Aquatic, Riparian, and Wetland Ecosystem Assessment

Bighorn National Forest, Wyoming

USDA Forest Service – Rocky Mountain Region

Report 3 of 3

Ecological Driver Analysis and Anthropogenic Influence Results: Synthesis and Discussion

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Chapter 1
Introduction

This chapter provides a meaningful link between the ecological driver analysis results of the 74 6th level HUBs intersecting the Bighorn National Forest and the potential effects related to anthropogenic activities. The ecological context has been characterized by the ecological driver analysis for both riparian and wetland ecosystems, as reported in The Ecological Driver Analysis Chapter in Report 1 of this assessment. Ecological drivers have been defined as environmental factors that constitute the physiochemical template of an ecosystem, which in turn influence the fitness of individual organisms and their populations.

This chapter includes two analyses. The first analysis attempts to characterize the overall potential influences that anthropogenic activities have upon riparian and wetland ecosystems at the management scale. The purpose of this analysis is to identify the degree to which riparian and wetland ecosystems may be influenced by anthropogenic activities throughout this scale. The second analysis synthesizes the results of the first analysis with the results of the ecological driver cluster analysis for both wetland and riparian ecosystems. The purpose of this analysis is to identify how each cluster may respond to the potential influences of anthropogenic activities.

Key Findings

Quartile Analysis

1. There is a direct relationship between the percentage of the quartile area within the Bighorn National Forest and the potential influence from anthropogenic activities. For example, Quartile 4 has 74% of its area within the Bighorn National Forest, while Quartile 1 has 28% of its area within the Bighorn National Forest. The steep topography associated with the edges of the Forest may in part have influenced these results.
2. Because of the high percentage of Quartile 4 within the Bighorn National Forest, there may be more opportunities to improve conditions within the potentially most influenced HUBs.
3. HUBs that are potentially least influenced by anthropogenic activities occupy less area within the Bighorn National Forest, and may provide reference conditions for individual clusters.

Wetland Clusters

1. Cluster 1w is a very important group of 6th level HUBs from a wetland perspective, and has a high potential for being influenced by anthropogenic activities. This cluster contains the HUB that ranks the highest in terms of cumulative percentile value of anthropogenic influences.
2. Cluster 2w has the highest overall percentage of groundwater-fed wetlands. Cluster 2w also has 8 of the 12 6th level HUBs in the top 20 highest potential to be influenced by anthropogenic activities at the management scale.
3. Cluster 3w is predominately comprised of stream related wetland ecosystems, and has a high potential to be influenced by anthropogenic activities.
4. Cluster 4w supports a small wetland area, with riparian areas being somewhat more abundant. This cluster has a lesser potential to be influenced by anthropogenic activities than Clusters 1-3w.
5. Cluster 5w is conducive to the establishment of lakes, meadows, and groundwater-fed wetland ecosystems. This cluster has a moderate to low potential to be influenced by anthropogenic activities.
6. Cluster 6w is predominately comprised of riparian areas and relatively few wetlands, and has a moderate potential to be influenced by anthropogenic activities.
7. Cluster 7w has the least area classified as wetlands, and has the lowest potential to be influenced by anthropogenic activities.

Riparian Clusters

1. Relative to the five other riparian clusters, Cluster 1r has a high potential to be influenced by anthropogenic activities. This cluster contains the HUB with the highest potential to be influenced by anthropogenic activities.
2. Cluster 2r is the most heterogeneous of the six riparian clusters. This particular set of driver combinations are relatively rare on the Bighorn National Forest, and are important areas for coldwater fisheries. Relative to the other five riparian clusters, Cluster 2r has the highest potential to be influenced by anthropogenic activities.
3. Cluster 3r is expected to have a higher overall aquatic productivity and fisheries value than those of Clusters 1r and 4r. Relative to the other five riparian clusters, Cluster 3r has a high potential to be influenced by anthropogenic activities.
4. Cluster 4r is expected to support higher invertebrate diversity and continuous aquatic productivity. Aquatic productivity in lower gradient reaches (such as those in mountain valleys) may be locally more productive than the higher gradient stream reaches. The ecological setting of this cluster is not conducive to the establishment of extensive riparian ecosystems. Relative to the other five wetland clusters, Cluster 4r has a moderate potential to be influenced by anthropogenic activities.
5. Cluster 5r is expected to have a high macroinvertebrate and fish productivity. These watersheds have the second lowest area of streamside riparian ecosystems, although having a large percentage of low gradient stream reaches. Relative to the other five wetland clusters, Cluster 5r has a moderate to low potential to be influenced by anthropogenic activities.
6. Cluster 6r is expected to have the lowest aquatic productivity as a result of higher water temperatures and intermittent flows. Streams originating at higher elevations may provide suitable habitat for coldwater fish species. Relative to the other five wetland clusters, Cluster 6r has the lowest potential to be influenced by anthropogenic activities.
7. A direct relationship is identified between the potential aquatic productivity and fish population diversity, and the potential amount of influence exerted on the riparian ecosystem by anthropogenic activities.

Anthropogenic Activities: Potential Additive Effects

The potential effects for all anthropogenic activities were analyzed by cumulating the percentile ranking for each of the twenty-four identified anthropogenic activities. There were a total of 28 different analysis used for this process using all the activities. For every analysis, each of the 74 6th level HUBs intersecting the Bighorn National Forest was assigned an ordinal value of 0, 1, 2, or 3. HUBs assigned a value of 0 did not have the identified activity present within its boundaries. The values of 1 – 3 were assigned based upon the percentile in which that HUB was located for the anthropogenic activity. Percentiles from .001% - 33% were given an ordinal value of 1. Percentiles from 33.001% - 67% were given an ordinal value of 2. Percentiles from 67.001% - 100% were given an ordinal value of 3. Each percentile rank was then cumulated for the 28 analyses of the 24 identified activities.

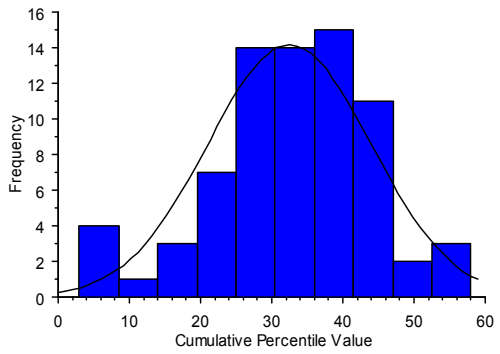

Figure 1.1. Histogram of overall additive effects cumulative percentile value.

It is assumed that the greater the ordinal value, the greater the potential influence of that activity upon aquatic, riparian, and wetland ecosystems. The highest possible value using this method was 84 (28 x 3). The highest identified value within the 74 HUBs was 58, and the lowest identified value was 3. The mean value was 32.47, with a standard deviation of 11.46. When viewed as a histogram (fig. 1.1), the distribution is skewed towards the higher values, and is slightly leptokurtic (peaked). These results indicate that a relatively higher percentage of 6th level HUBs associated with the Bighorn National Forest have more cumulative anthropogenic influences to aquatic, riparian, and wetland resources, than those with less influences.

For display and analysis purposes, the overall cumulative percentile value was divided into quartiles (table 1.1 and fig. 1.2). Quartile 1 is considered to be the grouping with ecosystems having the least potential influence resulting from anthropogenic activities. Quartile 2 is considered to be the grouping with ecosystems having a lesser potential influence resulting from anthropogenic activities. Quartile 3 is considered to be the grouping with ecosystems having a moderate potential influence resulting from anthropogenic activities. And Quartile 4 is considered to be the grouping with ecosystems having the highest potential influence resulting from anthropogenic activities.

Five HUBs have been identified as having the highest potential to be influenced by the 24 analyzed anthropogenic activities. These HUBs include Lower East Fork Big Goose Creek (100901010202) with a cumulative percentile value of 58; Muddy Creek (100902050103), with a cumulative percentile value of 57; Shell Creek-Granite Creek (100800100102), with a cumulative percentile value of 56; Lower South Tongue River (100901010104), with a cumulative percentile value of 51; and Middle North Fork Crazy Women Creek (100902050102), with a cumulative percentile value of 49.

Two HUBs have been identified as having the lowest potential to be influenced by the 24 analyzed anthropogenic activities. These HUBs include Salt Creek (100800100307), with a cumulative percentile value of 3, and Middle Porcupine Creek (100800100602), with a cumulative percentile value of 5.

Table 1.1. Quartiles and their cumulative percentile ranges and potential influence by anthropogenic activities.

Quartile	Percentile Range	Cumulative Percentile Value Range	Potential Influence
1	0 - 25	3 - 27	Least
2	25.1 - 50	28 - 33	Less
3	50.1 - 75	34 - 40	Moderate
4	75.1 - 100	41 - 58	High

The relationship between the geographic positions of the HUBs in relation to the boundary of the Bighorn National Forest plays a crucial role in the management of the anthropogenic activities occurring in each HUB. For example, a HUB in Quartile 4 (those HUBs considered to have the highest potential for being influenced by anthropogenic activities) that is completely contained by the Bighorn National Forest may require a different management strategy than another HUB in Quartile 4 that has only a small percentage of its total area located within the National Forest boundary. The percentage of the total area of each quartile within the National Forest boundary has been identified for two reasons: 1) to identify areas where management decisions concerning anthropogenic activities may significantly influence aquatic, riparian, and wetland ecosystems; and 2) to identify potential errors associated with cumulative values, as the cumulative values are extrapolated to areas outside the National Forest boundary based upon data that in some cases exists only for those areas within the Bighorn National Forest.

Of the eighteen HUBs comprising Quartile 4, seven HUBs are completely contained by the Bighorn National Forest (fig. 1.3). Two of these seven HUBs are within the five highest cumulative percentile values, and include the Lower East Fork Big Goose Creek (100901010202), value = 58; and Lower South Tongue River (100901010104), value = 51. When analyzing the area of all of the HUBs comprising Quartile 4, 74.2% of the area is contained within the Bighorn National Forest boundary. Since a large percentage of this area is incorporated within the Bighorn National Forest, management decisions concerning anthropogenic activities have the potential to alter or improve the aquatic, riparian, and wetland ecosystems within the quartile with the highest potential influence from anthropogenic activities.

Of the nineteen HUBs comprising Quartile 3, only three of the HUBs are completely contained within the Bighorn National Forest, and include South Clear Creek (100902060101), value = 39; Middle Clear Creek (100902060102), value = 36; and Upper East Fork Big Goose Creek (100901010201), value = 34. When analyzing the area of all of the HUBs comprising Quartile 3, 64.3% of the area are contained within the Bighorn National Forest boundary. Similar to Quartile 4, the management decisions associated with anthropogenic activities may significantly affect aquatic, riparian, and wetland ecosystems within this quartile.

Of the sixteen HUBs comprising Quartile 2, only three of the HUBs are completely contained within the Bighorn National Forest, and include Upper Tensleep Creek (100800080401), value = 33; South Piney Creek (100902060301), value = 31; and North Tongue River (100901010101), value = 28. When analyzing the area of all of the HUBs comprising Quartile 2, 53.7% of the area is contained within the Bighorn National Forest boundary. Since a majority of the area within Quartile 2 is located within the Forest boundary, management decisions concerning these moderate potential influence ecosystems may return them to a near reference condition.

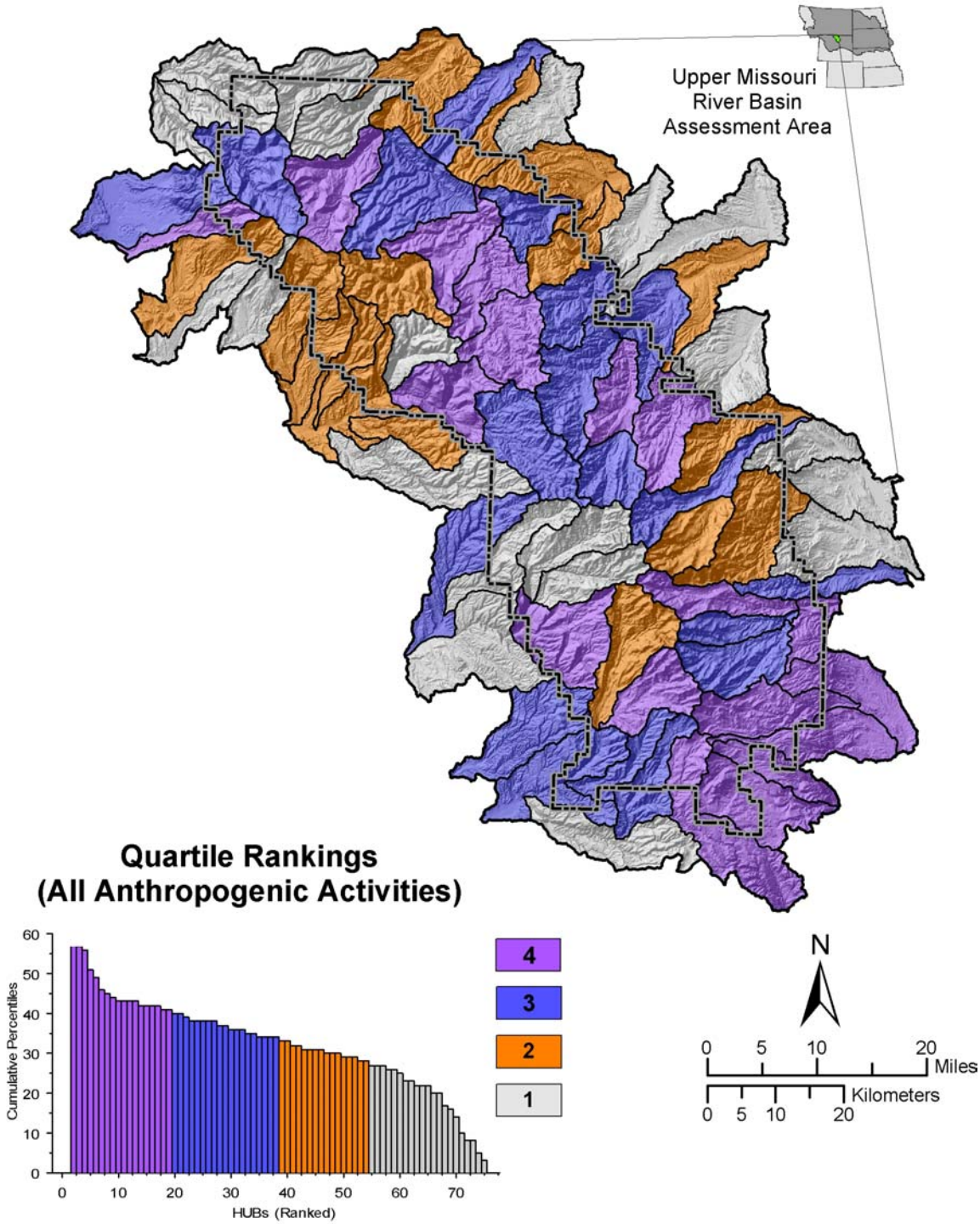

Figure 1.2. Cumulative percentile values grouped as quartiles.

