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MEMORANDUM

Date: January 8, 2007
From: Interior Columbia Technical Recovery Team
To: NMFS NW Regional Office, co-managers and other interested parties
Subject: Role of large extirpated areas in recovery

Summary and Conclusions

In this memo, the Interior Columbia TRT evaluates the role of extirpated Major Population Groups (MPGs) and populations in the functioning of listed ESUs in the Interior Columbia, as indicated in our viability criteria document (ICTRT, 2005). In our evaluation, we consider the potential contribution of the extirpated MPGs to ESU-level abundance, productivity, spatial structure and diversity in the context of the current and historical distribution of the ESU.

Restoring populations within currently extirpated MPGs to viability has the potential to increase the overall sustainability of several ESUs. However, predicting a quantitative benefit in risk reduction associated with re-establishment of populations in these areas is challenging and includes a high degree of uncertainty. Therefore, given the logistic challenges associated with re-introducing fish to many of these areas and the uncertainty of the contribution of re-established populations to ESU viability, we recommend a staged, adaptive approach to recovery planning and implementation. Such an approach gives highest priority initially to implementing actions within currently occupied areas and thus to improving the status of extant populations and MPGs. This approach emphasizes preserving existing genetic and phenotypic diversity. It does not suggest that historically occupied areas are not important to the ultimate long-term persistence of these ESUs, but rather that preserving extant populations should take temporal priority over reintroductions in situations where resources are limited. In this approach, recovery actions in currently occupied areas should be implemented concurrently with two supporting activities:

- A robust monitoring program, allowing evaluation of the likelihood of long-term persistence of the ESU when recovery goals in currently occupied areas are achieved.
- Scoping and planning for re-introductions into currently extirpated areas that would allow re-introductions to occur in a timely fashion when additional evaluations indicate that long-term persistence is dependent upon such re-introductions, or where they would be of most important to the viability of MPGs and ESUs

We concluded that the role of extirpated MPGs and populations varied from ESU to ESU as follows:

- Both Snake River fall chinook and Snake River sockeye are currently restricted to a single extant population. The probability of long-term persistence of both of these ESUs will be greatly enhanced with additional populations. In fact, these ESUs cannot meet the minimum ESU biological viability criteria established by the TRT without multiple viable populations.
- We have also concluded that viable populations within extirpated MPGs of the Upper Columbia spring chinook and steelhead ESUs would substantially increase the probability of long-term persistence of those ESUs.
- For the Snake River spring/summer chinook ESU, viable populations within the Clearwater ESUs would lower the overall risk to that ESU by improving the connectivity among extant MPGs and increasing the range of habitat types occupied by this ESU. However, due to the large number of populations and the spatial structure of the extant ESU, the relative contribution of these MPGs is somewhat lower than in cases where the extant ESU is more restricted.
- Viable populations within the extirpated areas of the Snake River steelhead ESU would lower overall risk, but likely not appreciably, again due to the large number of populations that are extant, and this ESU's current widespread spatial distribution.
- No MPGs are extirpated within the Mid-Columbia steelhead ESU. Extirpated populations and subpopulations within MPGs should be considered within the context of MPG and population viability.

An adaptive approach to recovery planning for extirpated areas

We are recommending that a step-wise, adaptive approach to these extirpated MPGs be taken due to uncertainties associated with reintroduction efforts.

The first consideration is uncertainty in quantifying ESU-level probability of persistence or risk of extinction or quasi-extinction. For example, simple metapopulation modeling efforts (e.g. Ruckelshaus et al. 2004) suggest that areas with fewer populations are at inherently greater risk than areas with more populations. However, quantifying the precise change in overall demographic risk is impossible, given uncertainty in a variety of factors including likely future environmental conditions, rates and impacts of potential catastrophic events, level of homing fidelity and likely historical distributions. Quantitative predictions are even less supportable when considering the biological benefits or costs of changes in components of ESU-level spatial structure and diversity. In most cases the diversity of those extirpated populations has been lost. The ability of introduced populations to restore some of that diversity is also highly uncertain. For these reasons, we describe the likely relative change in risk or likelihood of persistence that would result from the restoration of currently extirpated MPGs.

