Aquatic, Riparian, and Wetland Ecosystem Assessment

San Juan National Forest, Colorado
USDA Forest Service – Rocky Mountain Region

Report 2 of 3 Part 2

Anthropogenic Influence Results: Management Scale Analysis

Technical Coordinator:
David S. Winters
Aquatic Ecologist
Rocky Mountain Region

Contributor:
Dennis M. Staley
Geography Specialist
Rocky Mountain Region

Jenny Fryxell
Hydrologist, T.E.A.M.S Enterprise Team, USFS

Jaime Krezelok
Hydrologist, San Juan National Forest

Chapter 1
Introduction
Management Scale

This report documents the analysis of anthropological influences on aquatic, riparian and wetlands resources in the San Juan National Forest, at the management scale. In this report, the management scale is equivalent to 6th level watersheds or "HUB's". HUB is an acronym for Hydrologic Unit Boundary.

On the San Juan National Forest the anthropogenic influences that were studied consisted of water uses, transportation, recreation, minerals, vegetation management, and urbanization. Each of these anthropogenic influences is discussed in a separate chapter. Each chapter discusses the following elements:

- Key findings from the analysis for each chapter
- Influence of the anthropogenic Activity
- Management Implications at the 6th Level HUB (watershed)
- Direction for Reach/Site Analysis
- Information Needs
- Cumulative Percentile Rankings

A summary chapter was also generated to provide a place for an overall summary table of the analysis. This table lists the designated riparian and wetland clusters for each watershed, the cumulative percentile ranking for each anthropogenic activity by watershed, and the overall category rank. The overall category rank is the total cumulative percentile rank based on all of the ratings for all anthropogenic activities in that watershed. Watersheds highlighted in green are located entirely on-forest, while those that are not highlighted have a portion of their area located within the boundaries of the San Juan National Forest.

This chapter contains only the final summary table due to electronic volume limitations for this document. As there is more than one anthropogenic activity under each category, the data for these activities have been placed in ArcSde is accessible to those on the San Juan National Forest. This data includes the cumulative percentile rankings for each individual anthropogenic activity found under a given category, such as transportation.

This study also has two additional reports: Report 1 of 1 is "Introduction and Ecological Driver Analysis" and Report 3 of 3 is Ecological Driver Analysis and Anthropogenic Influence Results: Synthesis and Discussion. This chapter is Report 2 of 2 is "Anthropogenic Influences".

The reader is advised to consistently refer to these additional documents when using this chapter in developing watershed analyses, Forest Planning activities, or individual project development.

Chapter 2
Water Use Category
Management Scale

The purpose of this chapter is to identify water uses that influence aquatic, riparian, and wetland resources within the San Juan ecosystem and especially in lands managed by the San Juan National Forest. In addition, analysis will be performed at the appropriate scales to address the extent of uses across the landscape, improve the design of future site-specific projects and monitoring efforts.

Key Findings

1. The diversion ratios (number/ stream mile/ 6th level HUB) ranged from 0 to 0.8, with the highest values in HUBs that are located mostly outside the San Juan National Forest.
2. A total of 41 of the 74 6th level HUBs at the management scale were not influenced by any water diversion structures.
3. There were over 467 miles of water transmission ditches identified at the landscape scale, with only 8 (1.7%) miles located in the San Juan National Forest.
4. At the landscape scale, an estimated 47 miles of stream have been inundated by reservoirs, and only 0.7 (1.5%) located in the San Juan National Forest.
5. Natural spring density (number/ acre/ 6th level HUB) was low, ranging from .0012 to 0. Most of the springs appear to be associated with calcareous geology in the northern region and around the outside borders of the San Juan National Forest.
6. Nine watersheds are within the 100-80 percentile range for water uses, with four of them located entirely on-Forest. These watersheds are found in the far west and east portions of the Forest and have the highest potential for influencing aquatic health. Out of a possible maximum score of 25, those watersheds within the 100-80 percentile ranged varied from a total of 20 – 15 for the total cumulative water uses score.

Influence of Stream Diversions

Streams located within the Rocky Mountains are characterized by ephemeral natural barriers and an inherent connectivity of the drainage systems. Stream biota and fisheries resources evolved within these natural constraints. As a result, the life histories of riparian and aquatic organisms are often closely tied to the natural seasonal variation in the hydrologic regime of these streams (USFS, 2003).

With the influx of early settlers came the construction of the first stream diversions. Stream diversions are physical structures, or modifications to stream channel morphology, whose purpose is to transport water out of a natural stream channel. These first diversions were primarily used to divert water for mining and agricultural related activities. As the populations have increased additional uses for diversions included transportation of logs to timber mills, grain mills, hydroelectric power, fish hatcheries, municipal water supplies, and waste water treatment (USFS, 2003).

Although an individual diversion may be very small, the cumulative effects due to numerous diversion withdrawals can be dramatic and very harmful, especially in the lower reaches of a river system (USDA, 2003).

Observed effects include fragmentation of fish populations and impacts to the distribution and abundance of aquatic macro-invertebrates and fish, that are due to the alteration of seasonal hydrologic variations and dewatering of streams during low flow. Natural levels of organic debris and sedimentation within channels can be modified when they are either trapped or diverted by a diversion structure. In addition, diversions can impede nutrient transport to downstream organisms and energy dynamics within stream channels (USDA, 2003).

As diversions have become more common across the Forest, aquatic habitats have become increasingly fragmented, and reductions in habitat quantity and quality have been observed. As a result, populations of fish and other aquatic organisms have been affected. Population trends for the majority of native fish species are down and long-term population viability for many streams is in question.

The presence of water diversions and other man-made structures that can "fragment" or isolate populations creates a challenge to the management of existing native and desired non-native fish populations and other aquatic fauna. Identification of diversion structure density at the 6th level HUB or small watershed scale, would improve management by delineating watersheds that lack man-made barriers or identify those with numerous barriers and a high degree of fragmentation. This information would be particularly useful in managing mobile fisheries populations, as well as any other mobile aquatic organism.

To evaluate which watersheds have the highest potential for being influenced by diversion structures data was analyzed for the following three metrics: the number of diversions per stream mile in each 6th level HUB, the amount of water appropriated per 6th level HUB, and the percentage of stream length affected between the diversion downstream to the next perennial stream confluence.

Data was evaluated and summarized using GIS data available on the Forest. Due to the amount of data on water uses, and limited time and monetary resources, this analysis was restricted to information available for the Forest. The ranking of ratio values in this report are based on the 154 6th level HUBs associated with the San Juan National Forest. The ratios, and other associated analyses, are intended to provide a comparative evaluation of the relative abundance of potential fragmentation of stream systems within the study area. These rankings do not reflect absolute impacts and may not be comparable with rankings in other geographic areas. There are a total of 2,221 diversions distributed across the San Juan National Forest boundary (Figure 2.1). The data is from the State of Colorado, Department of Water Uses.

The ratio of number of diversion structures per stream mile for each 6th level HUB was calculated in order to delineate those watersheds with the largest number of diversion structures. 26 out of 154 HUBs, or 17% of the watersheds found on the Forest were found to be within the 100-80 percentile range. These HUB's are found across the Forest, except for the western-most part, are considered to have the highest potential for aquatic and hydrologic resources being influenced by the presence of diversion structures (Figure 2.1, Figure 2.2). Calculated ratios within the 100-80 percentile range from 1.47 for Elbert Creek (HUB 140801040502) to 0.4 for Laughlin Park (HUB 140801010303). However, Table 2.1 shows that three of the 26 watershed have significantly higher numbers of diversions than the other watersheds within the 100-80 percentile ranking.

Elbert Creek (HUB 14080104052) has the highest ratio at 1.5. It is one of the most highly diverted watersheds on the Forest. Water diverted from this watershed is used for nearby housing developments, irrigated agriculture, hydropower generation, and businesses along the Highway 550 corridor. In addition, the Elbert Creek watershed receives water via inter-basin transfer from Cascade Creek and the Durango Mountain Resort.

The Upper Animas Valley-Stevens Creek watershed (HUB 140801040503) has a ratio of 1.3 and the Lower Rio Blanco-San Juan River (HUB 140801010406) has a ratio of 1.0. Elbert Creek has a higher ratio than the Upper Animas Valley-Stevens Creek as it has fewer total stream miles. Not all of the Lower Rio Blanco-San Juan River (HUB 140801010406) is located on the Forest. However, the ratio for the Lower Rio Blanco-San Juan River (HUB 140801010406) can be considered to be a fair evaluation for potential effects related to diversions as over 80% of the watershed is located on-Forest. The Lower Rio Blanco-San Juan River watershed is also highly appropriated and diverted area, and it is not located entirely on-Forest.

Due to the concentration of diversion structures in these three watersheds, they should be examined further to determine the degree to which fragmentation of aquatic, riparian, and wetland biota populations has occurred.

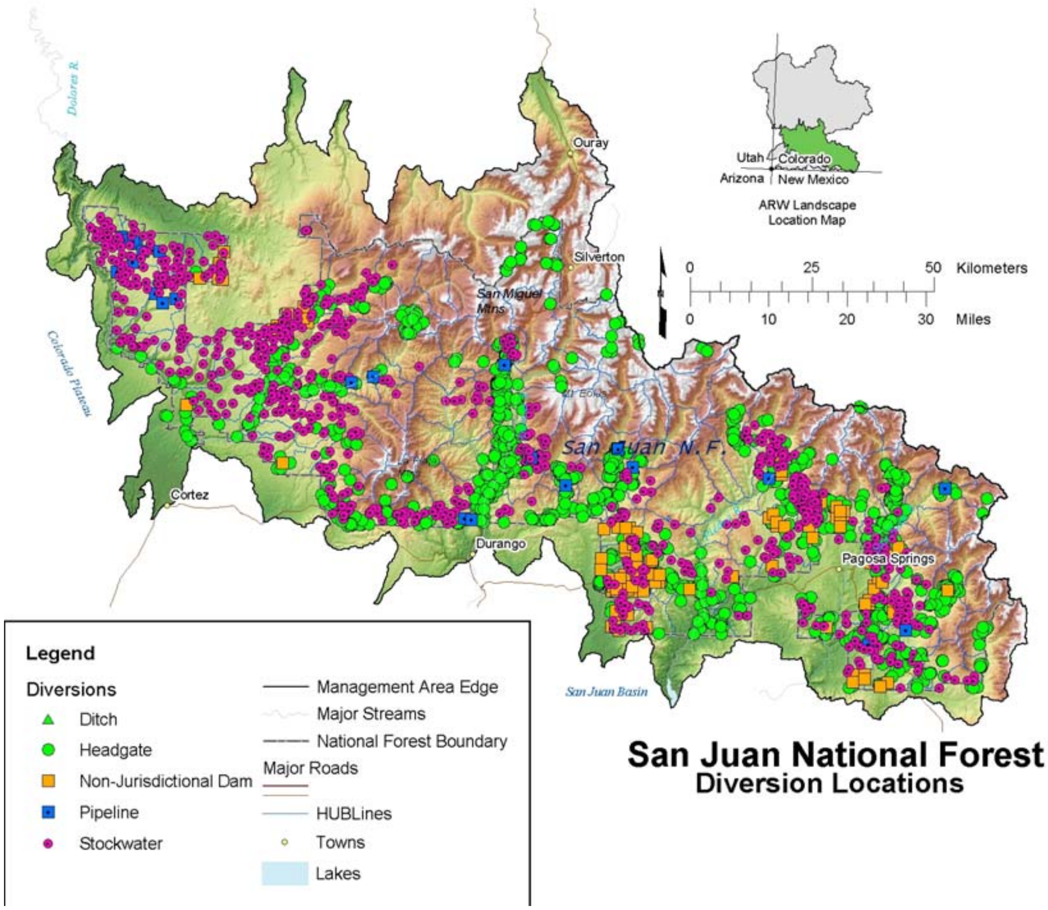

Figure 2.1 Locations of Diversion Sites on the San Juan National Forest

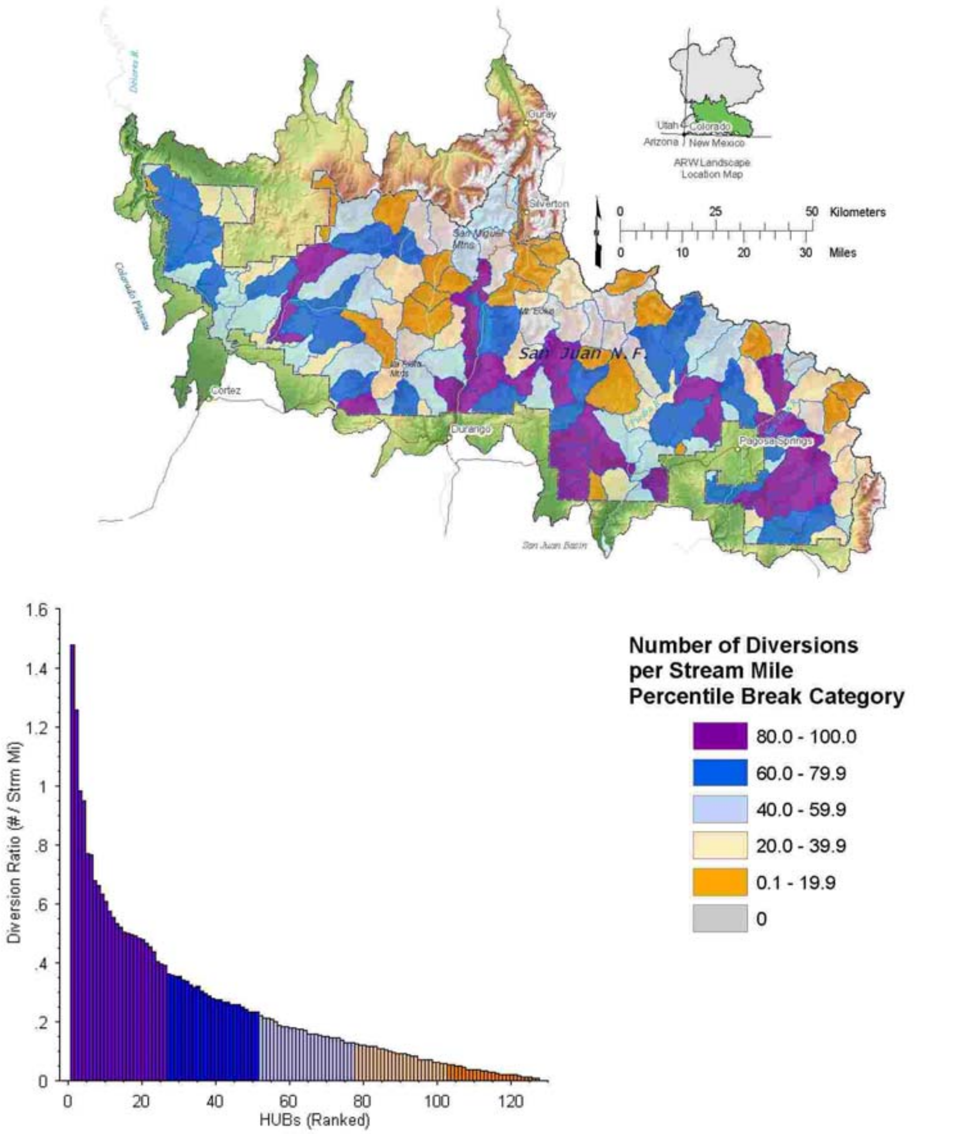

Figure 2.2 Rank and distribution of the number of diversion structures per stream mile per 6th level HUB, management scale, San Juan National Forest.

Table 2.1 Summary of HUBs within the 100-80 percentile range, for the ration of the number of diversion structures per stream mile, per 6th level HUB, management scale, San Juan National Forest. Watersheds highlighted in light green are located entirely within the Forest boundary.

HUB6	HUB6NAME	Number of Diversions	Total Stream Length (mi)	ratio diversion / stream
140801040502	Elbert Creek	71.0	48.3	1.5
140801040503	Upper Animas Valley-Stevens Creek	93.0	74.3	1.3
140801010406	Lower Rio Blanco-San Juan River	67.0	68.3	1.0
140801040303	Lower Cascade Creek	39.0	40.9	1.0
140801010204	Lower West Fork San Juan River	44.0	56.5	0.8
140300020105	Lower West Dolores River	62.0	80.9	0.8
140801011403	Lower Vallecito Creek	59.0	87.4	0.7
140801010403	Rio Blanco River-Blanco Basin	37.0	56.3	0.7
140801011603	Lower Beaver Creek	43.0	68.3	0.6
140801011602	Middle Beaver Creek	39.0	63.9	0.6
140801010304	Upper Pagosa Springs	31.0	54.4	0.6
140801020104	Piedra River-O'Neal Creek	36.0	65.3	0.6
140801040504	Upper Animas Valley-Trimble	41.0	77.3	0.5
140300020404	Stapleton Valley	24.0	45.6	0.5
140801020401	Martinez Creek-Dutton Creek	41.0	80.7	0.5
140801050105	Upper Cherry Creek	36.0	71.8	0.5
140801011704	Upper Spring Creek	41.0	83.2	0.5
140801011404	Vallecito Reservoir	32.0	65.2	0.5
140801020501	Yellowjacket Creek	40.0	83.1	0.5
140801040803	Lemon Reservoir	25.0	52.1	0.5
140801011703	Ute Creek	21.0	45.1	0.5
140801020404	Middle Stollsteimer Creek	35.0	76.8	0.5
140801010405	Rio Blanco	56.0	128.5	0.4
140801010404	Middle Rio Blanco	30.0	74.1	0.4
140801011601	Upper Beaver Creek	21.0	52.5	0.4
140801010303	Laughlin Park	18.0	46.3	0.4

As mentioned above, the amount of water appropriated per 6th level HUB, and the percentage of stream length affected between the diversion downstream to the next perennial stream confluence were also analyzed. These additional metrics were selected in order to better define how diversions are affecting aquatic, riparian, and wetland habitats in the Forest. The diversion ratio (number of diversions/stream mile) measurement is an indication of potential barriers, but may not be as strongly correlated with actual water use. To evaluate, in more detail, the effects on aquatic habitat the relationship between the amount of water appropriated under Colorado State water law and the available water in each 6th level HUB was assessed. Although this metric provides a measure of the quantity of water available for aquatic, riparian, and wetland habitats, there is limited ability at present to predict the discharge in a given watershed.

Analysis of water appropriation data from the State of Colorado, Department of Water Uses, indicates that nine watersheds have the highest potential for related effects on aquatic, hydrologic, and wetlands resources. These watersheds are found primarily in the eastern half of the Forest and immediately north of Durango (Figure 2.3). The estimated amount of water appropriated by watershed, for those HUBS within the 100-80 percentile range, is displayed in cubic feet per second (CFS) (Table 2.2). The Upper Animas Valley-Stevens Creek (HUB 140801040503) watershed has the most water appropriated at a total of 237 CFS, while approximately 58 CFS has been appropriated within the Upper Los Pinos River-Ricon La Vaca (HUB 140801011301) watershed.

The large amount of water appropriated in the Upper Animas Valley-Stevens Creek (HUB 140801040503) watershed is associated with large diversions for irrigation. The Rio Blanco River – Blanco Basin (HUB 14080101403) has the second largest amount of water appropriation of all Forest watersheds, primarily from large irrigation ditch diversions located on private land along the Blanco River.

The Lower West Fork San Juan River has the third highest level of appropriated water of all Forest watersheds. These diversions include many large ditches for irrigation, domestic, fisheries, and other uses. It should be noted that the Colorado Water Conservation Board has an 8-14 cfs instream flow water right for fisheries in this watershed which should have a beneficial effect on aquatic ecosystems.

Elbert Creek (HUB 140801040502) is considered an over-appropriated stream system in Colorado with many demands for water including hydroelectric power generation, irrigation, ski area uses and domestic uses. It has the fourth largest level of water appropriations of Forest watersheds.

Within the Upper Los Pinos-Ricon La Vaca (HUB 140801011301), East Fork Piedra River (HUB 140801020101) watersheds effects related to water appropriations are located on-Forest as these watersheds are well within the Forest boundary. Any potential effects would likely be in watersheds immediately downstream of the watersheds just listed. In the case of the East Fork Piedra River the effects are not as great downstream because the Piedra River is very large and flows year-round. The greatest impacts are to the East Fork Piedra River itself and the East Fork fishery due to dry stream bed conditions.

Off-forest effects may be associated with the Elbert Creek (HUB 140801040502), Upper Animas valley-Stevens Creek (HUB 140801040503), and Upper Animas Valley-Trimble (HUB 140801040504) watersheds, as these three watersheds flow into each other in the order listed. The Upper Animas Valley-Trimble (HUB 140801040504) watershed intercepts the Forest boundary and drains into systems located off-forest. As a result, drainage systems downstream of the Upper Animas Valley-Trimble (HUB 140801040504), and off-forest, have the potential for being affected by water appropriations in these three watersheds. Watersheds immediately downstream of the Rio Blanco River-Blanco Basin (HUB 14080101010403) and Upper Pagosa Springs (HUB 140801010304) watersheds would also have the potential for being influenced by water appropriations, as these two watersheds intersect the Forest boundary.

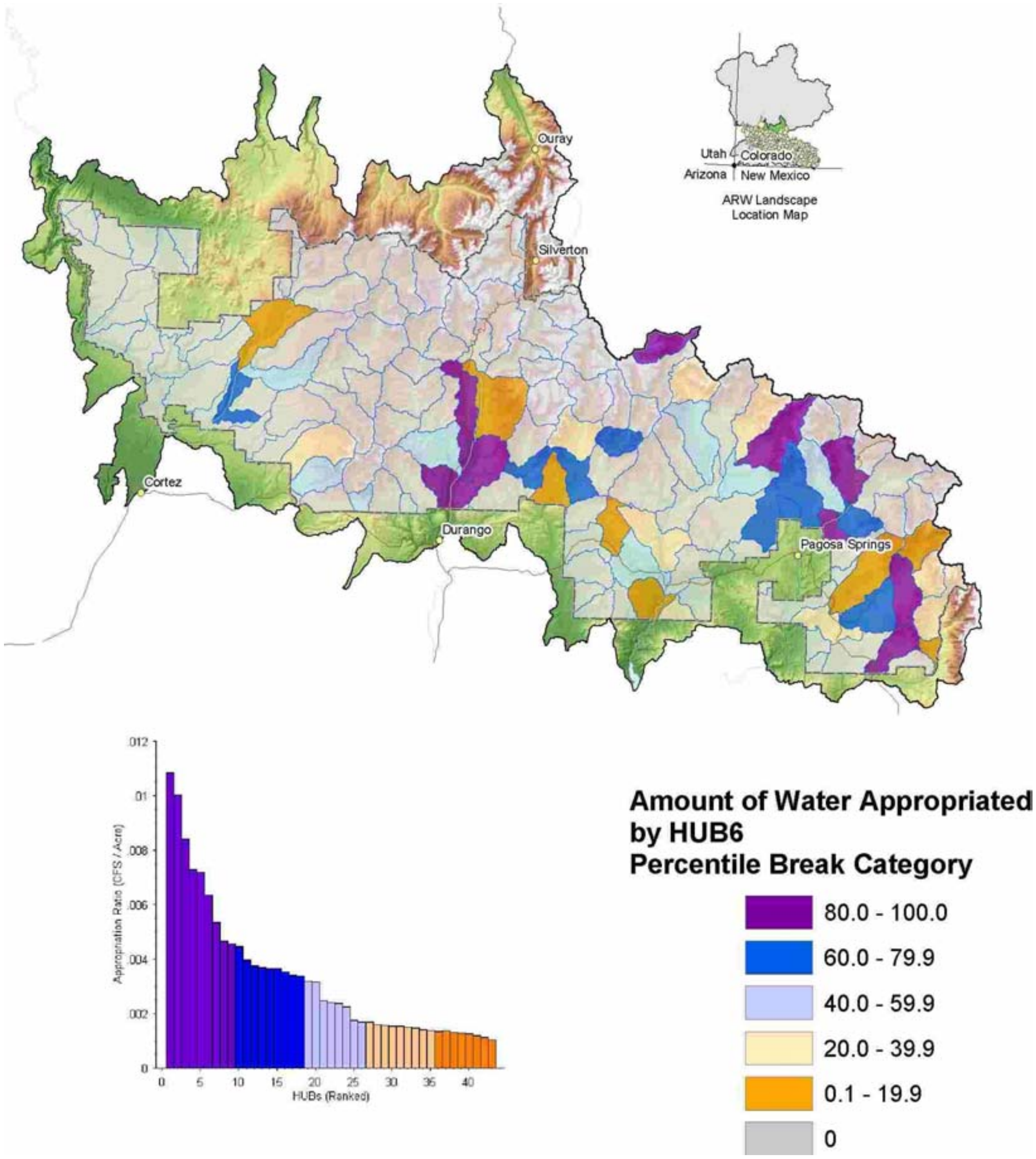

Figure 2.3 Ranking and distribution of the amount of water appropriated by 6th level HUB, management scale, San Juan National Forest.

Table 2.2 Summary of the 6th Level HUBs within the 100-80 percentile range for the amount of appropriated water within a HUB, management scale, San Juan National Forest. Watersheds highlighted in light green are located entirely within the Forest boundary.

HUB6	HUB6NAME	Total CFS
140801040503	Upper Animas Valley-Stevens Creek	237.0
140801010403	Rio Blanco River-Blanco Basin	168.7
140801010204	Lower West Fork San Juan River	159.6
140801040502	Elbert Creek	120.5
140801020101	East Fork Piedra River	192.4
140801010304	Upper Pagosa Springs	79.6
140801040504	Upper Animas Valley-Trimble	105.4
140801010506	Little Navajo River	70.0
140801011301	Upper Los Pinos River-Ricon La Vaca	58

6th Level HUB Information Needs

The available information on the location of diversions on the San Juan National Forest is fairly complete. The location and numbers of diversions was attainable through the State of Colorado, Division of Water. However, the actual amounts of water adjudicated for each diversion in each watershed was more difficult to identify. In addition there are several groups of diversions where water rights appear to be shared between them, making it difficult to accurately quantify the amount of adjudicated water.

To fully understand the relationship between potential water withdrawal and available water on aquatic, riparian, and wetland resources, an analysis of potential water withdrawal and water yield for each 6th level HUB on the Forest should be made. However, the information on watershed water yield is currently not available. This is an analysis that would be particularly valuable if future permit applications begin to be filed on the Forest. However, this type of analysis is being done case-by-case at the project level.

A surrogate measurement that integrates water allocation with actual yield might be the amount of water adjudicated per acre of watershed. This measurement is based on the assumption that there is a relationship between watershed size and the amount of discharge available (Wohl, 2001). Another complication is that water may be adjudicated, but not completely used. Overall, this surrogate measurement would at least give an estimation of the potential risk of aquatic impacts. It is extremely important to recognize that there may be significant reach/site level impacts from a particular diversion. The assessment results should be used to understand where the highest potential is for water removal on the Forest. Then the Forest can focus on more site-specific efforts to address the influence of these diversions on particular watersheds. In addition, if new permit applications are proposed, this information could be valuable in understanding the influence of existing water rights on a particular watershed.

Management Implications at the 6th HUB Level

The major influences of water diversions on stream and riparian ecosystems are migration barriers for aquatic biota through the structures and the influence that modified hydrology has on stream systems downstream of diversions.

The position of the structure in the watershed, if it is a migration barrier, can further promote isolation of populations upstream (Harig and Fausch 2002).

In addition, there is a higher risk of riparian influence if the reach directly downstream is associated with a low gradient "adjustable" stream channel. This may be an additional analysis consideration for future planning purposes.

Only one 6th level watershed was identified as being in the 1008-80 percentile range for both the number of diversion structures per stream mile and for the amount of appropriated water. That watershed was the Upper Animas Valley-Stevens Creek watershed. Elbert Creek and the Lower Rio Blanco-San Juan River watersheds were also in the top three for the number of diversion structures per stream mile. The Rio Blanco River-Blanco Basin and Lower West Fork San Juan River watersheds round out the top three for the highest levels of influence for the amount of appropriated water (Tables 2.1 and 2.2). Table 2.3 illustrates the cluster numbers for these watersheds both the number of diversion structures per stream mile and for the amount of appropriated water metrics. For the riparian vegetation, aquatic productivity, and benthic macro-invertebrates found in the riparian clusters listed in Table 2.3 their sensitivity to changes in hydrology have been categorized as high. All of the wetlands involved are also highly sensitive fluctuations in hydrologic regimes. For additional detail involving the clusters found in these six watersheds the reader is referred to Report 1of 1 and Report 3 of 3.

The sensitivities of both riparian and wetland clusters for the other watersheds found on the Forest can also be found in these reports. These clusters may or may not have the sensitivities noted in the six watersheds listed in Table 2.3.

Another often-overlooked analysis result is the absence of diversion influence within a 6th level HUB. These watersheds may be useful for the identification of "reference conditions". However, any watershed being considered for "reference" conditions must also be assessed for levels of influence by other anthropogenic activity categories discussed elsewhere in this document.

Table 2.3 Sixth level HUBs with the highest level of water diversion influence and associated cluster identification numbers

# of Diversions Per Stream Mile		
6th Level HUB Code	**Watershed Name**	**Riparian & Wetland Cluster Identification Numbers**
140801040502	Elbert Creek	5r, 7w
140801040503	Upper Animas Valley-Stevens Creek	1r, 2w
140801010406	Lower Rio Blanco-San Juan River	4r, 4w
Amount of Water Appropriated		
140801040503	Upper Animas Valley-Stevens Creek	5r, 2w
140801010403	Rio Blanco River-Blanco Basin	2r, 2w
140801010204	Lower West Fork San Juan River	2r, 7w

Direction for Reach/Site Scale Analysis

Addressing the influence of water diversion structures and subsequent withdrawal of water on aquatic, riparian, and wetland resources at the reach/site scale is outside of the scope of this assessment.

However, there are specific questions that should be addressed to identify influences on aquatic, riparian, and wetland resources for project level analysis related to Federal Land Policy and Management Act (FLPMA) on species viability and ecological sustainability.

Listed below are the specific questions that should be addressed at the reach or site level for water diversions:

1. What aquatic, riparian, and wetland values should be addressed when evaluating a current or potential water diversion?

    a. Municipal needs
    b. Recreational needs
    c. Stream channel maintenance
    d. Riparian and aquatic vegetation
    e. Aquatic organism needs
    f. Terrestrial organism needs
    g. Water quality
    h. Others

2. What specific questions related to resource values should be addressed?

    a. Will flow modifications influence stream channel form and function?
    b. Will flow modifications influence riparian vegetation form and function?
    c. Will flow modifications influence aquatic organism life-history strategies and population size (e.g., water temperature, timing of spawning)?
    d. Will flow modifications influence recreational and aesthetic values?
    e. Will flow modifications influence habitat needs for terrestrial animals (e.g., beavers, southwest willow fly catchers)?
    f. Will altered instream flows provide a competitive advantage for invasive species?
    g. Will flow modifications influence adjacent wetland communities?
    h. Are changes in water quality acceptable?
    i. Will the structure allow passage of organisms necessary to maintain species/population viability?

Influence of Water Transmission Ditches

Water transmission ditches are used to transport water from one stream system to another, transport water to some type of impoundment for later use, or to transport water directly to an area where it needs to be used. These ditches have the potential to significantly affect aquatic, riparian, and wetland resources. The following potential effects are summarized below (USDA, 2003):

A major potential effect is the alteration of flow regimes as ditches typically are designed to follow along contour with small drops in gradient. As the ditches cut across slopes, overland and subsurface flows are intercepted. The water is then transported out of a particular system. Water quality may be affected due to sediment transport from one system to another, which alters natural sediment regimes. Sediment may also be added when there are ditch failures or landslides associated with the ditches, or when structures are improperly designed.

Riparian and wetland conditions can be affected in a variety of ways. The creation of ditches can modify the types and distribution of plants present within an area including the creation of riparian communities adjacent to ditches. In addition, ditches can transport seed and seed propagules from one ditch system to another, which may include those of invasive plants. While most ditches are not located directly in riparian or wetland areas, they frequently start and/or terminate in these areas, and frequently run parallel to these habitats. This increases the surface area available to intercept erosion and sediment generation.

Channel morphology may be altered by changes in hydrologic regime including alteration of substrate composition due to increased sediment load. Channel constrictions and aggradation may occur where landslides or debris flows associated with ditch leakage or failure have entered a channel.

Changes to water quantity, quality, and channel form and function invariably lead to modifications in biotic condition. Organisms may be transported from one system to another, including those carrying diseases. Flow modification may degrade biotic community health or result in community mortality. Changes in plant communities, due to alteration of water quantity, quality, and channel morphology, may also lead to modification in bird or other animal populations.

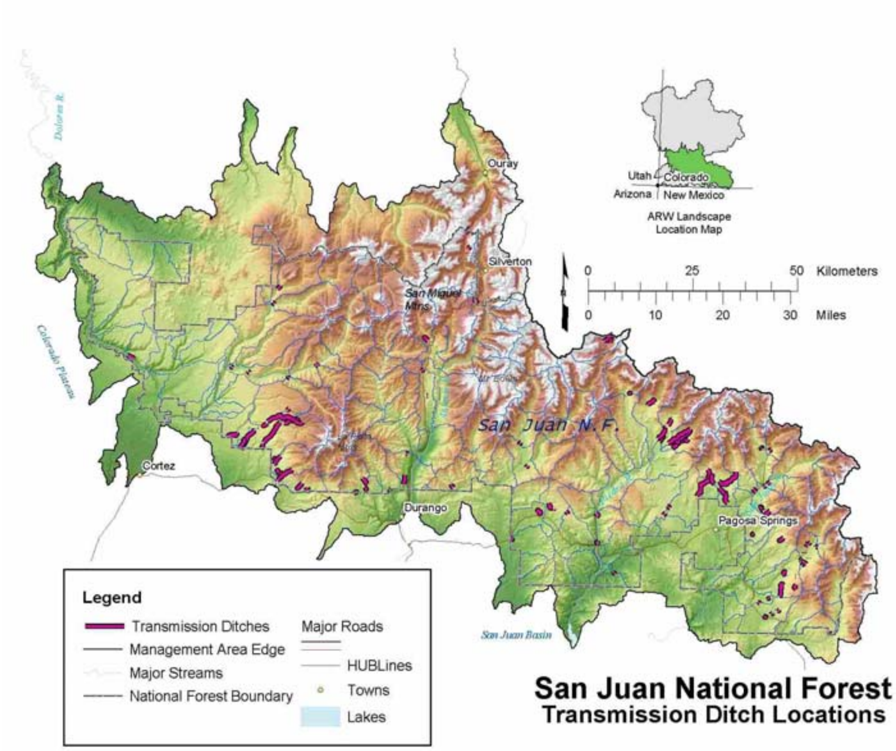

Figure 2.4 Location of transmission ditches, management scale, San Juan National Forest.

Transmission ditches are found scattered across the southern half and western half of the Forest (Figure 2.4). To determine which watersheds have the potential for the highest levels of influence due to transmission ditches two metrics were calculated: the miles of transmission ditch per watershed and the number of feet of transmission ditch per stream mile per HUB. In conducting the analysis, GIS data was clipped to the Forest boundary. Calculated ratios for both of these metrics do not include ditches that are abandoned, unrecorded or located on private land. The first metric evaluated which HUBS had the largest total number of ditch miles per HUB. This metric was chosen in order to assess the abundance and distribution of transmission ditches, and to help prioritize management activities in areas subject to impact. Figure 2.5 and Table1.3 summarize the analysis results for this metric. HUBS having the most potential for influence due to transmission ditches are located primarily in the eastern half of the Forest and along the southwestern boundary of the Forest near Cortez, Colorado (Figure 2.5).

52 watersheds, out of 154 HUBS on the Forest, had transmission ditches located within their boundaries. Chicken Creek (HUB 140801070103) had the highest ratio at 0.0008 and Middle Lost Canyon (HUB 140300020403) had the lowest ration at 0.0001. The ratio for Chicken Creek is substantially higher than the other watersheds within the 100-80 percentile range. This is due to the import of water, from several watersheds near the Chicken Creek watershed, which is then transmitted through the watershed to other locations.

Out of the 11 HUBs within the 100-80 percentile range, five of them are located entirely on the Forest. Any potential effects within these watersheds related to transmission ditches would most likely occur on-Forest, as boundaries of these watersheds are anywhere from just under 3 miles to over 27 miles to the Forest boundary. The major concerns would be changes to flow regimes and potentially associated erosion, especially in watersheds receiving water. Changes in flow regime are a direct impact to the stream as it flows across the Forest and these impacts may be found off-forest. The ratios of Fourmile Creek (0.0005), East Fork Piedra River (0.0004), and East Mancos River-Middle Mancos River (0.0004) are associated with high levels of diversion through ditches primarily constructed for irrigation purposes. Fourmile Creek also has a large diversion ditch for municipal water supply to Pagosa Springs.

