NODE DEFINITIONS AND COMMENTS FOR THE BAYESIAN BELIEF NETWORKS USED TO EVALUATE THE AQUATIC TRENDS FOR THE SDEIS

The following materials provide documentation for each node in the belief networks used in our analysis. Each node and the associated states are defined. Comments provide background on the logic and sources of information used to estimate either the direct inputs and their probabilities (root nodes) or the conditional probabilities linking the parent nodes and the node of interest. See the text for the general logic and structure of the model.

Twelve different models were actually used in the analysis. All of the models used the same structure and information to characterize aquatic habitat capacity (fig. OV-1a), but the conditional probability tables for several nodes in this portion of the network were estimated for both 10 year and 100 year scenarios (as shown below). The probabilities for aquatic habitat capacity were calculated for every subwatershed in the first stage of the analysis for both 10 and 100 years. Distinct models were used for each of the 6 salmonids considered in the analysis. The structure of the models for anadromous salmonids (stream type chinook salmon and steelhead) (fig. OV-1c) differed from the structure of the models used for non-anadromous salmonids (fig. OV-1b). The former included the influence of migrant survival and the latter included a node that represented community change rather than just exotic threat, and a node that represented connectivity with adjacent subwatersheds. The differences are discussed in the node definitions and comments. The anadromous and non-anadromous models shared the same conditional probabilities among their respective species except for the link with future population status. The conditional probabilities for that node were estimated independently for each species.

The 10- and 100-year networks are based on several broad premises that relate hydrologic and geomorphic response to disturbance. These include:

1) A decrease in ground cover and vegetation density is a likely consequence of timber harvest or fire, and leads to an increased likelihood of erosion and sediment production.

2) Severe wildfires are likely to induce soil water repellency, decrease soil infiltration capacity, and increase the likelihood of erosion on burned areas, and floods and debris flows in small watersheds.

3) Decades of fire suppression have increased the likelihood that severe fire effects will occur in some vegetation types, and vegetation treatments can reduce this risk.

4) Roads re-route and concentrate water, compact soils and result in some steeper slopes, increasing the likelihood of erosion and sediment delivery. Road obliteration can reduce this likelihood.

5) Improper grazing practices increase erosion, lead to vegetation change, and can cause long-lived, detrimental changes in stream channel geometry.

The prior history of disturbance in a watershed is important in determining how the watershed will respond to new disturbance. Effects diminish with time, but are cumulative.

Road Density

Definition:

This node characterizes road density (mi^{-1}) into one of three classes. The Landscape Team provides Road density information based on ownership within each subwatershed. Refer to their documentation on how road density is calculated. They provide 10-year trend (up, down, stable) and class for current (base) and the 100-year prediction. The output from their variable is 7 classes that we have collapsed into 3 classes.

States:

Low: 0- <0.7 mi^{-1}
Medium: 0.7-1.7 mi^{-1}
High: > 1.7 mi^{-1}

Comment: The 10-year trends in our Bayesian Network is problematic because changes are not large enough to produce differences in the probabilities among road classes. Our models reflect no trends related to changes in road densities at 10 years.

Slope Steepness

Definition:

This node characterizes a subwatershed as being in one of three slope steepness classes. Slope Steepness classes are calculated using a rule set for the landscape variables SLOPE4X and SLOPE1X. SLOPE4X is the proportion of area (based on 1 km grid point estimates) in a subwatershed that has slopes greater than 50 percent, and SLOPE1X is the proportion with slopes more gentle than or equal to 10 percent. The rule set for generating the classes is: If SLOPE4X > 10, then Steep. If SLOPE1X > 60, then Gentle. If SLOPE4X > 10 and SLOPE1X > 60, then Steep. All other is Medium.

States:

Gentle: More than 60 percent of subwatershed area has slope gradients < 10 percent.
Medium: Less than 60 percent of subwatershed with slopes < 10 percent and less than 10 percent of subwatershed with slopes steeper than 50 percent.
Steep: More than 10 percent of subwatershed area has slope gradients > 50 percent.

Comment: This rule set was efficient at discriminating among the three classes; only 9 subwatersheds had values of SLOPE4X >10 and SLOPE1X >60. We generated a map of the slope steepness classes for the entire basin, and queried various areas (both sub-basin and subwatershed) that we are familiar with to see that the rule set performs in a logical matter.

Road Disturbance

Definition:

The Road Disturbance variable characterizes both areal ground disturbance based on the relationship between road density and slope steepness described by Megahan (1976), and accelerated erosion and sediment delivery from roads as they are affected by slope and bare ground.

States:

Low: Low road disturbance will result in erosion rates that over the long term (decades) are sufficiently low that increases in road-caused sediment delivery to the main channel are not detectable.

Medium: Medium road disturbance causes detectable changes in delivered sediment, that, over the long term, average < 2x natural sediment delivery.

High: High road disturbance causes long-term measurable increases in road erosion at levels > 2x natural sediment delivery to the main channel.

Comment: Area disturbed per unit length for a road increases exponentially as sideslope angle increases. Information on the probability distribution of slope steepness within subwatersheds is not available, so the Road Disturbance node is based on expert opinion about the interaction of the road density and slope steepness classes. In addition to increased amount of disturbed area per unit length of road, the road disturbance node incorporates expert opinion about increased road erosion on disturbed land with increasing slopes, increased likelihood of groundwater interception as slopes increase (Megahan 1972), and increased transport distance and delivery efficiency as slopes increase (Ketcheson and Megahan 1996; Megahan and Ketcheson 1996). Three experts (Hydrologist, Geomorphologist, Soil Scientist) parameterized this node. Uncertainty inherent in this node includes road construction or obliteration timing, variation in road design and construction practices, and lack of information on the spatial relationship between road location and slope steepness.

			Road_Dist	
Road_D	Slope_S	Low	Mod	High
Low	G	80	16	4
Low	M	73	19	8
Low	S	58	26	16
Mod	G	48	39	13
Mod	M	33	48	19
Mod	S	13	42	45
Hi	G	22	53	25
Hi	M	17	40	43
Hi	S	4	14	82

Ground Disturbance Index

Definition:

Ground Disturbance Index is the Landscape Team’s estimate of “uncharacteristic soil disturbance resulting from prescribed activities that disturb vegetation, litter and wood that provide soil cover”. The effects are limited to those occurring from timber harvest and prescribed fire, and do not include road, wildfire and grazing disturbances.

States:

Low: 0 to 0.05
Medium: >0.05 to 0.15
High: > 0.15

Comments: A team of four experts (hydrology, soil science, geomorphology disciplines) set class breaks at 0.05 and 0.15 after applying the Landscape Team equation for calculating this variable for two hypothetical cases. In setting those breaks, we assumed that two levels of harvest take place: 10 percent and 25 percent (by area) are harvested using tractor and helicopter yarding methods. Based on a variety of published data (Chamberlin and others 1991; Clayton 1981), we feel that 10 percent area harvested by helicopter represents low soil disturbance whereas 10 percent tractor harvest represents medium soil disturbance. At the higher level, 25 percent by helicopter should be medium and, 25 percent by tractor should represent high soil disturbance.

We chose prescription P3 and A3 to represent tractor logging and helicopter logging, respectively. Using the equation provided to us dated March 25 (file: var22.wpd), prescription P3 returns a value of 0.9 and A3 returns a value of 0.3. When multiplied by the proportion of the watershed harvested, helicopter at 10 percent = 0.03; helicopter at 25 percent = 0.075; tractor at 10 percent = 0.09; and tractor at 25 percent = 0.225. Based on those numbers, we chose class breaks for Uncharacteristic Soil Disturbance at 0.05 and 0.15.

On May 6 we received a slightly different formulation of the equation for calculating Uncharacteristic Soil disturbance. Using our same assumptions of proportion harvested and P3 and A3 as representing tractor and helicopter yarding, we calculate: helicopter at 10 percent = 0.05; helicopter at 25 percent = 0.125; tractor at 10 percent = 0.11; and tractor at 25 percent = 0.275. Since these calculations fall into the same classes using the breaks at 0.05 and 0.15, we chose to maintain those breaks. Ground disturbance index assumes no uncertainty in the state estimated by the landscape team (i.e. the probability of a ground disturbance state was 1.0 for the class encompassing the estimates).

Standards and Guides

Definition:

Standards and Guides include the management direction in the SDEIS, Chapter 3 for FS/BLM lands and existing land and water use regulations and aquatic habitat restoration applied to non-federal lands. That direction will influence the disruptive or rehabilitative nature of the activities affecting aquatic habitat in the Basin. We consider only the standards and guides that are likely to influence the sediment and hydrologic regimes and riparian function, including shading, filtering of sediments, surface-ground water interchange, large and fine organic debris recruitment, and bank condition. The elements of standards and guides that are considered relevant to these processes include riparian buffers; watershed management designations (e.g., "key" and "priority" watersheds) where aquatic protection and restoration receive additional emphasis; planning and analysis, such as EAWS and subbasin review, that can help insure that activities are appropriate, minimize any adverse effects, and maximize benefits of restoration; monitoring that insures continuing refinement of management. Standards and Guides are summarized into the following three states.

States:

High maintenance/restoration: New activities and restoration are properly sited through subbasin and/or watershed analysis. Habitats important for aquatic species (e.g., maintenance of strong populations, aquatic biodiversity, areas of high quality habitat) are conserved, and watersheds degraded from past activities are being restored. Riparian buffers encompass the area affecting riparian function. The disruptive effects of activities are largely mitigated. New and ongoing activities will not likely impair watershed processes and will not retard the recovery of watershed processes or riparian function. Passive and active aquatic restoration measures will accelerate recovery beyond that expected with no activity. Aquatic conservation and restoration are implemented rapidly but planned strategically, monitored, and evaluated.

Moderate maintenance/restoration: Standards and guides result in some mitigation of new activities. However, they are not fully or properly implemented. The disruptive effect of new activities and reduced levels or rates of restoration, analysis, planning, implementation, and monitoring of conservation and restoration may lead to impairment in some areas or may slow recovery as much as 2x that expected under high maintenance/restoration.

Low maintenance/restoration: Standards and guides do not result in significant mitigation of activities and do not produce a positive trend in recovery because they are inadequate or poorly sited and implemented. The disruptive effect of activities and low levels of analysis, planning, restoration, and monitoring will lead to further impairment or slow recovery by more that 2x that expected under high maintenance/restoration.

Comment: Probabilities were estimated for the three states of this node defined for describing the direction in the SDEIS alternatives related to maintaining and restoring aquatic habitat. Probabilities were assigned for current condition, 10 years, and 100 years. Discrete aquatic management scenarios based on the alternatives were developed that could be applied to each 6th code subwatershed (see attachment A). Where the management for a given subwatershed consisted of more than 1 scenario (e.g., a mix of private and FS/BLM lands), the probabilities were averaged based on the weighted area for each scenario.