Re-introductions also are likely to have both initial or short-term effects and long-term benefits. In the short-term, they are unlikely to contribute substantially to abundance or productivity of the ESU. In addition, diversity benefits, particularly local adaptation, will require at least several generations to be realized. Similarly, the risk of outbreeding depression or introducing "domesticated" genes to neighboring populations is relatively high at the early stages of an introduction effort. At the low abundance and productivity that is likely in the initial stages, spatial structure benefits will also be minimal. However, in the long-term, as naturally-produced and locally-adapted populations become established, they can contribute to overall ESU abundance, productivity, and diversity. Finally, those populations will mitigate the risk of catastrophic loss, can provide connectivity between currently occupied populations and contribute to other natural interactions between populations.

Therefore, we recommend that initial, primary emphasis be placed on recovery of extant MPGs. In the case of ESUs with only one extant MPG, recovery actions should target the modified MPG risk levels defined for single-MPG ESUs in the July (2005) IC-TRT viability document. However, <u>the potential that re-introductions will be necessary should not be neglected, particularly in those areas with the most potential for increased occupancy to improve ESU-level status</u>. Concurrently with the implementation of recovery actions in currently occupied areas, a robust monitoring program should be implemented. This should be coupled with an ongoing evaluation or assessment of the likelihood of long-term persistence of the ESU as its status improves to determine whether re-introductions may be critical for long-term persistence. In addition, appropriate scoping or planning activities for re-introductions should occur, in the event that currently accessible habitat does not appear to be sufficient to assure the long-term persistence of the ESU. Appropriate scoping and planning activities include identifying suitable source broodstock for re-introduction, evaluating conditions in potentially accessible areas, improving those conditions if necessary, and other related activities that will improve the likelihood of a successful introduction.

<u>Considering extirpated MPGs in ESU-level risk.</u>

As with populations, ESU-level risk or probability of persistence is affected by abundance, productivity, spatial structure and diversity (McElhany et al. 2000). However, also as with populations, ESUs likely varied, even historically, in their inherent status. For example, the Upper Columbia spring chinook and steelhead ESUs appear presently and historically to contain fewer populations and MPGs than are currently occupied within the Mid-Columbia or Snake River steelhead ESUs. This simpler structure suggests that these smaller ESUs might have been at greater present or historical risk than some of the larger ESUs might be with the loss of one to several MPGs. The benefits of re-populating extirpated areas are thus dependent on this historical context.

We address three factors, described in our July (2005) document, that contribute to overall ESU viability for each extirpated MPG:

1. Demographic contribution of the MPG and its component populations to the ESU. This factor deals with the contribution of the MPG to the abundance and productivity of the ESU.
2. Spatial role of the MPG in the ESU. This factors deals with the contribution of the MPG to spatial processes, such as mitigating the risk of extinction due to localized catastrophes and ensuring normative demographic and genetic connectivity.
3. Contribution to overall ESU diversity. This factor deals with the likely degree of difference or variation likely to have been expressed by fish in the extirpated MPG.

We also considered the context of the extant and extirpated MPGs within each ESU, including:

- Total number of extant and extirpated populations
- Total number of extant and extirpated MPGs
- Total area available to the ESU historically and currently

In no case do data exist that allow us to evaluate the true contribution of currently extirpated areas to the ESU abundance, productivity, spatial structure or diversity. Thus, we used our analysis of likely intrinsic potential to evaluate several surrogate metrics as indicators. Specifically, we examined the number and proportion of stream kilometers (weighted by quality) that are currently accessible and that are no longer accessible as an indicator of contribution to ESU-level abundance and productivity. To assess the likely role of extirpated MPGs in ESU-level spatial structure, we estimated the distance from each MPG to its nearest neighbor under current and historical (i.e., all MPGs occupied) conditions. This process allowed us to evaluate quantitatively the likely role each MPG played in ESU-level connectivity. We evaluated the distribution of MPGs across the landscape (i.e., ensuring that some MPGs were relatively distant) qualitatively. We also qualitatively evaluated the risk of loss due to catastrophe. In particular, we anticipated that the presence of low-risk populations in multiple MPGs will reduce the risk of loss due to a single, local or sub-basin scale catastrophe, because we defined MPGs on the basis of geographic proximity and topographic and ecological similarity (and genetic similarity in currently occupied areas). Finally, to evaluate potential contributions to ESU diversity, we evaluated the distribution of high and moderate-quality stream kilometers across EPA ecoregions, using ecoregion as a proxy for potential phenotypic differences.

