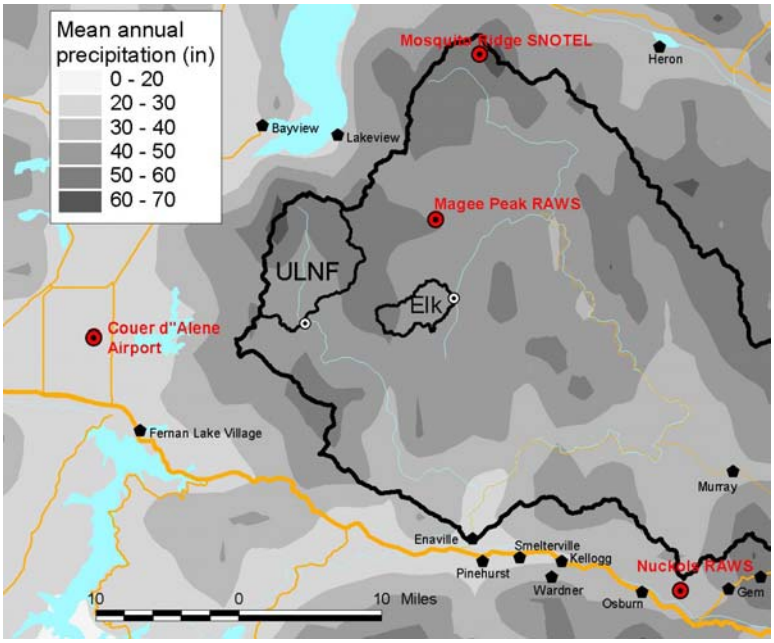
Hydrology Analysis
North Fork Coeur d'Alene River Subbasin



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Hydrology Report
North Fork Coeur d'Alene River Subbasin

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1.0 OVERVIEW

1.1 PURPOSE AND NEED

The North Fork Coeur d'Alene (NFCDA) TMDL (IDEQ, 2001) addressed water-quality limited stream segments in the NFCDA Subbasin. Several stream segments were listed as water quality limited due to "flow alteration", specifically, adverse changes in the magnitude of flood flows.

Section 2.3.2.1.1 of the NFCDA TMDL attempted to address the concerns of increased peak flow magnitudes in the NFCDA by comparing the magnitude of the largest regionally significant peak flow on record, the peak flow of January 1974, with the second largest peak flow on record, the flood of February 1996. Because the 1996 flood was of a smaller magnitude then the 1974 event the authors concluded that peak flow events have not been significantly affected by land use practices in the NFCDA Subbasin. Given that peak flow magnitude is driven by climate conditions during and immediately preceding the storm event, and given the complete lack of any analysis as to what these conditions were, the analysis presented in no way supported this claim. These results were cited in subsequent sections of the document to support the claim of no management-related impacts on peak streamflow. This conclusion could not be made based on the analysis presented.

Further study was needed given the legitimate concerns that hydrologic change issues were not adequately addressed in the NFCDA TMDL. An understanding of to what extent stream flows may have changed due to management-related activities (harvest and roads) was needed to assess the significance of hydrologic change on sediment production (primarily through bank erosion) and in-channel sediment dynamics.

1.2 THE DISTRIBUTED HYDROLOGY-SOIL-VEGETATION MODEL (DHSVM)

The Distributed Hydrology Soil Vegetation Model[1] (DHSVM) is a distributed hydrologic model originally developed to evaluate the effects of topography and vegetation on water movement through a watershed (Wigmosta et al., 1994). Spatially distributed models such as DHSVM provide a dynamic representation of the spatial distribution of soil moisture, snow cover, evapotranspiration, and runoff production, at the scale of digital elevation model (DEM) pixel (Figure 1). DHSVM has been used to assess changes in flood peaks due to enhanced rain-on-snow and spring radiation melt response (e.g., Thyer et al., 2004), effects of forest roads and road drainage (e.g., Lamarche and Lettenmaier, 2001), and the prediction of sediment erosion and transport (Doten and Lettenmaier. 2004).

[1] An overview of the DHSVM model, source code, and details of the model application, can be found at http://www.hydro.washington.edu/SurfaceWaterGroup/Models/DHSVM/index.shtml

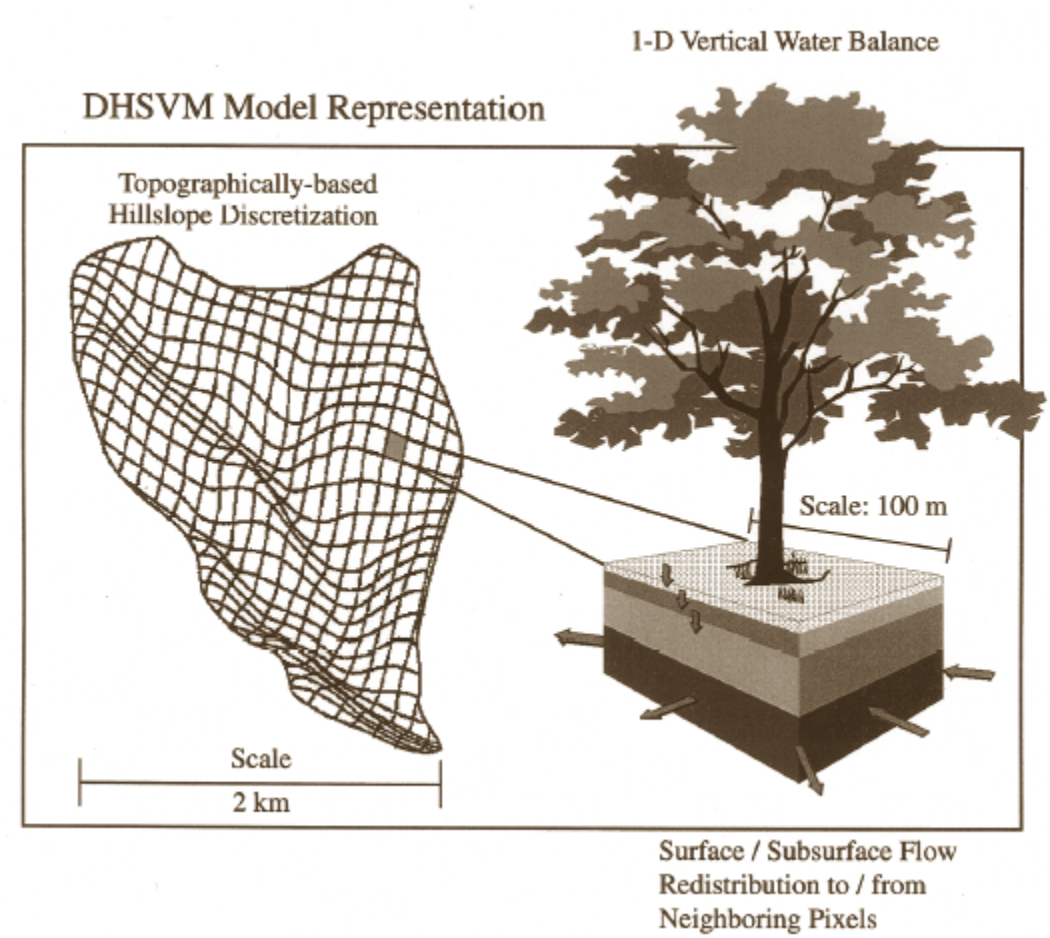


Figure 1. Model representation of watershed soil, vegetation and topography as discrete pixels (from Vanshaar and Lettenmaier, 2001).

1.3 OVERVIEW OF APPROACH

We used the DHSVM model to assess management-related impacts on stream flows from forest harvest and roads in two subwatersheds within the NFCDA. The two subwatersheds selected for analysis were the upper Little North Fork Coeur d'Alene River, upstream of the confluence with Burnt Cabin Creek (hereafter referred to as the ULNF), and Big Elk Creek (Figure 2). These subwatersheds had continuous stream flow data (for model calibration purposes), and had experienced moderate to high levels of forest harvest and road construction. The ULNF has a drainage area of 44 mi^2, and the period of record for the stream gage at the subwatershed outlet is from 2001 to present. Big Elk Creek is a tributary to Tepee Creek, draining an area 11.6 mi^2 in size, and the gage period of record is from1988 to present.

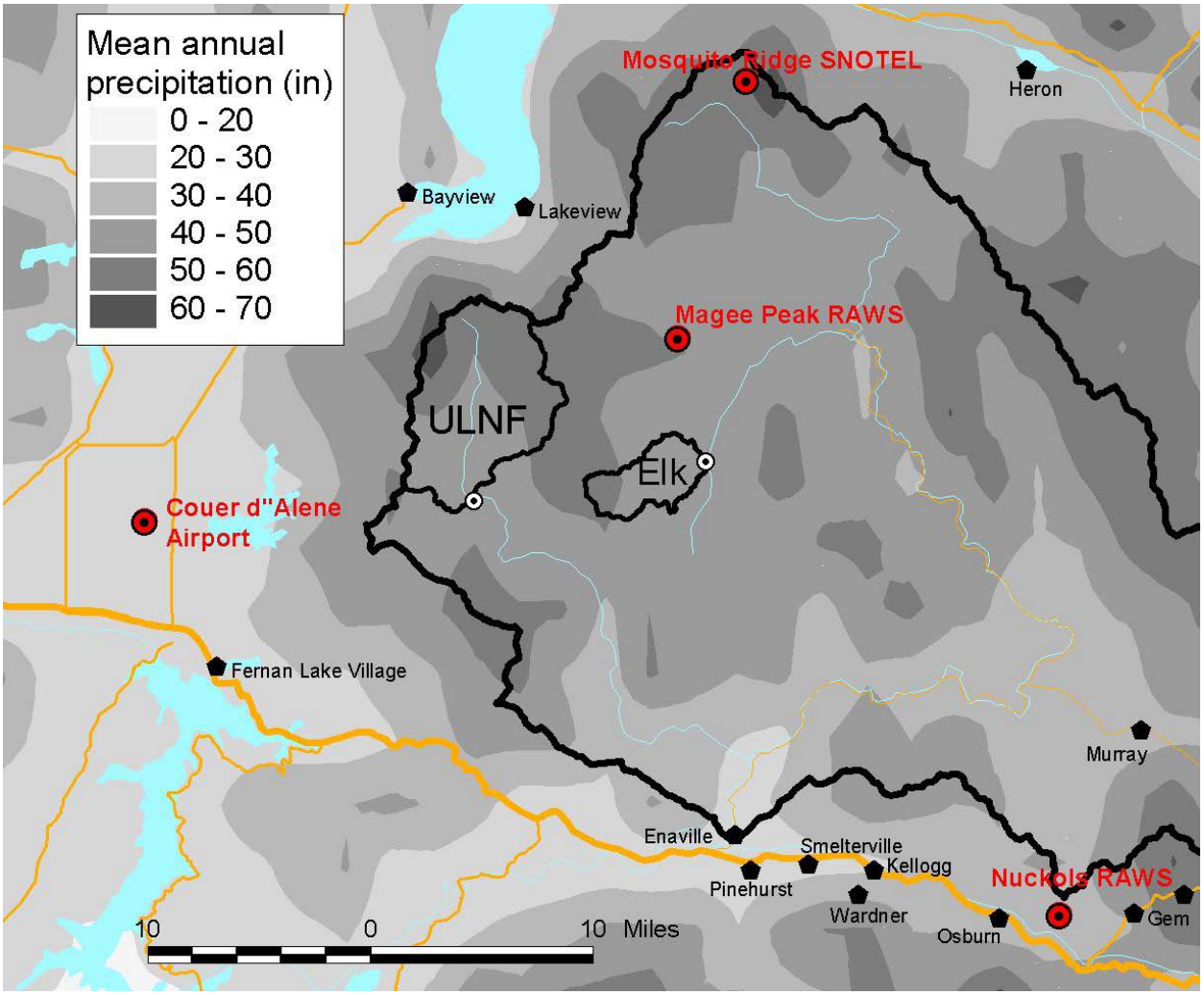


Figure 2. Location of the Upper Little North Fork (ULNF) and Big Elk subwatersheds within the NFCDA subbasin. Also shown are climate data stations within the vicinity.

For each subwatershed the model was first constructed for the current condition (i.e., current vegetation, and current road network). We then evaluated management-related impacts on stream flows by selectively removing each management impact (i.e., replacing areas currently occupied by roads and harvest units with the potential land cover appropriate for the area), and rerunning the model. Results from these allowed us to compare peak flow magnitudes for selected storm events under three scenarios:

- Current conditions (i.e., existing vegetation and road conditions)
- Current vegetation conditions with road effects removed
- Potential vegetation conditions (no management) and no roads

One additional model run was also conducted in the ULNF subwatershed to evaluate the effects of timber harvests planned as part of the Iron-Honey EIS.

2.0 METHODS

The DHSVM model requires several types of spatial and temporal data inputs. All spatial data was processed using ArcView 3.3 GIS software, with the Spatial Analyst extension. The DHSVM model itself was run on a Linux workstation running Debian Linux version 4.0.

2.1 SPATIAL INPUT DATA

Spatial data inputs include a digital representation of topography, vegetation, soils, streams, and roads. Topographical, soils, and stream data were constant among model runs. Vegetation and roads varied by management scenario.

2.1.1 Digital Elevation Model Data

The DHSVM model runtime is dependent on the length of the model run, as well as the resolution of the raster data sets. Typical values for raster data range from 25- to 150-meter pixel resolution. A pixel resolution of 30 meters was chosen for the Big Elk subwatershed, and a resolution of 60 meters was chosen for the ULNF (Figure 3).

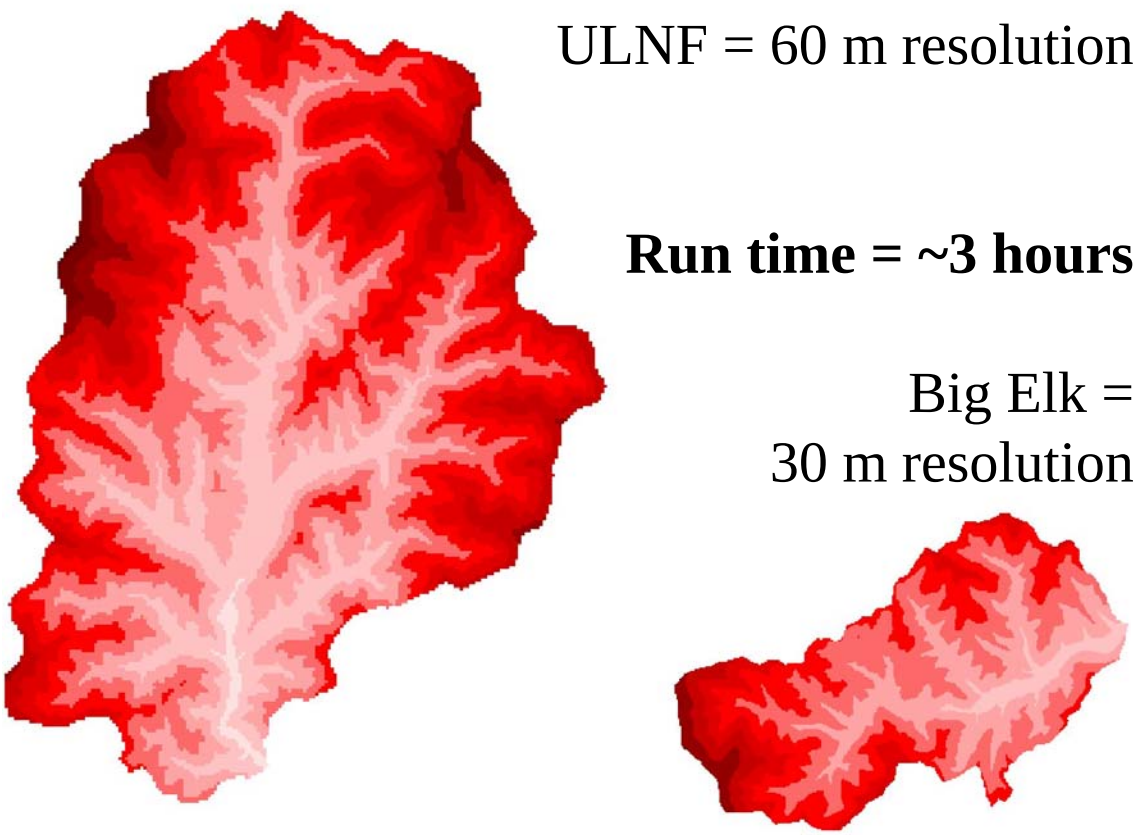


Figure 3. Digital elevation model (DEM) representations of the ULNF and Big Elk subwatersheds.