CURRENT CONDITION

Alternative Scenario	HI Maint./Rest.	MOD Maint./Rest.	LOW Maint./Rest.	Total
1. Wilderness	90	10		100
8. Selway/Salmon BO	41	36	23	100
9. Priority	39	35	26	100
10. PACFISH/INFISH Key BO	34	30	36	100
12. Roadless/S1	65	35	0	100
23. INFISH	15	35	50	100
24. BLM--no INFISH	5	48	47	100
25. Non-fed., TE	1	24	75	100
26. Non-fed., non-TE	0	20	80	100

10 YR

Alternative Scenario	HI Maint./Rest.	MOD Maint./Rest.	LOW Maint./Rest.	Total
1. Wilderness	90	10		100
2. A1/S2	80	20		100
3. A1/S3	75	25		100
11. Roadless/S2	65	35		100
12. Roadless/S1	65	35		100
13. Roadless/S3	65	35		100
4. A2+rest./S2	45	42	13	100
5. A2+rest./S3	39	40	21	100
14. S2 base, aq. rest., TEP	37	31	32	100
8. Selway/Salmon BO	43	36	21	100
9. Priority	41	35	24	100
15. S2 base, aq. rest., non-TEP	32	34	34	100
6. A2, no rest./S2	36	45	19	100
10. PACFISH/INFISH Key BO	36	30	34	100
16. S2 base, non-aq. rest., TEP	33	30	37	100
7. A2, no rest./S3	31	40	29	100
20. S3 base, aq. rest.	25	35	40	100
17. S2 base, non-aq. rest., non-TEP	29	32	39	100
18. S2 base, no rest., TEP	30	30	40	100
19. S2 base, no rest., non-TEP	26	33	41	100
22. S3 base, no rest.	20	35	45	100
23. INFISH	15	35	50	100
21. S3 base, non-aq. rest.	18	34	48	100
24. BLM--no INFISH	5	48	47	100
25. Non-fed., TE	2	26	72	100
26. Non-fed., non-TE	1	19	80	100

100 YR

Alternative Scenario	HI Maint./Rest.	MOD Maint./Rest.	LOW Maint./Rest.	Total
1. Wilderness	90	10		100
2. A1/S2	80	20		100
3. A1/S3	75	25		100
11. Roadless/S2	65	35		100
12. Roadless/S1	65	35		100
13. Roadless/S3	65	35		100
4. A2+rest./S2	55	35	10	100
5. A2+rest./S3	48	36	16	100
14. S2 base, aq. rest., TEP	50	35	15	100
8. Selway/Salmon BO	47	37	16	100
9. Priority	45	35	20	100
15. S2 base, aq. rest., non-TEP	45	35	20	100
6. A2, no rest./S2	40	45	15	100
10. PACFISH/INFISH Key BO	40	30	30	100
16. S2 base, non-aq. rest., TEP	40	30	30	100
7. A2, no rest./S3	35	40	25	100
20. S3 base, aq. rest.	35	35	30	100
17. S2 base, non-aq. rest., non-TEP	35	30	35	100
18. S2 base, no rest., TEP	30	30	40	100
19. S2 base, no rest., non-TEP	26	33	41	100
22. S3 base, no rest.	20	35	45	100
23. INFISH	20	35	45	100
21. S3 base, non-aq. rest.	15	30	55	100
24. BLM--no INFISH	5	48	47	100
25. Non-fed., TE	5	30	65	100
26. Non-fed., non-TE	2	19	79	100

For the current condition we used the scenarios for S1 (the no action alternative). For 10 yr probabilities for S2/3 scenarios in subbasins identified as integrated restoration priorities, we took the difference between the 100 yr probabilities for scenarios with and without aquatic restoration and assigned 1/3 of the increase for the 10 yr value, assuming at least 2/3 of the improvement due to restoration would occur from 10 yr to 100 yr. For the PACFISH/INFISH restoration areas (scenario 8, 9, 10) and A2 outside restoration priority subbasins, we assumed there would be approximately 1/3 of the restoration activities occurring in the integrated restoration priority subbasins in S2/3 and 1/3 of that would occur during the first 10 yrs and 2/3 would occur from yrs 10-100. We also assumed that in S3, non-aquatic restoration areas probabilities for the HI state would actually be higher in 10 yr than in 100 yr since the increased levels of non-aquatic restoration activities would be accompanied by less planning, analysis, and mitigation. Except for A2, probabilities for other scenarios outside of restoration priorities for S2/3 remained the same for all 3 analysis periods. We also assumed a slight increase in HI and MOD states for 10 and 100 yrs on non-federal land, most of which would occur in hucs with listed species.

Adverse effects of activities in wilderness on aquatic habitats are primarily limited to recreation, fire management, and light livestock grazing, in some areas. We assumed effects of fire and grazing management would be captured in the landscape variables used to model the fire/flood and grazing effects on habitat condition.

We assumed areas outside of designated wilderness included in MACs 1 and 2 (e.g., wilderness study areas), which were assigned the same conditional probabilities as designated wilderness, will not be used for activities that could reduce their capacity or function as aquatic habitat.

Probabilities of HI were lower for A1 than for wilderness because of higher levels of ongoing activities and uncertainties concerning how those areas were initially identified and subsequently adjusted. Designation of A1/2s under S3 are subject to an arbitrary acreage limitation. If the acreage of subwatersheds that meet the criteria for A1/2 exceeds the limitation, no direction is provided in the SDEIS for selecting those included in the network. We assumed that subwatersheds managed as A1/2 would be accurately assigned and meet the criteria as described.

There is greater uncertainty regarding the effectiveness of restoration in A2 subwatersheds and other aquatic restoration priority areas compared to conserving existing high quality aquatic habitat (e.g., wilderness, A1, roadless). That is, there is more certainty that high quality habitats can be conserved than there is in achieving restoration objectives for aquatic systems.

Effects of T watershed and old forest management on aquatics would be expected to be more similar to A2 than base level. However, the area within a subwatershed that would be managed for T or old forest objectives is uncertain. We assume base level management objectives and standards for aquatics would apply to T and old forest areas. Any differences in activities in those areas would be reflected in the landscape prescriptions affecting related landscape variables (e.g., bare ground, grazing).

Probabilities of HI for roadless areas outside of A1s were lower than for A1s because they were not specifically identified as aquatic emphasis areas. We assumed interim FS direction for roadless areas will be replaced by comparable long-term direction for FS lands. That direction primarily restricts road building but does not change the management allocation. For example, timber harvest and other uses could still occur but would rely on access not dependent on new roads. However, the landscape prescriptions used for roadless areas included only prescribed fire and grazing. Base level (S2, S3) or existing standards (e.g., PACFISH/INFISH) would apply to activities other than road building that occur in roadless areas outside of A1s. We assumed that current roadless areas on BLM will remain roadless.

Integrated restoration priorities are identified at the subbasin scale. The level of increased aquatic restoration and the specific subwatersheds where it will occur is uncertain. For modeling we assumed it would be proportional to the overall increase in funding for integrated restoration priority subbasins and that it would apply to all subwatersheds in the subbasin. Probabilities for benefits to aquatic species and habitats in integrated restoration subbasins will be higher in subbasins identified as priorities for aquatic restoration.

We assumed landscape restoration can have long-term beneficial effects on aquatic species. Although there will be higher levels of landscape restoration and resulting higher risks of short-term effects to aquatics in priority restoration subbasins, management area designation (i.e., A2 and TEP) and analysis and planning prior to restoration will reduce that risk compared to non-A2, non-TEP or non-restoration priority hucs. There is also higher probability of restoration being effective when preceded by subbasin review/analysis and EAWS.

We assumed that subbasin review and EAWS would be necessary to effectively manage and integrate a strategic approach to sustaining or restoring the complex resource, landscape, and socio-economic conditions within a subbasin. We considered that the information developed through subbasin review and EAWS provides the strategic focus and transparent logic from which multiple projects would be coordinated.

The ownership patterns in most of the subbasins in the Project area are skewed toward private landowners controlling the water and valleys. Thus, important fish habitats, riparian areas, and subsurface flows are in private ownership. Improving water quality and restoring riparian function and aquatic habitat will of necessity be a shared responsibility. Subbasin review and EAWS are the foundation for a watershed and landscape restoration management system more appropriate for today's ecological, social, and economic challenges. On this foundation subbasin or watershed councils can effectively plan, coordinate, complement, and monitor actions and can address socio-economic issues.

Under S2, subbasin review was required to be completed in all integrated priority subbasins within 2 years and all remaining subbasins within 5 years. We assumed EAWS would be completed for 50 percent of the triggered areas (e.g., potential effects on listed species and integrated restoration subbasins) within 5 years and all remaining watersheds within 13 years. The rate and frequency of subbasin review and EAWS would be lower. Subbasin review is not accelerated in integrated restoration priority subbasins, EAWS would cover 1/3 of the watersheds within 10 years, and there are no specific triggers for EAWs. Under S1, EAWS and subbasin review are required at a rate of 1 each/year/administrative unit (e.g., national forest) in PACFISH Key watersheds and INFISH Priority watersheds containing listed species and some containing westslope cutthroat. EAWS is also required prior to ground disturbing activities in priority watersheds of listed species where they have been identified.

We assumed that implementation of roads analysis and the water quality protocol would correspond with occurrence of EAWS (4/21/99 memo from S. Kozel).

Priority watersheds include those designated for Snake River steelhead and chinook, upper Columbia steelhead, and a proxy for bull trout using current distribution. Because all subwatersheds with known bull trout distribution are classified as priority watersheds, bull trout subwatersheds are not truly prioritized for conservation and restoration. Priority watersheds for mid-Columbia steelhead and upper Columbia chinook have not yet been designated. Fifth code hucs occupied by listed Klamath basin Lost River and short nose suckers, recently listed mid-Columbia steelhead and upper Columbia chinook, and other listed species were modeled as PACFISH Key/INFISH Priority BO watersheds under alternative S1.

Except for EAWS triggers, management direction for TEP species outside of the A network does not differ substantially from base level (i.e., no additional BO requirements for S2 and S3 are assumed).

Subwatersheds managed under base level (S2, S3), PACFISH/INFISH Key BO, and INFISH, and BLM scenarios will tend to have predominately moderate-low current habitat conditions since areas managed under the wilderness, roadless, and A1 scenarios will be more likely to have higher quality current habitat conditions. Habitats that are currently low quality will be more difficult to restore and take substantially longer to restore than habitats currently in moderate condition that still retain the components of functional watersheds. Forested subwatersheds can generally be restored more rapidly and extensively than more arid, rangeland habitats.

We assumed explicit standards based on ecological performance measures provide greater certainty that direction will be understood and implemented consistently. Performance measures include quantifiable biological or physical processes or capacities related to riparian composition and structure or water quality, for example. If the overall goal is to maintain or restore natural ecosystem processes, then some performance measures are needed that can be used to indicate if the current trend is moving in the desired direction (Sedell and others 1997). Outcome-based direction provides greater flexibility to tailor management to the situation and potentially greater ownership of the means to achieve objectives but requires increased oversight and monitoring to insure compliance and consistency. We assumed specific, explicit standards would be more readily understood initially and, therefore, initial compliance would be higher and ecological objectives achieved more rapidly.

Default riparian conservation area widths vary among the alternatives and scenarios with corresponding varying degrees of protection of riparian function, assuming similar management within the RCA. All scenarios for federal lands have a default RCA for fish-bearing streams of approximately 2 site-potential tree heights. S2 provides the most extensive default RCAs, including 2 site-potential tree heights for non-fish-bearing perennial streams, 1 site-potential (s.p.) tree height for intermittent streams, and a riparian influence areas for all streams designed to further reduce sediment transport in the area adjacent to the RCA with increasing slope. Priority and key watersheds (S1) have a 150 ft. or 1 s.p. tree height RCA for non-fish-bearing perennial streams, 100 ft. (somewhat less than 1 s.p. tree height) for intermittent streams, and no riparian influence area designation. RCAs for INFISH areas outside of key and priority watersheds and for S3 are similar and the least extensive on federal lands: 150 ft. or 1 s.p. tree height for non-fish-bearing perennial streams and 50 ft. or ½ s.p. tree height for intermittent streams. A 1 s.p. tree height RCA provides little margin for uncertainty (NRC 1995; Sedell and others 1997) and less than 1 s.p. tree height RCA would not provide for full ecological function (Sedell and others 1997). S3 does include a riparian influence area designation on intermittent streams.

