CHAPTER 3
ESU Structure and Desired Status

In this section we describe the hierarchical biological structure characteristic of salmonid ESUs and give an overview of the four Snake River ESUs. This section also contains a description of the ICTRT's recommendations for biological viability criteria for these ESUs and their component major population groups (MPGs) and independent populations. Applying the biological viability criteria enables us to generate a "desired status" for the salmon and steelhead populations in Snake River subbasins.

3.1 Salmonid Population Structure

Salmonid biological structure is hierarchical in the sense that the species' longterm persistence depends on a complex set of characteristics including homing propensity, distribution across the landscape, and diverse genetic, life history, and morphological characteristics that can be seen to "add up" from the smallest spawning populations in tributary creeks and streams to larger groups of populations and ultimately ESU and species.

Recovery planning efforts focus on this biologically based hierarchy, which reflects the apparent degree of connectivity between the fish in each of these levels (Figure 4-1). ESU and population were formally defined [by whom?] for listing, delisting, and recovery planning purposes. The ICTRT identified an additional level between the population and ESU, as follows:

- **Evolutionarily Significant Units:** Two criteria define an ESU of salmon and steelhead listed under the ESA: 1) it must be substantially reproductively isolated from other conspecific units, and 2) it must represent an important component of the evolutionary legacy of the species (Waples 1991). ESUs may contain multiple populations that are connected by some degree of migration, and hence may have broad geographic areas, transcending political borders.

- **Major Population Groups:** Within ESUs, independent populations can be grouped into larger aggregates that share similar genetic, geographic (hydrographic), and/or habitat characteristics (McClure et al. 2003). These "major groupings" are groups of populations that are isolated from one another over a longer time scale than that defining the individual populations, but which retain some degree of connectivity greater than that between ESUs. The ICTRT defines this level in the hierarchy as major population groups (MPGs). These MPGs are analogous to "strata" as defined by the Lower Columbia-Upper Willamette TRT and "geographic regions" described by the Puget Sound TRT.

- **Independent Populations:** McElhany et al. (2000) defined an independent population as: *"…a group of fish of the same species that spawns in a particular lake or stream (or portion thereof) at a particular season and which, to a substantial degree, does not interbreed with fish from any other group spawning*

> *in a different place or in the same place at a different season. For our purposes, not interbreeding to a 'substantial degree' means that two groups are considered to be independent populations if they are isolated to such an extent that exchanges of individuals among the populations do not substantially affect the population dynamics or extinction risk of the independent populations over a 100-year time frame."*

> Independent populations are the units that will be combined to form alternative recovery scenarios for MPG and ESU viability ─ and, ultimately, they are the objects of recovery efforts.