One arc second DEM data (~21 meter native resolution) was acquired for the project area[2] and resampled to 30- and 60-meter resolution. The resulting DEMs were then filled to eliminate "sinks"; locations where the model would not "drain" in a downstream direction. A mask file was also created from the resultant DEMs that is used by DHSVM to identify which pixels are inside and outside of the study subwatersheds. These DEM files (and all subsequent raster files) were then exported from the GIS in a binary format for input to the DHSVM model.

2.1.2 Vegetation

Vegetation data were obtained from available Forest Service databases[3]. GIS polygon data were clipped to the dimensions of each watershed (Big Elk and Upper Little Fork Coeur d'Alene watersheds), allowing for a 100 m buffer around each to ensure continuity of coverage for the DHSVM analysis.

Vegetation data from the available data sources ("Stands" and "Components") were reviewed for continuity of coverage, general agreement in classifications, and agreement of classifications with recent (2005) color digital orthoquad imagery (DOQ). There was good agreement in classifications at the coarse scale – that of major species identifications – though stand-level information involving tree species layers and stand metrics (basal area, trees per acre, volume) did not appear to be in good agreement, most likely due to the time since the last update, sampling intensities, or post measurement treatments.

The stand metrics that appeared to be in the best agreement with the DOQs and associated datasets, with the best geographic coverage included the following:

- Stand Type/ Major Species
- Size Class (immature, sawtimber, saplings, etc.)
- Canopy height
- Stand Age/ Origin

These data metrics were assigned structural and compositional classifications that follow (1) the major Biophysical Environments (BPEs) of North Idaho ecosystems, and (2) the major stages of stand development (structural stages). Combined, the classifications were made to place current conditions in context with the Historic Range of Variability (HRV) for North Idaho Ecosystems (Smith & Fisher 1993). While in reasonable agreement, the four available stand metrics were used to create a suite of classification codes used for the DHSVM analysis. The classification codes and their general descriptions are found in Table 1.

2.1.2.1 Current conditions

Understanding the limitations associated with the base data, DHSVM classifications were assigned at the stand level (average ~28 acres in size) using the USFS vegetation polygon GIS coverage. Following DHSVM classifications, data were examined with the color DOQ imagery and two major constraints defined the accuracy of the classification scheme. The first constraint

[2] http://seamless.usgs.gov/

[3] GIS data: http://www.fs.fed.us/ipnf/eco/yourforest/gis/index.html, stand attribute data from "Stands" and "Components" tables: http://www.fs.fed.us/ipnf/eco/yourforest/gis/veg/vegetation_readme.html

is BPE classifications were made on the basis of major species and plant associations identified in the available datasets, which did not take into account fire exclusion effects of species shifts (e.g. ponderosa pine/ Douglas-fir forest types converting to grand-fir/ western redcedar types). When classifying BPE's at landscape scales, it becomes problematic to determine the likely compositional range of vegetation based upon the current conditions – field crews typically identify species and plant associations on the basis of the regenerating layers and fire exclusion effects often promote the establishment of fire intolerant species (i.e. late seral species) in the understory strata. As such, the BPE classifications are probably biased toward the cooler-moist ecotypes and warm-dry/ warm-moist types are probably underrepresented in the classification scheme.

Table 1. Descriptions of vegetation classification codes used in the DHSVM analysis.

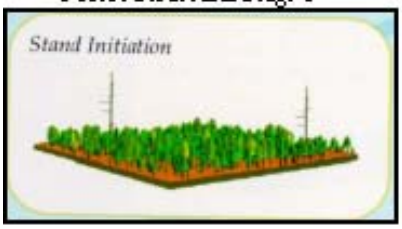
Biophysical Environment (BPE)	Major Structure Type	North Idaho Structural Stage[4]	DHSVM Classification Code
Cool-Dry	Large Trees	6-7	CDLT
Cool-Dry	Medium Trees	4-5	CDMT
Cool-Dry	Sapling/ Pole	1-3	CDSP
Cool-Moist	Large Trees	6-7	CMLT
Cool-Moist	Medium Trees	4-5	CMMT
Cool-Moist	Sapling/ Pole	1-3	CMSP
Unknown	Non-Forest	0	NONF
Unknown	Seedlings	1-3	SEED
Warm-Dry	Large Trees	6-7	WDLT
Warm-Dry	Medium Trees	4-5	WDMT
Warm-Dry	Sapling/ Pole	1-3	WDSP
Warm-Moist	Large Trees	6-7	WMLT
Warm-Moist	Medium Trees	4-5	WMMT
Warm-Moist	Sapling/ Pole	1-3	WMSP

The second constraint involves forest structural attributes, where vertical stand metrics were either not available, incomplete, or were not consistent with the latest GIS polygon coverage/ DOQ imagery. The constraint with this data gap involves the determination of single- or multi-strata forest types; this is especially important for determining the current shift from reference conditions for the warm-dry forest types following the Historic Range of Variability (i.e. "Stage 6" and "Stage 7" in Figure 1 cannot be differentiated). Hence, the most reliable source of stand structural information involved only coarse codes (sawtimber, immature, pole, etc), and stand age was needed to estimate and refine the structural stage condition. A common example in the original data involved an "immature stand" classification that was 80-100 years old. The DHSVM classifications presented here incorporated this stand age to classify the stand as having "large trees" (e.g. "WMLT" in Table 1).

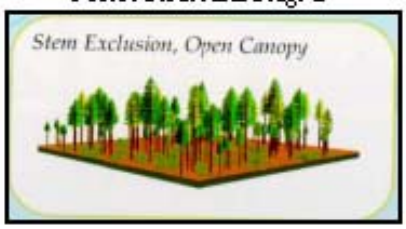
Despite these data gaps, the classification scheme is in relatively good agreement with observed conditions of the DOQ imagery, and provides a reasonable estimate for a landscape-scale Current Condition analysis for use in the DHSVM analysis. Both watersheds were pooled to reflect the spatial pattern of the basin as a whole. A summary of the Current Conditions by acres and land area is presented in Table 2 and Figure 5.

[4] See Figure 4

Forest Structural Stage 1



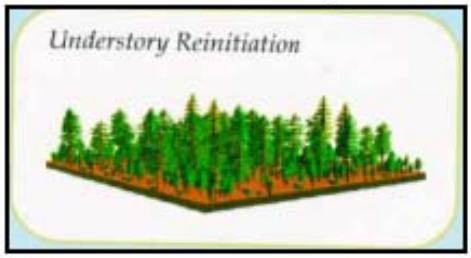
Forest Structural Stage 2



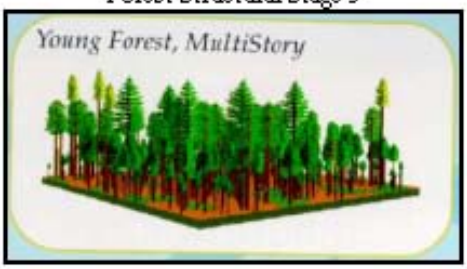
Forest Structural Stage 3

Stand Initiation through Stem Exclusion (Stages 1-3). These early stands are fully stocked by conifer trees that may range in size from seedlings through 15" diameter trees. The distinguishing characteristic is that all the trees are near the same age (same cohort), and all the trees are in the same canopy layer. A second canopy later of shade tolerant trees has not yet started to develop in the understory.

Forest Structural Stage 4

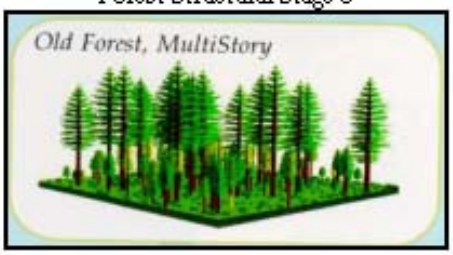


Forest Structural Stage 5



Understory Reinitiation and Multi-Stratum without Large Trees (Stages 4 & 5). A second cohort of trees is established under an older overstory in these middle stages. Openings start to appear in the canopy, and the amount of down wood increases. The trees in the overstory are typically seral (larch, pine, Douglas-fir, etc.) while the trees in the understory are typically shade-tolerant (western redcedar, hemlock). The stand may contain many sizes of trees, but large trees are uncommon.

Forest Structural Stage 6



Multi-Stratum with Large Trees (Stage 6). These late and old stands contain two or more cohorts of trees, and trees of all sizes are present. The overstory is discontinuous, and dominated by large trees.

Forest Structural Stage 7

Single-Stratum with Large Trees (Stage 7). A single layer of large seral trees is present in this late and old stage. The understory may be absent or may contain sparse or clumpy seedlings and samplings. These stands are sometimes called park-like.

Figure 4. Stages of Structural Development.

Table 2. Current Conditions of Biophysical Environments by Structural Stage.

BPE	Non-Forest		Structural Stage[5] by BPE						Total Acres
			1-3		4-5		6-7		
	Acres	%	Acres	%	Acres	%	Acres	%	
Cool-Dry			816	19%	890	20%	2,705	61%	4,411
Cool-Moist			2,121	23%	995	11%	6,088	66%	9,204
Unknown	305	30%	711	70%					1,017
Warm-Dry			1,284	20%	1,327	20%	3,912	60%	6,523
Warm-Moist			5,450	33%	1,470	9%	9,637	58%	16,558

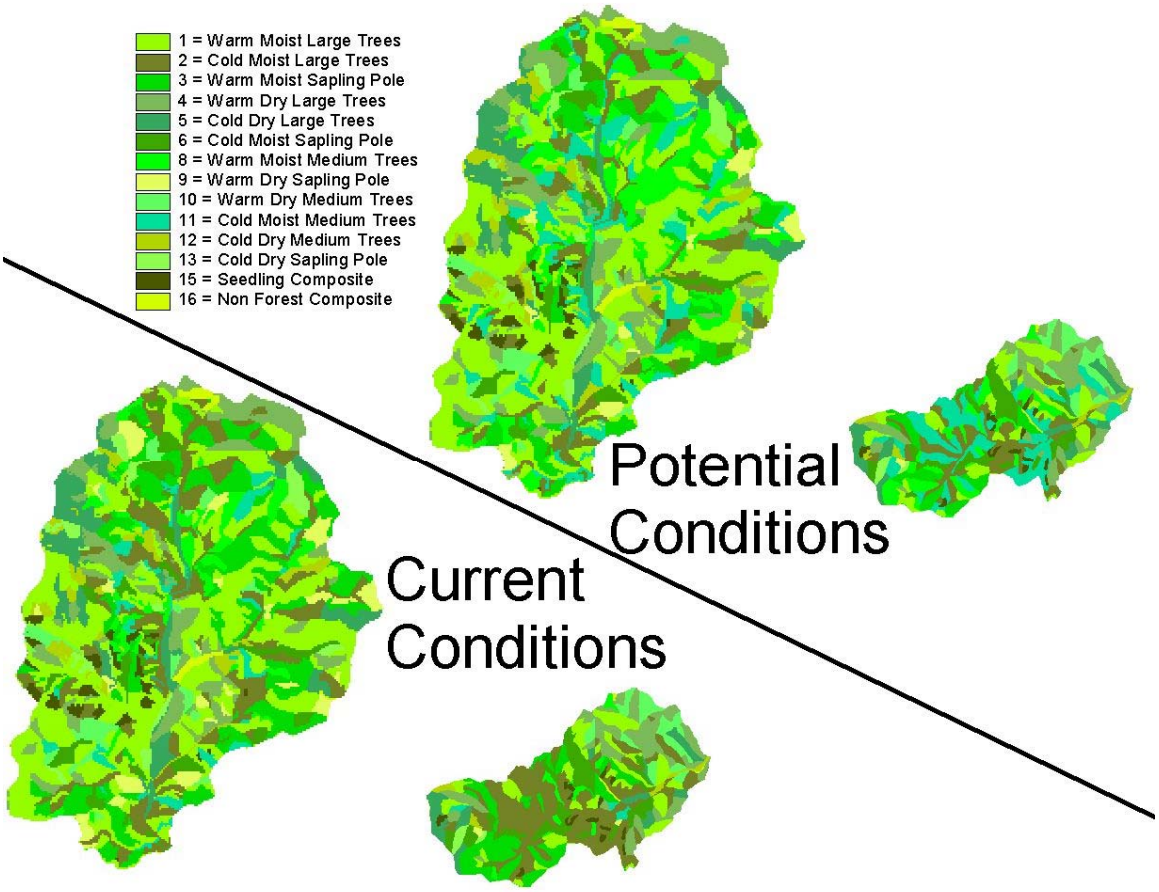


Figure 5. Current (lower) and potential (upper) vegetation conditions in the ULNF and Big Elk subwatersheds.

[5] See Figure 4

2.1.2.2 Potential (Reference/ Historic) Condition

In the assessment of the historic conditions of the landscape, it is important to consider the native disturbance patterns that helped to define those conditions, and to extrapolate a landscape-level view of how those disturbances affected the distribution of vegetation structures. The intent of the Historic Range of Variability (HRV) analysis is to describe the landscape-level patterns of forest structure and composition, assuming the natural (or historical) patterns of disturbance. An HRV analysis is not intended to be a stand-level analysis; rather it is used as a guide to evaluate how a landscape is functioning with respect to forest structure and composition, given a suite of disturbance patterns. For ease of interpretation, seven structural stages are identified that describe the age structure of a given stand (Figure 4).

With the assumption that the BPE's defined in the Current Condition were accurately described[6], it is possible to compare and contrast the distribution of forest structures at landscape scales. Distribution percentiles of structural stages are presented in Table 3; HRV distribution percentiles represent likely median values for the analysis area, though these percentages are typically expressed as a range[7].

Table 3. Reference Conditions of Biophysical Environments by Structural Stage (non-forest and unknown BPE's are excluded).

BPE	Structural Stage[8] by BPE						
	1-3		4-5		6-7		
	Acres	%	Acres	%	Acres	%	Total Acres
Cool-Dry	662	15%	1,323	30%	2,426	55%	4,411
Cool-Moist	1,841	20%	3,681	40%	3,681	40%	9,204
Warm-Dry	652	10%	1,304	20%	4,566	70%	6,523
Warm-Moist	2,484	15%	4,139	25%	9,935	60%	16,558

Though the HRV analysis is a landscape-scale analysis, the DHSVM inputs require stand-specific assignments of reference vegetation classifications. The primary assumption for this analysis was that historic disturbance followed stochastic events on the landscape; as such, stand-level Structural Stage classifications were altered from the Current Condition following a random distribution. For example, the current condition of the warm-moist young forest (stage 1-3, Table 2) included 5,450 acres of land area (33% of the warm-moist BPE). On average, the landscape-scale HRV would suggest only 2,484 acres, or 15% of the warm-moist BPE (Table 3). Hence, a random selection of these acres (2,966 acres) were reassigned to other structural stages (4-5 and 6-7) to alter the distribution of the current condition to better match the distribution described in the HRV (e.g. 2,669 acres were assigned to stage 4-5 and 298 acres were assigned to Stage 6-7 to emulate the historic distribution). Following this method, the entire analysis area was assigned a DHSVM classification code (Table 1, Figure 5) to represent a "snapshot" of a likely historic vegetative condition.

[6] See data gaps described in the Current Conditions section.
[7] HRV target values are composites from the North Idaho USDA FS guidance and Smith & Fisher (1993).
[8] See Figure 4.

2.1.2.3 Future (post-harvest) conditions in the Iron-Honey EIS area

At the request of the US Forest Service, an additional model run was included that allowed the evaluation of proposed harvest treatments included in the Iron-Honey EIS (Figure 6). The majority of the proposed treatments were Shelterwood removal (3,800 acres), with three proposed clearcut units (370 acres) and three thinning units (140 acres). All but one stand are proposed for harvest using skyline yarding methods. All shelterwood and clearcut stands would be under burned post-harvest.

