*California Fish and Game* 94(4):169-179 2008

# AERIAL IMPLEMENTATION MONITORING OF GREEN TREE RETENTION IN CLEARCUTS ON NORTHERN CALIFORNIA PRIVATE TIMBERLANDS

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**This effort was conducted to monitor the level of green-tree retention within clearcut harvest units in northern California. A sample of clearcuts containing habitat retention areas (HRAs) were photographed from a fixed-wing Cessna aircraft in September 2005. Photographs were then georectified to topographic maps where harvest and aggregated retention units could be digitized in ArcMap 8.3 and 9.1. The retention standard generally committed to in approved timber harvest plans is 1.5 to 2 % of the total harvest area. Our monitoring effort indicates that the agreed-to retention standard is generally being met. Depending on the value we placed on specific HRAs, retention varied between 1.7 and 2.3 percent. Size and content of HRAs, and their placement within harvest units should be evaluated in future assessments.**

## INTRODUCTION

The California Department of Fish and Game (DFG) reviews timber harvesting plans (THP) as a review team agency under the California Forest Practice Rules (FPR) and evaluates cumulative impacts of different silvicultural treatments on the landscape at the planning watershed level. The FPRs state that effects of Timber Harvesting Plans (THP) should be considered in watershed planning and that biological diversity should be maintained and adverse cumulative impacts should be reduced at the scale of the watershed (14CCR Section 897(b)(2)). These rules also specify that one of the objectives of forest management on a specific ownership shall be to help maintain functional wildlife habitat at the scale of the planning watershed (14CCR Section 897(a)(1)(B)).

Clearcutting, in addition to other even-aged silviculture, potentially reduces ability of a watershed to support species that depend on late-seral habitats. For some THPs, where DFG has demonstrated that negative cumulative impacts are occurring to late seral forest habitats, variable (aggregated) retention has been recommended as mitigation by DFG.

Importance of snag and legacy green tree retention has been described (Dickson et al. 1983; Franklin 1990; Swanson and Franklin 1992; Hanson et al. 1995; Sullivan et al. 2001; Mazurek and Zielinsk 2004), and continues to evolve with new information. For example, recent information from California north coast redwood forests, where large diameter, decadent "legacy" trees are now relatively rare because of past harvesting, demonstrates significantly higher biodiversity associated with "legacy" trees than with control trees (Mazurek and Zielinsk 2004). As large trees die, they provide a continuous source of snags and logs that support foraging by insectivorous animals and provide shelter to species that use cavities. Legacy trees provide structural complexity that enhances opportunities for species to re-establish in regenerating stands (Franklin et al, 2000).

Harris (1984) used the theory of island biogeography to describe an approach for maintaining a biologically diverse set of habitats on a forested landscape over time. He identified a planning strategy whereby "islands of old growth" would be connected by riparian corridors that spread across the landscape. For old growth to be maintained, a portion of the landscape around these islands would be periodically regenerated from early seral stages.

We embarked on this study to describe how variable retention is being implemented on private timberlands. We attempted to evaluate the retention of HRAs containing only high-value (i.e. inclusion of pre-dominant, dominant, and co-dominant conifers) versus retention of all HRAs, some of which had lower value (i.e. only contained intermediate or smaller conifers). The results are descriptive in nature and provide observational data for future development of a testable hypothesis.

## STUDY AREA

Our study area was on private industrial timberlands within the Southern Cascades ecoregion and includes THPs in portions of Modoc, Lassen, Shasta, and Tehama counties in northern California (Figure 1). Sample areas included approximately 3.8 $km^2$ in Modoc, 8.9 $km^2$ in Lassen, 9.9 $km^2$ in Shasta, and 6.5 $km^2$ in Tehama, for a total of 29.1 $km^2$. Elevation ranged from a low of 1,036 m in Tehama County to a high of 2,073 m in Lassen County.

Using the California Wildlife Habitat Relationships System (Mayer and Laundenslayer 1988), forest types in the study area were classified as Sierran Mixed Conifer, White Fir, and Eastside Pine. Dominant conifer composition includes white fir, *Abies concolor* and ponderosa pine, *Pinus ponderosa*, other subdominant species include: sugar pine, *P. lambertiana*, Jeffrey pine, *P. jeffreyi*, incense cedar, *Calocedrus decurrens*, Douglas fir, *Pseudotsuga menziesii* and red fir, *A. magnifica*. The California black oak, *Quercus keloggii*, is the dominant hardwood associated with these areas whereas quaking aspen, *Populus tremuloides*, mountain alder, *Alnus tenuifolia*, and black cottonwood, *Populus balsamifera L.* ssp. *trichocarpa* exist in the wet meadow complexes.

