Historical range of variability of forests of the Idaho Southern Batholith Ecosystem

Revised Final Report
June 12, 2001

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Preface

In this report, we present revised Historical Range of Variability (HRV) estimates by cover type,

Vegetation Growth Stage (VGS), and class (combinations of cover type and VGS) for each of the eleven forested habitat type classes within the Idaho Southern Batholith. The Idaho Southern Batholith is an area of 2.4 million ha located in the mountains of Central Idaho.

This report combines and replaces Morgan and Parsons (1998) and Parsons (1999), as well as any versions of those with different dates. We have made minor corrections to both to correct typographical errors and other minor inconsistencies. The historical range of variability estimates included here are from Parsons (1999), which were revisions of those presented by Morgan and Parsons (1998). This revision was prompted by questions from many users of the results, including the USDA Forest Service and Boise Cascade Corporation.

Specifically, the changes from the previous reports are as follows:

1. The size classes listed in Table 1 of Morgan and Parsons (1998) have been corrected.
2. We replaced Table 4 from Morgan and Parsons (1998) with Table 4 from Parsons (1999). In doing so, we eliminated a duplicate row.
3. The extent of the lodgepole pine cover type listed in Table 5 of Morgan and Parsons (1998) has been changed to correct a typographical error.
4. We have replaced Tables 6, 7, 8, 9, 10, 11, 12, and 13 in Morgan and Parsons (1998) with the corresponding tables from Parsons (1999).
5. We revised the description of how we estimated the historical range of variability of old growth forests to reflect the process used by Parsons (1999). In doing so, we included the two appendices from Parsons (1999).
6. We incorporated several new references, including Cissel et al. (1999), Landres et al. (1999), and Swetnam et al. (1999). All of these were published, along with other case studies, in a special issue of Ecological Applications devoted to historical range of variability.
7. The end of the discussion has changed somewhat. We added a new paragraph to the discussion. In it, we caution that the historical range of variability is much greater when landscapes are smaller, based upon simulations by Wimberley et al. (2000). We also make a link between HRV and long-term sustainability and resilience.
8. We changed the title, picture on the title page, and the font used throughout the document to help differentiate this revision from previous versions of this report. There remain some inconsistencies in terminology. At times, we refer to ponderosa pine as PIPO, and to Douglas-fir as DF. For the purposes of this report, nonlethal fires are the same as under burns, and lethal fires are the same as stand-replacing fires.

Historical range of variability for the Idaho Southern Batholith Ecosystem

Introduction

Describing historical conditions is part of a coarse-filter management strategy for sustaining biological diversity (Haufler et al. 1994 and 1996, Hunter et al. 1989, Swanson et al. 1994, Cissel et al. 1994). A description of past ecosystem structure and its variability is useful in exploring the causes and consequences of change in ecosystem characteristics over time, and thus for understanding the set of conditions and processes that sustained ecosystems prior to their recent alterations by humans (Landres et al. 1999, Swetnam et al.1999). It provides a context for interpreting natural processes, especially disturbance, and it allows variability in patterns and processes to be understood in terms of a dynamic system. Such information is often used by natural resource managers in identifying management goals to sustain biological diversity, restore severely altered ecosystems, and to evaluate change, especially change induced by people (Landres et al. 1999, Swetnam et al. 1999).

The historical range of variability (HRV) characterizes fluctuations in ecosystem conditions or processes over time (Morgan et al. 1994, Landres et al. 1999), and thus provides researchers and managers with a reference against which to evaluate recent and potential future ecosystem change. Landres et al. (1999) defined natural variability as “the ecological conditions and their variability over space and time relatively unaffected by people”. HRV defines bounds of system behavior that remain relatively consistent over time. We use "historical” to describe a time frame relevant to understanding the behavior of contemporary ecosystems and the implications for management. It is the period prior to the intensive influence of European-Americans and with relatively consistent climate. We use a time frame of 100 to 700 years before present to interpret successional dynamics and to characterize past variation in forest structure and composition. This includes burning and other actions of Native Americans, and encompasses climatic variability, such as the Little Ice Age. Historical data on disturbance occurrence and effects is increasingly limited the further back in time we look. Hann et al. (1997) used the last 2,000 years as the time frame for HRV for the ICRB.

Historical variability is often used in combination with societal values and other information to identify desired future conditions (Landres et al. 1999, Haufler et al. 1996). Historical information has been used to guide management of water flow on the Colorado River (Poff et al. 1997) and in the Everglades (Harwell 1997), fire (Skinner and Chang 1996, Brown et al. 1994), and forest structure (Gauthier et al. 1996, Baker 1992, Ripple 1994, Camp et al. 1997, Keddy and Drummond 1996, Cissel et al. 1999); and to deepen our understanding of the processes driving forest change (Mladenoff and Pastor 1993, Covington and Moore 1997, Lesica 1996, Lertzman et al. 1997 and others). Ecosystem management often relies heavily on a description of past variability in defining desired future conditions (Kaufman et al. 1994, Manley et al. 1995).

The overall goal of this project was to estimate the HRV (Morgan et al. 1994, Landres et al.,

1999) for the forests of the Idaho Southern Batholith. This area encompasses approximately 2.4 million ha in central Idaho, from dry ponderosa pine to high elevation subalpine fir. We used successional models parameterized by expert opinion and available data to estimate the minimum, maximum, and median abundance (percent of potential area occupied) for elements in the ecosystem diversity matrix (Haufler et al. 1994, 1996; Mehl et al. 1998). These elements are combinations of vegetation growth stage (VGS, a description of tree size and canopy layering) and dominant cover type (forest vegetation named for the species occupying majority of the stand) for each of eleven habitat type classes (these represent groups of similar biophysical conditions).

Methods

Ecosystem Diversity Matrix

The ecosystem diversity matrix (Haufler et al. 1994, 1996; Mehl et al. 1998) characterizes the variety in forest structure, composition, biophysical conditions, and disturbance regimes. We estimated the range (maximum and minimum) and median abundance (percent of the area of a given habitat type class) for elements of the ecosystem diversity matrix. Habitat type classes were developed to include similar biophysical settings at a level more general than individual habitat types (Steele et al. 1981, 1986) and more specific than region (ECOMAP 1993). Cover types are defined by the tree species with the majority of overstory canopy cover. Structure is described by VGS based on tree diameter and the number of canopy layers (Table 1).

Characterizing forest structure

We quantified the relationship between 7 structural stages used in the Interior Columbia Basin Ecosystem Management Project (O'Hara et al. 1996) and the 8 VGS (Tables 2 and 3). Initially, this was based upon our understanding of the different systems for describing forest structure. It was confirmed with comparison of the two different systems for 952 individual stands for which individual lists of the number of trees by species and diameter class and for which habitat type had been identified. We obtained all data with readily available digital data that included a list of the number of trees by diameter class for different species, habitat type, slope, aspect elevation, and location (UTM coordinates). We used chi-square and a simple percent correspondence analysis to evaluate the degree to which the different descriptors of structure differed.

Successional models

We modified the successional models used in the Interior Columbia Basin Ecosystem Management Project (ICBEMP, Keane et al. 1996, Long et al. 1997). These models are multiple pathway, probabilistic models. We assumed this was a mid-scale model appropriate for working with data mapped at a 1:24,000 mapping scales with a minimum-mapping unit of 4 ha.

First, we adapted the VDDT model (Beukema and Kurz 1998) to the VGS system for describing forest structure. The habitat type classes in the Ecosystem Diversity Matrix were very similar to the ICBEMP potential vegetation type groups; the majority of the individual habitat types included in each classification were the same. Similarly, the cover types were the same for the two approaches. Thus, the major modification we had to make was in how structure was handled.

Second, we modified the successional pathway diagrams (see Keane et al. 1996 for a description) to capture the successional dynamics in the absence of disturbance. Typically the sequence for a given cover type was from grass, forb or shrub to seedling/shrub to sapling to either single or multi-storied small trees, and from there to medium and then large tree multi-story structures. At the same time, we included likely transitions in cover type so that the final stages were large-tree multi-story structure dominated by the most shade-tolerant tree species capable of growing on the habitat type class. The latter stage is perpetuated in the absence of disturbance. Transition times between classes in the absence of disturbance were based upon the time required for stands projected with the Forest Vegetation Simulator (FVS, Teck et al. 1996) to change from one VGS to the next. The FVS runs were made using the Boise Cascade variant, which has been modified to represent local growth conditions. One randomly selected stand was used for each projection, and each was modeled from bare ground. In this first approximation of the models, we included the disturbance effects and probabilities from the equivalent combination of potential vegetation, cover type and structure used in the ICBEMP (Long et al. 1997).