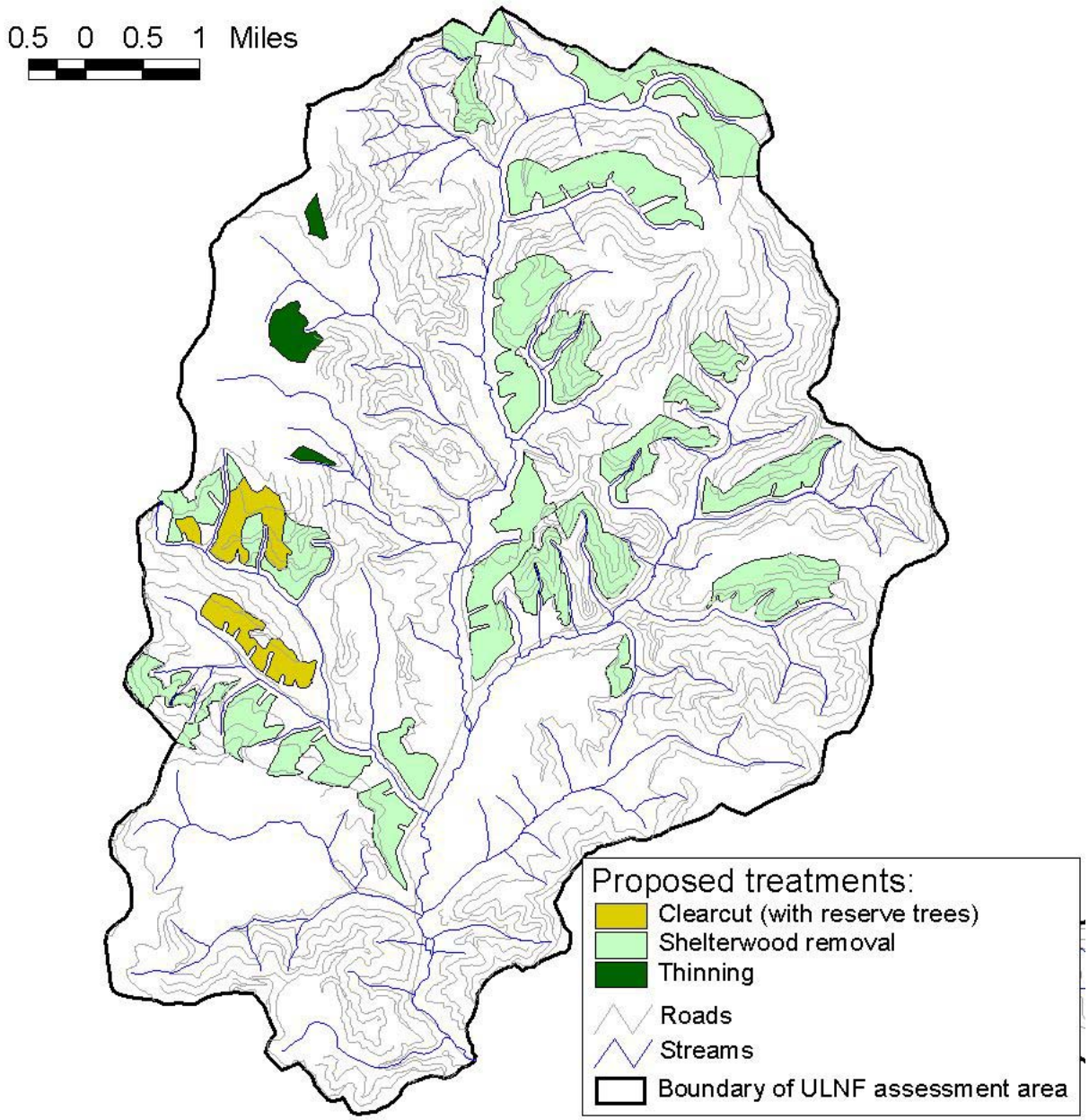


Figure 6. Proposed harvest units, Iron-Honey EIS (alternative 5), ULNF subwatershed.

2.1.2.4 DHSVM Vegetation Parameters

Each unique vegetation classification code (Table 1) was assigned a suite of parameters that the DHSVM model utilizes to predict the influence of vegetation on stream flows. Among all classifications, the primary differentiators included:

- Fractional Coverage (% cover in overstory trees)
- Canopy and understory heights
- Overstory monthly Leaf Area Index (LAI)

Other values were determined through published literature (Bowling and Lettenmaier, 1997; Storck and Lettenmaier, 2000), with minor adjustments explained in this section. Appendix A contains all parameter values for all vegetation types.

2.1.2.4.1 Fractional Coverage

Fractional Coverage is defined as the percent canopy cover of overstory trees. A qualitative review of the project area provided a very wide range of canopy closures in the analysis area, though general estimates were made to reflect the basic differences among BPEs and structural classes. Values ranged from 5% in non-forest to 90% closure in old structured forest types (Table 4).

Table 4. Fractional coverage assumptions for each DHSVM classification.

DHSVM Classification	Fractional Coverage (% cover)	DHSVM Classification	Fractional Coverage (% cover)
CDLT	0.9	WDLT	0.9
CDMT	0.8	WDMT	0.75
CDSP	0.6	WDSP	0.5
CMLT	0.9	WMLT	0.9
CMMT	0.8	WMMT	0.8
CMSP	0.66	WMSP	0.66
NONF[9]	0.05	Shelterwood harvest units	0.2
SEED	0.3	Thinning harvest units	0.54

2.1.2.4.2 Canopy Height

Tree heights were modeled from the existing "Components" dataset[10] obtained from the analysis area, where stands were grouped by the current DHSVM classifications. Summary values for tree heights are summarized in Table 5. As expected, canopy heights were highly variable in the sapling/pole condition (where 'SP' is in the final position), seedlings, and non-forested components.

[9] The non-forest type was also used to represent recently clearcut stands.
[10] http://www.fs.fed.us/ipnf/eco/yourforest/gis/veg/vegetation_readme.html

Table 5 Statistics for canopy heights obtained from existing stand components data, summarized by DHSVM classification group.

DHSVM Classification	Canopy Ht (m)	Canopy Ht (ft)	SE (ft)	SE%	N of Trees	Min Ht (ft)	Max Ht (ft)
CDLT	23.0	75.3	1.6	2%	85	46	130
CDMT	17.5	57.3	3.5	6%	23	10	82
CDSP	11.9	39.2	4.8	12%	20	2	73
CMLT	26.7	87.5	1.2	1%	199	30	129
CMMT	19.4	63.7	3.4	5%	32	12	116
CMSP	10.4	34.3	3.3	10%	38	2	100
NONF	12.5	41.1	8.6	21%	8	1	74
SEED	2.6	8.5	5.1	59%	26	1	114
WDLT	22.9	75.1	1.2	2%	118	16	102
WDMT	21.5	70.5	1.5	2%	42	49	86
WDSP	9.0	29.4	3.4	12%	34	5	83
WMLT	25.7	84.5	0.9	1%	237	35	111
WMMT	21.1	69.2	2.9	4%	45	11	100
WMSP	8.5	27.8	2.0	7%	95	2	93

2.1.2.4.3 Leaf Area Index

Leaf Area Index (LAI) is the ratio of leaf area (needle surface) per unit of ground area, and is useful to describe the primary productivity of a system, or the photosynthetic activity throughout the year. Because the DHSVM model utilizes time-series climate data, it is important to have an understanding of plant activity throughout the year to calculate the amount of moisture lost from evapotranspiration. Direct measures of LAI are complex and unavailable for this analysis; values were obtained from previous DHSVM studies (Bowling and Lettenmaier, 1997) and from the Land Data Assimilation System (LDAS)[11] to estimate appropriate ranges of monthly LAI for each of the vegetation types.

Canopy height and LAI measures reported elsewhere (Bowling and Lettenmaier, 1997) indicated there was a significant relationship ($P<0.01$) to use canopy height as a predictor for LAI (Figure 7). Though not a complete sample, the relationship provides a basis to "fine tune" LAI estimates with canopy height data specific to the analysis area.

[11] http://ldas.gsfc.nasa.gov/LDAS8th/MAPPED.VEG/web.veg.monthly.table.html

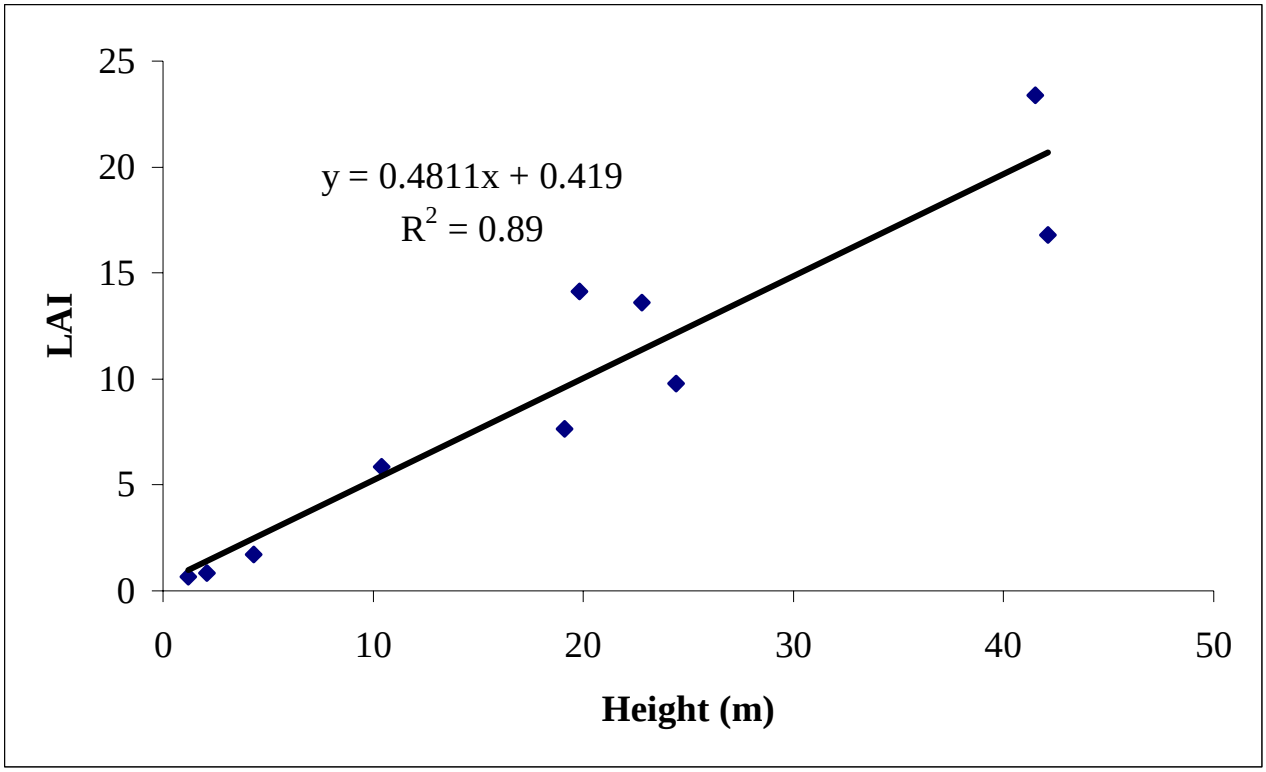


Figure 7. Relationship between mean annual LAI and canopy height (adapted from data presented in Bowling & Lettenmaier 1996).

Because LAI varies throughout the year, LDAS data were used to evaluate the seasonal flux for forest and non-forest ecosystems. Three general forest ecosystem types were selected to "bracket" the forested types represented in the analysis area (evergreen needle leaf, mixed cover, and deciduous needle leaf). The average of the monthly values provided a profile by which a monthly correction factor could be derived. This monthly correction factor was applied to the modeled mean LAI generated from canopy height information to provide an estimate of seasonal flux in LAI among the DHSVM vegetation classifications. Understory LAI was applied in a similar manner, grouping all DHSVM classes as either forested or non-forest/seedling components (closed shrub model from LDAS).

The set of monthly LAI parameters for overstory and understory components, including mean annual LAI and the monthly correction factors are presented in Table 6.

Table 6. Annual mean and monthly LAI overstory and values for each DHSVM classification.

DHSVM Class	Mean Annual LAI	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Correction Factor		84%	87%	94%	100%	109%	118%	117%	113%	108%	98%	88%	84%
Overstory													
CDLT[12]	11.48	9.58	10.01	10.83	11.48	12.48	13.58	13.41	12.93	12.35	11.22	10.11	9.58
CDMT	8.84	7.37	7.70	8.33	8.84	9.60	10.45	10.32	9.95	9.50	8.63	7.78	7.37
CDSP	6.14	5.15	5.38	5.82	6.17	6.71	7.30	7.21	6.95	6.64	6.03	5.43	5.15
CMLT	13.46	11.08	11.57	12.52	13.28	14.43	15.70	15.51	14.95	14.28	12.97	11.69	11.08
CMMT	9.75	8.15	8.52	9.21	9.77	10.62	11.55	11.41	11.00	10.51	9.54	8.60	8.15
CMSP	5.42	4.55	4.75	5.14	5.45	5.93	6.45	6.37	6.14	5.86	5.33	4.80	4.55
NONF[13]	6.43	0.87	0.91	0.99	1.05	1.14	1.24	1.22	1.18	1.13	1.02	0.92	0.87
SEED	1.67	1.40	1.46	1.58	1.67	1.82	1.98	1.96	1.88	1.80	1.64	1.47	1.40
WDLT	11.44	9.55	9.98	10.80	11.45	12.44	13.54	13.37	12.89	12.31	11.18	10.08	9.55
WDMT	10.76	8.99	9.39	10.16	10.78	11.71	12.74	12.58	12.13	11.59	10.53	9.49	8.99
WDSP	4.75	3.95	4.13	4.47	4.74	5.15	5.60	5.53	5.33	5.09	4.63	4.17	3.95
WMLT[14]	12.78	10.70	11.18	12.10	12.82	13.94	15.17	14.98	14.44	13.79	12.53	11.29	10.70
WMMT	10.57	8.83	9.22	9.98	10.58	11.50	12.51	12.36	11.91	11.38	10.34	9.32	8.83
WMSP	4.51	3.76	3.92	4.25	4.50	4.89	5.32	5.26	5.07	4.84	4.40	3.96	3.76
Understory													
Seed/ Non-forest	0.58	0.63	0.63	0.63	0.92	1.77	2.55	2.55	1.73	0.97	0.73	0.63	0.58
Forested	0.36	0.46	0.60	0.60	0.60	0.60	1.13	1.08	0.64	0.36	0.36	0.36	0.36

[12] These values were also used to represent thinning units. The majority of proposed thinning units fell within the CDLT type
[13] These values were also used to represent clearcut conditions
[14] These values were used to represent shelterwood harvest units. The majority of proposed shelterwood units fell within the WMLT type.

2.1.3 Soil

The DHSVM model requires spatially distributed information on both soil textural characteristics and soil depth. Model parameters associated with textural class determine the rate at which moisture moves through the soil profile under saturated and non-saturated conditions, while soil depth controls the volume of soil moisture, as well as the interception of soil moisture by stream and road cuts. Soil characteristics were held constant among all model runs.

2.1.3.1 Soil mapping

The Idaho Panhandle National Forest (IPNF) "Landtypes" GIS coverage was used to [15] map soil depths and textural classes (Figure 8). Landtype descriptions[16] that accompany the GIS coverage provided details on textural type and typical profile depth. Typically several soil types may be contained within a single Landtype. Conditions were averaged among soil types and among soil layers within a single soil type. Multiple land types with similar textural types were combined. Seven distinct textural types were defined for the assessment area (Figure 8).