Timber harvest in the study area has primarily been accomplished through clearcutting, commercial thinning, and shelterwood removal step silviculture as described

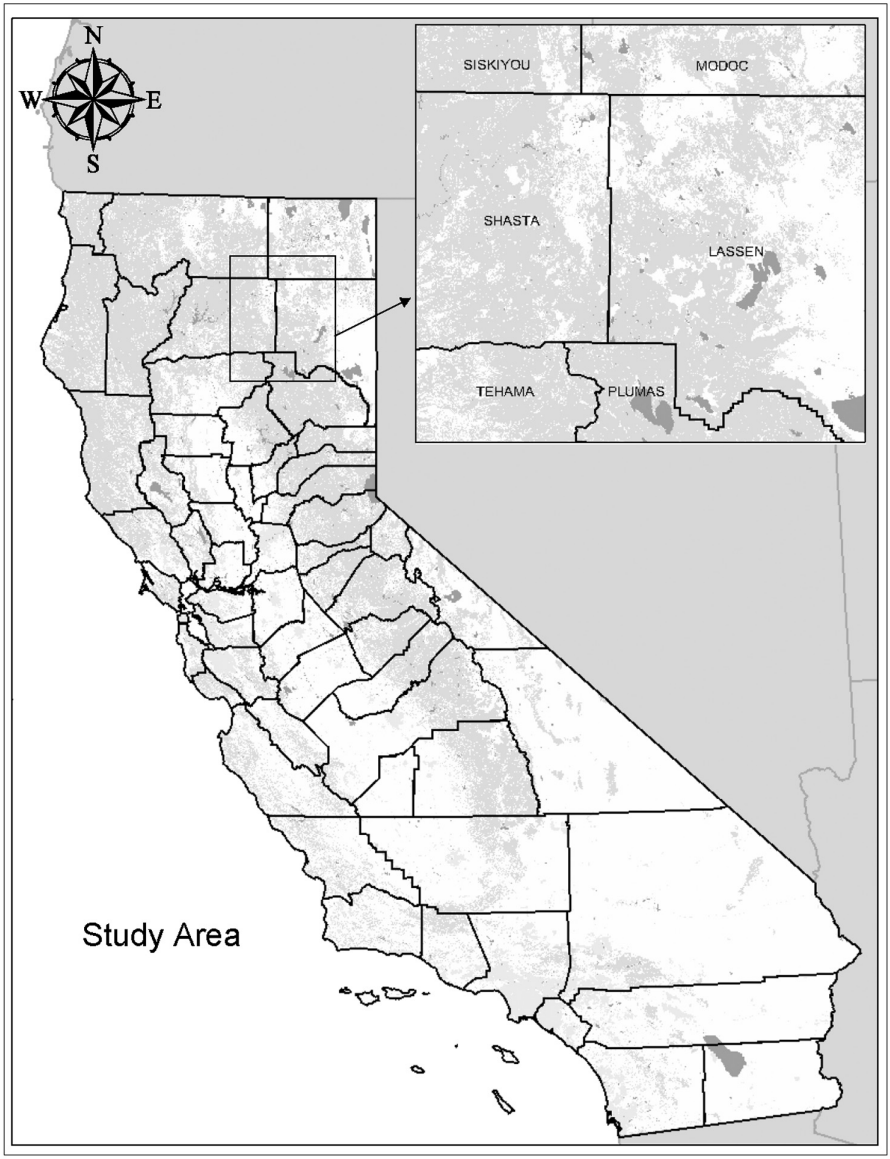


Figure 1. Variable retention monitoring.

in the FPR. Timber harvest in the study area is outside of the known range for the federally listed threatened northern spotted owl, *Strix occidentalis caurina*. Additionally, the only portion of our study area constrained by the California Forest Practice rules for anadromous fish was in Tehama County. Due to the volcanic nature of the southern Cascades ecoregions, the portion of landscape described as watercourse and lake protection zone (WLPZ) per the FPRs is far less than found in the Klamath

Mountains or California Coast Range ecoregions. For that reason, implementation of variable green-tree retention becomes more important.