We differentiated between small, medium and large tree classes developed historically under predominantly nonlethal and mixed fire regimes (STNLM, MTNLM, LTMLM, respectively) and those developed under predominantly mixed and stand-replacing fire regimes (STMMSR, MTMMSR, LTMMSR or simply STM, MTM, and LTM, respectively). The Ecosystem Diversity Matrix is structured this way. Most habitat type classes only had one or the other. However, the Moist Grand Fir and Moist Douglas-fir habitat type classes had both. For those classes we divided these according to the dominant cover type. All ponderosa pine and seral Douglas-fir were assigned to the nonlethal and mixed fire regimes; all other species were assigned to the predominantly mixed and stand-replacing group. The ecological difference we tried to represent here was the difference in the density of trees and canopy cover, both of which were generally considerably higher where stand-replacing and mixed fire regimes were the norm than where nonlethal and mixed fire regimes were common historically. This is a reflection of inherent site productivity as well as the environmental conditions conducive to burning.

To obtain the HRV estimates, we needed a reasonable starting point for simulations. To obtain the initial conditions, we ran the VDDT models with the probabilities estimated by the experts for 1200 (or more) simulated years with 1000 pixels. To obtain the HRV estimates, we then induced random variation around each of the probabilities. The latter was done to account for variation between years and across time. This was accomplished within VDDT by generating normally distributed random numbers and normalizing them to ensure that the overall average probabilities were those originally chosen by the experts (see next section). Where data were available this was scaled to represent the variation in fire frequency documented in fire history studies. The HRV estimates were summarized from the results of VDDT model runs for 300 years for each habitat type class.

The HRV was described by the minimum, maximum, mean, and 90% confidence interval around the mean. The numbers were normally distributed.

The last step was to compare our estimates with historical data. We used data from the ICBEMP project (Hann et al. 1997) for the area within the Idaho Southern Batholith.

Workshops with experts
We convened multiple workshops with local experts. They assisted us with developing the simulation models used to estimate HRV for the forests of the Idaho Southern Batholith.

We held two workshops in August 1998. In these, we worked with 11 local experts from the USDA Forest Service, Boise Cascade Corporation, University of Idaho, and a private consultant. They used VDDT, additional data (for instance on fire regimes, as described below) and their expertise to refine the first approximations. The approach was to first refine the successional pathway diagrams. Here we added or deleted cover types and VGS as appropriate. Then, we modified the effects of fire and other disturbances. We included all disturbances that could change the vegetation growth stage or cover type or both, or maintain the same cover type and vegetation growth stage but either slow or accelerate the successional transition. Then, we estimated probabilities of fire occurrence for each class based upon available data (Tables 4 and 5) and the expert opinion of those present, and then added insects and pathogens as deemed appropriate by the experts. Repeated runs of the VDDT model for each habitat type class helped us to refine and verify our thinking. There is little data available for estimating all of the probabilities we needed. Therefore, experts were needed. However, we were consistent with the data that was available. At this point, we had historical successional models for all habitat type classes, background assumptions, and based upon them, an estimate of the average abundance through time of each element of the ecosystem diversity matrix.

On February 17, 1999, a subset of this group of experts met again for a one–day workshop on the campus of the University of Idaho. The HRV estimates for the Idaho Southern Batholith were refined in two ways. First, minor inconsistencies were corrected within the models. In several cases, successional transition times between classes in a particular habitat type were not consecutive, causing an artificial time gap during which dynamics in cover type and structure stage were not properly accounted for. For example, one class would end at time step 35 and the next consecutive class would start at time step 50. This resulted in a 15-timestep gap in which stand dynamics were not properly accounted for. While minor and essentially typographical in nature, these inconsistencies did affect the outputs of the model. These edits were thus needed to more accurately represent successional and disturbance dynamics within the habitat types of the Idaho Southern Batholith. As these edits did affect the model, it was necessary to run the model again for each habitat type to reproduce all of the tables and graphic outputs.

The second revision resulting from this workshop was a more explicit representation of mixed severity historical fire regimes. In six of the eleven habitat types (Table 8), historical fire regimes were primarily lethal, stand-replacing and mixed severity fires. However, in certain cover types it was believed that some level of non-lethal fire might have been present in these ecosystems. Conversely, in the five habitat types generally characterized by non-lethal fire regimes (Table 7), it was believed that some degree of stand-replacing fire might have existed in certain cover types. An attempt was made to demonstrate this diversity of fire regimes in the Ecosystem Diversity Matrix.

The Ecosystem Diversity Matrix represents different types of forest structure as unique combinations of cover type and Vegetation Growth Stage. These unique combinations are easily modeled explicitly with the Vegetation Dynamics Development Tool, version 3.0 (VDDT)

(Beukema and Kurtz, 1998), the software used to develop the HRV estimates. However, in the Ecosystem Diversity Matrix, these unique combinations are further divided into those with primarily lethal, stand-replacing historical fire regimes and those with primarily non-lethal historical fire regimes. While the software used to develop the HRV estimates, VDDT, offers great flexibility in modeling disturbance and successional dynamics, it is not designed to classify the results into “lethal” and “non-lethal” fire regimes. Since this classification essentially requires multiples of the same cover type-structure combinations, it would be extremely difficult to explicitly model with VDDT (Beukema and Kurtz, 1998). The VDDT program requires that each cover type-structure combination be unique.

To allow the simplest possible modeling in VDDT while still discriminating between non-lethal and lethal fire regimes, a two-step process was used. First, forest ecosystem dynamics were explicitly modeled in VDDT using successional pathway diagrams developed in the previous workshops. Discrimination of lethal vs. non-lethal fire regimes was not made at this time. Second, outputs from the VDDT modeling were allocated in post-processing to either lethal fire regime or non-lethal fire regime based on cover type. Generally speaking, more shade-tolerant cover types were allocated to lethal fire regimes, and less shade-tolerant cover types were allocated to non-lethal fire regimes. In some cases, a given cover type was allocated to both lethal and to non-lethal fire regimes to some degree. The proportion allocated to the different fire regimes is explicitly shown in Tables 7 and 8, and the criteria used in making those allocations are presented in Appendix 2.

Old growth

With reservations, we have made HRV estimates for the extent of old growth (OG) forests. We have two major reservations about this approach. First, definitions of OG vary. For instance, many would designate all large tree, single-storied stands of ponderosa pine as old growth on habitat type classes that would support them. We use the definitions of OG developed by Mehl et al. (1998). Second, while we model these as a percentage of the large tree multi-story class dominated by the climax tree species (e.g. grand fir on the two grand fir habitat type classes), as done by both Morgan and Parsons (1998) and Parsons (1999), there is not clearly defensible way to estimate what that percentage should be. Therefore, we recommend that users develop other means of estimating the HRV of OG forests.

The HRV of OG was not modeled explicitly. Instead, they were calculated from the model output as follows. They are described in further detail in Appendices 1 and 2. First, using the allocation decision rules developed by Haufler (1999), the Large Tree Multistory class (LTM) of the most shade tolerant cover type that could occur on a given habitat type class was allocated between LTM (Iethal) and LTNLM (non -lethal). Second, allocations were then made to OG from the LTM (lethal) class. These allocations were calculated by multiplying the adjusted mean (mean after allocation to LTNLM (non-lethal)) by the proportion of cells expected to have grown to 24" DBH without having been subjected to any form of disturbance. Third, the proportion of cells expected to have grown to 24" DBH without having been subjected to any form of disturbance was calculated as 1 - [(sum of all disturbances for the LTM class in VDDT) * number of years to reach 24" DBH]. N Note that in the Dry Ponderosa Pine/ Xeric Douglas-fir habitat type class and in the Dry Douglas-fir habitat type class, all Large Tree Multistory classes (LTM) were allocated 100% to LTNLM (non-let hal). This resulted in no OG in those habitat type classes.

Model structure and assumptions

Successional pathway diagrams were developed for each of 11 different habitat type classes included in the Ecosystem Diversity matrix. Vegetation growth stage and the cover type (named for the dominant overstory plant species), transition times, and transitions are shown in the successional pathway diagrams. The effects of disturbances are also included. Disturbances effects included a change in Vegetation Growth Stage (e.g. a nonlethal underburn fire thinning from below and converting a large tree multiple storied stand into a large tree single story stand), dominant cover type (e.g. western pine beetle killing enough large ponderosa pine in a stand mixed with many large Douglas-fir trees to result in change in dominance from ponderosa pine to Douglas-fir while stand was and still is a large tree multi-storied one), both (e.g. western pine beetle killing enough large ponderosa pine in a stand mixed with many medium-sized Douglas-fir to convert this from a large to a medium VGS and from ponderosa pine to Douglas-fir) and/or successional time (e.g. when successive nonlethal underburns delay the successional replacement of dominant ponderosa pine and Douglas-fir by grand fir because the majority of the young grand fir are killed by fires) as the result of disturbance. Each disturbance-induced change is labeled with an abbreviation for the type of disturbance. Disturbances differ in type, severity or intensity. Some disturbances are a combination of other disturbances acting at the same time and in the same place. For instance, in the Moist Douglas-fir and Moist Grand Fir habitat type classes, we assumed that root diseases acted jointly with mixed severity fires. A complete listing of the disturbances and their 4 digit codes are included in Beukema and Kurz (1998). For more information about the model structure, see Keane and others (1996), Long et al. (1997), and Beukema and Kurz (1998).