A. Snake River spring/summer chinook

Of the seven extirpated MPGs potentially belonging to this ESU, restoration of Dry Clearwater MPG would have the greatest impact on ESU viability, given the current number and distribution of occupied MPGs . Other extirpated MPGs would clearly contribute to ESU persistence (Table A-1) but the extant MPGs would likely be sufficient to ensure long-term persistence of the ESU if viability of those MPGs is achieved, due to the number, diversity and distribution of populations and MPGs that are currently occupied.

Chinook in the Clearwater River were extirpated by the construction and operation of Lewiston Dam in 1918. Stream-type chinook currently in the Clearwater basin are derived from Rapid River and other hatchery stocks. The current populations found in the Clearwater may provide some ecological functions within the ESU – particularly connectivity between the Lower Snake and Grande Ronde/Imnaha or Salmon River MPGs. Though not currently part of the Snake River spring/summer chinook ESU, these non-local fish offer a unique opportunity to evaluate both the efficacy of alternative re-introduction strategies and the rate and quality of local adaptation processes.

We also evaluated the possibility that there might have been one or more ESUs above the current Hells Canyon dam complex historically (see Population Identification update memo; further discussion to be provided in final Population Identification document). Unfortunately, no phenotypic or genetic data pertinent to these areas are available. While there were clear ecoregional differences and large distances between the uppermost and lowermost populations in the Snake basin, there was no clear point of division between the two areas. Rather, populations and MPGs in the middle Snake (e.g., Payette, Boise, and Malheur rivers) had mosaic characteristics of both upper and lower areas and could have provided potential connectivity. Faced with clear differences between upper and lower regions, but without a clear point at which to divide ESUs, we did not delineate an extirpated ESU in this region. Rather, we maintained the dual possibility that historically there may have been one, extremely large, continuous ESU, or that there may have been multiple ESUs in the Snake Basin.

Table A-1. Summary of potential contributions to ESU function by extirpated MPGs in the Snake River spring/summer chinook ESU. Two plus marks "++" indicates that the MPG would play a relatively large role in the ESU for this characteristic. A single plus mark "+" indicates that the MPG would play a relatively smaller role in the ESU for this characteristic, or that several MPGs would be required for the benefit to be realized

MPG	Habitat Quantity	Spatial Structure	Diversity
Dry Clearwater (lower)	+	++	++
Wet Clearwater (upper)	+	+	++
Middle Snake (Pine to Weiser)	+	+	+
Payette/Boise	+	+	+
Malheur	+	+	++
Owyhee	+	+	++
Upper Snake (Snake tribs to Rock Cr.)	+	+	++

Abundance and Productivity – Habitat Quantity

In total, an area equaling more than twice the currently accessible area has been extirpated from the Snake River spring/summer chinook ESU (Table A-2). However, currently accessible area includes more than 2,000 kilometers of habitat (kilometers weighted by quality). Thus, while the inclusion of any additional MPG, particularly some of the larger MPGs (e.g. Payette/Boise or Malheur) would substantially increase available habitat, we did not feel that tributary habitat quantity (as a surrogate for ESU abundance and productivity) was limiting ESU viability.

Table A-2. Habitat quantity in extant and extirpated MPGs of the Snake River spring/summer Chinook ESU. Quantity is reported in weighted kilometers, with areas of "high" intrinsic potential receiving a weight of 1; moderate receiving a weight of 0.5, and low areas receiving a weight of 0.25. *Weighted kilometers of extant MPGs include any extirpated populations.

MPG	Weighted stream km	% of Extant ESU	% of Total ESU
EXTANT			
Lower Snake River	124.5	5.98	1.90
Grande Ronde / Imnaha*	526.4	25.28	8.02
South Fork Salmon River	232.6	11.17	3.54
Middle Fork Salmon River	422.5	20.29	6.43
Upper Salmon River*	775.9	37.27	11.82
Extant MPGs Total	*2081.9*	*100.00*	*31.71*
EXTIRPATED			
Dry Clearwater (lower)	318.60	15.30	4.85
Wet Clearwater (upper)	588.90	28.29	8.97
Middle Snake (Pine to Weiser)	628.74	30.20	9.58
Payette/Boise	819.65	39.37	12.48
Malheur	533.29	25.62	8.12
Owyhee	818.38	39.31	12.46
Upper Snake (Snake tributaries to Rock Cr.)	776.22	37.28	11.82
Extirpated MPGs Total	*4483.78*	*215.37*	*68.29*
Total ESU	***6565.68***	***315.37***	***100.00***

Connectivity -- Spatial Structure

Most of the area from which Snake River spring/summer chinook have been extirpated is in the most upstream areas of the potential range. However, extirpation from the Clearwater River resulted in a gap in connectivity between currently extant MPGs. The Lower Snake MPG, in particular, is currently more isolated from other components of the ESU than was likely historically (Table A-3).