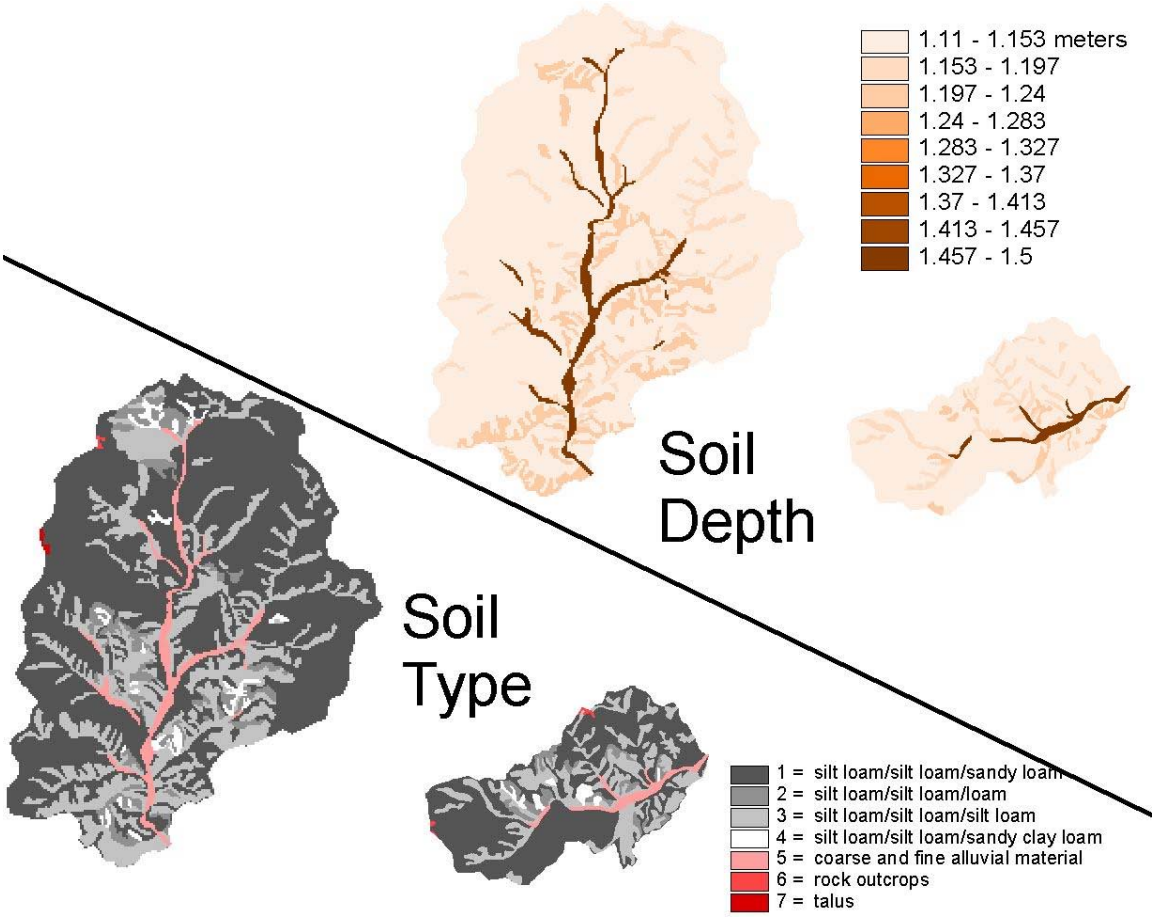


Figure 8. Soil depth (upper right) and textural class (lower left) for the ULNF and Big Elk subwatersheds.

[15] http://www.fs.fed.us/ipnf/eco/yourforest/gis/index.html#soils
[16] http://www.fs.fed.us/ipnf/eco/yourforest/gis/soils/landtype_descriptions.zip

2.1.3.2 DHSVM Soil Parameters

Sixteen soil parameters need to be defined for each of the seven soil textural types:

- Lateral hydraulic conductivity
- Exponential decrease in lateral hydraulic conductivity
- Maximum infiltration rate
- Capillary drive
- Surface albedo
- Number of soil layers
- Porosity
- Pore size distribution
- Bubbling pressure
- Field capacity
- Wilting point
- Bulk density
- Vertical conductivity
- Thermal conductivity
- Thermal capacity
- Mannings n

Values for each soil type were estimated based on published literature (Bowling and Lettenmaier, 1997; LaMarche and Lettenmaier, 1998; Freeze and Cherry, 1979; Dunne and Leopold, 1978). Appendix A lists the values used for each of the soil types.

2.1.4 Streams

The DHSVM model requires spatially distributed data on the location and characteristics of stream channel types. Stream locations and characteristics influence where and under what conditions subsurface flow becomes surface flow and the rate at which streamflow is routed to downstream locations. The model uses a simple linear routing algorithm to move water through the channel system.

2.1.4.1 Stream mapping

It is critical to the models operation that the vector stream coverage matches *exactly* the topographical low points (i.e., the valleys) in the DEM. Consequently, it was necessary to construct vector stream coverage from the DEM. This was done by varying the number of upstream pixels needed for channel initiation so that the created stream vectors reasonably approximated the best available stream coverage for the area[17]. The resultant coverages closely approximated mapped stream locations (Table 7).

Table 7. Comparison of DEM-derived stream coverage with best available coverage.

Subwatershed	Miles of stream from NHD	Miles of stream derived from DEM	Difference in total length
ULNF	104	106	2%
Big Elk	29	31	5%

[17] The IPNF suggests using the National Hydrography Data set coverage, available at http://nhd.usgs.gov/

2.1.4.2 DHSVM stream parameters

Parameters that need to be estimated for each stream segment include the following:

- Active channel width
- Active channel depth
- Channel slope
- Channel roughness

Channel width and depth were estimated based on drainage area (Figure 9). Regression equations for width and depth were based on stream survey data from within the NFCDA subbasin[18]. Channel width showed a strong correlation with drainage area. Although channel depth shows a much poorer relationship it is still adequate for the purposes of the model. Channel slope was calculated within GIS. A roughness value of 0.065 was used for all stream segments.

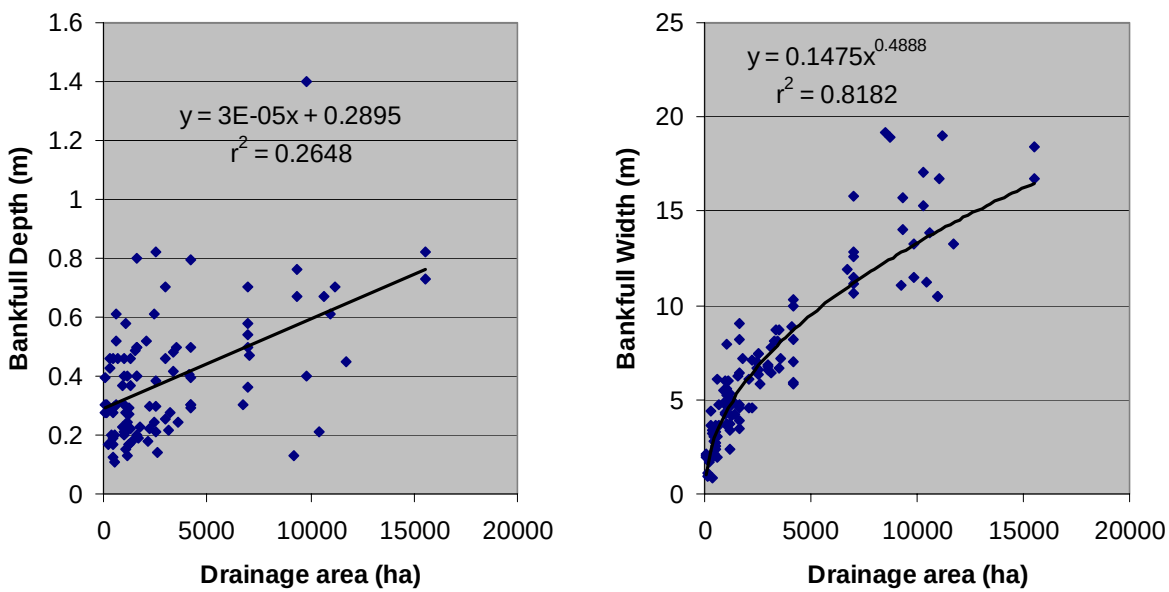


Figure 9. Relationship between bankfull width (right) and depth (left) and contributing area for streams in the NFCDA subbasin.

2.1.5 Roads and Road Drainage

Within DHSVM roads have two primary effects on modeled streamflow. First, road surfaces are treated as near-impervious surfaces and precipitation falling on these surfaces is treated as surface flow (although it may reenter the soil profile once it leaves the road surface). Secondly, road drainage ditches may convey all or a portion of the ditch flow to adjacent pixels, or directly to streams, altering the timing of streamflow at downstream locations. As with streams, road input has a spatial component that varies with road conditions.

[18] This data is described in detail in a companion channel assessment document.

2.1.5.1 Road mapping

Road locations were initially mapped within GIS using coverages available from the IPNF[19]. This initial coverage was edited by adding additional roads from hardcopy maps available from the IPNF, as well as from recent digital orthophotos (Figure 10). The majority of roads are no longer maintained and are not tracked as part of the road system. Only a small proportion has been formally decommissioned (Figure 10). Roads that have been decommissioned were removed from the analysis; however, all other roads were included. The decision to include all non-decommissioned roads is conservative, and may overestimate road effects.

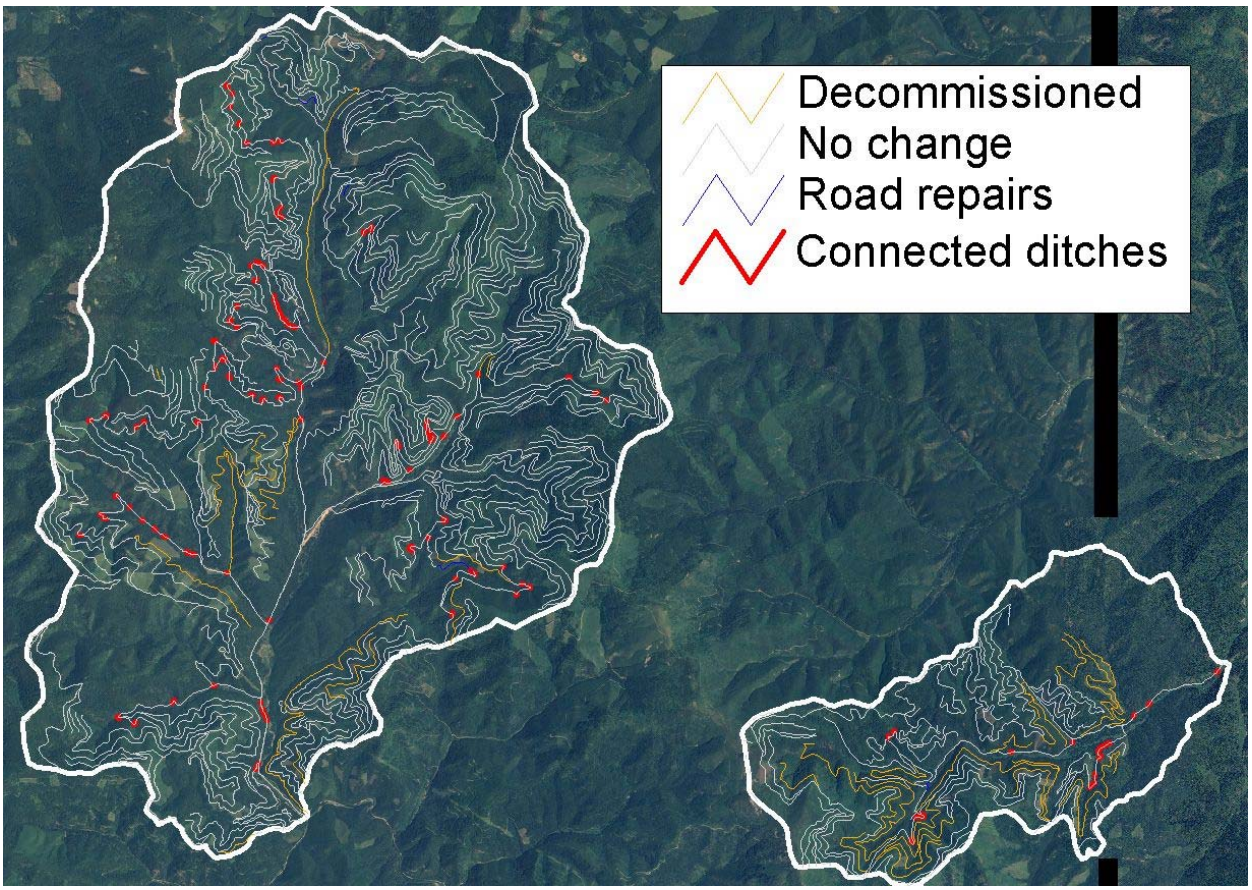


Figure 10. Road locations within the study watersheds. Also shown are areas where road ditches are hydrologically connected to the stream system.

All USFS system roads (i.e., currently maintained roads) were field surveyed during summer 2006[20]. Approximately 100 road ditches were identified during the road survey as having a surface connection to the stream network (Figure 10). Road characteristics within the study subwatersheds are summarized in Table 8.

[19] http://www.fs.fed.us/ipnf/eco/yourforest/gis/index.html#roads
[20] See the companion report on erosion and sediment for further details on the field sampling.

Table 8. Summary of road characteristics within the model watersheds.

Subwatershed	Miles of road that have not been decommissioned	Miles of road decommissioned	Road density (mi/mi2) not decommissioned	Miles of connected ditches
Big Elk Creek	228	100	19.6	0.7
ULNF	1,268	73	28.6	4.0

2.1.5.2 DHSVM road parameters

Model parameters for each road segment included:

- Ditch width
- Ditch depth
- Ditch slope
- Ditch roughness (Manning's n)
- Infiltration rate
- Outsloped / crowned / insloped
- Road width
- Cutbank height
- Ditch connectivity

Infiltration rate was assumed to be 0.00003 m/s in all situations. Ditch roughness was assumed constant with a value of 0.100. Slope was calculated from a 10-meter DEM. Field-survey values were used for all remaining fields for those roads that were surveyed. For all remaining roads the following assumptions were made:

- Ditch width and depth were assumed to be 1.0 and 0.5 feet respectively
- All ditches were assumed to be outsloped
- Road width was either available from the IPNF roads GIS layer, or assumed to be 12'
- Cutbank height was estimated from the local hillslope (as calculated using the DEM), by assuming that road cut and fill were balanced in the cross-section (Figure 11).
- Flow in all non-surveyed ditches was assumed to return to the pixel from which it originated (i.e., ditch flow lengths was ~100-200 feet)

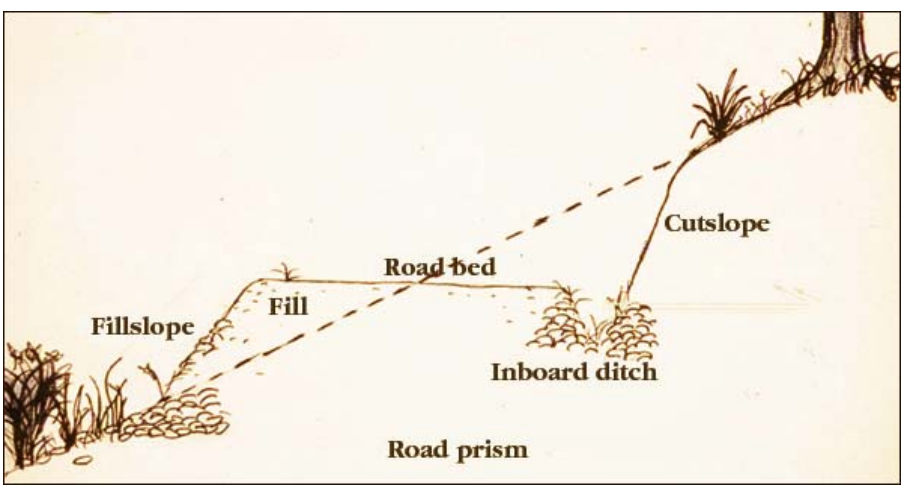


Figure 11. Road cross-section (From Switalski et al., 2004)

2.2 METEOROLOGICAL DATA

The DHSVM model is driven by meteorological data run at a sub-daily time step. Inputs to each grid cell, either as precipitation or as inflow from adjacent cells, is processed for each time step, and then is passed on to down-gradient cells. As such, model runtime is directly proportional to the time step chosen. For this application we chose a 3-hour time step. The following input data is needed for each time step:

- Air temperature
- Wind speed
- Relative humidity
- Shortwave radiation
- Longwave radiation

Several climate stations in the vicinity of the study watersheds have historical clime data at a sub-daily (typically hourly) time step (Figure 2). Ideally, data from the Magee Peak RAWS station[21] would have been used to drive the model, however, the data record was too short term and too sporadic to be used. The final data set used was a composite of values from the three remaining stations in the vicinity of the study area.