The probabilities of disturbance for a given vegetation growth stage and dominant cover type are expressed as a probability that a pixel will change in a given year. A disturbance that occurs, on average, every eight years will have an interval probability of 0.125 for each pixel each year. These probabilities can be interpreted in different ways. It can be the proportion of pixels that will change in a given year. It is also the probability that a given pixel will change in any given year. We considered the proportion of all pixels of a given vegetation growth stage and cover type combination being affected in a single year, the frequency of disturbance of any pixel, and the number of years that it takes for the effects of a disturbance to be fully manifest. The rationale and assumptions for disturbance probabilities were documented.

Simplifying assumptions were made as follows. Any single pixel may only be of one vegetation growth stage and dominant cover type at any one time, and only one pathway is allowed for any one disturbance type in a given VGS and dominant cover type combination. We did however, use designations, such as WMSF1, WMSF2, WMSF3, etc., to accommodate the different effects that a mixed severity fires, could have in a single class. In the absence of disturbance, a given pixel may only change in one direction. In any given year, a pixel must either change to one other vegetation growth stage and dominant cover type or it must remain in the same vegetation growth stage and dominant cover type. When it remains, the successional age advances by one year. The disturbance probabilities do not change with time. It is possible to input different probabilities for different phases of time (see Beukema and Kurz 1998), e.g. to represent the variations in climate, but we did not do that in this effort.

The disturbance probabilities are independent over space (there is no contagion to reflect the characteristics of adjacent pixels), and over time (there is no legacy of past disturbance except

as it influences the successional age, VGS or cover type of a given pixel in a given year). We included only those disturbances that alter the successional class or successional age. Thus, disturbances, by definition, change one or more of the cover type, vegetation growth stage or successional age. If the vegetation growth stage and dominant cover type remain the same (for example, the successional class does not change because the disturbance is not severe), the successional age may be advanced (+, accelerating the time at which a given pixel will develop through succession into a different vegetation growth stage and/or dominant cover type) or delayed (-, effectively delaying succession and extending the time that the pixel remains in the current vegetation growth stage and cover type). When the successional age is advanced or delayed, the age can never be changed beyond the minimum or maximum successional age for a given vegetation growth stage and dominant cover type combination. In the model, all impacts of disturbances are immediate. When a disturbance occurs, one or more of the vegetation growth stage, dominant cover type, or successional age changes.

Model limitations

Contagion, the spread of disturbances from one site to another, is not represented in this model (Keane and others 1996, Beukema and Kurz 1998). Clearly, the likelihood that fire, insects, pathogens, and other disturbances will disturb any one spot depends upon the characteristics of the surrounding vegetation and topography. Contagion should be incorporated into future modeling efforts, particularly for mid-scale and finer scale applications.

We did not assess the uncertainty with which the disturbance probabilities were assigned. The fire effects and insect and pathogen ecology is better known for the warm, dry forests than for moist forests or those at high elevations. For instance, very little is known about disturbance probabilities and effects in the Hydric Subalpine Forest habitat type class, so the probabilities are less certain. It is also difficult to assign probabilities of disturbance to all of the individual VGS and cover types with equal confidence.

Results

Stratifying the Idaho Southern Batholith landscape by habitat type class greatly facilitated modeling. The successional pathways, disturbance effects and disturbance probabilities differ by habitat type class, and within those classes by vegetation growth stage and cover type. The experts were able to estimate most disturbance probabilities with confidence. Thus, stratifying ecological conditions using the Ecological Diversity Matrix is instrumental in working with the wide range of conditions in the Idaho Southern Batholith landscape. A similar approach was effectively used to characterize succession, disturbance, and ecological integrity in the landscape ecology portion of the Interior Columbia Basin Ecosystem Management Project (Hann et al. 1997, Keane et al. 1996, Long et al. 1997).

We developed a crosswalk between two systems for classifying forest structure (Tables 2 and 3). There was little direct correspondence between the seven ICBEMP structural stages and the VGS. Only the large tree multi-story stands were similar to the old forest multi story structure. The relationships were equally poor for all of the habitat type classes and cover types, even though these were unevenly represented in the available stand data. The stand inventory data are contemporary, and there may be have been more similarity if historical stand conditions were compared. The discrepancies are the result both of differences in the

assumptions made and the key characteristics used to describe structure, and the algorithms used to classify the tree lists into structure classes.

Fire was historically the most important disturbance agent in the dry forests of the Idaho Southern Batholith landscape. Few fire history studies have been done in the Idaho Southern Batholith, so we relied upon and adjusted, through expert opinion, published fire probabilities. The probabilities used are similar to those documented in fire history studies throughout the western United States (Heyerdahl et al. 1995) (Table 4) and described for the Interior Columbia River Basin (Table 5). Although fire probabilities vary over space, there is remarkable similarity in the historical mean fire return intervals documented for a habitat type class (Table 4).

The HRV estimates are complete for forests in the Idaho Southern Batholith. These are presented by class (Tables 7 and 8), VGS regardless of species (Tables 9 and 10) and dominant cover type regardless of VGS (Tables 11 and 12). Historically, forests were often dominated by seral species growing in relatively open stands. Disturbances were prevalent. Few OG and climax conditions were found. Many stands were dominated by medium and large trees, and were often single-storied, especially on the dry habitat type classes where nonlethal fires occurred often and burned extensive areas.

Large trees (either single or multi-story) dominated forests on 18 to 99% of the extent of some habitat type classes in the Idaho Southern Batholith landscape historically (Tables 9 and 10). The HRV of forests dominated by large trees was greatest in the warm, dry forests where nonlethal fires would have maintained such forests. Historically, OG forests were important but not extensive. On all but the Hydric Subalpine Fir habitat type class, they occupied less than 15% of the area of a given habitat type class (Tables 9 and 10). Of course, this depends on what proportion of the forests dominated by large trees are considered old growth (see cautionary notes in methods).

Our HRV estimates differ from those made for cover types and structural stages (Tables 13 and 14) as part of the Interior Columbia Basin Ecosystem Management Project. For all cover types on all habitat type classes, the mean abundance of cover types estimated by ICBEMP is outside our HRV estimates. Similarly, our estimates of HRV for the combined total of all classes with large trees, including single and multiple-story stands as well as old growth, does not include the total areal extent for old single and multi-story stands estimated by ICBEMP (compare Tables 9 and 10 with Tables 13 and 14) except for the high elevation subalpine fir habitat type class. The discrepancy in estimates could be due to several factors. Most importantly, we are comparing mean values (ICBEMP) to our estimated HRV; the HRV estimated for ICBEMP were much broader, as ours are. Also, habitat types are grouped differently, forest structure is described differently, and the ICBEMP estimates are based upon VDDT models for the ICBEMP as a whole.

Discussion

The ICBEMP and VGS approaches to describing forest structure for ecosystem management differ. Neither is ideal. Forest structure classes should be ecologically meaningful, reliably detectable in the field or from aerial photographs and satellite imagery, and readily related to existing inventory data and forest management models. The ICBEMP structural stages were effective for capturing ecosystem processes, but it is challenging to identify them in the field

and to readily classify existing inventory information into them (Warren et al. 1997). They have been used for mapping fuels in the Gila and Selway-Bitterroot Wilderness Complexes. Forests have been mapped remotely with both systems. It is difficult to represent successional pathways through the VGS. Because the VGS are directly based upon tree size, it is easier to translate inventory data and remotely sensed imagery, such as aerial photographs or LANDSAT Thematic Mapper into VGS than into the ICBEMP structural stages. For both approaches to structure, developing reliable rules for classifying lists of tree size and diameters measured in a stand is complex. Such has been done for the VGS system (Warren et al. 1997, since revised Scharosh personal communication, July 1998) and ICBEMP (http://www.fs.fed.us/fmsc/fvs/htm) ensuring that both can be readily used with the Forest Vegetation Simulator.

Disturbances, especially fires, were prevalent historically. Few forests escaped fires, although the frequency and effects varied considerably from one habitat type class to another. Fire was historically the most important disturbance process in forests of the Southern Idaho Batholith. For those habitat type classes for which fire regimes were predominantly nonlethal, such as dry Douglas-fir and ponderosa pine, we have the most data (Table 4). Estimates are far less certain for the mesic and wet forests where there has been little fire history work (Morgan et al. 1996, Heyerdahl et al. 1995, Agee 1993). More fire history data are available for nonlethal fires (usually based on fire scars) than for stand-replacing fires (usually based on age structure). There are relatively fewer fire history records for mixed fire regimes, and the estimates of fire frequency vary greatly for moderate severity fires.

The most extensive habitat type classes (See first row in Tables 7 and 8) in the Idaho Southern Batholith are those greatly changed by human action. Dry forests have been greatly altered in the last century by fire exclusion, grazing, timber harvest, cessation of burning by Native Americans, roads, and settlement of the adjacent valley bottoms (Morgan et al. 1996, Agee 1993 and others). These include the dry forest types once dominated by ponderosa pine and Douglas-fir that occupy about 28% of the land area in the Idaho Southern Batholith. The high elevation subalpine forests once dominated by whitebark pine (12% of the Idaho Southern Batholith) have also changed greatly due to fire exclusion, mountain pine beetle, and the introduction of white pine blister rust (Keane and Arno 1993).