Table. A-3. Distance between extant and extirpated MPGs and the closest neighboring MPGs in the Snake River spring/summer chinook ESU under two conditions: 1) that only extant MPGs are occupied; and 2) that all MPGs are occupied. Distance measured from the most downstream area rated "moderate" in the IC-TRT's intrinsic potential analysis.

MPG	Closest Currently Occupied MPG	Distance (km)	Closest Historically Occupied MPG	Distance (km)	Difference in Distance
EXTANT					
Lower Snake River	Grande Ronde/ Imnaha	114.93	Dry Clearwater	30.79	84.14
Grande Ronde / Imnaha	Lower Snake	114.93	Lower Snake	114.93	0
South Fork Salmon River	Grande Ronde/ Imnaha	131.44	Grande Ronde/ Imnaha	131.44	0
Middle Fork Salmon River	Upper Salmon	38.13	Upper Salmon	38.13	0
Upper Salmon River	Middle Fork Salmon	38.13	Middle Fork Salmon	38.13	0
EXTIRPATED					
Dry Clearwater (lower)	Lower Snake	30.79	Lower Snake	30.79	0
Wet Clearwater (upper)	Lower Snake	85.79	Dry Clearwater	16.61	69.18
Middle Snake (Pine to Weiser)	Grande Ronde/ Imnaha	180.28	Grande Ronde/ Imnaha	180.28	0
Payette/Boise	Grande Ronde/ Imnaha	339.69	Malheur	19.88	319.81
Malheur	Grande Ronde/ Imnaha	331.31	Payette/Boise	19.88	311.43
Owyhee	Grande Ronde/ Imnaha	434.76	Upper Snake	96.78	337.98
Upper Snake (Snake tributaries to Rock Cr.)	Grande Ronde/ Imnaha	406.85	Owyhee	96.78	310.07

Habitat types – Diversity

All extirpated MPGs include a substantial amount of area in ecoregions different from those represented by extant MPGs (Table A-4). Therefore, we anticipate that all of these MPGs likely contributed to the phenotypic diversity expressed within the ESU with greatest potential contribution from Clearwater, Malheur, Owyhee, and Upper Snake MPGs. Thus, re-population of the upper reaches could contribute substantially to either basin-wide diversity as separate ESUs or within-ESU diversity as separate MPGs. Repopulation of the middle reaches would likely result in smaller increases in diversity.

Table A-4. Distribution (percentage) of extant and extirpated MPGs in the Snake River spring/summer chinook ESU across EPA ecoregions (level 3). Areas rated "moderate" and "high" in the IC-TRT's intrinsic potential analysis were included in this estimate.

MPG	**Blue Mountains**	**Columbia Plateau**	**Idaho Batholith**	**Middle Rockies**	**Northern Basin and Range**	**Northern Rockies**	**Snake River Plain**
EXTANT							
Grande Ronde / Imnaha	100.0						
Lower Snake	8.8	91.2					
South Fork Salmon River	6.0		94.0				
Middle Fork Salmon River			100.0				
Upper Salmon River			44.6	55.4			
Extant MPGs Total	25.5	5.3	47.0	22.3			
EXTIRPATED							
Dry Clearwater (lower)		14.6	37.0			48.4	
Wet Clearwater (upper)			39.4			60.6	
Middle Snake (Pine to Weiser)	67.4		0.3				32.3
Payette/Boise			73.9				26.1
Malheur	24.6				49.3		26.1
Owyhee					98.6		1.4
Upper Snake (Snake tributaries to Rock Cr.)			1.5		49.5		49.0
Extirpated MPGs Total	7.1	0.5	20.4		42.2	4.2	25.7
Total ESU	**10.2**	**1.3**	**24.9**	**3.8**	**35.0**	**3.5**	**21.3**

B. Snake River steelhead

None of the extirpated MPGs in the Snake River steelhead ESU would likely substantially increase the probability of long-term persistence of this ESU. Although the extirpated MPGs would contribute to the quantity and diversity of habitats available to the ESU, particularly those in the upper portion (Table B-1), there is currently a large amount of habitat available to the ESU, spread across several MPGs and ecoregions. This ESU is unique in having a small portion of a single population within an extirpated MPG (Hells Canyon) that is still accessible to anadromous fish. If fish in this area are descended from one or more historical populations, maintaining this genetic legacy would contribute to overall ESU diversity.