Air temperature and precipitation data were taken from the Mosquito Ridge SNOTEL station[22]. Wind speed data were not available from the Mosquito Ridge station. Unadjusted wind speed values from the Nuckols RAWS station[23] were used in the analysis. Missing values in the Nuckols data set were filled in using values from the Coeur d'Alene station[24]. Relative humidity values were used from the Nuckols RAWS station, with missing values estimated from the Coeur d'Alene station[25]. No useful shortwave radiation values were available from any of the stations during the period of record. Consequently, shortwave radiation was modeled using the SolarCalc[26] software available from the USDA Agricultural Resources Service (Spokas and Forcella, 2006). The SolarCalc software provides hourly estimates of shortwave radiation based on daily min/max temperatures, and precipitation. Incoming longwave radiation values were estimated from shortwave values using relationships from Bowling and Lettenmaier (1997).

Constant lapse rates were used for temperature (-0.0089 deg. C/meter) and precipitation (0.00000085 meters/meter). Lapse rates were calculated for the analysis area using grid data available from the PRISM climate mapping system[27].

2.3 MODEL CALIBRATION

We performed limited model calibration by adjusting model parameters (Appendix A) to achieve a better fit between observed and modeled discharge at the Big Elk (Figure 12) and ULNF stream gage locations. Saturated hydraulic conductivity is the single parameter that the model is

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[21] http://www.raws.dri.edu/cgi-bin/rawMAIN.pl?idIMGP
[22] http://www.wcc.nrcs.usda.gov/snotel/snotel.pl?sitenum=645&state=id
[23] http://www.raws.dri.edu/cgi-bin/rawMAIN.pl?idINUC
[24] http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?WWDI~StnSrch~CallSign~KCOE
[25] For a few days relative humidity values were not available from either the Nuckols or Coeur d'Alene stations. These missing values were estimated using the seven-day average values on either side of the missing period.
[26] http://www.ars.usda.gov/services/software/download.htm?softwareid=62
[27] http://www.ocs.oregonstate.edu/prism/index.phtml

most responsive to[28]. Initial hydraulic conductivity values were changed slightly, however, the final values used were within an order of magnitude of the original values.

The timing of modeled peak flow generally corresponded with observed values, however, the magnitude of the response often differed (e.g., Figure 12). This was most likely due to differences in meteorological conditions at the climate stations used to drive the model, and conditions within the subwatersheds themselves. However, these differences are not necessarily a major concern, as the subsequent analysis considers differences among *modeled* results; not between modeled and observed results.

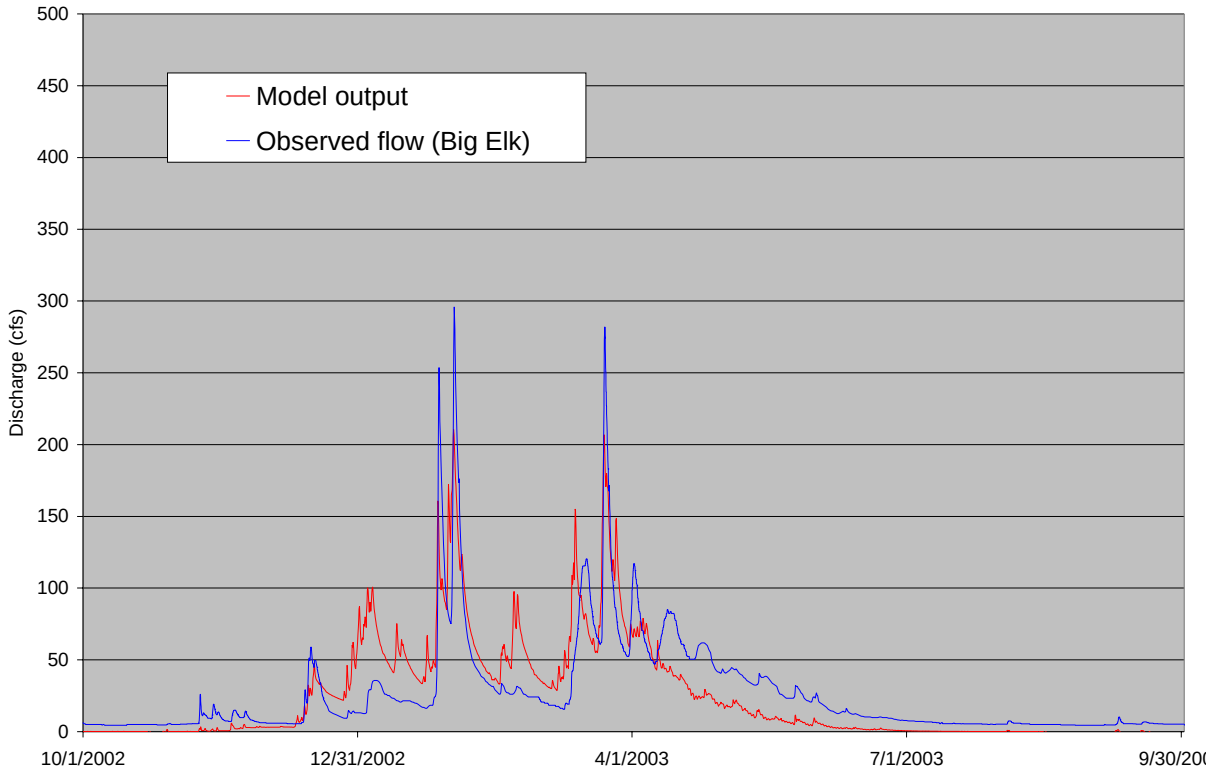

Figure 12. Observed and modeled streamflow for Big Elk Creek, Water Year 2003.

3.0 RESULTS

Model runs for each subwatershed were for the period 9/10/2001 to 1/25/2007. This was the longest continuous time period with available climate data. Results were evaluated for five water years; 2002 to 2006.

Results were evaluated by comparing the five largest peak flow events[29] in each water year across the range of modeled scenarios. The model run conducted using the potential vegetation condition with no roads was used as the baseline against which all other runs were compared. The magnitudes of all modeled peak flow events were equivalent to an annual peak flow

[28] http://www.hydro.washington.edu/SurfaceWaterGroup/Models/DHSVM/faqs.shtml
[29] This was the largest number of independent events that could be extracted from each water year.

magnitude of approximately 5 years or less[30]. Results were also included for the ULNF subwatershed using the post-harvest vegetation conditions (and current roads) that would result from implementation of alternative 5 from the USFS Iron-Honey EIS (Figure 6).

Results for the Big Elk subwatershed are given in Table 9, and for the ULNF subwatershed in Table 10.

Table 9. DHSVM results for the Big Elk Creek subwatershed.

WY	Date of modeled peak flow	Peak rank	Magnitude of peak flow (cfs) by model scenario			Percent change in modeled peak flows as compared to Historic	
			[Baseline] Historic vegetation, no roads	Current vegetation, no roads	Current vegetation, current roads	% Δ due to vegetation changes	% Δ due to vegetation & roads
2002	4/15/2002	1	244	243	256	0%	5%
	5/23/2002	2	224	219	227	-2%	1%
	5/6/2002	3	159	157	161	-1%	1%
	11/14/2001	4	148	146	153	-2%	3%
	12/4/2001	5	142	142	145	0%	2%
2003	1/31/2003	1	198	197	206	0%	4%
	3/22/2003	2	190	189	201	0%	5%
	1/26/2003	3	149	148	156	0%	5%
	3/13/2003	4	146	145	151	-1%	4%
	1/4/2003	5	98	96	99	-2%	1%
2004	1/30/2004	1	138	141	149	2%	8%
	11/29/2003	2	120	117	126	-3%	5%
	3/27/2004	3	88	85	90	-3%	2%
	3/5/2004	4	84	84	86	0%	2%
	2/18/2004	5	77	77	79	0%	3%
2005	12/11/2004	1	249	249	261	0%	5%
	3/30/2005	2	168	166	181	-1%	8%
	11/25/2004	3	137	135	144	-1%	6%
	11/2/2004	4	114	110	119	-3%	4%
	10/23/2004	5	59	55	63	-6%	7%
2006	1/11/2006	1	268	267	274	0%	2%
	1/24/2006	2	177	177	177	0%	0%
	4/15/2006	3	144	145	150	0%	4%
	3/1/2006	4	125	124	130	-1%	4%
	1/1/2006	5	140	139	144	-1%	3%
					min	-6%	0%
					mean	-1%	4%
					max	2%	8%

[30] As compared to estimates from Berenbrock (2002).

Table 10. DHSVM results for the ULNF subwatershed.

WY	Date of modeled peak flow	Peak rank	Magnitude of peak flow (cfs) by model scenario				Percent change in modeled peak flows as compared to Historic		
			[Baseline] Historic vegetation, no roads	Current vegetation, no roads	Current vegetation, current roads	ULNF Iron Honey	% Δ due to vegetation changes	% Δ due to vegetation & roads	% Δ due to Iron Honey
2002	5/23/2002	1	1,177	1,186	1,240	1,392	1%	5%	18%
	4/14/2002	2	1,071	1,089	1,201	1,190	2%	12%	11%
	11/14/2001	3	861	877	988	1,048	2%	15%	22%
	5/6/2002	4	720	744	773	870	3%	7%	21%
	3/12/2002	5	678	675	746	706	0%	10%	4%
2003	3/22/2003	1	1,140	1,154	1,306	1,314	1%	15%	15%
	1/31/2003	2	941	941	1,014	962	0%	8%	2%
	1/26/2003	3	833	828	959	901	-1%	15%	8%
	3/13/2003	4	732	730	836	789	0%	14%	8%
	3/26/2003	5	623	626	627	619	0%	1%	-1%
2004	1/29/2004	1	743	727	845	750	-2%	14%	1%
	11/29/2003	2	667	700	789	885	5%	18%	33%
	3/27/2004	3	402	420	477	459	5%	19%	14%
	2/18/2004	4	361	356	379	357	-1%	5%	-1%
	3/6/2004	5	361	357	379	348	-1%	5%	-4%
2005	12/11/2004	1	1,342	1,339	1,483	1,421	0%	11%	6%
	3/28/2005	2	741	767	939	938	3%	27%	26%
	11/25/2004	3	766	777	922	919	2%	20%	20%
	11/3/2004	4	574	589	673	727	3%	17%	27%
	1/18/2005	5	334	332	350	342	-1%	5%	2%
2006	1/11/2006	1	1,239	1,231	1,284	1,207	-1%	4%	-3%
	4/15/2006	2	883	919	1,002	1,196	4%	13%	35%
	1/24/2006	3	939	931	952	910	-1%	1%	-3%
	3/1/2006	4	693	689	801	756	-1%	16%	9%
	1/1/2006	5	600	598	665	620	0%	11%	3%
						min	-2%	1%	-4%
						mean	1%	11%	11%
						max	5%	27%	35%

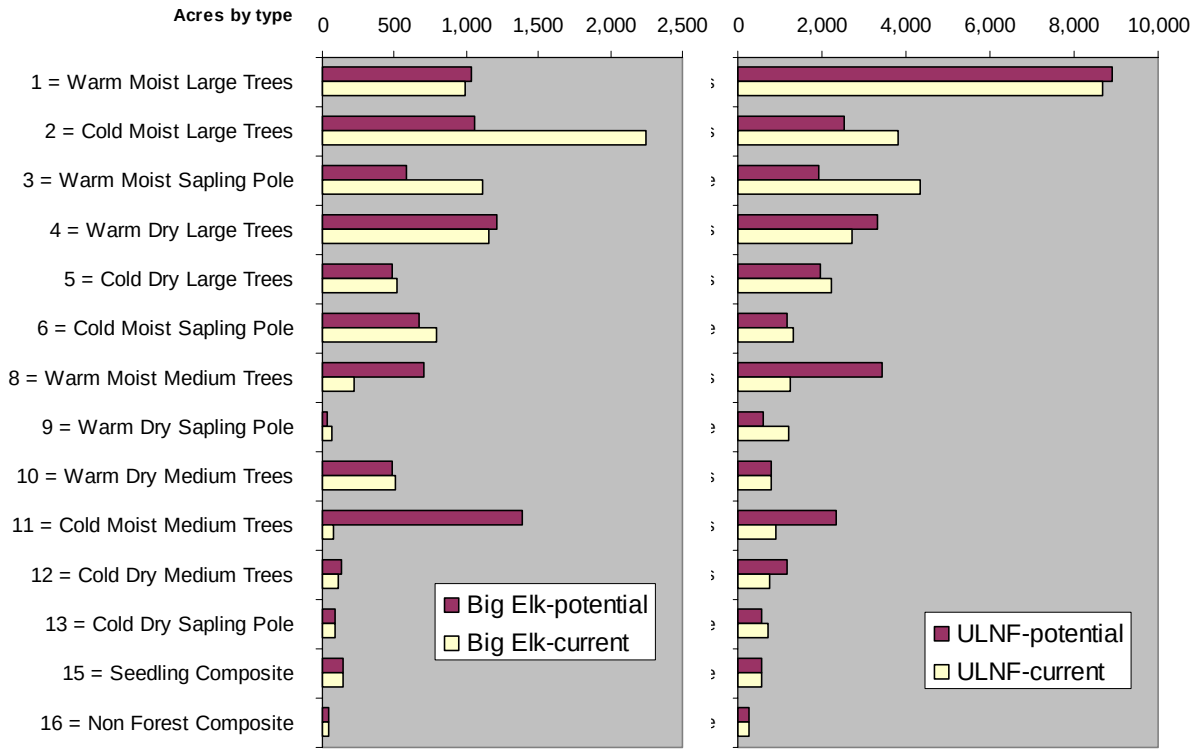

Figure 13. Distribution of vegetation types for the potential (or historic) and current conditions in the Big Elk and ULNF subwatersheds.

Modeled changes in peak flows due to differences in vegetation conditions alone are very small, averaging –1% (i.e., a one percent *decrease* in the overall magnitude of peak flows) in Big Elk Creek (Table 9), and +1% in the ULNF subwatershed (Table 10). These differences are likely due to having a greater proportion of large trees under current conditions (due to fire suppression) than are likely to have existed under historical conditions (Figure 13).

Roads appear to have a more significant effect on modeled peak flow changes. Within the Big Elk subwatershed the combination of current vegetation conditions and current roads resulted in an average increase of approximately 4% in the magnitude of modeled peak flows (Table 9). In the ULNF subwatershed the higher road densities (Table 8) result in average increases of 11% in the magnitude of modeled peak flows (Table 10).

In order to estimate the effects of recent road decommissioning (Figure 10; Table 8) we reran the model with recently decommissioned roads included as active roads. The net modeled result of road decommissioning has been a decrease of peak flows by ~3% in Big Elk Creek, and ~2% in the ULNF subwatersheds.

Implementation of the Iron Honey alternative 5 harvests resulted in no change of the average overall magnitude in peak flows as compared to current conditions (Table 10). Under both scenarios the overall increase, as compared to baseline, was 11%. Response of individual storm events however was much more variable; ranging from a decrease of 4% to an increase of 35%.

4.0 CONCLUSIONS

The Distributed Hydrology Soil Vegetation Model (DHSVM) was used to evaluate the effects of current vegetation and road conditions on peak flow magnitudes in two study subwatersheds within the North Fork Coeur d'Alene (NFCDA) subbasin. The Big Elk (11.6 mi^2 drainage area) and Upper Little North Fork (ULNF; 44.4 mi^2) subwatersheds were included in the evaluation. The two subwatersheds have had extensive past harvest, and high road densities, representative of some of the most impacted conditions in the NFCDA.