The appropriate size of RCAs is dependent on site specific characteristics, watershed influences, and consideration of activities that are occurring there. PACFISH/INFISH provide somewhat greater flexibility to delineate RCAs appropriate for the site since RCAs can be modified through EAWS, project analysis, or consultation where listed species occur. S2 and S3 require EAWS, LMP revisions or other programmatic plans for modification of default RCAs; consequently, it is likely that defaults will be used particularly for S3, which has a lower rate and frequency of EAWS.

Objectives for S2 and S3 (R-O25) recognize potential conflicts and risk trade-offs of forest health restoration activities in riparian vs. upland areas.

Increased conservation and restoration are anticipated in some areas outside of FS/BLM where listed species occur (e.g., Oregon Plan, Lemhi model watershed).

Mining could adversely affect aquatic habitat condition under all alternatives, but there were inadequate data to determine its potential effects in a spatial context.

Monitoring and adaptive management are important considerations in the evaluation of the alternatives. However, they were assumed to not differ substantially across the alternatives. That is, we did not specifically model adverse nor improved conditions based solely on the way monitoring or adaptive management would be applied in any one alternative.

We assumed field units will be staffed with adequate aquatic expertise to effectively implement analysis, conservation, and restoration direction.

Other differences among scenarios that were considered in assigning probabilities are described in Attachment A.

Sediment

Definition:

This node characterizes the probability that accelerated sediment will be delivered to a stream, and was parameterized by a panel of six people with expertise in hydrology, soil science, and fluvial geomorphology. The central concept for Low Sediment is that it is < 20 percent over natural (1.2x natural). The basis for this is that there is large natural variation in sediment yields, such that it takes approximately that much of a sustained increase in sediment yield to detect a statistically significant change in response to a disturbance by logging, fire, or roads based on retention dam sampling. Suspended sediment increases may need to be higher to detect significant change. Medium sediment is 20-100 percent over natural (1.2x to 2x). The basis for the 2x break is that this level of increase will generally result in bed morphology change such as pool filling and increased cobble embeddedness.

States:

Low: Accelerated sediment delivery to main stream is < 1.2x natural.
Medium: Accelerated sediment delivery is between 1.2x and 2x natural.
High: Accelerated sediment delivery is > 2x natural.

Comment: Several assumptions were discussed and generally agreed on by the panel including the following: (1) ground disturbance from fire and timber harvest is short-lived (several years) and recovers to natural levels; (2) in contrast, ground disturbance from road construction never recovers completely during the life of the road; and (3) there are no methods available to completely mitigate roads. There was a large amount of uncertainty among panel members regarding the interaction of the intent of High Maintenance/Restoration and the presence of High Disturbance.

Grnd	Stds &	Road	Sediment-Average		
Disturb	Guides	Disturb	Low	Med	High
Low	High	Low	91	7	2
Low	High	Mod	73	17	10
Low	High	High	62	23	15
Low	Mod	Low	74	20	6
Low	Mod	Mod	46	37	17
Low	Mod	High	27	44	29
Low	Low	Low	59	32	9
Low	Low	Mod	23	46	31
Low	Low	High	10	23	67
Mod	High	Low	85	10	5

Mod	High	Mod	66	21	13
Mod	High	High	55	22	23
Mod	Mod	Low	61	30	9
Mod	Mod	Mod	38	42	20
Mod	Mod	High	18	44	38
Mod	Low	Low	46	37	17
Mod	Low	Mod	18	44	38
Mod	Low	High	6	20	74
High	High	Low	74	18	8
High	High	Mod	60	21	19
High	High	High	50	28	22
High	Mod	Low	49	36	15
High	Mod	Mod	29	40	31
High	Mod	High	16	38	46
High	Low	Low	35	44	21
High	Low	Mod	15	40	45
High	Low	High	3	17	80

Future Grazing

Definition:

Future Grazing is the weighted average probability of severe grazing effect by alternative year, and is provided by the Landscape Team. Severe grazing effect is defined as one that leads to a successional change in upland vegetation (i.e., the plant community will be fundamentally changed by grazing). The Landscape Team's criterion for successional change is when more than 20 percent dissimilarity exists compared to native vegetation. This variable incorporates projected activity levels and standards and guides as they may influence upland grazing, but does not consider management that may influence the riparian condition. It can be viewed only as an index of the relative intensity of grazing with no modification by fencing or some other riparian management activity. The variable is an estimate of the mean probability of severe effect for the subwatershed.

States:

No: It is unlikely that severe grazing effects will lead to fundamental change in the riparian community; the probability is 1-probability of an effect.
Yes: It is likely that severe grazing effects will lead to fundamental change.

Both states are probabilities.

Prior Riparian Condition

Definition:

Prior Riparian Condition represents riparian habitat attributes including stream bank stability, vegetation, channel geometry and wood recruitment capabilities that have been influenced by prior land management.

States:

None to Light: Past management has had no or little impact on riparian function.
Moderate to Heavy: Past management has resulted in measurable, significant impact on riparian function.

Both states are probabilities.

Comment: The impact of future activities on riparian condition is strongly dependent on the current riparian condition including vegetation status, bank stability, channel morphology, etc. There are no variables available that provide that information at the subwatershed directly. Lee and others (1997) developed a variable named management cluster (MGCLUS) that is a categorical classification of each subwatershed based on past and present use, land ownership, land use life form (agriculture, range, or forest), etc. A cluster analysis procedure was used to identify 10 distinctive groupings of subwatersheds with similar properties. Six experts from the fields of range science, hydrology, soil science and fisheries science provided estimates of the probability of being in one of the 2 classes (None to Light Disturbance, Moderate to High Disturbance) based on attributes of the 10 clusters. These attributes include land type, management area classification, land ownership, area grazed, and percent wilderness. The conditional probabilities for the various clusters based on expert opinion are:

Cluster Name	None to Light	Moderate to High
Tribal Land	35	65
Private Agriculture	10	90
Private and BLM Rangeland	15	85
FS forest and range; mod. impact	25	75
NPS forest land	85	15
Private forest land	45	55
FS high impact; no grazing	40	60
BLM rangeland	15	85
FS-managed Wilderness	80	20
FS high impact; grazed	15	85

Riparian Condition

Definition:

Riparian habitat condition integrates changes from natural conditions for five major physical characteristics: stream bank stability; abundance and type of vegetation; channel geometry (either channel incision or widening); shading from vegetation; and the size and amount of wood recruited to the active stream channel.

States:

Intact: Stream bank stability >85 percent compared to natural conditions; vegetation is characterized as abundant and comprised of a healthy, native, hydrophilic plant community; a change in channel geometry is absent or very infrequent; natural levels of shading have not been substantially altered (<25 percent); and natural levels of wood recruitment have not been substantially altered.

Moderately degraded: Stream bank stability is 50-85 percent compared to natural; vegetation is characterized as abundant but there is 10 percent to 50 percent increase in non-hydrophilic plants in the plant community; a change in channel geometry is low to moderate; natural levels of shading have been moderately (25-50 percent) reduced; and natural levels of wood recruitment have been moderately reduced by land management activities.

Highly degraded: Stream bank stability is < 50 percent compared to natural conditions; increases of more than 50 percent of the plant community in non-hydrophilic plants; change in channel geometry is moderate to high; natural levels of shading and wood recruitment have been severely (>50 percent) reduced by land management activities.

Comments: The conditional probabilities for this node were estimated by five experts in the fields of hydrology (2), soil science, range science, and geomorphology. Separate tables are constructed for 10- and 100-year evaluations because of the time-dependence of this node on prior riparian condition. The Prior Riparian Condition, Future Grazing, and Standards and Guides influence this node. Future Grazing is the only dynamic variable directly driving Riparian Condition, however Standards and Guides, which constrain logging effects through buffer width, are used as a proxy for logging activity. We don't feel this is a problem for areas with high activity levels, however it could lead to overestimating effects in a situation where S and G are weakly constraining (e.g., narrow buffers) but for which there is little or no planned activity. The experts assumed that the importance of the five characteristics and their response to disturbance varies from watershed to watershed (ex. Some range watersheds don't have a coarse wood supply under natural conditions), and a highly degraded riparian condition is not a rare event. Some water quality parameters including temperature, nutrients, and to some extent, dissolved O_2 are included in the concept of riparian condition. Sediment is dealt with explicitly in the variable Sediment. Other water quality attributes like heavy metals, S^{2-}, pH, $Al_{(s)}$, etc. are not addressed in this model. Location: Electronic copies of various iterations by all experts are located on C:\netica\netica1.12\ripocomp.xls.

Stds & Guides	Future Grazing	Prior Riparian Condition	10 Yr Riparian Condition Intact	10 Yr Mod Degrad	10 Yr High Degrad	100 Yr Riparian Condition Intact	100 Yr Mod Degrad	100 Yr High Degrad
High Mit	No	None-Light	75	20	5	78	18	4
High Mit	No	Mod-High	17	46	37	45	38	17
High Mit	Yes	None-Light	59	31	10	69	23	8

High Mit	Yes	Mod-High	13	47	40	36	40	24
Mod Mit	No	None-Light	54	36	10	55	36	9
Mod Mit	No	Mod-High	13	49	38	30	43	27
Mod Mit	Yes	None-Light	47	40	13	45	41	14
Mod Mit	Yes	Mod-High	9	49	42	23	40	37
Low Mit	No	None-Light	45	40	15	32	47	21
Low Mit	No	Mod-High	7	47	47	13	42	46
Low Mit	Yes	None-Light	38	42	19	20	51	29
Low Mit	Yes	Mod-High	5	43	52	8	34	58

Fire-rain

Definition:

The Fire Rain variable is a probabilistic estimate of the occurrence of uncharacteristic severe wildfire and the coincident occurrence of a 40-year return interval of rain or similar hydrologic circumstances. Uncharacteristic severe wildfire effects result from wildfires that have an above average probability of burning more than 20 percent of the area of the subwatershed wildland vegetation with effects outside the normal range including: loss of litter, tree mortality, and fire-induced water repellency. This probability is provided by the Landscape Team. The phrase "occurrence of a set of hydrologic circumstances is used here to capture possible scenarios of precipitation and/or melting events combined with antecedent snowpack and soil conditions that generate large amounts of overland flow.

States:

Yes: A fire with severe soil effects has occurred on 20 percent of the subwatershed, and a 40-year storm/event has hit the area within 5 years of the fire.
No: That set of events didn't happen.

Both states are continuous probabilities.
Note: this is calculated from an equation rather than from a probability table.

Comment: In both cases, the window of concern is the 50-year period prior to the analysis (10-year or 100-year). We use the 10-year probability for uncharacteristic wildfire in the 10-year evaluation. For the 100-year evaluation, we interpolate between the current and 100-year probabilities for uncharacteristic fire, using the 75th percentile value which is assumed to be the midpoint of the value over the 50-year period. The 50-year evaluation period is based on an estimate of channel recovery as explained in the Flood Variable.

Slope2

Definition:

Slope2 is the proportion, expressed as a percentage, of the area of a subwatershed with slopes steeper than 50 percent.

States:

Continuous variable output.

Comment: This is the value of the variable SLOPE4X. Slope steepness affects both the frequency and magnitude of debris torrents by controlling the supply of material to headwater channels, channel steepness, stability of adjacent sideslopes, and peak discharge characteristics of the channel (Swanston 1991). Estimates of this variable were provided directly from existing ICBEMP landscape coverages for all subwatersheds.

Flood

Definition:

This is a flood event of sufficient magnitude that it is accompanied by one or more (typically several) debris torrents in headwater channels, resulting in widespread scour, deposition, and riparian vegetation mortality. The receiving channel changes produced by debris torrents are referred to here as a channel-reorganizing event, and may persist for centuries (Benda 1985). We define the channel-reorganizing event here as of sufficient magnitude to substantially alter channel characteristics throughout at least a third of the channel network in the subwatershed.