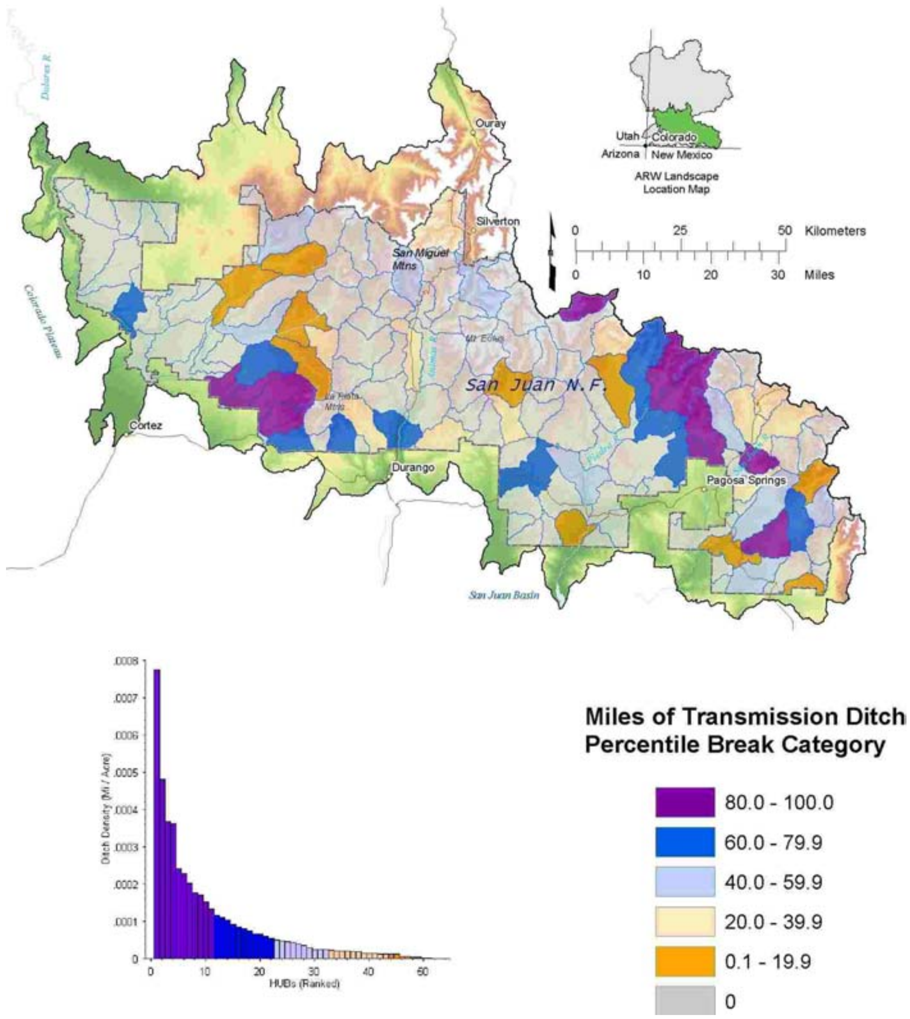

Figure 2.5 The ranking and distribution of the number of miles of transmission ditch per HUB, management scale, San Juan National Forest.

Table 2.4 Summary of watersheds within the 100-80 percentile range for the ratio of ditch miles to watershed acres (size), management scale, San Juan National Forest. Watersheds highlighted in light green are located entirely within the Forest boundary.

HUB #	HUB6NAME	Total Miles of Ditch	Total Watershed Acres	Ratio of Ditch Miles to Watershed Acres
140801070103	Chicken Creek	12.3	15875.3	0.0008
140801010302	Fourmile Creek	11.2	23215.5	0.0005
140801020101	East Fork Piedra River	9.9	26746.1	0.0004
140801070101	East Mancos River-Middle Mancos River	5.7	15620.3	0.0004
140801070102	West Mancos River	6.6	27535.8	0.0002
140801010305	McCabe Creek	2.9	12824.3	0.0002
140801011301	Upper Los Pinos River-Ricon La Vaca	2.6	12700.2	0.0002
140801010404	Middle Rio Blanco	3.5	19631.9	0.0002
140801010303	Laughlin Park	1.9	10804.8	0.0002
140801020102	Middle Fork Piedra River	3.6	23626.4	0.0002
140300020403	Middle Lost Canyon	1.7	12538.6	0.0001

The ratio of miles of ditch per total watershed acres is a function of watershed size. In addition, this metric focused more on the location, or distribution, of the transmission ditches. In order to obtain a more detailed assessment of the relationship between transmission ditches and stream drainages the second metric was run.

The second metric determined the ratio of the number of feet of transmission ditch per stream mile per 6th level HUB. The second metric assumes that the higher the ratio the greater chance there is for potential effects on the stream. The results of this metric are summarized in Figure 2.6 and Table 2.5.

The distribution of watersheds for this metric, across the Forest, is almost identical to that of the first metric. The only difference is that Middle Lost Canyon does not occur within the 100-80 percentile range for this metric. Middle Lost Canyon is a smaller watershed than Upper Lost Canyon and has a smaller total number of miles of stream. As a result, the ratio is lower and so the watershed is not within the 100-80%

Eleven watersheds were found to have the highest potential for transmission ditch-related effects on aquatic, hydrologic, and wetland resources (Table 2.5). . All of these watersheds eventually flow off-forest. Seven out of eleven, or 55%, of the watersheds are located entirely within the Forest boundary. However, some are located much closer to the Forest boundary than others or overlap the boundary. As a result, the following watersheds have the potential to influence resources located downstream and off-forest: Middle Lost Canyon, Chicken creek, West Mancos River, East Mancos River-Middle Mancos River, West Mancos River, McCabe Creek, and Four Mile Creek

A review of Chicken Creek shows that it has a significantly higher ratio than all other ten watersheds, indicating that it has a higher potential for impacting aquatic resources compared to the other watersheds in the 100-80 percentile range (Table 2.5).

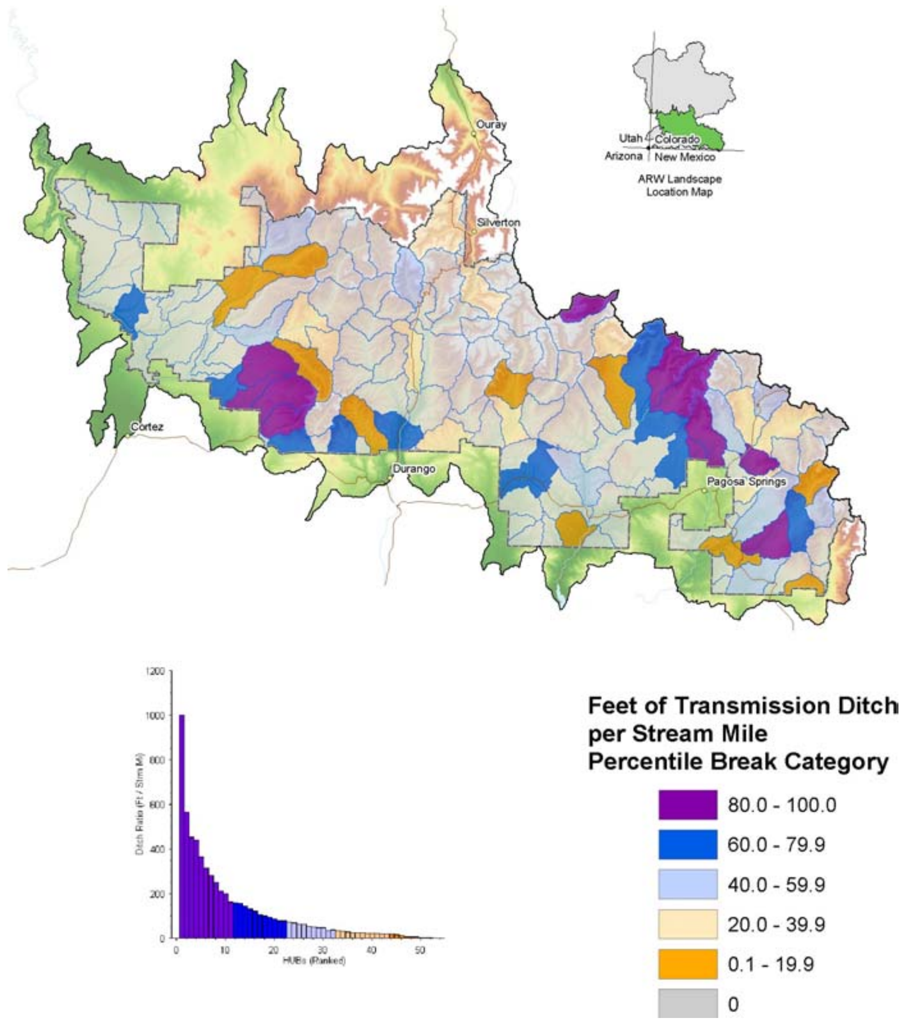

Figure 2.6 The ranking and distribution of the number of feet of transmission ditch per stream mile, management scale, San Juan National Forest

Table 2.5 The ranking and distribution of the number of feet of transmission ditch per stream mile, management scale, San Juan National Forest

6th Level HUB	6th Level HUB Name	Ratio of Ditch to Stream	Category
140801070104	Chicken Creek	1004.6	5
140801010302	Fourmile Creek	569.7	5
140801070101	East Mancos River-Middle Mancos River	454.6	5
140801020101	East Fork Piedra River	440.5	5
140801070102	West Mancos River	364.8	5
140801011301	Upper Los Pinos River-Ricon La Vaca	316.7	5
140801010305	McCabe Creek	281.3	5
140801010404	Middle Rio Blanco	248.9	5
140801010303	Laughlin Park	211.5	5
140801020102	Middle Fork Piedra River	199.9	5
140300020401	Upper Lost Canyon	164.1	5

6th Level HUB Information Needs

The information used for this analysis was derived from the San Juan National Forest GIS database. However the analysis did not include analysis of ditches that have been abandoned or on private land. In addition, it is highly likely that there are some unrecorded ditches. As a result, analysis has produced a reasonably accurate "first cut" assessment of which watersheds have the potential for transmission-related effects on aquatic, hydrologic and wetland resources. A refined analysis could be accomplished if it included the location of abandoned ditches and those on private land. Including this information might be valuable in prioritizing restoration efforts.

It may also be useful to determine how many ditches "on-the ground" may actually be unrecorded. However, the decision to undertake that endeavor should be made by Forest Hydrologist.

An analysis of ditches intersecting wetlands could also be valuable for this type of assessment. While these ditches may be quite old, and have possibly drained historic wetlands, impacts may still be present. Remnants may be identified through the existing riparian and wetland inventory on the Forest.

Management Implications at the 6th HUB Level

Ditches located along the south/southwest border of the Forest are located closer to crop lands and are used primarily for irrigation. Ditches are also used for used for stockwater pond filling, and hydropower, although this list is not inclusive.

All of the wetland clusters and almost all of the riparian clusters have a high sensitivity to changes in hydrologic regime. Ditches that are no longer used for management purposes may still be functioning, trapping overland flow. One management recommendation is to start with those watersheds listed in Table 2.4 and identify these "abandoned ditches" and restore them to the local topography. To help prioritize the watersheds it is recommended that wetlands identification be conducted prior to initiating a restoration program. Wetlands clusters 2w, 3w, 5w, and 8w have over 50% of their area located on-Forest. With large portions of their area located on-Forest, these clusters lend themselves to effective management, mitigation, and restoration. Cluster 9w is located entirely on-Forest; however it comprises only 1.8% of the Forest's area. This cluster provides a productive setting and rare wetland types are found within this cluster. As result, mitigation measures are recommended.

Another management consideration would be to identify where ditch sidewalls have been breached, creating erosion through gullying. These types of breaches can cause considerable erosion to downslope wetlands and streams, modifying channel morphology, degrading habitat, and potentially affecting water quality. Wetland clusters 7w, 8w, and 9w are all highly susceptible to alterations in sediment regime. Riparian clusters 1r, 2r, 3r, and 4r are also highly sensitive to changes in sediment loads. As a result all of these riparian and wetland clusters lend themselves to mitigation efforts.

<u>Directions for Reach/Site Scale Analysis</u>

52 out of 154 6th level HUBs associated with the San Juan National Forest contain diversion ditches. These structures can affect aquatic, riparian, and wetland resources whether or not they are currently being used to transport water. When evaluating the influences of each of these watersheds containing ditches the following questions should be considered:

a. Is the ditch abandoned or currently being used to transmit water?
b. Has the ditch been maintained by the permittee or Forest Service?
c. Does the ditch intercept surface flow that historically fed wetlands and other aquatic, riparian, and wetland habitats?
d. Has the ditch wall breached, resulting in gullying and erosion?
e. Has or does the ditch have the potential to transport undesirable plants and or animals?
f. Is the transported water degrading water quality?

g. Does the ditch intercept tributary flow that has not specifically allocated to it?

Influence of Transbasin Diversions

Transbasin diversions are those structures that divert and transport water from one watershed to another. They can have impacts similar to other diversion structures and transmission ditches. Modifications to hydrology and channel morphology, as well as chemical and biological to changes in receiving water bodies may occur. In addition, they add 'new water' to the receiving basin.

Hydrologic changes occur in both the removal water body and in the receiving water body. In the removal water body declines in water yield and stream flow occurs while in the receiving basin the altered hydrograph shows increased water yield and stream flow. This occurs in both water bodies for at least part of the year (USDA, 2003).

Channel modifications are reflected in adjustments to channel morphology which include changes in width/depth ratio, reduced sinuosity, and increased gradient. Other changes include alteration of substrate size, bank erosion, channel incision, and downcutting in the receiving waterbody. All of these channel adjustments can in turn lead to habitat simplification for aquatic species. Habitat alteration is a key concern, especially in low gradient streams as these tend to be the most productive reaches for aquatic organisms in the Rocky Mounts (USDA, 2004). Relatively steep, step-pool streams with large substrate may not be significantly affected by increased discharge (Wohl, 2001).

Water quality in both the removal and receiving streams may be affected. In removal streams decreased flow can result in alterations to stream temperature, pH, dissolved oxygen, and herbicides and pesticides. In transferring waters from a removal area to a receiving area water quality is "transferred", which may affect such water quality analytes such as dissolved solids and pH (USDA, 2003). Existing water quality characteristics of receiving streams may be diluted or modified, affecting analytes such temperature and dissolved oxygen. Increases in sediment loads of receiving streams may also increase. Nutrient retention in receiving streams may be reduced due to increased stream power (USDA , 2003).

Transbasin diversions can facilitate the invasion of non-native fish and other non-desirable species of plants and animals can enter a system where they can replace native species. Behnke (1979) found that several sub-species of cutthroat trout have been transported into other river basins where they would not normally occur. These introduced cutthroat trout subsequently hybridized with the native sub-species of cutthroat trout, leading to a loss of genetic diversity in native populations. Moreover, chemical and microbiological contamination can result from transbasin water transport.

Transbasin diversions are located in only 13 of the 154 watersheds associated with the San Juan National Forest. Transbasin diversions are located north and east of Cortez, Colorado, and southeast of Pagosa Springs (Figure 2.7). Out of the 13 watersheds with diversions, only three watersheds have the highest potential for transbasin related effects to hydrologic, aquatic, and wetland resources on the Forest (Figure 2.8, Table 2.6).

In the McPhee-Dolores River (HUB 140300020408) and the Middle Rio Blanco (HUB 1408010404) watersheds the effects are located primarily on-Forest as drainage systems have 22 and 6 miles respectively before their drainages reach the Forest boundary. It should be noted that although the McPhee-Dolores River (HUB 140300020408) watershed is not identified as being entirely within the Forest boundary in Table 2.6, the vast majority of the watershed is located in the Forest. Chicken Creek (HUB 14080107014) has a higher potential for impacting off-forest aquatic, hydrologic, and wetland resources as roughly one-third of the watershed is located off-forest. It should be noted that additional diversions occur after this stream leaves the Forest boundary. Aquatic conditions are impacted in this stream both on and off-forest and those impacts likely translate to the Mancos River, a perennial fisheries stream.

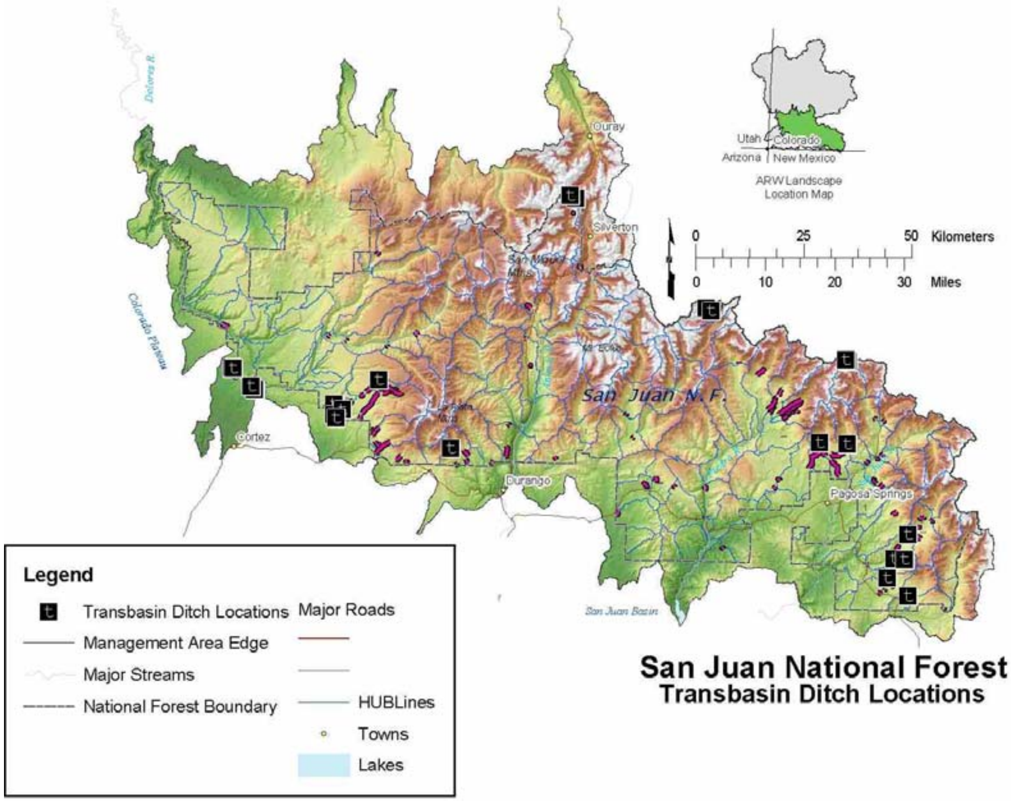

Figure 2.7 Location of Transbasin diversions, management scale, San Juan National Forest.

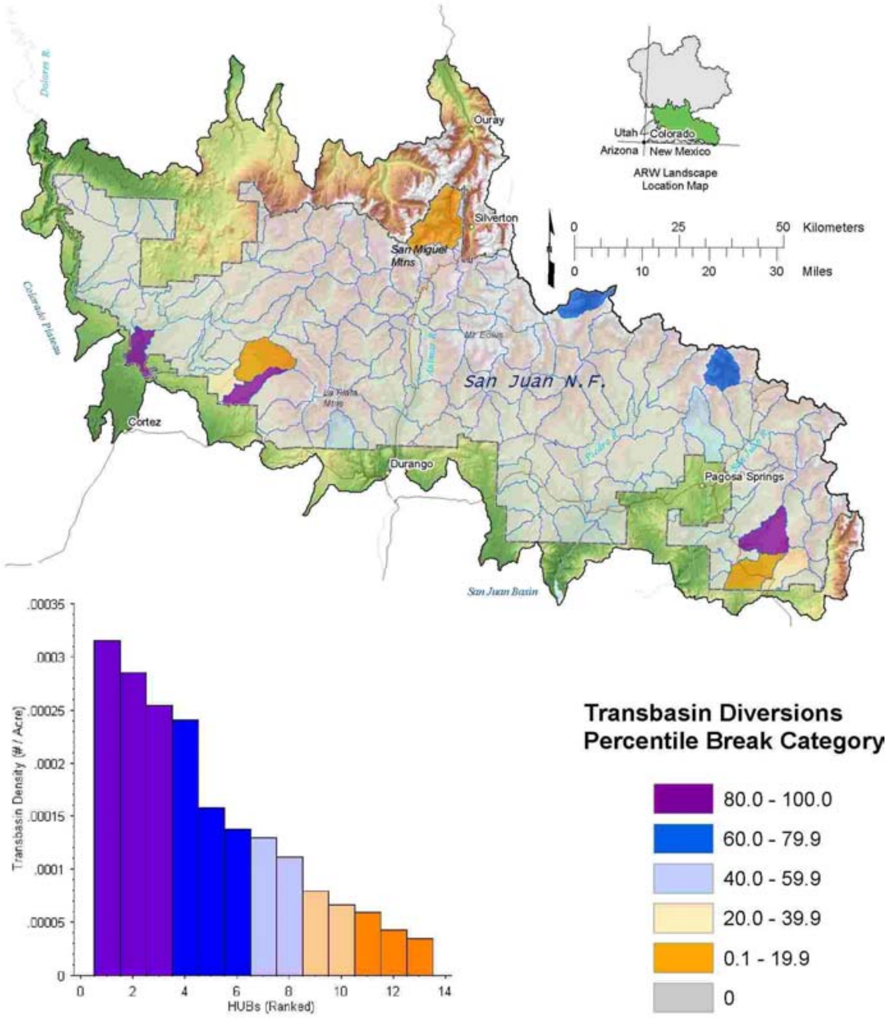

Figure 2.8 Location of ranking and distribution of transbasin diversions, 100-80 percentile range, management scale, San Juan National Forest.

Table 2.6 Summary of 6th Level HUBs in the 100-80 percentile range for number of transbasin diversions per HUB, management scale, San Juan National Forest.

HUB6	Name of 6th Level HUB	# of TRANSBASIN Diversions per HUB	Size of 6th Level HUB (acres)	Ratio of # of Diversions Per Size of 6th Level HUB
140801070104	Chicken Creek	5	15875	0.0003
140300020408	McPhee Reservoir-Dolores River	5	17546	0.0002
140801010404	Middle Rio Blanco	5	19632	0.0002

6th Level HUB Information Needs

An acknowledgement of the presence or absence of transbasin diversions and the total amount of water associated with the diversions needs to be completed. The analysis above looks at only the number of transbasin diversions in a watershed. There are several watersheds which have only one transbasin diversion, yet the large quantity of water exported from or imported to them has profoundly changed their associated aquatic ecosystems. This analysis would be relatively easy to complete with available data.

More detailed information on the quantity of water diverted, the timing of war diversions, or additions in trans-basin diversions are needed.

A survey needs to be conducted to determine where the threat of transporting non-native species into watersheds, especially on the continental divide, is of greatest concern and threat to native species.

Field investigations are needed to determine if the addition of water from transbasin diversions has physically destabilized any on-Forest channels.

Management Implications at the 6th HUB Level

Potential impacts to aquatic, hydrologic, and wetland resources could be most prominent in three watersheds: Chicken Creek (HUB 140801070104), McPhee Reservoir-Dolores River (HUB 140300020408), and to the Middle Rio Blanco (HUB 140801010404). These watersheds all have multiple transbasin diversions which receive water or export water, greatly altering natural hydrographs.

It is widely acknowledged that for the McPhee Reservoir-Dolores River (HUB 140300020408) and the Middle Rio Blanco (HUB 140801010404) aquatic ecosystems, stream health and channel conditions have been highly impacted. In the case of McPhee Reservoir-Dolores River, the aquatic ecosystem has been modified to such an extent that the presence of native fish is almost absent and non-native fish are on a downward trend (Japhet, 2006). This analysis indicates that transbasin diversions could be a contributing factor.

Analysis and recognition of the existing aquatic conditions for the three watersheds listed above could be a valuable comparison to use when evaluating new proposals for additional transbasin diversions.

Influence of Reservoirs

Reservoirs have been constructed in the Rocky Mountain Region for recreation, power production, snow-making, and flood control, but the predominant use for reservoirs has been to store water for irrigated agriculture and municipal consumption (Wohl 2001). Reservoirs were constructed as early as the mid-1800s to help facilitate the timing of downstream flows to coordinate with the agricultural growing season.

Dams clearly have an immediate influence on local conditions, and can influence resources many miles in either direction. Downstream of the reservoir hydrology is changed including the timing and quantity of flow, if diversion is involved.

Upstream, the most noticeable influence of a dam is accumulation of water behind the dam. This standing water displaces the steam's riparian or wetland areas and creates a lentic or a still water environment. In addition, there may be changes in the groundwater regime adjacent to the dam and reservoir as pressure due to impoundment develops (USDAA 2003).

In surface release reservoirs, water quality changes are typically summer warming and winter cooling. In bottom release reservoirs the trend is reversed with summer cooling of temperatures and winter warming. Downstream of the dam there may be a change in nutrient and organic material levels. Large woody debris recruitment from upstream in the watershed is eliminated. Reservoirs can function as a "sink" for pollutants, especially for heavy metals, where there are upstream mining activities. The retention of sediment can lead to dramatic reductions of suspended sediment in segments of drainages downstream from a dam and reservoirs.

As a dam fills, riparian vegetation is inundated and plant diversity is reduced. Riparian vegetation downstream of a dam can also be lost if the channel widens or down-cuts in response to the dam and reservoir. Animal diversity can be increased or decreased, depending on the system. For example, stream aquatic invertebrate and algae communities are replaced with lake benthos, zooplankton, and phytoplankton. While many salmonids can exist in reservoirs, some fish species like darters (Percidae) and sculpins (Cottidae) cannot tolerate the conditions found in standing water (Baxter and Stone 1995). Wetland soils may also be lost as well as the reproduction potential in the form of seed beds (USDA, 2003)

The loss of natural flood cycles can lead to a decrease or loss in vegetation regeneration if flooding is excluded downstream.

Channel adjustment due to a dam includes morphology modifications such as increased width/depth ratio, reduced sinuosity, substrate size changes, bank erosion, channel incision, and downcutting in the stream, below the dam. Habitat for aquatic, riparian, and wetland biota is decreased in conjunction with decreases in large woody debris supplies. Upstream of the dam, channel morphology is lost as the reservoir fills (USDA, 2003).

Within the reservoir, habitat for non-endemic species is increased. Downstream, habitat for algae, benthic macroinvertebrates, and fish populations is modified (USDA, 2003).

Reservoirs are found predominantly in the western half of the San Juan National Forest. Reservoirs are present in the eastern half of the Forest, but the density is less (Figure 2.9). 57 out of 154 HUBs on the Forest, or 37%, have inundation associated with reservoirs. For analysis purposes data was clipped to the Forest boundary.

Seven watersheds are within the 100-80 percentile range for the number of miles downstream of dams. All of these watersheds are located on-Forest and are found in the central and eastern portions of the Forest (Figure 2.10). The Upper Animas Valley-Canyon Creek (HUB#140801040501) and Lime Creek (HUB# 140801020205) watersheds are in the Electra Lake area, north of Durango. The Upper Piedra River-Box Canyon (HUB# 10801020205) watershed is in the Williams Creek Reservoir area.

These three watersheds have a noticeably higher sum of downstream stream miles affected by reservoir or stockponds, and are at the highest risk for impacts to aquatic resources compared to the other four watersheds (Table 2.7).

However, since all seven watersheds are within the 100-80 percentile range, they are at the most risk for downstream impacts compared to other watersheds in the Forest. These are the watersheds which also have the highest potential for alterations to downstream hydrology, changes in nutrients, organic material levels, lack of a large woody debris supply, and alteration of sediment loads.

These watersheds vary from approximately 6-12 miles from the Forest border. As dams can influence resources for many miles downstream, there is the potential for off-forest impacts to aquatic, riparian, and wetland resources.

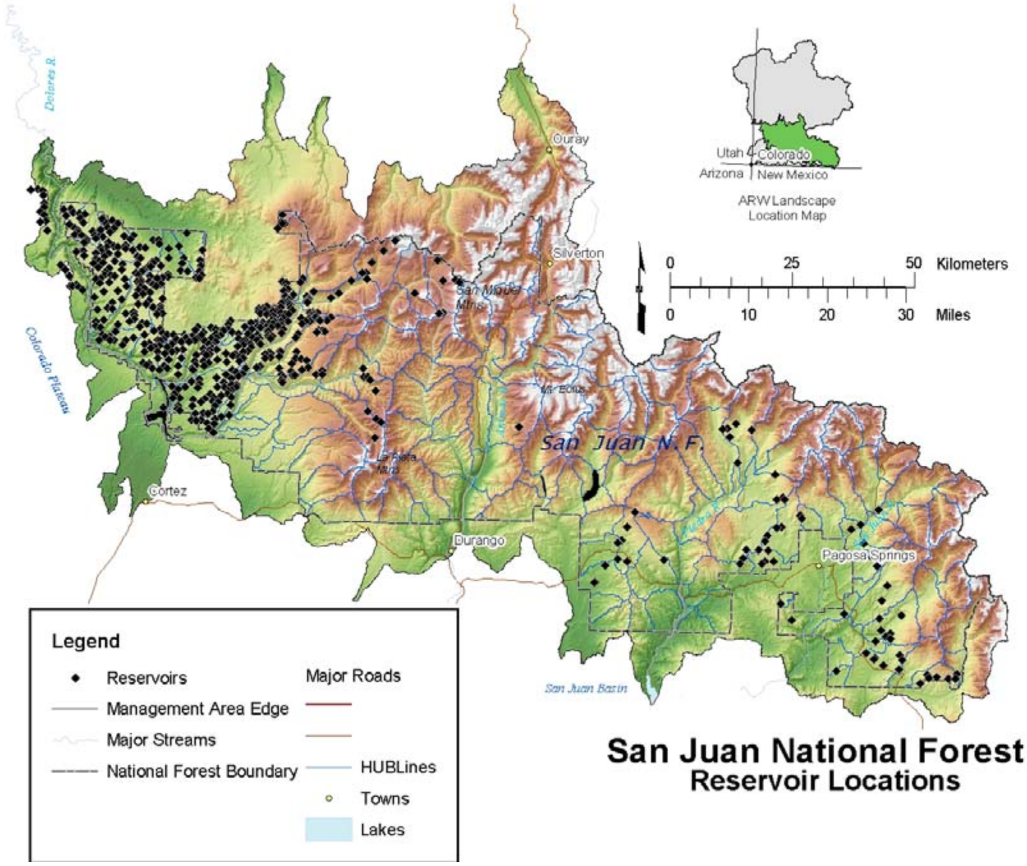

Figure 2.9 Location map for reservoirs located on the San Juan National Forest, management scale.

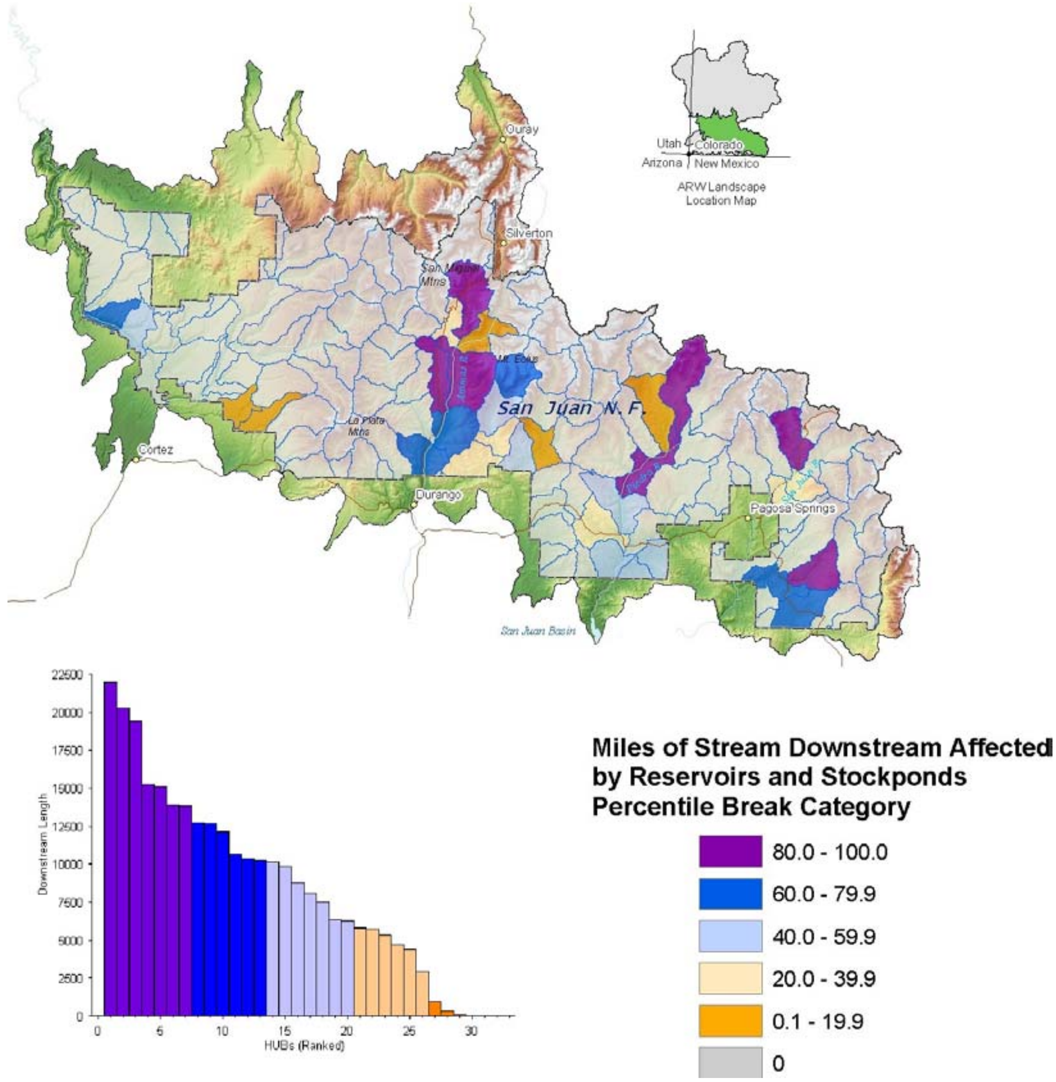

Figure 2.10 Rank and Distribution of 6th Level Watersheds, within the 100-80 Percentile Range, San Juan National Forest

Table 2.7 Rank and Distribution of 6th Level Watersheds, within the 100-80 Percentile Range, Sum of Downstream Miles Affected by Reservoirs and Stockponds, San Juan National Forest, Watersheds highlighted in light green are located entirely within the Forest boundary.

HUB #	Watershed Name	Sum of Downstream Stream Miles Affected by Reservoirs and Stockponds
140801040501	Upper Animas Valley-Canyon Creek	21974.0
140801020205	Upper Piedra River-Box Canyon	20261.1
140801040302	Lime Creek	19397.7
140801010404	Middle Rio Blanco	15208.3
140801010204	Lower West Fork San Juan River	15123.7
140801020103	Williams Creek	13887.5
140801040502	Elbert Creek	13805.1

There are 12 6th level HUBs within the 100-80 percentile range for Percent Stream Length Inundated (Table 2.8). Percent of inundated stream length per 6th level HUB in this percentile range varies from 7.1% to an eye-catching high of 57.4%. These 12 watersheds represent 8.0% of the watersheds on the San Juan National Forest. Most of these watersheds are found north and northeast of Cortez, while the rest are adjacent to, and east of, Durango (Figure 2.11).

With 57.4 % of the McPhee Reservoir-Dolores River (HUB#140300020408) watersheds streams inundated, it is most likely that aquatic, riparian, and wetlands resources have been impacted. There are also four other watersheds where over 15% of the watersheds stream length has been impacted. Based on the location of the 12 watersheds within this 100-80 percentile range there is potential for both on and off-forest effects (Figure 2.11).

Associated with inundation is displacement of the original riparian or wetland areas, reduction of plant diversity and retention of sediment. Based on this analysis the potential for impacts is very high, but data detailing their exact effects and extent are currently not available. As a result, analyses at the reach/site level are needed to pinpoint exactly the changes that have occurred due to inundation.

Table 2.8 Summary of 6th Level HUBs, within the 100-80 percentile range, for percent inundated stream length, due to reservoirs, management scale, San Juan National Forest; Watersheds highlighted in light green are located entirely within the Forest boundary

Watershed #	Watershed Name	Total Percent of Stream Length Inundated
140300020408	McPhee Reservoir-Dolores River	57.4
140300020306	McPhee Reservoir-Beaver Creek Inlet	24.8
140300020404	Stapleton Valley	21.1
140300020105	Lower West Dolores River	18.6
140300020209	Upper Dolores River-Taylor Creek	17.7
140300020601	Dolores River-Salter Canyon	12.8
140300020207	Dolores River-Priest Gulch	11.8
140300020103	Upper West Dolores River	10.4
140801011501	Middle Los Pinos River-Red Creek	8.0
140801020502	Piedra River-Stollsteimer	7.6
140300020301	Upper Beaver Creek -McPhee	7.2
140801040804	Upper Florida River-Red Creek	7.1

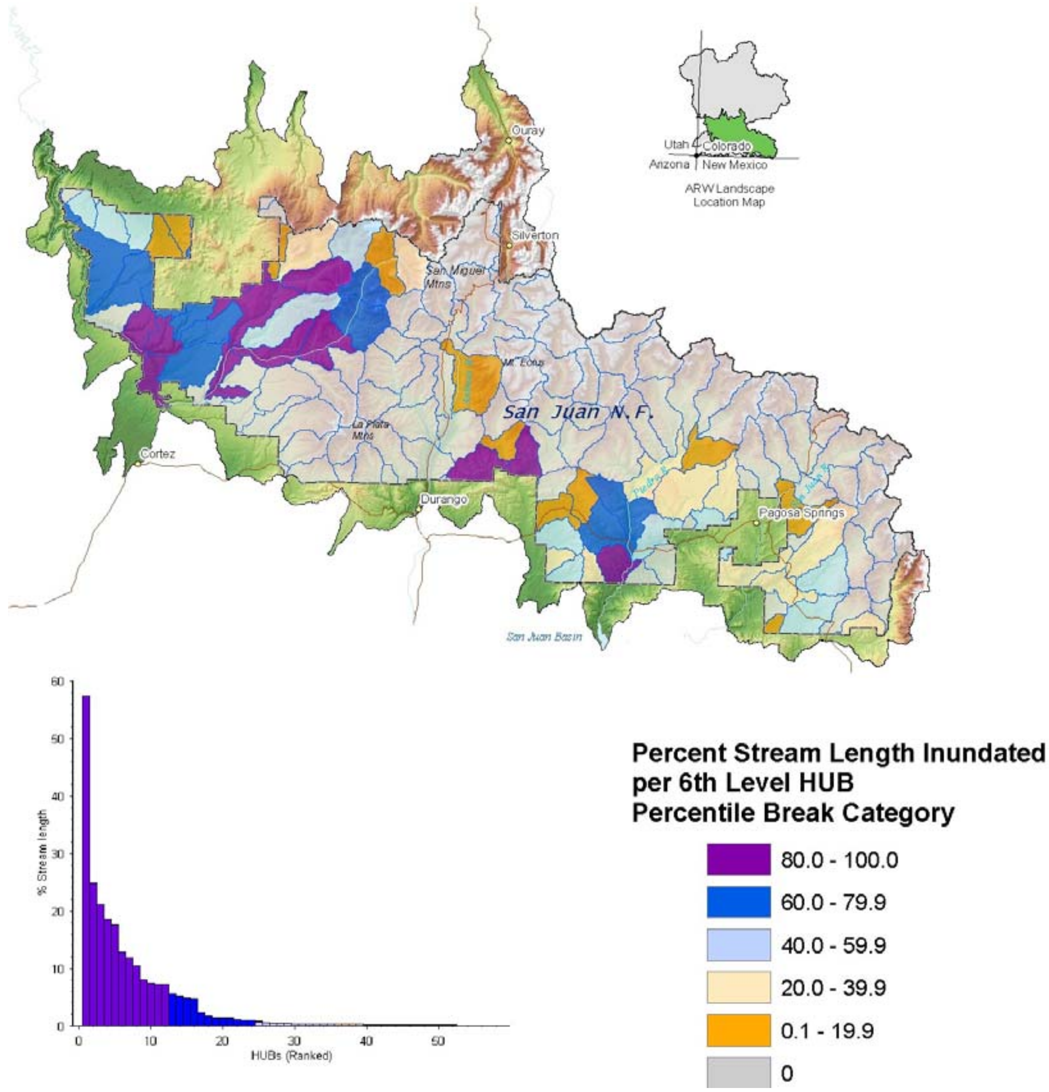

Figure 2.11 Ranking and distribution of 6th level HUBs for percent stream length inundated, due to reservoirs, 100-80 percentile range, management scale, San Juan National Forest

6th Level HUB Information Needs

Comprehensive information on the abundance and distribution of small impoundments such as stock ponds is lacking. These small impoundments can have large cumulative influences on watershed dynamics. These data will be necessary to understand the net cumulative influences of impoundments on aquatic, riparian, and wetland resources within the San Juan National Forest.