The model was first run using historic vegetation and no roads. The resultant values were used as the baseline against which all other model runs were compared. The five largest peak flow events (all with an estimated recurrence interval of 5 years or less) in each of five water years were used to evaluate management impacts.

Model results suggest that peak flow conditions due to current vegetation conditions are not significantly different then under the baseline condition. Roads and road drainage however appear to result in an increase of approximately 5-10% over the baseline condition. No correlation was seen in the results between percent change in peak flow value and flood size.

Model results suggest that road decommissioning performed to date has resulted in a ~2 to ~3% decrease in peak flow magnitudes, as compared to the most impacted past condition.

A proposed suite of timber harvests (primarily shelterwood removal with some clearcut and thinning units) in the ULNF was also evaluated using the DHSVM model. Model results suggest that average post-harvest peak flow magnitude would not be significantly different from current conditions. However, storm-to-storm variability among the 25 peak flows increased.

Uncertainty remains as to the continuing impacts of non-decommissioned, non-maintained roads in the watersheds. It is not known to what extent passive restoration of hydrologic function has occurred in these roads. The USFS has indicated (Lider et al., 2007) that they believe our model over represents the actual amount of roads in the study area. Further investigation is needed to map the condition of all roads. The model results presented here probably represent a "worst case" scenario in terms of hydrologic impact from roads.

Model results indicate that hydrologic response is not constant across all storm events (i.e., percent change varied widely by individual storm). Hydrologic response probably varies in response to antecedent conditions, within-storm weather patterns, and position of roads and harvest units within the landscape. For example, road location may affect the volume of water intercepted by road ditches, and the extent to which peak flow timing may be changed. La Marche and Lettenmaier (1998) theorize that although ridgetop roads may have the greatest potential to change the timing of flows (flow that would have traveled a relatively long distance as slower subsurface flow would now travel as quicker surface flow) the volume of flow intercepted is relatively small because of the small upslope contributing area. Conversely, valley bottom roads have the ability to capture large volumes of flow, but the timing change is small because of the close proximity of these roads to streams. Midslope roads may have the biggest

effect on peak streamflows because they capture moderately large volumes of water and the timing change may be significant.