States:

Yes: The flood event happened.
No: The flood event did not happen.

Both states are continuous, interdependent variable output.

Comments: The flood event can happen either with or without prior uncharacteristic fire. If uncharacteristic fire has occurred, the size of the hydrologic event needed to result in a flood is smaller because of changes in soil cover, infiltration capacity, root strength, and antecedent soil moisture conditions. We have set that event as one having a return interval of 40 years (see above). Alternatively, a less frequent but larger hydrologic event can result in the same flood and channel-reorganizing event. We have set the return period for this at 300 years. In addition, the probability of having slopes steeper than 50 percent influences this node. If the subwatershed has no slopes steeper than 50 percent (i.e., Slope2 = 0), then there is no possibility of the flood in this model. For the flood without a prior uncharacteristic fire, the probability increases linearly and has a 1:1 relationship with the value of Slope2/100. Uncharacteristic wildfire probability is positively correlated with slope, so there is a somewhat greater likelihood that if a fire occurs, it will burn slopes that are capable of generating a flood event. This interaction is modeled as a logarithmic function, and is described by the following equation:

$$\text{Pr Flood Yes} = \text{Pr Fire Event Yes} * \log(\text{Slope2} + 1)/2$$

Existing literature describing the recurrence of fire and non-fire related channel-reorganizing events is sparse. Meyer and others (1995) indicate that fire-related sedimentation events in Yellowstone National Park have occurred in cycles of 350-450 y in the late Holocene, whereas alluvial terrace deposits have a much lower frequency of about 1300 years, and are probably related to climate fluctuations. In contrast, Swanston (1991) suggests a recurrence interval for debris avalanches and flows of sufficient magnitude to affect fish habitat at 5 to 100 years in the Coast Range. Our observations in the Intermountain West suggest frequencies lower than the north Coast Range, but probably more frequent than that observed in Yellowstone. While we have selected 300 years, ranges from 200 to 500 are equally reasonable.

Aquatic Habitat Capacity

Definition:

This node represents the amount and quality, relative to potential, of aquatic habitats necessary to support the numbers, sizes or age classes, and life history types of salmonids that historically (before European settlement) have occurred within a subwatershed. Potential implies the optimal portion of a range of habitat conditions that has been realized during the past. Aquatic habitat is influenced by: (1) magnitude of increased sediment inputs relative to the most likely natural levels (*sediment node)*; (2) condition of the riparian corridor relative to natural levels (*riparian habitat node)*; and (3) occurrence of a widespread, channel-reorganizing, hydrological event (*flood node*). Sediment inputs affect both the amount of fine sediments in substrate interstices and the amount of coarser particles, thereby restricting interstitial flow of oxygen and reducing the volume of pools. Riparian habitat condition influences the amount and types of off-channel and pool habitats, the sizes and amounts of organic debris inputs (e.g., large wood), cover (e.g., undercut banks), and shading. A large, channel-reorganizing event will typically result in extensive channel scour, sediment transport and deposition, bank collapse, and large wood delivery, transport and log jam formation. We consider a 'large' event to be one that directly influences >33 percent of stream network, including the mainstem, within a subwatershed.

Our definition implies that a range in habitat conditions is possible at any point in time and recognizes that these conditions will vary through time with natural disturbance and vegetation succession. We do not assume that optimum conditions always will exist in the absence of human activity. However, we assume that a subwatershed where the sediment inputs, riparian habitat, and hydrologic regime have not been substantially altered by human activity will be more likely to contain aquatic habitat conditions that are closer to optimum for indigenous salmonid species than in a subwatershed where one or more of these components have been considerably altered by human activity.

States:

High: Sediment inputs and riparian conditions that influence the creation and maintenance of suitable habitats for salmonids have not been substantially altered or constrained by human influences. The likelihood of channel reorganizing events also has not be changed. At the time of evaluation, the subwatershed supports approximately 75 to 100 percent of the potential habitat capacity.

Moderate: Sediment inputs, riparian conditions and/or the frequency or likelihood of channel reorganizing events have been significantly altered by human activities such that, at the time of evaluation, a subwatershed supports 50 to 75 percent of the potential habitat capacity.

Low: Sediment inputs, riparian conditions, and/or the frequency or likelihood of channel reorganizing events have been significantly altered such that, at the time of evaluation, a subwatershed supports less than 50 percent of the potential habitat capacity.

Comments: Natural patterns of disturbance and geomorphology resulted in a mosaic of habitat conditions across a subwatershed with some tributary streams, stream segments, or stream reaches supporting a variety of habitats for salmonids. Although the range of possible habitats was dictated by geomorphic setting, the observed habitat within this range was a result of natural disturbance and physical and biological processes that influenced the supply and flow of sediments, coarse debris, nutrients, water and energy. The historical patterns of disturbance and recovery and the resulting distribution, amount, and condition of habitats suitable for salmonids provided a dynamic and diverse suite of habitat conditions that was important to support the full range of salmonid numbers, age classes, and life history types as well as the relative productivity and resilience of their population through time. Changes in watershed processes that alter the frequency, magnitude or duration of disturbance or the supply of materials important to the creation and maintenance of habitat may fundamentally alter both the potential range of habitat types, and the patterns of disturbance (Beechie and Bolton 1999). The result may be either a limitation in the range of possible habitats (i.e. habitat simplification) or a fundamental change in the timing or magnitude of events that a species has adapted to through a variety of life history types or strategies. Because disturbance is natural, habitat conditions will not always be optimal in any watershed. The number of subwatersheds in optimal or productive conditions may be expected to decline, however, as the processes that influence the creation and maintenance of habitat are substantially altered or constrained. The conditional probabilities for this node were estimated by 6 scientists in the fields of fisheries (2), hydrology (2), geomorphology, and soil science.

		Ripo	Aquatic Habitat Capacity		
Flood	Sed	Condition	High	Moderate	Low
No	Low	Intact	78	16	5
No	Low	Mod Deg	36	42	22
No	Low	High Deg	13	34	53
No	Mod	Intact	58	31	10
No	Mod	Mod Deg	23	43	33
No	Mod	High Deg	9	32	59
No	High	Intact	31	44	25
No	High	Mod Deg	16	34	50
No	High	High Deg	4	22	74
Yes	Low	Intact	43	34	23
Yes	Low	Mod Deg	15	41	45
Yes	Low	High Deg	5	23	71
Yes	Mod	Intact	25	43	33
Yes	Mod	Mod Deg	10	34	55
Yes	Mod	High Deg	4	18	79
Yes	High	Intact	13	37	51
Yes	High	Mod Deg	8	22	69

Yes	High	High Deg	3	10	88

Exotic Threat

Definition:

This node characterizes the occurrence and relative status of introduced or exotic species, forms or races that may influence the growth, survival, abundance, genetic integrity, or persistence of the species of interest. The exotic species considered are defined independently for each salmonid considered in the analysis. We focused on those forms that have the highest likelihood of effecting native salmonids in spawning and rearing areas. Where multiple forms are likely to occur we considered the probability of a threat to be the highest probability for any single form.

States:

Yes: The selected introduced fishes are relatively abundant (in relation to the species of interest), and broadly distributed or have the potential to become abundant and well distributed, throughout the subwatershed;

No: The selected introduced fishes are not present or are not abundant and occur only sporadically throughout the subwatershed, conditions do not favor expansion throughout the subwatershed.

Comment: We were selective in the exotic species considered as threats. We focused primarily on introduced salmonids. Because we are considering only spawning and rearing habitat the overlap with many of the non- salmonid exotics is limited. An important exception may be with overlap in the distributions of small mouth bass and chinook salmon and steelhead (Frissell and others, n.d.).

The exotic species we consider vary for each key salmonid we model. For bull trout we include only brook trout which have been the primary species of concern in work to date (Rieman and McIntyre 1993; Rieman and others 1997). Although introduced rainbow trout and brown trout may occur in bull trout habitats there is relatively little information on the interaction between either species and bull trout. (Williams and Mullan 1992) and G. Haas (personal communication of unpublished data) speculate that the overlap in local distribution and interaction between bull trout and rainbow trout is strongly influenced by temperature. Because of at least partial segregation for some life stages with thermal gradient and because rainbow trout and bull trout naturally co-exist in a portion of these species' ranges we do not anticipate that the introduction of rainbow trout will have a strong influence on bull trout. In any case there is too little information to speculate on the nature of that interaction. Introduced brown trout do occur across the range of bull trout (Lee and others 1997) but there appears to be relatively little overlap in local distribution (Dambacher and Jones 1997). Again there is little information to judge the strength of any interaction.

For westslope cutthroat trout and Yellowstone cutthroat trout we include introduced rainbow trout, brook trout, and cutthroat trout. Cutthroat trout clearly hybridize with rainbow trout (Lee and others 1997; Rieman and McIntyre 1995). Considerable work is now focused on the competitive interactions with brook trout and there is growing evidence that brook trout may negatively influence cutthroat (e.g., Dunham and others, in press; Schroeter 1998).

For redband we considered introduced rainbow trout. For chinook salmon we considered hatchery supplemented chinook salmon based on the interpretation of genetic integrity from (Lee and others 1997) brook trout, introduced rainbow trout, and small mouth bass. For steelhead we considered hatchery supplemented steelhead as with chinook, brook trout, introduced rainbow trout, and small mouth bass (as with chinook).

The probability of an exotic occurring as "strong" was estimated through models developed for categorical data analysis (CATDAT). Data from the USFS Region 1 data characterizing the status of introduced salmonids was used to fit the models. Predictive variables included the 5th code presence from (Lee and others 1997) and other landscape variables selected by the models. For introduced forms not included in the Region 1 data set (i.e., smallmouth bass; hatchery origin chinook salmon or steelhead) we estimated the probability of a threat based simply on the occurrence in existing species coverages Lee and others 1997).

Anadromous Loss *(Non-anadromous Network Only)*

Definition:

This is a root node that characterizes the loss of anadromous fishes from the community associated with each of the non-anadromous salmonids. Anadromous salmonids have been extirpated from much of their former range and the loss may have important implications for productivity, dynamics, habitat use, and behavior in the remnant community (Willson and Halupka 1995) . Because this condition is impossible in subwatersheds where anadromous forms persist, this node is used only in the network for non-anadromous forms. Anadromous loss cannot occur where these forms did not exist historically.

States:

Yes: Anadromous salmon or steelhead that once occurred in the subwatershed are no longer present.

No: Anadromous salmon or steelhead still occur.

Comment: The state of anadromous loss was characterized from the known and predicted distribution of anadromous salmonids as described in Lee and others 1997. Yes: the subwatershed is within the historical range for stream type chinook salmon; ocean type chinook salmon, or steelhead and anadromous access is now blocked or none of the anadromous forms still occurs in the subwatershed. No: At least one of the anadromous forms still occurs or the subwatershed or the subwatershed is outside the historical range of anadromous salmonids.

Community Change (Non-anadromous Network Only)

Definition:

This node summarizes information from the exotic threat, and anadromous loss nodes. It is used to identify subwatersheds where a change in the aquatic community that may substantially influence growth, survival, behavior, and ultimately the resilience of a fish population associated with the subwatershed, has occurred. It is used only in the networks for non-anadromous salmonids.

States:

Yes: An exotic threat exists in the subwatershed and/or the loss of an anadromous salmonid has occurred.

No: Neither of the above conditions exists.