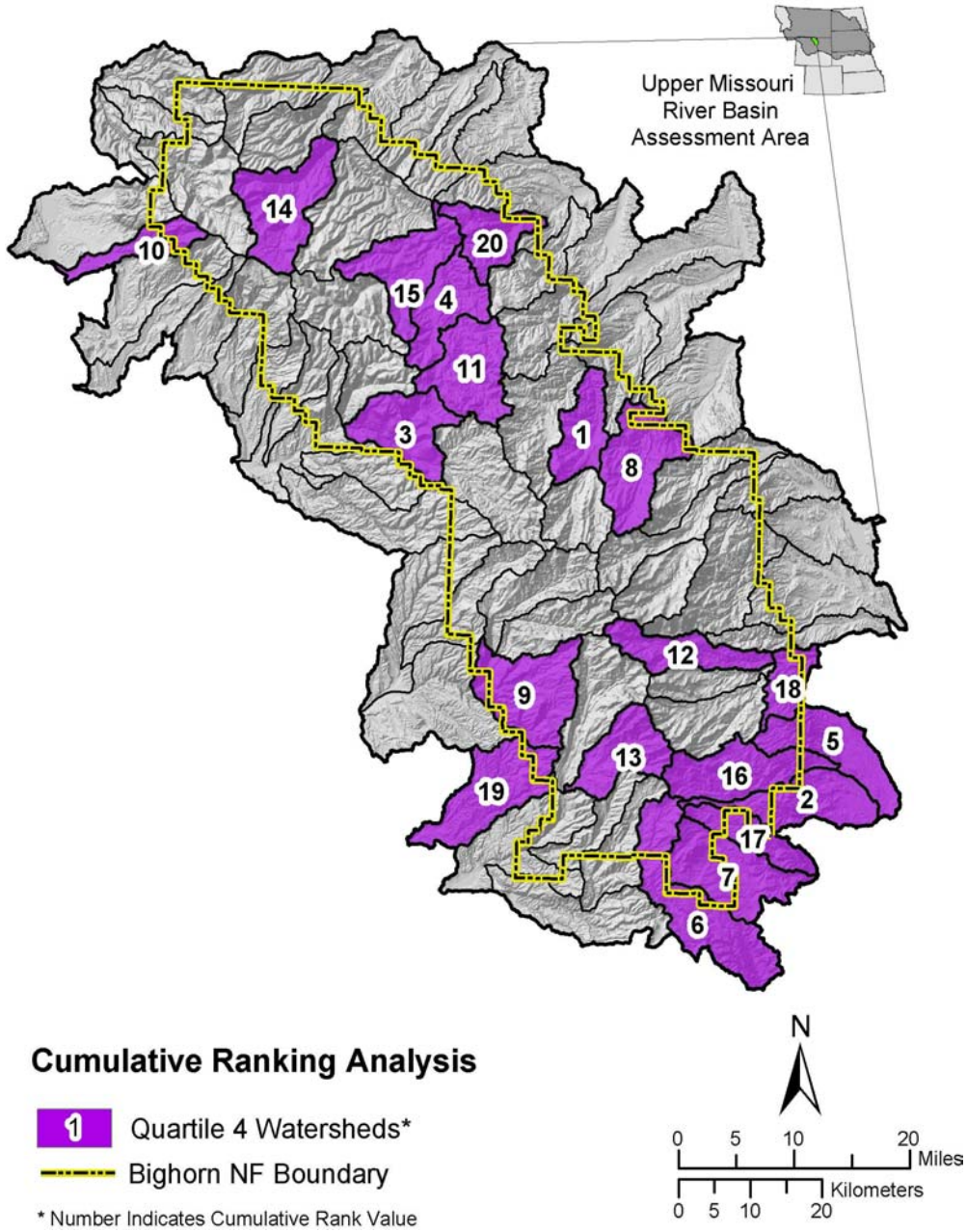

Figure 1.3. Distribution and ranking of all 6th level HUBs in the 4th quartile (most cumulative anthropogenic activities) for the 74 HUBs within or intersecting the Bighorn National Forest boundary.

Of the nineteen HUBs comprising Quartile 1, only three of the HUBs are completely contained within the Bighorn National Forest, and include Cedar Creek (100800100103), value = 27; Paint Rock Creek-Trout Creek (100800080601), value = 26; and Long Park Creek (100800080602), value = 20. When analyzing the area of all of the HUBs comprising Quartile 1, 28.0% of the area is contained within the Bighorn National Forest boundary. The ecosystems included within this quartile have a low potential to be influenced by anthropogenic activities. With only 28% of this quartile existing within the Bighorn National Forest, these may be important ecosystems to manage as reference areas.

There is an obvious trend in this analysis that shows a direct relationship between the level of potential influence by quartile and the percentage of quartile within the Bighorn National Forest boundary. While speculative at this point, these results may be a function of several different factors, including, but not limited to: the steep topography and inaccessibility of the flanks of the Big Horn Mountains (which coincide with the National Forest boundary), and the accessibility and relatively flat topography in the interior of the Forest.

Anthropogenic Activities: Synthesis with Ecological Driver Analysis

Understanding the link between anthropogenic influences and ecological setting requires the synthesis of the anthropogenic activities, and the ecological driver agglomerative cluster analysis discussed in Report 1 of this 3 part assessment. This cluster analysis identified similar groupings of 6th level HUBs based upon differences in the physiographic, geologic, and climatic setting variations with the watershed. As a result of the spatial variation of these ecological drivers within each HUB, each recognized cluster will vary in its sensitivity to alterations of the present hydrologic and sediment regime. It is the purpose of this section to identify the relationship between ecological driver cluster, sensitivity, and the extent of anthropogenic disturbance.

This information should be valuable for prioritizing 6th level HUBs for management considerations (e.g., restoration and protection). In addition, the range of conditions found in HUBs within each cluster should provide a template for identifying reference and threshold conditions for key reach/site scale characteristics.

Wetland Ecological Driver Clusters

The aggregate cluster analysis of the ecological drivers for wetland ecosystems at the management scale identified seven unique clusters. Each of these clusters has a distinct signature represented by spatial variations in geology (calcareous and non-calcareous lithology), climate (precipitation type) and presence or absence of Pleistocene glaciation (table 1.2).

Table 1.2. Ecological driver analysis results for wetland clusters.

	Percent Area Encompassed by a Specific Ecological Driver						
Wetland	**Geology**		**Glaciation**		**Climate (precipitation)**		
Clusters	**Ca**	**Cn**	**Qg**	**Qn**	**Ps**	**Prs**	**Pr**
1w	9.09	**90.91**	**64.64**	35.36	**89.74**	10.22	0.04
2w	37.41	**62.59**	4.02	**95.98**	**78.22**	21.67	0.11
3w	6.22	**93.78**	8.46	**91.54**	33.29	**61.54**	5.17
4w	**88.29**	11.71	4.08	**95.92**	23.34	**65.45**	11.21
5w	**83.45**	16.55	0.23	**99.77**	**66.65**	30.15	3.20
6w	39.09	**60.91**	0.04	**99.96**	14.55	**44.86**	40.60
7w	7.46	**92.54**	0.00	**100.00**	0.25	16.11	**83.64**

Ca *– calcareous geology,* ***Cn*** *- non-calcareous geology;* ***Qg*** *- glaciated valleys,* ***Qn*** *- non-glaciated valleys;* ***Ps*** *- snowmelt driven hydrology,* ***Prs*** *– rain-and-snow driven hydrology,* ***Pr*** *- rain driven hydrology.*

Wetland Cluster 1w

Wetland Cluster 1w has been identified as being sensitive to management activities that alter the sediment or hydrologic regime. A large portion of this cluster consists of high altitude glaciated valleys, non-glaciated ridgelines, non-calcareous bedrock (granitic and gneissic) and a predominately snow-driven precipitation regime. The combination of these ecological drivers derives an environment conducive to the establishment and persistence of wetland ecosystems.

In terms of anthropogenic influences, wetland Cluster 1w is comprised of four 6th level HUBs in Quartile 4 of the cumulative percentile values, six HUBs in Quartile 3, two HUBs in Quartile 2, and three HUBs in Quartile 1 (table 1.3). Ten of the 15 HUBs are completely contained by the Bighorn National Forest. 97.2% of the total area of Wetland Cluster 1w is located within the National Forest boundary. The Lower East Fork Big Goose Creek sub-watershed (100901010202) has the greatest potential to be influenced by anthropogenic activities (value = 58), both within the cluster, and within the 74 HUBs that comprise the management scale. This HUB is completely contained by the Bighorn National Forest, and indicates high use and high potential for influencing wetland ecosystems.

This cluster was then divided into equal size thirds based upon percentiles as a means of providing a comparison for the potential for anthropogenic influence within the cluster (fig. 1.4). Within Cluster 1w, the Lower East Fork Big Goose Creek has a significantly higher potential to be influenced by anthropogenic activities than the other 14 HUBs. The HUBs with the lowest potential to be influenced by anthropogenic activities (within Cluster 1w) include Upper Medicine Lodge Creek (100800080605), Paint Rock Creek-Trout Creek (100800080601) and Long Park Creek (100800080602). These watersheds may have the potential to be reference areas within this cluster.

Table 1.3. Wetland Cluster 1w: cumulative percentile values, ranks, and quartile designations.

HUB ID	HUB Name	Cumulative Percentile Value	Overall Rank	Rank w/in Wetland Cluster	Quartile
100901010202	Lower East Fork Big Goose Creek	58	1	1	4
100800080603	Paint Rock Creek-South Paint Rock Creek	43	9	2	4
100902060103	Seven Brothers Creek	43	10	3	4
100800080402	East Tensleep Creek	42	13	4	4
100902060101	South Clear Creek	39	21	5	3
100800100101	Shell Creek-Willett Creek	37	27	6	3
100902060102	Middle Clear Creek	36	30	8	3
100902060302	Kearny Creek	36	29	7	3
100901010201	Upper East Fork Big Goose Creek	34	35	10	3
100901010203	West Fork Big Goose Creek	34	34	9	3
100800080401	Upper Tensleep Creek	33	38	11	2
100902060301	South Piney Creek	31	42	12	2
100800080605	Upper Medicine Lodge Creek	27	54	13	1
100800080601	Paint Rock Creek-Trout Creek	26	57	14	1
100800080602	Long Park Creek	20	65	15	1

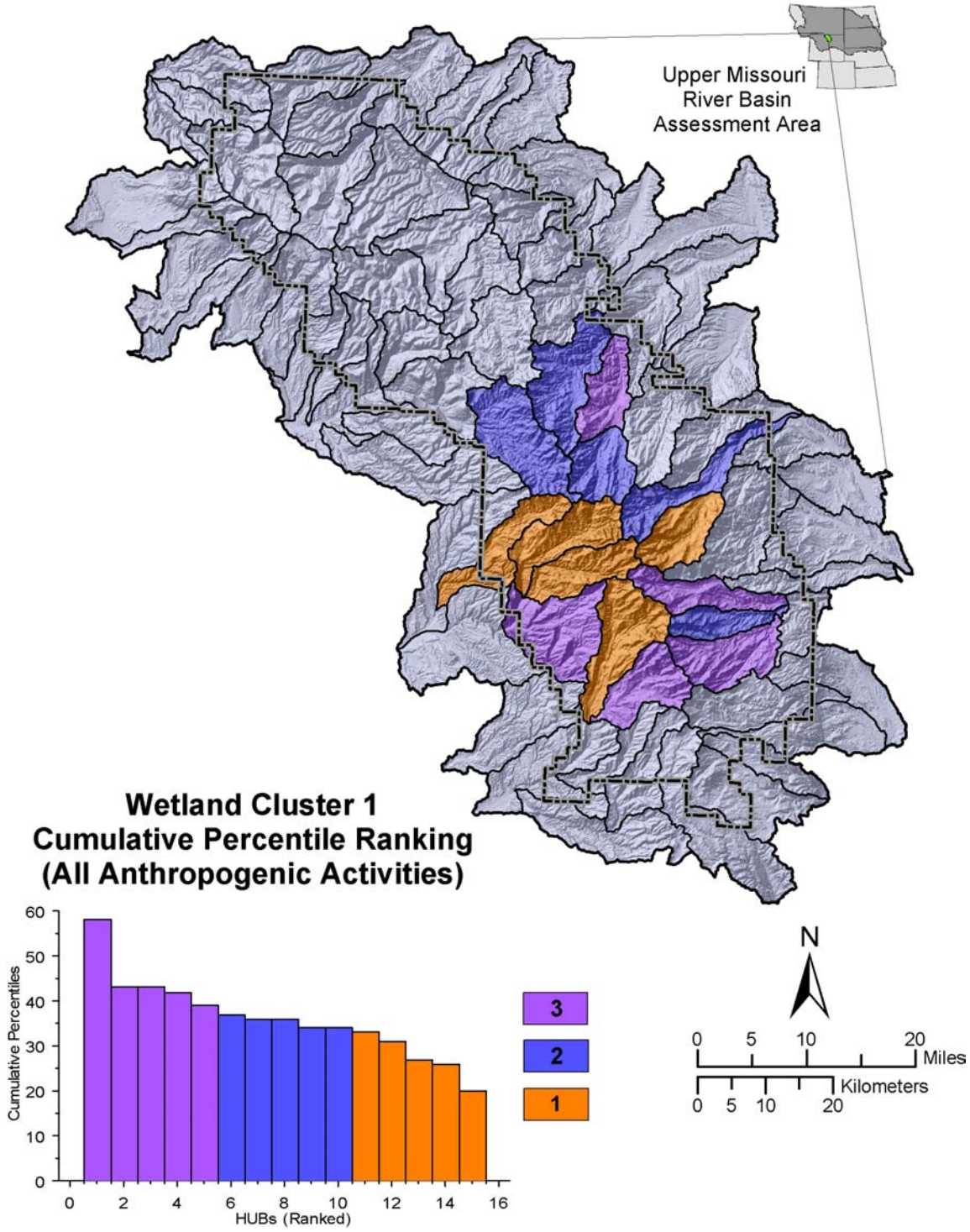

Figure 1.4. Wetland Cluster 1: cumulative percentile values.