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APPENDIX A. DHSVM CONFIGURATION FILE

```
################################################################################
# DHSVM INPUT FILE FORMAT
################################################################################
# The file is organized in sections [...], which contain key = entry pairs.
# The file is free format, in that correct reading of the file is not dependnt
# on spaces and/or the order of the key-entry pairs within a section.
# The keys are not case-sensitive, but the entries are, because filenames on a
# UNIX platform are case-sensitive.
# Comments are preceded by a '#', and run from the occurrence of '#' till the
# end of the line. You can comment out an entire line (like in this
# header), or you can place a comment after an entry.
# It is important to place the key-entry pair in the correct section, since it
# will not be found if it is in another section.
# The easiest way to make the input file is to fill out this default template.
# Since DHSVM will only use the keys that it requires you do not have to worry
# about empty entries for keys that are not needed. For example, if you are
# running the model in point mode, you do not have to fill out the routing
# section.  If you have already filled it out you can leave it, since DHSVM will
# not use the information.  This allows easy switching between point and basin
# mode.
# For more information about the specific entries see the DHSVM web page
#################################################################################
# OPTIONS SECTION
#################################################################################
[OPTIONS]                                   # Model Options
Format               = BIN                  # BIN, BYTESWAP or NETCDF
Extent               = BASIN                # POINT or BASIN
Gradient             = WATERTABLE           # TOPOGRAPHY or WATERTABLE
Flow Routing         = NETWORK              # UNIT_HYDROGRAPH or NETWORK
Sensible Heat Flux   = FALSE                # TRUE or FALSE
Sediment             = FALSE                # TRUE or FALSE
Sediment Input File  =                      # path for sediment configuration file
Overland Routing     = CONVENTIONAL         # CONVENTIONAL or KINEMATIC
Interpolation        = NEAREST              # NEAREST or INVDIST or VARCRESS
MM5                  = FALSE                # TRUE or FALSE
QPF                  = FALSE                # TRUE or FALSE
PRISM                = FALSE                # TRUE or FALSE
PRISM data path      =                      # path for PRISM files
PRISM data extension =                      # file extension for PRISM files
Canopy radiation attenuation mode = FIXED # FIXED or VARIABLE
Shading              = FALSE                # TRUE or FALSE
Shading data path    =                      # path for shading files
Shading data extension =                    # file extension for shading files
Skyview data path    =                      # path for skyview file; for use with
shading only
Snotel               = FALSE                # TRUE or FALSE
Outside              = TRUE                 # TRUE or FALSE
Rhoverride           = FALSE                # TRUE or FALSE
Precipitation Source = STATION              # STATION or RADAR
Wind Source          = STATION              # STATION or MODEL
Temperature lapse rate = CONSTANT           # CONSTANT or VARIABLE
Precipitation lapse rate = CONSTANT         # CONSTANT, MAP, or VARIABLE
Infiltration         = STATIC               # STATIC or DYNAMIC
Cressman radius      =                      # in model pixels
Cressman stations    =                      # number of stations

#################################################################################
# MODEL AREA SECTION
#################################################################################
[AREA]                                      # Model area
```

```
Coordinate System    = UTM                # UTM or USER_DEFINED Albers
Extreme North        = 5306374.23833      # Coordinate for northern edge of grid
Extreme West         = 532371.06209201    # Coordinate for western edge of grid
Center Latitude      = 47.91114385600     # Central parallel of basin
Center Longitude     = -116.4094260900    # Central meridian of basin
Time Zone Meridian   = -105               # Time zone meridian for area
Number of Rows       = 257                # Number of rows
Number of Columns    = 196                # Number of columns
Grid spacing         = 60                 # Grid resolution in m

################################################################################
# TIME SECTION
################################################################################
[TIME]                                    # Model period cod
Time Step            = 3                  # Model time step (hours)
# spin up
#Model Start          = 09/10/2001-03     # Model start time (MM/DD/YYYY-HH)
#Model End            = 10/01/2001-00

#Validation
Model Start          = 09/10/2001-03     # Model start time (MM/DD/YYYY-HH)
Model End            = 01/25/2007-00

################################################################################
# CONSTANTS SECTION
################################################################################
[CONSTANTS]                               # Model constants
Ground Roughness     = 0.02               # Roughness of soil surface (m)
Snow Roughness       = 0.02               # Roughness of snow surface (m)
Rain Threshold       = 1.0                # Minimum temperature at which rain
                                          # occurs (C) minor decrease in snow from 0
Snow Threshold       = 0.5                # Maximum temperature at which snow
                                          # occurs (C)
Snow Water Capacity  = 0.03               # Snow liquid water holding capacity
                                          # (fraction)
Reference Height     = 70.0               # Reference height (m)
Rain LAI Multiplier  = 0.0001             # LAI Multiplier for rain interception
Snow LAI Multiplier  = 0.0005             # LAI Mulitplier for snow interception
Min Intercepted Snow = 0.005              # Intercepted snow that can only be
                                          # melted (m)
Outside Basin Value  = 0                  # Value in mask that indicates outside
                                          # the basin
Temperature Lapse Rate   = -0.0089        # Temperature lapse rate (C/m)
Precipitation Lapse Rate =  0.00000085    # Precipitation lapse rate (m/m)

################################################################################
# TERRAIN INFORMATION SECTION
################################################################################
[TERRAIN]                                 # Terrain information
DEM File             = /input/dem.bin   # path for DEM file
Basin Mask File      = /input/mask.bin  # path for mask file

################################################################################
# ROUTING SECTION
################################################################################
[ROUTING]                                 # Routing information. This section is
                                          # only relevant if the Extent = BASIN

################ STREAM NETWORK ################################################
# The following three fields are only used if Flow Routing = NETWORK

Stream Map File      = /input/stream.map.dat     # path for stream map file
Stream Network File  = /input/stream.network.dat # path for stream network file
```

```
Stream Class File    = /input/stream.class.dat   # path for stream class file

################ ROAD NETWORK ##################################################
# The following three fields are only used if Flow Routing = NETWORK and there
# is a road network

#Scenario 1 - all existing roads
Road Map File        = /input/road.map.dat     # path for road map file
Road Network File    = /input/road.network.dat # path for road network file
Road Class File      = /input/road.class.dat   # path for road network file


################ UNIT HYDROGRAPH ###############################################
# The following two fields are only used if Flow Routing = UNIT_HYDROGRAPH

Travel Time File     =                     # path for travel time file
Unit Hydrograph File =                     # path for unit hydrograph file

##############################################################################
# METEOROLOGY SECTION
##############################################################################
[METEOROLOGY]                              # Meteorological stations
Number of Stations = 1                     # Number of meteorological stations

# The following set of lines is to be repeated for each station, with the one
# replaced by 2, 3, etc.

Station Name     1 = Mosquito_Ridge        # Name for station 1
North Coordinate 1 = 5322743.861           # North coordinate of station 1
East Coordinate  1 = 557337.932            # East coordinate of station 1
Elevation        1 = 1584.9                # Elevation of station 1 in m
Station File     1 = /input/Mosquito_Ridge_no_lapse.txt  # path for station 1 file

################ MM5 ###########################################################
# The following block only needs to be filled out if MM5 = TRUE.  In that case
# This is the ONLY block that needs to be filled out

MM5 Start              =                   # Start of MM5 file (MM/DD/YYYY-HH),
MM5 Rows               =
MM5 Cols               =
MM5 Extreme North      =
MM5 Extreme West       =
MM5 DY                 =

# MM5 met files
MM5 Temperature File   =
MM5 Humidity File      =
MM5 Wind Speed File    =
MM5 Shortwave File     =
MM5 Longwave File      =
MM5 Pressure File      =
MM5 Precipitation File =
MM5 Terrain File       =
MM5 Temp Lapse File    =

# For each soil layer make a key-entry pair as below (n = 1, ..,
# Number of Soil Layers)

MM5 Soil Temperature File 0 =
MM5 Soil Temperature File 1 =
MM5 Soil Temperature File 2 =

################ RADAR #########################################################
```

```
# The following block only needs to be filled out if Precipitation Source =
# RADAR.
Radar Start            =
Radar File             =
Radar Extreme North    =
Radar Extreme West     =
Radar Number of Rows   =
Radar Number of Columns =
Radar Grid Spacing     =

################ Wind ##########################################################
# The following block only needs to be filled out if Wind Source = MODEL
Number of Wind Maps    =
Wind File Basename     =
Wind Map Met Stations  =

################ Precipitation lapse rate ######################################
# The following block only needs to be filled out if Precipitation lapse rate
# = MAP
Precipitation lapse rate =

##############################################################################
# SOILS INFORMATION SECTION
##############################################################################
[SOILS]                                  # Soil information

Soil Map File      = /input/soil.bin

# minimum depth still 0.1 maximum depth 2
Soil Depth File      = /input/soild.bin

Number of Soil Types = 7

################ SOIL 1 ########################################################
Soil Description       1 =  silt loam | silt loam | sandy loam
Lateral Conductivity   1 =  1.0e-4
Exponential Decrease   1 =  2.0
Maximum Infiltration   1 =  3.0e-5
Capillary Drive        1 =  0.2
Surface Albedo         1 =  0.1
Number of Soil Layers  1 =  3
Porosity               1 =  .46 .46 .40
Pore Size Distribution 1 =  .26 .26 .21
Bubbling Pressure      1 =  .21 .21 .15
Field Capacity         1 =  .32 .32 .21
Wilting Point          1 =  .12 .12 .09
Bulk Density           1 =  1419. 1419. 1569.
Vertical Conductivity  1 =  2.0e-5 2.0e-5 8.0e-5
Thermal Conductivity   1 =  7.114  6.923 7.0
Thermal Capacity       1 =  1.4e6 1.4e6 1.4e6
Mannings n             1 =  0.01

################ SOIL 2 ########################################################
Soil Description       2 =  silt loam | silt loam | loam
Lateral Conductivity   2 =  1.0e-4
Exponential Decrease   2 =  2.0
Maximum Infiltration   2 =  3.0e-5
Capillary Drive        2 =  0.2
Surface Albedo         2 =  0.1
Number of Soil Layers  2 =  3
Porosity               2 =  .46 .46 .43
Pore Size Distribution 2 =  .26 .26 .19
Bubbling Pressure      2 =  .21 .21 .11
```

```
Field Capacity         2 =  .32 .32 .29
Wilting Point          2 =  .12 .12 .14
Bulk Density           2 =  1419. 1419. 1485.
Vertical Conductivity  2 =  2.0e-5 2.0e-5 4.0e-5
Thermal Conductivity   2 =  7.114  6.923 7.0
Thermal Capacity       2 =  1.4e6 1.4e6 1.4e6
Mannings n             2 =  0.01

################ SOIL 3 ##########################################################
Soil Description       3 =  silt loam | silt loam | silt loam
Lateral Conductivity   3 =  1.0e-4
Exponential Decrease   3 =  2.0
Maximum Infiltration   3 =  3.0e-5
Capillary Drive        3 =  0.2
Surface Albedo         3 =  0.1
Number of Soil Layers  3 =  3
Porosity               3 =  .46 .46 .46
Pore Size Distribution 3 =  .26 .26 .26
Bubbling Pressure      3 =  .21 .21 .21
Field Capacity         3 =  .32 .32 .32
Wilting Point          3 =  .12 .12 .12
Bulk Density           3 =  1419. 1419. 1419.
Vertical Conductivity  3 =  2.0e-5 2.0e-5 2.0e-5
Thermal Conductivity   3 =  7.114  6.923 7.0
Thermal Capacity       3 =  1.4e6 1.4e6 1.4e6
Mannings n             3 =  0.01

################ SOIL 4 ##########################################################
Soil Description       4 =  silt loam | silt loam | sandy clay loam
Lateral Conductivity   4 =  1.0e-4
Exponential Decrease   4 =  2.0
Maximum Infiltration   4 =  3.0e-5
Capillary Drive        4 =  0.2
Surface Albedo         4 =  0.1
Number of Soil Layers  4 =  3
Porosity               4 =  .46 .46 .38
Pore Size Distribution 4 =  .26 .26 .32
Bubbling Pressure      4 =  .21 .21 .29
Field Capacity         4 =  .32 .32 .27
Wilting Point          4 =  .12 .12 .17
Bulk Density           4 =  1419. 1419. 1600.
Vertical Conductivity  4 =  2.0e-5 2.0e-5 8.0e-6
Thermal Conductivity   4 =  7.114  6.923 7.0
Thermal Capacity       4 =  1.4e6 1.4e6 1.4e6
Mannings n             4 =  0.01

################ SOIL 5 ##########################################################
Soil Description       5 =  Coarse and fine alluvial material (using sl|sl|sl)
Lateral Conductivity   5 =  1.0e-4
Exponential Decrease   5 =  2.0
Maximum Infiltration   5 =  3.0e-5
Capillary Drive        5 =  0.2
Surface Albedo         5 =  0.1
Number of Soil Layers  5 =  3
Porosity               5 =  .46 .46 .46
Pore Size Distribution 5 =  .26 .26 .26
Bubbling Pressure      5 =  .21 .21 .21
Field Capacity         5 =  .32 .32 .32
Wilting Point          5 =  .12 .12 .12
Bulk Density           5 =  1419. 1419. 1419.
Vertical Conductivity  5 =  2.0e-5 2.0e-5 2.0e-5
Thermal Conductivity   5 =  7.114  6.923 7.0
Thermal Capacity       5 =  1.4e6 1.4e6 1.4e6
```

```
Mannings n             5 =  0.01

################ SOIL 6 ##########################################################
Soil Description       6 =  Rock outcrops
Lateral Conductivity   6 =  1.0e-10
Exponential Decrease   6 =  1
Maximum Infiltration   6 =  1.0e-5
Capillary Drive        6 =  0.1
Surface Albedo         6 =  0.1
Number of Soil Layers  6 =  1
Porosity               6 =  .1
Pore Size Distribution 6 =  .08
Bubbling Pressure      6 =  .36
Field Capacity         6 =  .05
Wilting Point          6 =  .04
Bulk Density           6 =  1650.
Vertical Conductivity  6 =  1.0e-8
Thermal Conductivity   6 =  7.114
Thermal Capacity       6 =  1.4e6
Mannings n             6 =  0.01

################ SOIL 7 ##########################################################
Soil Description       7 =  Talus
Lateral Conductivity   7 =  1.0e-4
Exponential Decrease   7 =  2
Maximum Infiltration   7 =  2.0e-4
Capillary Drive        7 =  0.1
Surface Albedo         7 =  0.1
Number of Soil Layers  7 =  1
Porosity               7 =  .6
Pore Size Distribution 7 =  .45
Bubbling Pressure      7 =  .07
Field Capacity         7 =  .08
Wilting Point          7 =  .03
Bulk Density           7 =  1492.
Vertical Conductivity  7 =  3.5e-3
Thermal Conductivity   7 =  7.114
Thermal Capacity       7 =  1.4e6
Mannings n             7 =  0.01

##############################################################################
# VEGETATION INFORMATION SECTION
##############################################################################
[VEGETATION]

Vegetation Map File        = /input/veg_ih.bin
Number of Vegetation Types = 16

################ VEGETATION 1 ###############################################

Vegetation Description   1 = Warm Moist Large Trees
Overstory Present        1 = TRUE
Understory Present       1 = TRUE
Fractional Coverage      1 = 0.9
Trunk Space              1 = 0.5
Aerodynamic Attenuation  1 = 3.5
Radiation Attenuation    1 = 0.5
Hemi Fract Coverage      1 =
Clumping Factor          1 =
Leaf Angle A             1 =
Leaf Angle B             1 =
Scattering Parameter     1 =
Max Snow Int Capacity    1 = 0.04
```

```
Mass Release Drip Ratio  1 = 0.4
Snow Interception Eff    1 = 0.6
Impervious Fraction      1 = 0.0
Height                   1 = 25.7 0.5
Maximum Resistance       1 = 1000. 5000.
Minimum Resistance       1 = 333.3 250.
Moisture Threshold       1 = 0.33 0.13
Vapor Pressure Deficit   1 = 4000 4000
Rpc                      1 = .108 .108
Number of Root Zones     1 = 3
Root Zone Depths         1 = 0.10 0.30 0.70
Overstory Root Fraction  1 = 0.31 0.36 0.33
Understory Root Fraction 1 = 0.60 0.40 0.00
Overstory Monthly LAI    1 = 10.7 11.2 12.1 12.8 13.9 15.2 15.0 14.4 13.8 12.5 11.3
10.7
Understory Monthly LAI   1 = 0.363 0.462 0.600 0.600 0.600 0.600 1.125 1.075 0.638
0.363 0.363 0.363
Overstory Monthly Alb    1 = 0.18 0.18 0.18 0.18 0.18 0.18 0.18 0.18 0.18 0.18 0.18
0.18
Understory Monthly Alb   1 = 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2

################ VEGETATION 2 ##################################################

Vegetation Description   2 = Cold Moist Large Trees
Overstory Present        2 = TRUE
Understory Present       2 = TRUE
Fractional Coverage      2 = 0.9
Trunk Space              2 = 0.352
Aerodynamic Attenuation  2 = 3.5
Radiation Attenuation    2 = 0.5
Hemi Fract Coverage      2 =
Clumping Factor          2 =
Leaf Angle A             2 =
Leaf Angle B             2 =
Scattering Parameter     2 =
Max Snow Int Capacity    2 = 0.04
Mass Release Drip Ratio  2 = 0.4
Snow Interception Eff    2 = 0.6
Impervious Fraction      2 = 0.0
Height                   2 = 26.7 0.5
Maximum Resistance       2 = 1000. 5000.
Minimum Resistance       2 = 333.3 250.
Moisture Threshold       2 = 0.33 0.13
Vapor Pressure Deficit   2 = 4000 4000
Rpc                      2 = .108 .108
Number of Root Zones     2 = 3
Root Zone Depths         2 = 0.10 0.30 0.70
Overstory Root Fraction  2 = 0.31 0.36 0.33
Understory Root Fraction 2 = 0.60 0.40 0.00
Overstory Monthly LAI    2 = 11.1 11.6 12.5 13.3 14.4 15.7 15.5 14.9 14.3 13.0 11.7
11.1
Understory Monthly LAI   2 = 0.363 0.462 0.600 0.600 0.600 0.600 1.125 1.075 0.638
0.363 0.363 0.363
Overstory Monthly Alb    2 = 0.18 0.18 0.18 0.18 0.18 0.18 0.18 0.18 0.18 0.18 0.18
0.18
Understory Monthly Alb   2 = 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2

################ VEGETATION 3 ##################################################

Vegetation Description   3 = Warm Moist Sapling Pole
Overstory Present        3 = TRUE
Understory Present       3 = TRUE
Fractional Coverage      3 = 0.66
```

```
Trunk Space              3 = 0.5
Aerodynamic Attenuation  3 = 3.5
Radiation Attenuation    3 = 0.5
Hemi Fract Coverage      3 =
Clumping Factor          3 =
Leaf Angle A             3 =
Leaf Angle B             3 =
Scattering Parameter     3 =
Max Snow Int Capacity    3 = 0.04
Mass Release Drip Ratio  3 = 0.4
Snow Interception Eff    3 = 0.6
Impervious Fraction      3 = 0.0
Height                   3 = 8.5 0.5
Maximum Resistance       3 = 1000. 5000.
Minimum Resistance       3 = 333.3 250.
Moisture Threshold       3 = 0.33 0.13
Vapor Pressure Deficit   3 = 4000 4000
Rpc                      3 = .108 .108
Number of Root Zones     3 = 3
Root Zone Depths         3 = 0.10 0.30 0.70
Overstory Root Fraction  3 = 0.31 0.36 0.33
Understory Root Fraction 3 = 0.60 0.40 0.00
Overstory Monthly LAI    3 = 3.8 3.9 4.2 4.5 4.9 5.3 5.3 5.1 4.8 4.4 4.0 3.8
Understory Monthly LAI   3 = 0.363 0.462 0.600 0.600 0.600 0.600 1.125 1.075 0.638
0.363 0.363 0.363
Overstory Monthly Alb    3 = 0.18 0.18 0.18 0.18 0.18 0.18 0.18 0.18 0.18 0.18 0.18
0.18
Understory Monthly Alb   3 = 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2

################ VEGETATION 4 ##################################################

Vegetation Description   4 = Warm Dry Large Trees
Overstory Present        4 = TRUE
Understory Present       4 = TRUE
Fractional Coverage      4 = 0.9
Trunk Space              4 = 0.352
Aerodynamic Attenuation  4 = 3.5
Radiation Attenuation    4 = 0.5
Hemi Fract Coverage      4 =
Clumping Factor          4 =
Leaf Angle A             4 =
Leaf Angle B             4 =
Scattering Parameter     4 =
Max Snow Int Capacity    4 = 0.04
Mass Release Drip Ratio  4 = 0.4
Snow Interception Eff    4 = 0.6
Impervious Fraction      4 = 0.0
Height                   4 = 22.9 0.5
Maximum Resistance       4 = 1000. 5000.
Minimum Resistance       4 = 333.3 250.
Moisture Threshold       4 = 0.33 0.13
Vapor Pressure Deficit   4 = 4000 4000
Rpc                      4 = .108 .108
Number of Root Zones     4 = 3
Root Zone Depths         4 = 0.10 0.30 0.70
Overstory Root Fraction  4 = 0.31 0.36 0.33
Understory Root Fraction 4 = 0.60 0.40 0.00
Overstory Monthly LAI    4 = 9.6 10.0 10.8 11.4 12.4 13.5 13.4 12.9 12.3 11.2 10.1 9.6
Understory Monthly LAI   4 = 0.363 0.462 0.600 0.600 0.600 0.600 1.125 1.075 0.638
0.363 0.363 0.363
Overstory Monthly Alb    4 = 0.18 0.18 0.18 0.18 0.18 0.18 0.18 0.18 0.18 0.18 0.18
0.18
Understory Monthly Alb   4 = 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2
```

```
################ VEGETATION 5 ##################################################

Vegetation Description   5 = Cold Dry Large Trees
Overstory Present        5 = TRUE
Understory Present       5 = TRUE