The Forest also needs to study and/or develop methodologies to accurately identify the types of discharges that are needed to support a broad spectrum of aquatic natural resource needs below any existing or proposed reservoir. The discharge information that needs to be collected would include, but is not limited to temperature, water quantity, timing, and duration. This information would be especially useful when new facilities are proposed or when existing facilities are being re-permitted.

Management Implications at the 6th HUB Level

Reservoirs can have profound influence on aquatic, riparian, and wetland resources. Often the recreational, domestic and agricultural needs have outweighed the natural processes they replace. It has only been in the last few decades that the downstream influences have been thoroughly studied. On the San Juan National Forest, 12 watersheds are within the 100-80 percentile range for the total percent of the 6th level watershed stream length that is inundated. Percentages range from a high of 57.4 to a low of 7.1. These results would indicate that aquatic biota, stream channel dynamics, and riparian ecology probably have been influenced in a high proportion of the HUBs that receive water from associated reservoirs.

Understanding the relationship between reservoir releases and downstream influences, especially from a channel-morphology, riparian and aquatic biota perspective may be a consideration for future management. By understanding the influence that existing reservoirs have on aquatic, riparian, and wetland resources, the effects of future reservoirs could be better understood, especially within similar clusters.

13%, or 20, of the Forest's watersheds are associated with reservoirs within the San Juan National Forest, includes influences from downstream flows (Figures 2.9 and 2.10).

Inundation and dam construction could have a profound influence on reintroduction efforts for native species of salmonids and other fishes, as well as being habitat for non-native species that otherwise may not be found there. Clusters 4r, 5r, and 6r have the highest proportion of low gradient streams for riparian clusters on the Forest. These three riparian clusters are probably more influenced by modified stream flows relative to the other five clusters.

HUBs within the rain-and-snow driven hydrology and non-calcareous geology include riparian clusters 4r, 5r, and 7, and to a lesser extent cluster 6r. These clusters would be more prone to erosion and channel modification with fluctuating flows.

For future reservoir project consideration, the sensitivity of fisheries, riparian vegetation, aquatic productivity, and benthic macroinvertebrates identified within a specific cluster could be used for identifying resource values. HUBS containing wetland clusters 2w, 5w, 7w, 8w and 9w are characterized a high percentage of glaciation, which would indicate a high chance of influencing wetlands. Watersheds containing riparian clusters 4r, 5r, and 6r where a dam is located upstream of low gradient stream channels may have a high chance of stream channel and riparian modification.

Direction for Reach/Site Scale Analysis

Reservoirs can influence ecological conditions upstream, downstream, and adjacent to their actual locations. Listed below are specific items that should be addressed when studying the influences of reservoirs on aquatic, riparian, and wetland resources at the reach or site scale level.

1. When evaluating a current or potential water diversion the following resource needs should be addressed:
   a. Municipal and recreational needs
   b. Stream channel maintenance needs
   c. Riparian and aquatic vegetation needs
   d. Aquatic organism needs
   e. Terrestrial organism needs
   f. Water quality influences
   g. Channel maintenance needs
   h. Aquatic habitat needs
   i. Invasive species introductions

2. When evaluating a current or potential water diversion the following questions should be answered:
   a. Will the dam structure allow passage of organisms necessary to maintain species/population viability?
   b. Will flow modifications influence downstream channel form and function?
   c. Will flow modifications influence riparian vegetation form and function?
   d. Will flow modifications influence aquatic organism life-history strategies and population size (e.g., water temperature, timing of spawning)?
   e. Will flow modifications influence recreational and aesthetic values?
   f. Will flow modifications influence habitat needs for terrestrial animals (e.g., beavers, southwest willow fly catchers)?
   g. Will altered instream flows provide a competitive advantage for invasive species?
   h. Will flow modifications influence adjacent wetland communities?
   i. Are changes in water quality acceptable?
   j. Will/is inundation influence wetlands or rare ecosystem types such as fens?

Influence of Spring Developments

Grasslands of the Rocky Mountain Region are located in an arid to semi-arid landscape, with low total annual rainfall and high annual rainfall variability (Wohl 2001). Because permanent streams and ponds were often not readily accessible for human and livestock utilizing these grasslands, users had to seek other water sources. Wetlands not associated with streams are often formed by springs (Winter et al. 1988).

As the number of settlers and domestic cattle increased in the 1800s and 1900s, utilization of springs increased. Typically, spring water was concentrated through pipes to fill watering tanks or ponds, which were to water livestock. Early settlers also used springs for drinking water.

Springs and associated wetlands provide unique and dramatic habitats on an arid landscape. Wetlands often have high biodiversity because of unique hydrologic, soil, and microclimatic conditions (Cooper 1986). Mosses, herbaceous plants, woody plants, or combinations of all of these groups may dominate spring vegetation. These communities are quite variable between distinct wetlands. Most plants associated with springs are very sensitive to water chemistry, seasonality of water flow, and disturbance. Many invertebrates and amphibians also inhabit these environments due to constant water temperatures, abundant food supplies, and general lack of predators (Hammerson 1986).

Development of springs, and accompanying wetlands, results in direct impacts to these two resources, as a result of alterations to the associated natural hydrologic regime. Developed springs often lose their unique hydrologic characteristics, and may be transformed into areas with upland habitat characteristics.

Direct influences such as ponding of springs can also modify a system's nutrients dynamics, making conditions unfavorable for endemic species. Indirectly, the concentration of domestic livestock at these watering places can alter the biological communities via intensive grazing activity, soil compaction, degradation of water quality, and nutrient addition.

For this analysis spring data was clipped to watershed boundaries. Within the project analysis area there are 353 springs. 278 of these springs, or 79% of them, are located within the Forest boundary. Springs are most common in the eastern most and western most thirds of the Forest.

To focus on which watersheds have high spring concentrations, the number of springs per acre per HUB was determined. Out of the 154 HUBs on the Forest 83 of them, or 54% have springs found within those watersheds. 17 of the 154 watersheds were ranked within the 100-80 percentile range for having the highest potential for land management activities impacting springs and associated aquatic, wetlands and riparian resources. These watersheds are summarized in Figure 2.12 and Table 2.9.

For those watersheds located entirely on Forest, any associated impacts to spring resources would be found primarily on-Forest (Table 2.9). For those watersheds which are not located entirely on-Forest, the areas of potential impact are both on and off-forest

Within the 100-80 percentile range spring density (# springs per # acres per HUB) ranged from 0.0014 in the Upper Piedra River-Indian Creek (HUB# 140801020206) to a low of 0.0003 for the McPhee Reservoir-Beaver Creek Inlet (HUB# 140300020306). At the other end of the spectrum 23 watersheds had only one spring per watershed. Even though the total spring count per watershed is very low it is important information when evaluating the potential risk of various management activities on spring ecosystems. The watersheds listed in Table 2.9 may warrant special management consideration. However, HUBs with fewer springs should not be neglected because springs are relatively rare within a watershed.

6th Level HUB Information Needs

Information on spring locations at the management scale was available through U.S. Geological Survey topographic quadrangles. This information probably identifies only a portion of the springs present in the study area. While springs and seeps have been used for domestic and agricultural purposes for centuries, their ecological importance is only beginning to be understood. Several plants and animals on the Region 2 sensitive species list are associated with springs, especially plants. In addition, springs are typically the water source for wetlands, such as fens, which are also rare.

Gathering existing, and collecting new data, on the San Juan for both wetlands and springs is a current data need. Additional inventory or summary data is also needed to fully evaluate potential impacts to these resources when a project is proposed.

In addition, information on anthropogenic influences on springs, such as domestic and agricultural use is needed and would provide the information to help evaluate anthropogenic influences on spring related hydrologic systems.

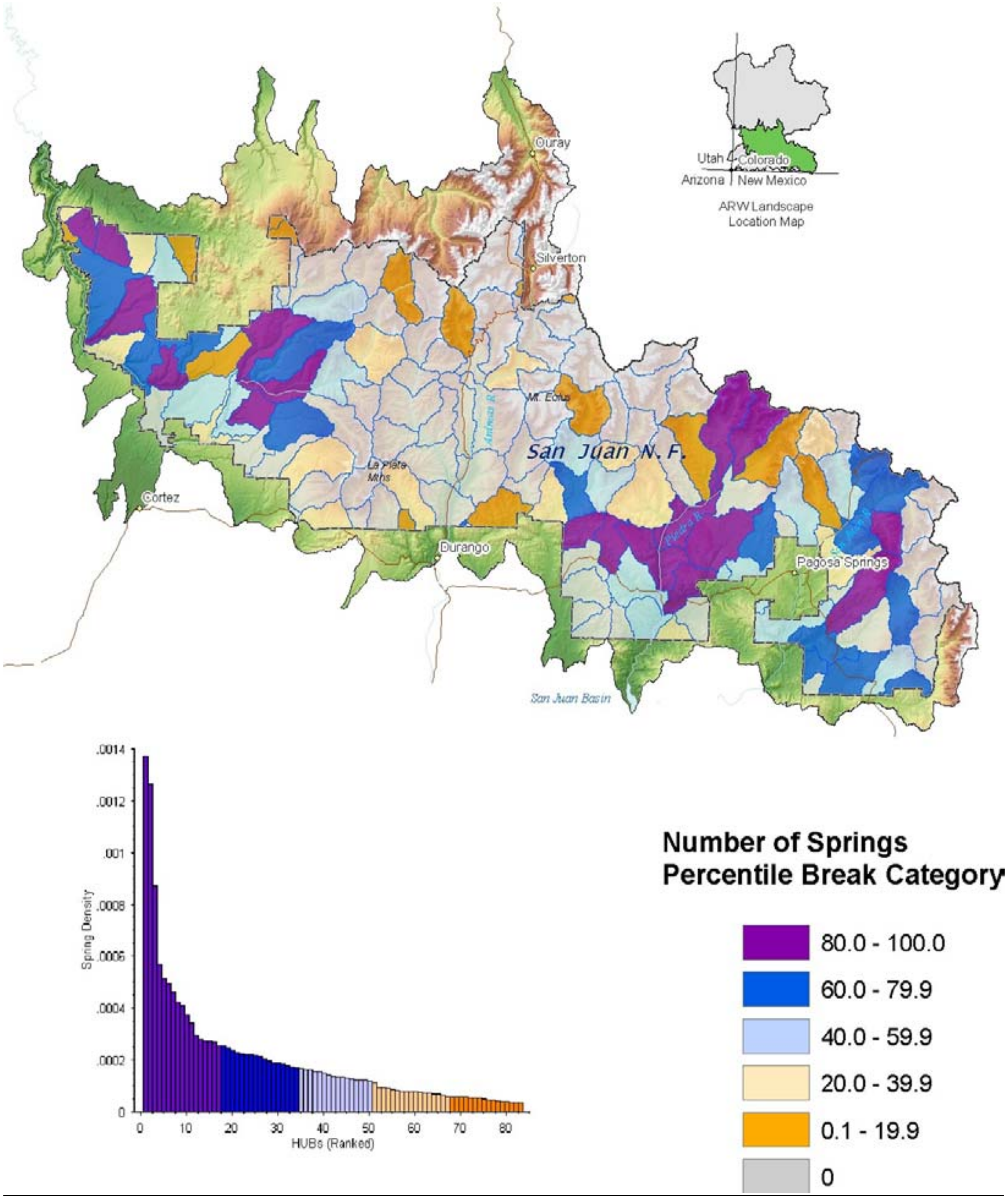

Figure 2.12 The rank and distribution of the number of springs by HUB, management scale, San Juan National Forest

Table 2.9 Summary of Number of Springs by HUB, 100-80 percentile range, San Juan National Forest; Watersheds highlighted in light green are located entirely within the Forest boundary

HUB #	Watershed Name	# Springs per HUB	
140801020206	Upper Piedra River-Indian Creek	20	0.001371
140801011502	Bear Creek	17	0.001264
140801011601	Upper Beaver Creek	16	0.000872
140801020301	Upper Devil Creek	13	0.000567
140801020103	Williams Creek	13	0.000515
140801010405	Rito Blanco	11	0.000497
140801020302	Lower Devil Creek	9	0.000464
140801020205	Upper Piedra River-Box Canyon	9	0.000423
140300020507	Dawson Draw	9	0.000414
140801020102	Middle Fork Piedra River	7	0.000377
140300020602	Narraguinnep Canyon Natural Area	7	0.000343
140300020105	Lower West Dolores River	7	0.000296
140300020402	Spruce Water Canyon	6	0.000281
140300020209	Upper Dolores River-Taylor Creek	5	0.000275
140801010103	Sand Creek	4	0.000274
140300020509	Pine Arroyo	3	0.000270
140300020306	McPhee Reservoir-Beaver Creek Inlet	3	0.000257

Management Implications at the 6th HUB Level

As mentioned previously, 84 watersheds, or 54% of the watersheds in the Forest contain springs. Within the project area there are 353 springs total with 278 of them located on-forest boundaries. 17 of the watersheds received a cumulative total ranking of “5” for the spring category. As a result, they are an important aquatic, riparian and wetlands resource (Table 2.9).

Springs are fed by an upwelling of groundwater, and are often associated with calcareous geology, and start at a “point source”. Once the spring leaves the ground land management activities such as water diversions, grazing and ground disturbing activities can have a profound effect on the form and function of a spring.

When an analysis is conducted to determine the extent of influence from anthropogenic sources, protection is probably the best management consideration of high priority springs. Changing the hydrologic regime of springs can have a dramatic effect on the form and function of springs because they typically have a relatively constant discharge. The flora and fauna associated with springs also are adapted to this consistent flow. Three of the 15 watersheds that received a cumulative total of “5” for the spring’s category also received a “5” for the cumulative reservoir category. These watersheds are the Upper Piedra River-Indian creek, Upper Dolores River-Taylor Creek, and Lower West Dolores river watersheds.

In all three cases riparian and wetlands clusters 5r and 3w were involved. Riparian vegetation and aquatic productivity are categorized as highly sensitive to alterations in hydrologic regime as is wetlands cluster 3w. All 15 watersheds that received a cumulative total rating of “5” for springs have the highest potential for experiencing anthropogenic influences on function and health. However, the three watersheds which also received a cumulative total score of “5” for reservoirs are especially vulnerable to hydrologic and aquatic plant and macroinvertebrate modification. There is a high probability that springs within them have been hydrologically modified.

Due to the constant flow regime, habitats associated with springs (e.g., fens) contain relicts of the last ice age, and are found nowhere else in the landscape. Thus, the conditions under which they evolved no longer exist. It is recommended that springs be located that are relatively unimpaired and to protect their integrity, health, and function thru proactive management.

<u>Reach/Site Scale</u>

In arid environments, springs tend to be small and rare, and larger springs are rarer still. Thus evaluating springs at the reach/site scale will be necessary to understand their influence on aquatic, riparian, and wetland biota. Specific questions to be answered when addressing spring influences include:

1. Has the spring been developed for domestic or livestock use?
2. Are rare native flora and fauna present that should be evaluated (e.g., northern leopard frogs)? And, are these taxa federal or state listed?
3. What are the influences that management activities have had on the spring ecosystem? Are ecologically similar springs present that could be used for comparative analyses?
4. What other resource values should be considered (e.g., recreational hunting)?

Water Uses Overall Cumulative Percentile Ranking

The water uses analyzed on the Forest consisted of diversions, ditches, transbasin water transfers, reservoirs, and springs. The nine metrics used in this analysis are summarized in Table 2.10. To determine the total combined effects of these water uses, the results of all metrics were combined and re-ranked, and an overall cumulative percentile ranking was determined. This analysis is relative only to the portion of the 6th level HUBs surface area within the San Juan National Forest boundary, and is intended to provide the reader with the additive rankings at this scale. Unlike the previous methodology, the results are evenly distributed across the total number of HUBs at this scale.

This analysis was performed at the management scale, with data existing for all portions of the 154 HUBs within the San Juan National Forest boundary. Data is from State and Forest data bases. The combined ranking of all water uses within these watersheds delineates which watersheds have the most potential for impacts on aquatic, riparian, and wetland resources. Rankings were divided into five differing groups, each with a 20 percentile ranges. Watersheds within the 100-80 percentile range have the most susceptibility to impacts on aquatic health while those falling within the 19.9-0.1 percentile range have the lowest potential for being influenced water-use activities.

The results of the cumulative ranking process for all water use metrics, in all watersheds associated with the San Juan National Forest, and are summarized in Table 2.12 at the end of this section. This table also summarizes which riparian and wetland clusters are associated with each watershed on the Forest. Essentially this table will function as a "look up" table, so at a glance one can determine which water use activities affect each watershed, as well as have a reference to watershed sensitivity. The table also indicates which watersheds are located entirely on-Forest.

The cumulative percentile ranking for the 100-80 percentile range is summarized in Table 2.11and displayed in map format in Figure 2.12. Nine watersheds in the recreation synthesis analysis were within the 100-80 percentile range. The maximum cumulative ranking for water uses is 25. Cumulative totals for water uses, in the 100-80 percentile range, varied from 20-15. These watersheds are found in the far west and eastern half of the Forest. These watersheds primarily reflect high levels of activity for diversions, ditches, reservoirs and springs. Transbasin diversions are not abundant on the San Juan and as a result, seven out of nine watersheds in this percentile range did not include diversions. The Middle Rio Blanco (HUB# 140801010404) and the Fourmile Creek (HUB#140801010302) watersheds had a count of five and three transbasin diversions, respectively. Watersheds within this percentile range have the highest potential for both on and off-forest impacts to aquatic resources.

Table 2.10 Summary of criteria used in Water Uses cumulative analysis.

Metric	Explanation
Diversion Ratio	Number of diversions per stream mile per 6th level HUB
CFS Appropriated per Acre	The total number of cubic feet per sec (CFS) appropriated for use per acre per 6th level HUB
Ditch Total	Total number of miles of ditch per 6th level HUB
Transbasin Total	Total number of transbasin diversions per 6th level HUB
% Inundated in SJNF	The percentage of HUBs on the San Juan National Forest that streams inundated due to reservoirs
% Inundated Mgmt. Scale	Percent of stream length that is inundated per 6th level HUB
Total Inundated Stream Length (mi)	The total number of miles of streams inundated due to reservoirs and stockponds, per 6th level HUB
Stream Length Downstream of Reservoir (mi)	Total number of miles stream located downstream of reservoirs and stockponds
Spring Total	Total number of springs per 6th level HUB

23 watersheds on the Forest fell within the 79.9-60 percentile range, which corresponds to a cumulative water uses total of "4". 15 of these watersheds are located entirely on-Forest Table 2.12. These watersheds are found across the Forest, however watersheds within this percentile range are largely absent from the La Plata Mountains north to the San Miguel Mountains, west of Durango. Watersheds in this group are dominated by diversions, ditches, reservoirs and springs. As most of these watersheds within this group are located on-Forest the potential for on-Forest effects is generally greater than for off-forest effects. However, there is potential for off-Forest downstream effects along the southern border of the eastern half of the Forest and along the southern border of the Forest Figure 2.12.

33 watersheds were found to be within the 59.9-40 percentile range. This percentile range corresponds to a water uses cumulative total of "3". These watersheds are found predominantly in the far western and eastern thirds of the Forest. Only 11 of these watersheds were located entirely on-Forest (Table 2.12). As a result, there is the potential for on-Forest impacts but it is likely there is more potential for off-Forest downstream impacts to aquatic, riparian, and wetland resources. This is especially true in the western half of the Forest were the drainages in the 59-.9-40 percentile range eventually drain into the Dolores River. The Dolores flows to the northwest, paralleling the Forest boundary before flowing on BLM managed lands.

27%, or 42 6th level HUBs, have cumulative totals placing them in the 39.9-20.0 percentile range. This percentile range corresponds to the water uses cumulative total of "2" (Table 2.12). This is the highest total number of watersheds for any of the five percentile ranges, although this total does not dramatically exceed the totals for the 59-.9-40 and 19.9-0.1 percentile ranges.

These watersheds are found primarily in the western three-quarters of the Forest. 18 of these watersheds are located entirely on-Forest. Although there is still potential for both on and off-Forest impacts to aquatic resource exists, an examination of water use cumulative totals indicates a decline in potential for impacts, based on the lower cumulative totals by category. Diversions and reservoirs dominate this percentile range with springs influencing totals to a lesser degree. Ditches and transbasin diversions are largely absent.

The 19.9-0.1 percentile range is comprised of 35 watersheds, the 2nd highest total for a percentile range. This percentile range is denoted by a "1" under the cumulative water uses total column (Table 2.12). These watersheds are found in the central portion of the Forest although they are also found in the eastern and western most portions of the Forest (Figure 2.12). 19 of these watersheds are located entirely on-Forest. Cumulative totals by water use category are very low ranging from a total of 2-0. This percentile range is dominated by diversions and, to some extent, reservoirs. The influences of ditches, transbasin diversions, and springs, are largely absent. As a result, there is relatively little potential for impacts to aquatic resources both on and off-forest.

Twelve watersheds, or 8% of the watersheds on the Forest, are not influenced by water use activities as indicated by cumulative water use total of "0" (Table 2.12). Six of these watersheds are located entirely on-Forest. Groundhog (HUB# 140300020104), Cement Creek ((HUB# 140801040102), Animas River above Howardsville (HUB# 140801040101), Upper Cat Creek (HUB# 140801010604), Sheep Camp Valley (HUB# 140300020503), Bear Creek-Disappointment Creek (HUB# 140300020501) are located primarily on private or BLM land. Water uses activity is absent in the Three Sisters (HUB# 140801011304), Lake Creek (HUB# 140801011303), and Beaver Creek (HUB# 140801010202) watersheds as they are in the Weminuche Wilderness area.

Table 2.11 Water Uses Cumulative Percentile Ranking 100-80 Percentile Ranking; Watersheds located entirely on-Forest highlighted in light green

HUB6	HUB6 NAME	Diversion Cumulative Category	Ditch Cumulative Category	Transbasin Cumulative Category	Reservoir Cumulative Category	Spring Cumulative Category	Water Use Total	Cate-gory	Riparian Cluster	Wet-lands Cluster
140801020401	Martinez Creek-Dutton Creek	5	4	0	2	4	15	5	5	4
140801020206	Upper Piedra River-Indian Creek	3	3	0	5	5	16	5	5	3
140801011601	Upper Beaver Creek	4	4	0	2	5	15	5	5	4
140801010404	Middle Rio Blanco	5	5	5	5	0	20	5	4	3
140801010303	Laughlin Park	5	5	0	1	4	15	5	5	1
140801010302	Fourmile Creek	5	5	3	0	3	16	5	2	3
140300020601	Dolores River-Salter Canyon	3	4	0	5	4	16	5	4	3
140300020209	Upper Dolores River-Taylor Creek	4	3	0	5	5	17	5	5	3
140300020105	Lower West Dolores River	4	1	0	5	5	15	5	5	3

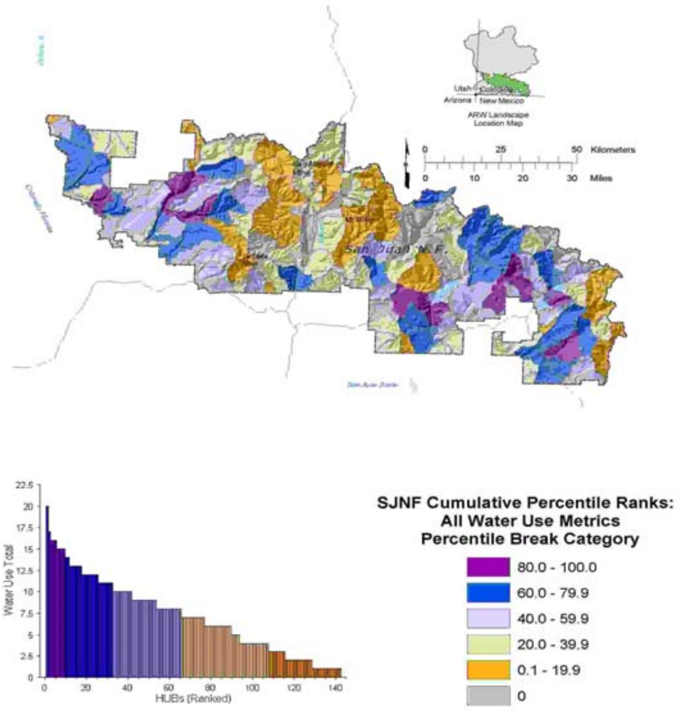

Figure 2.12 Water Uses Category, Cumulative 100-80 Percentile Ranking for Watersheds, management scale, San Juan National Forest

Table 2.12 Water Uses Category-Cumulative Percentile Ranking of Watersheds on the San Juan National Forest); Watersheds located entirely with the Forest boundary are highlighted in light green

HUB6	HUB6NAME	Diversion Cumulative Category	Ditch Cumulative Category	Transbasin Cumulative Category	Reservoir Cumulative Category	Spring Cumulative Category	Water Use Cumulative Total	Category	Riparian Cluster	Wetlands Cluster
140801020401	Martinez Creek-Dutton Creek	5	4	0	2	4	15	5	5	4
140801020206	Upper Piedra River-Indian Creek	3	3	0	5	5	16	5	5	3
140801011601	Upper Beaver Creek	4	4	0	2	5	15	5	5	4
140801010404	Middle Rio Blanco	5	5	5	5	0	20	5	4	3
140801010303	Laughlin Park	5	5	0	1	4	15	5	5	1
140801010302	Fourmile Creek	5	5	3	0	3	16	5	2	3
140300020601	Dolores River-Salter Canyon	3	4	0	5	4	16	5	4	3
140300020209	Upper Dolores River-Taylor Creek	4	3	0	5	5	17	5	5	3
140300020105	Lower West Dolores River	4	1	0	5	5	15	5	5	3
140801040504	Upper Animas Valley-Trimble	5	4	0	2	0	11	4	5	5

Table 2.12 Continued Water Uses Category-Cumulative Percentile Ranking of Watersheds on the San Juan National Forest); Watersheds located entirely with the Forest boundary are highlighted in light green

HUB6	HUB6NAME	Diversion Cumulative Category	Ditch Cumulative Category	Transbasin Cumulative Category	Reservoir Cumulative Category	Spring Cumulative Category	Water Use Cumulative Total	Category	Riparian Cluster	Wetlands Cluster
140801020502	Piedra River-Stollsteimer	2	1	0	5	3	11	4	6	4
140801020501	Yellowjacket Creek	5	0	0	5	3	13	4	4	4
140801020104	Piedra River-O'Neal Creek	5	4	0	3	0	12	4	5	4
140801020103	Williams Creek	3	4	0	2	5	14	4	2	2
140801020102	Middle Fork Piedra River	3	5	0	0	5	13	4	2	7
140801020101	East Fork Piedra River	5	5	0	0	1	11	4	1	7
140801011404	Vallecito Reservoir	5	2	0	1	4	12	4	5	3
140801011301	Upper Los Pinos River-Ricon La Vaca	4	5	4	0	0	13	4	2	8
140801010507	Coyote Creek	3	3	1	3	4	14	4	4	3
140801010406	Lower Rio Blanco-San Juan River	4	1	0	2	4	11	4	4	4
140801010405	Rito Blanco	4	3	0	1	5	13	4	5	4
140801010403	Rio Blanco River-Blanco Basin	5	4	0	0	4	13	4	2	2
140801010204	Lower West Fork San Juan River	5	2	0	2	3	12	4	2	7

Table 2.12 Continued Water Uses Category-Cumulative Percentile Ranking of Watersheds on the San Juan National Forest); Watersheds located entirely with the Forest boundary are highlighted in light green

HUB6	HUB6NAME	Diversion Cumulative Category	Ditch Cumulative Category	Transbasin Cumulative Category	Reservoir Cumulative Category	Spring Cumulative Category	Water Use Cumulative Total	Category	Riparian Cluster	Wetlands Cluster
140300020604	Dolores Canyon-Lake Canyon	3	0	0	4	4	11	4	4	3
140300020602	Narraguinnep Canyon Natural Area	3	0	0	4	5	12	4	4	4
140300020507	Dawson Draw	3	0	0	4	5	12	4	4	3
140300020404	Stapleton Valley	5	0	0	5	3	13	4	4	3
140300020403	Middle Lost Canyon	2	5	3	1	0	11	4	4	3
140300020401	Upper Lost Canyon	3	4	1	0	4	12	4	2	1
140300020306	McPhee Reservoir-Beaver Creek Inlet	2	0	0	5	5	12	4	4	3
140300020207	Dolores River-Priest Gulch	2	1	0	5	3	11	4	2	1
140300020103	Upper West Dolores River	3	1	0	5	3	12	4	2	1
140801070105	East Fork of Mud Creek	2	5	0	1	0	8	3	4	4
140801070104	Chicken Creek	0	3	5	0	0	8	3	4	3
140801070103	Upper Mancos Valley	3	5	0	0	0	8	3	5	4
140801070102	West Mancos River	3	5	0	0	2	10	3	2	1

Table 2.12 Continued Water Uses Category-Cumulative Percentile Ranking of Watersheds on the San Juan National Forest); Watersheds located entirely with the Forest boundary are highlighted in light green

HUB6	HUB6NAME	Diversion Cumulative Category	Ditch Cumulative Category	Transbasin Cumulative Category	Reservoir Cumulative Category	Spring Cumulative Category	Water Use Cumulative Total	Ranking Category	Riparian Cluster	Wetlands Cluster
140801070101	East Mancos River-Middle Mancos River	4	5	0	0	0	9	3	2	1
140801050105	Upper Cherry Creek	3	4	0	0	2	9	3	5	4
140801040602	Upper Lightner Creek	3	4	3	0	0	10	3	5	3
140801040502	Elbert Creek	5	2	0	2	0	9	3	5	7
140801020402	Upper Stollsteimer Creek	2	0	0	3	3	8	3	5	4
140801020302	Lower Devil Creek	2	0	0	3	5	10	3	6	3
140801020301	Upper Devil Creek	3	0	0	2	5	10	3	5	3
140801020205	Upper Piedra River-Box Canyon	2	0	0	3	5	10	3	5	3
140801011602	Middle Beaver Creek	3	4	0	2	0	9	3	5	4
140801011502	Bear Creek	3	0	0	0	5	8	3	5	4
140801011403	Lower Vallecito Creek	4	1	0	0	3	8	3	1	2
140801010506	Little Navajo River	5	0	2	0	3	10	3	2	3
140801010504	Navajo River-Weisel Flat	2	1	0	1	4	8	3	4	3
140801010306	Mill Creek	3	2	0	2	2	9	3	4	4

Table 2.12 Continued Water Uses Category-Cumulative Percentile Ranking of Watersheds on the San Juan National Forest); Watersheds located entirely with the Forest boundary are highlighted in light green

HUB6	HUB6NAME	Diversion Cumulative Category	Ditch Cumulative Category	Transbasin Cumulative Category	Reservoir Cumulative Category	Spring Cumulative Category	Water Use Cumulative Total	Category	Riparian Cluster	Wetlands Cluster
140801010305	McCabe Creek	4	5	0	1	0	10	3	5	4
140801010304	Upper Pagosa Springs	5	0	0	2	2	9	3	4	3
140801010301	Turkey Creek	3	3	2	0	1	9	3	2	2
140801010203	Wolf Creek	2	2	0	0	4	8	3	1	7
140801010104	East Fork San Juan River-The Clamshell	2	2	0	0	4	8	3	1	7
140300020509	Pine Arroyo	3	0	0	2	5	10	3	4	3
140300020408	McPhee Reservoir-Dolores River	2	0	5	2	0	9	3	4	4
140300020407	House Creek	2	0	0	3	3	8	3	4	3
140300020402	Spruce Water Canyon	3	0	0	0	5	8	3	4	3

Table 2.12 Continued Water Uses Category-Cumulative Percentile Ranking of Watersheds on the San Juan National Forest); Watersheds located entirely with the Forest boundary are highlighted in light green

HUB6	HUB6NAME	Diversion Cumulative Category	Ditch Cumulative Category	Transbasin Cumulative Category	Reservoir Cumulative Category	Spring Cumulative Category	Water Use Cumulative Total	Category	Riparian Cluster	Wetlands Cluster
140300020305	Beaver Creek-Trail Canyon	3	0	0	4	1	8	3	4	3
140300020304	Lower Plateau Creek	2	0	0	4	4	10	3	5	4
140300020303	Calf Creek	2	0	0	3	4	9	3	5	4
140300020301	Upper Beaver Creek -McPhee	2	0	0	4	3	9	3	5	1
140300020208	Stoner Creek	2	0	0	3	4	9	3	2	1
140300020204	Upper Dolores River-Scotch Creek	2	0	0	5	2	9	3	2	1
140802020106	Lower Alkali Canyon-Narraguinnep Canyon	0	0	4	0	0	4	2	6	6
140801050102	Mayday Valley	4	0	0	0	0	4	2	7	3
140801040804	Upper Florida River-Red Creek	3	2	0	1	1	7	2	5	3
140801040803	Lemon Reservoir	5	0	0	1	0	6	2	2	1
140801040604	Animas River-Spring Creek	0	0	0	0	4	4	2	6	5
140801040601	Junction Creek	2	2	0	0	2	6	2	2	3
140801040503	Upper Animas Valley-Stevens Creek	5	0	0	2	0	7	2	5	2

Table 2.12 Continued Water Uses Category-Cumulative Percentile Ranking of Watersheds on the San Juan National Forest); Watersheds located entirely with the Forest boundary are highlighted in light green

HUB6	HUB6NAME	Diversion Cumulative Category	Ditch Cumulative Category	Transbasin Cumulative Category	Reservoir Cumulative Category	Spring Cumulative Category	Water Use Cumulative Total	Category	Riparian Cluster	Wetlands Cluster
140801040501	Upper Animas Valley-Canyon Creek	3	0	0	4	0	7	2	1	2
140801040407	Lower Hermosa Creek	4	0	0	0	0	4	2	5	1
140801040303	Lower Cascade Creek	3	0	0	1	0	4	2	2	8
140801040301	Upper Cascade Creek	2	3	0	0	1	6	2	2	8
140801040204	Animas River-Needleton	1	0	0	1	2	4	2	2	8
140801040202	Animas River-Tenmile Creek	1	3	0	0	0	4	2	2	8
140801040103	Mineral Creek	2	2	2	0	0	6	2	2	8
140801020405	Lower Stollsteimer Creek	3	0	0	1	2	6	2	6	4
140801020404	Middle Stollsteimer Creek	3	0	0	1	0	4	2	6	3
140801020403	Stollsteimer Creek-Dyke Valley	1	0	0	0	3	4	2	4	4

Table 2.12 Continued Water Uses Category-Cumulative Percentile Ranking of Watersheds on the San Juan National Forest); Watersheds located entirely with the Forest boundary are highlighted in light green

HUB6	HUB6NAME	Diversion Cumulative Category	Ditch Cumulative Category	Transbasin Cumulative Category	Reservoir Cumulative Category	Spring Cumulative Category	Water Use Cumulative Total	Category	Riparian Cluster	Wetlands Cluster
140801020202	Lower Weminuche Creek	4	1	0	1	1	7	2	2	3
140801020201	Upper Weminuche Creek	2	2	0	0	0	4	2	1	8
140801011704	Upper Spring Creek	3	0	0	3	0	6	2	6	4
140801011703	Ute Creek	3	0	0	1	0	4	2	6	4
140801011603	Lower Beaver Creek	3	0	0	3	0	6	2	5	4
140801011501	Middle Los Pinos River-Red Creek	3	0	0	1	2	6	2	5	3
140801011306	East Creek	3	0	0	0	3	6	2	2	1
140801011305	Indian Creek	3	0	0	0	2	5	2	2	2
140801010602	Montezuma Creek	2	0	0	2	0	4	2	4	4
140801010601	San Juan River-Trujillo	2	0	0	0	4	6	2	6	3
140801010402	Fish Creek	3	3	0	0	0	6	2	1	7

Table 2.12 Continued Water Uses Category-Cumulative Percentile Ranking of Watersheds on the San Juan National Forest); Watersheds located entirely with the Forest boundary are highlighted in light green