We evaluated the possibility that there might have been one or more ESUs above the current Hells Canyon dam complex historically (see Population Identification update memo; further discussion to be provided in final Population Identification document). Unfortunately, no phenotypic data pertinent to these areas are available; currently available genetic data on resident redband trout were not illuminating, and may not be relevant for the anadromous life history. While there were clear ecoregional differences and large distances between the uppermost and lowermost populations in the Snake basin, there was no clear point of division between the two areas. Rather, populations and MPGs in the middle Snake (e.g. Payette, Boise, and Malheur Rivers) had mosaic characteristics of both upper and lower areas and could have provided potential connectivity. Faced with clear differences between upper and lower regions, but without a clear point at which to divide ESUs, we did not delineate an extirpated ESU in this region. Rather, as with the Snake River spring/summer Chinook ESU, we maintained the dual possibility that historically there may have been one, extremely large, continuous ESU, or that there may have been multiple ESUs in the Snake Basin.

Table B-1. Summary of potential contributions to ESU function by extirpated MPGs in the Snake River steelhead ESU. Two plus marks "++" indicates that the MPG would play a relatively large role in the ESU for this characteristic. One plus mark "+" indicates that the MPG would play a relatively smaller role in the ESU for this characteristic, or that several MPGs would be required for the benefit to be realized.

MPG	Habitat Quantity	Spatial Structure	Diversity
Hells Canyon*	+	+	+
Payette/Boise	+	+	+
Malheur/Owyhee	+	+	++
Bruneau and Salmon Falls	+	+	++

* Several small tributaries in the lower reaches of Hells Canyon are currently occupied by steelhead. However, this is an extremely small component of the entire MPG; we thus treat this MPG as an extirpated area for calculation of comparison statistics.

Habitat Quantity – Abundance and Productivity

Extirpated areas in the Snake River steelhead ESU are approximately equal to the areas currently occupied (Table B-2). However, currently there are more than 12,000 stream km (weighted by intrinsic quality) available to this ESU. Thus, we did not consider habitat quantity (as a surrogate for abundance and productivity) to be impairing the viability of this ESU.

Table B-2. Habitat quantity in extant and extirpated MPGs of the Snake River steelhead ESU. Quantity is reported in weighted kilometers, with areas of "high" intrinsic potential receiving a weight of 1; moderate receiving a weight of 0.5, and low areas receiving a weight of 0.25. *Weighted kilometers of extant MPGs include any extirpated populations.

MPG	Weighted stream km	% of extant ESU	% of total ESU
EXTANT			
Lower Snake	834.16	6.91	3.24
Clearwater River	3757.26	31.11	14.59
Grande Ronde River	2259.92	18.71	8.77
Salmon River	4760.29	39.42	18.48
Imnaha River	465.58	3.86	1.81
Extant MPGs Total	*12077.21*	*100.00*	*46.89*
EXTIRPATED			
Hells Canyon*	3,193.17	26.44	12.40
Payette/Boise	3,236.94	26.80	12.57
Malheur/Owyhee	4,348.90	36.01	16.89
Bruneau and Salmon Falls	2,898.40	24.00	11.25
Extirpated MPGs Total	*13,677.41*	*113.25*	*53.11*
Total ESU	***25,754.62***	***213.25***	***100.00***

* Several small tributaries in the lower reaches of Hells Canyon are currently occupied by steelhead. However, this is an extremely small component of the entire MPG; we thus treat this MPG as an extirpated area for calculation of comparison statistics.

Connectivity – Spatial Structure

None of the extirpated MPGs alone impair the connectivity of extant MPGs (Table B-3). Extirpated MPGs in this ESU are all congruent, and located in the upstream portion of the potential range. However, if areas currently occupied in the Hells Canyon MPG contain remnants of historical populations, extirpated areas of that MPG would be important to the MPG spatial structure in light of the limited distribution and size of extant populations.