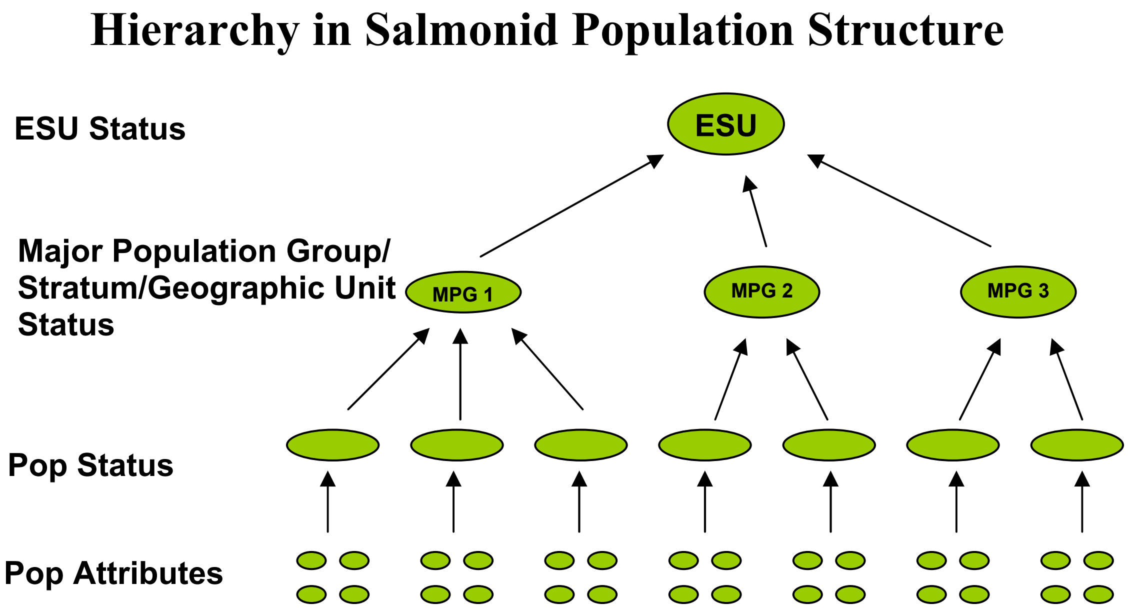

Figure 3-1. Hierarchical levels of ESA-listed ESU, MPG, and independent populations.

NMFS has adopted the ESU, MPG, and population structure defined by the ICTRT for purposes of Snake River salmon and steelhead recovery planning. These groups were defined based on genetic, geographic (hydrographic) and habitat considerations (McClure et al. 2003) with guidance provided in the NMFS technical memorandum, *Viable salmon populations and the recovery of evolutionarily significant units* (McElhany et al. 2000).

3.2 Population Identification

As one of its first tasks in recovery planning, the ICTRT delineated independent populations within the listed ESUs in the Interior Columbia Basin, including those in the Snake River Basin. This delineation of population boundaries is critical for effective conservation planning, since incorrect lumping or splitting of populations (or portions of populations) can provide an inaccurate picture of population status. Over- or underestimating the true status (abundance/productivity, spatial structure/diversity) may lead to failed recovery efforts. Similarly, if two "true" populations are treated as a single unit, the status of one may mask the other, potentially leading to the loss of one of the populations (McClure et al. 2003).

The ICTRT assessed a variety of information sources to delineate independent populations (McClure et al. 2003). They initially classified major groups of populations within ESUs, and then identified independent populations within major groups. They used a variety of data types to define MPGs and independent populations. However, in no case was the entire array of desired information available to inform their decision process. They relied heavily on genetic information, distances between spawning areas related to dispersal (straying distance) as evidence of reproductive isolation, and habitat characteristics. Phenotypic (life history and morphological) characteristics were also considered for distinction at the population level. In addition, they considered two demographic factors. First, because the goal was to identify demographically independent populations, they examined the correlation in abundance time series between areas. Second, they considered historical population size in determining potential population capacity (McClure et al. 2003).

3.3 Snake River Salmonid ESUs

There are four salmonid ESUs in the Snake River Basin: Snake River spring/summer Chinook salmon and Snake River fall Chinook salmon (*O. tshawytscha*), Snake River sockeye salmon (*O. nerka*), and Snake River steelhead (*O. mykiss*).

Snake River Spring/Summer Chinook Salmon ESU

The Snake River Spring/Summer Chinook Salmon ESU includes those fish that spawn in the Snake River drainage and its major tributaries, including the Grande Ronde River and the Salmon River, and that complete their adult, upstream migration (passing Bonneville Dam) between March and July. These stream-type fish rear in freshwater for slightly more than a year before smoltification and seaward migration. Since the late 1800s, the ESU has suffered dramatic declines as a result of heavy harvest pressures, habitat modification and loss, and likely inadvertent negative effects of hatchery practices. More recent declines, since the 1950s, have occurred with the construction of the hydropower system on the Snake and Columbia Rivers. As a result of these declines in abundance, this ESU was listed as threatened under the Endangered Species Act in 1992.

The ICTRT (2003) identified five major population groupings in this ESU, with a total of 31 extant demographically independent populations. The total is 32 if Panther Creek, where spring/summer Chinook are being reintroduced, is counted, but 28 if Panther and three other populations are excluded because they are not the original, native stock. Asotin Creek, Big Sheep Creek, Lookingglass Creek, and Panther Creek populations are considered "functionally extirpated" (personal communication, Michelle McClure, 2006) because they are made up of hatchery fish from non-local broodstock.