Management Considerations: Cluster 1w is valuable from a wetland ecosystem standpoint. This cluster contains the highest percentage of wetlands and riparian areas (41%) on the National Forest even though it occupies only 33% of the Forest area. This cluster is almost exclusively restricted to the Bighorn National Forest, and thus we have considerable management responsibility. The variability in amounts of anthropogenic activities occurring in this cluster indicates that from a biodiversity and habitat diversity standpoint there may be important areas for restoration and protection. In addition, because of the relative importance of this cluster from a biodiversity and habitat diversity standpoint, more strategic emphasis on management for wetland resources may be necessary rather than a mitigation approach to other resources.

Wetland Cluster 2w

Wetland Cluster 2w is comprised predominately of high elevation, non-glaciated terrain that is underlain by non-calcareous geology. The largest proportion of groundwater-fed wetlands within the National Forest is supported within this cluster, thus making it sensitive to fluctuations in the hydrologic regime of the drainage basin. 50.1% of the total area of this cluster is contained within the National Forest boundary.

Relative to the six other wetland clusters, Cluster 2w has the highest potential to be influenced by anthropogenic activities from a wetland ecosystem perspective. Eight of the twelve HUBs are within Quartile 4, with the remainder included in Quartile 3 of the cumulative percentile values (table 1.4). Three of the HUBs designated as Quartile 4 are within the National Forest, including Lower South Tongue River (100901010104), value = 51; Upper Tongue River (100901010103), value = 43; and Little Big Horn River-Wagon Box Creek (100800160101), value = 42.

This cluster was then divided into equal size thirds based upon percentiles as a means of providing a comparison for the potential for anthropogenic influence within the cluster (fig. 1.5). The Shell Creek – Granite Creek (100800100102) HUB has the highest potential to be influenced by anthropogenic activities within Cluster 2w.

Table 1.4. Wetland Cluster 2w: cumulative percentile values, ranks, and quartile designations.

HUB ID	HUB Name	Cumulative Percentile Value	Overall Rank	Rank w/in Wetland Cluster	Quartile
100800100102	Shell Creek-Granite Creek	56	3	1	4
100901010104	Lower South Tongue River	51	4	2	4
100902010301	Upper North Fork Powder River	46	6	3	4
100902050106	Upper Middle Fork Crazy Women Creek	45	7	4	4
100901010103	Upper Tongue River	43	11	5	4
100800160101	Little Big Horn River-Wagon Box Creek	42	14	6	4
100902050101	Upper North Fork Crazy Women Creek	42	15	7	4
100902050107	Poison Creek	41	17	8	4
100800100601	Upper Porcupine Creek	38	22	9	3
100901010109	Upper Quartz Creek	38	23	10	3
100800080404	Leigh Creek	37	28	11	3
100800080405	Upper Canyon Creek	36	31	12	3

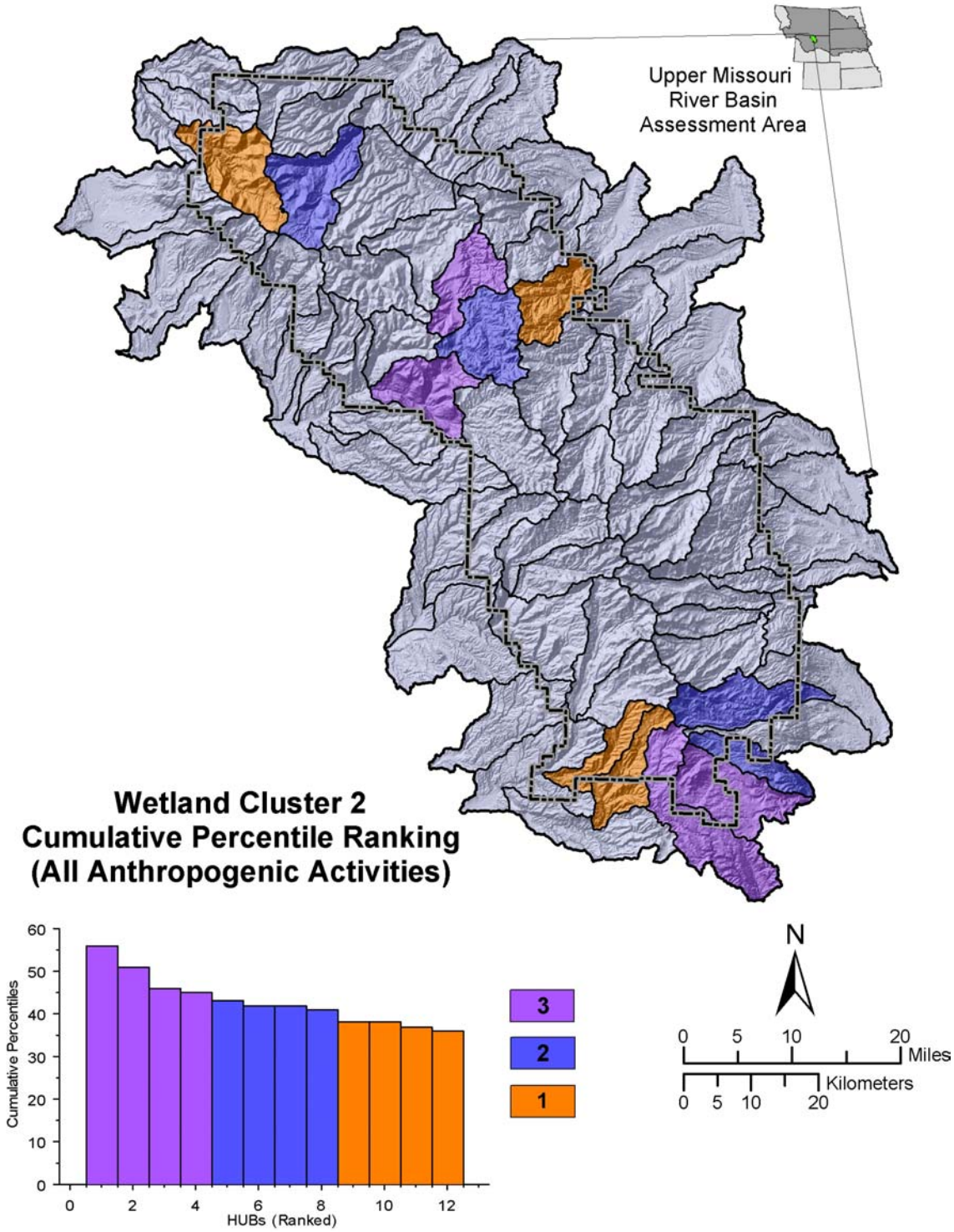

Figure 1.5. Wetland Cluster 2: cumulative percentile values.

Upper Canyon Creek (100800080405) has the least potential to be influenced by anthropogenic activities relative to the other 11 HUBs comprising Cluster 2w, but still has a relatively high potential to be influenced in comparison to all 74 of the HUBs included in the management scale.

Management Considerations: As stated previously, Cluster 2w contains the highest percentage of groundwater-fed wetlands and second highest total wetlands at this scale. Anthropogenic influences that could intercept water to these wetlands would alter their form and function. Watersheds within this cluster could be considered one of the highest for strategic wetland protection and management. Four of the HUBs in this cluster are within the top 10 ranking of 74 HUBs at this scale for cumulative anthropogenic activities. Based on these results, it would appear that there is a high potential for restoration in these HUBs Rather than mitigating for other activities, which seems to have been the historical management strategy, a more proactive management strategy may be more effective in maintaining the integrity of these HUBs.

Wetland Cluster 3w

Wetland Cluster 3w is comprised of six mid-elevation HUBs on the southeastern slope of the Big Horn Mountains. These watersheds are largely non-calcareous, non-glaciated, and have a rain-and-snow driven precipitation regime. This cluster mainly supports stream related riparian ecosystems, with very few groundwater-fed wetlands. This cluster is most sensitive to fluctuations in surface water hydrology. 69.7% of the total area of Cluster 3w is located within the Bighorn National Forest.

Relative to the other six wetland clusters, Cluster 3w has a high potential to be influenced by anthropogenic activities. Three of the six HUBs in this cluster are within Quartile 4, one HUB is within Quartile 3, and two HUBs are within Quartile 2 (table 1.5). No HUBs within Cluster 3w are completely contained by the Bighorn National Forest

This cluster was then divided into equal size thirds based upon percentiles as a means of providing a comparison for the potential for anthropogenic influence within the cluster (fig. 1.6). Within Cluster 3w, the Middle North Fork Crazy Women Creek watershed (100902050102) has the highest potential to be influenced by anthropogenic activities (value = 49), while the North Pine Creek (100902060303) and North Rock Creek (100902060201) have the lowest potential to be influenced (value = 29). However, Cluster 3w still has a relatively high potential to be influenced in comparison to all 74 of the HUBs included in the management scale.

Table 1.5. Wetland Cluster 3w: cumulative percentile values, ranks, and quartile designations.

HUB ID	HUB Name	Cumulative Percentile Value	Overall Rank	Rank w/in Wetland Cluster	Quartile
100902050102	Middle North Fork Crazy Women Creek	49	5	1	4
100901010206	Upper Little Goose Creek	44	8	2	4
100902060104	Clear Creek-Grommund Creek	41	18	3	4
100902060107	French Creek	38	24	4	3
100902060201	North Rock Creek	29	49	5	2
100902060303	North Piney Creek	29	50	6	2

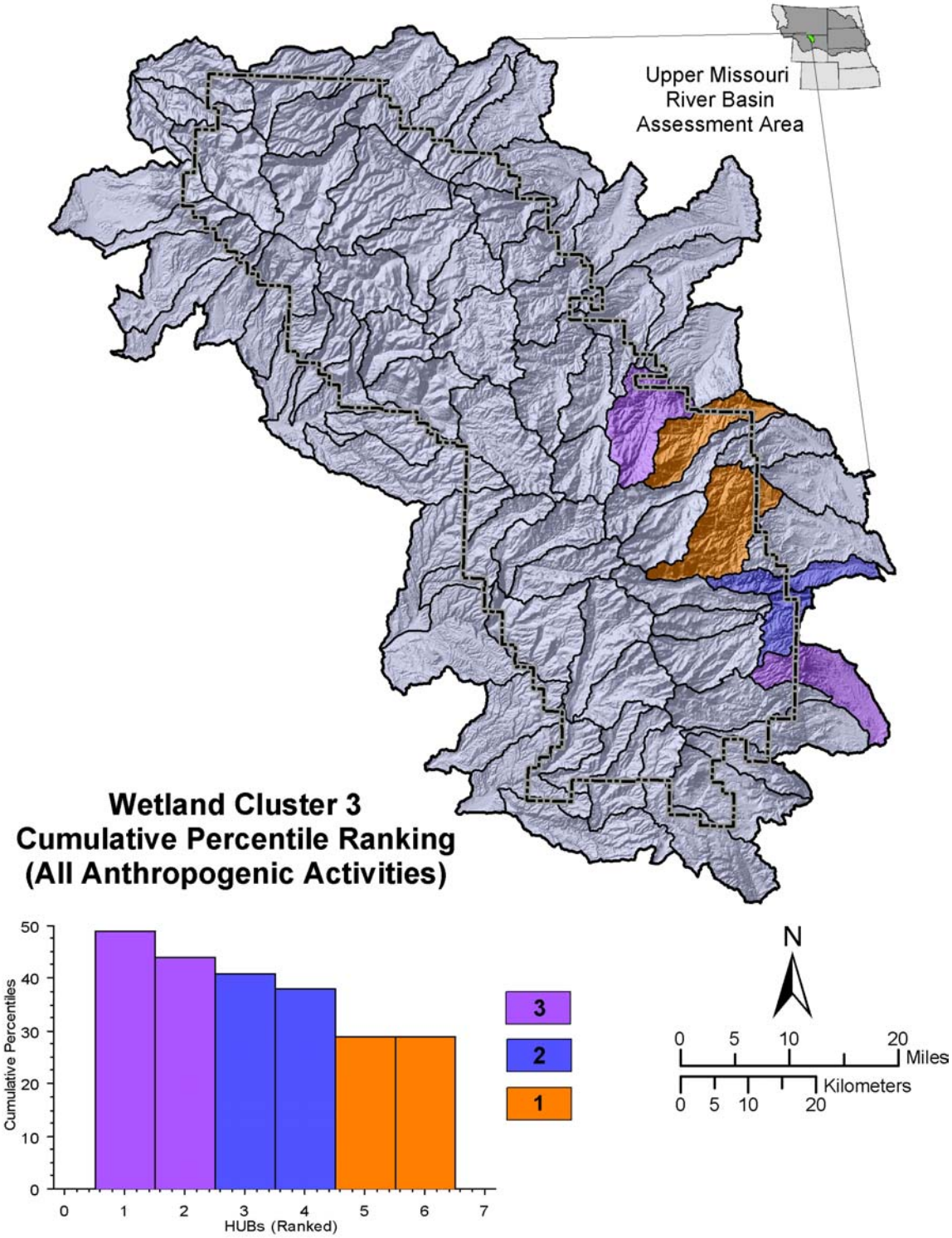

Figure 1.6. Wetland Cluster 3: cumulative percentile value.