## METHODS

Harvest units selected for sampling were on private timberlands with recent (<5 years) clearcutting. Over the course of repeated flights, a representative number of recently harvested clearcuts were sampled.

### Photography

A Canon Rebel 6 megapixel digital camera was bolted to the belly of a Cessna 135 fixed-wing aircraft, pointing to the ground through a plexiglass window. The camera was connected to a timer controlled repetitive switching circuit in the front passenger seat. The switch was set to trigger a photograph every 6 seconds. A second, lower resolution digital camera was bolted to the aircraft in the same fashion and connected to a laptop computer with viewfinder software. Using two cameras, we could view the ground using the laptop and take photographs by triggering the automated switch. A Garmin XC12 global position system unit was attached to the laptop, where latitude and longitude coordinates could be recorded and stored as a route tracking file as photographs were taken. We photographed transects of the landscape from a predetermined height of approximately 1,200 m above ground elevation.

### Data Generation

Photographs were georectified using ArcMap versions 8.3 and 9.1. In ArcMap, a Digital Ortho Quarter Quads (DOQQ) layer was added that depicted black and white air photos over the landscape. The flight line recorded from a geographical positioning system (gps) unit was added as a layer in ArcMap over the DOQQ layer. The flight line assisted in locating the starting and subsequent points of the images taken. Raw images were converted to tag image files (.tif) and added as independent themes to ArcMap.

The process of delineating harvest units and HRAs was linked to timber harvest plans (THP) because they contain maps reviewed by the approving agency. Details of creating polygons and populating attributes, for harvest units and HRAs, are provided in the Appendix.

Criteria were identified to make delineation consistent. For harvest units, polygons were attributed with essential information including but not limited to: (1) THP number assigned by lead agency, (2) area in hectares, (3) number of HRAs, and (4) whether dispersed green trees were retained in addition to HRAs. For HRAs, we also attempted to determine retention type, distance to edge, and visual distinctness. For retention type, we described the HRA as either: (1) inclusion of pre-dominant, dominant, or co-dominate conifers (H1), (2) inclusion of intermediates only (H2), or (3) association with a watercourse and lake protection zone (W 1, 2, or 3). HRAs labeled

as H1 were considered to have high value; conversely, H2 means low value. After consulting several THP maps, it was determined that some retention was required per the FPRs and not as mitigation for the reduction in large green trees. It was decided that retention associated with WLPZs would be evaluated at a different level.

### Quality Control

A two-step process was used to assure consistency between our analysis and THP information. First, errors in polygon delineation could be caused by physical features such as shadows, roads, meadows, or errors of omission (excluded harvest units or retention areas). From sampled clearcut units, we selected a random set of 24 (7.7%) harvest units and 77 (10.3%) HRAs to review their boundaries. Second, errors in area calculation could be caused during georectification of the raw images. Estimates of harvest unit area were provided in approved THPs and correspondence with company representatives. Estimated hectares were compared to calculated harvest unit hectares in 247 of the 311 clearcuts analyzed.

## RESULTS

### Accuracy Assessment

We delineated 311 clearcuts and 748 retention areas. Quality control of polygons indicated that the process was fairly accurate, and all 24 randomly selected harvest units were delineated. Of the 77 retention areas checked, 2 (2.6%) retention areas were falsely excluded from the analyses. The remaining retention areas were delineated according to the methods described above, and none was falsely included. The two excluded retention areas were in a single harvest unit. These were aggregated retention clusters that did not include pre-dominant, dominant, or co-dominant conifers (H2).

Harvest unit area was compared between what we calculated and what was provided by the THP or correspondence with the appropriate company representative. For all harvest units checked, calculated area totaled 2,336 ha, and provided area totaled 2269 ha (error rate = 2.8%). Range in error for individual harvest unit area, between what was calculated and what was provided was 0.04 ha to 6.7 ha. Excessive and deficient differences occurred at both the THP and GIS analysis levels.

### Data Analysis

Data from the attributes table were imported to excel files for analysis. A total of 52 harvest units and 53 retention areas was not included in the final analysis. Some harvest units could not be attributed to a particular timber harvesting plan. Retention areas were excluded if they were required for watercourse or lake protection. This means that 259 harvest units and 695 retention areas were used in the final analyses. The 259 harvest units were distributed among 5 separate flight paths within 13 THPs

in 4 northern California counties (Table 1).