Snake River Fall Chinook ESU

The Snake River fall Chinook ESU includes fish spawning in the lower mainstem of the Snake River, and lower reaches of the Clearwater, Imnaha, Grande Ronde, Salmon, and Tucannon rivers. The Lyons Ferry Hatchery stock, originally derived from returns to the lower Snake River, was included in the ESU. Unlike the other listed Chinook ESUs in the Interior Columbia River basin, Snake River fall Chinook exhibit a subyearling, ocean-type life history. These fish return to the Snake River basin in September and October and spawn shortly thereafter. Juveniles outmigrate the next summer. This ESU has lost approximately 80 percent of its habitat as a result of construction of dams on the mainstem Snake River, culminating in the completion of the Hells Canyon Dam complex in the 1960s. The ICTRT identified a single population in this ESU on the basis of current spawning distribution and abundance.

Snake River Sockeye Salmon ESU

The Snake River Sockeye Salmon ESU had the dubious distinction of being the first Pacific Northwest salmon species to be listed under the Endangered Species Act. Once abundant in a variety of lakes in the Snake River drainage, beginning in the late nineteenth century anadromous sockeye salmon (*Oncorhynchus nerka*) were affected by heavy harvest pressures, unscreened irrigation diversions, and dam construction (see Bjornn et al. 1968). In addition, in the 1950s and 1960s, the Idaho Department of Fish and Game actively eradicated sockeye salmon from some locations. As a result of these varied impacts, and the consequent drop in abundance, Snake River sockeye salmon were listed as endangered in November 1991 (NMFS 1991).

O. nerka in general show a great diversity of life histories. In the Snake River basin, three forms are currently recognized: an anadromous form, beach-spawning resident/residual fish, and resident kokanee (Brannon et al. 1994). A number of genetic studies have been conducted to determine the relationships between the variety of life-history types and stocks in the interior Columbia River basin (Monan 1991; Winans et al. 1996; Waples et al. 1997; Faler and Powell 2003). These analyses indicate that in the Sawtooth Valley *O. nerka* are genetically distinct from all other kokanee and sockeye salmon sampled in Idaho, Washington, and British Columbia. Waples et al. (1997) allozyme-based analysis further indicates that Redfish Lake sockeye and beach spawners are distinct from Redfish Lake kokanee (Figure VII-1). Importantly, although the residual sockeye salmon are morphologically most similar to kokanee (small size), they spawn in the same location and at the same time as anadromous sockeye, whereas kokanee spawning is segregated both temporally and spatially from the anadromous fish (Brannon et al. 1994). Otolith microchemistry analyses (Rieman et al. 1994) revealed that some Redfish Lake *O. nerka* outmigrants were progeny of resident females. Based on this information, the Snake River sockeye salmon ESU was determined to include Redfish Lake anadromous sockeye and residual/resident beach spawners (Waples et al. 1991, BRT 2003).

The anadromous component of this ESU travels a greater distance from the sea (approximately 900 miles) to a higher elevation (6,500 feet) than any other sockeye salmon population.

The Snake River steelhead ESU was listed as threatened on August 18, 1997 (62 FR 43937). Recently, NMFS revised its species determinations for West Coast steelhead under the ESA, delineating steelhead-only distinct population segments (DPSs). The former steelhead ESU included both the anadromous steelhead and resident, non-anadromous, rainbow trout. The steelhead DPS does not include rainbow trout, which are under the jurisdiction of USFWS. The Federal Register Notice contains a more complete explanation of this listing decision. NMFS listed the Snake River steelhead DPS as threatened on January 5, 2006 (71 FR 834).

To avoid confusion in this recovery plan, which draws upon some of the scientific literature that was written before the DPS listing decision was posted, we ask the reader to understand that references to "ESU viability criteria" or "ESU-level plans or considerations" imply the steelhead DPS as well. Also, since both salmon ESUs and steelhead DPSs are considered to be “species,” as defined in Section 3 of the ESA, we may refer to “species-level” plans, implying both ESU and DPS.

The Snake River steelhead DPS includes only the anadromous *O. mykiss* that spawn in the Snake River and its tributaries. These fish are genetically differentiated from other Interior Columbia steelhead populations; they spawn at higher altitudes (up to 2,000 m) and after longer freshwater migrations (up to 1,500 km) (Busby et al. 1996). Like other salmonid species in the Snake River basin, these populations have been affected by a wide variety of impacts, from the development of the hydropower corridor to habitat degradation and loss to inadvertent negative effects of hatchery practices. Although total abundance is relatively high, the large majority of these fish are of hatchery origin. In addition, the ESU/DPS has suffered dramatic declines in at least the last 20 years. As a result of these factors, this ESU was listed as threatened in 1999.