HUB6	HUB6NAME	Diversion Cumulative Category	Ditch Cumulative Category	Transbasin Cumulative Category	Reservoir Cumulative Category	Spring Cumulative Category	Water Use Cumulative Total	Category	Riparian Cluster	Wetlands Cluster
140801010308	San Juan River-Eightmile Mesa	3	0	0	1	3	7	2	5	4
140801010201	Upper West Fork San Juan River	1	0	4	0	2	7	2	2	8
140801010103	Sand Creek	0	0	0	0	5	5	2	1	7
140300020605	Dolores Canyon-Joe Davis Hill	1	0	0	4	1	6	2	4	3
140300020603	Dolores Canyon-Cabin Creek	2	0	0	3	2	7	2	4	3
140300020506	Brumley Valley	2	0	0	3	2	7	2	6	4
140300020505	Upper Disappointment Creek	2	0	0	2	1	5	2	5	4
140300020504	Ryman Creek	2	0	0	2	3	7	2	5	4
140300020406	Upper Dolores River-Italian Creek	2	0	0	2	2	6	2	4	3
140300020302	Upper Plateau Creek	1	0	0	3	1	5	2	5	4
140300020205	Roaring Forks Creek	2	2	0	0	0	4	2	2	1
140300020203	Rico Valley	3	0	0	4	0	7	2	2	1
140300020102	Fish Creek	2	3	0	2	0	7	2	2	1
140300020101	El Deinte Peak	1	0	0	3	0	4	2	2	1

Table 2.12 Continued Water Uses Category-Cumulative Percentile Ranking of Watersheds on the San Juan National Forest); Watersheds located entirely with the Forest boundary are highlighted in light green

HUB6	HUB6NAME	Diversion Cumulative Category	Ditch Cumulative Category	Transbasin Cumulative Category	Reservoir Cumulative Category	Spring Cumulative Category	Water Use Cumulative Total	Category	Riparian Cluster	Wetlands Cluster
140802020201	Upper Yellowjacket Canyon	1	0	0	0	0	1	1	4	3
140802020103	Hartman Canyon	0	0	0	1	0	1	1	6	6
140801050101	La Plata River headwaters	2	0	0	0	0	2	1	2	8
140801040901	Lower Florida River-Ticalotte	1	0	0	0	0	1	1	5	4
140801040802	Upper Florida River-Transfer Park	2	0	0	1	0	3	1	1	7
140801040801	Florida River Headwaters	0	0	0	2	0	2	1	8	9
140801040603	Lower Lightner Creek	2	0	0	0	1	3	1	4	4
140801040406	Hermosa Creek-Dutch Creek	2	0	0	0	0	2	1	1	1
140801040404	Middle Hermosa Creek	1	0	0	0	0	1	1	2	1
140801040403	Upper Hermosa Creek	1	0	0	0	0	1	1	2	1
140801040402	East Fork Hermosa Creek	1	0	0	0	0	1	1	2	1

Table 2.12 Continued Water Uses Category-Cumulative Percentile Ranking of Watersheds on the San Juan National Forest); Watersheds located entirely with the Forest boundary are highlighted in light green

HUB6	HUB6NAME	Diversion Cumulative Category	Ditch Cumulative Category	Transbasin Cumulative Category	Reservoir Cumulative Category	Spring Cumulative Category	Water Use Cumulative Total	Category	Riparian Cluster	Wetlands Cluster
140801040401	Hermosa Creek headwaters	1	0	0	0	0	1	1	2	1
140801040302	Lime Creek	0	0	0	2	0	2	1	2	8
140801040203	Needle Creek	2	0	0	0	0	2	1	8	9
140801040201	Elk Creek	1	0	0	0	0	1	1	3	8
140801040104	Animas River-Cunningham Creek	1	0	0	0	1	2	1	2	8
140801020503	Piedra River-Navajo Reservoir Inlet	1	0	0	1	0	2	1	6	3
140801020204	First Fork	1	0	0	0	2	3	1	2	1
140801011503	Los Pinos River-Bayfield	0	0	0	0	1	1	1	5	4
140801011402	Middle Vallecito Creek	0	0	0	0	1	1	1	2	8
140801011401	Upper Vallecito Creek	2	0	0	0	0	2	1	2	8
140801010503	Navajo Peak	3	0	0	0	0	3	1	2	1
140801010502	West Fork Navajo River	3	0	0	0	0	3	1	1	7
140801010401	Rio Blanco Headwaters	2	1	0	0	0	3	1	1	7

Table 2.12 Continued Water Uses Category-Cumulative Percentile Ranking of Watersheds on the San Juan National Forest); Watersheds located entirely with the Forest boundary are highlighted in light green

HUB6	HUB6NAME	Diversion Cumulative Category	Ditch Cumulative Category	Transbasin Cumulative Category	Reservoir Cumulative Category	Spring Cumulative Category	Water Use Cumulative Total	Category	Riparian Cluster	Wetlands Cluster
140801010307	Echo Canyon Reservoir	2	0	0	0	0	2	1	5	4
140801010102	Quartz Creek	1	0	0	0	0	1	1	1	7
140801010101	Headwaters East Fork San Juan River	1	0	0	0	0	1	1	1	7
140300036101	Naturita Creek	0	0	0	0	1	1	1	5	4
140300020511	Disappointment Valley-Wild Horse Reservoir	0	0	0	0	2	2	1	6	3
140300020510	Upper Disappointment Valley	0	0	0	0	2	2	1	6	6
140300020502	Disappointment Creek Headwaters	1	0	0	0	1	2	1	5	1
140300020206	Bear Creek	1	1	0	0	0	2	1	2	1
140300020202	Upper Dolores River-Cayton Valley	0	0	0	2	1	3	1	2	1
140300020201	Dolores River Headwaters-Tin Can Basin	0	0	0	1	0	1	1	2	1

Table 2.12 Continued Water Uses Category-Cumulative Percentile Ranking of Watersheds on the San Juan National Forest); Watersheds located entirely with the Forest boundary are highlighted in light green

HUB6	HUB6NAME	Diversion Cumulative Category	Ditch Cumulative Category	Transbasin Cumulative Category	Reservoir Cumulative Category	Spring Cumulative Category	Water Use Cumulative Total	Category	Riparian Cluster	Wetlands Cluster
140300020104	Groundhog Creek	1	0	0	2	0	3	1	2	1
140801040405	South Fork Hermosa Creek	0	0	0	0	0	0	0	2	1
140801040102	Cement Creek	0	0	0	0	0	0	0	3	8
140801040101	Animas River above Howardsville	0	0	0	0	0	0	0	2	8
140801020203	Sand Creek	0	0	0	0	0	0	0	2	1
140801011304	Three Sisters	0	0	0	0	0	0	0	8	9
140801011303	Lake Creek	0	0	0	0	0	0	0	2	8
140801011302	Upper Los Pinos River-Flint Creek	0	0	0	0	0	0	0	2	8
140801010604	Upper Cat Creek	0	0	0	0	0	0	0	4	3
140801010202	Beaver Creek	0	0	0	0	0	0	0	1	7
140300020503	Sheep Camp Valley	0	0	0	0	0	0	0	5	4
140300020501	Bear Creek-Disappointment Creek	0	0	0	0	0	0	0	5	4
140300020405	Lower Lost Canyon	0	0	0	0	0	0	0	4	3

Chapter 3
Transportation Category
Management Scale

Transportation- Key Findings

1. 81 watersheds on the Forest have no system roads located in the valley bottoms (0.1 miles of road or less). There are 72 HUBs with roads (≥ 0.1 mile of road) located within valley bottoms. For watersheds, located entirely on-Forest paved road densities (mi/sq. mi. valley bottom) range from 2.4 to 0.1. For watersheds located entirely on the Forest, with greater than on-tenth of a mile unpaved road/valley floor densities range from 46.9 to 1.8.
2. There are 14 watersheds located entirely on the Forest that have no non-system roads. For watersheds located entirely on the Forest, with greater than on-tenth of a mile non-system road/valley floor densities range from 5.9 to 0.1.
3. Forest Service system roads, which include both paved and unpaved roads, average 1.0 miles of road per square mile. When non-system road mileage is included in calculating a road density the average doubles to 2.0 miles of road per square mile of Forest land. This includes wilderness and private land within the Forest boundary.
4. Foot trails are found through out the Forest, except for its western most portions. Those HUBs defined with the highest potential for effects on aquatic, riparian, and wetland resources are found in the west-central, north central, and northeastern most portions of the Forest.
5. Approximately 79% of the Forest is open to OHV use.
6. Railroads are found in eight of the Forests 15 watersheds. Only two watersheds were found to have high potential for railroad related effects on aquatic, riparian, and wetlands. In these two watersheds the ratio of miles of rail road per square mile of valley bottom ranged from 7.16 to 3.54. One watershed is located completely on the Forest. The other has only a very small percentage of the watershed located off-Forest.
7. The additive effects analysis revealed only very minor portions of six 6th level HUBs that are not influenced by activities in the transportation category with the San Juan National Forest
8. The 6th level HUBs with the highest levels of influence from transportation activities appears to be in the very northern and central portion of the Forest, with the remainder of the Forest exhibiting fewer influences.
9. The maximum possible cumulative ranking value was 30 (meaning that each of the 10 parameters measured would have to have the highest rank of 3). More than 45 of the 74 the 6th level HUBs had values of 15.

Influence of Roads

Influence of System Roads

At present there are approximately 3191 miles of Forest Service system road, including paved and unpaved, covering a total of 3273 square miles within the San Juan National Forest boundary. As a result, system road density averages approximately 1.0 miles of road per square mile of Forest land, including wilderness and private land in the Forest. As displayed in Figure 3.1 roads are found through out the Forest except within the Lizard Head, Weminuche, and San Juan Wilderness areas.

System roads are defined as roads within, partially within, or adjacent to a Forest National boundary and necessary for protecting, administering, and using Forest National lands.
The Forest Service authorizes and maintains jurisdiction over these roads. There are approximately 309 miles of paved road and 2883 miles of unpaved road.

Non-system roads are defined as roads which are no longer required for management purposes, or which have been created by off-road vehicle use, but a road foot print still exists. Data analysis indicates that there is approximately a total of 3,549 miles of non-system road on the Forest, with approximately 868 of those miles in valley bottoms (Table 3.1).

It should be noted though that several data quality issues were not resolved due to time constraints prior to analysis. As a result, it appears that the non-system road numbers may be higher than what is on the ground (See Information Needs section). However, Forest staff felt the existing data was of sufficient quality that analysis could still be conducted.

Table 3.1 Summary of Road Mileage, by Type, management scale, San Juan National Forest

Road Surface Type	Total Miles On-Forest*	% of Total Road Miles on-Forest
Paved	309	4
Unpaved	2883	43
Non-system roads	3,549	53
Total	6,740	100%

Mileage determined using ArcGIS. Numbers have been rounded to the nearest whole mile

Evaluating road densities at the 6th HUB level is an effective tool for defining areas that may have potentially elevated levels of road-related effects on aquatic resources. Calculated road densities do not include un-authorized or non-system road mileages. System road densities for the San Juan N.F. are displayed and summarized in Figure 3.2 and Table 3.2. Calculated road densities include both paved and unpaved roads. At this time complete road data beyond Forest boundaries is unavailable.

Approximately 27 HUBs are ranked within the 100-80 percentile range, which are summarized in Table 3.2. This percentile range defines those watersheds which have the most potential for road-related effects on aquatic health. Road densities vary from a high of 5.6 mi/sq. mi for the East Fork of Mud Creek (HUB#140801070105) to a low of 1.9 mi/sq. mi in the beaver Creek-Trail Canyon (HUB 140300020305) watersheds.

For those watersheds, such as the East Fork of Mud Creek (HUB#140801070105), which are not located completely within Forest boundaries, road density values may be skewed. This is a function of the amount of watershed area within the Forest boundary and/or the amount of stream length within of the portion of the watershed within Forest boundaries. Examination of GIS data indicates that this combination of factors explains the elevated road densities within the East Fork of Mud Creek watershed.

However, for watersheds such as the East Fork Hermosa Creek, which are located completely within the Forest boundary, other explanations are needed for elevated road densities. High road densities in the East Fork of Hermosa Creek are most likely associated with the mining and logging activity within this watershed, although recreational use is also common in this watershed.

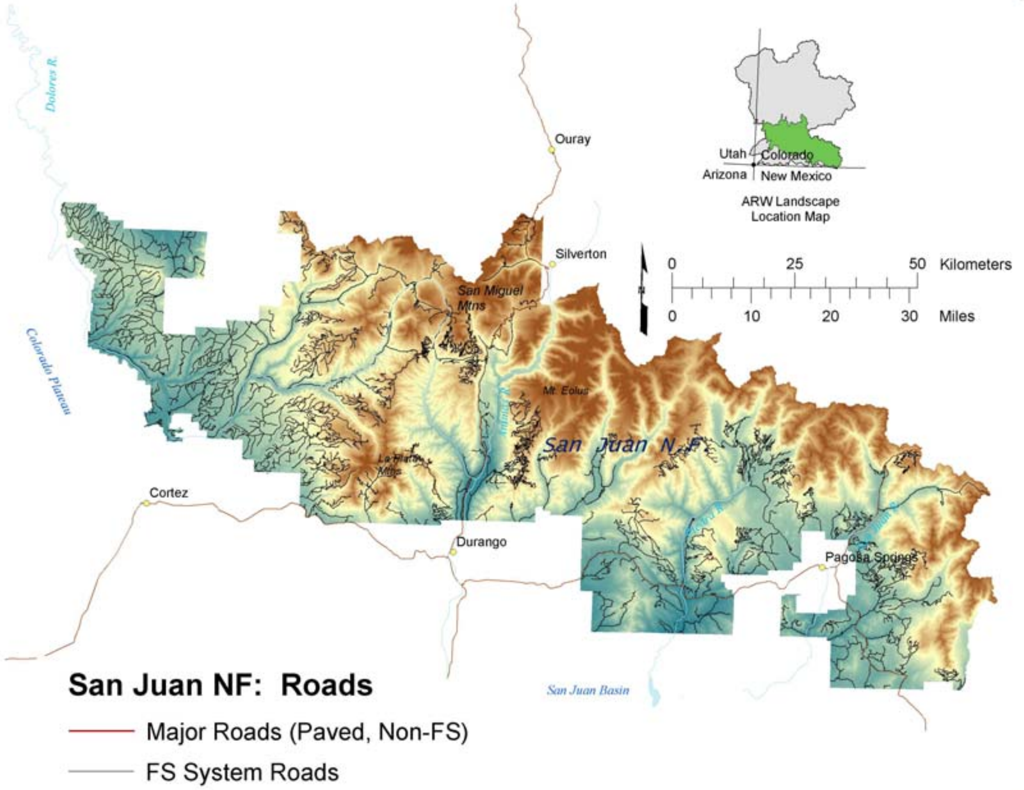

Figure 3.1 Locations of Paved and Unpaved System Roads within the San Juan National Forest

Although evaluating road densities at the 6th level, or management scale, defines watersheds of interest, it does not take into account other important factors that influence how roads affect resources aquatic and riparian resources. The position of the road within the landscape (e.g., within the valley bottom versus uplands) and structural associations (e.g., culverts, stream crossings) and road surface composition (paved vs. unpaved) are better factors for evaluating the scale and magnitude of road-related effects on these resources.

For these reasons, analysis for this report focused on two more specific types of measurements. These measurements are more indicative of the relationship between roads and aquatic and riparian resources. Ratios were calculated to determine the number of miles of road (paved or unpaved) per stream mile as well as the number of road crossings per stream mile.

Ratio's help avoid bias in interpretation when comparing low and high density drainage watersheds to each other.

Road densities, within the area defined as the "valley floor", were analyzed to provide a focused assessment of road-related effects on aquatic and riparian habitat.

The valley floor has been defined as a stable environment containing dynamic components such as perennial and intermittent streams, primary and secondary stream channels, and active terraces and floodplains (Bighorn ARWEA, 2004). As this area includes riparian zones, separate calculations involving these areas, were not conducted. The ratio's for miles of paved road and unpaved road per stream mile, located within the valley floor for each 6th level HUB, were calculated for all watersheds intersected by the San Juan National Forest boundary. These results define areas of varying potential effects and the calculated values provide a means of relative comparison between HUBs.

The densities of paved and unpaved roads located in valley bottoms were also measured to further evaluate road-related impacts on aquatic and riparian resources. Unpaved roads are either naturally surfaced or are topped with aggregate. Both of these surface types have a higher potential for contributing sediment via surface runoff than paved roads, which are paved with asphalt.

Figures 3.3 and 3.4, and Tables 3.3 and 3.4, display calculated road densities and HUB ranking for paved and unpaved system roads, located within the valley floor areas in the San Juan National Forest.

Analysis of paved system roads displayed in Figure 3.3 and Table 3.3 indicate that there are 13 watersheds within the 100-80 percentile range. Ranking these HUBs determines which watersheds have the highest potential for road-related impacts. Those HUBs ranked within the 100-80 percentile range are those most susceptible to road-related influences and are listed in Table 3.3. For watersheds located completely within the Forest boundary, the highest density of paved roads located in a valley floor area occurs in the Rico Valley watershed (HUB 140300020203), with a density of 2.4 miles per square mile. The high density in the Rico Valley is a function of a high total number of paved road miles (U.S. Highway 145) relative to the amount of valley bottom. The lowest density is 0.8 miles per square mile of valley floor area, in the Lower Cascade Creek watershed (HUB 140801040303).

The rest of the watersheds listed in Table 3.3 contain only portions of the watershed within the Forest boundary. As a result, the road densities are not reflective of paved road densities for the entire individual watershed. Most of the paved roads located on the Forest are highways passing through NFS lands.

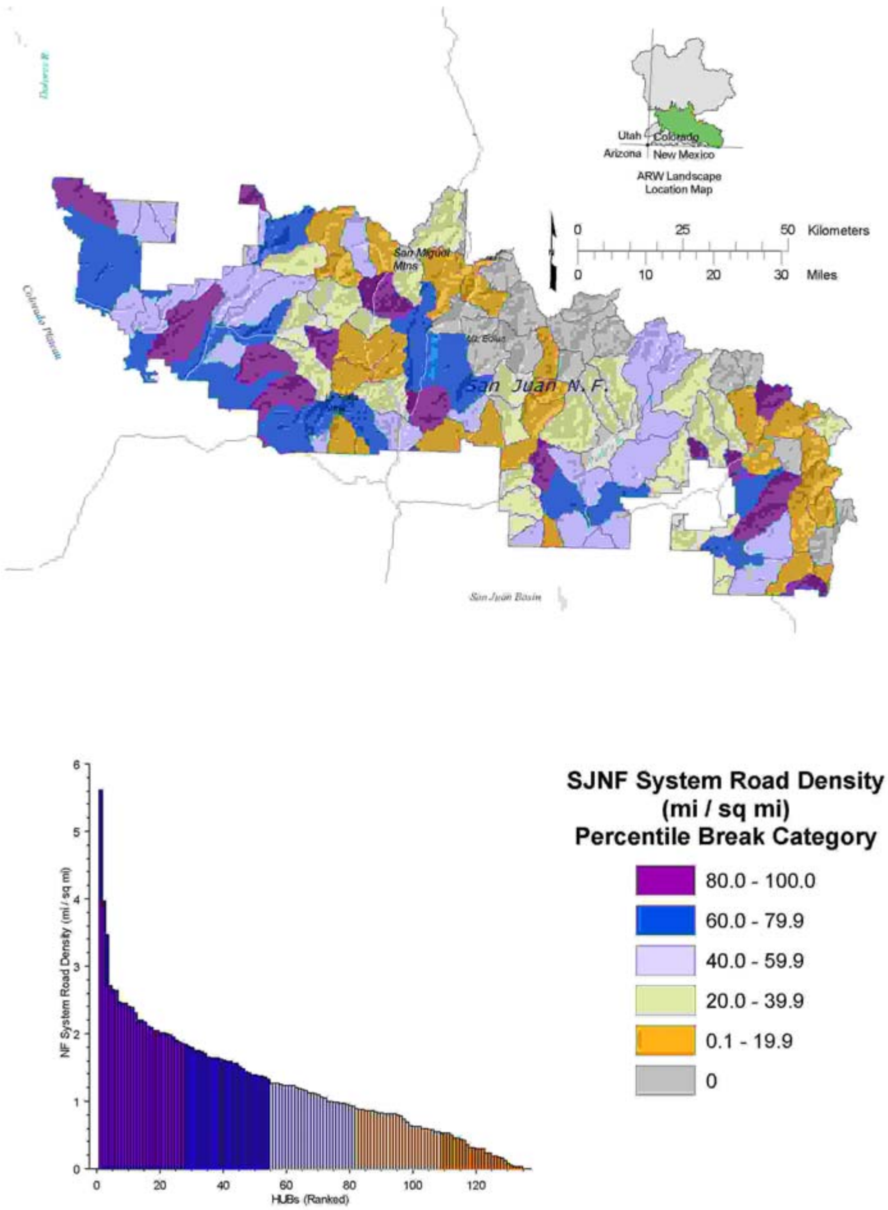

Figure 3.2 Rank and distribution of total (paved and unpaved) system road densities, management level, San Juan National Forest.

Table 3.2 HUB Numbers and Calculated Road Densities (mi/sq.mi) for System Roads within the 100-80 Percentile, San Juan National Forest*. Watersheds highlighted in green are located entirely on the Forest National.

6th Level HUB	6th Level HUB Name	NF System Road Density (mi / sq mi)
140801070105	East Fork of Mud Creek	5.6
140801040402	East Fork Hermosa Creek	4.0
140802020103	Hartman Canyon	3.5
140802020106	Lower Alkali Canyon-Narraguinnep Canyon	2.7
140801040401	Hermosa Creek headwaters	2.7
140801010304	Upper Pagosa Springs	2.6
140801070103	Upper Mancos Valley	2.5
140300020509	Pine Arroyo	2.5
140300020511	Disappointment Valley-Wild Horse Reservoir	2.5
140300020401	Upper Lost Canyon	2.4
140801040503	Upper Animas Valley-Stevens Creek	2.4
140300020605	Dolores Canyon-Joe Davis Hill	2.3
140300020302	Upper Plateau Creek	2.2
140300020407	House Creek	2.2
140300036101	Naturita Creek	2.2
140300020507	Dawson Draw	2.1
140801010203	Wolf Creek	2.1
140801010504	Navajo River-Weisel Flat	2.1
140801010405	Rito Blanco	2.0
140300020510	Upper Disappointment Valley	2.0
140300020205	Roaring Forks Creek	2.0
140801040604	Animas River-Spring Creek	2.0
140801070102	West Mancos River	2.0
140801011601	Upper Beaver Creek	1.9
140801010305	McCabe Creek	1.9
140300020502	Disappointment Creek Headwaters	1.9
140300020305	Beaver Creek-Trail Canyon	1.9

* All acreage data was generated using Arcview GIS and associated spreadsheets. All numbers rounded to nearest tenth of a mile.

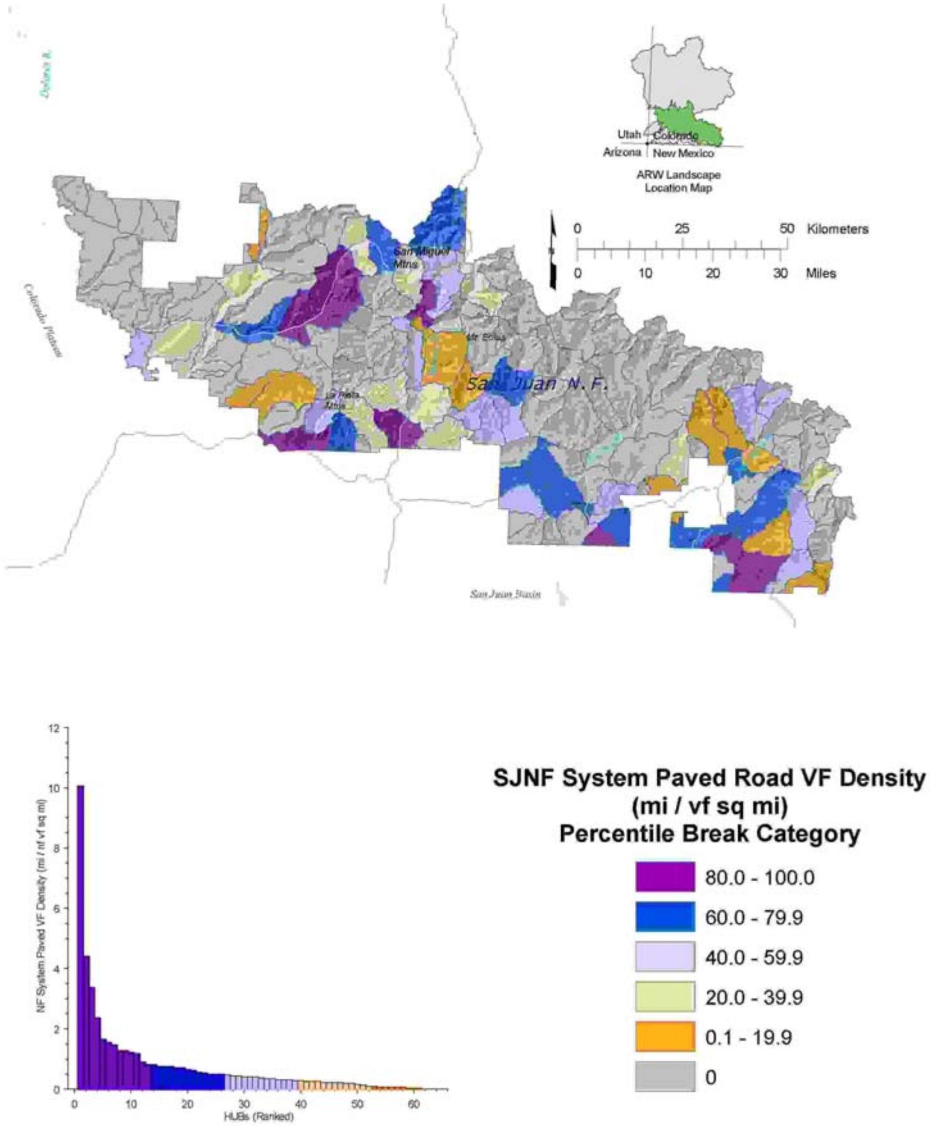

Figure 3.3 Rank and distribution of system paved road densities in valley floor areas.

Table 3.3 Summary Table of Valley Floor Paved System Roads within the 100-80 Percentile Range, San Juan National Forest. Watersheds highlighted in green are located entirely on the Forest National.

6th Level HUB	6th Level HUB Name	NF System Paved VF Density (mi / sq mile of valley floor)
140802020103	Hartman Canyon	10.1
140802020106	Lower Alkali Canyon-Narraguinnep Canyon	4.4
140801070103	Upper Mancos Valley	3.4
140300020203	Rico Valley	2.4
140801050102	Mayday Valley	1.7
140801010406	Lower Rio Blanco-San Juan River	1.5
140801020405	Lower Stollsteimer Creek	1.5
140801050105	Upper Cherry Creek	1.3
140300020207	Dolores River-Priest Gulch	1.3
140801040504	Upper Animas Valley-Trimble	1.2
140300020204	Upper Dolores River-Scotch Creek	1.2
140801010507	Coyote Creek	0.9
140801040303	Lower Cascade Creek	0.8

Figure 3.4 and Table 3.4, which follow below, summarize data analysis of unpaved system roads within the Forest boundary. 27 out of 154 HUBSs were in the 100-80 percentile range. Of these 27 watersheds only 13 were located completely within the Forest boundary. The Hermosa Creek headwaters watershed (HUB 140801040401) had the highest unpaved valley floor road density at 46.9 mi/sq. mi. valley floor, while the Upper Hermosa Creek watershed had the lowest unpaved valley floor road density at 14.3 mi/sq. mi. valley floor. The high unpaved road valley floor densities are associated with municipal development in the Hermosa Creek headwaters may be related to mining.

The Lower Florida-Ticalotte (HUB #140801040901), the Upper Disappointment Valley (#HUB 140300020510), and the East Fork of Mud Creek (HUB # 140801070105) all have extremely high road densities and have only a small portion of their watershed area located on the San Juan. The portions within the Forest boundary though contain high amounts of unpaved road miles.

Determining which watersheds fall within the 100-80 percentile range defines those watersheds with the greatest potential for aquatic and riparian resources to be impacted by the unpaved road system located in valley bottom areas. It is important to remember that road systems provide the means for generating increased surface runoff, disruption of hydrology and erosion. This potential is highest where road ditches connect to stream channels and infiltration rates are reduced. Roads commonly result in increased sediment delivery to streams, as well as higher peak flows, and accelerated timing of peak flow (Nelson, 2002).

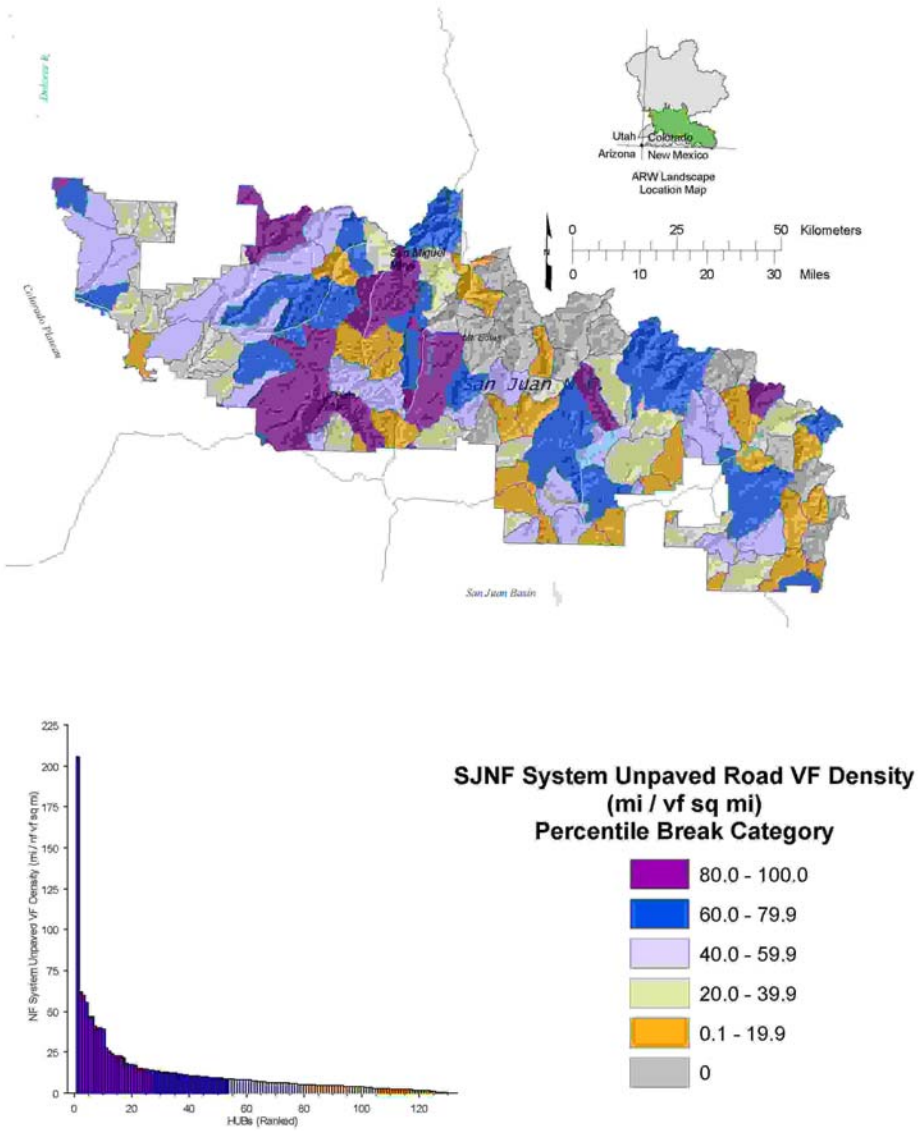

Figure 3.4 Rank and distribution of system unpaved road densities in valley floor areas at the management level

Table 3.4 Summary of Unpaved Roads in the 100-80 Percentile Category for Unpaved System Roads Located in the Valley Floor; Watersheds highlighted in green are located entirely on the San Juan National Forest.

6th Level HUB	6th Level HUB Name	NF System Unpaved VF Density (mi / National Forest valley floor sq. mi)
140801040901	Lower Florida River-Ticalotte	205.4
140300020510	Upper Disappointment Valley	62.3
140801070105	East Fork of Mud Creek	59.9
140801040604	Animas River-Spring Creek	55.6
140801040401	Hermosa Creek headwaters	46.9
140300036101	Naturita Creek	46.7
140300020205	Roaring Forks Creek	41.0
140801050101	La Plata River headwaters	40.0
140300020405	Lower Lost Canyon	39.8
140801040402	East Fork Hermosa Creek	39.4
140801010604	Upper Cat Creek	27.4
140801040503	Upper Animas Valley-Stevens Creek	25.9
140801010203	Wolf Creek	24.1
140300020511	Disappointment Valley-Wild Horse Reservoir	22.8
140300020102	Fish Creek	22.8
140801011503	Los Pinos River-Bayfield	22.6
140801040601	Junction Creek	21.9
140801020203	Sand Creek	18.0
140300020502	Disappointment Creek Headwaters	17.7
140300020206	Bear Creek	17.3
140801070102	West Mancos River	16.8
140801040301	Upper Cascade Creek	15.4
140801070101	East Mancos River-Middle Mancos River	15.0
140300020104	Groundhog Creek	14.5
140801040501	Upper Animas Valley-Canyon Creek	14.4
140801040403	Upper Hermosa Creek	14.3
140801050105	Upper Cherry Creek	13.8

While paved or unpaved road density values are not a direct measure of road-related impacts, they can be utilized to help identify areas at risk. This type of data could be used to: help screen areas in which road construction is proposed in valley bottoms, identify areas for future inventories and monitoring, and to define possible watershed improvement needs.

To provide an even more focused evaluation of potential road-related impacts two additional ratios were calculated: the number of road miles per stream mile and the number of stream crossings per stream mile. These ratios were calculated for both paved and unpaved system roads. The number of stream crossings per stream mile is important as all road crossings have the potential for impacting water quality and quantity.

Roads modify runoff and groundwater through interception (USDA Forest Service, 1996). Surface runoff from roads can not only contribute sediment to streams but additional flow volume as well (MacDonald, 1991, USDA Forest Service, 2003). Culverts that become plugged and fail can contribute high volumes of sediment to streams (http://www.srs.fs.usda.gov/pubs/; Steven E. Taylor).

Other types of road-associated influences on aquatic systems include erosion of fill associated with culverts, perching of culverts with associated erosion and scouring, including bank erosion, and channel modification related to increased sediment input (USDA Forest Service, 2003). Increased sediment contribution and modified flow can impact water quality, degrade aquatic habitat, reduce stream productivity, and in some cases, modify channel morphology. Havlick, 2002, documents stream crossings as a significant source of sediment delivery to many streams.

Figure 3.5 displays the ratio for system road miles per stream mile. 27 watersheds are with the 100-80 percentile range for this metric. The vast majority of these watersheds are found in the western half of the Forest, along both the northern, western, and southern Forest boundaries. However, only six of these watersheds are located entirely on-Forest (Table 3.5). As a result, most of the potential for road-related effects on aquatic, riparian and wetland resources are located off-Forest. However, for those six watersheds located entirely within the Forest boundary there is the potential for on-Forest effects.

Forest Service paved road system ratios and rankings are displayed in Figure 3.6 and Table 3.6. 15 out of 154 HUBS' are found within the 100-80 percentile range. Only four of these watersheds occur completely within the Forest and are highlighted in light green. These watersheds are found in the western half of the Forest and in the eastern most part of the Forest.

Paved road crossing ratios vary from a high of 4.8 in the Harman Canyon watershed (HUB # 140802020103) to a low of 0.1 crossings per stream mile in the Lower Rio Blanco-San Juan River watershed (HUB # 1408010406). The Hartman Canyon, Upper Mancos Valley, and Lower Alkali Canyon-Narraguinnep Canyon watersheds are all located almost entirely outside of the Forest boundary. Their very high ratios of paved stream crossings are reflective of the small amount of watershed within the Forest boundary. However, the Upper Animas Valley-Trimble watershed is mostly within the Forest boundary and the density of 0.3 paved road stream crossings is a more accurate reflection of conditions within this watershed.