Table 1. Harvest Unit Distribution

| County | # Flight Paths | # THPs | # Harvest Units |
|---|---|---|---|
| Modoc | 1 | 1 | 38 |
| Lassen | 2 | 5 | 104 |
| Shasta | 1 | 2 | 65 |
| Tehama | 1 | 5 | 52 |
| Total | 5 | 13 | 259 |

Calculations indicated variable results based on values placed on retention standards (Table 2). Retention assigned a "W" for its value was omitted for this analysis. There was a total of 2,463 hectares of harvest units analyzed.

Table 2. Retention calculations from total harvest area (2,463ha).

| Retention Standard | Total Retention Hectares | Percent Retention |
|---|---|---|
| **1** Any HRA, all values | 56.9 | 2.3% |
| **2** Any HRA, high value | 55.2 | 2.2% |
| **3** Distinct HRA, all values | 51.6 | 2.1% |
| **4** Distinct HRA, high value | 50.1 | 2.0% |
| **5** Any HRA, e•7.6m edge | 45.1 | 1.8% |
| **6** High Value HRAs, e"7.6 m edge | 43.8 | 1.8% |
| **7** Any HRA, e•15.2 m edge | 43.3 | 1.7% |
| **8** High Value HRAs, e"15.2 m edge | 41.9 | 1.7% |

Multiple calculations were derived from identified variables. Retention calculation **1** included all HRAs regardless if dominant or co-dominant conifers were retained. It also included any HRA on the harvest unit edge, which may or may not be easily identifiable (e.g. separated by a road). Retention calculation **4** included only HRAs that retained dominant or co-dominant conifers (H1). HRAs may be on the harvest unit edge but it was identified through the air because of a logging road. Retention calculations **6** and **8** include H1 values and are separated by at least 7.6 m and 15.2 m respectively.

## DISCUSSION

In THPs where HRAs are agreed to in a THP, the project proponent typically commits about 1.5 % to 2 % of the acreage that will be harvested. Variable green tree retention within a given THP ranged from 0.93% to 3.52 % for HRAs with high and low values, regardless of distance from harvest unit edge. Figure 2 shows three clearcut harvest units with varying degrees of aggregated retention. Overall, the