Like steelhead in other areas, these fish exhibit a wide range of life-history strategies, including varying times of freshwater rearing or ocean residence, or elimination of an ocean residence altogether. Traditionally, two prominent life-history strategies have been recognized in this area. A-run fish are smaller, on average have a shorter freshwater and ocean residence, and apparently begin their up-river migration earlier in the year. B-run fish are larger, spend more time rearing in both fresh and salt water, and appear to begin their up-river migration later in the year.

The ICTRT identified 24 populations in 5 major groupings in this ESU. Both genetic distances and distances between spawning aggregates played an important role in defining the major groupings, while life history and habitat or environmental considerations played a larger role at a finer scale. Importantly, allozyme data (Winans unpublished; Marshall unpublished) suggested that spatial distance was more predictive of differentiation than run-type. In analyses of both A- and B-run fish, within-basin genetic distances are uniformly lower than those between basins (McClure et al. 2003).

3.4 Desired Status

The ICTRT recommendations for viability criteria define viability characteristics for each population, MPG, and ESU.

3.4.1 Biologically Based Viability Criteria

NMFS' technical recovery teams (TRTs) were asked to recommend biologically based viability criteria for the listed salmonid species. They used principles described in a NMFS technical memorandum, *Viable Salmon Populations and the Recovery of Evolutionarily Significant Units* (McElhany et al., 2000). Viable salmonid populations (VSP) are defined in terms of four parameters: abundance, population productivity or growth rate, population spatial structure, and life history and genetic diversity. A viable ESU is defined as naturally self-sustaining. Viability criteria identify the metrics and thresholds that may be used to determine the status of a population and the viability risk. ESU-level viability criteria consider the appropriate distribution and characteristics of component populations to maintain a viable ESU in the face of longer-term ecological and evolutionary processes.

The general approach identified for viability criteria has five essential elements:

> ***Stratified Approach:*** Life history and ecological complexity that historically existed should have a high probability of persistence. The ICTRT stratified the Snake River ESUs into groups based on ecoregion characteristics, life history types (e.g. run timing) and other geographic and genetic considerations.
>
> ***Viable Populations:*** Some individual populations within an MPG should have persistence probabilities consistent with a high probability of MPG persistence. The ICTRT defined high persistence probability based on the presence of at least two, or one-half of historical populations, whichever is greater, with a negligible risk of extinction.
>
> ***Representative Populations***: Representative populations need to achieve viability criteria or be maintained, but not every historical population needs to meet viability criteria. Viable combinations of populations should include "core" populations that are highly productive, "legacy" populations that represent historical genetic diversity, and dispersed populations that minimize susceptibility to catastrophic events.
>
> ***Non-deterioration:*** No population should be allowed to deteriorate until ESU recovery is assured, and all extant populations must be maintained. Current populations and population segments must be preserved. Recovery measures will be needed in most areas to arrest declining status and offset the effects of future impacts.
>
> ***Safety Factors:*** Higher levels of recovery should be attempted in more populations than the minimum needed to achieve ESU viability, because not all attempts will be successful. Recovery efforts must target more than the minimum number of

populations and more than the minimum population levels thought to ensure viability. Some populations should be highly viable.

During recovery planning, viability objectives are being recommended at the ESU, MPG, and component population levels as defined by the ICTRT (McClure et al. 2003). Assessments of viability at these different levels follow guidelines and approaches recommended by the ICTRT. The ICTRT's ESU-level viability criteria are designed to assess risk for abundance/productivity and spatial structure/diversity at the population level. These assessments are then "rolled up" to arrive at composites for the MPG and ESU levels.

3.4.2 Independent Population-level Viability Criteria

McElhany et al. state that a viable population should be large enough

- To have high probability of surviving environmental variation observed in the past and expected in the future,
- To be resilient to environmental and anthropogenic disturbances,
- To maintain genetic diversity, and
- To support/provide ecosystem functions.