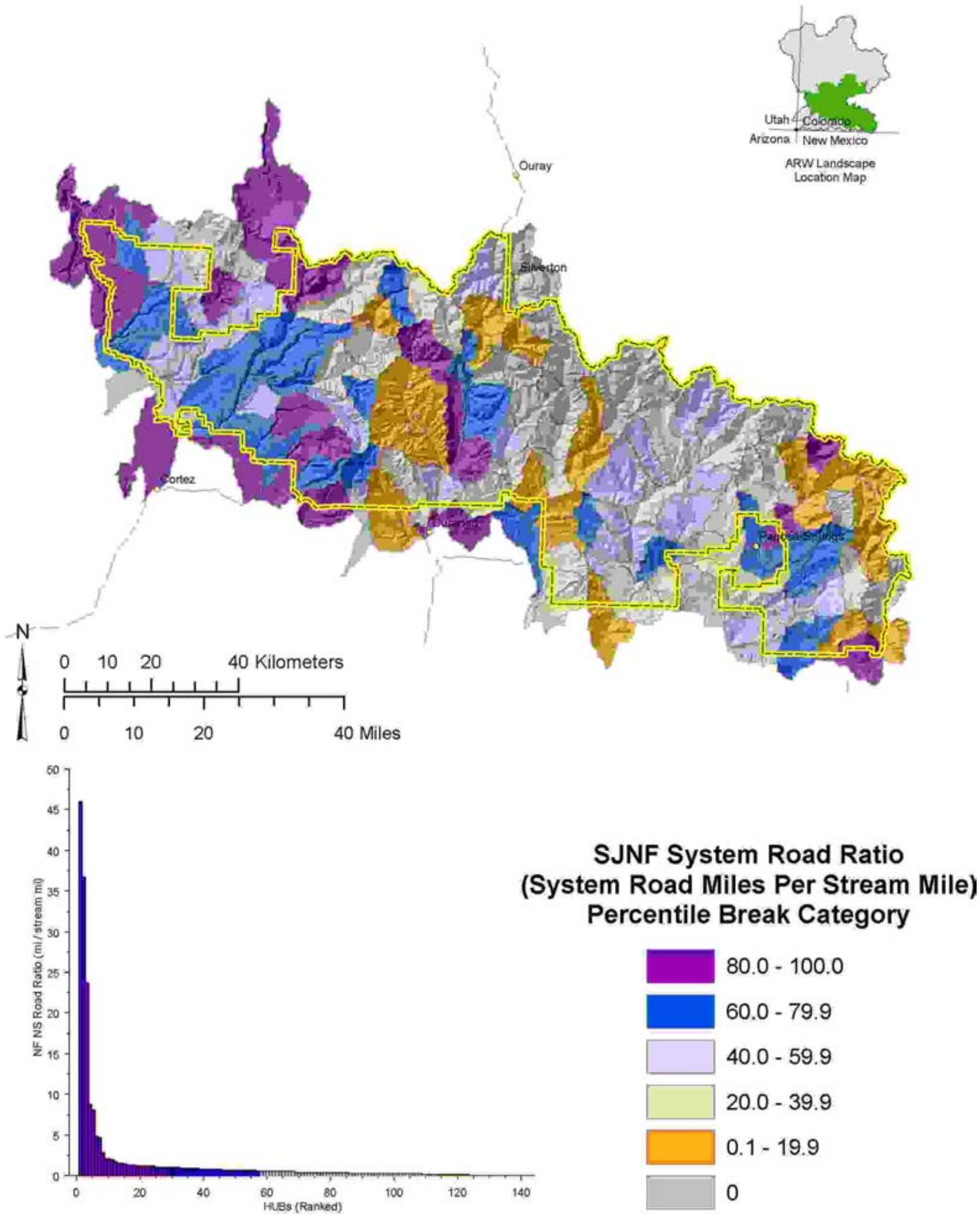

Figure 3.5 Ranks and Distribution of System Road Ratios by HUB, San Juan National Forest

Table 3.5 Rank and Distribution of System Road Ratios by HUB, San Juan National Forest, Watersheds highlighted in green are located entirely on the San Juan National Forest.

6th Level HUB	6th Level HUB Name	NF System Road Ratio (mi / stream mi)
140801040901	Lower Florida River-Ticalotte	122.9
140300020510	Upper Disappointment Valley	35.7
140801070105	East Fork of Mud Creek	27.0
140802020103	Hartman Canyon	4.8
140801040604	Animas River-Spring Creek	4.2
140300020605	Dolores Canyon-Joe Davis Hill	3.3
140300020511	Disappointment Valley-Wild Horse Reservoir	2.8
140300036101	Naturita Creek	2.7
140801070103	Upper Mancos Valley	2.6
140801040402	East Fork Hermosa Creek	1.7
140300020405	Lower Lost Canyon	1.7
140802020106	Lower Alkali Canyon-Narraguinnep Canyon	1.3
140801010203	Wolf Creek	1.2
140801010504	Navajo River-Weisel Flat	1.1
140801040503	Upper Animas Valley-Stevens Creek	1.1
140300020509	Pine Arroyo	1.1
140300020502	Disappointment Creek Headwaters	1.1
140300020401	Upper Lost Canyon	1.0
140300020102	Fish Creek	1.0
140801040401	Hermosa Creek headwaters	1.0
140801070102	West Mancos River	1.0
140801050105	Upper Cherry Creek	0.9
140300020604	Dolores Canyon-Lake Canyon	0.9
140300020104	Groundhog Creek	0.9
140300020302	Upper Plateau Creek	0.9
140801010304	Upper Pagosa Springs	0.9
140801040502	Elbert Creek	0.9

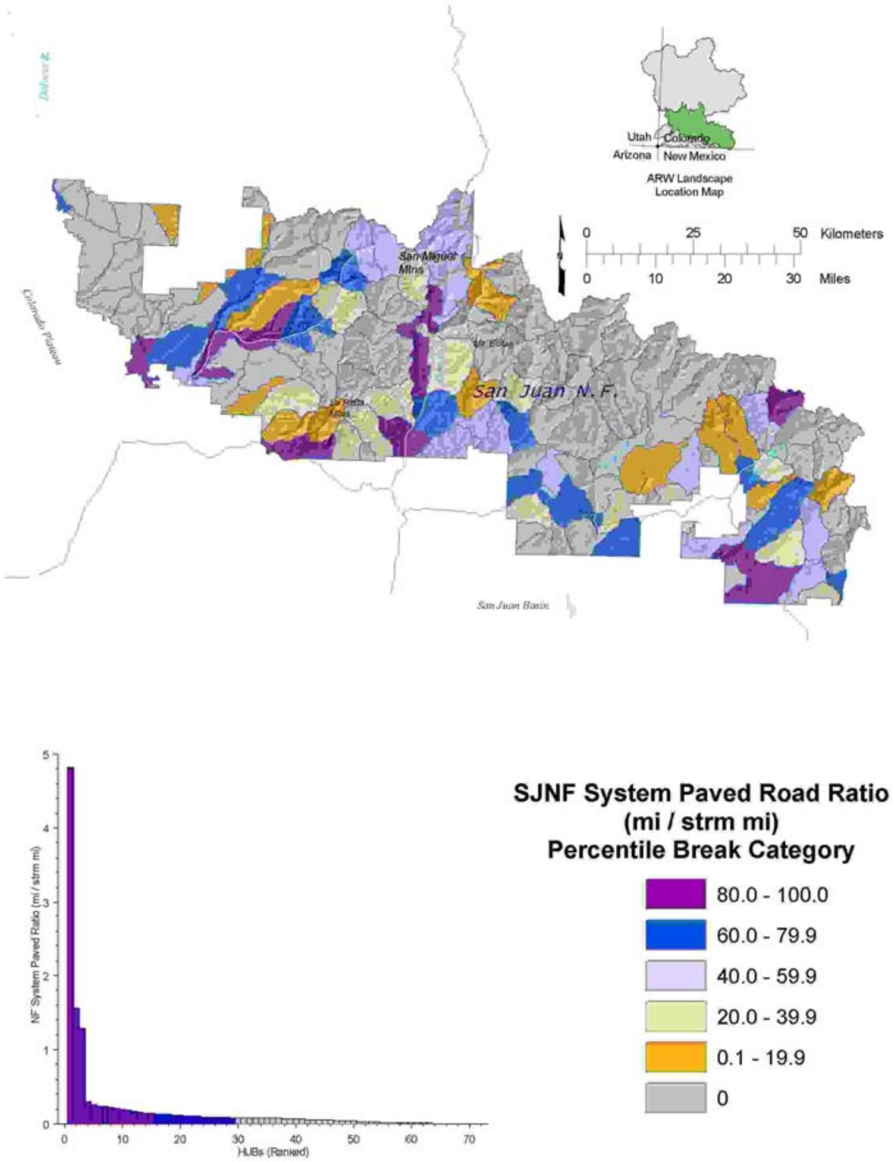

Figure 3.6 Rank and distribution Paved System Road Ratios within the San Juan National Forest, management scale.

Table 3.6 Summary of Paved System Road Crossing Ratios within the 100-80 percentile range, management scale, San Juan National Forest. Watersheds highlighted in green are located entirely on the San Juan National Forest.

6th Level HUB	6th Level HUB Name	NF System Paved Ratio (mi / stream mi)
140802020103	Hartman Canyon	4.8
140801070103	Upper Mancos Valley	1.6
140802020106	Lower Alkali Canyon-Narraguinnep Canyon	1.3
140801040504	Upper Animas Valley-Trimble	0.3
140801010203	Wolf Creek	0.3
140801010602	Montezuma Creek	0.2
140801040502	Elbert Creek	0.2
140801050105	Upper Cherry Creek	0.2
140801050102	Mayday Valley	0.2
140300020408	McPhee Reservoir-Dolores River	0.2
140801040303	Lower Cascade Creek	0.2
140300020404	Stapleton Valley	0.2
140801010507	Coyote Creek	0.2
140300020209	Upper Dolores River-Taylor Creek	0.1
140801010406	Lower Rio Blanco-San Juan River	0.1

Although all road crossings have the potential to impact water quality and affect channel morphology, the risk of impact is greater with unpaved crossings. Unpaved roads can either be naturally surfaced or surfaced with aggregate. Both are more susceptible to surface erosion and runoff than paved roads (Clinton and Vose, 2003).

Unpaved system road ratios are displayed in Figures 3.7 and Table 3.7. 26 out of 154 HUBS' are within the 100-80 percentile range. Eight of the 26 HUBs are located completely within the Forest boundary. These eight HUBs are highlighted in light green in Table 3.7. Unpaved road ratios, for watersheds located entirely within the Forest, range from a high of 1.7 crossings per stream mile in the East Fork Hermosa Creek watershed (HUB 140801040402) to a low of 0.9 crossings per stream mile in the Roaring Fork Creek watershed (HUB 140300020205). Watersheds within this group are at higher risk of road-related watershed impacts.

The Lower Florida-Ticalotte, Upper Disappointment Valley, and East Fork of Mud Creek watersheds have especially high number of unpaved road ratios. These three watersheds have only very small portions of their watershed area within the Forest boundary with a high number of road miles in these areas. To more fully asses the potential for road-related impacts additional data outside of the Forest would have to be obtained.

Results of this data analysis would be useful for identifying watershed improvement needs, habitat restoration projects, or for fisheries stocking projects.

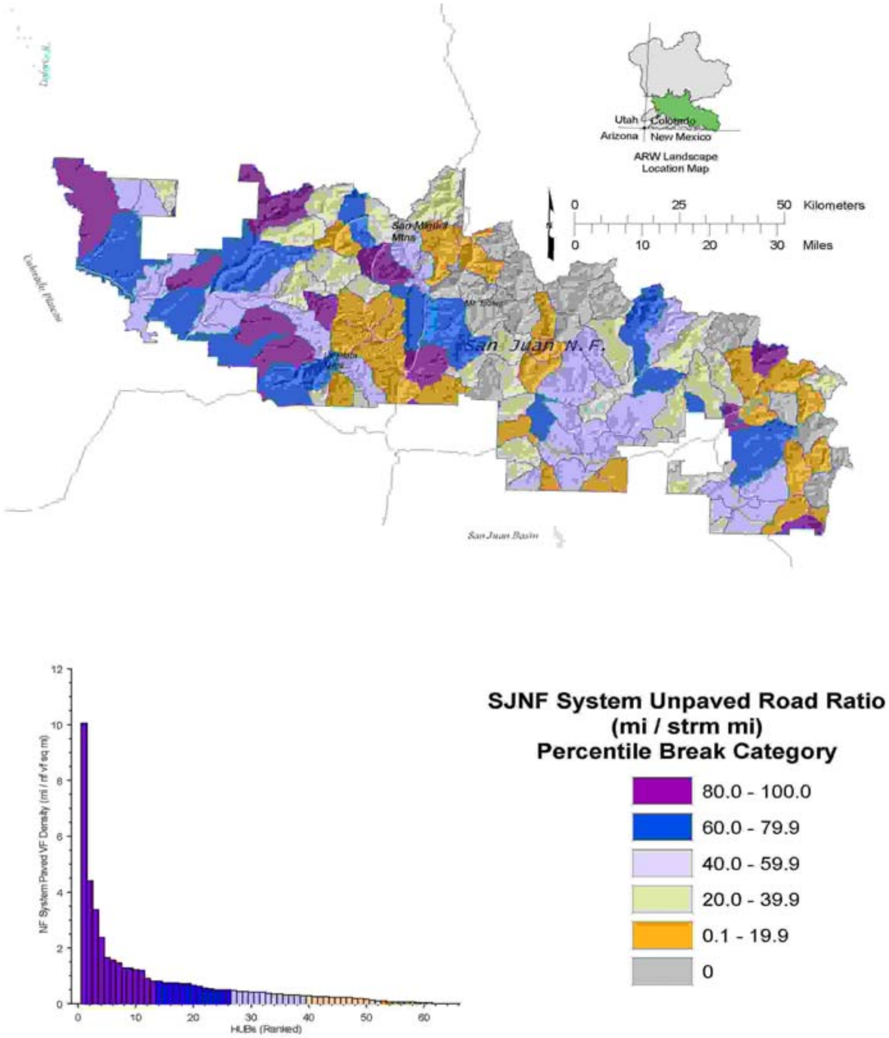

Figure 3.7 Rank and distribution of Unpaved System Road Ratios within the San Juan National Forest, management scale.

Table 3.7 Summary of Unpaved System Road Ratios within the 100-80 Percentile Range, management scale, San Juan National Forest. Watersheds highlighted in green are located entirely on the San Juan National Forest

6th Level HUB	6th Level HUB Name	NF System Unpaved Ratio (mi / stream mile)*
140801040901	Lower Florida River-Ticalotte	122.9
140300020510	Upper Disappointment Valley	35.7
140801070105	East Fork of Mud Creek	27.0
140801040604	Animas River-Spring Creek	4.2
140300020605	Dolores Canyon-Joe Davis Hill	3.2
140300020511	Disappointment Valley-Wild Horse Reservoir	2.8
140300036101	Naturita Creek	2.7
140801040402	East Fork Hermosa Creek	1.7
140300020405	Lower Lost Canyon	1.7
140300020509	Pine Arroyo	1.1
140801010504	Navajo River-Weisel Flat	1.1
140300020502	Disappointment Creek Headwaters	1.1
140300020401	Upper Lost Canyon	1.0
140300020102	Fish Creek	1.0
140801070103	Upper Mancos Valley	1.0
140801040401	Hermosa Creek headwaters	1.0
140801010203	Wolf Creek	1.0
140801040503	Upper Animas Valley-Stevens Creek	1.0
140801070102	West Mancos River	0.9
140300020604	Dolores Canyon-Lake Canyon	0.9
140300020104	Groundhog Creek	0.9
140300020302	Upper Plateau Creek	0.9
140300020305	Beaver Creek-Trail Canyon	0.9
140300020507	Dawson Draw	0.9
140300020205	Roaring Forks Creek	0.9
140801010304	Upper Pagosa Springs	0.8

* All ratios calculated using ArcGIS. Numbers may not be statistically significant. All numbers rounded to the nearest 10^{th} of a unit.

Roads related impacts to streams are not restricted to where roads parallel streams. Roads can also impact streams where crossings exist. Road crossings were also analyzed as road use, construction, and maintenance can degrade channel morphology and integrity, especially at stream crossings (Waters, 1995), Hagans, et al, and Heede 1980). Alterations may include modification of channel geometry at the road/stream intersection, compaction of the substrate, and/or changing substrate size distribution. Other channel morphological features may also be affected such as pool depth, modification of change longitudinal profile, and modification or loss of spawning habitat (USDA Forest Service, 2003).

The number of paved road stream crossings per stream mile is displayed in Figure 3.8 and Table 3.8.

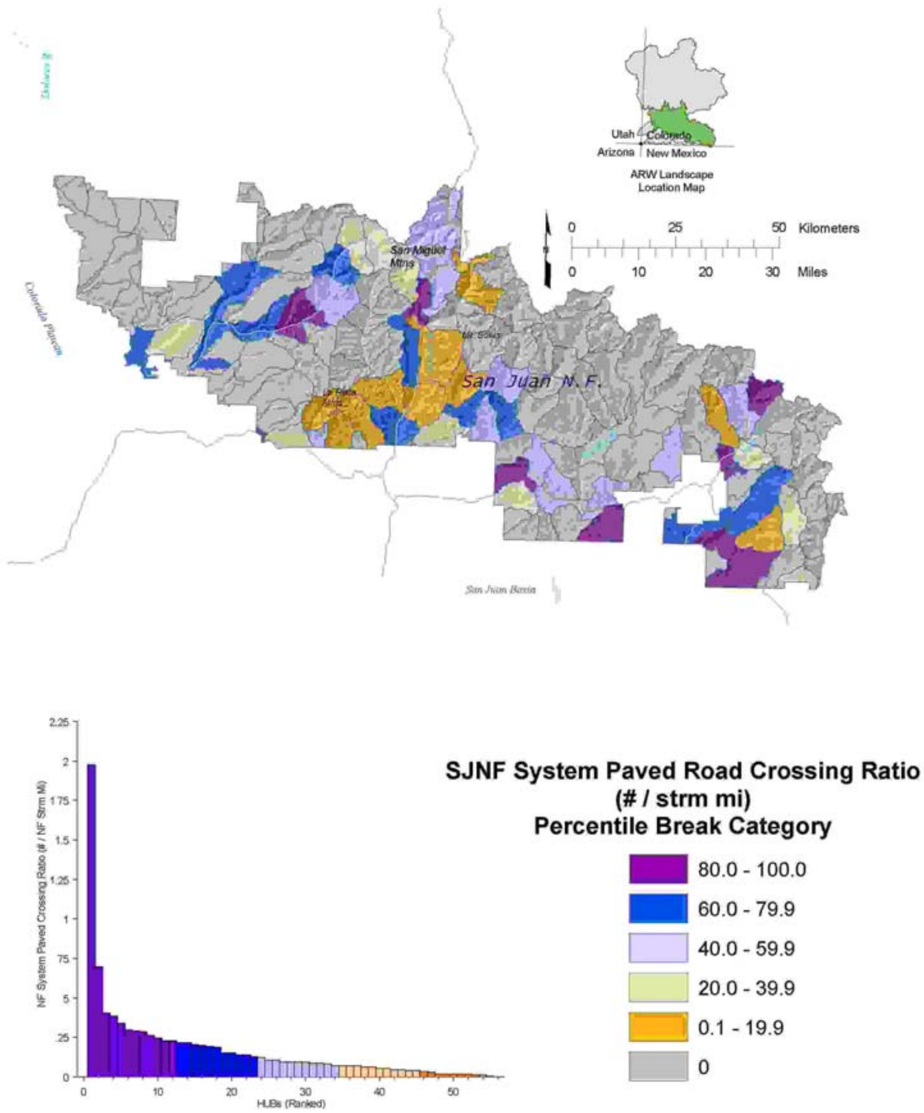

Figure 3.8 Rank and distribution of paved system road stream crossings, management scale, San Juan National Forest.

Table 3.8 Summary of paved system road stream crossing ratios within the 100-80 percentile range, management scale, San Juan National Forest. Watersheds highlighted in green are located entirely on the San Juan National Forest.

6th Level HUB	6th Level HUB Name	NF System Paved Crossing Ratio (# / NF Stream Mi)	HUB Drainage Density (mi/sq.mile)
140802020106	Lower Alkali Canyon-Narraguinnep Canyon	2.0	3.3
140801070103	Upper Mancos Valley	0.7	2.6
140801010203	Wolf Creek	0.4	1.7
140801010406	Lower Rio Blanco-San Juan River	0.4	2.8
140801040303	Lower Cascade Creek	0.3	2.7
140801010507	Coyote Creek	0.3	2.0
140801020405	Lower Stollsteimer Creek	0.3	3.3
140801011602	Middle Beaver Creek	0.3	3.3
140300020207	Dolores River-Priest Gulch	0.3	2.4
140801010602	Montezuma Creek	0.2	2.0
140801010304	Upper Pagosa Springs	0.2	2.8
140801020404	Middle Stollsteimer Creek	0.2	3.5

*All ratios calculated using ArcGIS. Numbers may not be statistically significant. Numbers are rounded to the nearest tenth of a unit.

12 HUBs were found to have paved system road crossing ratios within the 100-80 percentile range (Table 3.8). Ratio values range from a high of 2.0 in the Lower Alkali Canyon-Narraguinepp Canyon watershed (HUB # 140802020106) to a low of 0.2 in the Middle Stollsteimer Creek watershed (HUB# 140801020404). As in the other tables of this report, watersheds highlighted in green are within Forest boundaries. Watersheds which are not highlighted only have a portion of their area within the Forest boundary.

Lower Alkali Canyon-Narraguinepp Canyon watershed has only a very small portion of its area within the Forest boundary. In addition, the watershed has a relatively high drainage density. The combination of these two factors results in the artificially high number of stream crossings.

Figure 3.8 displays the watershed rankings and the location where the watersheds occur. Most of the watersheds within the 100-80 percentile range are found in the southeastern most portion of the Forest. Drainage densities within the 100-80 percentile groups vary from a high of 3.5 in the Middle Stollsteimer Creek watershed (HUB 140801020404) to a low of 2.0 in the Montezuma Creek watershed (HUB 140801010602) and in Coyote Creek (HUB 140801010507).

Unpaved road ratio crossings were also calculated. Unpaved roads produce higher amounts of sediment compared to paved roads, especially if they are not constructed or maintained properly (Clinton and Vose, 2003). The results of this metric analysis are displayed in Figure 3.9 and Table 3.9. Those watersheds located entirely on the Forest are highlighted in light green.

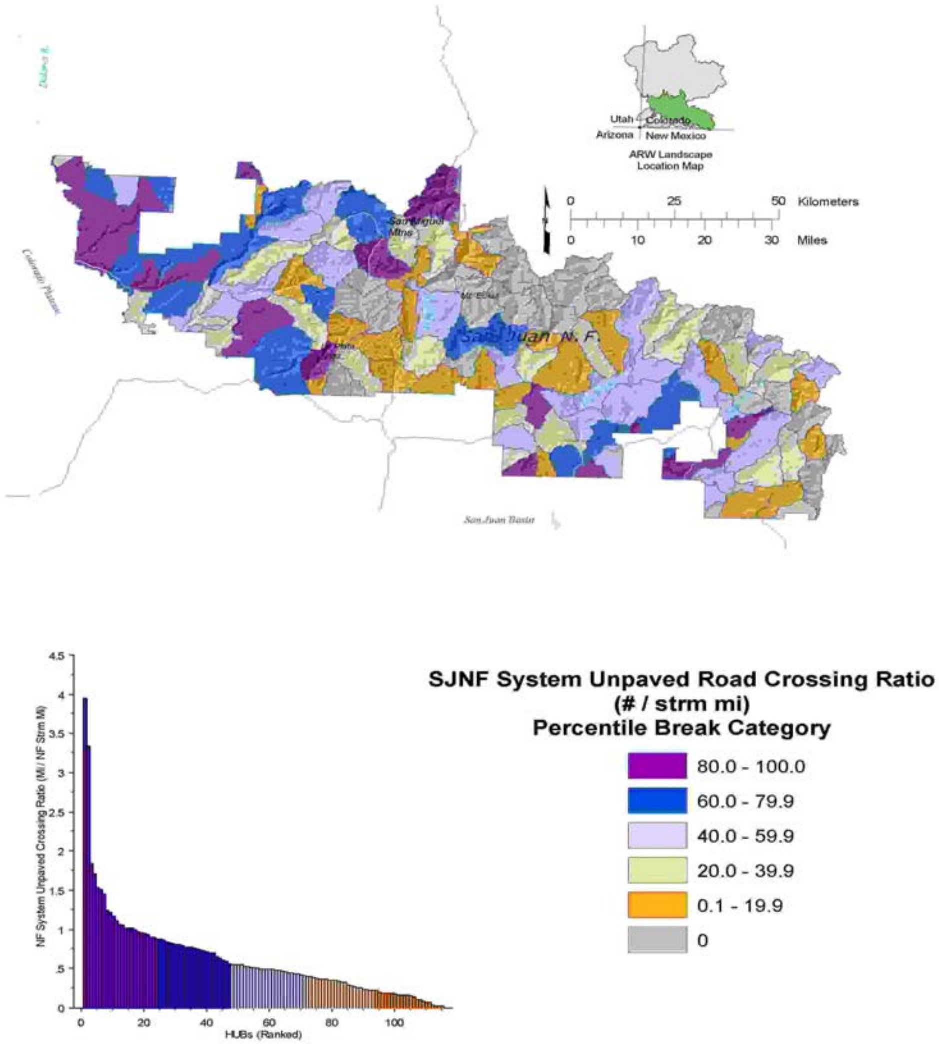

Figure 3.9 Rank and distribution of unpaved system road stream crossings, management scale, San Juan National Forest.

Table 3.9 Summary of unpaved system road stream crossing ratios within the 100-80 percentile range, management scale, San Juan National Forest. Watersheds highlighted in green are located entirely on the San Juan National Forest.

6th Level HUB	6th Level HUB Name	Unpaved System Road Crossing Ratio (# / Stream mile)	HUB Drainage Density (mi/sq.mile)
140802020106	Lower Alkali Canyon-Narraguinepp Canyon	3.9	3.3
140300020405	Lower Lost Canyon	3.3	3.0
140300020605	Dolores Canyon-Joe Davis Hill	1.8	1.8
140801040402	East Fork Hermosa Creek	1.7	2.3
140300020401	Upper Lost Canyon	1.5	2.3
140801020403	Stollsteimer Creek-Dyke Valley	1.5	2.7
140801040401	Hermosa Creek headwaters	1.5	2.7
140300020604	Dolores Canyon-Lake Canyon	1.2	2.2
140801010308	San Juan River-Eightmile Mesa	1.2	2.9
140801020405	Lower Stollsteimer Creek	1.2	3.3
140300020509	Pine Arroyo	1.1	2.5
140801011704	Upper Spring Creek	1.1	2.8
140801040103	Mineral Creek	1.1	2.2
140801010306	Mill Creek	1.0	3.1
140300020504	Ryman Creek	1.0	3.2
140300020502	Disappointment Creek Headwaters	1.0	2.1
140300020602	Narraguinepp Canyon Natural Area	1.0	2.2
140801011601	Upper Beaver Creek	1.0	2.7
140300020306	McPhee Reservoir-Beaver Creek Inlet	1.0	2.3
140801070104	Chicken Creek	0.9	2.6
140300020603	Dolores Canyon-Cabin Creek	0.9	2.0
140300036101	Naturita Creek	0.9	1.8
140801050101	La Plata River headwaters	0.9	2.3
140300020305	Beaver Creek-Trail Canyon	0.9	2.1

*All ratios calculated using ArcGIS. Numbers are rounded to the nearest tenth of a unit.

24 HUBs were found to be within the 100-80 percentile range for unpaved system road crossings. This is twice the number of paved road crossings within the same percentile range. Unpaved road crossing ratios vary from a high of 3.9 in the Lower Alkali Canyon-Narraguinepp Canyon watershed (HUB #140802020106) to a low of 0.9 in the Beaver Creek-Trail Canyon watershed (HUB# 140300020305). However, Lower Alkali Canyon-Narraguinepp Canyon and Lower Lost Creek Canyon watersheds have only 0.4% and 2% of their respective areas within Forest boundaries. As a result, it is likely there are minimal effects related to unpaved road crossings on-Forest aquatic resources in these watersheds. For the other un-highlighted watersheds the potential for on-Forest influence is a function of what percent of the watershed is located on the Forest.

Watersheds located entirely within the Forest include the East Fork Hermosa Creek, Upper Lost Canyon, Upper Beaver Creek, McPhee Reservoir-Beaver Creek Inlet, La Plata River headwaters, and Beaver Creek-Trail Canyon (Table 3.9). For these watersheds the unpaved road ratios vary from 1.7 in the East Fork Hermosa Creek watershed to a low of 0.9 in the Beaver Creek-Trail Canyon watersheds.

As these watersheds are within the 100-80 percentile range there is the potential for aquatic resources to be influenced by unpaved road stream crossings. However, the East Fork Hermosa Creek and Beaver Creek-Trail Canyon watersheds appear to have the most potential for influence as their ratios are 50-70% higher than the other four watersheds. The higher drainage densities and increased number of stream crossings may reflect the influence of the HUBs bedrock geology.

Influence of Non-System Roads

As mentioned earlier non-system roads are either roads which are no longer required for management purposes or they are roads which have been created by off road vehicle use (ORV's). Roads no longer used for management purposes are typically "put to bed" using Best Management Practices (BMPs) to help stabilize the road bed, reducing or preventing erosion and sedimentation. However indiscriminant ORV use is known to be a major source for creating new non-system roads. These ORV created roads have been shown to cause extensive environmental impacts.

Initial disturbance is generated when an ORV trail is first generated. However, with proper placement and the implementation of BMPs, effects to aquatic resources may be prevented or limited to acceptable levels. However, when ORV's are ridden indiscriminately across the landscape, including riparian areas and streams, unrestricted ORV use contributes to a wide range of adverse impacts due to soil, hydrologic, and vegetation disturbance.

Disturbance can result in reduced species diversity as well as trophic interaction. Impacts may occur throughout the year depending on habitat uses. Channel morphology is degraded as vehicles drive across streams, increasing erosion and sedimentation, as well as physically altering channel bed morphology and aquatic habitat. With increased erosion and sedimentation both water quality and aquatic habitat can be affected. As streams are crossed riparian and wetland vegetation is disturbed and function disrupted. Soils are also affected due to loss of vegetation, erosion and/or compaction. ORV use is also known to affect wildlife as well as air pollution http://www.sdafs.org/tcafs/content/orvpol.htm.

Because the impacts of ORV use can be so considerable, metrics were also calculated on available non-system road data. Available data indicates that there is approximately 3,549 miles of non-system road on the Forest with 868 of those miles occurring in valley bottoms. These totals may be high due to some data quality concerns (see Information Needs section). However, as the total non-system road number is an order of magnitude higher than what is shown for paved roads it is assumed that non-system roads represent a substantial watershed and aquatic resources health concern.

Due to the data quality concerns regarding non-system roads it is recommended that the following metric results be treated as estimates.

Table 3.10 summarizes non-system road density by HUB and their rank and distribution is shown in Figure 3.10. These watersheds occur mainly in the western half and south central portions of the Forest, in association with nearby towns, reservoirs, or recreational areas.

29 watersheds occur within the 100-80 percentile range. Watersheds highlighted in light green in Table 3.9 are within Forest boundaries. Road data is not available at this time beyond the Forest boundary. As a result non-system road densities in un-highlighted watersheds are a function of the amount of non-system road relative to the portion of the watershed within the Forest boundary. For example, Naturita Creek (HUB 140300036101) and Dolores Canyon-Joe Davis Hill (HUB 140300020605), which have the highest road densities in Table 3.9, have 3% and 7% of their watersheds, respectively, within the Forest's boundary. Calf Creek, which has the lowest density, has 40% of its area within the Forest with approximately 18.4 miles of non-system road within the watershed.

Table 3.10 Summary of Non-system road density by HUB, management scale, San Juan National Forest. Watersheds highlighted in green are located entirely on the San Juan National Forest

6th Level HUB	6th Level HUB Name	Non-system Road Density (mi / sq mi)
140300036101	Naturita Creek	6.4
140300020605	Dolores Canyon-Joe Davis Hill	6.1
140801070105	East Fork of Mud Creek	4.9
140300020511	Disappointment Valley-Wild Horse Reservoir	4.2
140300020604	Dolores Canyon-Lake Canyon	4.0
140300020401	Upper Lost Canyon	3.8
140802020201	Upper Yellowjacket Canyon	3.8
140801011503	Los Pinos River-Bayfield	3.7
140300020402	Spruce Water Canyon	3.7
140802020106	Lower Alkali Canyon-Narraguinnep Canyon	3.4
140300020407	House Creek	3.2
140300020406	Upper Dolores River-Italian Creek	3.2
140300020509	Pine Arroyo	3.1
140300020507	Dawson Draw	2.8
140801070101	East Mancos River-Middle Mancos River	2.8
140300020603	Dolores Canyon-Cabin Creek	2.7
140300020304	Lower Plateau Creek	2.7
140801010503	Navajo Peak	2.6
140300020510	Upper Disappointment Valley	2.6
140801020402	Upper Stollsteimer Creek	2.6
140300020405	Lower Lost Canyon	2.6
140801011501	Middle Los Pinos River-Red Creek	2.6
140801020104	Piedra River-O'Neal Creek	2.6
140801011601	Upper Beaver Creek	2.6
140801020401	Martinez Creek-Dutton Creek	2.5
140801010307	Echo Canyon Reservoir	2.4
140300020205	Roaring Forks Creek	2.3
140801040402	East Fork Hermosa Creek	2.2
140300020303	Calf Creek	2.2

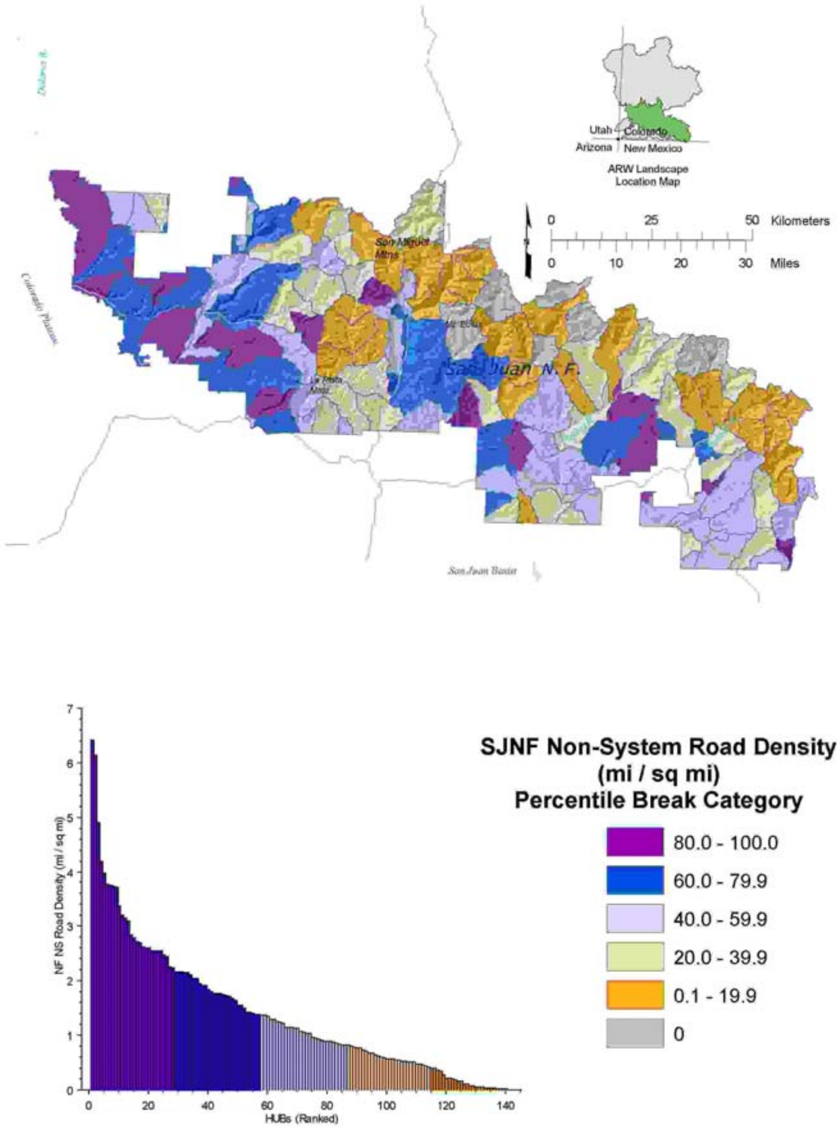

Figure 3.10 The rank and distribution of non-system road densities, management scale, San Juan National Forest.

The ratio of miles of non-system road per stream mile was also calculated to help evaluate the overall potential influences of non-system roads. 29 HUBs were found to be within the 100-80 percentile range for this metric Table 3.11. Watersheds shown in highlighted in light green are located entirely within Forest boundaries. The majority of these HUBS are located within western most quarter of the Forest (Figure 3.11).

According to the San Juan National Forest maps travel management designations the majority of these HUBs are designated as travel areas "F", or open to year round to passenger car, 4 wheel drive, all terrain vehicles, motorcycles or snowmobile use. Minor components of lands involved in Area "A" and B are also involved. Area "A" means closed year round to all types of traffic for erosion control and due to conflicts of interest. Areas included under designation "B" have the same travel restrictions except for snowmobiles and for the same reason. Watersheds falling within this 100-80% range can approximately be related to the following areas in a west to east direction: Glade Canyon south to Lone Dome State Recreation and Wildlife area, Hinchman Reservoir south to House Creek recreation area, Lost Canyon and Hay Camp Mesa areas, Little Fish Creek and Fish Creek Trail, and Taylor Mesa and the area immediately to the northwest. Upper Disappointment Valley (HUB 140300020510), lower Florida River-Ticalotte (HUB 140801040901), East Fork of Mud Creek (HUB 1401070105), Dolores Canyon-Joe David Hill (HUB 140300036101), Naturita Creek (14030036101) have ratios that are almost two to six times higher than all the other watersheds in Table 3.11. These high ratios are due to amount of non-system road relative to the amount of watershed within Forest boundaries. These watersheds only have 1-7% of their area within the Forest's boundary.

Ratios for watersheds located entirely on-Forest range from a high of 1.6 for Upper Lost Canyon (HUB 140300020401) to a low of 1.0 for Stoner Creek (HUB 140300020602) and Piedra River-O'Neal Creek (HUB 140801020104).

As with system roads, the densities of non-system roads in valley floor areas were also analyzed. This metric provides a more focused evaluation of which watersheds have the highest risk potential for non-system road impacts on aquatic and riparian resources. Figure 3.12 and Table 3.12 summarizes the analysis results for this metric. Watersheds within the 100-80 percentile range for this metric are found primarily in the western and southern portions of the Forest. They appear to be correlated to the Glade Canyon to Lone Dome State Recreation and Wildlife area, House Creek recreation area, Lost Canyon and Hay Camp Mesa areas, Fish Creek and Taylor Mesa areas, Lemon Creek Reservoir and south of Vallecito Reservoir areas, Hatcher Reservoir and Eightmile Mesa areas.