Comment: The conditional probabilities linking exotic threat and anadromous loss is defined by a rule set as follows:

Exotic Threat	Anadromous Loss	Altered	Not Altered
Yes	Yes	100	0
Yes	No	100	0
No	Yes	100	0
No	No	0	100

Current Status

Definition:

This is a root node with the probability for the current status of a population associated with each subwatershed. The definition is identical to that for future status. The characterization is limited to subwatersheds that currently support or could support spawning and rearing life stages.

States:

Strong; Depressed; Absent; described as in future status below.

Source: The probabilities for current status were estimated for each subwatershed and each species using CATDAT and the same data sets and general approach outlined by Lee and others 1997. The classification trees used by Lee and others 1997 were dropped in favor of Nearest Neighbor approach in the CATDAT module because the latter models provide better out-of-sample classification success rates.

Potential Spawn/Rear

Definition:

This is a root node with the estimated probability that the subwatershed contains suitable spawning and rearing habitat. It is based only on environmental conditions independent of habitat disruption or degradation from anthropogenic effects. This node informs Long Term Potential and is included primarily to identify subwatersheds that represent potential habitat for a species that currently may be absent. Subwatersheds that have an estimated probability of 0 (i.e., none of the subwatersheds in the same predictive class support spawning and rearing) are excluded from the analysis.

States:

Potential: General environmental characteristics and stream habitat conditions (independent of any anthropogenic effects) in the subwatershed are within the range of conditions suitable for spawning and early rearing for the species of interest.

No Potential: Characteristics are not within the range suitable for the species.

Source: The probabilities for Potential Spawn/Rear were estimated using CATDAT and the same data sets and general approach outlined above for Current Status. The variables used for prediction were limited to those reflecting essentially unchanging landscape characteristics (i.e., climate, landform, geology)

Refounding/Support

Definition:

This is a root node that informs Recovery Potential. Refounding/Support represents the potential for genetic and demographic support via dispersal from surrounding subwatersheds in the local subbasin. The states are defined from general assumptions about straying rates (described below) and existing information about the number of known or predicted strong or strong + depressed subwatersheds (sources) in the encompassing subbasin for the salmonid of interest. For resident salmonids the potential sources include only other strong populations. For anadromous salmonids the sources may include strong or depressed subwatersheds. The difference is based on the overwhelming influence of migratory and corridor conditions on anadromous salmonids and evidence that straying and gene flow among anadromous populations substantially exceeds that for nonanadromous forms (e.g., Gyllensten 1985). Where populations persist, many depressed anadromous populations may recover quickly with changes in ocean or migratory conditions, thus remnant depressed populations of anadromous salmonids may reflect a much better potential for the genetic and demographic support among subwatersheds than for non-anadromous salmonids.

States:

High: More than 50 adult immigrants are expected in the subwatershed in the period of evaluation.

Moderate: Three to 49 adult immigrants are expected in the subwatershed in the period of evaluation.

Low: Less than three immigrants are expected..

Comments: Simple rules of thumb suggest that an effective population size smaller than 50 adults may result in substantial risk of inbreeding (Larkin 1981; Soulé 1980). We assume that a new (or recolonized) population founded with fewer than 50 adults from a variety of sources, or a population that has been through a serious bottleneck and receives new genetic material from fewer than 50 adults over the period of evaluation may face an important risk of inbreeding or limited genetic variation. Colonization may occur with far fewer fish and the benefits of gene flow with fewer fish cannot be discounted. We conclude, however, that 50 adults is the minimal level necessary to mitigate the effects of a genetic bottleneck and a rational bound between high and moderate potential. Low becomes the point where refounding is unlikely and gene flow would be extremely limited or non-existent. To estimate the probability for the different states we considered both the number of potential sources and the number of subwatersheds that might receive the emigrants from those sources. We made the following assumptions: 1) dispersal was randomly directed (i.e., dispersing individuals are equally likely to go to any subwatershed in the subbasin); 2) only "strong" non-anadromous populations are likely to generate dispersing individuals, while both strong and depressed anadromous subwatersheds can generate dispersing individuals; 3) straying rates average about 2 percent per year for all salmonids although they may range considerably higher (e.g., Fontaine and others 1997; Labelle 1992; Tallman and M.C. Healey 1994; R. Thurow, personal communication of unpublished data for Yellowstone cutthroat trout) and are probably not uniform through time (the implication here is that straying individuals are likely to be clustered in time); and 4) subwatersheds that produce dispersing individuals support about 500 adults or produce an average of about 10 dispersing individuals per generation. To estimate the refounding/support probabilities, we first estimated the total number of potential immigrants, *M*, for each subwatershed, *i*, by salmonid species as:

$$M_{ij} = Y*10*S_j/(T_j-1),$$

where Y is the number of years in the evaluation period, *S* is the number of subwatersheds containing strong (+ depressed for anadromous species) populations, excluding subwatershed *i* if strong, and T is the total number of subwatersheds in subbasin *j*. Refounding/support probabilities were then estimated by assuming that the potential number of immigrants were distributed as a Poisson (i.e., random) with an expected value *M* and calculating the probability of receiving at least 50, 2 to 49, or less than 2 immigrants for high, moderate and low states, respectively.

Connectivity

Definition:

Connectivity is a root node that informs *recovery potential*. *Connectivity* reflects the physical access (i.e., barriers to movement) as well as the relative condition of the connecting corridor necessary for dispersal among subwatersheds within the subbasin. This node is relevant only for resident (nonanadromous) forms because all remaining anadromous stocks, by definition, must occur in subbasins that retain connectivity in the mainstem corridor.

States:

Yes: Primarily subbasins in category 1 and 2. The subwatersheds remain connected by a mainstem suitable for movement, rearing, or overwintering of migratory forms.

No: Primarily subbasins in category 3. The mainstem habitat conditions have been seriously compromised by water diversion, habitat degradation, or water quality issues, the introduction and expansion of multiple exotic species, or by impassable dams. The full expression of migratory life histories is not possible.

Comment: our interpretation of connectivity is based on subbasin categories from the HUC 4 data base (see Lee and others 1997). Every subwatershed within a subbasin assumes the same value. Although category 2 and 3 subbasins are largely differentiated by the condition of the mainstem (Lee and others 1997), we cannot conclude that the connection among all subwatersheds is severed in category 3 so we could not assume an absolute condition here. There are also subbasins in category 2 where some subwatersheds codes are isolated at least seasonally, by water diversions or other effects (i.e., Bitterroot subbasin, Lee and others 1997). For these reasons, we parameterized connectivity with some uncertainty in the category 2 and category 3 subbasins as follows:

Subbasin Category	Yes	No
Category 1	100	0
Category 2	75	25
Category 3	25	75

Recovery Potential

Definition:

This node represents the inherent potential for the population associated with the subwatershed or collection of subwatersheds to recover from depressed conditions including a local extinction. The node is informed by Refounding/Support , Connectivity, and Potential Spawn and Rear, and summarizes information on the potential for demographic and genetic support from surrounding populations, the potential for a diversity of life-history strategies (i.e., resident/migratory) that can stabilize populations in the face of environmental variation, and the relative suitability as habitat (independent of anthropogenic effects). The intent is to identify subwatersheds that have the potential to support viable populations even though none may exist there now, and subwatersheds with populations that retain genetic and life history characteristics important to resilience and an ability to recover from a local depression in abundance.

States:

High: The subwatershed contains suitable habitat (independent of any anthropogenic effects) and has the potential for regular immigration from surrounding populations that could result in refounding or the genetic and demographic support necessary to mitigate any population bottlenecks or founder effects within 50 years. Connectivity with the mainstem allows the full expression of migratory life histories.

Moderate: The subwatershed contains suitable habitat but the genetic and demographic support from surrounding populations may be limited or occur sporadically because the number and strength of surrounding populations is considered moderate. Refounding in the case of a local extinction is possible, but may take longer than under high because of fewer or weaker sources. Connectivity with the mainstem may partially restrict migratory life histories.

None: The subwatershed contains habitat that is not suitable and cannot be refounded or it contains suitable habitat and is isolated from surrounding populations and has no potential for natural genetic or demographic support or the full expression of migratory life history. We assume that active (human aided) dispersal as a function of management will not be a factor in the long term dynamics of these species.

Comment: in estimating the conditional probabilities for this node we assumed that recovery potential was influenced primarily by connectivity and by habitat potential, and secondarily by refounding and support. Subwatersheds that are not potential habitat cannot support spawning and rearing and cannot be colonized so we assumed that recovery conditions must be none by definition. Connectivity will influence the potential for dispersal and demographic support, but also the expression of alternative life history patterns which may be particularly key in the persistence of local populations. For this reason we viewed the connectivity as particularly important (i.e., it effects both immigration and life history expression). Where connection between a subwatershed and mainstem is severed, immigration is impossible and the expression of some life history forms becomes impossible or at least far more restricted. This seriously limits the possibility for mitigation of a genetic bottleneck and excludes recolonization following a local extirpation. The loss of the life history pattern may also seriously reduce resilience (e.g., Rieman and Clayton 1997). We conclude that refounding/support is irrelevant when there is no connectivity (i.e., the probabilities for recovery potential do not change with refounding/support). Lack of connectivity does not necessarily exclude the possibility of an internal recovery where the population is only reduced to a low level. Some larger subwatersheds may support some migratory life history within the system or may contain a small portion of a larger mainstem. For these reasons we retain some chance of moderate potential even where connectivity is no.

Immigration should vary with the number and strength of the potential sources where connectivity is retained. Because we are relatively uncertain about dispersal rates we remain uncertain about how strongly the reduction in sources will influence the numbers of potential immigrants or how to weight that effect in relation to the possible expression of migratory life histories. By definition recovery potential could not be high if either refounding/support was low. Recovery potential also could not be none if potential sources and connectivity exist. In that case, we assumed the best possible condition defined high recovery potential and split the probabilities more equally (uncertain which state more likely) where it was moderate. The conditional probabilities for recovery potential were estimated as follows:

RECOVERY POTENTIAL (non-anadromous)

Potential Spawn & Rear	Refound & Support	Connectivity	High	Mod.	None
Potential	High	Yes	80	15	5
Potential	High	No	0	10	90
Potential	Mod.	Yes	50	50	0
Potential	Mod	No	0	10	90
Potential	Low	Yes	0	50	50
Potential	Low	No	0	10	90
No Potential	High	Yes	0	0	100
No Potential	High	No	0	0	100
No Potential	Mod.	Yes	0	0	100
No Potential	Mod	No	0	0	100
No Potential	Low	Yes	0	0	100
No Potential	Low	No	0	0	100

RECOVERY POTENTIAL (anadromous)

Potenial Spawn&Rear	Refound & Support	High	Mod.	Low
Potential	High	80	15	5

Potential	Mod.	50	40	10
Potential	Low	0	50	50
No Potential	High	0	0	100
No Potential	Mod	0	0	100
No Potential	Low	0	0	100

Corridor Conditions (Anadromous Only)

Definition:

This root node summarizes the condition of the migratory path for anadromous salmonid smolts and adults. It is a rule set characterizing the number of mainstem Snake and Columbia river dams that occur in the migratory corridor for the species and subwatershed of interest.

States:

High:(0-2 dams).
Moderate: (3-5 dams)
Low: (>5 dams).

Comment: The states are based on an interpretation of anadromous smolt mortality estimates at mainstem dams. Construction and operation of mainstem dams on the Columbia and Snake rivers is considered the major cause of decline of anadromous fish (CBFWA 1990). Steelhead and adult chinook salmon are delayed during upstream migrations and smolts may be killed by turbines, become disoriented or injured, making them more susceptible to predation; or become delayed in the large impoundments behind dams (Bevan and others 1994; Chapman and others 1994b; IDFG and others 1990). Development and operation of hydropower facilities in the Basin has reduced salmon and steelhead production by about 8 million fish: 4 million from blocked access to habitat above Chief Joseph and Hells Canyon dams, and 4 million from ongoing passage losses at other facilities (NWPPC 1986). Passage losses are cumulative depending on the number of dams, steelhead and chinook salmon in the Basin must pass 1 to 9 dams. Losses of mid- and upper-Columbia chinook salmon were estimated to be about 5 percent per dam for adults and 18 to 23 percent per dam for juveniles (Chapman and others 1994b). Smolt-to-adult return rates decreased substantially for both Snake River steelhead and chinook salmon since 1969 when the Lower Snake River dam complex was constructed and operated (Marmorek and others 1998).