To address these guidelines, the ICTRT grouped specific population level criteria into two categories: measures addressing abundance and productivity, and measures addressing spatial structure/diversity considerations. They also developed a framework for compiling an aggregate risk score for a population based on the results of applying the individual criteria.

3.4.2.1 Population Abundance and Productivity

Abundance refers to the average number of spawners in a population over a generation or more. Productivity, or population growth rate, refers to the performance of the population over time in terms of recruits produced per spawner.

Viable populations should demonstrate sufficient productivity to support a net replacement rate of 1:1 or higher at abundance levels established as long-term targets. Productivity rates at relatively low numbers of spawners should, on average, be sufficiently greater than 1.0 to allow the population to rapidly return to abundance target levels. Following guidelines from McElhany et al. (2000), the ICTRT identified the following objective for population abundance and productivity:

> *Abundance should be high enough that 1) in combination with intrinsic productivity, declines to critically low levels would be unlikely assuming recent historical patterns of environmental variability; 2)compensatory processes provide resilience to the effects of short term perturbations; and, 3) subpopulation structure is maintained (e.g., multiple spawning tributaries, spawning patches, life history patterns).*

The ICTRT used the viability curve concept (e.g., LC/WTRT 2003) as a framework for defining population-specific abundance and productivity levels to meet this objective. A viability curve describes those combinations of abundance and productivity that yield a particular risk threshold. The two parameters are linked relative to extinction risks associated with short-term environmental variability. This approach recognizes that relatively large populations are more resilient in the face of year-to-year variability in overall survival rates than smaller populations. Populations with relatively high intrinsic productivity ─ the expected ratio of spawners to their parent spawners at low levels of abundance ─ are also more robust at a given level of abundance than populations with lower intrinsic productivity.

Combinations of abundance and productivity are characterized by viability curves that represent specific extinction risks. The ICTRT developed viability curves representing 1 percent, 5 percent, and 25 percent extinction risk. Populations were grouped into four size categories based on historical capacity, represented by the weighted intrinsic potential area within the population boundaries. In order to determine quantity and quality of salmon and steelhead habitat within defined populations, the ICTRT developed a model for calculating intrinsic spawning habitat potential. This metric enabled the ICTRT to quantify and qualify potential habitat based on the relationship of spawning habitat use and local geo-physical features. A Geographic Information System (GIS) was used for the compilation of ecological data, and model development and output. Datasets describing spawning distribution and instream habitat characteristics were key in developing the relationship. After spatial data acquisition, model parameters were established by comparing mapped salmon and steelhead distribution to stream physiography.

In general, spawning surveys were used to describe a species' spatial structure by locality and density. Mapped distributions were then evaluated against stream attributes calculated from common spatial data themes. These included Digital Elevation Models (DEM), the National Hydrography Dataset (NHD), and climatic data from the National Climatic Data Center (NCDC). The NHD layer was subdivided into a continuous series of 200 meter reaches, and this became our basic analysis unit. Using information derived from our GIS layers, the ICTRT was able to compute stream gradient, wetted and bankfull width, and channel confinement, and then assign this information to each 200 meter segment within the stream network. These attributes were concatenated into groupings representing all observed combinations, which included 4 width classes, 6 gradient classes, and 3 confinement classes. Each discrete category was assessed by using statistical methods to compare the relative density of spawners observed within each group. Each habitat class was then assigned a rating of "high", "moderate", "low", or "none" in regards to spawning habitat potential (Table 3-2).

From this analysis, the ICTRT generated similar categories for all stream segments within the Interior Columbia ESUs and assigned their corresponding habitat ratings. By using reach length and width values they computed habitat area for all streams and weighted this value by intrinsic spawning potential, so that "good" = (area * 1.0), "moderate" = (area * 0.5), "low" = (area * 0.25), and "none" = (area * 0.0). The ICTRT identified areas above natural barriers and assigned these reaches a rating of “none.” Natural barriers were identified through expert opinion from field biologists and gradient breaks computed from the DEM. Once calculated, the weighted stream area was summarized for each population and size categories were generated based on these values.