Table B-3. Distance between extant and extirpated MPGs and the closest neighboring MPGs under two conditions: 1) that only extant MPGs are occupied; and 2) that all MPGs are occupied. Distance measured from the most downstream area rated "moderate" in the IC-TRT's intrinsic potential analysis.

MPG	Closest Currently Occupied MPG	Distance (km)	Closest Historically Occupied MPG	Distance (km)	Difference in Distance
EXTANT					
Lower Snake	Grande Ronde	2.68	Grande Ronde	2.68	0
Clearwater River	Grande Ronde	12.23	Grande Ronde	12.23	0
Grande Ronde River	Lower Snake	2.68	Lower Snake	2.68	0
Salmon River	Imnaha River	29.06	Imnaha River	29.06	0
Imnaha River	Hells Canyon	3.00	Hells Canyon	3.00	0
EXTIRPATED					
Hells Canyon*	Imnaha River	129.49	Imnaha River	129.49	0
Payette/Boise	Imnaha River	304.49	Malheur/Owyhee	45.34	259.15
Malheur/Owyhee	Imnaha River	318.73	Bruneau and Salmon Falls	31.16	287.57
Bruneau and Salmon Falls	Imnaha River	355.52	Malheur/Owyhee	31.16	324.36

Habitat Types – Diversity

All of the extirpated MPGs, if occupied, would expand the range of ecoregions encountered by fish in this ESU (Table B-4). However, the currently occupied areas cover five ecoregions. Re-population of the upper reaches could contribute substantially to either basin-wide diversity as separate ESUs or within-ESU diversity as separate MPGs. Repopulation of the middle reaches would likely result in smaller increases in diversity.

Importantly, fish that currently occupy the remaining accessible small tributaries of the Hells Canyon MPG may be the only remnants of upstream populations. Alternatively, they may be strays from hatchery programs. Emphasis should be placed on determining the origin of these fish. If they do appear to be remnants of an historical population, maintaining these fish would preserve this genetic legacy.

Table B-4. Distribution (percentage) of extant and extirpated MPGs in the Snake River steelhead ESU across EPA ecoregions (level 3). Areas rated “moderate” and “high” in the IC-TRT’s intrinsic potential analysis were included in this estimate.

MPG	**Blue Mountains**	**Columbia Plateau**	**Idaho Batholith**	**Middle Rockies**	**Northern Basin and Range**	**Northern Rockies**	**Snake River Plain**
EXTANT							
Lower Snake	17.8	82.2					
Clearwater River	0.3	5.2	43.7			50.9	
Grande Ronde River	97.5	2.5					
Salmon River	4.7	0.3	72.0	23.1			
Extant MPGs Total	23.1	8.6	42.8	9.2		16.3	
EXTIRPATED							
Hells Canyon	67.2		0.3				32.4
Payette/Boise			75.0				25.0
Malheur/Owyhee	4.5				92.6		2.9
Bruneau and Salmon Falls			1.5		49.6		48.9
Extirpated MPGs Total	5.8		19.0		48.1		27.1
Total ESU	**16.0**	**5.1**	**33.1**	**5.5**	**19.7**	**9.6**	**11.1**

C. Snake River fall chinook

We include all three Snake River fall chinook populations in a single MPG. This ESU does not include any extirpated MPGs. However, the single MPG must be at low risk for the ESU to be considered viable. This would require the re-establishment of at least one population to meet the minimum viability criteria we have established. We recognize that there are significant difficulties in re-establishing fall chinook populations above the Hells Canyon complex, and suggest that initial effort be placed on recovery for the extant population, concurrently with scoping efforts for re-introduction, as described above in the adaptive approach.

D. Snake River sockeye

We do not have data to support an intrinsic potential analysis for Snake River sockeye. Lakes or groups of lakes that formerly supported sockeye salmon in the Snake River drainage are: Wallowa Lake, Payette Lake basin, and Warm Lake. However, each of these lake groups is separated by distances that are consistent with those between other sockeye ESUs. It is unclear, and currently irresolvable, whether these lake groups were MPGs of the same ESU or separate ESUs. Thus, re-population of these additional lake basins could contribute substantially to either basin-wide diversity as separate ESUs or within-ESU diversity as separate MPGs. Ultimately, three populations within the Stanley Lakes Basin, however, will be required for this ESU to meet minimum ESU viability criteria. This issue is treated in greater detail in our MPG-ESU scenarios memo.