Management Considerations: Cluster 3w has considerably less wetlands than clusters 1w and 2w. Wetlands are most likely isolated and smaller. As a result, mitigation measures for other management activities may be the most reasonable means of managing wetlands. However, individual wetlands may be important for habitats for rare species as well as maintaining connectivity across the landscape. Restoration of individual wetlands may be an important means of improving conditions in these relatively rare wetlands.

Wetland Cluster 4w

Wetland Cluster 4w occupies most of the southwestern portion of the Big Horn Mountains. This cluster has predominately calcareous geology, non-glaciated valleys and ridges, and a rain-and-snow driven precipitation regime. These HUBs support only a small wetland ecosystem area, and are mainly sensitive to fluctuations in surface water hydrology and sedimentation. Only 16.1% of the total area of Cluster 4w is within the Bighorn National Forest.

Relative to the other six wetland clusters, Cluster 4w has a lower potential to be influenced by anthropogenic activities. Three of the nine HUBs comprising Cluster 4w are designated as Quartile 3, with the remainder in Quartile 1 (table 1.6). No HUBs within Cluster 4w are completely contained by the Bighorn National Forest.

This cluster was then divided into equal size thirds based upon percentiles as a means of providing a comparison for the potential for anthropogenic influence within the cluster (fig. 1.7). Within Cluster 4w, the Brockenback Creek watershed (100800080502) has the highest potential to be influenced by anthropogenic activities (value = 40), while the North Middle Porcupine Creek watershed has the lowest potential to be influenced (value = 5). Cluster 4w has a relatively low potential to be influenced in comparison to all 74 of the HUBs included in the management scale.

Table 1.6. Wetland Cluster 4w: cumulative percentile values, ranks, and quartile designations.

HUB ID	HUB Name	Cumulative Percentile Value	Overall Rank	Rank w/in Wetland Cluster	Quartile
100800080502	Brockenback Creek	40	19	1	3
100800080403	Lower Tensleep Creek	38	25	2	3
100800080606	Lower Medicine Lodge Creek	35	32	3	3
100800100106	Trapper Creek	27	55	4	1
100800100604	Trout Creek	25	59	5	1
100800080604	Paint Rock Creek-Luman Draw	22	62	6	1
100800100603	Deer Creek	14	69	7	1
100800080406	Lower Canyon Creek	8	71	8	1
100800100602	Middle Porcupine Creek	5	73	9	1

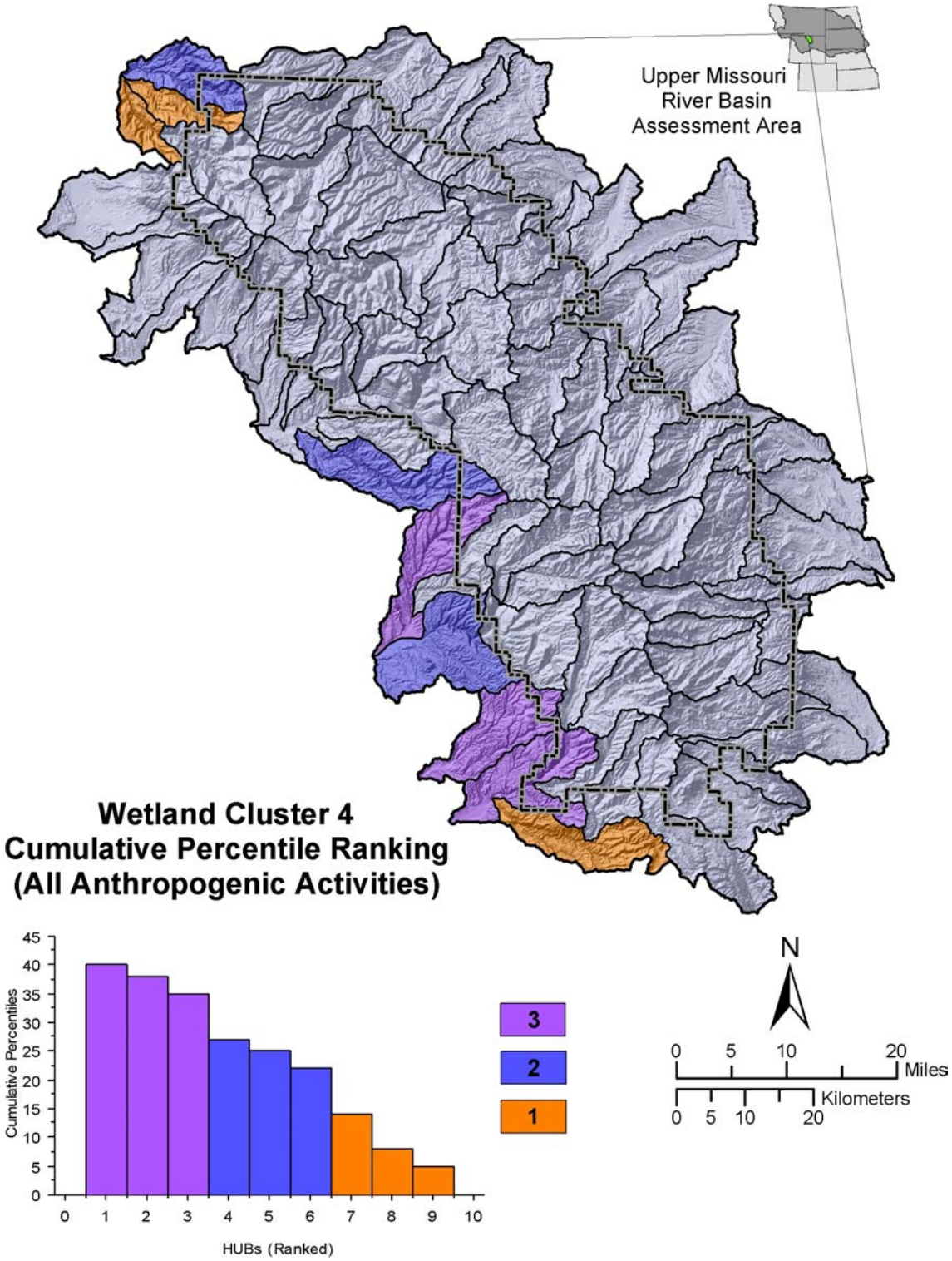

Figure 1.7. Wetland Cluster 4: cumulative percentile value.

Management Considerations: Similar to Cluster 3w, Custer 4w contains mostly isolated, smaller wetlands. In addition, HUBs within this cluster have relatively small areas within the Bighorn National Forest boundary. As a result, mitigation measures could be taken on a project-by-project basis to maintain the integrity of most wetlands. In addition, these watersheds exhibit a relatively low ranking for cumulative anthropogenic activities, indicating limited management influences. HUBs within this cluster would not be considered as high a priority as Clusters 1w and 2w for strategic management. It is important to note that because of the calcareous geology and position at the lower flanks of the Big Horn Mountains, Cluster 4w could have a higher percentage of groundwater-fed springs and flora associated with them. While these important habitats have not been adequately mapped, additional emphasis on them could be valuable from a biodiversity and habitat diversity standpoint.

Wetland Cluster 5w

Cluster 5w occupies the north-central portion of the Big Horn Mountains, and has predominately calcareous geology, non-glaciated valleys, and a snow-driven precipitation regime. The low gradient valleys within these watersheds are conducive to the establishment of lakes, meadows, and groundwater-fed wetlands. Indeed, this cluster contains the second highest percentage of lakes and meadows of any wetland cluster. These watersheds are sensitive to fluctuations in sediment and hydrology (both surface water and groundwater) regime. 82.6% of the total area of Cluster 5w is within the Bighorn National Forest.

Relative to the other six wetland clusters, Cluster 5w has a moderate to high potential to be influenced by anthropogenic activities. Of the eight HUBs comprising Cluster 5w one HUB is designated as Quartile 4, one HUB is designated as Quartile 3, three HUBs are designated as Quartile 2, and three HUBs are designated as Quartile 1 (table 1.7). Three HUBs within Cluster 5w are completely contained by the Bighorn National Forest, and include Fool Creek (100901010102), value = 42; White Creek (100800100105), value = 28; and Cedar Creek (100800100103), value = 27.

This cluster was then divided into equal size thirds based upon percentiles as a means of providing a comparison for the potential for anthropogenic influence within the cluster (fig. 1.8). Within Cluster 5w, the Fool Creek watershed (100901010102) has the highest potential to be influenced by anthropogenic activities (value = 42), while the West Fork Little Big Horn River (100800160104) and Lodge Grass Creek-Line Creek (100800160301) watershed have the lowest potential to be influenced (value = 23). Cluster 4w has a relatively moderate to low potential to be influenced in comparison to all 74 of the HUBs included in the management scale.

Table 1.7. Wetland Cluster 5w: cumulative percentile values, ranks, and quartile designations.

HUB ID	HUB Name	Cumulative Percentile Value	Overall Rank	Rank w/in Wetland Cluster	Quartile
100901010102	Fool Creek	42	16	1	4
100800160102	Dry Fork Little Big Horn River	34	36	2	3
100800100107	Horse Creek	32	40	3	2
100800100105	White Creek	28	53	5	2
100901010101	North Tongue River	28	52	4	2
100800100103	Cedar Creek	27	56	6	1
100800160104	West Fork Little Big Horn River	23	60	7	1
100800160301	Lodge Grass Creek-Line Creek	23	61	8	1

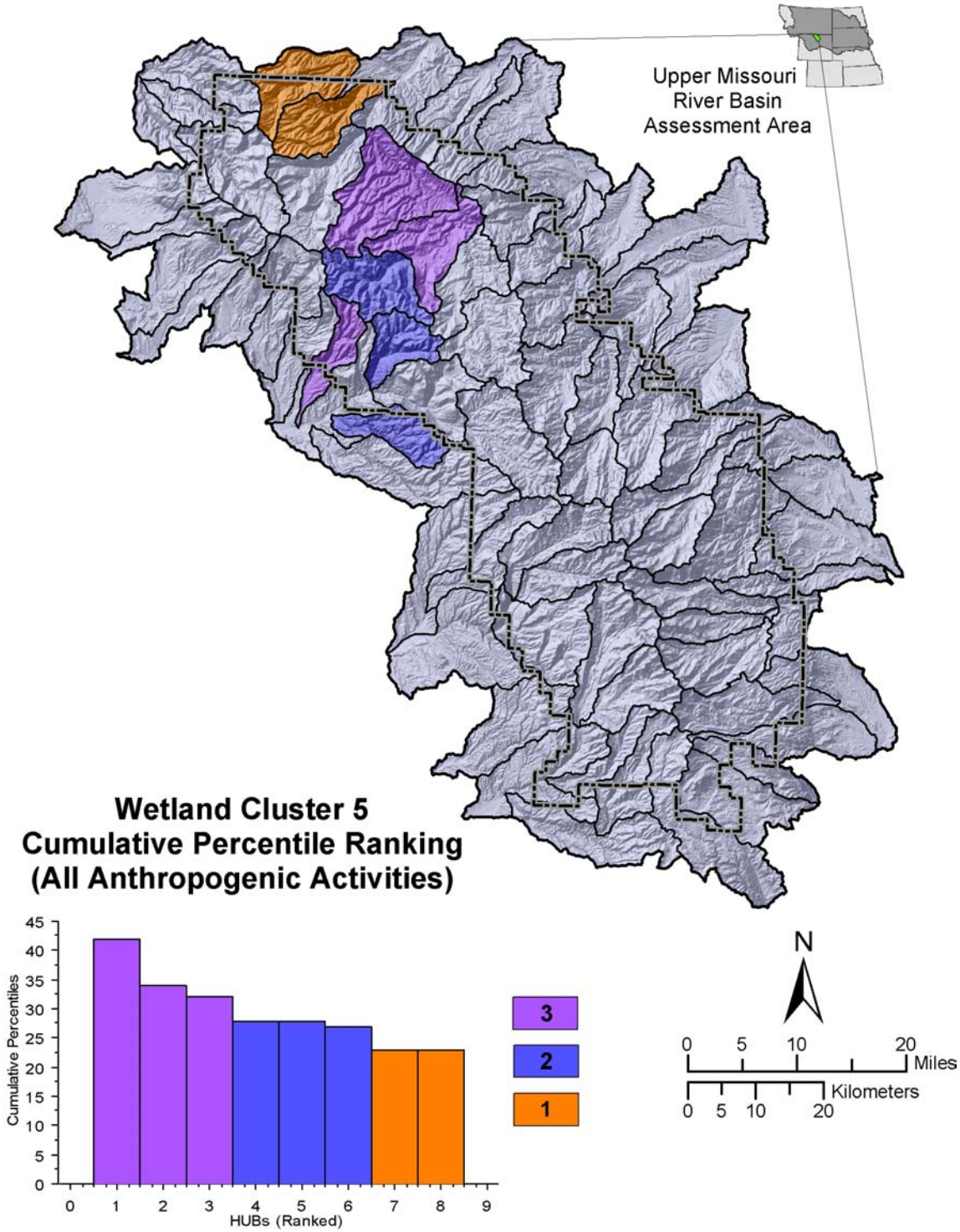

Figure 1.8. Wetland Cluster 5: cumulative percentile values.

Management Considerations: Because of the relatively high percentage of calcareous geology and broad valleys in Cluster 5w there is a high potential for spring habitats and other wetland types, with associated rare species of plants and animals. While these springs are currently not sufficiently mapped, additional efforts could be focused on this effort and subsequent management. The relatively high percentage of mesic meadow environments also is indicative of springs. Anthropogenic activities that influence vegetation and water quality could be considered important influences within these environments.

Wetland Cluster 6w

Cluster 6w HUBs have both calcareous and non-calcareous bedrock, unglaciated valleys, and occur at low elevations with hydrologic regimes driven by rain and rain-and-snow precipitation. Stream valley associated wetlands are the most common form of wetland occurring in this cluster. As a result, wetlands within these clusters are most sensitive to fluctuations in the sediment and surface water hydrologic regimes. Only 30.0% of the total area of Cluster 6w is located within the Bighorn National Forest.