Additionally, they analyzed how weighted habitat was aggregated within populations and labeled reaches with continuous high and moderate ratings as spawning branches. A spawning branch was defined as a stream reach with enough habitat to support 50 spawners. The accumulation of branches within populations then became the basis for defining major spawning areas (MSA). A process was developed for aggregating MSAs by evaluating the continuity of branch habitat and the spatial composition of stream junctions. An MSA was required to have enough weighted habitat to support 500 spawners. MSAs are an important habitat unit for assessing ecological complexity within populations, and for the spatial structure/diversity viability assessment.

Table 3-2. Habitat classes showing spawning potential by steelhead and chinook.

Habitat Factors			Relative Rating	
Stream Width	Gradient	Valley Width	Steelhead	Chinook
<3.7 m (chin) WETTED <3.8 m (sthd) BANKFULL	all gradient classes		None	None
ABOVE to 25 m	0 to .5	20x > BF > 4x	Low	High
		> 20x BF	Low	High
		confined (<= 4x BF)	Low	Medium
	.5 to 1.5	20x > BF > 4x	Medium	Medium
		> 20x BF	Medium	High
		confined (<= 4x BF)	Medium	Low
	1.5 to 4.0	20x > BF > 4x	High	Low
		> 20x BF	High	Medium
		confined (<= 4x BF)	High	Low
	4.0 to 7.0	>4x BF	High	Low
		confined (<= 4x BF)	High	None
	7.0 to 15.0	>4x BF	Low	None
		confined (<= 4x BF)	Low	None
	>15.0	>4x BF	None	None
		confined (<= 4x BF)	None	None
25 to 50	0 to 0.5	>4x BF	Low	Medium
		confined (<= 4x BF)	Low	None
	.5 to 4.0	>4x BF	Medium	Low
		confined (<= 4x BF)	Medium	Low
	4.0 to 10.0	>4x BF	Low	Low
		confined (<= 4x BF)	Low	Low
	10.0 to 15.0	>4x BF	Low	None
		confined (<= 4x BF)	Low	None
	> 15.0	>4x BF	None	None
		confined (<= 4x BF)	None	None
greater than 50 m wetted	all gradient classes	>4x BF	Low	Low
		confined (<= 4x BF)	None	None

The ICTRT determined that abundance levels below 500 individuals for any population would pose unacceptable risk for inbreeding depression and other genetic concerns (McClure et al. 2003), and established a minimum abundance threshold of 500 individuals for the basic size populations. Higher spawning threshold sizes were established incrementally for the three larger population sizes. Viability curves for all four size categories were truncated at the minimum abundance threshold level. Populations were also categorized by their historic spatial distribution pattern and complexity.

The ICTRT also developed specific guidance for assessing current status relative to the abundance/productivity viability risk curves (Cooney et al. in preparation).

Figure 3-1 provides an example of an abundance/productivity viability curve.

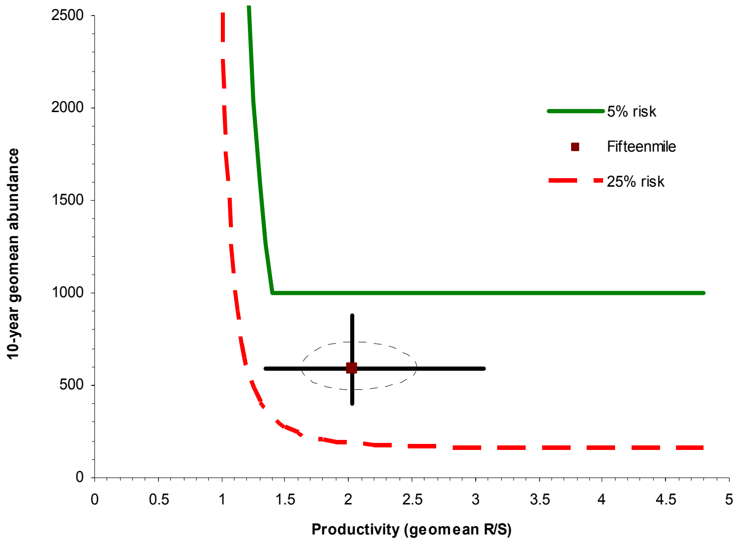

Figure 3-1. Example of abundance/productivity viability curves including Fifteenmile Creek current abundance productivity point estimate with standard error ellipse and adjusted standard error bounds.