Fractional Coverage      5 = 0.9
Trunk Space              5 = 0.352
Aerodynamic Attenuation  5 = 3.5
Radiation Attenuation    5 = 0.5
Hemi Fract Coverage      5 =
Clumping Factor          5 =
Leaf Angle A             5 =
Leaf Angle B             5 =
Scattering Parameter     5 =
Max Snow Int Capacity    5 = 0.04
Mass Release Drip Ratio  5 = 0.4
Snow Interception Eff    5 = 0.6
Impervious Fraction      5 = 0.0
Height                   5 = 23.0 0.5
Maximum Resistance       5 = 1000. 5000.
Minimum Resistance       5 = 333.3 250.
Moisture Threshold       5 = 0.33 0.13
Vapor Pressure Deficit   5 = 4000 4000
Rpc                      5 = .108 .108
Number of Root Zones     5 = 3
Root Zone Depths         5 = 0.10 0.30 0.70
Overstory Root Fraction  5 = 0.31 0.36 0.33
Understory Root Fraction 5 = 0.60 0.40 0.00
Overstory Monthly LAI    5 = 9.6 10.0 10.8 11.5 12.5 13.6 13.4 12.9 12.4 11.2 10.1 9.6
Understory Monthly LAI   5 = 0.363 0.462 0.600 0.600 0.600 0.600 1.125 1.075 0.638
0.363 0.363 0.363
Overstory Monthly Alb    5 = 0.18 0.18 0.18 0.18 0.18 0.18 0.18 0.18 0.18 0.18 0.18
0.18
Understory Monthly Alb   5 = 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2

################ VEGETATION 6 ##################################################

Vegetation Description   6 = Cold Moist Sapling Pole
Overstory Present        6 = TRUE
Understory Present       6 = TRUE
Fractional Coverage      6 = 0.66
Trunk Space              6 = 0.5
Aerodynamic Attenuation  6 = 3.5
Radiation Attenuation    6 = 0.5
Hemi Fract Coverage      6 =
Clumping Factor          6 =
Leaf Angle A             6 =
Leaf Angle B             6 =
Scattering Parameter     6 =
Max Snow Int Capacity    6 = 0.04
Mass Release Drip Ratio  6 = 0.4
Snow Interception Eff    6 = 0.6
Impervious Fraction      6 = 0.0
Height                   6 = 10.4 0.5
Maximum Resistance       6 = 1000. 5000.
Minimum Resistance       6 = 333.3 250.
Moisture Threshold       6 = 0.33 0.13
Vapor Pressure Deficit   6 = 4000 4000
Rpc                      6 = .108 .108
Number of Root Zones     6 = 3
Root Zone Depths         6 = 0.10 0.30 0.70
Overstory Root Fraction  6 = 0.31 0.36 0.33
```

```
Understory Root Fraction 6 = 0.60 0.40 0.00
Overstory Monthly LAI    6 = 4.5 4.8 5.1 5.5 5.9 6.4 6.4 6.1 5.9 5.3 4.8 4.5
Understory Monthly LAI   6 = 0.363 0.462 0.600 0.600 0.600 0.600 1.125 1.075 0.638
0.363 0.363 0.363
Overstory Monthly Alb    6 = 0.18 0.18 0.18 0.18 0.18 0.18 0.18 0.18 0.18 0.18 0.18
0.18
Understory Monthly Alb   6 = 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2

################ VEGETATION 7 ##################################################

Vegetation Description   7 = Shelterwood - post harvest
Overstory Present        7 = TRUE
Understory Present       7 = TRUE
Fractional Coverage      7 = 0.2
Trunk Space              7 = 0.5
Aerodynamic Attenuation  7 = 3.5
Radiation Attenuation    7 = 0.5
Hemi Fract Coverage      7 =
Clumping Factor          7 =
Leaf Angle A             7 =
Leaf Angle B             7 =
Scattering Parameter     7 =
Max Snow Int Capacity    7 = 0.04
Mass Release Drip Ratio  7 = 0.4
Snow Interception Eff    7 = 0.6
Impervious Fraction      7 = 0.0
Height                   7 = 25.7 0.25
Maximum Resistance       7 = 1000. 5000.
Minimum Resistance       7 = 333.3 250.
Moisture Threshold       7 = 0.33 0.13
Vapor Pressure Deficit   7 = 4000 4000
Rpc                      7 = .108 .108
Number of Root Zones     7 = 3
Root Zone Depths         7 = 0.10 0.30 0.70
Overstory Root Fraction  7 = 0.31 0.36 0.33
Understory Root Fraction 7 = 0.60 0.40 0.00
Overstory Monthly LAI    7 = 10.7 11.2 12.1 12.8 13.9 15.2 15.0 14.4 13.8 12.5 11.3
10.7
Understory Monthly LAI   7 = 0.363 0.462 0.600 0.600 0.600 0.600 1.125 1.075 0.638
0.363 0.363 0.363
Overstory Monthly Alb    7 = 0.18 0.18 0.18 0.18 0.18 0.18 0.18 0.18 0.18 0.18 0.18
0.18
Understory Monthly Alb   7 = 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2

################ VEGETATION 8 ##################################################

Vegetation Description   8 = Warm Moist Medium Trees
Overstory Present        8 = TRUE
Understory Present       8 = TRUE
Fractional Coverage      8 = 0.8
Trunk Space              8 = 0.5
Aerodynamic Attenuation  8 = 3.5
Radiation Attenuation    8 = 0.5
Hemi Fract Coverage      8 =
Clumping Factor          8 =
Leaf Angle A             8 =
Leaf Angle B             8 =
Scattering Parameter     8 =
Max Snow Int Capacity    8 = 0.04
Mass Release Drip Ratio  8 = 0.4
Snow Interception Eff    8 = 0.6
Impervious Fraction      8 = 0.0
Height                   8 = 21.1 0.5
```

```
Maximum Resistance       8 = 1000. 5000.
Minimum Resistance       8 = 333.3 250.
Moisture Threshold       8 = 0.33 0.13
Vapor Pressure Deficit   8 = 4000 4000
Rpc                      8 = .108 .108
Number of Root Zones     8 = 3
Root Zone Depths         8 = 0.10 0.30 0.70
Overstory Root Fraction  8 = 0.31 0.36 0.33
Understory Root Fraction 8 = 0.60 0.40 0.00
Overstory Monthly LAI    8 = 8.8 9.2 10.0 10.6 11.5 12.5 12.4 11.9 11.4 10.3 9.3 8.8
Understory Monthly LAI   8 = 0.363 0.462 0.600 0.600 0.600 0.600 1.125 1.075 0.638
0.363 0.363 0.363
Overstory Monthly Alb    8 = 0.18 0.18 0.18 0.18 0.18 0.18 0.18 0.18 0.18 0.18 0.18
0.18
Understory Monthly Alb   8 = 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2

################ VEGETATION 9 ##################################################

Vegetation Description   9 = Warm Dry Sapling Pole
Overstory Present        9 = TRUE
Understory Present       9 = TRUE
Fractional Coverage      9 = 0.5
Trunk Space              9 = 0.5
Aerodynamic Attenuation  9 = 3.5
Radiation Attenuation    9 = 0.5
Hemi Fract Coverage      9 =
Clumping Factor          9 =
Leaf Angle A             9 =
Leaf Angle B             9 =
Scattering Parameter     9 =
Max Snow Int Capacity    9 = 0.04
Mass Release Drip Ratio  9 = 0.4
Snow Interception Eff    9 = 0.6
Impervious Fraction      9 = 0.0
Height                   9 = 9.0 0.5
Maximum Resistance       9 = 1000. 5000.
Minimum Resistance       9 = 333.3 250.
Moisture Threshold       9 = 0.33 0.13
Vapor Pressure Deficit   9 = 4000 4000
Rpc                      9 = .108 .108
Number of Root Zones     9 = 3
Root Zone Depths         9 = 0.10 0.30 0.70
Overstory Root Fraction  9 = 0.31 0.36 0.33
Understory Root Fraction 9 = 0.60 0.40 0.00
Overstory Monthly LAI    9 = 4.0 4.1 4.5 4.7 5.1 5.6 5.5 5.3 5.1 4.6 4.2 4.0
Understory Monthly LAI   9 = 0.363 0.462 0.600 0.600 0.600 0.600 1.125 1.075 0.638
0.363 0.363 0.363
Overstory Monthly Alb    9 = 0.18 0.18 0.18 0.18 0.18 0.18 0.18 0.18 0.18 0.18 0.18
0.18
Understory Monthly Alb   9 = 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2

################ VEGETATION 10 #################################################

Vegetation Description   10 = Warm Dry Medium Trees
Overstory Present        10 = TRUE
Understory Present       10 = TRUE
Fractional Coverage      10 = 0.75
Trunk Space              10 = 0.5
Aerodynamic Attenuation  10 = 3.5
Radiation Attenuation    10 = 0.5
Hemi Fract Coverage      10 =
Clumping Factor          10 =
Leaf Angle A             10 =
```

```
Leaf Angle B             10 =
Scattering Parameter     10 =
Max Snow Int Capacity    10 = 0.04
Mass Release Drip Ratio  10 = 0.4
Snow Interception Eff    10 = 0.6
Impervious Fraction      10 = 0.0
Height                   10 = 21.5 0.5
Maximum Resistance       10 = 1000. 5000.
Minimum Resistance       10 = 333.3 250.
Moisture Threshold       10 = 0.33 0.13
Vapor Pressure Deficit   10 = 4000 4000
Rpc                      10 = .108 .108
Number of Root Zones     10 = 3
Root Zone Depths         10 = 0.10 0.30 0.70
Overstory Root Fraction  10 = 0.31 0.36 0.33
Understory Root Fraction 10 = 0.60 0.40 0.00
Overstory Monthly LAI    10 = 9.0 9.4 10.2 10.8 11.7 12.7 12.6 12.1 11.6 10.5 9.5 9.0
Understory Monthly LAI   10 = 0.363 0.462 0.600 0.600 0.600 0.600 1.125 1.075 0.638
0.363 0.363 0.363
Overstory Monthly Alb    10 = 0.18 0.18 0.18 0.18 0.18 0.18 0.18 0.18 0.18 0.18 0.18
0.18
Understory Monthly Alb   10 = 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2

################ VEGETATION 11 ##################################################

Vegetation Description   11 = Cold Moist Medium Trees
Overstory Present        11 = TRUE
Understory Present       11 = TRUE
Fractional Coverage      11 = 0.8
Trunk Space              11 = 0.5
Aerodynamic Attenuation  11 = 3.5
Radiation Attenuation    11 = 0.5
Hemi Fract Coverage      11 =
Clumping Factor          11 =
Leaf Angle A             11 =
Leaf Angle B             11 =
Scattering Parameter     11 =
Max Snow Int Capacity    11 = 0.04
Mass Release Drip Ratio  11 = 0.4
Snow Interception Eff    11 = 0.6
Impervious Fraction      11 = 0.0
Height                   11 = 19.4 0.5
Maximum Resistance       11 = 1000. 5000.
Minimum Resistance       11 = 333.3 250.
Moisture Threshold       11 = 0.33 0.13
Vapor Pressure Deficit   11 = 4000 4000
Rpc                      11 = .108 .108
Number of Root Zones     11 = 3
Root Zone Depths         11 = 0.10 0.30 0.70
Overstory Root Fraction  11 = 0.31 0.36 0.33
Understory Root Fraction 11 = 0.60 0.40 0.00
Overstory Monthly LAI    11 = 8.2 8.5 9.2 9.8 10.6 11.6 11.4 11.0 10.5 9.5 8.6 8.2
Understory Monthly LAI   11 = 0.363 0.462 0.600 0.600 0.600 0.600 1.125 1.075 0.638
0.363 0.363 0.363
Overstory Monthly Alb    11 = 0.18 0.18 0.18 0.18 0.18 0.18 0.18 0.18 0.18 0.18 0.18
0.18
Understory Monthly Alb   11 = 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2

################ VEGETATION 12 ##################################################

Vegetation Description   12 = Cold Dry Medium Trees
Overstory Present        12 = TRUE
Understory Present       12 = TRUE
```

```
Fractional Coverage      12 = 0.8
Trunk Space              12 = 0.5
Aerodynamic Attenuation  12 = 3.5
Radiation Attenuation    12 = 0.5
Hemi Fract Coverage      12 =
Clumping Factor          12 =
Leaf Angle A             12 =
Leaf Angle B             12 =
Scattering Parameter     12 =
Max Snow Int Capacity    12 = 0.04
Mass Release Drip Ratio  12 = 0.4
Snow Interception Eff    12 = 0.6
Impervious Fraction      12 = 0.0
Height                   12 = 17.5 0.5
Maximum Resistance       12 = 1000. 5000.
Minimum Resistance       12 = 333.3 250.
Moisture Threshold       12 = 0.33 0.13
Vapor Pressure Deficit   12 = 4000 4000
Rpc                      12 = .108 .108
Number of Root Zones     12 = 3
Root Zone Depths         12 = 0.10 0.30 0.70
Overstory Root Fraction  12 = 0.31 0.36 0.33
Understory Root Fraction 12 = 0.60 0.40 0.00
Overstory Monthly LAI    12 = 7.4 7.7 8.3 8.8 9.6 10.5 10.3 9.9 9.5 8.6 7.8 7.4
Understory Monthly LAI   12 = 0.363 0.462 0.600 0.600 0.600 0.600 1.125 1.075 0.638
0.363 0.363 0.363
Overstory Monthly Alb    12 = 0.18 0.18 0.18 0.18 0.18 0.18 0.18 0.18 0.18 0.18 0.18
0.18
Understory Monthly Alb   12 = 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2

################ VEGETATION 13 ##################################################

Vegetation Description   13 = Cold Dry Sapling Pole
Overstory Present        13 = TRUE
Understory Present       13 = TRUE
Fractional Coverage      13 = 0.6
Trunk Space              13 = 0.5
Aerodynamic Attenuation  13 = 3.5
Radiation Attenuation    13 = 0.5
Hemi Fract Coverage      13 =
Clumping Factor          13 =
Leaf Angle A             13 =
Leaf Angle B             13 =
Scattering Parameter     13 =
Max Snow Int Capacity    13 = 0.04
Mass Release Drip Ratio  13 = 0.4
Snow Interception Eff    13 = 0.6
Impervious Fraction      13 = 0.0
Height                   13 = 11.9 0.5
Maximum Resistance       13 = 1000. 5000.
Minimum Resistance       13 = 333.3 250.
Moisture Threshold       13 = 0.33 0.13
Vapor Pressure Deficit   13 = 4000 4000
Rpc                      13 = .108 .108
Number of Root Zones     13 = 3
Root Zone Depths         13 = 0.10 0.30 0.70
Overstory Root Fraction  13 = 0.31 0.36 0.33
Understory Root Fraction 13 = 0.60 0.40 0.00
Overstory Monthly LAI    13 = 5.1 5.4 5.8 6.2 6.7 7.3 7.2 6.9 6.6 6.0 5.4 5.1
Understory Monthly LAI   13 = 0.363 0.462 0.600 0.600 0.600 0.600 1.125 1.075 0.638
0.363 0.363 0.363
Overstory Monthly Alb    13 = 0.18 0.18 0.18 0.18 0.18 0.18 0.18 0.18 0.18 0.18 0.18
0.18
```

```
Understory Monthly Alb   13 = 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2

################ VEGETATION 14 ##################################################

Vegetation Description   14 = Thinning - post harvest
Overstory Present        14 = TRUE
Understory Present       14 = TRUE
Fractional Coverage      14 = 0.54
Trunk Space              14 = 0.352
Aerodynamic Attenuation  14 = 3.5
Radiation Attenuation    14 = 0.5
Hemi Fract Coverage      14 =
Clumping Factor          14 =
Leaf Angle A             14 =
Leaf Angle B             14 =
Scattering Parameter     14 =
Max Snow Int Capacity    14 = 0.04
Mass Release Drip Ratio  14 = 0.4
Snow Interception Eff    14 = 0.6
Impervious Fraction      14 = 0.0
Height                   14 = 23.0 0.5
Maximum Resistance       14 = 1000. 5000.
Minimum Resistance       14 = 333.3 250.
Moisture Threshold       14 = 0.33 0.13
Vapor Pressure Deficit   14 = 4000 4000
Rpc                      14 = .108 .108
Number of Root Zones     14 = 3
Root Zone Depths         14 = 0.10 0.30 0.70
Overstory Root Fraction  14 = 0.31 0.36 0.33
Understory Root Fraction 14 = 0.60 0.40 0.00
Overstory Monthly LAI    14 = 9.6 10.0 10.8 11.5 12.5 13.6 13.4 12.9 12.4 11.2 10.1
9.6
Understory Monthly LAI   14 = 0.363 0.462 0.600 0.600 0.600 0.600 1.125 1.075 0.638
0.363 0.363 0.363
Overstory Monthly Alb    14 = 0.18 0.18 0.18 0.18 0.18 0.18 0.18 0.18 0.18 0.18 0.18
0.18
Understory Monthly Alb   14 = 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2

################ VEGETATION 15 ##################################################

Vegetation Description   15 = Seedling Composite
Overstory Present        15 = TRUE
Understory Present       15 = TRUE
Fractional Coverage      15 = 0.3
Trunk Space              15 = 0.2
Aerodynamic Attenuation  15 = 3.5
Radiation Attenuation    15 = 0.5
Hemi Fract Coverage      15 =
Clumping Factor          15 =
Leaf Angle A             15 =
Leaf Angle B             15 =
Scattering Parameter     15 =
Max Snow Int Capacity    15 = 0.04
Mass Release Drip Ratio  15 = 0.4
Snow Interception Eff    15 = 0.6
Impervious Fraction      15 = 0.0
Height                   15 = 2.6 0.5
Maximum Resistance       15 = 1000. 5000.
Minimum Resistance       15 = 333.3 250.
Moisture Threshold       15 = 0.33 0.13
Vapor Pressure Deficit   15 = 4000 4000
Rpc                      15 = .108 .108
Number of Root Zones     15 = 3
```

```
Root Zone Depths         15 = 0.10 0.30 0.70
Overstory Root Fraction  15 = 0.31 0.36 0.33
Understory Root Fraction 15 = 0.60 0.40 0.00
Overstory Monthly LAI    15 = 1.4 1.5 1.6 1.7 1.8 2.0 2.0 1.9 1.8 1.6 1.5 1.4
Understory Monthly LAI   15 = 0.58 0.63 0.63 0.63 0.92 1.77 2.55 2.55 1.73 0.97 0.73
0.63
Overstory Monthly Alb    15 = 0.18 0.18 0.18 0.18 0.18 0.18 0.18 0.18 0.18 0.18 0.18
0.18
Understory Monthly Alb   15 = 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2

################ VEGETATION 16 ##################################################

Vegetation Description   16 = Non Forest Composite (also used for clearcut - post
harvest)
Overstory Present        16 = TRUE
Understory Present       16 = TRUE
Fractional Coverage      16 = 0.05
Trunk Space              16 = 0.5
Aerodynamic Attenuation  16 = 3.5
Radiation Attenuation    16 = 0.5
Hemi Fract Coverage      16 =
Clumping Factor          16 =
Leaf Angle A             16 =
Leaf Angle B             16 =
Scattering Parameter     16 =
Max Snow Int Capacity    16 = 0.04
Mass Release Drip Ratio  16 = 0.4
Snow Interception Eff    16 = 0.6
Impervious Fraction      16 = 0.0
Height                   16 = 12.5 0.5
Maximum Resistance       16 = 1000. 5000.
Minimum Resistance       16 = 333.3 250.
Moisture Threshold       16 = 0.33 0.13
Vapor Pressure Deficit   16 = 4000 4000
Rpc                      16 = .108 .108
Number of Root Zones     16 = 3
Root Zone Depths         16 = 0.10 0.30 0.70
Overstory Root Fraction  16 = 0.31 0.36 0.33
Understory Root Fraction 16 = 0.60 0.40 0.00
Overstory Monthly LAI    16 = 0.9 0.9 1.0 1.0 1.1 1.2 1.2 1.2 1.1 1.0 0.9 0.9
Understory Monthly LAI   16 = 0.58 0.63 0.63 0.63 0.92 1.77 2.55 2.55 1.73 0.97 0.73
0.63
Overstory Monthly Alb    16 = 0.18 0.18 0.18 0.18 0.18 0.18 0.18 0.18 0.18 0.18 0.18
0.18
Understory Monthly Alb   16 = 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2

##############################################################################
# MODEL OUTPUT SECTION

##############################################################################
[OUTPUT]                                  # Information what to output when
Output Directory           = /output/
Initial State Directory    = /modelstate/


################ PIXEL DUMPS ####################################################

Number of Output Pixels    =

# For each pixel make a key-entry pair as indicated below, varying the
# number for the output pixel  (1, .. , Number of Output Pixel)

North Coordinate         1 =
```

```
East Coordinate          1 =
Name                     1 =

################ MODEL STATE ##################################################

Number of Model States     =  0          # Number of model states to dump

# For each model state make a key-entry pair as indicated below, varying the
# number for the model state dump (1, .. , Number of Model States)

State Date               1 =  10/01/2001-03    # Time for model state dump

################ MODEL MAPS ###################################################

Number of Map Variables    = 0            # Number of different variables for
                                          # which you want to output maps

# For each of the variables make a block like the one that follows, varying
# the number of the variable (n = 1, .. , Number of Map Variables)

Map Variable             1 = 404          # ID of the variable to output
Map Layer                1 = 1            # If the variable exists for a number
                                          # of layers, specify the layers here
                                          # with the top layer = 1
Number of Maps           1 = 1            # Number of maps you would like to
                                          # output for this variable
Map Date 1               1 =              # Vary the first number from
                                          # 1 to number of maps


Map Variable             2 = 406          # ID of the variable to output
Map Layer                2 = 1            # If the variable exists for a number
                                          # of layers, specify the layers here
                                          # with the top layer = 1
Number of Maps           2 = 1            # Number of maps you would like to
                                          # output for this variable
Map Date 1               2 =              # Vary the first number from
                                          # 1 to number of maps


Map Variable             3 = 501          # ID of the variable to output
Map Layer                3 = 1            # If the variable exists for a number
                                          # of layers, specify the layers here
                                          # with the top layer = 1
Number of Maps           3 = 1            # Number of maps you would like to
                                          # output for this variable
Map Date 1               3 =              # Vary the first number from
                                          # 1 to number of maps


Map Variable             4 = 503          # ID of the variable to output
Map Layer                4 = 1            # If the variable exists for a number
                                          # of layers, specify the layers here
                                          # with the top layer = 1
Number of Maps           4 = 1            # Number of maps you would like to
                                          # output for this variable
Map Date 1               4 =              # Vary the first number from
                                          # 1 to number of maps

################ MODEL IMAGES #################################################

Number of Image Variables  =              # Number of variables for which you
                                          # would like to output images
```

```
# For each of the variables make a block like the one that follows, varying
# the number of the variable (n = 1, .. , Number of Image Variables)

Image Variable        1 =                 # ID of the variable to output
Image Layer           1 =                 # If the variable exists for a number
                                          # of layers, specify the layers here
                                          # with the top layer = 1
Image Start           1 =                 # First timestep for which to output
                                          # an image
Image End             1 =                 # Last timestep for which to output
                                          # an image
Image Interval        1 =                 # Time interval between images (hours)
Image Upper Limit     1 =                 # All values in the output equal to or
                                          # greater than this limit will be set
                                          # to 255
Image Lower Limit     1 =                 # All values in the output equal to or
                                          # smaller than this limit will be set
                                          # to 0
################ GRAPHIC IMAGES ##################################################

Number of Graphics      =                 # Number of variables for which you
                                          # would like to output images
Graphics ID           1 =                 # ID of the variable to output

##############################################################################
# END OF INPUT FILE
##############################################################################
[End]                                     # This is probably not needed, but
                                          # just in case (to close the previous
                                          # section)
```