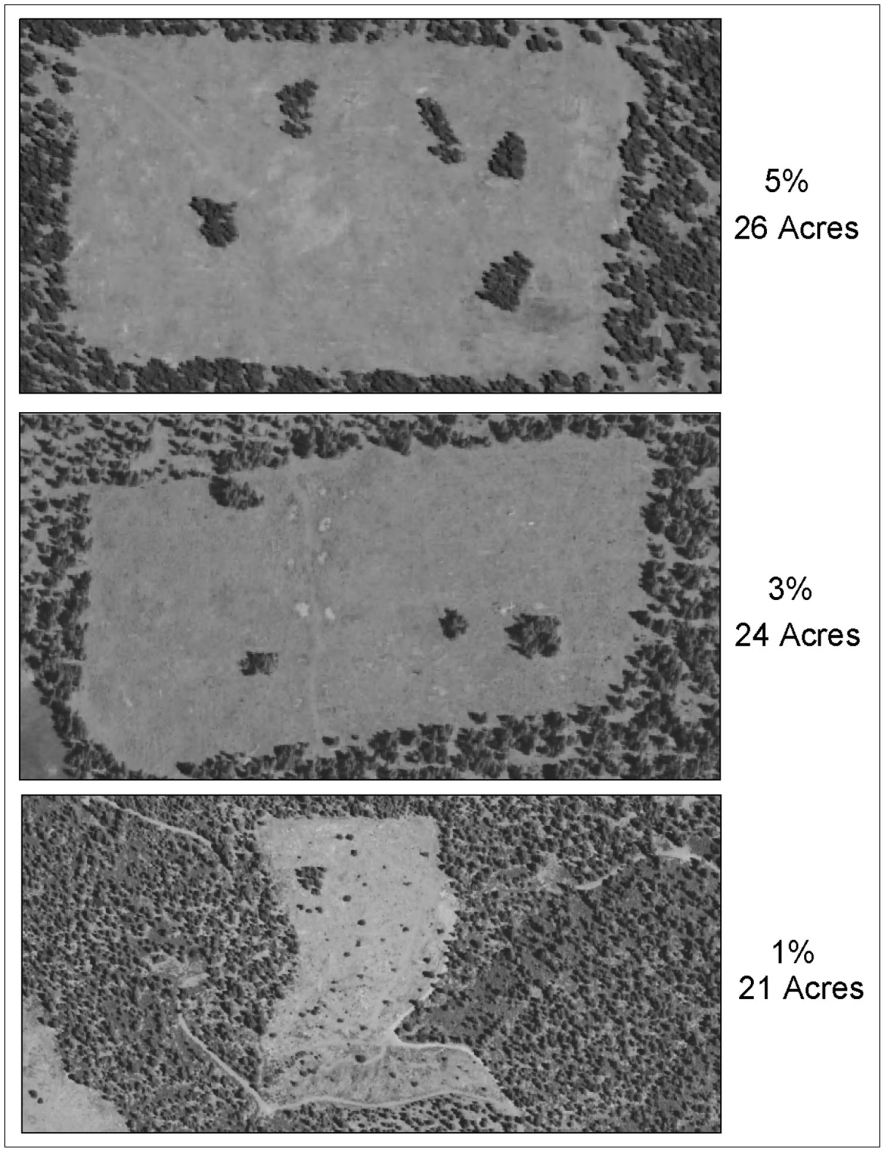


Figure 2.

agreed to standard was met in 10 of the 13 THPs (77%). Approximately 25% of the retention areas may be of lesser value because of smaller trees or proximity to unit edges. Eliminating "edge" or low-value HRAs would result in 6 to 8 of the 13 THPs having met the agreed-to standard.

HRA value and proximity to edge are two items worthy of discussion. The purpose of HRAs is to mitigate loss of late seral forest habitat characteristics removed

on the landscape. Intermediate trees are not expected to differentiate in size from regenerating trees over time. Pre-dominant and dominant conifers have a head start and are likely to provide more habitat complexity than the regenerating stand.

Distance to edge has not been evaluated for effectiveness. One concern is that future logging operators won't recognize the HRAs and they'll be removed prior to achieving their intended purpose. Another component of an HRA is its edge effect. The proportion of the fresh clearcut that is within a set distance (e.g. 100 m) of a forest is less when HRAs are part of a harvest unit boundary as compared to when they are separated by some distance. However, the home ranges of most species are large enough that the location may not be as important as the habitat elements retained.

Anecdotal information and recent data collection suggests that some species, or even associated groups of species, will benefit from aggregated retention in the short term. Based on anecdotal snow-track observations, rare species such as the Sierra Nevada red fox, *Vulpes necator* and American fisher, *Martes pennanti* may prefer to travel on forest edges rather than open spaces (J.Perrine, Museum of Vertebrate Zoology, U.C. Berkely, pers. com.; S.Yaeger, Wildlife Biologist, U.S. Fish and Wildlife Service, pers. comm.). Common species such as California mule deer, *Odocoileus hemionus fuliginatus* and American robin, *Turdus migratorius* have been incidentally flushed from resting areas within HRAs (J. Ravenscroft, Forester, Fruit Growers Supply Company, pers. comm.). In a point count survey to determine avian response to bioforestry units (HRAs), species such as western tanager, *Piranga ludoviciana*, mountain chickadee, *Parus gambeli*, dusky flycatcher, *Empidonax oberholseri*, yellow-rumped warbler, *Dendroica coronata*, and western bluebird, *Sialia mexicana* showed a significant preference for edge habitat where conifers, hardwoods, and snags were adjacent to openings created by clearcuts (Farber and Hewitt 2004).

In the long term, HRAs are expected to provide legacy habitat elements within regenerating stands. Depending on ecoregion, conifers and hardwoods typically require at least 80 to 150 years to develop features such as cavities, furrowed bark, basal hollows, and large lateral branches. It may take longer to develop large snags. Farber and Hewitt (2004) have observed pileated woodpeckers, *Dryocopus pileatus* and mountain chickadees nesting in retained snags within clearcut units. American fisher has been tracked to resting and denning sites within mature black oaks retained in harvest units (R. Klug, Wildlife Biologist, Roseburg Resources Company, pers. comm.). The presence of a basal hollow, which only occur in legacy trees, was the feature that appeared to provide the greatest habitat value, especially for bats, to legacy trees (Mazurek and Zielinsk 2004).