To estimate the HRV for an area, you must know the extent of each of the habitat type classes. The HRV estimates we report are percent of each of those habitat type classes. If you wish to know the HRV large tree, single-storied stands of ponderosa pine, you would then have to calculate the total minimum and maximum extents of this class across all of the habitat types where it could have occurred. These numbers should be interpreted with some caution, particularly for small watersheds. Wimberley et al. (2000) showed through simulation modeling that the HRV of any class is much greater for the same ecosystems when it is calculated for smaller landscapes. This should be a precautionary note to all users of the HRV estimates we report.

The potential consequences to biological diversity and sustainability are great whenever forest conditions are outside of and remain outside of the HRV. Consequences include, for instance, increased vulnerability to stand-replacing fires where few ever occurred historically, which can put soils, streams, and fish at risk. However, this does not mean that we must return our forests completely to historical conditions to sustain biological diversity and forest ecosystems.

Ideally, we should focus on managing for forest conditions that are resilient to disturbances and therefore sustainable for long into the future. Doing so requires understanding and facilitating ecosystem processes that maintain the resilience and function of forest ecosystems. Thoughtful evaluation of change from historical conditions, evaluation of social needs, presence of exotic species, structures, and processes, and future climate all should play a role in identifying desired future conditions and the management alternatives to achieve them (Landres et al. 1999).

Acknowledgments

We thank these experts for their involvement: Doug Basford from Salmon National Forest; Susan Boudreau from the Payette National Forest; Kathy Geier-Hayes, Lyn Morelan, and Norm Nass from the Boise National Forest; Jon Haufler and Brad Holt from Boise Cascade Corporation, Al Harvey and Geral McDonald from the US Forest Service Rocky Mountain Research Station; Bob Steele, a private consultant; and Ralph Thier from the Intermountain Region of the US Forest Service.

Boise Cascade Corporation provided funding, maps, analysis and inventory data to support this project. Nick Blacklock, who obtained and organized the stand inventory data, and Steve Warren were especially helpful. The workshops were held at the Remote Sensing and GIS lab in the College of Forestry, Wildlife and Range Sciences (now the College of Natural Resources) at the University of Idaho. Sarah Beukema provided technical advice on VDDT. Bob Steele reviewed our results.

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Table 1. Vegetation growth stages (VGS) describe structure for forests in terms of the diameter of the largest trees and the number of canopy layers.

Vegetation Growth Stage	Abbreviation	DBH (inches)
Grass/Forb Seedlings	GF	0
Shrub/seedling	SSL	0.01 to 2.00
Sapling	SAP	2.01 to 5.00
Small Tree Single-Story	STS	5.01 to 12.0
Small Tree Multi-story	STM	5.01 to 12.0
Medium Tree Single-Story	MTS	12.01 to 20.00
Medium Tree Multi-story	MTM	12.01 to 20.00
Large Tree Single-Story	LTS	20.01+
Large Tree Multi-Story	LTM	20.01+

Table 2. Correspondence of the ICBEMP structural stages and the VGS. Numbers are percent of all of the sample plots in a given ICBEMP structural stage that are then identified to a given VGS.

ICBEMP Structural Stages	N (% of total plots)	SSE	SMT	MET	LAT
Herbaceous	31 (3)	29	52	19	0
Shrub	41 (4)	13	68	19	0
Stand Initiation (SI)	91 (10)	15	65	20	0
Stem Exclusion Closed-Canopy (SECC)	36 (4)	11	58	31	0
Stem Exclusion Open Canopy (SEOC)	3 (0)	0	33	67	0
Understory Reinitiation (UR)	14 (1)	7	93	0	0
Young Multi-Story (YMS)	470 (49)	11	55	34	0
Old Multi-Story (OMS)	254 (27)	5	25	41	1
Old Single-Story (OSS)	15 (2)	7	67	27	0

Table 3. Correspondence of the Vegetation Growth Stages (VGS) and the ICBEMP structural stages (abbreviations as in Table 2). Numbers are the percentage of the sample plots in a given VGS that classify to each ICBEMP structural stage.

VGS[1]	N (%)	Herb.	Shrub SI	SI	SECC	UR	YMS	OMS	OSS
SSE	102 (11)	8	5	14	4	1	50	18	1
SMT	492 (52)	3	5	12	4	3	53	18	2
MET	354 (37)	7	2	5	4	0	45	41	1
LAT	4 (0)	0	0	0	0	0	25	75	0

[1]SSE=Shrub and tree seedlings, SMT=Small tree, MET=Medium Tree, LAT=Large Tree

Table 4. Fire regime (typical severity, frequency, and probability) documented by Heyerdahl et al. (1996) and those actually used in the models for the habitat type classes in the Idaho Southern Batholith landscape. Experts chose to include low probabilities for low and moderate severity fires in most of the forest habitat type classes. ALL refers to frequency of all fires, regardless of severity.

Habitat Type Class	Fire Regime (Heyerdahl et al. 1996)			Freq.	Prob.
	Severity	Frequency (yr)	Probability	(yr)	Used
Dry ponderosa pine / Xeric Douglas-fir	Low (67%)	26 (7 to 60)	0.039	10	0.0960
	Moderate (33%)	22 (6 to 99)	0.046	25	0.0408
	Stand-Replacing			559	0.0018
	ALL			10	0.1026
Warm, dry Douglas-fir / Moist ponderosa pine	Low (77%)	8 (2 to 18)	0.131	17	0.0603
	Moderate (23%)	41 (16 to 130)	0.125	97	0.0103
	Stand-Replacing			80	0.0036
	ALL			26	0.0379
Cool, dry Douglas-fir	Low			121	0.0083
	Moderate (86%)	32 (13 to 99)	0.031	67	0.0150
	High (14%)	131 (44 to 175)	0.008	295	0.0034
	ALL			74	0.0135
Dry grand fir	Low (79%)	24 (9 to 49)	0.041	60	0.0165
	Moderate (21%)	52 (43 to 68)	0.019	136	0.0073
	Stand-Replacing			217	0.0046
	ALL			56	0.0177
Cool, moist grand fir	Low (7%)	9 (NA[1])	0.111	55	0.0183
	Moderate (43%)	34 (18 to 54)	0.030	39	0.0254
	High (50%)	50 (29 to 68)	0.020	43	0.0232
	ALL			27	0.0374
Warm, dry subalpine fir	Low			50	0.0200
	Moderate (82%)	47 (22 to 75)	0.021	177	0.0057
	High (18%)	132 (88 to 175)	0.008	159	0.0063
	ALL			94	0.0107
Warm, moist subalpine fir	Low (53%)	25 (16 to 33)	0.041	179	0.0056
	Moderate (37%)	42 (19 to 155)	0.024	101	0.0099
	High (10%)	192 (175 to 209)	0.005	111	0.0092
	ALL			62	0.0162
Hydric subalpine fir	Low (53%)	No Observations	No Obs.	400	0.0025
	Moderate (37%)			186	0.0054
	High (10%)			290	0.0034
	ALL			164	0.0061
Persistent lodgepole pine	Low (25%)	157 (151 to 163)	0.006	111	0.009
	Moderate (25%)	73 (66 to 80)	0.014	182	0.0055
	High (50%)	60 (10 to 109)	0.017	82	0.0123
	ALL				
High elevation subalpine fir	Low			56	0.0180
	Moderate (92%)	73 (29 to 106)	0.014	166	0.006
	High (8%)	419 (NA[1])	0.002	80	0.0125
	ALL			85	0.0118

Table 5. Historical fire regimes were identified for dominant cover types and associated biophysical conditions for the Interior Columbia River Basin by Morgan et al. (1996). Historical (circa 1900) and current (circa 1990) extent is for the entire Interior Columbia River Basin. Only those cover types that occur within the Idaho Southern Batholith are included here.