Relative to the other six wetland clusters, Cluster 6w has a moderate potential to be influenced by anthropogenic activities. Of the 19 HUBs comprising Cluster 6w, two HUBs are designated as Quartile 4, four HUBs are designated as Quartile 3, eight HUBs are designated as Quartile 2, and four HUBs are designated as Quartile 1 (table 1.8). No HUBs within Cluster 6w are completely contained by the Bighorn National Forest. In relation to the 74 HUBs comprising the management scale, Cluster 6w has the watershed with the second highest potential to be influenced by anthropogenic activities (Muddy Creek), and the watershed with the lowest potential to be influenced (Salt Creek).

This cluster was then divided into equal size thirds based upon percentiles as a means of providing a comparison for the potential for anthropogenic influence within the cluster (fig. 1.9). Within Cluster 6w, the Muddy Creek watershed (100902050103) has the highest potential to be influenced by anthropogenic activities (value = 57), while the Salt Creek watershed (100800100307) has the lowest potential to be influenced (value = 3). Overall, Cluster 6w has a moderate potential to be influenced in comparison to all 74 of the HUBs included in the management scale, with the widest range of potential influences.

Management Considerations: HUBs in Cluster 6w are largely at the periphery of the Bighorn National Forest, but are extremely important because of the presence of rare wetland plants. Springs are typically associated with these plants because water percolating through the Big Horn Mountains and are found largely within this cluster. The relatively high percentage of calcareous geology in some of the HUBs within this cluster also aids in the development of springs. Proper management of these springs is important for the persistence of rare plants within this cluster. Management that influences the hydrology and vegetation of these low elevation springs and mesic meadows could be considered a threat to their form and function and could be managed for this resource value.

Table 1.8. Wetland Cluster 6w: cumulative percentile values, ranks, and quartile designations.

HUB ID	HUB Name	Cumulative Percentile Value	Overall Rank	Rank w/in Wetland Cluster	Quartile
100902050103	Muddy Creek	57	2	1	4
100800100401	Five Springs Creek	43	12	2	4
100901010105	Tongue River-Sheep Creek	40	20	3	3
100901010204	Upper Big Goose Creek	38	26	4	3
100800160107	West Pass Creek	35	33	5	3
100800100402	Big Horn River-Willow Creek	34	37	6	3
100901010107	Little Tongue River	33	39	7	2
100800100309	Crystal Creek	32	41	8	2
100800100204	Lower Beaver Creek	31	43	9	2
100800160103	Little Big Horn River-Red Canyon Creek	31	45	11	2
100901010106	Tongue River-Columbus Creek	31	44	10	2
100800100104	Shell Creek-Cottonwood Creek	30	47	13	2
100800100203	Upper Beaver Creek	30	46	12	2
100800160108	East Pass Creek	29	51	14	2
100800100305	Upper Bear Creek	26	58	15	1
100902060304	Upper Piney Creek	20	66	16	1
100902060202	Rock Creek	17	67	17	1
100800100307	Salt Creek	3	74	18	1

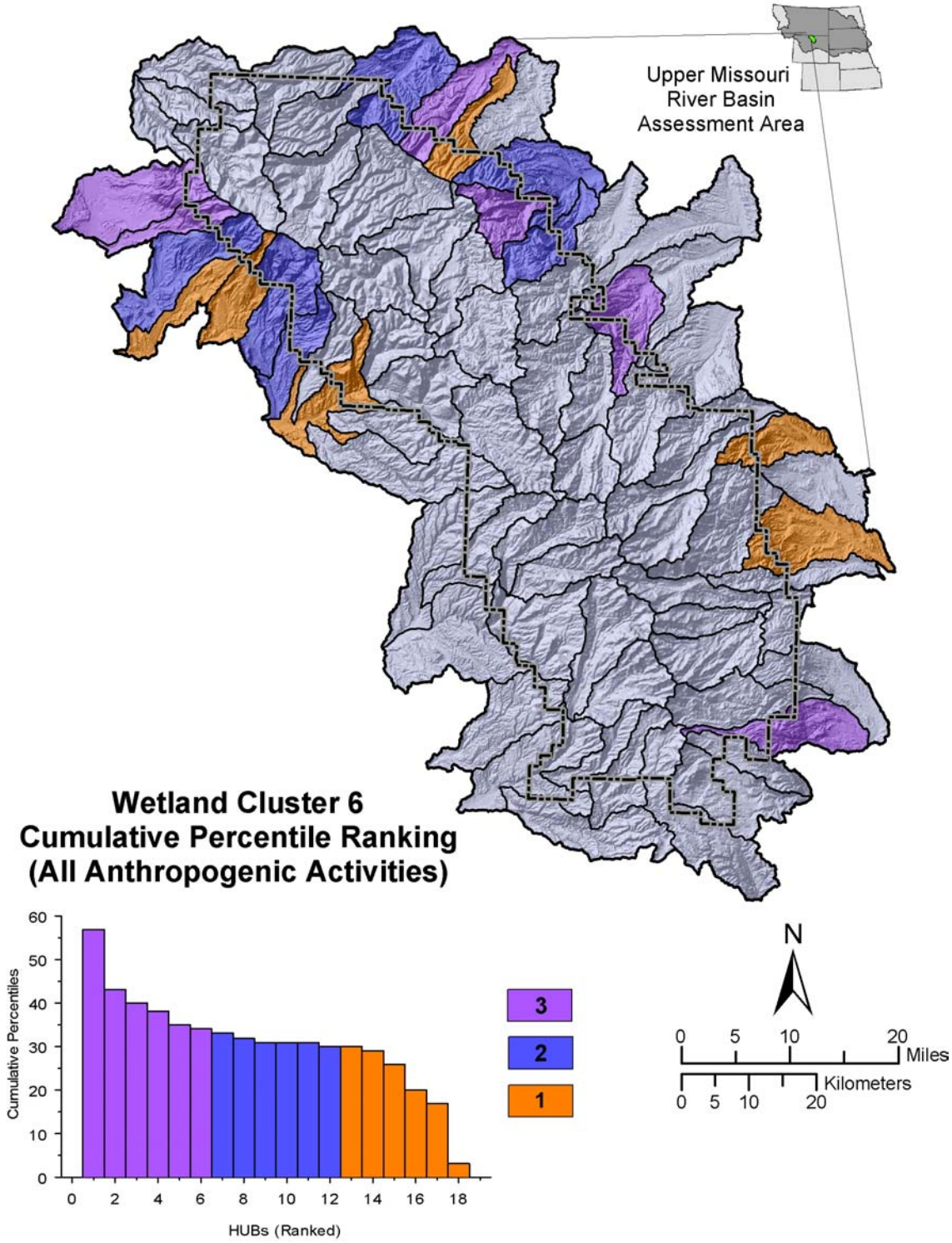

Figure 1.9. Wetland Cluster 6: cumulative percentile values.

Wetland Cluster 7w

Cluster 7w watersheds are at low elevations and have non-calcareous geology, non-glaciated valleys, and rain-driven precipitation regimes. These watersheds tend to be located on the eastern flanks of the Big Horn Mountains. This cluster has the least area classified as wetlands. The few existing wetlands are related to stream reaches, and are sensitive to fluctuation in sediment and surface water hydrologic regimes. Only 2.1% of the total area of Cluster 7w is located within the Bighorn National Forest.

Relative to the other six wetland clusters, Cluster 7w has the lowest potential to be influenced by anthropogenic activities. Of the six HUBs comprising Cluster 7w one HUB is designated as Quartile 2, with the remainders designated as Quartile 1 (table 1.9). No HUBs within Cluster 6 are completely contained by the Bighorn National Forest.

This cluster was then divided into equal size thirds based upon percentiles as a means of providing a comparison for the potential for anthropogenic influence within the cluster (fig. 1.10). Within Cluster 7w, the Lower Big Goose Creek watershed (100901010205) has the highest potential to be influenced by anthropogenic activities (value = 30), while the North Prong Shell Creek watershed (100902060305) has the lowest potential to be influenced (value = 3). Cluster 7w has the lowest potential to be influenced in comparison to all 74 of the HUBs included in the management scale.

Table 1.9. Wetland Cluster 7w: cumulative percentile values, ranks, and quartile designations.

HUB ID	HUB Name	Cumulative Percentile Value	Overall Rank	Rank w/in Wetland Cluster	Quartile
100901010205	Lower Big Goose Creek	30	48	1	2
100901010207	Middle Goose Creek	22	63	2	1
100901010209	Goose Creek	22	64	3	1
100800160109	Twin Creek	16	68	4	1
100901010110	Lower Quartz Creek	10	70	5	1
100902060305	North Prong Shell Creek	8	72	6	1

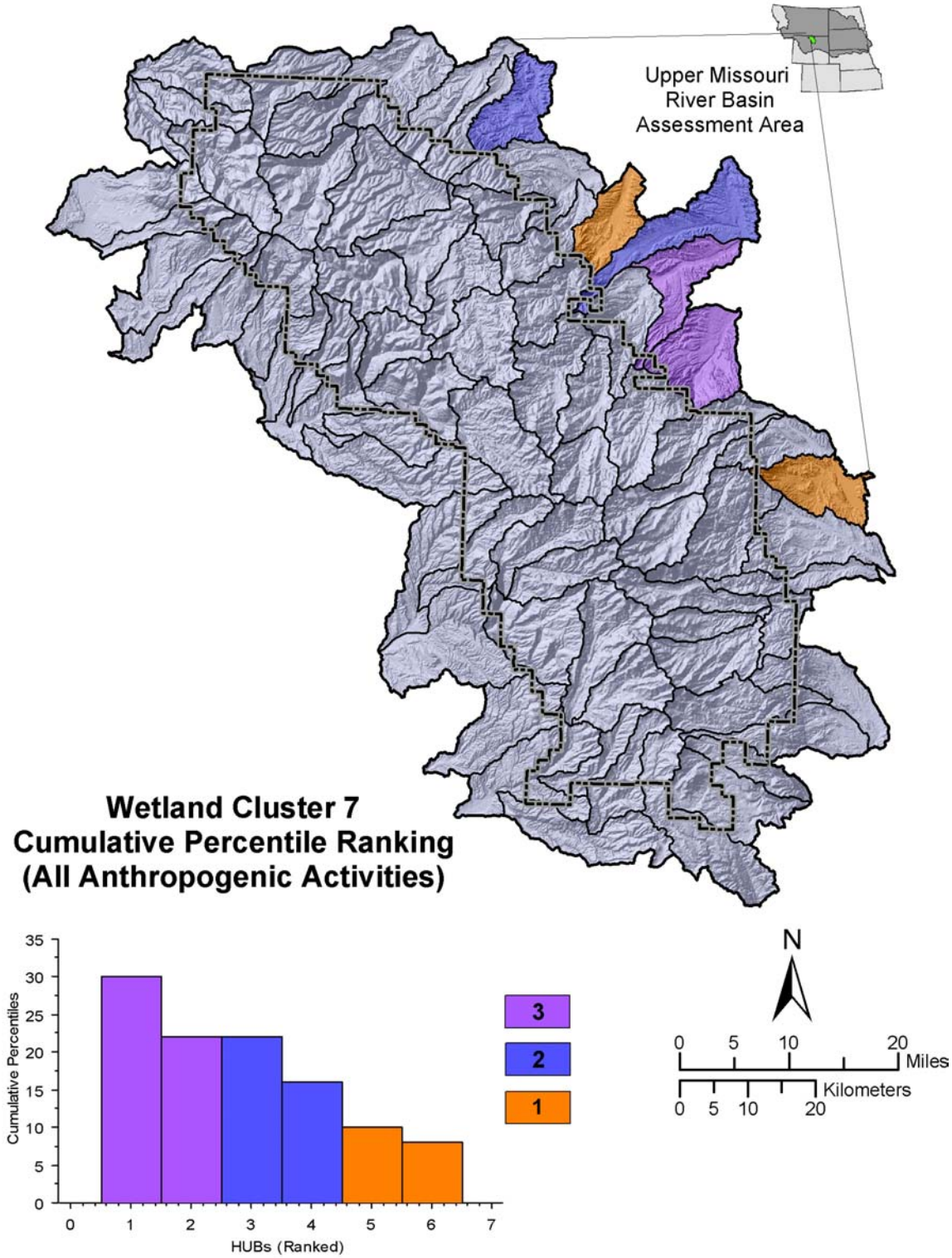

Figure 1.10. Wetland Cluster 7: cumulative percentile values.

Management Considerations: There are limited management opportunities within Cluster 7w. However, there are important management considerations that could be considered. While limited, there are probably important springs and associated rare plants that could be protected to maintain their integrity. Adequate inventory of these wetlands would be important to prioritize management of these wetlands.

Riparian Ecological Driver Clusters

The aggregate cluster analysis of the ecological drivers for riparian ecosystems at the management scale identified six unique clusters. Each of these clusters has a distinct signature represented by aerial variations in geology (calcareous and non-calcareous lithology), climate (precipitation regime) and stream gradient (table 1.10). The ecological context of each driver combination will influence channel morphology, species diversity, and aquatic productivity.

Table 1.10. Ecological driver results for riparian clusters.

	Percent Area or Length Encompassed by a Specific Ecological Driver							
	Geology		Climate (precipitation)			Stream Gradient		
Riparian Clusters	Ca	Cn	Pr	Prs	Ps	Gh	Gm	Gl
1r	11.37	88.63	0.07	21.22	78.71	57.16	32.33	10.52
2r	52.57	47.43	0.46	46.89	52.65	44.68	34.40	20.92
3r	9.86	90.14	17.43	66.09	16.49	50.12	20.09	29.78
4r	58.84	41.16	8.95	21.18	69.87	79.76	13.20	7.04
5r	77.13	22.87	31.34	53.94	14.72	62.00	18.23	19.78
6r	16.79	83.21	76.61	20.61	2.78	31.90	28.38	39.72

Ca *– calcareous geology,* ***Cn*** *- non-calcareous geology;* ***Pr*** *- rain driven hydrology,* ***Prs*** *– rain-and-snow driven hydrology,* ***Ps*** *- snowmelt driven hydrology;* ***Gh*** *- high gradient stream reaches,* ***Gm*** *– moderate gradient stream reaches,* ***Gl*** *- low gradient stream reaches*

Riparian Cluster 1r

Riparian Cluster 1r is dominated by high elevation, high gradient streams, with non-calcareous geology and a snow-driven precipitation regime. A majority of the riparian areas are related to perennial stream channels. These channels are likely to be influenced by fluctuations in surface water hydrologic regime and sediment regime (for lower gradient, pool-riffle channels). These high gradient, coldwater streams are expected to be perennial and thus support higher invertebrate diversity and continuous aquatic productivity. From a fisheries viewpoint, this combination of ecological drivers is least conducive to fish production. While limited by temperature, self-sustaining fish populations would be expected where habitat conditions are adequate. HUBs in this cluster support the largest riparian classified areas. 56.7% of the total area of Cluster 1r is within the Bighorn National Forest.