Lower Lost Canyon (HUB 140300020405), Naturita Creek (14030036101), Dolores Canyon-Joe David Hill (HUB 140300036101), have the highest non-system road densities as they only have 2-7% of their watershed area within the Forest (Table 3.12). As a result, on-Forest effects related to non-system roads are minimal in these watersheds. Watersheds located entirely on-Forest have valley floor densities ranging from 5.9-3.1. All six watersheds have the potential for on-Forest effects as they fall within the 100-80 percentile range. However, Upper Lost Canyon, Spruce Water Canyon, and Upper Beaver Creek watersheds have the highest potential for contributing effects to downstream aquatic and riparian resources, as they are nearest to the southern border of the Forest.

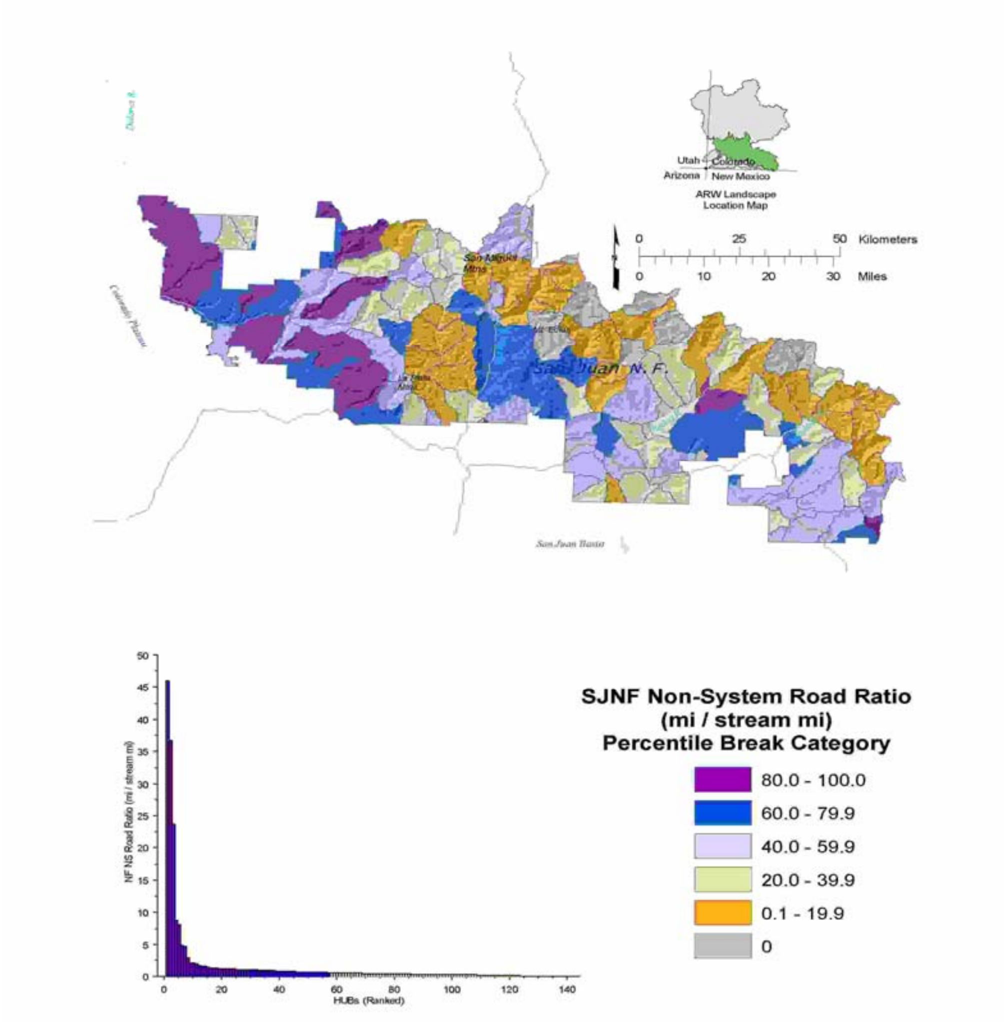

Figure 3.11 Rank and distribution of non-system road ratios within the San Juan National Forest, management scale.

Table 3.11 Summary of watersheds within the 100-80 percentile range of non-system road ratios. Watersheds highlighted in green are located entirely on the San Juan National Forest.

6th Level HUB	6th Level HUB Name	NF NS Road Ratio (mi / stream mi)
140300020510	Upper Disappointment Valley	46.0
140801040901	Lower Florida River-Ticalotte	36.7
140801070105	East Fork of Mud Creek	23.6
140300020605	Dolores Canyon-Joe Davis Hill	8.8
140300036101	Naturita Creek	8.0
140300020511	Disappointment Valley-Wild Horse Reservoir	4.8
140801011503	Los Pinos River-Bayfield	4.7
140300020405	Lower Lost Canyon	2.9
140802020201	Upper Yellowjacket Canyon	2.1
140300020604	Dolores Canyon-Lake Canyon	2.1
140802020103	Hartman Canyon	1.9
140300020401	Upper Lost Canyon	1.6
140802020106	Lower Alkali Canyon-Narraguinepp Canyon	1.6
140300020402	Spruce Water Canyon	1.5
140300020509	Pine Arroyo	1.4
140300020407	House Creek	1.3
140300020102	Fish Creek	1.3
140801010503	Navajo Peak	1.3
140300020304	Lower Plateau Creek	1.2
140300020603	Dolores Canyon-Cabin Creek	1.2
140300020406	Upper Dolores River-Italian Creek	1.2
140801070103	Upper Mancos Valley	1.2
140300020502	Disappointment Creek Headwaters	1.2
140300020507	Dawson Draw	1.2
140801070102	West Mancos River	1.1
140801070101	East Mancos River-Middle Mancos River	1.0
140300020208	Stoner Creek	1.0
140300020602	Narraguinnep Canyon Natural Area	1.0
140801020104	Piedra River-O'Neal Creek	1.0

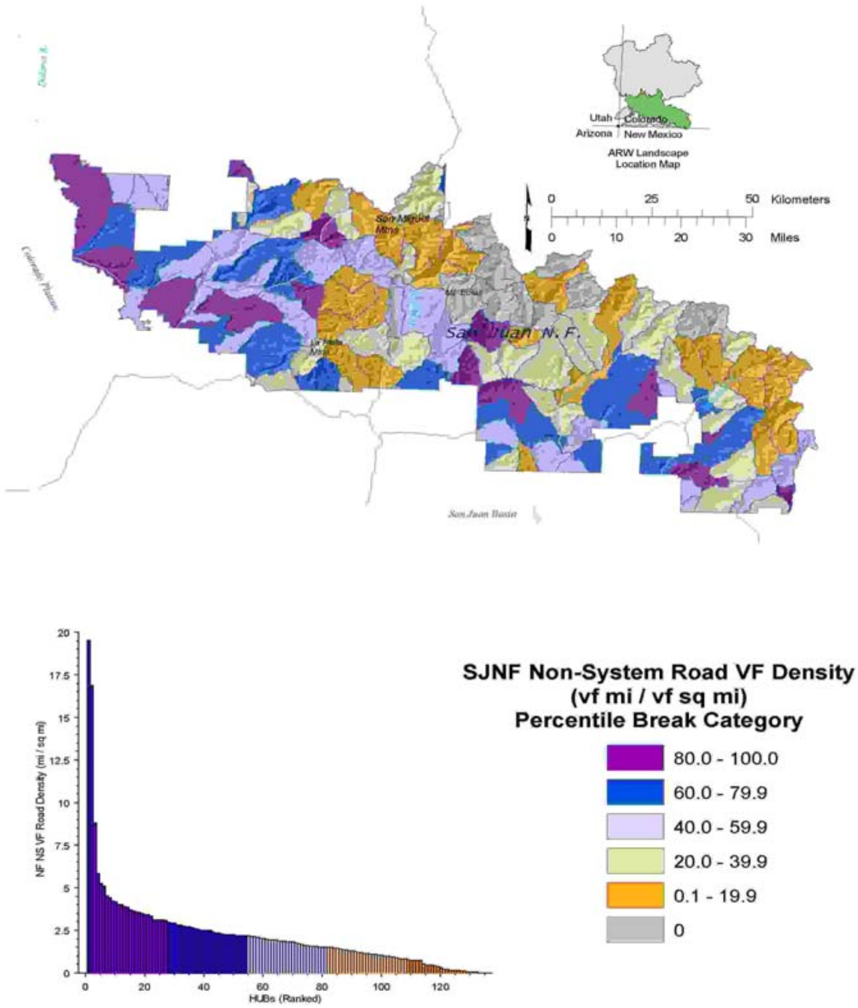

Figure 3.12 The rank and distribution of non-system valley floor road densities, management scale, San Juan National Forest.

Table 3.12 Summary of HUBs within the 100-80 percentile range for non-system road valley floor densities, management scale, San Juan National Forest. Watersheds highlighted in green are located entirely on the San Juan National Forest.

6th Level HUB	6th Level HUB Name	NF NS VF Road Density (mi / sq mi)
140300020405	Lower Lost Canyon	19.5
140300036101	Naturita Creek	16.9
140300020605	Dolores Canyon-Joe Davis Hill	8.8
140801011403	Lower Vallecito Creek	5.9
140801011501	Middle Los Pinos River-Red Creek	5.3
140300020604	Dolores Canyon-Lake Canyon	5.1
140300020509	Pine Arroyo	4.5
140801010307	Echo Canyon Reservoir	4.4
140300020511	Disappointment Valley-Wild Horse Reservoir	4.2
140300020401	Upper Lost Canyon	4.2
140802020103	Hartman Canyon	4.0
140801010406	Lower Rio Blanco-San Juan River	4.0
140300020402	Spruce Water Canyon	3.9
140300020601	Dolores River-Salter Canyon	3.8
140801020401	Martinez Creek-Dutton Creek	3.7
140801070105	East Fork of Mud Creek	3.6
140300020603	Dolores Canyon-Cabin Creek	3.6
140300020507	Dawson Draw	3.5
140300020407	House Creek	3.5
140300020502	Disappointment Creek Headwaters	3.4
140300020205	Roaring Forks Creek	3.4
140300020406	Upper Dolores River-Italian Creek	3.3
140801011601	Upper Beaver Creek	3.1
140300020203	Rico Valley	3.1
140801010503	Navajo Peak	3.1
140802020201	Upper Yellowjacket Canyon	3.1
140801011502	Bear Creek	3.1

25 HUBs were found to have the highest potential for stream crossing related effects. As mentioned earlier, Naturita Creek, Lower Lost Canyon, and Dolores Canyon-Joe Davis Hill watersheds have only a small percentage of their area within the forest. As a result, the number of calculated stream crossings in the watershed is disproportionate to watershed size. The four watersheds, highlighted in light green in Table 3.13, are all found within the Forest's boundary. As all four watersheds are within the 100-80 percentile range there is a high potential that non-system road crossings are influencing aquatic and riparian health on the Forest. However, Lemon Reservoir watershed (HUB 140801040803) is the most likely to influence downstream conditions, as it is the closest to the Forest's border.

These 25 watersheds are found mainly in the western, south-central, and south east portions of the Forest.

They appear to be correlated to the following areas: Glade Canyon south to Lone Dome State Recreation and Wildlife area, the Ferris Canyon north to Crooked Reservoir, House Creek Recreation Area, and area of old rail grade, Spruce Lake, Lost Canyon, Hay Camp Mesa, Durango Mountain Resort in the East Fork Hermosa Creek Drainage, Lemon Reservoir and south of Vallecito Reservoir, Hatcher Reservoir, and Eightmile Mesa.

Although the majority of these areas have a travel designation of "F", there are areas where travel designations of "A", "E", and "B" appear to be involved. This indicates that travel closures are not being enforced or observed.

Table 3.13 Summary of non-system road crossings by HUB within the 100-80 percentile range, management scale, San Juan National Forest. Watersheds highlighted in green are located entirely on the San Juan National Forest.

6th Level HUB	6th Level HUB Name	Non-System Road Crossing Ratio (# / stream mi)
140300036101	Naturita Creek	8.6
140300020405	Lower Lost Canyon	3.3
140300020605	Dolores Canyon-Joe Davis Hill	3.3
140300020604	Dolores Canyon-Lake Canyon	2.0
140801010307	Echo Canyon Reservoir	2.0
140801011501	Middle Los Pinos River-Red Creek	1.8
140801040803	Lemon Reservoir	1.5
140801040102	Cement Creek	1.5
140801010406	Lower Rio Blanco-San Juan River	1.4
140300020507	Dawson Draw	1.4
140300020407	House Creek	1.3
140300020601	Dolores River-Salter Canyon	1.3
140300020509	Pine Arroyo	1.3
140801020401	Martinez Creek-Dutton Creek	1.2
140300020502	Disappointment Creek Headwaters	1.2
140300020304	Lower Plateau Creek	1.2
140801011601	Upper Beaver Creek	1.2
140801040402	East Fork Hermosa Creek	1.2
140801011502	Bear Creek	1.2
140300020406	Upper Dolores River-Italian Creek	1.1
140801011403	Lower Vallecito Creek	1.1
140300020303	Calf Creek	1.0
140801070101	East Mancos River-Middle Mancos River	1.0
140801011602	Middle Beaver Creek	1.0
140300020401	Upper Lost Canyon	1.0

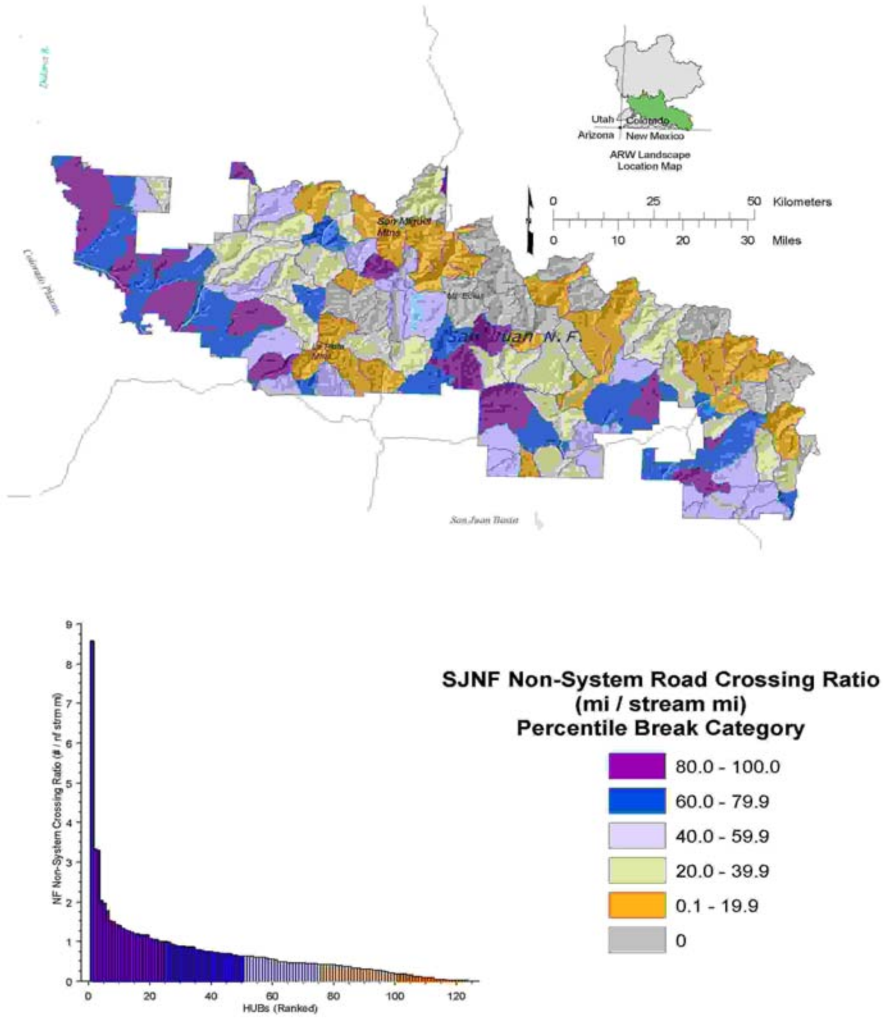

Figure 3.13 Rank and distribution of non-system stream crossings, management scale, San Juan National Forest.

6th Level HUB Information Needs

At present, there is no interdisciplinary comprehensive Forest roads analysis report. Completion of such a report would help identify areas where roads are contributing sediment and water to streams, help identify potential watershed improvement projects. It would also help identify areas to survey for aquatic impacts from roads.

In addition it would be helpful to collect and create an accurate GIS coverage for non-system roads beyond the Forest boundary

Current Forest plan road density standards are only related to wildlife not watershed concerns. Hydrological and hydrologically related resources would be better protected if aquatic based standards and guidelines for watershed road densities and stream crossings were developed. It is recommended that these be developed during the current Forest plan revision process.

Management Implications at the 6th HUB Level

Table 3.8 summarizes the cumulative road class score for all watersheds. However, it should be noted that these existing road densities will be modified when an alternative is selected and implemented for the Northern San Juan Basin Coalbed Methane Development project and other large development proposals. It is recommended that road densities be re-evaluated in the watersheds involved prior to planning additional land management activities.

The information and recommendations presented in subsequent paragraphs are taken from the Ecological Driver Analysis (Report 1 of 3) and the Synthesis (Report 3 of 3), in the 2006 San Juan Aquatic, Riparian, and Wetland Ecosystem Assessment. To obtain detailed information on the sensitivity of fisheries, riparian vegetation, aquatic productivity, and benthic macroinvertebrate responses changes in hydrology, sediment, thermal regime, nutrients, and biota for a proposed site specific or area specific project these reports should be referred to for more detailed data and interpretations.

27 watersheds, or 18% of the watersheds found on the San Juan National Forest, scored a cumulative road class score of "5", the highest possible rating. 20 of these watersheds are not located entirely on-Forest while seven of the watersheds are found entirely within the Forest's boundary (Table 3.28). The Upper Cherry Creek (HUB# 140801050105), Upper Animas Valley-Canyon Creek (HUB# 140801040501), Lower Lost Canyon (HUB# 140300020405), and the Upper Dolores River-Taylor Creek (HUB# 140300020209) watersheds all have the highest total transportation score of 12, out of a possible 15. All 27 watersheds have a high potential for exhibiting effects on aquatic, riparian, and wetland health due to roads, while the Upper Cherry Creek, Upper Animas Valley-Canyon Creek, Lower Lost Canyon, and the Upper Dolores River-Taylor Creek watersheds are even more likely to have impacts due to their cumulative transportation rank scores.

Riparian Clusters 1r, 2r, 4r, 5r, and 6r and wetland Clusters 1w, 2w, 3w, 4w, and 7w were associated with the watersheds receiving a score of "5", which is equated with the 100-80 percentile range. Riparian Clusters 4r and wetlands Cluster 3w were the most common clusters to occur in association with these watersheds.

Fisheries and riparian resources in riparian Clusters 1r, 2r, 4r, 5r, 6r, and 7r have a moderate to high sensitivity to fluctuations in both hydrology and sediment, however riparian vegetation is low in its sensitivity to changes in sediment compared to the other clusters. Fish, aquatic productivity, and benthic macroinvertebrates have variable sensitivity to thermal regime changes depending on which cluster is under consideration. Cluster 1r is among the most sensitive to changes in thermal regime aquatic productivity and benthic macroinvertebrates, as is Cluster 2r. The other clusters, 4r, 5r, 6r, and 7r which have low to moderate sensitivity to changes in thermal regime for aquatic productivity and macroinvertebrates. Sensitivities appear to be related to hydrologic/climatic regimes (San Juan Aquatics Reports 1 of 1 and 3 of 3).

Although wetlands Cluster 3w was the most common in its occurrence, 1w and 4w were also prevalent. Clusters 2w and 7w are each only associated with one watershed in the 100-80 percentile range. Clusters 1w, 3w, and 4w are all very sensitive to fluctuations in hydrology. However, Cluster 1w is moderately sensitive to sediment load alterations compared to Clusters 3w and 4w have been evaluated to be low in sediment sensitivity. Sensitivity to changes in hydrology are high for wetlands Cluster 2w and 7w, with sediment load changes having a high influence in wetlands Cluster 7w. Sediment load variations are categorized as having a moderate response in wetland Cluster 2w.

Specific recommendations are discussed below and are based upon the results of additive analysis and the ecological driver's analysis (San Juan Aquatics Reports 1 of 1 and 3 of 3) which has defined the characteristics of riparian and wetland clusters. Recommendations include:

- Out of the three activity categories under transportation, roads have the highest potential for influencing aquatic, riparian, and wetland health, due to alterations in sediment loads, water quality, and water quantity. With 27 watersheds within the 100-80 percentile range, site specific project planning needs to consider the percentile ranking for roads within that area, confirm what types of road activity is within the project area and if it is located in valley floor areas. In addition, the level of activity of other activity categories must be considered, especially those that influence hydrologic and sedimentologic modifications, such as vegetation management or developed recreation.
- Within the 27 watersheds in the 100-80 percentile range, riparian Clusters 4r and 5r were the most common, with Clusters 1r, 2r, and 6r being much less common. Lower Lost Canyon is the only watershed that scored a total transportation category score of 12 and did not have another activity category ranked within the 100-80 percentile range.
- The Upper Animas Valley-Canyon Creek also was ranked as within the 100-80 percentile range for vegetation management. The Upper Cherry Creek watershed was also ranked as within the 100-80 percentile range for urbanization. The Upper Dolores River-Taylor Creek watershed was also ranked as within the 100-80 percentile range for water uses. Vegetation management, urbanization, and water uses can alter hydrologic and sedimentologic regimes. Any future projects in these proposed watersheds must evaluate the potential for further impacts, or improvements to both sedimentologic and hydrologic regimes.
- With the very high potential for anthropogenic influences in the Upper Animas Valley-Canyon Creek watershed, mitigation efforts are recommended for any low gradient reaches within the watershed, as the importance of low gradient reaches for riparian vegetation and aquatic plans and animals is magnified. Wetland Cluster 2w has been rated as one of the highest for strategic wetland protection and management, as all watersheds containing this wetland are within the top 12 rankings for cumulative effects related to anthropogenic activities.
- As a result, proactive management to maintain the integrity of these wetlands should be emphasized when considering any future projects that may influence hydrologic and sedimentologic regimes relating to wetlands Cluster 3w, as should the high potential of these wetlands for restoration.
- Both the Upper Cherry Creek and Upper Dolores River-Taylor Creek watersheds are categorized as

containing riparian Cluster 5r. This riparian cluster is dominated by calcareous geology, making it one of the most productive for aquatic and riparian systems. As the overall potential for anthropogenic influence is high, these two watersheds should be considered candidates for mitigation measures.

- Upper Cherry Creek contains wetlands which are designated as 4w, which are mostly isolated and smaller in extent. Mitigation measures are recommended for a project by project basis to ensure the integrity of these wetlands, are maintained.
- The wetlands in Lower Lost Canyon and the Upper Dolores River-Taylor Creek watersheds are both classified as 3w. These wetlands are expected to be of less importance than those in other clusters. However, due to the relative rarity of these wetlands, and the high potential for influence by roading and water uses, restoration of individual wetlands should be considered important for improving the health and function of these wetlands.
- For any watershed receiving a cumulative road class score of "4" potential projects would verify the level of other activity categories, determine wetland and riparian class within the proposed project area, and discuss the potential for impacts in context of the wetland and riparian class's sensitivity to changes in hydrology, sediment, thermal regime, nutrients, and biota for fisheries, riparian vegetation, aquatic productivity, and benthic macroinvertebrates.

Direction for Reach/Site Scale Analysis

In order to identify specific influences from roads on aquatic, riparian, and wetland resources, analysis at the reach/site scale is critical.

It would be beneficial for aquatic, riparian, and wetland resource management if the San Juan National Forest continues its annual inspection of stream crossings and culverts. The information collected could be used to determine which crossings are performing as intended and which are in need of remediation.

Tables 3.14 through 3.16 provide direction for prioritization of watersheds for analysis at the reach or site level. These HUBs have been identified to have the highest risk of road-related impacts.

Table 3.14 lists watersheds with the highest total (paved and unpaved) system road miles. Table 3.15 is those HUBs listed based on unpaved road stream crossing ratios. Table 3.16 lists those HUBs which are at risk due to the amount of non-system road mile totals. The watersheds listed in this table are recommended for receiving the highest priority for more detailed analysis. HUBs listed in light green are located entirely within the Forest's boundaries.

The following questions should be considered for a reach/site scale analysis:

1. Are the crossings adequate to pass the design flow including associated debris?
2. Is the crossing appropriate for the expected traffic levels?
3. Is fish passage an issue? If so, is the crossing designed to allow unimpeded passage of aquatic organisms?
4. Are Best Management Practices adequate to prevent chronic inputs of sediment into the stream?
5. Are culverts being properly maintained on an annual basis?

Table 3.14 Watershed Prioritization List for Reach/Site scale analysis based on those watersheds within the 100-80 percentile ranges for total (paved and unpaved) Forest system road densities by HUB.

6th Level HUB	6th Level HUB Name	NF System Road Density (mi / sq mi)
140801070105	East Fork of Mud Creek	5.6
140801040402	East Fork Hermosa Creek	4.0
140802020103	Hartman Canyon	3.5
140802020106	Lower Alkali Canyon-Narraguinnep Canyon	2.7
140801040401	Hermosa Creek headwaters	2.7
140801010304	Upper Pagosa Springs	2.6
140801070103	Upper Mancos Valley	2.5
140300020509	Pine Arroyo	2.5
140300020511	Disappointment Valley-Wild Horse Reservoir	2.5
140300020401	Upper Lost Canyon	2.4
140801040503	Upper Animas Valley-Stevens Creek	2.4
140300020605	Dolores Canyon-Joe Davis Hill	2.3
140300020302	Upper Plateau Creek	2.2
140300020407	House Creek	2.2
140300036101	Naturita Creek	2.2
140300020507	Dawson Draw	2.1
140801010203	Wolf Creek	2.1
140801010504	Navajo River-Weisel Flat	2.1
140801010405	Rito Blanco	2.0
140300020510	Upper Disappointment Valley	2.0
140300020205	Roaring Forks Creek	2.0
140801040604	Animas River-Spring Creek	2.0
140801070102	West Mancos River	2.0
140801011601	Upper Beaver Creek	1.9
140801010305	McCabe Creek	1.9
140300020502	Disappointment Creek Headwaters	1.9
140300020305	Beaver Creek-Trail Canyon	1.9

Table 3.15 Watershed Prioritization List for Reach/Site scale analysis based on those watersheds within the 100-80 percentile ranges for unpaved road stream crossing ratios by HUB.

6th Level HUB	6th Level HUB Name	Unpaved System Road Crossing Ratio (mi / Stream mile)	HUB Drainage Density (mi/sq.mile0
140802020106	Lower Alkali Canyon-Narraguinepp Canyon	3.9	3.3
140300020405	Lower Lost Canyon	3.3	3.0
140300020605	Dolores Canyon-Joe Davis Hill	1.8	1.8
140801040402	East Fork Hermosa Creek	1.7	2.3
140300020401	Upper Lost Canyon	1.5	2.3
140801020403	Stollsteimer Creek-Dyke Valley	1.5	2.7
140801040401	Hermosa Creek headwaters	1.5	2.7
140300020604	Dolores Canyon-Lake Canyon	1.2	2.2
140801010308	San Juan River-Eightmile Mesa	1.2	2.9
140801020405	Lower Stollsteimer Creek	1.2	3.3
140300020509	Pine Arroyo	1.1	2.5
140801011704	Upper Spring Creek	1.1	2.8
140801040103	Mineral Creek	1.1	2.2
140801010306	Mill Creek	1.0	3.1
140300020504	Ryman Creek	1.0	3.2
140300020502	Disappointment Creek Headwaters	1.0	2.1
140300020602	Narraguinepp Canyon Natural Area	1.0	2.2
140801011601	Upper Beaver Creek	1.0	2.7
140300020306	McPhee Reservoir-Beaver Creek Inlet	1.0	2.3
140801070104	Chicken Creek	0.9	2.6
140300020603	Dolores Canyon-Cabin Creek	0.9	2.0
140300036101	Naturita Creek	0.9	1.8
140801050101	La Plata River headwaters	0.9	2.3
140300020305	Beaver Creek-Trail Canyon	0.9	2.1

Table 3.16 Watershed Prioritization List for Reach/Site scale analysis based on those watersheds within the 100-80 percentile ranges for non-system road densities by HUB.

6th Level HUB	6th Level HUB Name	Non-system Road Density (mi / sq mi)
140300036101	Naturita Creek	6.4
140300020605	Dolores Canyon-Joe Davis Hill	6.1
140801070105	East Fork of Mud Creek	4.9
140300020511	Disappointment Valley-Wild Horse Reservoir	4.2
140300020604	Dolores Canyon-Lake Canyon	4.0
140300020401	Upper Lost Canyon	3.8
140802020201	Upper Yellowjacket Canyon	3.8
140801011503	Los Pinos River-Bayfield	3.7
140300020402	Spruce Water Canyon	3.7
140802020106	Lower Alkali Canyon-Narraguinepp Canyon	3.4
140300020407	House Creek	3.2
140300020406	Upper Dolores River-Italian Creek	3.2
140300020509	Pine Arroyo	3.1
140300020507	Dawson Draw	2.8
140801070101	East Mancos River-Middle Mancos River	2.8
140300020603	Dolores Canyon-Cabin Creek	2.7
140300020304	Lower Plateau Creek	2.7
140801010503	Navajo Peak	2.6
140300020510	Upper Disappointment Valley	2.6
140801020402	Upper Stollsteimer Creek	2.6
140300020405	Lower Lost Canyon	2.6
140801011501	Middle Los Pinos River-Red Creek	2.6
140801020104	Piedra River-O'Neal Creek	2.6
140801011601	Upper Beaver Creek	2.6
140801020401	Martinez Creek-Dutton Creek	2.5
140801010307	Echo Canyon Reservoir	2.4
140300020205	Roaring Forks Creek	2.3
140801040402	East Fork Hermosa Creek	2.2
140300020303	Calf Creek	2.2

Influences of Railroads

Current and historical railroad lines are found primarily in the western half of the forest (Figure 3.14). At present there are approximately 65 miles of railroad located within valley floor areas in the San Juan National Forest, which totals 3,732 square miles. This represents an average of 0.02 miles of rail line per square mile of national forest land.

Two types of metrics were run to evaluate the potential for railroad related effects on aquatic, hydrologic, and riparian resources in the assessment area. The first metric determined the miles of railroad line per square mile of valley bottom. This metric was pertinent as historically railroad construction has been concentrated in valley floor areas. These areas were favored for the location and construction of rail grades as gradients are relatively consistent, due to the presence of rivers and streams. The second metric calculated the number of stream crossings per stream mile. This metric was evaluated because stream crossings are also areas where direct effects to streams commonly occur.

It is important to remember that these valley bottoms are very susceptible to the influences of land management activities, including railroads. Potential impacts are related to track construction, maintenance, and operation. Furniss et al., 1991, note that the impacts of railroads are similar to that of roads and other vehicles. Potential effects include: increased erosion and sedimentation associated with construction and the existence of the rail bed prism. This in turn could affect water quality and channel condition; modification of surface and groundwater hydrology by disrupting wetlands and concentrating surface runoff; surface and groundwater contamination related to railroad ties or hazardous material spills; and modification of biotic conditions as a result of disrupting riparian and wetland function, alteration of habitat and its complexity, generation of stream crossing barriers, and increasing the habitat available for invasive plants (USDA Forest Service, 2003).

As both historical and current rail road data is available, the first metric was calculated to determine the total amount of railroad line per square mile of valley floor. However, it should be noted that the historical layer is not entirely complete. If this layer is completed and similar analysis conducted then there will be some variation in the calculated results.

The statistical analysis and ranking of the density of the total (historical + current) amount of railroad per square mile of valley floor, by HUB, is displayed in Figure 3.15 and Table 3.17. Eight HUBs' are found within the 80-100 percentile range and have the most potential to have railroad related effects to hydrologic, aquatic and riparian resources.

Total valley floor railroad densities range from a high of 17.4 mi/sq. mi in HUB # 140300020405 (Lower Lost Canyon) to a low of 2.2 mi/sq.mi of valley floor area in HUB #140801040504 (Upper Animas Valley-Trimble) to a (Table 3.17).

Table 3.17 also summarizes the presence of current and/or historical rail road components. Lower Lost Canyon has the highest total valley floor density of the eight watersheds in the 80-100 percentile range. This watershed contains only historical railroad grades. These lines were likely used to haul harvested timber, ore, and mining.

The East Fork of Mud Creek watershed also contains historical railroad line related to these activities. Both of these watersheds lie largely outside of the forest boundary, with only very small portions of their headwater areas within the forest. As a result, railroad related effects on hydro- logically related resources, is likely to be very minimal from National Forest lands.

Rico Valley and the Upper Dolores-Scotch Creek watersheds contain only historical railroad lines within their boundaries. Railroad densities in Rico Valley and Upper Dolores River-Scotch Creek watersheds are associated with the historical mining activity. Mines were active in the area from around 1880's into the late 1920's. These two watersheds are part of the drainage system to the Dolores River. The river flows to the southwest, enters McPhee Reservoir, and eventually it flows off-forest and on to BLM administered land, just east of the small town of Cahon. As these watersheds are within the 80-100 percentile range, there is high potential for railroad related effects, both within and off the forest. However, as mining and timber harvest activities were also present, it would be hard to separate actual effects and impacts.

Valley floor railroad densities associated with the Animas River-Needleton, Animas River-Tenmile Creek, Upper Animas Valley-Canyon Creek, and Upper Animas Valley-Trimble watersheds all contain historical and current railroad line. The historical line was part of initial Rio Grande Southern rail line established in 1890, and extending from Durango to Ridgway. These initial railroads in the San Juan's were developed in conjunction with the turn of the century boom in mining for silver (Ferrell, 1973).

Today the old line is now part of the currently active Durango Silverton railroad. The railroad is used to transport tourists up to the historic town of Silverton. All four watersheds are drain in to the Animas River. Valley floor densities in the Animas River-Tenmile Creek, Upper Animas Valley-Canyon Creek, and Upper Animas Valley-Trimble watersheds are substantially less than those in the Animas River Needleton. The risk for potential effects is likely to be less in these watersheds due to the lower railroad densities. However, all four watersheds are within the 80-100 percentile range. As drainage by the Animas River is to the south/southwest, there is the potential for downstream effects to off-forest hydrologically influenced resources.

Current valley floor railroad densities are found in Table 3.18. These densities are based only on rail lines currently being used. Analysis indicates that there are only two HUBs' that fall within the 80-100 percentile range. The Animas River-Needleton (HUB #140801040204) has a density of 7.2 mi of railroad per square mile of valley bottom. The Animas River-Tenmile Creek (HUB #140801040202) has a density of 3.5. As mentioned in the previous pattern these watersheds flow into the Animas. As a consequence there is the potential for off-forest effects.

Railroad related effects also occur where rail grades cross streams and rivers. The ratio of total railroad stream crossings per stream mile per 6^{th} level HUB was also calculated. Figure 3.16 and Table 3.19 summarize the analysis results. Seven watersheds are within the 80-100 percentile range for total stream crossings. They are located primarily in the western half of the forest, and include the watersheds drained by the Animas River (Figure 3.16).

The concentration of these watersheds in the western half of the forest likely reflect the higher concentration of historical rail lines associated within mining and logging.

Only Lower Lost Canyon watershed has a total stream crossing ratio of greater than 0.4. The historical rail line is located in the valley bottom of a 5^{th} order stream. It appears, based on examination of GIS data, that the rail line crosses almost all of the tributaries to the 5^{th} order stream as well as crossing the major drainage in several places.

As Lower Lost Creek Canyon has a stream crossing ratio of almost a magnitude higher than the other watersheds in Table 3.19. As a result, it is the most likely of the watersheds within the 80-100 percentile range for total stream crossing ratios to have possible effects on hydrologically related resources.

All the other watersheds have stream crossing ratios of 0.3-0.4. This appears to be a function of fewer stream crossings vs. lower stream densities in these drainages.