E. Upper Columbia spring chinook

The repopulation of either the Spokane or the Kettle/Colville/San Poil MPG would substantially reduce the overall risk faced by the Upper Columbia spring chinook ESU. This judgment was based on the combination of likely contribution to overall ESU abundance and productivity, diversity and spatial structure (Table E-1), given the small number and extent, potential for catastrophic loss, and low diversity of the single extant MPG.

Table E-1. Summary of potential contributions to ESU function by extirpated MPGs in the Upper Columbia spring chinook ESU. Two plus marks "++" indicates that the MPG would play a relatively large role in the ESU for this characteristic. One plus mark "+" indicates that the MPG would play a relatively smaller role in the ESU for this characteristic, or that several MPGs would be required for the benefit to be realized.

MPG	Habitat Quantity	Spatial Structure	Diversity
Kettle/Colville/ San Poil	++	++	++
Spokane	++	++	++

Habitat Quantity – Abundance and Productivity

While the currently occupied East Cascades MPG is the largest MPG in this ESU, the total currently accessible habitat is relatively low (less than 700 weighted stream km) (Table E-2). Some of the area noted within the extirpated areas may have been occupied by summer chinook, which are a different ESU. However, either of the extirpated MPGs would contribute substantially to the total amount of available habitat. If both were occupied, habitat quantity could as much as double.

Table E-2. Habitat quantity in extant and extirpated MPGs of the Upper Columbia River spring Chinook ESU. Quantity is reported in weighted kilometers, with areas of "high" intrinsic potential receiving a weight of 1; moderate receiving a weight of 0.5, and low areas receiving a weight of 0.25. *Weighted kilometers of extant MPGs include any extirpated populations.

MPG	Weighted stream km	% of extant ESU	% of total ESU
EXTANT			
East Cascades*	640.1	100.00	43.62
Extant MPGs Total	*640.1*	*100.00*	*43.62*
EXTIRPATED			
Kettle/Colville/San Poil	443.1	69.22	30.19
Spokane	384.27	60.03	26.19
Extirpated MPGs Total	*827.37*	*129.26*	*56.38*
Total ESU	***1467.47***	***229.26***	***100.00***

Connectivity – Spatial Structure

Neither extirpated MPG would contribute substantially to connectivity of the single MPG. However, the presence of either would alleviate the likelihood of a common catastrophe or other spatially-linked impact affecting the entire ESU.

Table E-3. Distance between extant and extirpated MPGs and the closest neighboring MPGs under two conditions: 1) that only extant MPGs are occupied; and 2) that all MPGs are occupied. Distance measured from the most downstream area rated "moderate" in the IC-TRT's intrinsic potential analysis.

MPG	Closest Currently Occupied MPG	Distance (km)	Closest Historically Occupied MPG	Distance (km)	Difference in Distance
EXTANT					
East Cascades	none		Kettle/Colville/San Poil	182.52	182.52
EXTIRPATED					
Kettle/Colville/San Poil	East Cascades	182.52	Spokane	31.99	150.53
Spokane	East Cascades	214.36	Kettle/Colville/San Poil	31.99	182.37

Habitat Types – Diversity

Both extirpated MPGs occur in ecoregions that are different from those in the currently accessible MPG. Access to these areas would likely increase the potential for a greater range of phenotypic diversity within the ESU.

Table E-4. Distribution (percentage) of extant and extirpated MPGs in the Upper Columbia spring chinook ESU across EPA ecoregions (level 3). Areas rated "moderate" and "high" in the IC-TRT's intrinsic potential analysis were included in this estimate

MPG	**Columbia Plateau**	**North Cascades**	**Northern Rockies**
EXTANT			
Below Chief Joseph Dam	26.1	73.9	0.1
EXTIRPATED			
Kettle/Colville/San Poil	1.9		98.1
Spokane	48.1		51.9
Extirpated MPGs Total	33.1		66.9
Total ESU	**30.5**	**27.2**	**42.2**

F. Upper Columbia steelhead

Repopulation of either the Spokane or the Kettle/Colville/San Poil MPG would substantially reduce the risk of the Upper Columbia steelhead ESU. This judgment was based on the combination of likely contribution to overall ESU abundance and productivity, diversity and spatial structure (Table F-1). This situation and our rationale are similar to that for Upper Columbia Spring Chinook.