If a stand of timber is scheduled for a 20-40 year harvest rotation, an even-aged, regenerating stand with multiple harvest entries will not provide significant complexity unless retention of legacy features occurs. A commitment must be made to retain aggregated and dispersed habitat elements over a minimum100-year rotation to produce the desired result of maintaining legacy habitat elements over time.

## ACKNOWLEDGEMENTS

We are grateful to the retired CDFG warden/pilot R. Anthes, who equipped and flew the aircraft that made photography possible, and got us back safely. Timber harvesting plan information was provided by M. Bacca from California Department of Forestry and Fire Protection, W. E. Hultgren from Roseburg Resources Company, and T. Harrington from Sierra Pacific Industries. ArcMap assistance was provided by CDFG GIS Analyst K. Morefield. We thank Roseburg Resources Company and Sierra Pacific Industries for allowing us to access their lands. Finally, we would like to thank Dr. R. Sullivan and D. Richter for the time they added to their schedules to ask questions, make suggestions, and provide input that enhanced this report.

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Received: 3 July 2007
Accepted: 2 October 2007

## APPENDIX

**Polygon creation – harvest units.**

- Use vertex tool to create polygons roughly tracing boundaries of all pre-green-up (less than 10 years old) clearcut units.
- Trace along shadow lines when necessary.
- If boundary is unclear, consult harvest unit map from applicable THP and then use best judgment on what is the logical harvest unit boundary based on visual cues including roads and site preparation.
- In general, exclude landings that are visibly distinct from the harvest unit, pre-existed per the DOQ, and remain compacted after site preparation.
- Only create polygons for harvest units with complete imagery coverage.

**Field creation – harvest units**

| Name | Type | Description |
|---|---|---|
| THP Number | String | Full THP number for the harvest unit. |
| Submitter | String | THP submitter. |
| Hectares_1 | Number | Calculated polygon area in hectares. |
| Hectares_2 | Number | Harvest unit hectares from THP. |
| Perimeter | Number | Calculated polygon perimeter in meters. |
| Num_HRAs | Number | Number of aggregated retention clusters (HRAs) within harvest unit. |
| BisecWLPZ | String | No, I, II, III, ?, I/II, etc for occurrence and classes (per THP) of bisecting WLPZs within harvest unit. |
| DispRetent | Number | 0: <1%, 1: <10%, 2: 10-50%, 3: >50%, assessed for % area with dispersed retention > 25 % of trees of intermediate, co-dominant or dominant crown classes based on comparison with adjacent stands. |

**Polygon creation – variable retention**

- Use vertex tool to create polygons precisely tracing the boundaries of all visibly distinct aggregated retention clusters (HRAs) that lie within obvious THP boundaries per cursory review of applicable THP map.
- Zoom in to highest pixel resolution scale and carefully trace to exclude shadow lines.
- In deciding whether to map a single HRA or break up mapping into several smaller polygons, make best judgment based on connectivity/ continuity and lack of site preparation in open areas between retained trees.
- Similarly map bisecting WLPZs after consultation with applicable THP maps.

**Field creation – variable retention**

| Name | Type | Description |
|---|---|---|
| THP_Number | String | Full THP number for the harvest unit. |
| Unit_Num | String | THP submitter. |
| VR_Type | String | H1: aggregated retention cluster that includes dominant or co-dominant conifers.<br>H2: aggregated retention cluster that does not include dominant or co-dominant conifers.<br>W1: class 1 bisecting WLPZ.<br>W2: class 2 bisecting WLPZ.<br>W3: class 3 bisecting WLPZ.W?: bisecting WLPZ of unknown class.<br>X: special retention area (e.g., unstable area, Arcsite).<br>?: unknown/uncertain retention area. |
| Hectares | Number | Calculated polygon area in hectares. |
| Perimeter | Number | Calculated polygon perimeter in meters. |
| DistEdge | Number | Shortest tree crown to tree crown distance between retention area and harvest unit edge. Measured in meters. Measure between actual trees instead of using polygon boundaries. Record a zero for immeasurable or negligible distances. |
| Adj _Code | Number | For cases where DistEdge is recorded as zero.<br>1: VR feature is immediately adjacent to harvest unit edge but it separated by a road.<br>2: VR feature is immediately adjacent to harvest unit, is not apparently separated by a road, but appears visually distinct from adjacent stand in that the feature “juts out” into the harvest unit. |