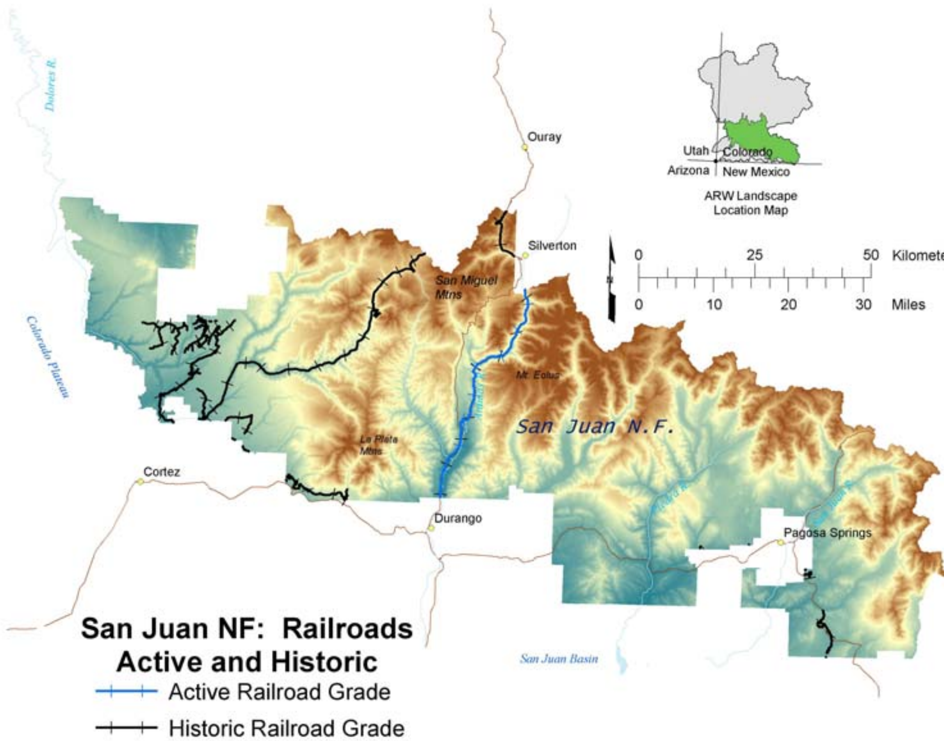

Figure 3.14 Location of current and historical railroad lines, management scale, San Juan National Forest

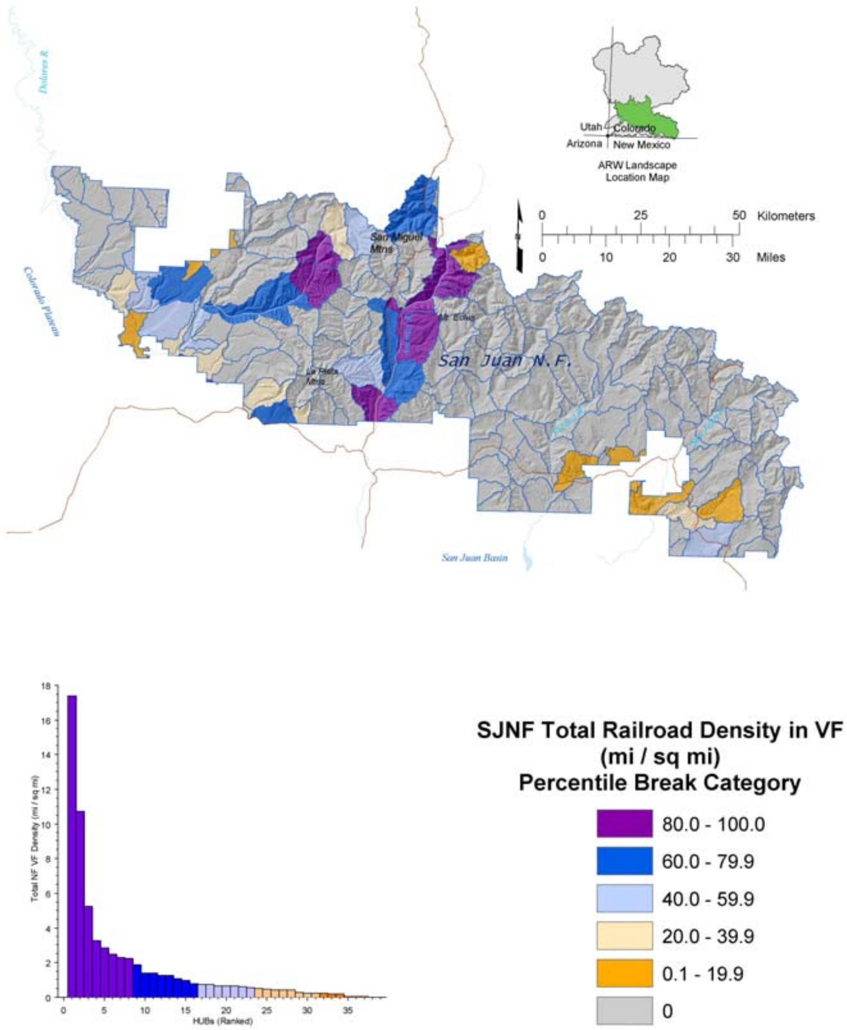

Figure 3.15 Rank and distribution of valley floor total (current + historic) railroad densities, management scale, San Juan National Forest.

Table 3.17 HUB numbers and calculated total valley floor railroad densities within the 80-100 percentile range, management scale, San Juan National Forest. Watersheds highlighted in light green are located entirely within the forest boundary.

6th Level HUB	6th Level HUB Name	Total NF VF Density (mi / sq mi)*	Presence of Current and/or Historical Activity**
140300020405	Lower Lost Canyon	17.4	H
140801040204	Animas River-Needleton	10.7	H, C
140801040202	Animas River-Tenmile Creek	5.3	H, C
140300020203	Rico Valley	3.3	H
140801070105	East Fork of Mud Creek	2.9	H
140300020204	Upper Dolores River-Scotch Creek	2.5	H
140801040501	Upper Animas Valley-Canyon Creek	2.3	H, C
140801040504	Upper Animas Valley-Trimble	2.3	H, C

Table 3.18 HUB numbers and calculated valley floor current railroad densities within the 80-100 percentile range, management scale, San Juan National Forest. Watersheds highlighted in light green are located entirely within the forest boundary.

6th Level HUB	6th Level HUB Name	NF VF Rail Density (mi / national forest valley floor sq. mi)
140801040204	Animas River-Needleton	7.15677
140801040202	Animas River-Tenmile Creek	3.54468

Railroad stream crossing ratios were also calculated for current railroad lines. The data and the location of HUB's within the 80-100 percentile range are displayed in Figure 3.17 and Table 3.20. Only the Animas River-Tenmile Creek (HUB # 140501040202) and Animas River-Needleton (HUB #140801040204) watersheds were found to be in this percentile range (Figure 3.17).

These two HUB's are located at the northern end of the portion of the Durango and Silverton railroad located within the Forest boundary (Figure 3.16). HUB 140801040202 has a railroad crossing ratio of 0.25 crossings per stream mile and HUB 140801040204 has a crossing ratio of 0.17.

Due to these low railroad crossing ratios, effects on aquatic and riparian resources, related to railroad stream crossings, is probably fairly low.

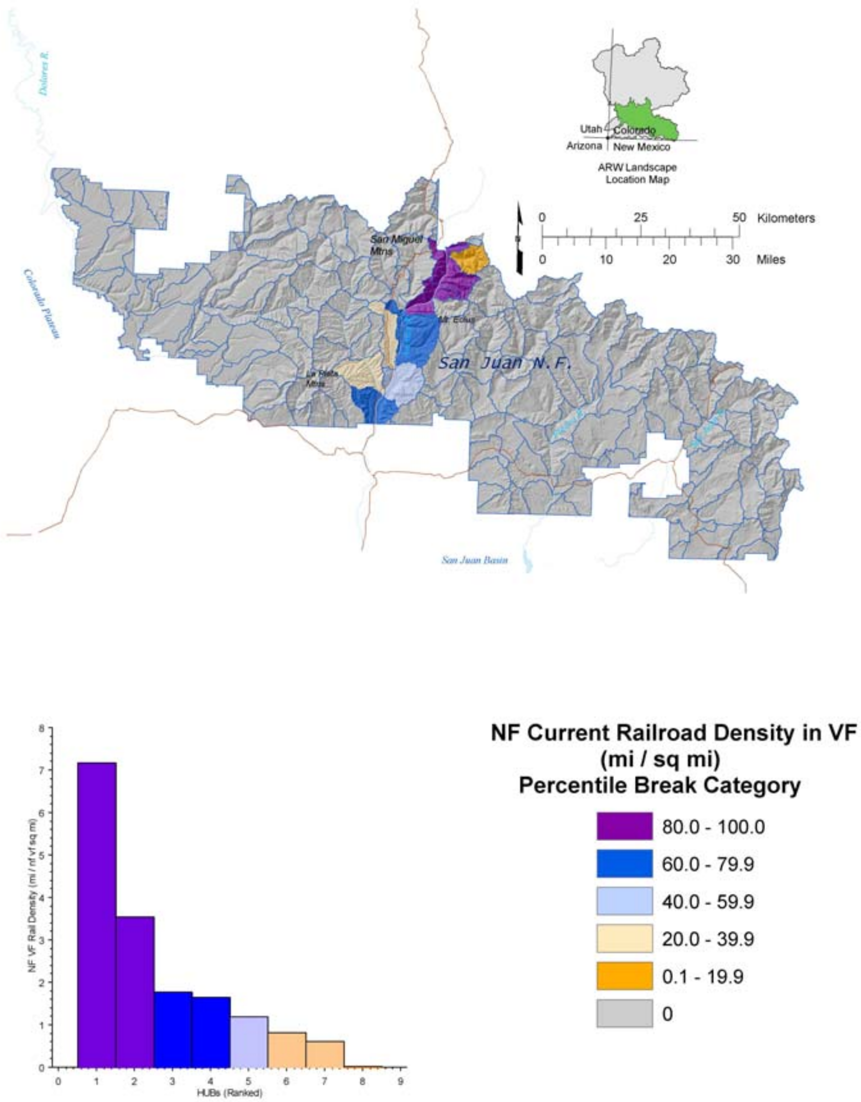

Figure 3.16 Rank and distribution of current valley floor railroad densities, management scale, San Juan National Forest.

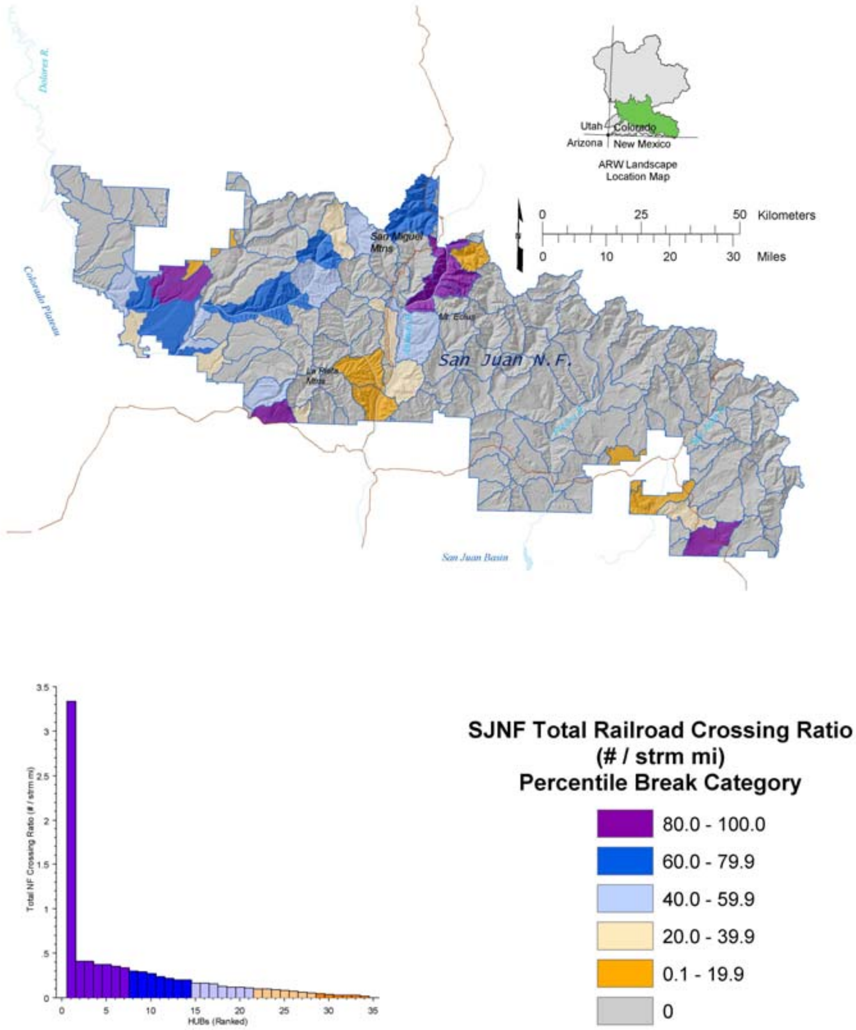

Figure 3.17 Rank and distribution of railroad stream crossing ratios, management scale, San Juan National Forest.

Table 3.19 Summary of HUB's within the 80-100 percentile range for total railroad stream crossings, management scale, San Juan National Forest. Watersheds highlighted in light green are located entirely within the forest boundary.

6th Level HUB	6th Level HUB Name	Total # Stream Crossings per Stream Mile (# / stream mi)
140300020405	Lower Lost Canyon	3.3
140801040202	Animas River-Tenmile Creek	0.4
140300020305	Beaver Creek-Trail Canyon	0.4
140801050105	Upper Cherry Creek	0.4
140801010507	Coyote Creek	0.4
140300020304	Lower Plateau Creek	0.4
140801040204	Animas River-Needleton	0.3

Table 3.20 Summary of HUB's within the 80-100 percentile range for current railroad stream crossings, management scale, San Juan National Forest. Watersheds highlighted in light green are located entirely within the forest boundary.

6th Level HUB	6th Level HUB Name	NF Crossing Ratio (# / national forest stream mi)
140801040202	Animas River-Tenmile Creek	0.24795
140801040204	Animas River-Needleton	0.16861

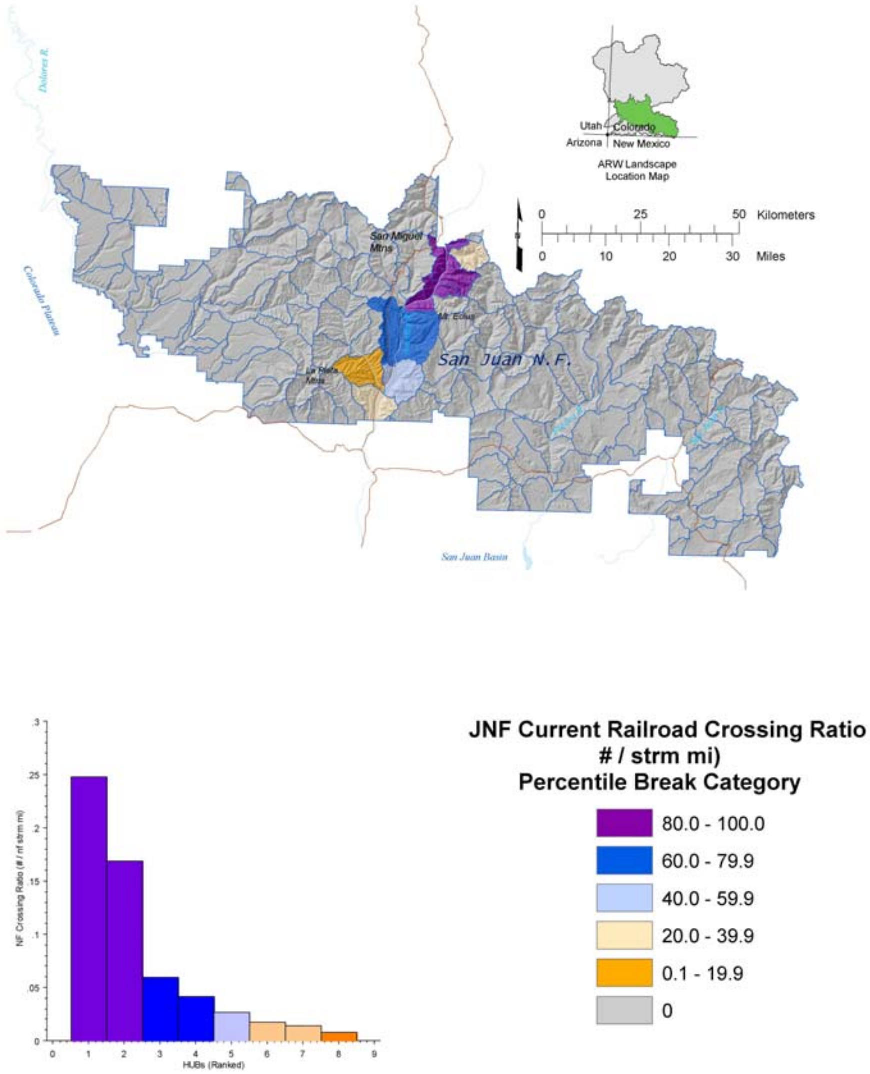

Figure 3.18 Rank and distribution of railroad stream crossing ratios, management scale, San Juan National Forest.

6th Level HUB Information Needs

The historical railroads layer should be finalized. Some historical railroad beds have now been converted to roads. The historical railroad layer needs to be revised to reflect this. In addition, there are still some historical lines which need to be added (Roper, 2004).

Currently there is some historical data located off the forest. Current rail road data is located only on the forest. It would be of benefit to obtain as much data as possible, located off-forest, but adjacent to the forest boundary. It would also be helpful to know the dates when railroads where active, from a cumulative effects analysis standpoint.

Currently there is no inventory of historical or current rail grades and their condition, especially where they are located within valley bottoms or at stream crossings. Such an inventory would again be useful for cumulative effects analysis as well as in planning watershed improvement projects or fisheries projects.

Management Implications at the 6th HUB Level

Furniss et al. 1991 note that the impacts aquatic resources from railroad tract construction and operation are similar to that of roads. Basic effects include displacement of riparian vegetation and soils; interception of surface and groundwater; modification of stream channel morphology, increased sedimentation, water quality impairment (USDA Forest Service, 2003).

Active use of the railroads for the transportation of goods and services experienced a long decline and was ended in the early 1950's. Today the Durango and Silverton railway is active between Durango and Silverton. Future expansion of active use of the rail lines is not very likely.

Only six watersheds out of the 154 on the Forest had rankings of "5" for railroad activity. These are the Upper Cherry Creek (HUB# 140801050105), Upper Animas Valley-Canyon Creek (HUB# 140801040501), Lower Lost Canyon (HUB #_140300020405), Lower Plateau Creek (HUB# 140300020304), Rico Valley (HUB# 140300020203), and Beaver Creek-Trail Canyon.

All of the watersheds had high levels of road activity in addition to that of railroads. Upper Cherry Creek also has high urbanization influences, while Upper Animas Valley-Canyon Creek and Lower Plateau Creek have additional influences due to vegetation management (Table 3.18, Report 3 of 3). Beaver Creek-Trail Canyon watershed has the most additional influences other than railroads, with roading, minerals, and vegetation management all scoring the maximum values.

Riparian and aquatic systems in riparian Clusters 1r, 2r, 4r, and 5r, are all sensitive to changes in hydrology and sediment loads. The associated anthropogenic activities to these watersheds all involve alterations to hydrology and especially sedimentation. Wetland clusters 1w and 2w both have a high sensitivity to changes in their hydrologic systems and moderate sensitivity to alteration of sediment load. However 3w and 4w are sensitive to changes in hydrology but not sedimentation.

Recommendations are as follows:

- Mitigation for low gradient reaches in riparian Clusters 1r and 2r are recommended in order to enhance riparian vegetation in both these clusters. In both clusters the importance of riparian vegetation and aquatic plants and animals are magnified as these reaches are scarce in these clusters. Mitigation should also focus on the controlling sediment loads and any modification to base level and subsurface hydrology. Mitigation would also improve the health of wetland clusters 1w and 2w which are the most sensitive to changes in sedimentation and hydrology.

- Mitigation efforts in Lower Lost Canyon, and especially the Beaver

Creek-Trail Canyon watershed, are recommended. Minimizing increased sediment loads will improve fisheries habitat and populations in low gradient reaches. Beaver Creek-Trail Canyon is the watershed most at risk for sediment and hydrologic modifications related to multiple anthropogenic activities.

- Riparian Cluster 5r is one of the most productive for aquatic and riparian systems. Upper Cherry Creek and Lower Plateau Creek watersheds are both candidates for mitigation efforts due to the levels of anthropogenic activities. Increased riparian cover and mitigation of sediment loads would result in moderation of thermal regime fluctuations and improve habitat productivity.
- Mitigation of wetlands Clusters 3w and 4w can be undertaken on a case by case basis.

Direction for Reach/Site Scale Analysis

Inventory historical railroad lines for the following:

1) Are railroad lines influencing surface runoff patterns?
2) Are there cases of railroad bed failure into creeks or other situations where railroad related erosion is contributing additional sediment loading to streams?

3) determine if, and where, channels have been constricted by railroad track prism impingement. If constriction has occurred determine if there is associated stream bank instability.

4) determine if, and where, there has been impairment of large woody debris recruitment due to the presence of the track prism. If so, has there been a related observable change in channel morphology?

Influences of Foot Trails

The San Juan National Forest boundary has an approximate total of 1, 171 miles of foot trail within its boundaries. Approximately 15%, or 173 miles, of these trails are located in valley floor areas (Fig. 3.19).

In assessing the impacts of foot trails on aquatic, hydrologic, and riparian resources several metrics were analyzed. These were: 1) determining the Forest system trail density by HUB, 2) the density of system trails in valley floor or bottom areas, and 3) the number of stream crossings, by foot trails, by HUB. Valley bottom areas also include riparian zones so a separate analysis for riparian areas was not conducted. At the time of analysis, foot trail data was available only within the Forest. For watersheds with only a portion of their area within the Forest, any calculated metrics most likely represent a "minimum" as foot trail data outside the Forest boundary is currently unavailable.

Figure 3.20 and Table 3.21 summarize Forest system foot trail density for those HUBs which fell within the 100-80 percentile range. 20 HUBs were found in this range. HUBs found within the 100-80 percentiles have the highest potential for having trail related impacts to hydrologic related resources.

Within the 100-80 percentile range the highest trail densities, by HUB, were located in the Bear Creek and Lower Lightner Creek drainages. They had densities of 1.2 miles of trail per square mile of watershed. Lower Lightner Creek watershed is located immediately west of Durango, Colorado, and Bear Creek is on the northern boundary of the Forest, in the Weminuche Wilderness. Trail densities for the other HUBs are listed in Table 3.21. They range from a high of 1.08 to a low of 0.67 miles per square mile in the Upper Devil creek watershed (HUB#140801020301). In both cases, the high densities are related to recreational use.

HUBs highlighted in light green are located entirely within the Forest boundary. As a result, trail densities are representative of on-the-ground conditions. Those HUBs which are not highlighted are not located entirely within the Forest. Trail densities for these HUBs are determined by the proportion of the watershed within the Forest boundary. As a consequence these trail densities may not be reflective of actual on-the-ground conditions, but they do indicate which additional HUBs have a high potential for being influenced by trail related impacts.

Foot trail density within valley floor, or bottom areas, and the number of foot trail stream crossings were also evaluated. These metrics provide a more focused assessment of impacts as valley bottom areas are the most susceptible to the impacts associated with land management activities.

Figure 3.21 and Table 3.22 summarize the results of those HUBs with valley floor densities within the 100-80 percentile range. 19 HUBs were found within the 100-80 percentile range with 16 of those HUBs located entirely on the Forest. The highest valley floor density was found in Fish Creek watershed (HUB#140801010402) with the lowest density, of 1.35, found in the Lightner Creek watershed.

Impacts within the valley floor area are of concern as several studies have indicated that trails can directly affect watershed health and function. Cole, 2000, Leung and Marion, 1996, and Shelby, et al, 1992, indicate that trails can be considered as miniature roads, with similar impacts to watershed integrity and function, though typically of less magnitude.

Water quality may be directly impacted due to trail construction, use, and/or maintenance. Trail location is a critical element in the potential for trail impacts on water quality (Helgath, 1975). Trails can function as conduits for erosion and sediment transport, as well as providing a means of dispersing bacterial and viral contaminants due to human and animal waste (USDA Forest Service, 2003).

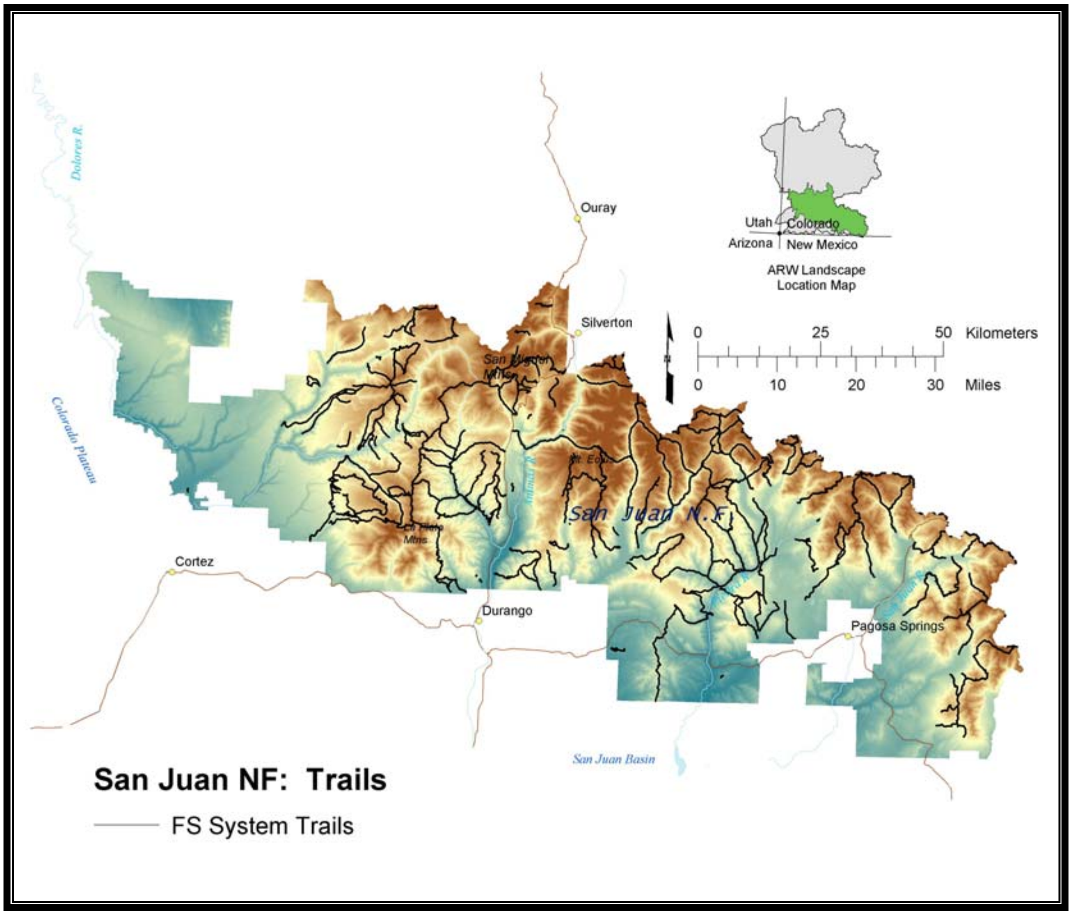

Figure 3.19 Location of foot trails within the San Juan National Forest.

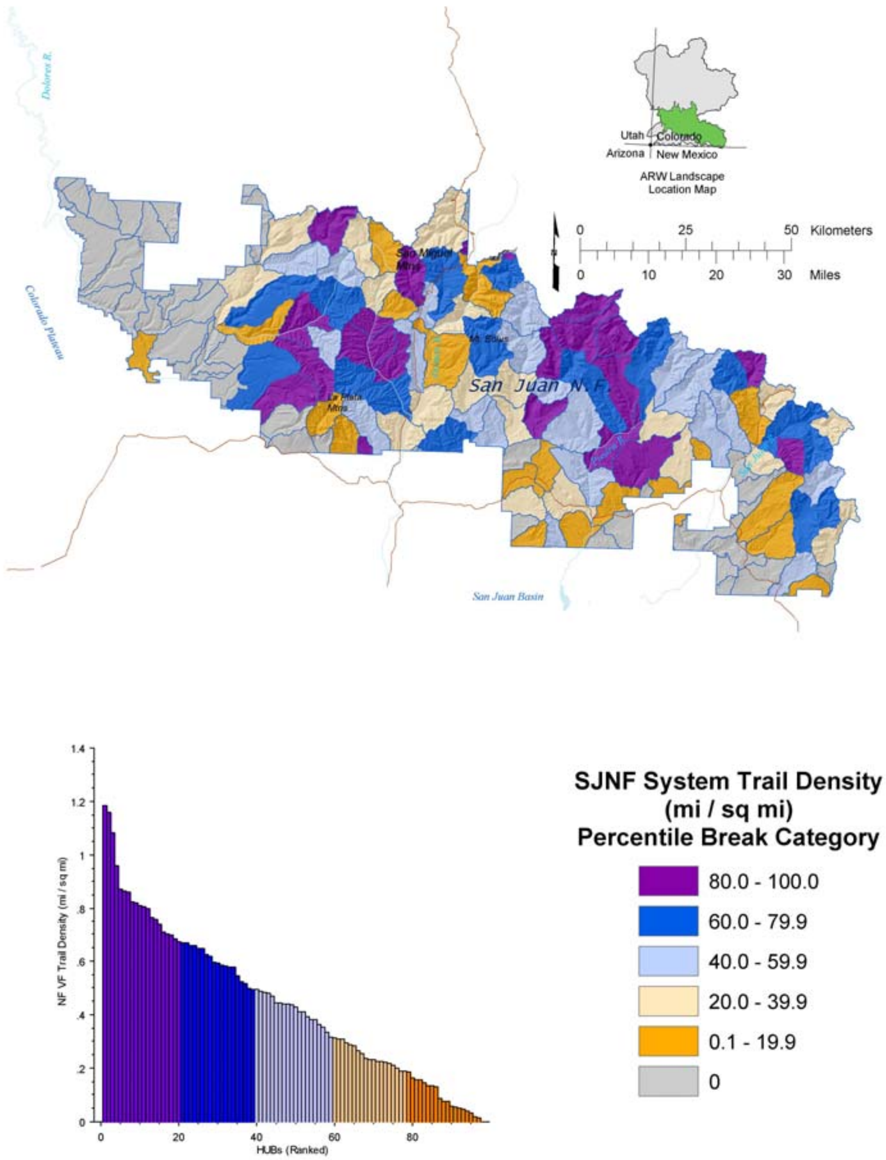

Figure 3.20 Rank and distribution of foot trail density, by HUB, management scale, San Juan National Forest.

Table 3.21 Summary of System Foot Trail Density, by HUB, in the 100-80 percentile range.

6th Level HUB	6th Level HUB Name	NF Trail Density (mi / sq mi)*
140801040603	Lower Lightner Creek	1.20
140300020206	Bear Creek	1.20
140801040406	Hermosa Creek-Dutch Creek	1.08
140801011301	Upper Los Pinos River-Ricon La Vaca	1.00
140801020202	Lower Weminuche Creek	0.87
140801020205	Upper Piedra River-Box Canyon	0.86
140801040301	Upper Cascade Creek	0.86
140801011306	East Creek	0.82
140801040403	Upper Hermosa Creek	0.82
140300020207	Dolores River-Priest Gulch	0.81
140801040104	Animas River-Cunningham Creek	0.80
140801011302	Upper Los Pinos River-Flint Creek	0.80
140801010202	Beaver Creek	0.77
140300020101	El Deinte Peak	0.76
140801040404	Middle Hermosa Creek	0.74
140801070102	West Mancos River	0.71
140801011303	Lake Creek	0.70
140801020201	Upper Weminuche Creek	0.70
140801010103	Sand Creek	0.68
140801020301	Upper Devil Creek	0.67

* All acreage data was generated using Arcview GIS and associated spreadsheets. Information may not be statistically accurate. These numbers have been rounded to the nearest 100th of a mile

Other effects include soil compaction and degradation of vegetation, which may particularly affect riparian health and function.

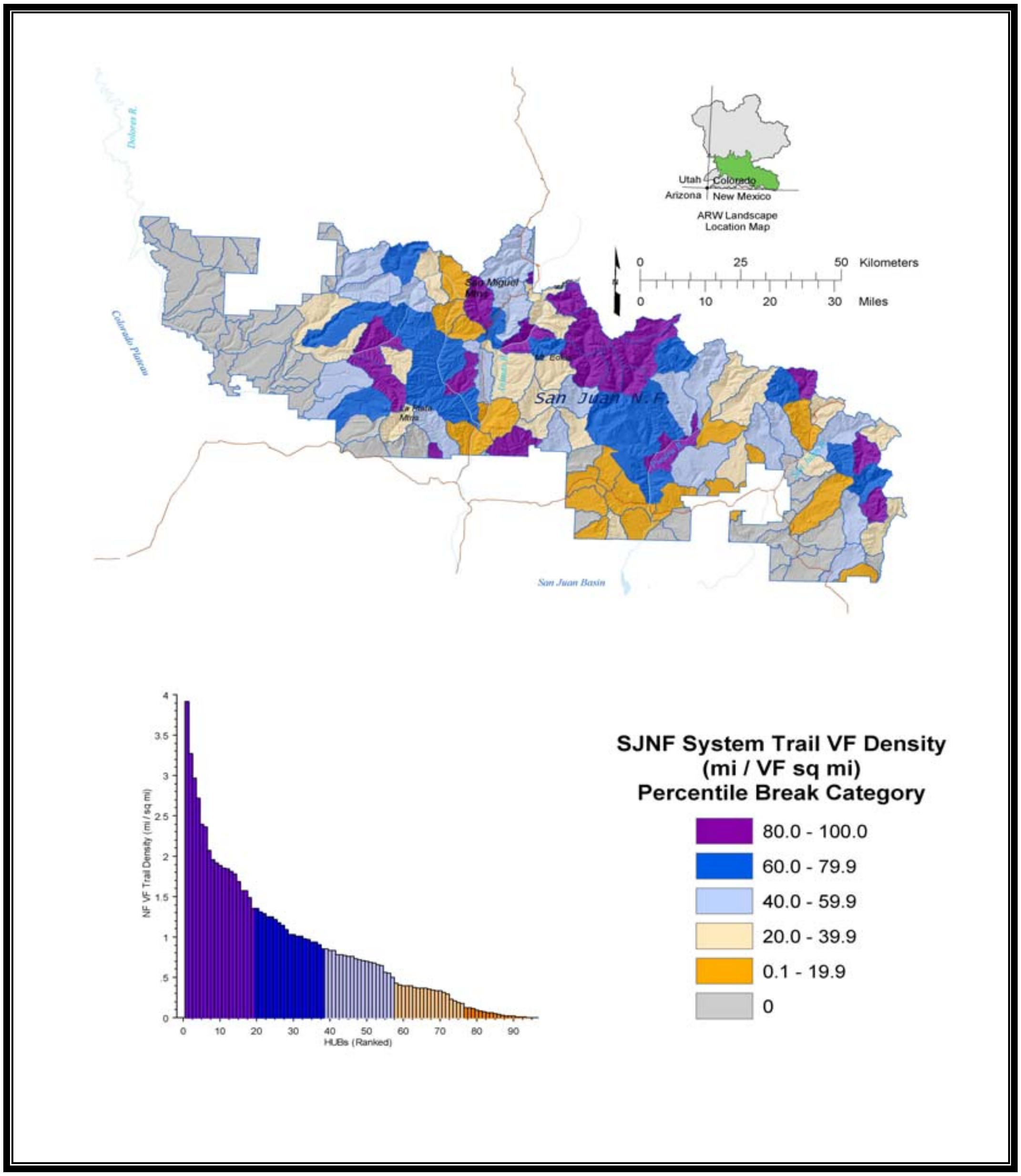

Figure 3.21 Distribution and ranking of foot trail densities, within the valley floor areas, management scale, San Juan National Forest.

Table 3.22 Summary of Valley Floor System Foot Trail Density, by HUB, in the 100-80 percentile range.

6th Level HUB	6th Level HUB Name	NF VF Trail Density (vf mi / vf sq mi)
140801010402	Fish Creek	3.91704
140801011302	Upper Los Pinos River-Flint Creek	3.26749
140801011304	Three Sisters	2.96748
140801020205	Upper Piedra River-Box Canyon	2.71364
140801011402	Middle Vallecito Creek	2.40089
140801040406	Hermosa Creek-Dutch Creek	2.36578
140300020206	Bear Creek	2.07467
140801040301	Upper Cascade Creek	1.95640
140801010202	Beaver Creek	1.91760
140801040204	Animas River-Needleton	1.88073
140801040201	Elk Creek	1.85057
140801011303	Lake Creek	1.84119
140801040804	Upper Florida River-Red Creek	1.81259
140300020207	Dolores River-Priest Gulch	1.78521
140801040104	Animas River-Cunningham Creek	1.68452
140801011301	Upper Los Pinos River-Ricon La Vaca	1.57712
140801011401	Upper Vallecito Creek	1.57609
140801010102	Quartz Creek	1.48777
140801040603	Lower Lightner Creek	1.35560

* All acreage data was generated using Arcview GIS and associated spreadsheets. Information may not be statistically accurate. These numbers have been rounded to the nearest 100th of a mile

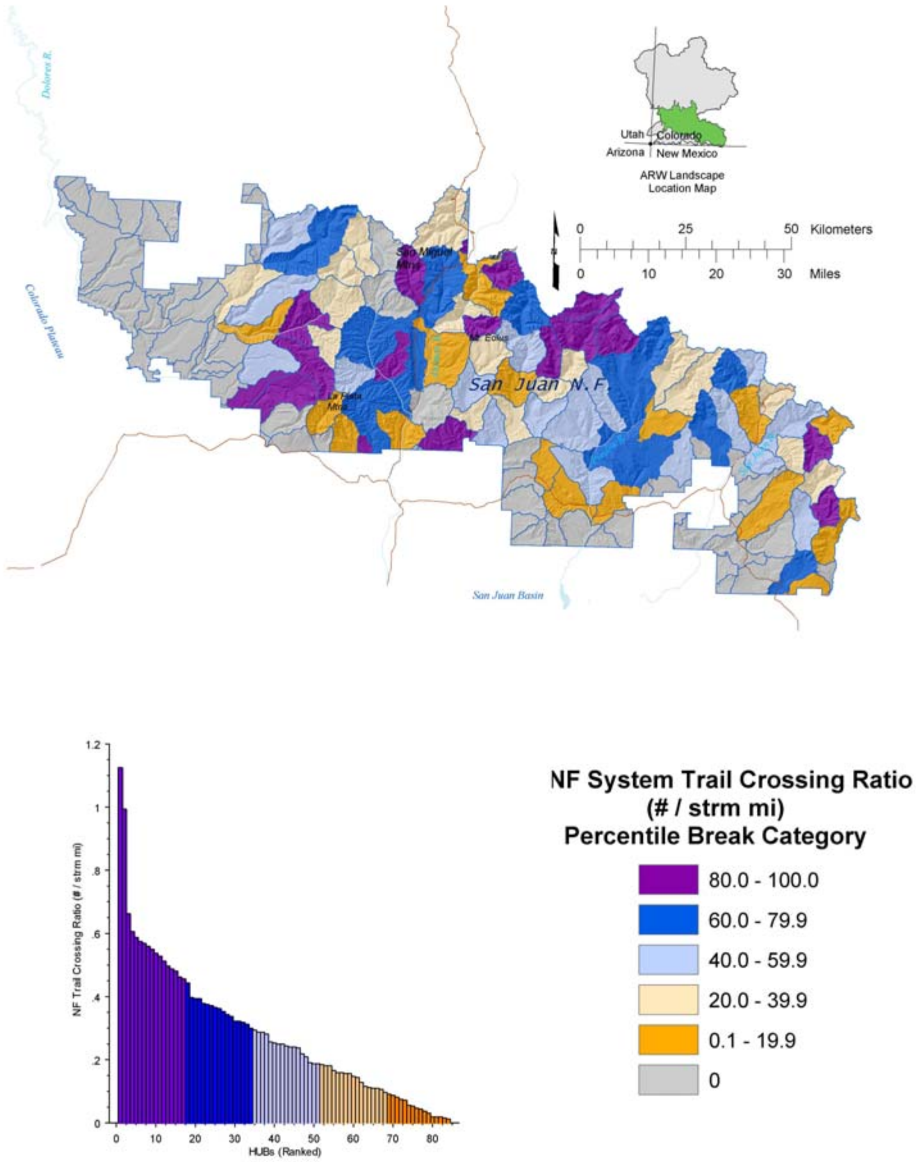

Figure 3.22 Foot trail stream crossings ratios, management scale, San Juan National Forest.