Forest Cover Type	Biophysical Setting	Historical fire Frequency[1] and Severity[2]		Historical Extent (ha)	Current Extent (ha)
Grand fir / white fir	cool/moist	Stand-repl.	Very Infrequent	0	4098
	cool/dry	Stand-repl.	Infrequent	1984	6622
	warm/moist	Stand-repl.	Infrequent	625	6994
	warm/dry	Mixed	Infrequent	465	13430
Western larch	cool/moist	Mixed	Frequent	6952	3705
	cool/dry	Mixed	Frequent	2669	1661
	warm/moist	Mixed	Frequent	7995	5093
	warm/dry	Mixed	Very Frequent	3722	3246
Interior Douglas-fir	cool/moist	Mixed	Frequent	7765	10641
	cool/dry	Nonlethal	Frequent	17280	21711
	warm/moist	Mixed	Frequent	3877	8414
	warm/dry	Nonlethal	Infrequent	20891	29181
Interior ponderosa pine	cool/moist	Nonlethal	Very Frequent	5163	5101
	cool/dry	Nonlethal	Very Frequent	16683	7839
	warm/moist	Nonlethal	Very Frequent	14614	12154
	warm/dry	Nonlethal	Very Frequent	61508	50729
Aspen	cool/moist	Stand-repl.	Infrequent	833	2567
	cool/dry	Stand-repl.	Infrequent	1466	6550
	warm/moist	Stand-repl.	Infrequent	984	1153
	warm/dry	Stand-repl.	Infrequent	5605	6890
Engelmann spruce/ subalpine fir	cool/moist	Stand-repl.	Very Infrequent	8834	7699
	cool/dry	Stand-repl.	Very Infrequent	18522	25588
	warm/moist	Stand-repl.	Very Infrequent	1048	383
	warm/dry	Mixed	Infrequent	2248	3636
Lodgepole pine	cool/moist	Stand-repl.	Very Infrequent	12937	13897
	cool/dry	Mixed	Infrequent	41223	33114
	warm/moist	Stand-repl.	Infrequent	4129	4433
	warm/dry	Mixed	Infrequent	9056	12689
Whitebark pine	cool/moist	Stand-repl.	Very Infrequent	1612	1491
	cool/dry	Mixed	Infrequent	13439	7704
	warm/moist	Mixed	Infrequent	0	0
	warm/dry	Mixed	Infrequent	69	157
Whitebark pine / alpine larch	cool/moist	Stand-repl.	Very Infrequent	626	0
	cool/dry	Mixed	Infrequent	1482	99
	warm/moist	Mixed	Infrequent	0	0
	warm/dry	Mixed	Infrequent	0	0

[1]Severity classes: Nonlethal fires kill less than 70% of the basal area or less than 90% of the canopy cover that existed prior to the burn; Stand-replacing fires leave less than 20% of the basal area or less than 10% of the canopy cover of the overstory vegetation; Mixed Severity fires have intermediate effects.
[2]Fire frequency classes are based on average years between fires: Very Frequent, less than 25 yr between fires; Frequent, 26-75 yr, Infrequent 76-150 yr; Very Infrequent 151-300 yr; Extremely Infrequent, More than 300 yr

Table 6. Percentage of old growth forest in each habitat type class. See text and table footnotes for calculation methods.

Potential Vegetation Type	OG class	Sum disturbances	Proportion	Time 20-24	Explicitly Modeled Mean LTM	Calculated post-modeling Mean LTM - lethal	Min.	Max.	% O G	Min.	Max.
Cool Dry Douglas-fir	DF - LTM	0.0433	0.4804	12	17.3	17.3	10	23	8	5	11
Hydric Subalpine fir	SAF - LTM	0.012	0.7	25	37.1	37.1	31	44	26	22	31
Cool Moist Douglas-fir	DF - LTM	0.0365	0.708	8	17.0	8.4	3	8	6	2	5
Cool Moist Grand fir	GWF - LTM	0.0408	0.388	15	6.5	6.5	2	14	3	1	5
Warm Dry Subalpine fir	SAF - LTM	0.0266	0.468	20	8.3	8.3	4	13	4	2	6
Subalpine Fir High Elev.	SAF - LTM	0.02	0.2	40	5.9	5.9	2	12	1	0	2
Warm Moist Subalpine fir	SAF - LTM	0.0258	0.613	15	9.1	9.1	5	13	6	3	8
Ponderosa pine warm	IPP-LTM	0.18201	0	8	35.9	0.0	0	0	0	0	0
Dry Douglas-fir	DF - LTM	0.0461	0.6312	8	14.2	0.0	0	0	0	0	0
Lodgepole pine	(none)										
Dry Grand fir	GWF - LTM	0.0733	0.1204	12	0.43	0.43	0 1		0.43 **	0 1 *	

Proportion OG = 1 - [(sum of disturbances) X time for growth from DBH 20 - 24 inches)] X mean area occupied by climax LTM (lethal) class.
Note that LTM (lethal) represents a subset of LTM as explicitly modeled in VDDT.
Lightly shaded areas in the table above represent significant changes between VDDT modeling and post-modeling calculations.
Darker shading represents conditions that are unlikely to occur
Note: A proportion of 0 % indicates that virtually no cells would be unaffected by disturbance due to high frequency of disturbance.
For the Dry Grand Fir habitat type, all LTM GF was assigned to Old Growth. This represents 0.43 % of the area of that habitat type.

Table 7. Historical Range of Variability estimates by class (cover type and VGS) for those habitat types characterized by predominantly non-lethal fire regimes.

	Habitat Type Class														
	Dry Ponderosa pine/ Xeric Douglas-fir 5%			Warm, Dry Douglas-fir/ Moist Ponderosa Pine 15%			Cool, Moist Douglas-fir 5%			Cool, Dry Douglas-fir 13%			Dry Grand fir 3.00%		
VGS	Cover	Range	Mean	Cover	Range	Mean	Cover	Range	Mean	Cover	Range	Mean	Cover	Range	Mean
Grass/forb	Native Bunchgrass	0 - 2	0.15	Grass/forb	0 - 3	0.79				Grass/forb	0 - 3	0.82	grass/forb	0 - 4	1
	grass/sage	0 - 1	0.19												
	ALL	0 - 2	0.34	ALL	0 - 3	0.79				ALL	0 - 3	0.83	All	0 - 4	1
SSL	shrub	0 - 2	0.5	closed shrub	0 - 2	0.72	shrub	0 - 5	1.2	Shrub	0 - 4	0.86	closed shrub	0 - 5	1.42
	PONDEROSA PINE	0 - 4	1.28	open shrub	0 - 5	0.64	PONDEROSA PINE	0 - 5	1.02	DF	0 - 5	1.29	PONDEROSA PINE	0 - 4	0.97
				PONDEROSA PINE	0 - 3	0.86	DF	1 - 13	5.08	Aspen	0 - 4	0.52	DF	0 - 3	0.62
				DF	0 - 2	0.46	Aspen	0 - 4	1.11	LPP	0 - 5	1.46			
	ALL	0 - 4	1.8	ALL	0 - 4	2.68	ALL	1 - 14	8.49	ALL	0 - 7	4.17	ALL	0 - 6	3.01
SAP	PONDEROSA PINE	0 - 3	0.94	PONDEROSA PINE	0 - 5	1.19	PONDEROSA PINE	0 - 5	1.4	DF	0 - 5	1.25	PONDEROSA PINE	0 - 3	0.89
				DF	0 - 2	0.6	DF	1 - 13	4.57	Aspen	0 - 5	1.72	DF	0 - 4	0.91
							Aspen	0 - 6	2.32	LPP	1 - 9	4.66			
	ALL	0 - 3	0.95	ALL	0 - 7	1.79	ALL	3 - 18	8.37	ALL	3 - 18	7.71	ALL	0 - 6	1.8
STS				* Allocated 100% to STNLM			IPP *Allocated 100% to non-lethal			Aspen	0 - 9	3.62	PONDEROSA PINE *Allocated 100% to STNLM		
							Aspen	0 - 6	2.21	LPP	2 - 12	6.53	DF *Allocated 100% to STNLM		
							ALL	0 - 6	2.23	ALL	4 - 21	10.25			
STM (Lethal)	* Allocated 100% to STNLM			* Allocated 100% to STNLM			DF *Allocated 30% to non-lethal			DF * Allocated 50% to STNLM					
							DF	3 - 13	7.6	Aspen	0 - 6	2.43			

									DF	0 - 4	2.02			
						ALL	3 - 13	7.68	ALL	0 - 10	4.49			
STNLM (Non-Lethal)	PONDEROSA PINE	0 - 4	1.89	DF STM	0 - 4	1.06	DF	1 - 6	3.26	DF	0 - 4	2.02	PONDEROSA PINE	0 - 6	1.96
				PONDEROSA PINE STS	0 - 5	1.88	IPP	0 - 8	3.86				DF	0 - 5	2.45
	ALL	0 - 4	1.91	ALL	0 - 4	2.94	ALL	1 - 14	7.19	All	0 - 4	2.04	ALL	0 - 11	4.41
MTS				* Allocated 100% to MTNLM			IPP * Allocated 100% to MTNLM			DF * Allocated 50% to MTNLM			PONDEROSA PINE *Allocated 100% to MTNLM		
							DF	0 -5	1.89	LPP	0 - 5	1.78			
										DF	3 - 10	6.87			
							ALL	0 - 5	1.91	ALL	3 - 15	8.74			
MTM (Lethal)	* 100% allocated to MTNLM			* Allocated 100% to MTNLM			IPP * Allocated 100% to MTNLM			DF * Allocated 50% to MTNLM			PONDEROSA PINE *Allocated 100% to MTNLM		
							DF *Allocated 30% to non-lethal			DF MTM	5 - 16	9.84	DF *Allocated 100% to MTNLM		
							DF	4 - 15		LPP	0 - 2	0.75			
							ALL	4 - 15		ALL	5 - 18	10.7			
MTNLM (Non-Lethal)	PONDEROSA PINE	1 - 6	3.89	PONDEROSA PINE MTM	0 - 7	2.54	IPP MTM	4 - 13		DF MTM	5 - 16	9.84	PONDEROSA PINE MTM	0 - 6	2.3
				DF MTM	3 - 9	6.33	DF	2 - 7		DF MTS	3 - 10	6.87	DF	0 - 6	2.47
				PONDEROSA PINE MTS	0 - 6	2.68	IPP MTS	0 -5					PONDEROSA PINE MTS	0 - 4	1.33
	ALL	1 - 6	3.93	ALL	3 - 22	11.55	ALL	6 - 25		ALL	8 - 26	16.88	ALL	0 - 16	6.1

