish a foundation of relevant literature, concepts, and principles that continuously evolve as an issue matures, and hence they may experience many iterations through time. [But also note that some papers have not changed since their initial development, in which case they reflect historical concepts or procedures.]
(4) Papers synthesize science viewed as particularly relevant to geographical and management contexts for the Umatilla National Forest. This is considered to be the Forest's self-selected 'best available science' (BAS), realizing that non-agency commenters would generally have a different conception of what constitutes BAS – like beauty, BAS is in the eye of the beholder.
(5) The objective of some papers is to locate and summarize the science germane to a particular topic or issue, including obscure sources such as master's theses or Ph.D. dissertations. In other instances, a paper may be designed to wade through an overwhelming amount of published science (dry-forest management), and then synthesize sources viewed as being most relevant to a local context.
(6) White papers function as a citable literature source for methodologies, models, and procedures used during environmental analysis – by citing a white paper, specialist reports can include less verbiage describing analytical databases, techniques, and so forth, some of which change little (if at all) from one planning effort to another.

(7) White papers are often used to describe how a map, database, or other product was developed. In this situation, the white paper functions as a ‘user’s guide’ for the new product. Examples include papers dealing with historical products: (a) historical fire extents for the Tucannon watershed (WP Silv-21); (b) an 1880s map developed from General Land Office survey notes (WP Silv-41); and (c) a description of historical mapping sources (24 separate items) available from the Forest’s history website (WP Silv-23).

The following papers are available from the Forest’s website: Silviculture White Papers

Paper #	Title
1	Big tree program
2	Description of composite vegetation database
3	Range of variation recommendations for dry, moist, and cold forests
4	Active management of Blue Mountains dry forests: Silvicultural considerations
5	Site productivity estimates for upland forest plant associations of Blue and Ochoco Mountains
6	Blue Mountains fire regimes
7	Active management of Blue Mountains moist forests: Silvicultural considerations
8	Keys for identifying forest series and plant associations of Blue and Ochoco Mountains
9	Is elk thermal cover ecologically sustainable?
10	A stage is a stage is a stage…or is it? Successional stages, structural stages, seral stages
11	Blue Mountains vegetation chronology
12	Calculated values of basal area and board-foot timber volume for existing (known) values of canopy cover
13	Created opening, minimum stocking level, and reforestation standards from Umatilla National Forest Land and Resource Management Plan
14	Description of EVG-PI database
15	Determining green-tree replacements for snags: A process paper
16	Douglas-fir tussock moth: A briefing paper
17	Fact sheet: Forest Service trust funds
18	Fire regime condition class queries
19	Forest health notes for an Interior Columbia Basin Ecosystem Management Project field trip on July 30, 1998 (handout)
20	Height-diameter equations for tree species of Blue and Wallowa Mountains
21	Historical fires in headwaters portion of Tucannon River watershed
22	Range of variation recommendations for insect and disease susceptibility
23	Historical vegetation mapping
24	How to measure a big tree
25	Important Blue Mountains insects and diseases
26	Is this stand overstocked? An environmental education activity
27	Mechanized timber harvest: Some ecosystem management considerations

Paper #	Title
28	Common plants of south-central Blue Mountains (Malheur National Forest)
29	Potential natural vegetation of Umatilla National Forest
30	Potential vegetation mapping chronology
31	Probability of tree mortality as related to fire-caused crown scorch
32	Review of "Integrated scientific assessment for ecosystem management in the interior Columbia basin, and portions of the Klamath and Great basins" – Forest vegetation
33	Silviculture facts
34	Silvicultural activities: Description and terminology
35	Site potential tree height estimates for Pomeroy and Walla Walla Ranger Districts
36	Stand density protocol for mid-scale assessments
37	Stand density thresholds related to crown-fire susceptibility
38	Umatilla National Forest Land and Resource Management Plan: Forestry direction
39	Updates of maximum stand density index and site index for Blue Mountains variant of Forest Vegetation Simulator
40	Competing vegetation analysis for southern portion of Tower Fire area
41	Using General Land Office survey notes to characterize historical vegetation conditions for Umatilla National Forest
42	Life history traits for common Blue Mountains conifer trees
43	Timber volume reductions associated with green-tree snag replacements
44	Density management field exercise
45	Climate change and carbon sequestration: Vegetation management considerations
46	Knutson-Vandenberg (K-V) program
47	Active management of quaking aspen plant communities in northern Blue Mountains: Regeneration ecology and silvicultural considerations
48	Tower Fire…then and now. Using camera points to monitor postfire recovery
49	How to prepare a silvicultural prescription for uneven-aged management
50	Stand density conditions for Umatilla National Forest: A range of variation analysis
51	Restoration opportunities for upland forest environments of Umatilla National Forest
52	New perspectives in riparian management: Why might we want to consider active management for certain portions of riparian habitat conservation areas?
53	Eastside Screens chronology
54	Using mathematics in forestry: An environmental education activity
55	Silviculture certification: Tips, tools, and trip-ups
56	Vegetation polygon mapping and classification standards: Malheur, Umatilla, and Wallowa-Whitman National Forests
57	State of vegetation databases for Malheur, Umatilla, and Wallowa-Whitman National Forests

Paper #	Title
58	Seral status for tree species of Blue and Ochoco Mountains

REVISION HISTORY

October 2014: minor formatting and text edits were made throughout the document, and a new appendix was added describing a white paper system, including a list of available white papers.