Relative to the five other riparian clusters, Cluster 1r has a high potential to be influenced by anthropogenic activities. Eight of the nineteen HUBs are within Quartile 4 of the cumulative percentile values, seven HUBs included in Quartile 3, two HUBs within Quartile 2, and two HUBs within Quartile 1 (table 1.11). Two of the HUBs designated as Quartile 4 are within the National Forest, including the Lower South Tongue River watershed (100901010104), value = 51; and Paint Rock Creek-South Paint Rock Creek watershed (100800080603), value = 43.

This cluster was then divided into equal size thirds based upon percentiles as a means of providing a comparison for the potential for anthropogenic influence within the cluster (fig. 1.11). This cluster includes the Lower East Fork Big Goose Creek watershed (100901010202), the HUB with the highest potential for anthropogenic influence among all HUBs within the management scale (value = 58). Long Park Creek (100800080602) has the least potential to be influenced by anthropogenic activities relative to the other 18 HUBs comprising Cluster 1r (value = 20).

Table 1.11. Riparian Cluster 1r: cumulative percentile values, ranks, and quartile designations.

HUB ID	HUB Name	Cumulative Percentile Value	Overall Rank	Rank w/in Riparian Cluster	Quartile
100901010202	Lower East Fork Big Goose Creek	58	1	1	4
100901010104	Lower South Tongue River	51	4	2	4
100800080603	Paint Rock Creek-South Paint Rock Creek	43	9	3	4
100901010103	Upper Tongue River	43	11	5	4
100902060103	Seven Brothers Creek	43	10	4	4
100800080402	East Tensleep Creek	42	15	8	4
100800160101	Little Big Horn River-Wagon Box Creek	42	14	7	4
100902050101	Upper North Fork Crazy Women Creek	42	13	6	4
100902060101	South Clear Creek	39	21	9	3
100800100601	Upper Porcupine Creek	38	22	10	3
100800100101	Shell Creek-Willett Creek	37	27	11	3
100902060102	Middle Clear Creek	36	30	13	3
100902060302	Kearny Creek	36	29	12	3
100901010201	Upper East Fork Big Goose Creek	34	35	15	3
100901010203	West Fork Big Goose Creek	34	34	14	3
100800080401	Upper Tensleep Creek	33	38	16	2
100902060301	South Piney Creek	31	42	17	2
100800080601	Paint Rock Creek-Trout Creek	26	57	18	1
100800080602	Long Park Creek	20	65	19	1

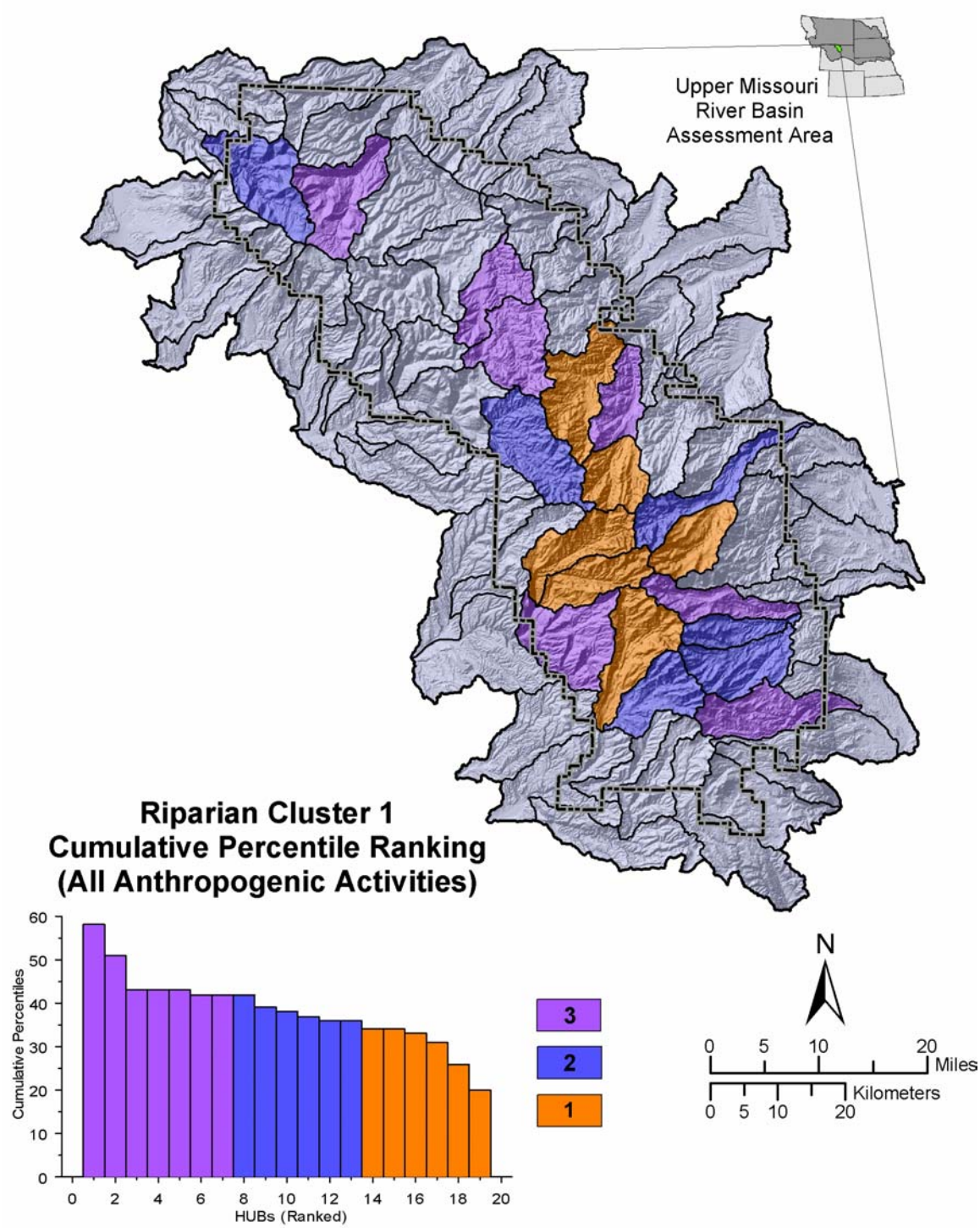

Figure 1.11. Riparian Cluster 1: cumulative percentile values.

Management Considerations: Cluster 1r occupies a considerable amount of land within the Bighorn National Forest, and exhibits a wide range of anthropogenic activities (from the highest rank to 65 of 74). Because of the high percentage of riparian area within this cluster, developing reference conditions and relative impacts should be attainable for vegetation and physical characteristics. Obviously, the HUBs with the highest ranking should be considered more closely for restoration efforts. It would appear that riparian vegetation would be one of the key emphasis areas for restoration.

Riparian Cluster 2r

Cluster 2r is the most heterogeneous of the six riparian clusters. HUBs tend to be located both north and south of the core of the Bighorn Range. Calcareous geology occupies a higher percentage of the HUB area than non-calcareous geology. The hydrologic regime is driven by snow or rain-and-snow precipitation, and channels typically have moderate to high gradient reaches, although local low gradient reaches are abundant. The cool-water, perennial streams associated with this combination of ecological drivers are likely to support a high invertebrate diversity and continuous aquatic productivity. Watersheds in this cluster should have a high diversity of fish habitat conditions. Coldwater fish production could be considered high in this cluster. This particular set of driver combinations are relatively rare on the Bighorn National Forest, and are important areas for coldwater fisheries. A large proportion of the riparian area is related to stream channels, thus making this cluster sensitive to fluctuations in surface water hydrologic regime and sediment regime. 57.2% of the total area of Cluster 2r is located within the Bighorn National Forest.

Relative to the other five riparian clusters, Cluster 2r has the highest potential to be influenced by anthropogenic activities. Of the seven HUBs comprising Cluster 2r, three are within Quartile 4 of the cumulative percentile values, two are within Quartile 3 and one is within Quartile 1 (table 1.12). Three HUBs are completely contained by the Bighorn National Forest: Leigh Creek (100800080404), value = 37; Upper Canyon Creek (100800080405), value = 36; and Upper Medicine Lodge Creek (100800080605), value = 27.

This cluster was then divided into equal size thirds based upon percentiles as a means of providing a comparison for the potential for anthropogenic influence within the cluster (fig. 1.12). Within Cluster 2r, the Upper North Fork Powder River watershed (100902010301) has the highest potential to be influenced by anthropogenic activities (value = 46), while the Upper Medicine Lodge Creek (100800080605) has the lowest potential to be influenced (value = 27). Cluster 2r has the highest potential to be influenced in comparison to all 74 of the HUBs included in the management scale.

Table 1.12. Riparian Cluster 2r: cumulative percentile values, ranks, and quartile designations.

HUB ID	HUB Name	Cumulative Percentile Value	Overall Rank	Rank w/in Riparian Cluster	Quartile
100902010301	Upper North Fork Powder River	46	6	1	4
100902050106	Upper Middle Fork Crazy Women Creek	45	7	2	4
100901010102	Fool Creek	42	16	3	4
100902050107	Poison Creek	41	17	4	4
100800080404	Leigh Creek	37	28	5	3
100800080405	Upper Canyon Creek	36	31	6	3
100800080605	Upper Medicine Lodge Creek	27	54	7	1

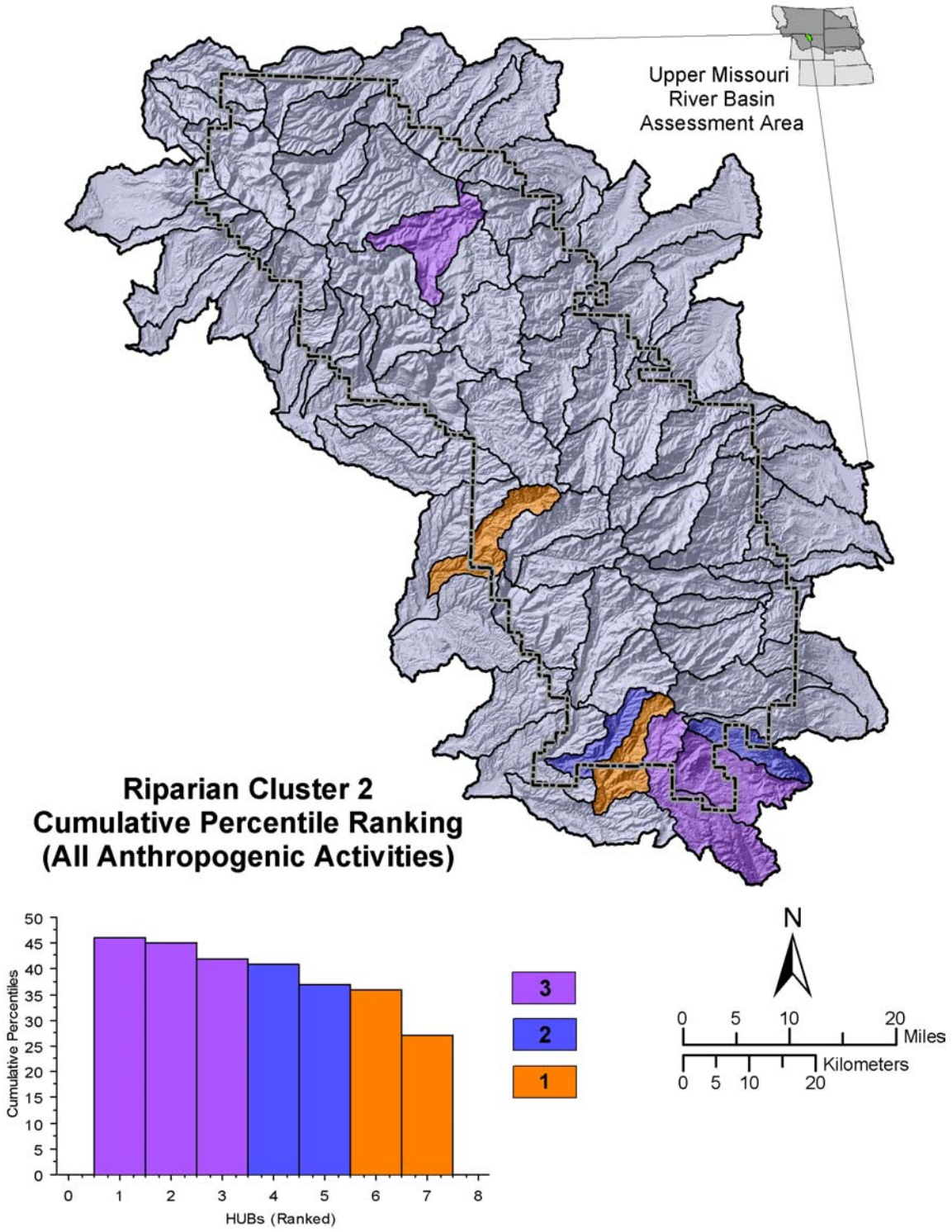

Figure 1.12. Riparian Cluster 2: cumulative percentile values.

Management Considerations: While there are relatively few 6th level HUBs within Cluster 2r, they are very important from a riparian and aquatic productivity standpoint. Because this cluster has the highest percentage of each HUB identified as riparian area and high potential for aquatic (including fishery) productivity it could be an important cluster to manage for native fish and riparian communities. The Fool Creek HUB in particular would appear to be an important watershed for restoration because it is located totally within the Bighorn National Forest boundary, and also within the City of Sheridan water supply system. The Upper Medicine Lodge HUB would also be a likely place to understand reference conditions for this cluster. This type of productive watershed is relatively rare within the Bighorn National Forest, also making it a valuable resource for aquatic, riparian, and wetland resources.