LTS	* 100% allocated to LTNLM			* Allocated 100% to LTNLM			IPP *Allocated 100% to LTNLM			DF *Allocated 100% to LTNLM			PONDEROSA PINE *Allocated 100% to LTNLM		
							DF *Allocated 100% to LTNLM								
LTM	* 100% allocated to LTNLM			* Allocated 100% to LTNLM			IPP *Allocated 100% to LTNLM			DF *Allocated 50% to LTNLM			PONDEROSA PINE *Allocated 100% to LTNLM		
							DF *Allocated 70.8% to OG								
(Lethal)							DF *Allocated 30% to LTNLM			DF	2.5 -5.75	4.49	DF *Allocated 100% to LTNLM		
							DF	2.1 - 5.11					WGF *Allocated 100% to OG		
							ALL	2.1 - 5.11		ALL	2.5 - 5.75	4.53			
LTNLM	LTM PONDEROSA PINE	13 - 55	35.85	PONDEROSA PINE-LTM	6 - 22	14.2	IPP LTM	11 - 25		DF LTM	2.5 - 5.75	4.49	PONDEROSA PINE LTM	14 - 26	18.76
(Non-Lethal)	LTS PONDEROSA PINE	34 - 77	54.33	DF	.4 -3.3	1.91	DF LTM	3 - 8		DF LTS	9 - 24	16.59	DF	3 - 9	6.03
				PONDEROSA PINE LTS	33.3-45.4	38.98	IPP LTS	0 - 2					PONDEROSA PINE LTS	49 - 66	58.45
				PONDEROSA PINE OG	18.7-25.6	21.92	DF LTS	2 - 12							
				DF OG	.6 - 5.7	3.25									
	ALL	47 - 99	91.07	ALL	59 - 99	80.25	ALL	16 - 47		ALL	11.5 - 29.75	21.29	ALL	66 - 99	83.25
OG	PONDEROSA PINE	0	0	Allocated 100% to LTNLM			DF	5 - 13		DF	5 - 11	8.29	GWF LTM	0 - 1	0.43

	proportion:	0 * LTM + 0 * LTS			proportion:	0.708 * DF-LTM			proportion	.4804 * (DF LTM + DF LTNLM)		proportion	.12 GWF LTM	
	ALL	0	0		ALL	5 - 13			ALL	5 - 11	8.37	ALL	0 - 1	0.43

Light shaded boxes represent those classes found on the Ecosystem Diversity Matrix but not explicitly modeled in VDDT. Allocations to these stages were made from the classes modeled in VDDT after modeling was done. Criteria used in these post-modeling allocations were developed By Haufler (1999) and are presented in Appendix 2.

Dark shaded boxes represent those classes unlikely to occur on the Ecosystem Diversity Matrix.

An Asterix (*) indicates that the box in question was explicitly modeled in VDDT but was allocated (post-modeling) to another class.

Table 8. Historical Range of Variability estimates by class (cover type and VGS) for those habitat types characterized by predominantly lethal and mixed severity fire regimes.

	Habitat Type Class																	
	Cool, Moist Grand Fir			Warm, Dry Subalpine Fir			Warm, Moist Subalpine Fir			Hydric Subalpine Fir			Persistent Lodgepole Pine			High Elevation Subalpine Fir		
			5%			24%			2%			1%			15%			12%
VGS	Cover	Range	Mean	Cover	Range	Mean	Cover	Range	Mean	Cover	Range	Mean	Cover	Range	Mean	Cover	Range	Mean
Grass/forb				Grass/forb	0 - 9	3				nat forb	0 - 6	2						
										grass/carex	0 - 4	2						
				ALL	0 - 9	3				ALL	0 - 6	4						
SSL	Shrub1	0 - 5	2	Shrub1	0 - 2	0	shrub	0 - 6	1	LPP	0 - 4	1	closed shrub	6 - 18	10.99	shrub	1 - 12	7
	Shrub2	0 - 6	2	Shrub2	0 - 7	3	SAF	0 - 5	2	SAF	0 - 7	2	LPP	5 - 17	10.4	WBP	0 - 5	3
	DF	0 - 5	1	SAF	0 - 2	0	DF	0 - 12	5							SAF	1 - 9	6
	IPP	0 - 5	1	DF	0 - 5	2	WL	0 - 2	0							LPP	0 - 4	1
	GWF	0 - 4	1	Aspen	0 - 3	1	LPP	0 - 6	2									
	WL	0 - 5	2	LPP	0 - 9	3												
	LPP	0 - 2	0															
	ALL	5 - 16	9	ALL	0 - 11	9	ALL	3 - 19	11	ALL	2 - 14	4	ALL	11 - 25	21.39	ALL	8 - 21	16
SAP	DF	0 - 4	1	SAF	0 - 2	0	SAF	0 - 7	3	LPP	0 - 6	3	LPP	3 - 15	9.24	WBP	0 - 7	4
	IPP	0 - 7	2	DF	0 - 7	3	DF	0 - 10	3	SAF	0 - 6	2				SAF	2 -10	6
	GWF	0 - 4	1	Aspen	0 - 6	2	WL	0 - 1	0							LPP	0 - 8	2
	WL	0 - 3	1	LPP	4 - 17	9	LPP	0 - 9	4									
	LPP	0 - 2	0															
	SAF	0 - 3	0															
	ALL	1 - 12	6	ALL	6 - 22	14	ALL	3 - 20	11	ALL	1 - 12	5	ALL	3 - 15	9.24	ALL	6 - 20	12
STS	IPP *Allocated 100% to STNLM			Aspen	0 - 9	4	WL	0 - 4	1				LPP	39 - 59	50.11	LPP	2 - 12	7
	WL *Allocated 100% to STNLM			LPP	1 - 10	4	LPP	3 - 12	7									

	LPP	0 - 3	1													
	SAF	0 - 3	1													
	ALL	0 - 6	1	ALL	2 - 19	8	ALL	4 - 13	8				ALL	39 - 59	50.1	ALL	2 - 12	7
STM	DF	0 - 3	1	SAF	0 - 4	1	SAF	1 - 8	4	LPP	6 - 20	13				WBP *Allocated 100% to STNLM		
(lethal)	GWF	0 - 8	4	DF * Allocated 50% to STNLM			DF	3 - 14	7	SAF	2 - 15	7				SAF	2 - 9	6
				DF	0 - 4	2												
				Aspen	0 - 7	2												
				LPP	4 - 14	9												
	ALL	1 - 9	5	ALL	8 - 26	15	ALL	5 - 21	12	ALL	12 - 30	20				ALL	2 - 9	6
STNLM	IPP STS	0 - 8	2	DF	0 - 4	2										WBP	1 - 8	5
(non-lethal)	WL STS	0 - 4	1															
	ALL	0 - 12	4	ALL	0 - 4	2										ALL	1 - 8	5
MTS	IPP *Allocated 100% to MTNLM															WBP	0	0
	WL *Allocated 100% to MTNLM															LPP	1 - 10	5
																ALL	1 - 10	5
MTM	DF * Allocated 50% to MTNLM			SAF	6 - 12	9	SAF	4 - 16	9	LPP	10 - 23	16	LPP	11 - 27	19.27	WBP * Allocated 100% to MTNLM		
(lethal)	DF	0 - 4	1	DF * Allocated 50% to MTNLM			DF	4 - 17	10	SAF	7 - 23	14				SAF	5 - 14	9
	IPP * Allocated 100% to MTNLM			DF	2 - 8	4	WL	0 - 7	3							LPP	2 - 9	6
	GWF	1 - 8	4	LPP	5 - 18	10	LPP	13 - 19	16									
	WL * Allocated 100% to MTNLM																	
	LPP	1 - 4	2															
	SAF	0 - 3	0															
	ALL	2 - 19	8	ALL	12 - 26	24	ALL	28 - 44	37	ALL	20 - 38	30	ALL	11 - 27	19.27	ALL	7 - 23	15
MTNLM	DF MTM	0 - 4	1	DF	2 - 8	4										WBP	0 - 11	7
(non-lethal)	IPP MTM	1 - 9	4															
	WL MTM	1 - 9	5															