Table F-1. Summary of potential contributions to ESU function by extirpated MPGs in the Upper Columbia steelhead ESU. Two plus marks "++" indicates that the MPG would play a relatively large role in the ESU for this characteristic. One plus mark "+" indicates that the MPG would play a relatively smaller role in the ESU for this characteristic, or that several MPGs would be required for the benefit to be realized.

MPG	Habitat Quantity	Spatial Structure	Diversity
Kettle/Colville/ San Poil	++	++	++
Spokane	++	++	++

Habitat Quantity – Abundance and Productivity

Currently accessible habitat for steelhead in the Upper Columbia total approximately 3500 weighted kilometers (Table F-2). However, the MPG with the largest potential habitat quantity in this ESU is currently extirpated.

Table F-2. Habitat quantity in extant and extirpated MPGs of the Upper Columbia River steelhead ESU. Quantity is reported in weighted kilometers, with areas of "high" intrinsic potential receiving a weight of 1; moderate receiving a weight of 0.5, and low areas receiving a weight of 0.25. *Weighted kilometers of extant MPGs include any extirpated populations.

MPG	Weighted stream km	% of extant ESU	% of total ESU
EXTANT			
East Cascades*	3527.55	100.00	40.98
Extant MPGs Total	*3527.55*	*100.00*	*40.98*
EXTIRPATED			
Kettle/Colville/San Poil River	4,009.35	113.66	46.58
Spokane River	1,070.32	30.34	12.44
Extirpated MPGs Total	*5,079.67*	*144.00*	*59.02*

Total ESU	5,079.67	244.00	100.00

Connectivity – Spatial Structure

Neither extirpated MPG would contribute substantially to connectivity of the single MPG (Table F-3). However, the presence of either would alleviate the likelihood of a common catastrophe or other spatially-linked impact affecting the entire ESU.

Table F-3. Distance between extant and extirpated MPGs and the closest neighboring MPGs under two conditions: 1) that only extant MPGs are occupied; and 2) that all MPGs are occupied. Distance measured from the most downstream area rated "moderate" in the IC-TRT's intrinsic potential analysis.

MPG	Closest Currently Occupied MPG	Distance (km)	Closest Historically Occupied MPG	Distance (km)	Difference in Distance
EXTANT					
East Cascades	None		Kettle/Colville/San Poil	49.44	
EXTIRPATED					
Kettle/Colville/San Poil River	East Cascades	49.44	Spokane	19.87	29.57
Spokane River	East Cascades	199.88	Kettle/Colville/San Poil	19.87	180.01

Habitat Types – Diversity

Both extirpated MPGs occur in ecoregions that are different from those encountered by fish in the currently accessible MPG. Access to these areas would likely increase the potential for a greater range of phenotypic diversity within the ESU.

Table F-4. Distribution (percentage) of extant and extirpated MPGs in the Upper Columbia steelhead ESU across EPA ecoregions (level 3). Areas rated “moderate” and “high” in the IC-TRT’s intrinsic potential analysis were included in this estimate.

MPG	**Columbia Plateau**	**Eastern Cascades Slopes and Foothills**	**North Cascades**	**Northern Rockies**
EXTANT				
East Cascades - Below Chief Joseph Dam	40.0	0.4	58.8	0.9
EXTIRPATED				
Kettle/Colville/San Poil River	0.9			99.1
Spokane River	42.5			57.5
Extirpated MPGs Total	19.7			80.3
Total ESU	**26.9**	**0.1**	**21.0**	**52.0**

G. Mid-Columbia steelhead

No MPGs in the Mid-Columbia steelhead ESU have been completely extirpated. Extirpated populations and subpopulations within this ESU should be considered within the context of MPG viability. We treat these areas in greater detail in our MPG-ESU scenario memo.

References

Ruckelshaus, M., P. McElhany, M. McClure and S. Heppell. 2004. Chinook salmon in Puget Sound: Effects of spatially correlated catastrophes on persistence.   Pp. 208-218, In R. Ackakaya, M. Burgman, O. Kindvall, C.C. Wood, P. Sjogren-Gulve, J. S. Hatfield and M. A. McCarthy (eds.) Species Conservation and Management: Case Studies. Oxford Univ. Press.