Riparian Cluster 3r

Riparian Cluster 3r is primarily located on the eastern flanks of the Big Horn Mountains. This cluster is dominated by non-calcareous geology, high gradient streams (with localized, low gradient reaches), and a rain-and-snow precipitation regime. Fisheries productivity is likely higher in this cluster than in Clusters 1r and 4r, as the thermal regime is less harsh, and there are a relatively high percentage of low gradient stream channels. However, the non-calcareous geology could limit aquatic productivity and fish biomass somewhat. A vast majority of the riparian areas in this cluster are related to stream channels, thus making them sensitive to fluctuations in the surface water hydrologic regime and sediment regime. Of the total area included within Cluster 3r, 36.5% is contained within the Bighorn National Forest.

Relative to the other five riparian clusters, Cluster 3r has a high potential to be influenced by anthropogenic activities. Of the eleven HUBs comprising Cluster 3r, five are within Quartile 4 of the cumulative percentile values, three are within Quartile 3, two are within Quartile 2, and one is within Quartile 1 (table 1.13). One HUB is completely contained by the Bighorn National Forest: Shell Creek-Granite Creek (100800100102), value = 56.

This cluster was then divided into equal size thirds based upon percentiles as a means of providing a comparison for the potential for anthropogenic influence within the cluster (fig. 1.13). Within Cluster 3r, the Muddy Creek watershed (100902050103), value = 57; and the Shell Creek-Granite Creek (100800100102), value = 56; have the highest potential to be influenced by anthropogenic activities, while the Rock Creek (100902060202) has the lowest potential to be influenced (value = 17). Cluster 3r has the highest potential to be influenced in comparison to all 74 of the HUBs included in the management scale.

Table 1.13. Riparian Cluster 3r: cumulative percentile values, ranks, and quartile designations.

HUB ID	HUB Name	Cumulative Percentile Value	Overall Rank	Rank w/in Riparian Cluster	Quartile
100902050103	Muddy Creek	57	2	1	4
100800100102	Shell Creek-Granite Creek	56	3	2	4
100902050102	Middle North Fork Crazy Women Creek	49	5	3	4
100901010206	Upper Little Goose Creek	44	8	4	4
100902060104	Clear Creek-Grommund Creek	41	18	5	4
100901010105	Tongue River-Sheep Creek	40	19	6	3
100901010109	Upper Quartz Creek	38	24	8	3
100902060107	French Creek	38	23	7	3
100902060201	North Rock Creek	29	50	10	2
100902060303	North Piney Creek	29	49	9	2
100902060202	Rock Creek	17	67	11	1

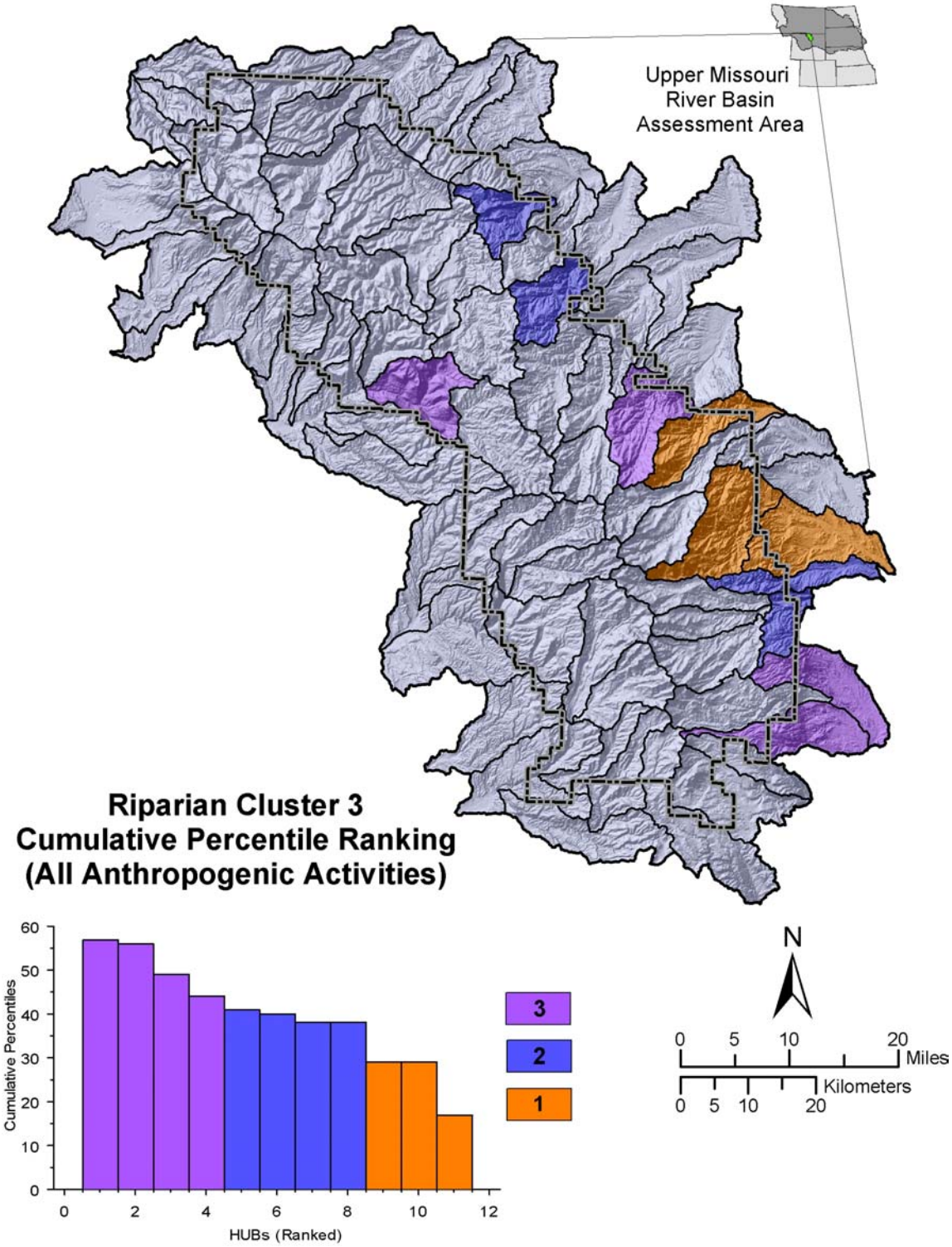

Figure 1.13. Riparian Cluster 3: cumulative percentile values.

Management Considerations: While sensitive to anthropogenic activities because of the dominance of granitic geology, Cluster 3r has three HUBs that rank in the top five of 74 HUBs for cumulative anthropogenic activities. In addition, the relatively high percentage of low gradient stream channel and warmer water temperatures would indicate that fishery and aquatic productivity could be relatively high. Restoration of these HUBs could be a priority with HUBs exhibiting relatively few influences like North Rock and Rock Creek watersheds could be used to identify reference conditions. Because of the rain-and-snow climate and granitic geology, it would be expected that other activities could influence sediment movement in steeper portions of the HUBs. Travel management as well as other ground disturbing activities within the valley bottom could be considered priorities for management.

Riparian Cluster 4r

Riparian Cluster 4r is located primarily at high elevations on the northern side of the Big Horn Mountains. These HUBs are generally underlain with calcareous bedrock, have high gradient stream channels, and are dominated by a snow-driven precipitation regime. The higher gradient, cool-water streams in this ecological setting are expected to be perennial and thus support moderate invertebrate diversity and continuous aquatic productivity. Aquatic productivity in lower gradient reaches (such as those in mountain valleys) may be locally more productive than the higher gradient stream reaches. Coldwater fish species should be more adapted to this environment than warm-water species, but high stream gradients and cold temperatures would limit fish production. The ecological setting of this cluster is not conducive to the establishment of extensive riparian ecosystems. As a result, the cluster is sensitive to fluctuations in the hydrologic, sediment and precipitation regimes. 85.3% of the total area of Cluster 4r is located within the Bighorn National Forest.

Relative to the other five wetland clusters, Cluster 4r has a moderate potential to be influenced by anthropogenic activities. Of the three HUBs comprising Cluster 4r, two are within Quartile 2 and one is within Quartile 1 (table 1.14). One HUB is completely contained by the Bighorn National Forest: Horse Creek (100800100107), value = 32.

This cluster was then divided into equal size thirds based upon percentiles as a means of providing a comparison for the potential for anthropogenic influence within the cluster (fig. 1.14). Within Cluster 4r, the Horse Creek (100800100107), value = 32, has the highest potential to be influenced by anthropogenic activities, while the Cedar Creek (100800100103) has the lowest potential to be influenced (value = 27). Cluster 4r has a moderate potential to be influenced in comparison to all 74 of the HUBs included in the management scale. Unlike the other clusters, the cumulative percentile values of Cluster 4 have a low variance.

Table 1.14. Riparian Cluster 4r: cumulative percentile values, ranks, and quartile designations.

HUB ID	HUB Name	Cumulative Percentile Value	Overall Rank	Rank w/in Riparian Cluster	Quartile
100800100107	Horse Creek	32	40	1	2
100901010101	North Tongue River	28	52	2	2
100800100103	Cedar Creek	27	55	3	1

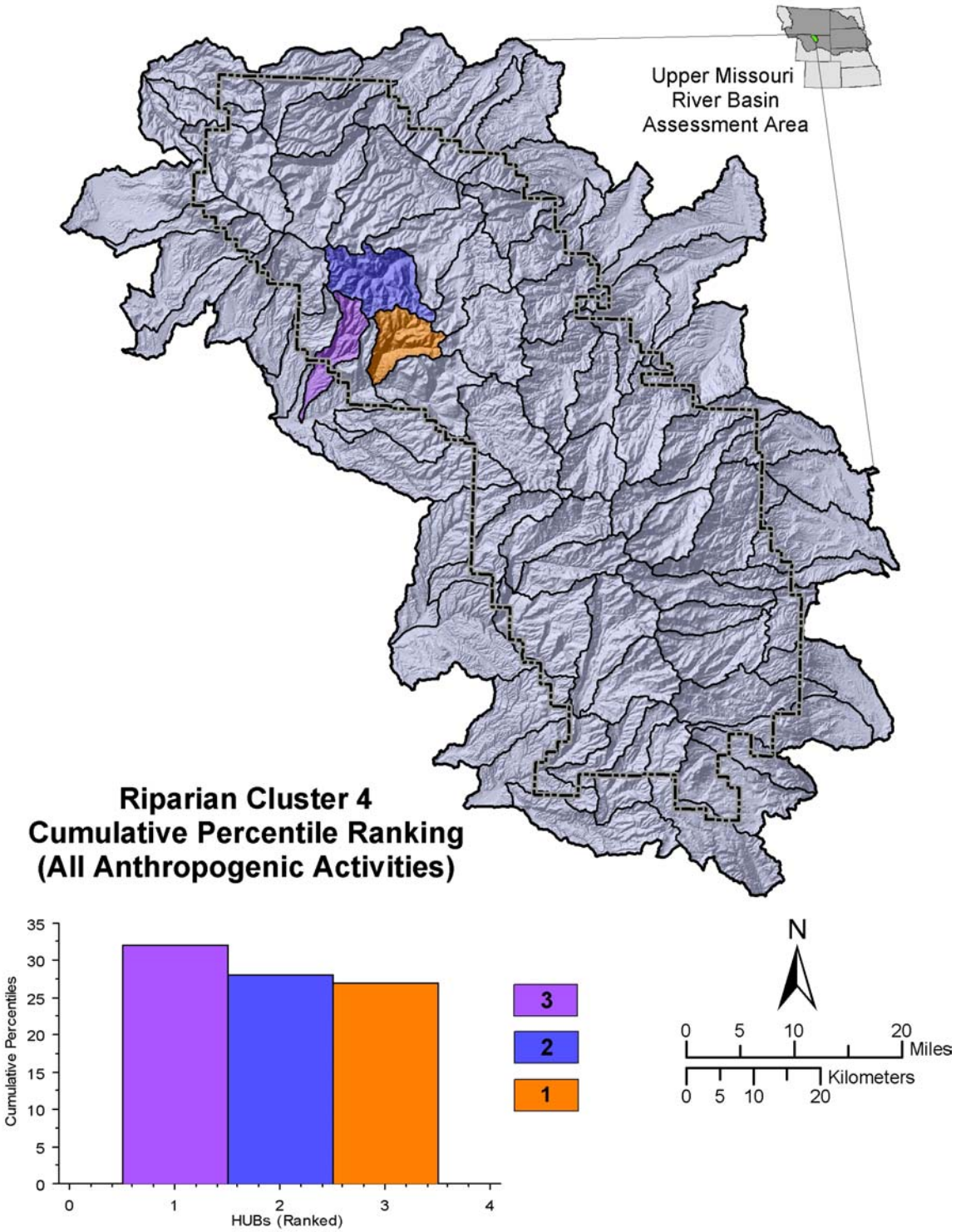

Figure 1.14. Riparian Cluster 4: cumulative percentile values.

Management Considerations: Because of their high elevation and relatively low ranking of anthropogenic activities, Cluster 4r is probably not as important for restoration or active management as some of the other clusters. Aquatic and riparian productivity may be limited. However, they are still important in the overall context of the Bighorn National Forest and activities that compromise ecological integrity should be managed appropriately.

Riparian Cluster 5r

HUBs in Cluster 5r occur at the mountain front on the western and northern sides of the Bighorns. Their watersheds are largely calcareous, with rain-and-snow precipitation regimes and abundant moderate and low gradient streams. As a result of the highly calcareous nature of the bedrock, aquatic productivity is expected to be high. Coldwater fish species are expected to thrive with this combination of ecological drivers. Lower elevation stream reaches are expected to have a diverse fish population. These watersheds have the lowest mean area of riparian ecosystems, and the second lowest area of streamside riparian ecosystems, although having a large percentage of low gradient stream reaches. As a result, the cluster is sensitive to fluctuations in the hydrologic, sediment and precipitation regimes. 55.8% of the total area of Cluster 5r is located within the Bighorn National Forest.