We applied an estimate of 20 percent loss per dam for both juveniles and adults of a given brood year to estimate the influence of the number of dams on survival through the migration corridor. With two dams in place, and 20 percent loss per dam, about 64 percent of migrating fish survive; we considered zero to two dams to reflect high survival of migrants in the corridor. With three-to-five dams in place, from 33 to 51 percent of migrating fish survive and we considered this to reflect moderate survival.

With more than 5 dams in place, less than 33 percent of migrants survive and we considered this to reflect low survival.

Ocean Conditions

Definition:

Relative productivity of the ocean environment in the area utilized by Columbia River Basin anadromous salmonids. This node addresses the potential importance of the hypothesized ocean cycle of productivity on migrant fish growth and survival.

States:

High: Ocean productivity is high and favorable for growth and survival.

Low: Ocean productivity is low and unfavorable for growth and survival.

Comment: A growing body of evidence illustrates that Pacific salmon experience large annual fluctuations of juvenile survival in the marine environment (Hare and others 1999). These fluctuations in survival appear to be influenced by cycles in ocean productivity and climate. Climate and ocean productivity do not vary randomly over time, rather, they appear to oscillate (Beamish and Bouillon 1993), perhaps in a predictable pattern. It has been hypothesized that ocean productivity varies nonlinearly in a 40-60 year cycle (Lawson 1993; Lichatowich and Mobrand 1995; Ware and Thomson 1991). Factors influencing this cycle appear to be associated with coastal upwelling and large scale climate changes that effect temperature, precipitation, and wind (Beamish and Bouillon 1993; Ware and Thomson 1991). We considered this node to be uninformed because of two inherent uncertainties. First, the cycle of ocean productivity is based on a hypothesis that to date has not been clearly confirmed. Second, even if we assume the cycle does occur, we remain uncertain where we currently are in the cycle trajectory and where the cycle may move in the future. As a result, we parameterized the high and low states equally as 0.5, 0.5.

Migrant Survival (Anadromous Only)

Definition:

Relative survival of migrant fish from the time they depart their natal subwatershed to the time they return. Migrations may be associated with rearing or overwintering. This node reflects the need for anadromous salmonids to have open access and favorable migration conditions to areas much larger than a single subwatershed in order to complete their life cycle and it addresses the influence of ocean conditions on smolt-to-adult growth and survival. The *corridor conditions* and *ocean conditions* nodes influence this node.

States:

High: For a given brood year, survival of migrants back to natal areas is sufficient to more than replace the number of adults that produced those migrants.

Moderate: For a given brood year, survival of migrants back to natal areas replaces the

number of adults that produced those migrants.
Low: For a given brood year, survival of migrants back to natal areas fails to replace the number of adults that produced those migrants.

Comment: If high corridor conditions exist, the most likely condition of migrant survival would be for the population to more than replace itself (High). This was judged to be the case regardless of whether ocean conditions were high or low. High ocean conditions, however, were judged to increase the likelihood of high migrant survival compared to low ocean conditions. With moderate corridor conditions, the most likely condition of migrant survival was to replace itself (Moderate), followed by High. As noted above, high ocean conditions were judged to increase the likelihood of high migrant survival compared to low ocean conditions. With low corridor conditions, the most likely condition of migrant survival was to not replace itself (Low), regardless of whether ocean conditions were high or low. High ocean conditions were judged to reduce the likelihood of low migrant survival compared to low ocean conditions.

The estimated conditional probabilities are as follows:

Migrant Survival

Corridor	Ocean Condition	High	Moderate	Low
High	High	90	9	1
High	Low	75	20	5
Moderate	High	30	60	10
Moderate	Low	20	70	10
Low	High	10	15	75
Low	Low	5	10	85

Because species status is so strongly linked to the corridor, it is possible that the effects of dams may have masked the potential benefits associated with each alternative. To consider this possibility, we analyzed an additional scenario (alternatives S1, S2, S3 in SDEIS designated as D2_1, D2_2, D2_3 or D1, D2, D3, respectively in the data tables) in which we removed the influence of three lower dams on the Snake River via changes to the conditional probability table below. All other inputs for the networks remained the same for each alternative. This final analysis was not intended to describe the relative effects of land management and dams but to determine whether assumptions regarding the effects of dams might obscure the relative differences expected among alternatives.

Corridor	Ocean Condition	High	Moderate	Low
High	High	75	15	10
High	Low	75	10	15
Moderate	High	60	25	15
Moderate	Low	60	20	20

Low	High	40	40	20
Low	Low	30	30	40

Biological Potential

Definition:

This node summarizes the influence of biotic and abiotic conditions that may constrain the long term adaptability, resilience and abundance, and persistence of a population associated with a subwatershed or collection of subwatersheds. These constraints are independent of habitat condition influenced by anthropogenic disturbance. For anadromous forms they are independent of the effects of migrant and ocean conditions that influence smolt to adult survival. This node summarizes information from *current status, recovery potential, and exotic threat* for anadromous salmonids. For non-anadromous salmonids this node summarizes information from *current status, recovery potential,* and *community change.* For any state except *none,* fish are assumed to be present in the watershed at the beginning of the period of the evaluation. None is carried forward only to track watersheds where future occurrence is not possible because no fish are present and colonization or recolonization is not possible (i.e., recovery potential is none). We assume that colonization of the subwatersheds will not be accomplished through artificial means.

States:

High: The inherent biological/ecological and evolutionary potential for a population in a subwatershed has not been substantially reduced from historical (pre European development) conditions. The population retains its full potential to respond positively to improving habitat conditions and to retain or reach a "strong" status assuming that habitat conditions in the subwatershed are not constraining. Populations that are reduced to low levels through environmental variation retain strong connectivity to other populations and the potential for enough immigration to mitigate the effect of bottlenecks. Connection to mainstems also allows the full expression of migratory life histories in non-anadromous forms. The potential for competition or predation via non-native fishes is minimal or non-existent. In demographic terms if the population is reduced to a low level (10 percent of local carrying capacity in the subwatershed) nothing in the subwatershed will constrain **?** (finite annual growth rate) from being greater than 1 or high enough to return to carrying capacity within approximately three to five generations.

Moderate: There is some reduction in potential through a reduction in growth, survival, or the spatial, temporal distribution that reduces the inherent fitness and resilience of the population and its resistence to disturbance. This reduction may result from a genetic bottleneck and limited (although not absent) gene flow necessary to mitigate a bottleneck, or by a substantial change in the fish community represented by the addition of exotic competitors, predators, or hybridizing forms; extirpation of anadromous species; or by some restriction of connectivity on migratory life histories. If the population is reduced to a low level biological/ecological potential will constrain **?** such that it will be greater than 1 but not high enough to return the population to carrying capacity within five generations.

Low: The local population faces substantial biological constraint from one or all of the factors considered under moderate and is also isolated. Refounding or demographic support will be very slow or unlikely. The expression of migratory life histories will not be possible or seriously constrained. If the population is not already at a low level and it is reduced to a low level **?** will be ≤ 1.

None: The local population is absent with no potential for recolonization.

Comment: The probabilities were estimated for this node by three biologists, Bruce Rieman, Jason Dunham, and Danny Lee, all with experience and background in conservation biology, metapopulation theory, and its application to salmonids. Each reviewed the definitions and then estimated the probabilities independently. The estimates and justifications were shared among them and then each reviewed and revised their estimates where inconsistency in interpretation of the definitions or states was apparent. We developed the final estimates from the evenly weighted mean of the three independent estimates.

This node is informed by *Community Change* for non-anadromous fishes and by *Exotic Threat* for anadromous fishes but the values in the table remain the same. Where a population is already strong, the most likely condition should be that it retains the potential to be strong, i.e. High Potential. Even where the community has changed or recovery potential is reduced the fact that the population is currently strong indicates that other factors have not substantially constrained population dynamics. The highest potential should obviously be where nothing else appears to be compromised. By definition if the population is present long term potential cannot be none. The uncertainty is high however if a long term change has occurred and recovery potential is none. If current condition is strong High Potential must remain a possibility (it's already strong) but the current condition and recovery potential are in conflict. Several possibilities exist: characteristics of the subwatershed are such that they don't constrain the population; characteristics have changed and the condition of the population has yet to respond (i.e., a lag); or the effects will remain unimportant until the population drops to a low level in response to some environmental disturbance. In this case we were largely uncertain as to whether long term potential was constrained or not and simply broke the conditions more evenly between high and the other states. Because the population was already strong, moderate was more likely than low and none is impossible.

The other combinations of conditions with current status strong were largely interpolated from these two end points. Because we remain uncertain about the relative influence of metapopulation processes on the limited time scale relevant to this evaluation (Rieman and Dunham, in press), we weighted the influence of community change more strongly than recovery potential.

Where current status was depressed we concluded that long term potential is more uncertain. Populations may be depressed either from biotic constraints or from conditions that have changed in habitat or the environment. A depressed population may be isolated and have been through a serious bottleneck or may have remained at modest population levels with no genetic consequences. The information from recovery potential and community change should help to mitigate some of the uncertainty. Because the actual population size remains in question in any case, we split probabilities between high and moderate or moderate and low depending on the relative influence of the conditioning nodes. Again we tended to place more weight on the community change effects than on recovery potential.

Where the population is absent we concluded that recovery potential is the most important consideration. If there is no recovery potential there is no chance that the subwatershed can be colonized or refounded. We concluded that high recovery potential did provide some chance of a high, long term potential but because we remain uncertain about why the population is absent the most likely condition remains none. We were more pessimistic about the potential where there was a community change or exotic threat. Biotic resistence imposed by the new species (Adams 1999; Moyle and Light 1996), a dramatic change in the productivity of the system with the loss of anadromous salmonids, or both could make colonization (or recolonization) an unlikely event.

Mean Probabilities and Standard Errors Estimated by three biologists For Biological Potential:

Current Status	Recovery Potential	Community Change or Exotic Threat	Mean Biological Potential				Standard Error Biological Potential			
			High	Mod.	Low	None	High	Mod.	Low	None
Strong	High	Yes	78	16	5	0	6.0	4.1	2.9	0.0
		No	95	3	2	0	2.9	2.0	0.9	0.0
	Moderate	Yes	55	36	9	0	7.6	7.5	0.7	0.0
		No	75	22	3	0	7.6	9.2	1.5	0.0
	None	Yes	40	40	20	0	10.0	5.8	5.8	0.0
		No	58	32	9	0	10.1	10.1	0.7	0.0
Depressed	High	Yes	22	58	20	0	4.4	8.3	5.8	0.0
		No	30	62	8	0	5.8	7.3	1.7	0.0
	Moderate	Yes	12	55	33	0	4.4	5.0	6.3	0.3
		No	22	62	17	0	6.7	7.3	4.4	0.0
	None	Yes	1	28	70	1	0.7	1.5	2.9	1.0
		No	3	39	58	0	1.3	1.3	1.7	0.3
Absent	High	Yes	1	6	35	58	0.7	4.6	13.2	13.0
		No	7	13	32	48	1.7	3.3	14.8	13.0
	Moderate	Yes	0	2	14	83	0.3	1.2	3.8	4.4
		No	1	6	20	73	0.7	1.0	5.0	6.7
	None	Yes	0	0	0	100	0.0	0.0	0.0	0.0
		No	0	0	0	100	0.0	0.0	0.0	0.0

Future Population Status

Definition:

The terminal node for all of our models was the future status for the salmonid population associated with the subwatershed or collection of subwatersheds. The analysis is limited to subwatersheds that support habitat for spawning and rearing life stages. This node is influenced by the *aquatic habitat condition*, *migrant survival*, and *biological potential* nodes. Because the analysis is restricted to the potential range for the species or form in question, all subwatersheds in the analysis either did or could have supported populations historically.