	IPP MTS	0 - 1	0												
	WL MTS	0 - 3	1												
	ALL	2 - 26	12	ALL	2 - 8	4								ALL	0 - 11	7
LTS	IPP * Allocated 100% to LTNLM WL * Allocated 100% to LTNLM						WL *combined 100% w WL LTM							WBP * Allocated 100% to LTNLM		
LTM	DF * Allocated 25% to LTNLM			SAF	2 - 7	4	SAF	2 - 5	4	SAF	10 - 13	11		WBP * Allocated 100% to LTNLM		
(lethal)	DF	7 - 15	11	DF * Allocated 50% to LTNLM			DF	0 - 8	4					SAF	2 - 10	5
	GWF	1 - 9	4	DF	3 - 8	6	WL LTS	0 - 3	1							
	IPP * Allocated 100% to LTNLM						WL LTM	4 - 11	8							
	SAF	0 - 2	0													
	WL * Allocated 100% to LTNLM															
	ALL	8 - 26	15	ALL	5 - 15	11	ALL	15 - 26	16	ALL	10 - 13	11		ALL	2 - 10	5
LTNLM	DF LTM	2 - 5	4	DF	3 - 8	6								WBP LTM	12 - 26	19
(non-lethal)	IPP LTM	5 - 19	11											WBP LTS	0 - 5	2
	WL LTM	4 - 13	9													
	IPP LTS	8 - 16	12													
	WL LTS	0 - 6	2													
	ALL	19 - 59	38	ALL	3 - 8	6								ALL	12 - 31	21
OG	GWF	1 - 5	3	SAF	2 - 6	4	SAF	3 - 8	6	SAF	21 - 31	26		SAF	0 - 2	1
	proportion: 0.388 * GWF-LTM			proportion: 0.468 * SAF-LTM			proportion: 0.613 * SAF-LTM			proportion: .7 * SAF LTM				proportion: 0.2 * SAF-LTM		
	ALL	1 - 5	3	ALL	2 - 6	4	ALL	3 - 8	6	ALL	21 - 31	26		ALL	0 - 2	1

Light shaded boxes represent those classes found on the Ecosystem Diversity Matrix but not explicitly modeled in VDDT. Allocations to these stages were made from the classes modeled in VDDT after modeling was done. Criteria used in these post-modeling allocations were developed By Haufler (1999) and are presented in Appendix 2.

Dark shaded boxes represent those classes unlikely to occur on the Ecosystem Diversity Matrix.

An Asterix (*) indicates that the box in question was explicitly modeled in VDDT but was allocated (post-modeling) to another class.

Table 9.Historical Range of Variability (HRV)by Vegetation Growth Stage (VGS), regardless of cover type, for habitat type classes characterized by non-lethal fire regimes

	Dry Ponderosa pine/ Xeric Douglas-fir		Warm, Dry Douglas-fir/ Moist Ponderosa Pine		Cool, Moist Douglas-fir		Cool, Dry Douglas-fir		Dry Grand fir	
% area		5%		15%		5%		11%		2%
	range	mean	range	Mean	range	mean	range	mean	range	mean
Grass/forb	0 - 2	0.34	0 - 3	0.79			0 - 3	0.83	0 - 4	1
SSL	0 - 4	1.8	0 - 4	2.68	1 - 14	8.49	0 - 7	4.17	0 - 6	3.01
SAP	0 - 3	0.95	0 - 7	1.79	3 - 18	8.37	3 - 18	7.71	0 - 6	1.8
STNLM	0 - 4	1.91	0 - 4	2.94	1- 14	7.19	0 - 4	2.04	0 - 11	4.41
MTNLM	1 - 6	3.93	3 - 22	11.55	6 - 25	13.21	8 - 26	16.88	0 - 16	6.1
LTNLM	47 - 99	91.07	59 - 99	80.25	16 - 47	29.28	12 - 30	21.29	66 - 99	83.25
STM					3 - 13	7.68	0 - 10	4.49		
STS					0 - 6	2.23	4 - 21	10.25		
MTM					4 - 15	9.63	5 - 18	10.7		
MTS					0 - 5	1.91	3 - 15	8.74		
LTM					2 - 5	3.51	3 - 6	4.53		
LTS										
OG					5 - 13	8.50	5 - 11	8.37	0 - 1	0.43
Total		100		100		100		100		100

Dark shaded boxes represent those classes unlikely to occur on the Ecosystem Diversity Matrix.

Table 10. Historical Range of Variability estimates for Vegetation Growth Stage (VGS), regardless of cover type, for habitat type classes dominated by stand-replacing fire regimes

	Cool, Moist Grand Fir		Warm, Dry Subalpine Fir		Warm, Moist Subalpine Fir		Hydric Subalpine Fir		Persistent Lodgepole Pine		High Elevation Subalpine Fir	
% area		5%		24%		1%		1%		15%		12%
	range	mean	range	mean	range	mean	range	mean	range	mean	range	mean
Grass/forb			0 - 9	3.2			0 - 6	3.8				
SSL	5 - 16	9.34	0 - 11	8.66	3 - 19	10.53	2 - 14	3.56	11 - 25	21.39	8 - 21	15.83
SAP	1 - 12	5.84	6 -22	14.26	3 - 20	11.18	1 - 12	5.09	3 - 15	9.24	6 - 20	12.02
STNLM	0 - 12	3.77	0 - 4	2.05							1- 8	4.64
MTNLM	2 - 26	11.51	2 - 8	4.35							0 - 11	6.87
LTNLM	19 - 59	37.71	3 - 8	6.03							12 - 31	21.41
STM	1 - 9	5.16	8 - 26	14.6	5 - 21	11.79	12 - 30	20.13			2 - 9	5.51
STS	0 - 6	1.35	2 - 19	8.23	4 - 13	8.11			39 - 59	50.1	2 - 12	7.4
MTM	2 - 19	7.87	12 - 26	24.09	28 - 44	37.02	28 - 44	30.3	11 - 27	19.27	7 - 23	15.19
MTS											1 - 10	5.24
LTM	8 - 26	14.92	5 - 15	10.51	15 - 26	15.83	10 - 13	11.14			2- 10	4.71
LTS												
OG	1 - 5	2.53	2 - 6	4.02	3 - 8	5.54	21 - 31	25.98			0 - 2	1.18
Total		100		100		100		100		100		100

Note: Totals for VGS STM, MTM, and LTM include their respective allocated counterparts, STNLM, MTNLM, and LTNLM.

The approximate division between lethal and non-lethal parts is presented in more detail in Tables 7 and 8.

Dark shaded boxes represent those classes unlikely to occur on the Ecosystem Diversity Matrix.

Table 11.HRV estimates by cover type, regardless of VGS, for habitat type classes characterized by predominantly non-lethal fire regimes

	Habitat Type Class									
	Dry Ponderosa pine/ Xeric Douglas-fir		Warm, Dry Douglas-fir/ Moist Ponderosa Pine		Cool, Moist Douglas-fir		Cool, Dry Douglas-fir		Dry Grand fir	
		3 %		13 %		2%		0 %		12%
Cover Type	range	median	range	median	range	median	range	median	range	median
Grass/Forb	0 - 3	< 1	0 - 3	1			0 - 3	1	0 - 4	1
Shrub	0 - 2	< 1	0 - 7	1	0 - 5	1	0 - 4	1	0 - 5	1
PONDEROSA PINE	96 - 99	98	81 - 87	84	26 - 41	33			80 - 88	85
DF			10 - 16	14	47 - 69	59	66 - 81	74	7 - 17	12
SAF										
GWF									0 - 1	0
LPP							10 - 20	15		
WL										
WBP										
Aspen					1 - 11	6	4 - 13	8		

Table 12.HRV estimates by cover type for habitat type classes historically characterized by predominantly lethal and mixed severity fire regimes.

	Habitat Type Class											
	Cool, Moist Grand Fir		Warm, Dry Subalpine Fir		Warm, Moist Subalpine Fir		Hydric Subalpine Fir		Persistent Lodgepole Pine		High Elevation Subalpine Fir	
		2%		1%		12%		8%		0 %		28%
Cover Type	range	median	range	median	range	median	range	median	range	median	range	median
Grass/Forb			0 - 9	3			0 - 10	3				
Shrub	0 - 11	4	0 - 9	3	0 - 6	1			6 - 18	11	1 - 12	7
PONDEROSA PINE	23 - 41	34										
DF	15 - 25	20	24 - 34	29	23 - 37	29						
SAF	0 - 5	1	15 - 26	19	21 - 34	28	57 - 66	63			26 - 42	32
GWF	9 - 23	18										
LPP	1 - 5	4	28 - 42	36	25 - 34	30	29 - 37	33	82 - 94	89	18 - 25	21
WL	15 - 29	20			9 - 16	12						
WBP											32 - 47	40
Aspen			6 - 11	9								

Dark shaded boxes represent those classes unlikely to occur on the Ecosystem Diversity Matrix.