Relative to the other five riparian clusters, Cluster 5r has a moderate to low potential to be influenced by anthropogenic activities. Of the eighteen HUBs comprising Cluster 5r, five are within Quartile 3, five are within Quartile 2 and eight are within Quartile 1 (table 1.15). Three HUBs are completely contained by the Bighorn National Forest: Lower Tensleep Creek (100800080403), value = 38; Shell Creek-Cottonwood Creek (100800100104), value = 30; and Paint Rock Creek-Luman Draw (100800080604), value = 22.

This cluster was then divided into equal size thirds based upon percentiles as a means of providing a comparison for the potential for anthropogenic influence within the cluster (fig. 1.15). Within Cluster 5r the Brockenback Creek (100800080502), value = 40; and the Lower Tensleep creek (100800080403), value = 38; have the highest potential to be influenced by anthropogenic activities, while the Middle Porcupine Creek (100800100602) has the lowest potential to be influenced (value = 5). Cluster 5r has a moderate to low potential to be influenced in comparison to all 74 of the HUBs included in the management scale.

Management Considerations: Most of the HUBs in Cluster 5r have only a small portion of their area within the Bighorn National Forest boundary, so management would probably be limited to mitigation from projects effecting downstream resources. The three HUBs within the Bighorn National Forest could be considered high priorities for native coldwater fish recovery. Two of these HUBs; Shell Creek-Cottonwood Creek and Paint Rock Creek-Luman Draw rank quite low in terms of anthropogenic activities, while Lower Tensleep Creek has more activities. Because of the high calcareous geology and low elevation, springs are also probably abundant and should be considered important resource values.

Table 1.15. Riparian Cluster 5r: cumulative percentile values, ranks, and quartile designations.

HUB ID	HUB Name	Cumulative Percentile Value	Overall Rank	Rank w/in Riparian Cluster	Quartile
100800080502	Brockenback Creek	40	20	1	3
100800080403	Lower Tensleep Creek	38	25	2	3
100800080606	Lower Medicine Lodge Creek	35	32	3	3
100800160107	West Pass Creek	35	33	4	3
100800160102	Dry Fork Little Big Horn River	34	36	5	3
100800100204	Lower Beaver Creek	31	44	7	2
100800160103	Little Big Horn River-Red Canyon Creek	31	43	6	2
100800100104	Shell Creek-Cottonwood Creek	30	46	8	2
100800160108	East Pass Creek	29	51	9	2
100800100105	White Creek	28	53	10	2
100800100106	Trapper Creek	27	56	11	1
100800100604	Trout Creek	25	59	12	1
100800160104	West Fork Little Big Horn River	23	60	13	1
100800160301	Lodge Grass Creek-Line Creek	23	61	14	1
100800080604	Paint Rock Creek-Luman Draw	22	62	15	1
100800100603	Deer Creek	14	69	16	1
100800080406	Lower Canyon Creek	8	71	17	1
100800100602	Middle Porcupine Creek	5	73	18	1

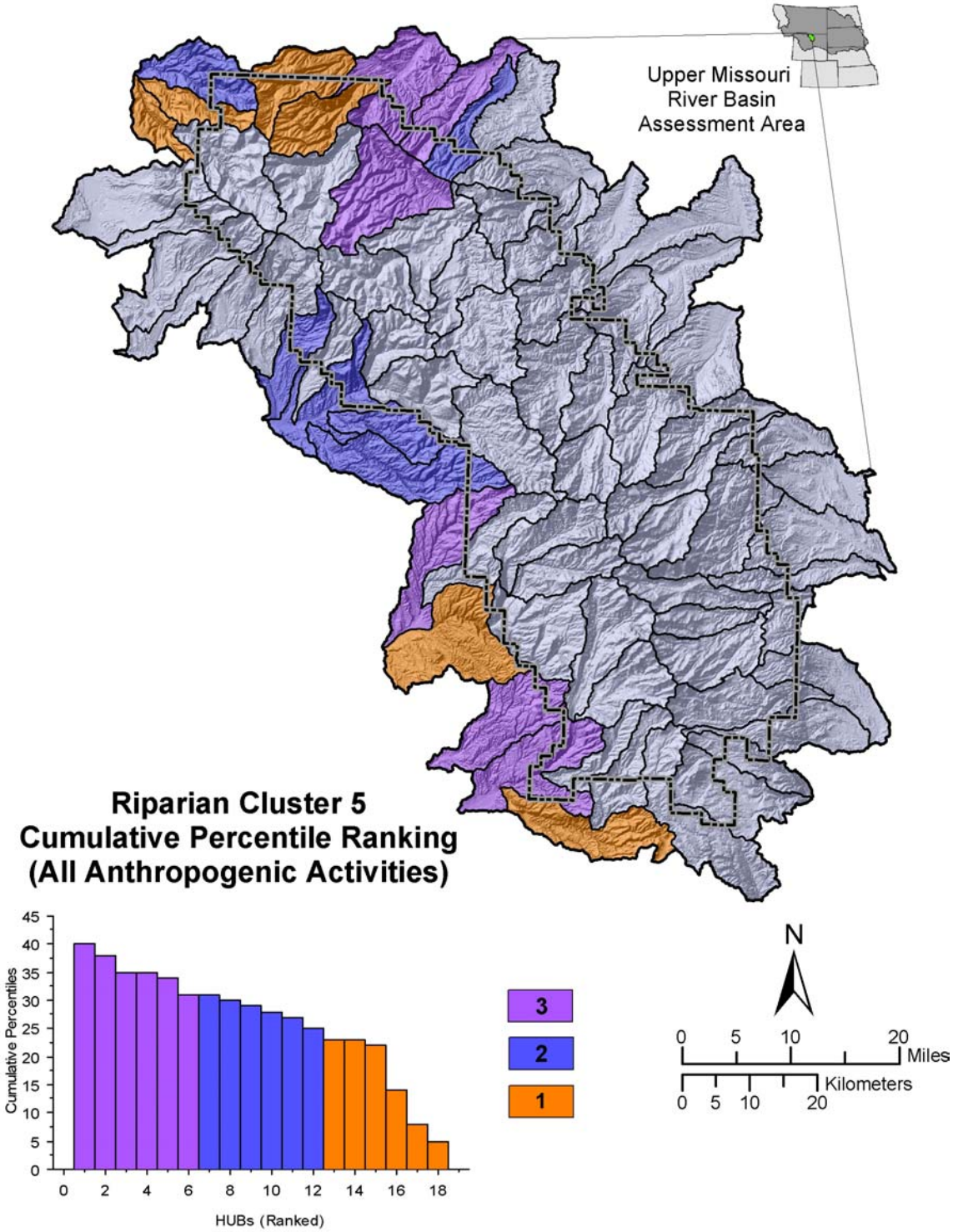

Figure 1.15. Riparian Cluster 5: cumulative percentile values.

Riparian Cluster 6r

HUBs in Cluster 6r have primarily non-calcareous bedrock, rain-driven precipitation regimes, and low gradient streams. They occupy low elevation areas on the far eastern and northwestern portion of the Big Horn Mountains. Aquatic productivity is likely lowest in this cluster as a result of higher water temperatures and intermittent and flashy flows. Streams originating in this cluster are expected to be warm-water systems not conducive to coldwater fish species. Warm-water species may be expected in this cluster. Streams originating at higher elevations may provide suitable habitat for coldwater fish species. The foothills portions of HUBs within the Bighorn National Forest likely have lower proportions of riparian areas than the plains areas where the gradient is lower. Riparian areas are likely to be associated with stream channels. As a result, the cluster is sensitive to fluctuations in the hydrologic, sediment, and precipitation regimes. 55.9% of the total area of Cluster 6r is located within the Bighorn National Forest.

Relative to the other five wetland clusters, Cluster 6r has the lowest potential to be influenced by anthropogenic activities. Of the eighteen HUBs comprising Cluster 6r, one is within Quartile 4, two are within Quartile 3, five are within Quartile 2 and eight are within Quartile 1 (table 1.16). Three HUBs are completely contained by the Bighorn National Forest: Little Tongue River (100901010107), value = 33; Lower Big Goose Creek (100901010205), value = 30; and Lower Quartz Creek (100901010110), value = 10.

This cluster was then divided into equal size thirds based upon percentiles as a means of providing a comparison for the potential for anthropogenic influence within the cluster (fig. 1.16). Within Cluster 6r the Five Springs Creek watershed (100800100401), value = 43, has the highest potential to be influenced by anthropogenic activities, while the Salt Creek watershed (100800100602) has the lowest potential to be influenced (value = 3). The Salt Creek watershed also has the lowest potential to be influenced by anthropogenic activities than any of the 74 HUBs comprising the management scale. Cluster 6r has the least potential to be influenced in comparison to all 74 of the HUBs included in the management scale.

Management Considerations: All of the HUBs in Cluster 6r intersect the National Forest boundary, typically with very little of their area within. Several of these HUBs are within municipal watersheds, and mitigation measures to ensure good water quality should be expected. National Forest management would be restricted, in terms of watershed management, unless cooperation from private landowners downstream could be agreed on. As with the previous cluster, this one probably contains springs and rare plants that should be considered when management activities are identified.

Table 1.16. Riparian Cluster 6r: cumulative percentile values, ranks, and quartile designations.

HUB ID	HUB Name	Cumulative Percentile Value	Overall Rank	Rank w/in Riparian Cluster	Quartile
100800100401	Five Springs Creek	43	12	1	4
100901010204	Upper Big Goose Creek	38	26	2	3
100800100402	Big Horn River-Willow Creek	34	37	3	3
100901010107	Little Tongue River	33	39	4	2
100800100309	Crystal Creek	32	41	5	2
100901010106	Tongue River-Columbus Creek	31	45	6	2
100800100203	Upper Beaver Creek	30	48	8	2
100901010205	Lower Big Goose Creek	30	47	7	2
100800100305	Upper Bear Creek	26	58	9	1
100901010207	Middle Goose Creek	22	64	11	1
100901010209	Goose Creek	22	63	10	1
100902060304	Upper Piney Creek	20	66	12	1
100800160109	Twin Creek	16	68	13	1
100901010110	Lower Quartz Creek	10	70	14	1
100902060305	North Prong Shell Creek	8	72	15	1
100800100307	Salt Creek	3	74	16	1

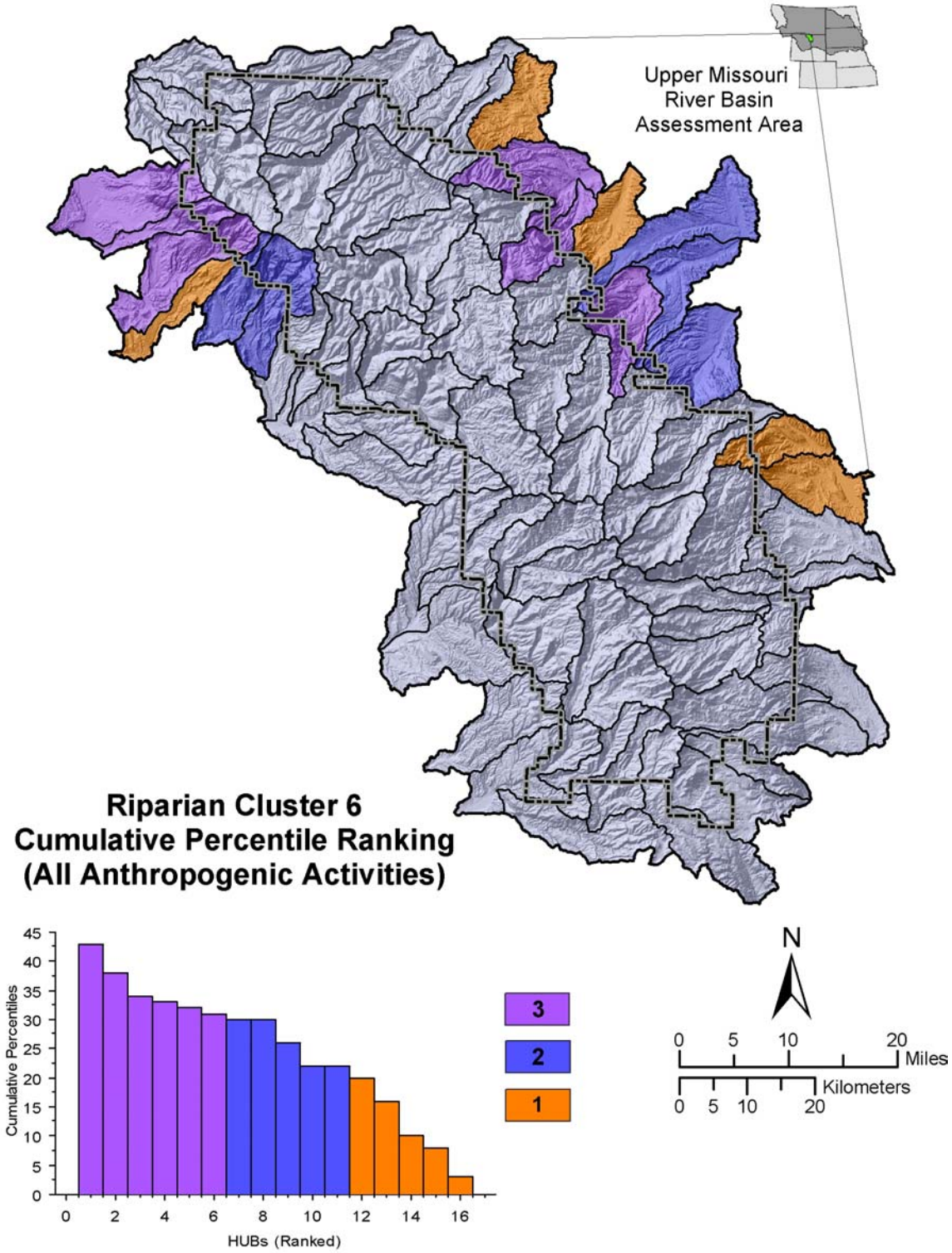

Figure 1.16. Riparian Cluster 6: cumulative percentile values.