States:

Strong: All major life history types that historically occurred are still present; numbers are stable or increasing, and the population is likely to be at half or more of mean historical size or density or that expected in comparable environments that have not been significantly altered through human disruption. The population associated with the subwatershed retains the overall resilience to return from low levels (i.e., 10 percent of carrying capacity) within 3 to 5 generations.

Depressed: The spawning and rearing stages occur but the population associated with the subwatershed fail to meet one or more of the other criteria above.

Absent: Spawning and rearing life stages do not occur in the subwatershed.

Source: The conditional probabilities for this node were estimated independently through expert opinion for each species in the analysis (bull trout, westslope cutthroat trout, redband trout, Yellowstone cutthroat trout, stream type chinook salmon, and steelhead). The estimates were made in a series of workshops that included four to seven biologists with substantial field and analytical experience with each species. In each workshop we reviewed the goal and approach of our analysis and then reviewed and discussed the definition for *Future Status* as well as the definitions for the parent nodes. Each biologist made a preliminary estimate of the conditional probabilities based on their personnel experience, available data, and interpretation of the nodes. Each participant then reviewed and discussed the estimates made by other participants. Obvious discrepancies in interpretation were used to focus discussions intended to clarify definitions to the extent possible develop a consistent interpretation of contributing information. Following the review and discussion each participant was allowed to revise their estimates. Because some definitions were revised between workshops, all participants were asked to review and revise their estimates a third and final time. The conditional probabilities for each participant were pooled with equal weights to develop the final tables used in the networks.

Average of the conditional probabilities for Stream Type Chinook salmon estimated by five biologists. Standard errors are shown in parentheses.

Habitat Capacity	Biological Potential	Migrant Survival	Stream-Type Chinook		
			Strong	Depressed	Absent
High	High	High	90.0 (0.00)	8.0 (0.89)	2.0 (0.89)
		Moderate	49.0 (5.57)	33.0 (4.06)	18.0 (4.64)
		Low	1.4 (0.98)	20.6 (5.33)	78.0 (5.83)
	Moderate	High	67.0 (5.39)	27.6 (4.27)	5.4 (1.29)
		Moderate	33.0 (7.00)	46.0 (2.92)	21.0 (4.30)
		Low	1.4 (0.98)	14.6 (4.32)	84.0 (4.85)
	Low	High	15.0 (5.48)	55.0 (6.71)	30.0 (10.37)
		Moderate	6.0 (2.92)	50.0 (9.08)	44.0 (10.30)
		Low	0.6 (0.40)	9.4 (4.92)	90.0 (5.24)
	None	High	0	0	100
		Moderate	0	0	100
		Low	0	0	100
Moderate	High	High	67.0 (4.90)	27.6 (4.56)	5.4 (1.29)
		Moderate	30.0 (7.91)	48.0 (5.61)	22.0 (6.44)
		Low	1.4 (0.98)	11.6 (3.47)	87.0 (3.39)
	Moderate	High	45.0 (8.94)	39.4 (4.57)	15.6 (5.56)
		Moderate	19.0 (8.12)	56.0 (2.92)	25.0 (5.92)
		Low	0.6 (0.40)	10.4 (3.08)	89.0 (2.92)
	Low	High	6.0 (2.92)	55.0 (9.08)	39.0 (11.45)
		Moderate	1.4 (0.98)	46.6 (9.41)	52.0 (10.07)
		Low	0.4 (0.24)	2.4 (0.93)	97.2 (0.97)
	None	High	0	0	100
		Moderate	0	0	100
		Low	0	0	100
Low	High	High	17.6 (4.82)	63.8 (6.86)	18.6 (3.60)
		Moderate	6.4 (1.57)	59.6 (6.18)	34.0 (6.20)
		Low	0.8 (0.58)	10.8 (4.82)	88.4 (4.70)
	Moderate	High	9.4 (2.62)	64.6 (4.38)	26.0 (4.30)
		Moderate	3.0 (1.38)	56.4 (4.52)	40.6 (4.99)
		Low	0.6 (0.40)	4.2 (2.75)	95.2 (2.67)
	Low	High	1.6 (1.03)	45.4 (8.70)	53.0 (9.17)
		Moderate	1.2 (0.97)	27.2 (7.64)	71.6 (8.52)
		Low	0.2 (0.20)	0.6 (0.24)	99.2 (0.37)
	None	High	0	0	100
		Moderate	0	0	100
		Low	0	0	100

Average of the conditional probabilities for steelhead estimated by six biologists. Standard errors are shown in parentheses.

Habitat Capacity	Biological Potential	Migrant Survival		Steelhead	
			Strong	Depressed	Absent
High	High	High	91.8 (1.17)	7.0 (1.32)	1.2 (0.31)
		Moderate	61.7 (5.58)	28.2 (2.52)	10.1 (4.00)
		Low	5.3 (2.47)	26.2 (5.83)	68.5 (7.04)
	Moderate	High	70.8 (3.75)	23.8 (3.65)	5.4 (2.01)
		Moderate	38.3 (5.58)	42.2 (3.52)	19.5 (4.89)
		Low	3.2 (1.56)	17.5 (5.18)	79.3 (6.09)
	Low	High	32.5 (9.81)	49.2 (6.38)	18.3 (6.67)
		Moderate	14.2 (4.90)	50.0 (5.92)	35.8 (5.54)
		Low	2.0 (1.00)	13.3 (4.55)	84.7 (5.29)
	None	High	0	0	100
		Moderate	0	0	100
		Low	0	0	100
Moderate	High	High	76.7 (3.07)	17.8 (2.50)	5.5 (1.57)
		Moderate	40.8 (6.64)	39.2 (3.96)	20.0 (5.00)
		Low	2.8 (1.64)	17.0 (3.74)	80.2 (4.40)
	Moderate	High	53.3 (5.27)	36.7 (5.20)	10.0 (2.22)
		Moderate	25.5 (6.92)	49.8 (4.40)	24.7 (5.52)
		Low	2.0 (1.13)	16.0 (4.55)	82.0 (5.29)
	Low	High	14.7 (5.84)	49.8 (5.10)	35.5 (7.02)
		Moderate	7.5 (4.79)	43.3 (8.13)	49.2 (9.08)
		Low	1.0 (0.45)	8.0 (3.30)	91.0 (3.50)
	None	High	0	0	100
		Moderate	0	0	100
		Low	0	0	100
Low	High	High	24.0 (6.15)	56.5 (7.48)	19.5 (5.04)
		Moderate	16.8 (5.33)	56.7 (6.67)	26.5 (5.50)
		Low	1.2 (0.54)	19.5 (6.13)	79.3 (6.06)
	Moderate	High	12.5 (3.82)	55.8 (8.89)	31.7 (8.43)
		Moderate	7.0 (3.21)	48.8 (7.83)	44.2 (8.60)
		Low	0.8 (0.40)	15.2 (5.04)	84.0 (4.95)
	Low	High	4.7 (3.18)	39.5 (6.37)	55.8 (7.79)
		Moderate	2.2 (1.25)	31.2 (6.82)	66.7 (7.26)
		Low	0.5 (0.34)	2.3 (0.76)	97.2 (0.87)
	None	High	0	0	100
		Moderate	0	0	100
		Low		0	100

Averages of the conditional probabilities for four non-anadromous salmonids . The probabilities for bull trout were estimated by seven biologists, for Yellowstone cutthroat by five biologists, for Westslope cutthroat by five biologists, and for redband trout by six biologists. The standard errors are shown in parentheses.

Habitat Capacity	Biological Potential	Bull Trout			Redband Trout		
		Strong	Depressed	Absent	Strong	Depressed	Absent
High	High	87.7 (3.20)	9.6 (1.96)	2.7 (1.27)	86.5 (2.50)	11.8 (1.92)	1.7 (0.71)
	Moderate	41.5 (6.61)	47.4 (6.56)	11.1 (2.74)	54.2 (7.35)	36.7 (7.03)	9.2 (2.07)
	Low	7.2 (1.49)	60.7 (6.59)	32.1 (6.80)	22.3 (9.82)	48.2 (8.83)	29.5 (7.85)
	None	0	0	100	0	0	100
Moderate	High	42.9 (9.50)	41.7 (6.85)	15.4 (4.75)	61.7 (4.59)	31.8 (3.33)	6.5 (1.63)
	Moderate	20.7 (7.35)	50.0 (6.64)	29.3 (8.96)	38.3 (9.89)	43.5 (6.26)	18.2 (4.69)
	Low	2.4 (1.17)	39.0 (8.77)	58.6 (8.84)	12.8 (4.51)	51.7 (7.38)	35.5 (10.61)
	None	0	0	100	0	0	100
Low	High	6.4 (2.37)	50.0 (9.51)	43.6 (11.00)	19.7 (4.98)	64.2 (5.97)	16.2 (4.13)
	Moderate	3.0 (1.11)	37.3 (9.15)	59.7 (9.63)	10.8 (3.96)	56.5 (9.29)	32.7 (9.62)
	Low	0.9 (0.70)	15.6 (4.09)	83.6 (4.04)	4.7 (3.16)	34.5 (10.17)	60.8 (12.81)
	None	0	0	100	0	0	100

Habitat Capacity	Biological Potential	Westslope Cutthroat Trout			Yellowstone Cutthroat Trout		
		Strong	Depressed	Absent	Strong	Depressed	Absent
High	High	86.0 (2.92)	11.0 (2.28)	3.0 (0.84)	91.0 (1.87)	7.2 (1.16)	1.8 (0.86)
	Moderate	44.0 (12.39)	50.4 (12.15)	5.6 (1.17)	49.0 (5.57)	42.4 (5.08)	8.6 (3.08)
	Low	10.0 (7.74)	54.8 (9.53)	35.3 (6.73)	8.4 (3.17)	63.0 (8.46)	28.6 (9.38)
	None	0	0	100	0	0	100
Moderate	High	57.0 (8.31)	35.6 (8.18)	7.4 (1.66)	61.0 (5.57)	33.6 (5.14)	5.4 (1.29)
	Moderate	31.0 (13.73)	49.0 (11.34)	20.0 (4.18)	32.6 (7.33)	52.6 (7.76)	14.6 (4.86)
	Low	5.6 (3.70)	41.4 (11.65)	53.0 (10.20)	3.6 (1.81)	57.4 (10.98)	39.0 (11.34)
	None	0	0	100	0	0	100
Low	High	12.6 (5.68)	52.8 (7.64)	34.6 (4.20)	15.0 (6.12)	71.0 (6.96)	14.0 (1.87)
	Moderate	4.4 (2.80)	36.6 (10.18)	59.0 (9.14)	6.0 (2.92)	60.0 (8.80)	34.0 (7.97)
	Low	1.0 (1.00)	18.0 (8.15)	81.0 (7.97)	0.6 (0.60)	34.4 (9.27)	65.0 (9.49)
	None	0	0	100	0	0	100

BD Node Values

The nature of the networks made it difficult to interpret the relative magnitude of the trends observed. So we estimated the "maximum" possible change in salmonid status given the constraints of our networks. The maximum or "BD" was estimated by assuming that all disruptive effects of current and future land management were removed from Federal lands to provide a simple comparison of the change in conditions expected with any alternative relative to what might be possible given the constraints in biological potential and migrant survival. The following changes to node values were used:

Landscape Road Density data: rddlow=1
rddmod=0
rddhigh=0
Landscape uncharacteristic grazing: grzyes=0
grzno=1
Landscape uncharacteritic soil disturbance: grdlow=1
grdmod=0
grdhi=0
Standards and Guides: sghi=1
sgmod=0
sglow=0

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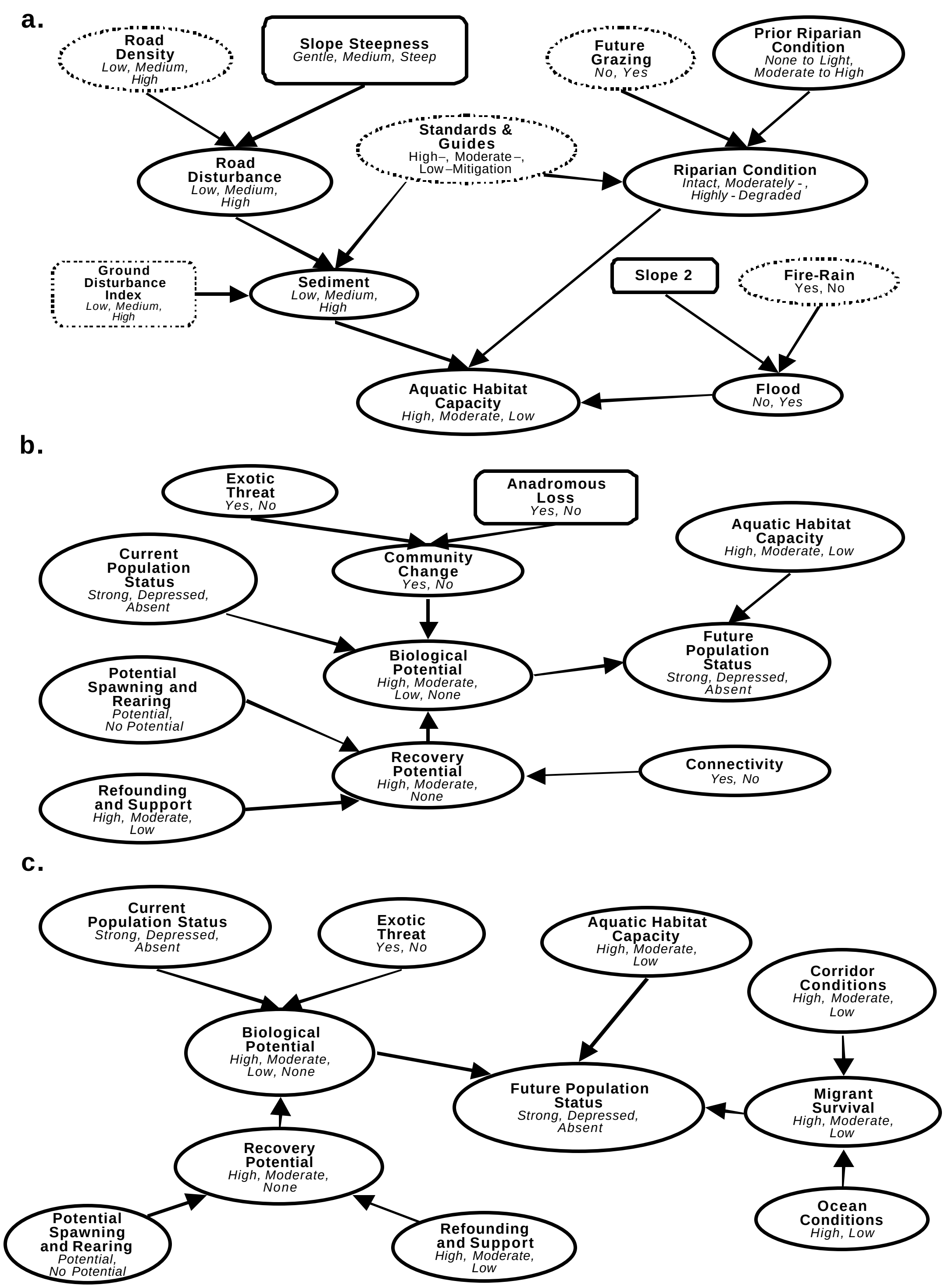
Figure OV-1. Bayesian Belief Networks for estimation of (a) aquatic habitat capacity and future population status for (b) resident and © anadromous salmonids for subwatersheds under all alternatives. Definitions of each node and a brief summary of the source information are in Appendix 1. Shaded nodes represent inputs for projected land management impacts.


a.
Road Density
Low, Medium, High
Slope Steepness
Gentle, Medium, Steep
Future Grazing
No, Yes
Prior Riparian Condition
None to Light, Moderate to High
Standards & Guides
High–, Moderate–, Low–Mitigation
Road Disturbance
Low, Medium, High
Riparian Condition
Intact, Moderately - , Highly - Degraded
Ground Disturbance Index
Low, Medium, High
Sediment
Low, Medium, High
Slope 2
Fire-Rain
Yes, No
Aquatic Habitat Capacity
High, Moderate, Low
Flood
No, Yes
b.
Exotic Threat
Yes, No
Anadromous Loss
Yes, No
Aquatic Habitat Capacity
High, Moderate, Low
Current Population Status
Strong, Depressed, Absent
Community Change
Yes, No
Biological Potential
High, Moderate, Low, None
Future Population Status
Strong, Depressed, Absent
Potential Spawning and Rearing
Potential, No Potential
Recovery Potential
High, Moderate, None
Connectivity
Yes, No
Refounding and Support
High, Moderate, Low
c.
Current Population Status
Strong, Depressed, Absent
Exotic Threat
Yes, No
Aquatic Habitat Capacity
High, Moderate, Low
Corridor Conditions
High, Moderate, Low
Biological Potential
High, Moderate, Low, None
Future Population Status
Strong, Depressed, Absent
Migrant Survival
High, Moderate, Low
Recovery Potential
High, Moderate, None
Ocean Conditions
High, Low
Potential Spawning and Rearing
Potential, No Potential
Refounding and Support
High, Moderate, Low

Attachment A
SDEIS Alternative Aquatic Management Scenarios

<u>Alternative S1</u>

<u>10. Key PACFISH, priority INFISH and BO</u> (T&E, some Westslope CT)

RHCAs–150 ft (1+ site trees) perennial non-fish-bearing
100 ft (1- site trees) intermittent
Modification of RHCAs for T&E through consultation

Greater restoration and monitoring emphasis

Roads evaluation

EAWS emphasis (1/admin. unit/yr), subbasin assessment (1/admin. unit/yr)–aquatics only

<u>9. Priority watersheds</u>

EAWS prior to ground disturbing activities

Additional RMOs (e.g., fine sediment)

Limited road densities

<u>8. Selway-Salmon BO</u>

More restriction on ground disturbance

Greater restoration emphasis

<u>23. INFISH</u> (FS outside of bull trout and anadromous spp.)

RHCAs–150 ft (1+ site trees) perennial non-fish-bearing
50 ft intermittent
Modification through project or EAWS analysis

<u>24. BLM</u> (outside of bull trout and anadromous spp.)

Land management plan direction

1. Wilderness and natural areas (MACs 1&2) **Same for all alts.**

Impacts limited to recreation and grazing not regulated thru PACFISH/INFISH and fire management (PNF)

12. Roadless (outside of wilderness) **Same for all alts.**

Roadless policy

Roads analysis

Existing allocation (e.g., timber harvest)

26. Non-federal outside of T&E **Same for all alts.**

Existing land and water regulations

25. Non-federal T&E **Same for all alts.**

Some increased emphasis on protection and restoration

Alternative S2

2. A1

Conservative, passive management

No road building (accounted for in road density variable)

Adjustment prior to ROD (also applies to A2); no acreage limitation??

4. A2/Integrated restoration/aquatic priority

Conservative, active management

No road building

Lower probability of high aquatic habitat condition than A1 due to short-term effects and uncertainty of restoration

6. A2 outside of integrated restoration priority

No road building

Lower probability of high aquatic habitat condition than A2/restoration priority–
Less restoration
Lower priority for subbasin review, EAWS, roads analysis, water quality protocol

14. Base level, TEP, integ. restoration/aquatic priority

RCAs–2 site trees perennial non-fish bearing
1 site tree intermittent
RIA on all streams
EAWS required for modification

Higher frequency and rate of subbasin review, EAWS (50 percent of TEP hucs in 5 yrs.), roads analysis, and water quality protocol

Greater restoration (long term benefits vs. short-term disruption, greater benefits where these correspond to aquatic restoration priorities)

15. Base level, integ. restoration/aquatic priority, non-TE

Higher frequency and rate of subbasin review

Lower frequency and rate of EAWS (50 percent of hucs in 13 yrs.), roads analysis, and water quality protocol

18. Base level, TEP outside of restoration priorities

Higher frequency and rate of EAWS (50 percent of TEP hucs in 5 yrs.), roads analysis, and water quality protocol

Lower frequency and rate of subbasin review

17, Base level, restoration priority (non-aquatic), non-TE

Higher frequency and rate of subbasin review

Restoration does not correspond to aquatic priorities

19. Base level outside of restoration priority, non-TE

Lower frequency and rate of subbasin review

Lower frequency and rate of EAWS (50 percent of hucs in 13 yrs.), roads analysis, and water quality protocol

<u>11. Roadless (outside of wilderness)</u> **Same for all alts.**

Roadless policy

Roads analysis

Existing allocation (e.g., timber harvest)

<u>26. Non-federal outside of T&E</u> **Same for all alts.**

Existing land and water regulations

<u>25. Non-federal T&E</u> **Same for all alts.**

Some increased emphasis on protection and restoration

<u>1. Wilderness and natural areas</u> **Same for all alts.**

Impacts limited to recreation and grazing not regulated thru base level and fire management (PNF)

Alternative S3

<u>3. A1</u>

Network adjustment post ROD through LMP revision (interim locations may not match selection criteria); acreage limitation

<u>5. A2/Integrated restoration/aquatic priority</u>

Network adjustment post ROD through LMP revision (interim locations may not match selection criteria); acreage limitation

Lower frequency and rate of subbasin review, EAWS (33 percent of hucs in 10 yrs.), roads analysis, and water quality protocol

<u>7. A2 outside of integrated restoration priority</u>

Network adjustment post ROD through LMP revision (interim locations may not match selection criteria); acreage limitation

20. Base level, integ. restoration/aquatic priority

RCAs–1 site tree perennial non-fish-bearing
½ site tree intermittent
RIA intermittent
EAWS required for modification

Lower frequency and rate of subbasin review, EAWS (33 percent of hucs in 10 yrs.), roads analysis, and water quality protocol

Increased restoration (greater benefits where these correspond to aquatic restoration priorities)

21. Base level, restoration priority (non-aquatic)

Lower frequency and rate of subbasin review, EAWS (33 percent of hucs in 10 yrs.), roads analysis, and water quality protocol than S2

Restoration does not correspond to aquatic priorities

22. Base level outside of restoration priority

No restoration emphasis

13. Roadless (outside of wilderness) **Same for all alts.**

Roadless policy

Roads analysis

Existing allocation (e.g., timber harvest)

26. Non-federal outside of T&E **Same for all alts.**

Existing land and water regulations

25. Non-federal T&E **Same for all alts.**

Some increased emphasis on protection and restoration

1. Wilderness and natural areas **Same for all alts.**

Impacts limited to recreation and grazing not regulated thru base level and fire management (PNF)