Table 13. Historical (circa 1900) abundance (percent) of cover types for the 11 habitat type classes in the Idaho Southern Batholith as mapped in the Interior Columbia Basin Ecosystem Management project. Source: www.icbemp.gov

Habitat type class	PP	DF	LP	SAF/ES	WBP	GF	Shrub	Grass/ Forb
Warm, dry ponderosa pine / Xeric Douglas-fir	93	--	--	--	--	--	5	2
Warm, dry Douglas-fir / Moist ponderosa pine	43	45	--	--	--	--	--	11
Cool, dry Douglas-fir	Did not occur							
Dry grand fir	48	43	--	--	--	3	6	--
Warm, dry subalpine fir	--	56	21	8	--	--	15	--
Cool, moist Douglas-fir	47	44	0	--	--	--	9	--
Cool, moist grand fir	54	15	1	--		1	30	--
Warm, moist subalpine fir	--	35	35	21	--	--	8	--
Hydric subalpine fir	--	55	15	29	--	--	1	--
Persistent lodgepole pine	Did not occur							
High elevation subalpine fir	--	--	27	55	16	--	2	--

Table 14. Historical abundance (percent) of structural stages for the 11 habitat type classes in the Idaho Southern Batholith. Source: www.icbemp.gov

Habitat Type Class	SI	SECC	UR	YMS	OMS	OSS	Shrub	Grass/Forb /Herb
Warm, dry ponderosa pine / Xeric Douglas-fir	9	33	0	1	25	24	2	5
Warm, dry Douglas-fir / Moist ponderosa pine	12	40	1	2	16	16	2	11
Cool, dry Douglas-fir	Did not occur							
Dry grand fir	16	39	1	2	18	18	6	0
Warm, dry subalpine fir	21	46	4	3	8	4	15	0
Cool, moist Douglas-fir	13	43	5	0	17	12	9	0
Cool, moist grand fir	7	27	0	0	18	17	30	0
Warm, moist subalpine fir	20	36	5	12	15	3	8	0
Hydric subalpine fir	25	47	3	7	17	0	1	0

Appendices

Appendix 1. Changes made to the Successional Pathway Diagrams

All changes made by Parsons (1999) to the Successional Pathway Diagrams described by Morgan and Parsons (1998) are presented below by habitat type. A brief statement of the justification or assumptions used to make these changes is included. Note that allocations to non-lethal and lethal fire regime designations were done in calculations after the HRV modeling was complete. Because of this, they did not affect the modeling itself, but were simply derived from model outputs. A complete documentation of the process used in these post-modeling allocations is presented in Appendix 2.

Habitat Type (Potential Vegetation Type)	**Changes made:**
Dry Ponderosa Pine/ Xeric Douglas-fir	No modifications to model.
Warm, Dry Douglas-fir/ Moist Ponderosa Pine	No modifications to model.
Cool, Moist Douglas-fir	Transition times in Ponderosa Pine
Cool, Dry Douglas-fir	Lodgepole pine cover type added. Some fire disturbance pathways modified.
Dry Grand Fir	No modifications to model.
Cool, Moist Grand Fir	Transition times were corrected. Some probabilities were altered.
Warm, Dry Subalpine Fir	Transition times were corrected.
Warm, Moist Subalpine Fir	Transition times were corrected. Some single story VGS were eliminated from certain cover types.
Hydric Subalpine Fir	Transition times were corrected.
Persistent Lodgepole Pine	No modifications to model.
High Elevation Subalpine Fir	Transition times were corrected.

The specific changes made, by habitat type, follow:

Cool, Moist Douglas-fir

Transition times in ponderosa pine cover type were modified slightly to more accurately represent growth within that habitat type. No changes were made to disturbance probabilities.

Cool, Dry Douglas-fir

A new cover type, lodgepole pine, was added to this habitat type in an attempt to represent lethal fire regimes within this type. To properly account for this change, some fire disturbance pathways in the Douglas-fir cover type were modified to include the lodgepole pine shrub-seedling VGS as a potential possibility. Total disturbance probabilities within each Douglas-fir cover type class were not changed; they were simply partitioned between the different potential destinations resulting from a class-changing disturbance.

Cool, Moist Grand Fir

Transition times in the Grand/White Fir cover type were corrected to eliminate time step gaps. Probabilities of Wild UnderBurns (WUB) were adjusted in Class

O and Q in an attempt to make the Ponderosa Pine cover type more dominant than Western Larch. It was believed by those present that the past proportion between these cover types was inconsistent with data for this habitat type.

Warm, Dry Subalpine Fir
Transition times in the Spruce/Subalpine Fir were corrected to eliminate inconsistencies in time step gaps. Specifically, Class E (SAF –STM) was edited from 82 – 112 to 51 – 81. This eliminated time step gaps between that class and both of its adjacent successional neighbors. No other edits were made to this Successional Pathway Diagram.

Warm, Moist Subalpine Fir
Transition times in the Spruce/Subalpine Fir (SAF) cover type (all classes) were corrected to eliminate time step gaps. Similar changes were made to the Western Larch (WL) cover type. The Large Tree Single story vegetation growth stage in the Douglas-fir cover type was eliminated, as was the Medium Tree Single story vegetation growth stage in the Lodgepole pine cover type. It was considered unlikely by the participants that these single story classes would have existed under past conditions in this habitat type.

Hydric Subalpine Fir
Transition times were corrected in Subalpine Fir classes F and G, and in Lodgepole pine classes I and J. No other edits were made to this habitat type.

High Elevation Subalpine Fir
Transition times were corrected to eliminate a ten time step gap between Subalpine Fir classes G and J, and a ten time step gap between White Bark Pine classes B and L. No other modifications were made.

Appendix 2. Criteria used in allocations between fire regimes. These were important in making post-modeling allocations to old growth.

Decisions regarding allocations between non-lethal and lethal fire regime designations for the Ecosystem Diversity Matrix were developed by Haufler (1999), and are presented below. Criteria used in these expert-opinion-based decisions were dominant historical fire behavior within specific cover types and accumulation of fuels with time and vegetation growth stage. For example, in the Cool Moist Grand Fir habitat type, all ponderosa pine classes were assigned to the non-lethal fire regime designation, and Douglas–fir increased from 50% lethal /50% non-lethal to 75% lethal and 25% non-lethal with accumulation of fuels.

Note that allocations to non-lethal class LTNLM took precedence over allocations to OG. For example, in the Cool Moist Douglas-fir habitat type, 30% of the DF-LTM class was allocated to LTNLM. Of the remaining 70%, 70.8%, or 49.56% of the original LTM class, was then allocated to Old Growth (OG). The order of priority used in these calculations tends to reduce the number of acres classified as Old Growth. The rationale for this decision is that a certain proportion of LTM classes would have been maintained by frequent understory burns, and would thus be classified as non-lethal types. As the definition of Old Growth used (Hamilton, 1993) considers Old Growth stands as those stands that have not yet been disturbed, such stands are thus omitted from consideration as Old Growth.

Habitat Type (Potential Vegetation Type)	**Allocations to Non-lethal and Lethal fire regime designations, developed by Haufler (1999)**
Dry Ponderosa Pine/ Xeric Douglas-fir	All multi-story and single-story classes were considered non-lethal. All small tree to STNLM, all medium tree to MTNLM, all large tree to LTNLM. Note: Since all LTM were allocated to LTNLM, there was no old growth.
Warm, Dry Douglas-fir/ Moist Ponderosa Pine	All multi-story and single-story classes were considered non-lethal. All small tree to STNLM, all medium tree to MTNLM, all large tree to LTNLM. Note: Since all LTM were allocated to LTNLM, there was no old growth.
Cool, Moist Douglas-fir	DF STM, MTM and LTM were allocated 30% to non-lethal and 70% to lethal fire regimes. All PONDEROSA PINE classes were allocated 100% to non-lethal fire regimes. Aspen-STS goes to STS. PONDEROSA PINE-LTS and DF-LTS allocated 100% to LTNLM. After allocation of 30% to LTNLM, 70.8% of DF-LTM was allocated to OG.
Cool, Dry Douglas-fir	DF – LTS was allocated 100% to LTNLM. All remaining DF classes were allocated 50% to non-lethal fire regimes and 50%. Lodgepole pine and aspen were allocated 100% to lethal fire regimes. After allocation of 50% to LTNLM, 48.04% of DF-LTM allocated to OG.
Dry Grand Fir	All PONDEROSA PINE classes were allocated 100% to non-lethal fire

	regimes. All DF classes were allocated 100% to non-lethal fire regimes. All GWF-LTM was allocated 100% to OG.
Cool, Moist Grand Fir	DF MTM was allocated 50% to non-lethal. DF LTM was allocated 25% to non-lethal. All PONDEROSA PINE classes were allocated 100% to non-lethal fire regimes. All Western Larch classes were allocated 100% to non-lethal fire regimes. All LPP, GWF and SAF classes were allocated 100% to lethal fire regimes. After allocation of 25% to LTNLM, 38.8% of GWF-LTM was allocated to OG.
Warm, Dry Subalpine Fir	DF STM, MTM and LTM were allocated 50% to non-lethal and 50% to lethal fire regimes. LPP, SAF and Aspen were allocated 100% to lethal fire regimes. SAF-LTM was allocated 46.8% to OG.
Warm, Moist Subalpine Fir	All classes were allocated 100% to lethal fire regimes. WL-LTS was combined into LTM (lethal) 100%. SAF-LTM was allocated 61.3% to OG.
Hydric Subalpine Fir	All classes were allocated 100% to lethal fire regimes. SAF-LTM was allocated 0.7 to OG.
Persistent Lodgepole Pine	All classes were allocated 100% to lethal fire regimes. Since modeling produced no LTM class, there was no Old Growth in this type.
High Elevation Subalpine Fir	All White Bark Pine (WBP) classes were allocated 100% to non-lethal fire regimes. All LPP and SAF classes were allocated 100% to lethal fire regimes. SAF-LTM was allocated 20% to OG.