3.4.2.2 Spatial Structure and Diversity

Spatial structure and diversity considerations are combined in the evaluation because they are closely integrated. Spatial structure concerns a population's geographic distribution and the processes that affect that distribution. Diversity refers to the distribution of genetic, life history, and phenotypic variation within and among populations.

Distribution influences a population's viability because populations with restricted distribution and few spawning areas are at a higher risk of extinction due to catastrophic environmental events than are populations with more widespread and complex spatial structures. A population with a complex spatial structure, including multiple spawning areas, may experience more opportunity for gene flow, developmental substructure, and life history diversity.

Population-level diversity is similarly important for long-term persistence. Populations exhibiting greater diversity are generally more resilient to short-term and long-term environmental changes. Phenotypic and life history diversity allow populations to use a wider array of environments and protect populations against short-term temporal and spatial environmental changes. Underlying diversity provides the ability to survive longterm environmental changes.

McElhany et al. (2000) provide a number of guidelines for the spatial structure and diversity of viable salmonid populations that consider these principles (Figure 3-2).

Figure 3-2. Viable salmonid population spatial structure and diversity guidelines (McElhany et al. 2000).

The ICTRT identified two primary goals that spatial structure and diversity criteria should address: 1) maintaining natural rates and levels of spatially mediated processes, and 2) maintaining natural patterns of variation. They also provided a format outlining guidelines for achieving these goals. The format identifies mechanisms, factors, and metrics appropriate for assessing population status. Table 3-3 summarizes the associations between these goals, mechanisms, factors, and metrics. Some viability metrics include variable criteria that are dependent on the spatial complexity designation of the population. Spatial complexity designations are presented in Table 3-3.

Table 3-3. Organization of goals, mechanisms, factors and metrics for spatial structure and diversity risk rating.

Goal	Mechanism	Factor	Metrics
A. Allowing natural rates and levels of spatially-mediated processes.	1. Maintain natural distribution of spawning aggregates.	a. number and spatial arrangement of spawning areas.	Number of MSAs, distribution of MSAs, and quantity of habitat outside MSAs.
		b. Spatial extent or range of population	Proportion of historical range occupied and presence/absence of spawners in MSAs
		c. Increase or decrease gaps or continuities between spawning aggregates.	Change in occupancy of MSAs that affects connectivity within the population.
B. Maintaining natural levels of variation.	1. Maintain natural patterns of phenotypic and genotypic expression.	a. Major life history strategies.	Distribution of major life history expression within a population
		b. Phenotypic variation.	Reduction in variability of traits, shift in mean value of trait, loss of traits.
		c. Genetic variation.	Analysis addressing within and between population genetic variation.
	2. Maintain natural patterns of gene flow.	a. Spawner composition.	(1) Proportion of hatchery origin natural spawners derived from a local (within population) brood stock program using best practices.
			(2) Proportion of hatchery origin natural spawners derived from a within MPG brood stock program, or within population (not best practices) program.
			(3) Proportion of natural spawners that are unnatural out-of MPG strays.
			(4) Proportion of natural spawners that are unnatural out-of ESU strays.
	3. Maintain occupancy in a natural variety of available habitat types.	a. Distribution of population across habitat types.	Change in occupancy across ecoregion types

3.4.2.3 Integrating the Four VSP Parameters

These abundance/productivity and spatial structure/diversity considerations form the centerpiece of the ICTRT's framework for assessing ESU viability (Cooney et al. 2005). The approach is based on guidelines in McElhany et al. (2000), the results of previous applications (i.e., Puget Sound and Lower Columbia/Willamette TRTs and Upper Columbia Qualitative Analysis Review), and a review of specific information available relative to listed Interior Columbia ESU populations.

The ICTRT integrates all four VSP parameters using a simple matrix approach (Figure 3-3). The abundance/productivity risk level combines the abundance and productivity VSP criteria using a viability curve. The spatial structure/diversity risk level integrates across 12 measures of spatial structure and diversity. The overall diversity viability rating that any population is assigned is determined using two guiding principles. First, the VSP concept (McElhany et al. 2001) provides a 5 percent risk criterion to define a viable population. Therefore, any population scored moderate or high risk in the abundance/productivity criteria would not meet the recommended viable standards. In addition, any population that is high risk in SS/D would not be considered viable. Second, populations with a Very Low rating for A/P and at least a Low rating for SS/D are considered to be "Highly Viable." Populations with a Low rating for A/P and a Moderate rating for SS/D are considered "Minimally Viable." This integration approach places greater emphasis on the abundance/productivity criteria. These individual ratings are then integrated to determine the viability of major population groups within an ESU. The assessments of individual MPGs are aggregated to assess the ESU as a whole (ICTRT 2005).

Figure 3-3. Matrix of possible Abundance/Productivity and Spatial Structure/Diversity scores for application at the population level. Percentages for abundance and productivity (A/P) scores represent the probability of extinction in a 100-year time period. Cells that contain a "V" are considered viable combinations; "HV" indicates Highly Viable combinations and "MV" indicates Minimally Viable combinations. Cells that are not labeled "HV," "V," or "MV" are a risk level below what the ICTRT recommends as viable. (Cooney et al. 2005).

		Spatial Structure/Diversity Risk			
		Very Low	Low	Moderate	High
Abundance/ Productivity Risk	**Very Low (<1 percent)**	**HV**	**HV**	**V**	
	Low (<5 percent)	**V**	**V**	**MV**	
	Moderate (6-25 percent)				
	High >(25 percent)				

3.4.3 Major Population Group Viability Criteria

The ICTRT recommended Major Population Group (MPG) level risk criteria that assess the level of risk associated with its component populations. While individual populations meeting viability criteria are expected to have low risk of extinction, these additional, MPG-level criteria ensure robust functioning of the population group and provide resilience to catastrophic loss of one or more populations. In developing these criteria, the ICTRT assumed that catastrophes do not increase dramatically in frequency, that populations are not lost permanently (due to catastrophe or anthropogenic impacts) and that permanent reductions in productivity, including long-term, gradual reductions in productivity do not occur (Cooney et al. 2005).

MPG Viability Criteria (from Cooney et al. 2005)

The following six criteria must be met for an MPG to be regarded as at low risk (viable):

1. One-half of the populations historically within the MPG (with a minimum of two populations) must meet at least minimum viability standards.
2. At least one population must be categorized as being "Highly Viable".
3. Viable populations within an MPG must include some populations classified (based on historical intrinsic potential) as "Very Large," or "Large," and "Intermediate" in the same proportion as were present within the MPG historically.
4. Populations not meeting viability standards should be maintained with sufficient productivity that the overall MPG productivity does not fall below replacement (i.e. these areas should not serve as significant population sinks).
5. Where possible, given other MPG viability requirements, some populations meeting viability standards should be contiguous AND some populations meeting viability standards should be disjunct from each other.
6. All major life history strategies (e.g. spring and summer run timing) that were present historically within the MPG must be represented in populations meeting at least the minimum viability requirements.

3.4.4 ESU Viability Criteria

The ICTRT determined that, because MPGs are geographically and genetically cohesive groups of populations, they are critical components of ESU-level spatial structure and diversity. Having all MPGs within an ESU at low risk provides the greatest probability of persistence of any ESU. The box below shows ESU-level viability criteria defined by the ICTRT.

ESU Viability Criteria (from Cooney et al. 2005)

1. All extant MPGs and any extirpated MPGs critical for proper functioning of the ESU must be at low risk.
2. ESUs that contained only one MPG historically or that include only one MPG critical for proper function must meet the following criteria:
    a. The single MPG must meet all the requirements to be at low risk (see above). In addition:
    b. Two-thirds or more of the populations within the MPG historically must meet minimum viability standards; AND
    c. At least two populations must meet the criteria to be "Highly Viable."

These extirpated areas will be evaluated to determine whether extirpated MPGs are critical for proper functioning of the ESU using the following considerations:

- Likely demographic (abundance and productivity) contribution of the MPG and its component populations to the ESU.
- Spatial role of the MPG in the ESU (e.g. does the extirpated MPG create a gap in the distribution of the ESU?)
- Likely contribution to overall ESU diversity (e.g. does the extirpated MPG occupy habitats that are substantially different from other habitats currently occupied in the ESU?)