Table 3.23 Summary of valley floor foot trail stream crossings, by HUB, in the 100-80 percentile range, San Juan National Forest.

6th Level HUB	6th Level HUB Name	NF Trail Crossing Ratio (#per stream mile)	Total # of Stream Crossings	Stream Density (mi/sq. mile)
140801040104	Animas River-Cunningham Creek	1.13	13	2.5
140801070104	Chicken Creek	1.00	42	7.8
140801040301	Upper Cascade Creek	0.67	46	5.2
140801011301	Upper Los Pinos River-Ricon La Vaca	0.61	26	4.3
140801011302	Upper Los Pinos River-Flint Creek	0.59	44	3.0
140801020201	Upper Weminuche Creek	0.58	33	3.5
140300020207	Dolores River-Priest Gulch	0.57	45	4.2
140801040603	Lower Lightner Creek	0.56		0.4
140300020206	Bear Creek	0.55	43	4.4
140801040201	Elk Creek	0.54	32	5.4
140801011303	Lake Creek	0.53	20	3.1
140801010102	Quartz Creek	0.51	27	4.7
140801040804	Upper Florida River-Red Creek	0.50	31	3.7
140801040203	Needle Creek	0.50	23	5.6
140801070102	West Mancos River	0.48	37	4.3
140801040406	Hermosa Creek-Dutch Creek	0.46	30	3.8
140801010402	Fish Creek	0.46	20	

* All acreage data was generated using Arcview GIS and associated spreadsheets. Information may not be statistically accurate. These numbers have been rounded to the nearest 100th of a mile

Figure 3.22 and Table 3.23 display data results for analyzing the number of stream crossings per mile per HUB. 17 HUBs were found to be in the 100-80 percentile range. These HUBs are found primarily in the western half of the Forest and along the northern boundary (Figure 3.22).

The ratio for number of stream crossings per stream mile ranges from a low of 0.46 in Fish Creek (HUB # 140801010402) to a high of 1.13 for the Animas River-Cunningham Creek watershed (HUB# 140801040104). Only a very small portion of the headwater areas of Fish Creek are located within the Forest boundary. Potential effects would largely be downstream, off the Forest.

Watersheds highlighted in light green are located on the Forest. Ratios are representative of on-the-ground conditions. According to Clark and Gibbons, 1991, and Waters, 1995, trail construction, use and maintenance can result in localized and direct influences on channel conditions when stream crossings are part of a trails design. In higher elevation areas where precipitation is greater, and more intense, severe erosion results in trail entrenchment. Consequently the trails act as funnel delivering large amounts of sediment directly into streams where the trail crosses the stream. Bank widening and modification of stream banks may occur if properly developed crossings are not installed. This may in turn result in alterations to substrate distribution, increased embeddedness, and degradation and loss of habitat (USDA Forest Service, 2003).

6^{th} Level HUB Information Needs

At the time this report was written there were some quality issues with the GIS data. It is recommended that the coverage be updated and data quality issues resolved before the Forest plan revision.

Wetlands data is currently unavailable on the Forest. As trails often wind along valley bottoms, and in wetland area, it would be useful if there was GIS coverage that delineated riparian and wetland ecosystem types. There are five differing ecosystem types occurring in Region 2 of the Forest Service. Each ecosystem occurs within differing landforms and is driven by differing hydrogeologic processes. In order to address specific influences within the valley bottom, intersecting wetlands and stream crossing inventories of their specific influences must be made. This would include the stream crossing conditions and their influence on invasive species and erosion processes should all be considered. The availability of such GIS data would enhance the ability of the Forest in developing and administering land management activities within these fragile ecosystems.

Trails may be used for the unauthorized introduction of exotic fish species, to the detriment of endemic species. An additional concern related to trails and fisheries is the introduction of Myxobolus cerebralis spores, which cause whirling disease in fish. The spores are transported by boots, mountain bike tires, or anything else that may carry mud from one stream to another. Anywhere a trail intersects a waterway there is an increased chance of the spores being introduced. As a result, it is suggested that an inventory of streams be conducted to evaluate the presence and extent of Myxobolus spores.

Trails also provide a means of transportation and introduction of invasive plant species into the Forest. Additional invasive species information needs include inventorying invasive and sensitive plants impacts on local sensitive plant species through ongoing noxious weed management activities. Finally, potential herbicide use impacts on sensitive plant species, through a risk assessment, should also be evaluated.

It would also be useful to know how the type and amount of recreation use along trails may be influencing the spread of invasive plants. In conjunction with this it would be valuable to monitor for the establishment of new invasive species 9those species, while currently not on the Forest, that could be expected to become established within 10 years or so), especially in high use/easy access portions of the trail system.

Data should be collected with a GPS unit where possible and all collected data should be compiled on to a GIS coverage using a geo database. Monitoring and inventory information should be used to update the Forest noxious weed EA BA/BE as required.

Management Implications at the 6^{th} HUB Level

12 watersheds, or 8% of the Forest's watersheds, had scores of "5" for recreation-trails activity. Nine of these watersheds are located entirely on-Forest, with only three being partially located within the Forest.

The Three Sisters (HUB# 140801011304), Upper Los Pinos-Flint Creek (HUB# 140801011302), Upper Los Pinos-Ricon La Vaca (HUB# 140801011301) and Fish Creek (HUB# 1408010402) are associated, either entirely or partially, with the Weminuche Wilderness areas. In the Fish Creek and Upper Los Pinos-Flint Creek watersheds the high potential for impacts to aquatic, riparian and wetland resources, is magnified by the high score these watersheds received for dispersed recreation. Dispersed recreation levels are less in the Three Sisters and Upper Los Pinos-Ricon La Vaca watersheds where this category received a cumulative percentile score of "3" compared to "4" for the other two watersheds (See Table 3.28).

For the Chicken Creek (HUB# 140801070104), West Mancos River (HUB# 140801070102), Fourmile (HUB# 140801010302), Stoner Creek (HUB# 140300020208), Upper Piedra River-Box Canyon (HUB# 140801020205), East Creek (HUB# 140801011306), and Fish Creek (HUB# 1408010402) watersheds there is at least one additional anthropogenic activity that has ranked high for either a subset of a category, or for an entire category. Generally vegetation management was the most common secondary anthropogenic activity, followed by roads. Fourmile Creek watershed also had ranked out with a maximum possible score for water uses. Fish Creek scored the highest possible score for developed recreation as well but did not rank high for roads or vegetation management (Table 3.28).

Research indicates, as mentioned earlier in this section, that trails essentially function a miniature roads, directly affecting watershed health and function, though on a smaller scale. As a result, in the Three Sisters, Upper Los Pinos-Flint Creek, and Fish Creek watersheds, there may be alterations in alterations to water quality, quantity and timing, and to sediment loads, similar to roads, but on a smaller scale. In the Chicken Creek, West Mancos River, Fourmile, Stoner Creek, Upper Piedra River-Box Canyon, and East Creek watersheds the high scoring of roads and vegetation management suggests that any potential alterations of water quality, hydrology, and sediment loads due to trails may be further magnified.

Specific recommendations follow below and are based upon Reports 1 of 1 and 3 of 3.

- Riparian Cluster r2 was noted in the West Mancos River, Fourmile Creek, East Creek and the Upper Los Pinos River-Flint Creek watersheds, making it the most commonly occurring riparian cluster in association with foot trails. Riparian vegetation is especially important in this cluster and is very sensitive to changes in sediment load, local base level or subsurface hydrology, all of which can occur in association with trails, water uses, and developed recreation. Watershed management strategies should emphasize restoration and mitigation of riparian vegetation, focusing on low gradient reaches.
- Riparian Clusters 1r, 4r, and 5r are all sensitive to increases in sediment production relative to aquatic systems, including fisheries, and riparian vegetation. As roading, vegetation management and foot trail activity are present, and are at high rankings in some combination in the Chicken Creek and Upper Piedra River-Box Canyon mitigation efforts are recommended.
- Wetlands Clusters 1w and 3w occur most commonly in the watersheds associated with high levels of foot trail activity although clusters 7w, 8w and 9w also occur (Table 3.28). Both Cluster 1w and 3w have been evaluated as highly sensitive to changes in hydrology, with cluster 1w moderately sensitive to changes in sediment versus cluster 3w which has a low sensitivity to change. Both Clusters offer important opportunities for protection and restoration. However, more strategic management approaches may be needed in Cluster 1w.
- Cluster 7w was found to be present in the Fish Creek watershed, which is dominated by foot trail and developed recreation activities. While this watershed ranks high for these two activities, it lacks influences major influences from the other anthropogenic activity categories. At a minimum the Fish Creek watershed is a candidate for mitigation and it may present opportunities for restoration or use as a reference site.
- The Upper Los Pinos River-Flint Creek watershed contains wetlands rated as 8w. Wetlands in this watershed should be considered for mitigation and restoration. Management of these wetland ecosystems should be made a priority.
- Cluster 9w wetlands in the Three Sisters watershed can be considered for restoration effort as foot trails are the only major anthropogenic influence.

Direction for Reach/Site Scale Analysis

At the reach/site scale, trails located within the valley bottom areas and adjacent to or intersecting wetlands, should be given priority for reach/site scale assessments. Specific questions that should be considered include the following:

1. Are there rare species concerns associated with trail location?
2. Is there the presence or risk of presence of non-native, invasive species such as plants, fish, or disease associated with the trails?
3. What is the relationship between trail location and sediment production to the riparian and/or wetland environment?
4. What is the influence of recreational users on populations of vertebrate, invertebrate, and plant species?
5. What is the effect of trails and associated uses on water quality?
6. Is the recreational use associated with the trail, such as dispersed camping negatively influencing aquatic, riparian, and wetland resources?
7. Are trails intercepting water flow from upslope, which may influence aquatic, riparian, and wetland resources down slope (primarily wetland ecosystems)?

Influences of OHV Use

Since 1972 the number of users of off-highway vehicles (OHVs) has risen approximately seven-fold from 5 million users to approximately 35 million users in 2004 (*Http://www.fs.fed.us/recreaton/programs/ohv*). Off-road or off-highway vehicles (OHVs) are defined as a class of commercially available recreational vehicles that include all-terrain vehicles, also known as ATVs, dirt bikes, snowmobiles, dune buggies, 4x4 sport utility vehicles (SUVs), and 4x4 trucks (USDA Forest Service, 2003). In 2004 the Chief of the Forest Service listed unmanaged recreation, especially that of OHV use, as one of the key threats facing the Nation's Forests and grasslands today (*Http://www.fs.fed.us/recreaton/programs/ohv*).

Due to data quality issues with the existing Forest data set it was decided that quantitative analyses would could not be conducted for this anthropogenic factor. As a result, a qualitative summary of OHV use on the Forest is provided. Data quality concerns are summarized under information needs.

Approximately 79% of the San Juan National Forest is open cross-country OHV use based on the Forest's travel management plan (San Juan National Forest Map). The type of authorized access and their total number of acres on the Forest is summarized in Table 3.24. Authorized access varies from designated seasonal use (summer or winter) to open all year to either OHV's or snowmobiles. OHV or snowmobile is not allowed, at any time, in the South San Juan, Weminuche, Lizard Head Wilderness areas.

Major OHV routes exist across the Forest. Named major routes are listed in Table 3.21. The 2001 version of the San Juan Forest map displays major OHV (snowmobile, high clearance 4WD vehicles, ATVs, and snowmobiles) located on the Forest. Data quality concerns have prevented a more quantitative approach, but measurements by hand indicated that there are approximately 131 miles of OHV trail in travel management area A and approximately 48 miles located in travel management area B (Table 3.25). However, the Forest is aware that there are numerous unauthorized trails that have been generated by those riding off designated trails. Typically an unauthorized ATV trail is classified as a "non-system" road. The definition of a non-system road includes those roads which have been created by OHV use. Non-system roads are discussed under the roads sub-section of the transportation section. Preliminary data analysis indicates that the number of such unauthorized non-system roads totals approximately 3, 549 miles, which may be excessively high due to several data quality issues. For further information on non-system roads refer to the roads sub-section.

Impacts to aquatic, riparian and wetland ecosystems are a relatively recent occurrence (ATV History/Honda website); and International Snowmobile Manufacturers Association website). OHV related recreation is relatively recent land management activity when compared to logging or road building. The sky-rocketing numbers mean that even very small amounts of use off of planned Forest roads and trails has resulted in considerable environmental impact to the environment, including aquatic, riparian, and wetland resources. (*Http://www.fs.fed.us/recreaton/programs/ohv*).

The extent that intensive OHV use can affect these ecosystems is dependent primarily on watershed size (USDA Forest Service, 2003). Changes to water quality and to the health and function of riparian and wetland systems are primarily related to petrol-chemicals, heavy metals contaminants, compaction, erosion, and sedimentation.

Degradation of water quality has been closely associated with OHV use according to Dissmeyer, 2000. Ibarra and Zipperer, 2001, note that dry and wet deposition of fuel-emission products, heavy metal contaminants from engine exhaust and catalytic converters resulted in degraded water quality. The introduction of these wet and dry deposits can lead to modification of pH and alkalinity, as well as increase the level of toxic substances in the water column.

Unregulated OHV traffic has been correlated with severe channel geometry alteration as well as modifying stream substrate composition (Clark and Gibbons, 1991). Channel cross-section geometry can be modified at stream crossings. Where stream crossings by OHVs are un-controlled uncontrolled increased erosion and sedimentation can increase in substrate embeddedness. With increased erosion and sedimentation there would be correlated increases in turbidity, water temperature, and a decrease in dissolved oxygen, in both the lotic (moving water) and lentic (sluggish) water environments.

Indiscriminant use of OHV in riparian and wetland areas can degrade or destroy the structure and function of these ecosystems (Natural Trails and Water Coalition, 2001). Potential effects to these environments include exhaust affecting plant photosynthesis and primary productivity, compaction, alteration of surface and subsurface flow due to compaction related to tire ruts.

In addition altering flow, compaction by OHV use alters soil structure. Soil porosity and infiltration rates are typically decreased. With indiscriminant OHV use riparian vegetation is typically crushed and/or ripped from the soil profile.

Degradation of biotic conditions can be related to three major factors: erosion, sedimentation, chemical contamination. An additional factor that should be considered is direct mortality due to crushing. Of these factors, the decline in water quality has the most pervasive effects to aquatic, riparian, and wetland biota (USDA Forest Service, 2003). This is due to water quality requirements by numerous life-stages of aquatic plants, insets and animals. Ibarra and Zipperer, 2001, Rawlins, 1993, and Hagan and Langeland, 1973) indicate that aquatic insect nymphs and amphibian eggs and larvae are the most sensitive to changes.

OHV use can also facilitate the introduction of both exotic plant and animal species due to access corridors and transport on the machines themselves. The spread of infectious disease (e.g. whirling disease and bacterial kidney disease) is also associated with OHV use. This is due to contaminated sediments being compacted into tire treads that then come into contact with an uncontaminated aquatic environment. Elevated OHV use may also result in increased exploitation of recreational fisheries stocks by providing increase access (USDA Forest Service, 2003).

Table 3.24 Summary of Forest travel management designations and associated acreages

Travel Management Designation	Travel Designation Definition	Management Purpose	# Acres on the Forest*
A	Closed all year to passenger cars, high clearance 4WD, ATVs, motorcycles, snowmobiles	Erosion Control and Conflict of Interest	524,481
B	Closed year long to all vehicles types except for snowmobiles	Erosion Control and Conflict of Interest	565,917
C	Open to ATV's and motorcycles June1st-November 30th	Big Game Winter Range and Erosion Control	77,331
D	Open year long to ATVs, snowmobiles, and motorcycles. Closed to all other types of vehicle traffic	Erosion Control	81,606
E	Special Closures	See local office	13,555
F	Open all year to all types of vehicles traffic	Open	407,772

*Acreages calculated using GIS. Numbers have been rounded to nearest whole number.

Table 3.25 Summary of Designated OHV Routes*

Designated Route Name	Designated Route Name	Designated Route Name
Aspen Loop Trail	Bolam Pass	Silverton to Animas Forks
Bear Creek Trail	Hermosa Park Road	Minnie Gulch
Clear Lake Trail	Tuckerville	Maggie Gulch
Hermosa Creek Trail	Lime Creek Road	Engineer Pass
Little Bear Trail	Missionary Ridge Road	Cinnamon Pass
Lower Calico Trail	Junction Creek Good Hope Road	South Mineral Road
LaPlata Canyon to Kennebec Pass	Miller Mountain	Scotch Creek Road
Bedrock Creek Road	Cunningham Gulch	Brown's Gulch to Red Mountain Pass

6th Level HUB Information Needs

Off-highway vehicle use data on the San Juan National Forest is inconsistent. Data quality issues include OHV trails which are not included in the Forest's data set and several existing trails appear to be inconsistently attributed with system and non-system roads and foot trails. In order to fully understand and quantify the OHV use implications for the San Juan National Forest a Forest wide inventory of this activity is recommended. Activities that should be incorporated into this inventory include authorized and unauthorized snowmobile trails, ATV, and 4x4 trails.

It would also be very useful to have data collected that would define specific trends in OHV use to help evaluate and quantify the impacts related to OHV's on aquatic resources. For example what is the number of user days for OHV's and where are the highest areas of use?

By addressing the above information needs, questions such as how many inventoried campsites, associated with OHV use, do not meet Forest Plan standards could be answered. What percentages of these sites are located in valley bottoms? Which watersheds have the highest use and are most susceptible to OHV related impacts to aquatic resources? Such information is needed to help set priorities in fulfilling recreational needs and ensuring Forest Plan standards and guidelines are met for aquatic resources.

Management Implications at the 6th HUB Level

As data was not available to conduct quantitative analysis specific information on riparian and wetland clusters was not generated. However, if mitigation measures and effective management strategies are implemented regarding OHV use, the primary benefit to aquatic resources is expected to be that ecosystem function and health be maintained. For areas damaged by OHV use it is expected that health and function would be improved.

Direction for Reach/Site Scale Analysis

The reach/site scale is the appropriate scale to quantify the direct influences of OHV use on aquatic, riparian, and wetland ecosystems.
Priority should be given to areas located adjacent to and crossing aquatic resources. If inventories are conducted recommended focus areas include the magnitude and distribution of damage to soils, vegetation, stream channel morphology, water quality, and aquatic biota due to OHV use.

Specific questions related to inventory activity at the reach/site scale include:

1. Is OHV use restricted to a single route, or are multiple routes being used?
2. For any OHV trail of interest, has the route been located by GPS and has the route length been determined? Has the amount of aerial disturbance (# square feet) been determined? Has a visual description been made of the disturbance? Included in the description should be the types of erosion and their relative amount as more than one type of damage may occur. Damage types include, but are not restricted to: new track formation, multiple trail syndrome, trail incision and rill erosion, switch back cutting, damage to wet areas, bog formation, bank and channel disturbance, and splash erosion (www.timberlinellamasa.com/rgnforvuse/)Have photographs been taken? Have there been any measurements been made to help quantify and describe the influence of the trail on aquatic, riparian, and wetland resources?
3. Are excessive aquatic, riparian, and wetland vegetation being disturbed, and soils being compacted or is excessive rutting on wet/saturated soils occurring? The amount of disturbance, which may be classified as "excessive" should be defined prior to any studies at the reach level with Forest hydrologist.

4. Is there noticeable soil movement into aquatic, riparian, and wetland resources?
5. Is there noticeable invasive plant species colonizing the areas associated with OHV use?
6. Are there influences of OHV use on rare native flora and fauna, as well as desirable nonnative species?
7. Are there water quality concerns, such as fuel leakage, related to OHV use other than sediment?
8. Has OHV use and influences on aquatic, riparian, and wetland resources been monitored to identify trends over time?
9. Identify possible sites for monitoring trends over time and/or watershed restoration.

Transportation Overall Cumulative Percentile Ranking

In order to understand the total combined effects of roads, railroads, and trails on watersheds, the results of these metrics were combined, re-ranked, and a cumulative percentile ranking was determined. This analysis is relative only to the portion of the 6th level HUBs surface area within the San Juan National Forest boundary, and is intended to provide the reader with the additive rankings at this scale. Unlike the previous methodology, the results are evenly distributed across the total number of HUBs at this scale.

This analysis was performed at the management scale, with data existing for all portions of the 154 HUBs within the San Juan National Forest boundary. Ranking these watersheds delineates which watersheds have the most susceptible to transportation-related impacts on aquatic and riparian health. Rankings were divided into five differing groups, each with a 20 percentile ranges. Watersheds within the 100-80 percentile range have the most susceptibility to impacts on aquatic health while those falling within the 19.9-0.1 percentile range have the lowest potential for being influenced. The results of the cumulative ranking process for all transportation metrics, in all watersheds on the Forest, are summarized in Table 3.24 at the end of this section. This table also summarizes which riparian and wetland clusters are associated with each watershed on the Forest. Essentially this table will function as a "look up" table, so at a glance one can determine the influence of individual transportation types as well as have a reference to watershed sensitivity.

The sum of the percentile ranks of the 12 criteria of the urbanization category was calculated to identify the additive effects of transportation activity on aquatic, riparian, and wetland resources. The 12 criteria used in this analysis are summarized in Table 3.23.

The cumulative percentile ranking for the 100-80 percentile range is also summarized in Table 3.24 and displayed in map format in Figure 3.26.

Fourteen watersheds in the transportation category synthesis analysis fell within the 100-80 percentile range. The maximum cumulative ranking for transportation was 15. Four watersheds had a cumulative ranking of 12; six watersheds had ranked out at an "11", while four had rankings of "10". They all are found in the western half of the Forest. These watersheds reflect high levels of road, railroad and foot trail activity Table 3.25. However, railroads are not a dominant transportation activity where the cumulative transportation class values are "3" or less.

Upper Cherry Creek (HUB # 140801050105), Upper Animas Valley-Canyon Creek (HUB # 140801040501), Lower Lost Canyon (HUB # 140300020405), Upper Dolores River-Taylor Creek (HUB # 140300020209) all have the highest transportation category total score of 12. However, only the Upper Animas Valley-Canyon Creek and Upper Dolores River-Taylor Creek watersheds are located entirely on the Forest. As a result, these two watersheds could have the most influence on downstream on- Forest drainages. The Lower Lost Canyon watershed is located almost entirely off- Forest so there would be essentially no on- Forest impacts to aquatic health. The Upper Cherry Creek watershed is located about half on and half off the Forest. The result is that activities in the headwaters of this watershed, which is on National Forest land, has the very likely potential for downstream, off-Forest, impacts to aquatic health (See Table 3.24).

Elbert Creek (HUB # 140801040502), Lower Plateau Creek (HUB # 140300020304), Dolores River-Priest Gulch (HUB # 140300020207), and Upper Dolores River-Scotch Creek (HUB # 140300020204) have a total transportation category of 11. All these watersheds, except for Lower Plateau Creek are located on Forest and would have the potential for on- Forest downstream effects.

The head waters of Lower Plateau Creek are located off- Forest with the lower half of the watershed on- Forest. There may be potential for both on and off-Forest downstream impacts (See Table 3.24).

The six watersheds with a total transportation category of 10 are found in the western half of the Forest (See Table 3.24). Rico Valley (HUB # 140300020203) is the only one of the six completely located on- Forest.

Any impacts would be on- Forest and downstream. The majority of House Creek (HUB # 14030002040207) is on- Forest, but not entirely, as is Mineral Creek (HUB # 140801040103). As a result, any impacts to aquatic health would be off- Forest, would potential effects related to Chicken Creek (HUB #14080107014), West Mancos River (140801070102), and Upper Dolores River-Italian Creek (HUB # 140300020406) watersheds (See Table 3.24).

Watersheds falling within the 40-59.9 percentiles dominated the rankings and are found across the entire Forest (See Figure 3.23). Table (Transportation Cumulative Percentile Ranking All Watersheds on the San Juan National Forest) summarizes the dominant activity within each watershed and which watersheds are located entirely on-forest. The dominant transportation activities in this category are both roads and trails.

Watersheds falling within the 39.9-20 percentile range are found predominantly in the eastern two-thirds of the Forest, especially along the northern rim of the Forest, in the eastern half (Figure 3.23; Table 3.25). The dominant transportation activities in this category are again both roads and trails.

There are only four watersheds within the 19.9-0 percentile range and are located primarily off- Forest on a mixture of BLM and private land. Although these watersheds eventually flow onto National Forest land, any associated impacts to aquatic resources are expected to be minimal as trails are the major transportation activity.

Table 3.23 Summary of criteria used in transportation cumulative analysis, management scale, San Juan National Forest

Metric	Explanation
System Road Density	Miles of system road per square mile
System Paved Road Valley Floor Density	Miles of system road per square mile of valley floor
System Unpaved Road Valley Floor Density	Miles of system road per square mile of valley floor
System Road Ratio	System road miles per stream mile
System Paved Road Ratio	System paved road miles per stream mile
System Unpaved Road Ratio	System unpaved road miles per stream mile
System Paved Road Stream Crossing Ratio	Number of system paved road stream crossings per stream mile
System Unpaved Road Stream Crossing Ratio	Number of system unpaved road stream crossings per stream mile
Nonsystem Road Density	Miles of nonsystem road per square mile
Nonsystem Road Ratio	Nonsystem road miles per stream mile
Nonsystem Road Valley Floor Density	Miles of nonsystem road per square mile of valley floor
Nonsystem Road Stream Crossing Ratio	Number of nonsystem paved road stream crossings per stream mile

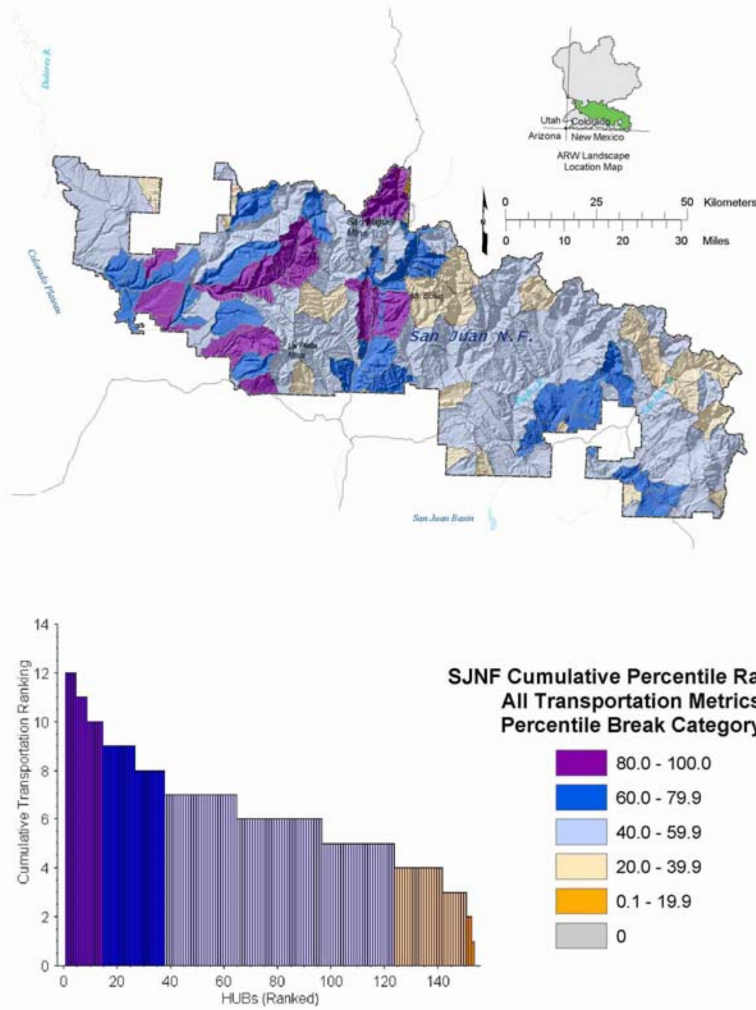

Figure 3.23 Transportation Categories, Cumulative Percentile Ranking for 6th Level HUB's, management scale, San Juan National Forest

Table 3.24 Transportation Categories, 100-80 percentile range, 6th HUB's, management scale, San Juan National Forest; Watersheds located entirely with the forest boundary are highlighted in light green

6th Level HUB	6th Level HUB Name	Cumulative Road Class	Cumulative Rail Class	Cumulative Trail Class	Total Transportation Categories	Cumulative Transportation Class	Riparian Cluster	Wetland Cluster
140801070104	Chicken Creek	5	0	5	10	5	4	3
140801070102	West Mancos River	5	0	5	10	5	2	1
140801050105	Upper Cherry Creek	5	5	2	12	5	5	4
140801040502	Elbert Creek	4	4	3	11	5	5	7
140801040501	Upper Animas Valley-Canyon Creek	5	5	2	12	5	1	2
140801040103	Mineral Creek	4	4	2	10	5	2	8
140300020407	House Creek	5	3	2	10	5	4	3
140300020406	Upper Dolores River-Italian Creek	5	3	2	10	5	4	3
140300020405	Lower Lost Canyon	5	5	2	12	5	4	3
140300020304	Lower Plateau Creek	4	5	2	11	5	5	4
140300020209	Upper Dolores River-Taylor Creek	5	4	3	12	5	5	3
140300020207	Dolores River-Priest Gulch	3	4	4	11	5	2	1
140300020204	Upper Dolores River-Scotch Creek	4	4	3	11	5	2	1
140300020203	Rico Valley	3	5	2	10	5	2	1

Figure 3.25 Transportation Category-Cumulative Percentile Rankings of all 6th level HUB's, management scale, San Juan National Forest; Watersheds located entirely with the forest boundary are highlighted in light green

6th Level HUB	6th Level HUB Name	Cumulative Road Class	Cumulative Rail Class	Cumulative Trail Class	Total Transportation Categories	Cumulative Transportation Class	Riparian Cluster	Wetland Cluster
140801070104	Chicken Creek	5	0	5	10	5	4	3
140801070102	West Mancos River	5	0	5	10	5	2	1
140801050105	Upper Cherry Creek	5	5	2	12	5	5	4
140801040502	Elbert Creek	4	4	3	11	5	5	7
140801040501	Upper Animas Valley-Canyon Creek	5	5	2	12	5	1	2
140801040103	Mineral Creek	4	4	2	10	5	2	8
140300020407	House Creek	5	3	2	10	5	4	3
140300020406	Upper Dolores River-Italian Creek	5	3	2	10	5	4	3
140300020405	Lower Lost Canyon	5	5	2	12	5	4	3
140300020304	Lower Plateau Creek	4	5	2	11	5	5	4
140300020209	Upper Dolores River-Taylor Creek	5	4	3	12	5	5	3
140300020207	Dolores River-Priest Gulch	3	4	4	11	5	2	1
140300020204	Upper Dolores River-Scotch Creek	4	4	3	11	5	2	1
140300020203	Rico Valley	3	5	2	10	5	2	1
140801070101	East Mancos River-Middle Mancos River	5	3	1	9	4	2	1
140801040804	Upper Florida River-Red Creek	3	0	5	8	4	5	3
140801040504	Upper Animas Valley-Trimble	3	4	2	9	4	5	5
140801040503	Upper Animas Valley-Stevens Creek	5	3	1	9	4	5	2
140801040303	Lower Cascade Creek	4	0	4	8	4	2	8
140801040204	Animas River-Needleton	1	5	3	9	4	2	8
140801040202	Animas River-Tenmile Creek	2	5	2	9	4	2	8
140801020402	Upper Stollsteimer Creek	4	1	3	8	4	5	4
140801020401	Martinez Creek-Dutton Creek	4	0	4	8	4	5	4

6th Level HUB	6th Level HUB Name	Cumulative Road Class	Cumulative Rail Class	Cumulative Trail Class	Total Transportation Categories	Cumulative Transportation Class	Riparian Cluster	Wetland Cluster
140801020302	Lower Devil Creek	5	1	2	8	4	6	3
140801020301	Upper Devil Creek	4	0	4	8	4	5	3
140801010507	Coyote Creek	4	4	1	9	4	4	3
140801010406	Lower Rio Blanco-San Juan River	5	2	1	8	4	4	4
140801010302	Fourmile Creek	3	0	5	8	4	2	3
140300020601	Dolores River-Salter Canyon	4	3	2	9	4	4	3
140300020408	McPhee Reservoir-Dolores River	4	2	2	8	4	4	4
140300020404	Stapleton Valley	4	3	1	8	4	4	3
140300020401	Upper Lost Canyon	5	0	4	9	4	2	1
140300020306	McPhee Reservoir-Beaver Creek Inlet	4	4	1	9	4	4	3
140300020305	Beaver Creek-Trail Canyon	4	5	0	9	4	4	3
140300020208	Stoner Creek	4	0	5	9	4	2	1
140300020202	Upper Dolores River-Cayton Valley	4	2	3	9	4	2	1
140300020102	Fish Creek	5	0	3	8	4	2	1
140802020106	Lower Alkali Canyon-Narraguinnep Canyo	4	0	1	5	3	6	6
140802020103	Hartman Canyon	4	0	1	5	3	6	6
140801070105	East Fork of Mud Creek	4	3	0	7	3	4	4
140801070103	Upper Mancos Valley	5	1	1	7	3	5	4
140801050102	Mayday Valley	4	2	1	7	3	7	3
140801050101	La Plata River headwaters	4	0	3	7	3	2	8
140801040901	Lower Florida River-Ticalotte	4	0	2	6	3	5	4
140801040803	Lemon Reservoir	4	0	3	7	3	2	1
140801040802	Upper Florida River-Transfer Park	4	0	3	7	3	1	7
140801040603	Lower Lightner Creek	2	0	4	6	3	4	4
140801040601	Junction Creek	3	0	3	6	3	2	3

6th Level HUB	6th Level HUB Name	Cumulative Road Class	Cumulative Rail Class	Cumulative Trail Class	Total Transportation Categories	Cumulative Transportation Class	Riparian Cluster	Wetland Cluster
140801040407	Lower Hermosa Creek	2	2	3	7	3	5	1
140801040406	Hermosa Creek-Dutch Creek	1	0	4	5	3	1	1
140801040405	South Fork Hermosa Creek	2	0	3	5	3	2	1
140801040403	Upper Hermosa Creek	2	0	3	5	3	2	1
140801040402	East Fork Hermosa Creek	5	0	1	6	3	2	1
140801040401	Hermosa Creek headwaters	4	0	1	5	3	2	1
140801040302	Lime Creek	2	0	3	5	3	2	8
140801040301	Upper Cascade Creek	3	0	4	7	3	2	8
140801040201	Elk Creek	1	2	4	7	3	3	8
140801020502	Piedra River-Stollsteimer	3	0	2	5	3	6	4
140801020501	Yellow Jacket Creek	4	0	2	6	3	4	4
140801020405	Lower Stollsteimer Creek	3	0	2	5	3	6	4
140801020404	Middle Stollsteimer Creek	3	0	2	5	3	6	3
140801020206	Upper Piedra River-Indian Creek	3	0	4	7	3	5	3
140801020205	Upper Piedra River-Box Canyon	2	0	5	7	3	5	3
140801020204	First Fork	3	0	3	6	3	2	1
140801020203	Sand Creek	3	0	3	6	3	2	1
140801020202	Lower Weminuche Creek	2	0	4	6	3	2	3
140801020104	Piedra River-O'Neal Creek	4	0	2	6	3	5	4
140801020103	Williams Creek	3	0	3	6	3	2	2
140801020102	Middle Fork Piedra River	3	0	3	6	3	2	7
140801020101	East Fork Piedra River	2	0	4	6	3	1	7
140801011704	Upper Spring Creek	3	0	2	5	3	6	4
140801011603	Lower Beaver Creek	4	0	2	6	3	5	4

6th Level HUB	6th Level HUB Name	Cumulative Road Class	Cumulative Rail Class	Cumulative Trail Class	Total Transportation Categories	Cumulative Transportation Class	Riparian Cluster	Wetland Cluster
140801011602	Middle Beaver Creek	4	0	2	6	3	5	4
140801011601	Upper Beaver Creek	5	0	2	7	3	5	4
140801011501	Middle Los Pinos River-Red Creek	3	0	4	7	3	5	3
140801011404	Vallecito Reservoir	3	0	3	6	3	5	3
140801011403	Lower Vallecito Creek	4	0	2	6	3	1	2
140801011306	East Creek	2	0	5	7	3	2	1
140801011305	Indian Creek	1	0	4	5	3	2	2
140801011304	Three Sisters	0	0	5	5	3	8	9
140801011303	Lake Creek	1	0	5	6	3	2	8
140801011302	Upper Los Pinos River-Flint Creek	1	0	5	6	3	2	8
140801011301	Upper Los Pinos River-Ricon La Vaca	0	0	5	5	3	2	8
140801010602	Montezuma Creek	3	0	2	5	3	4	4
140801010506	Little Navajo River	3	0	4	7	3	2	3
140801010504	Navajo River-Weisel Flat	4	0	2	6	3	4	3
140801010502	West Fork Navajo River	2	0	3	5	3	1	7
140801010405	Rito Blanco	5	0	2	7	3	5	4
140801010404	Middle Rio Blanco	3	1	1	5	3	4	3
140801010403	Rio Blanco River-Blanco Basin	2	0	4	6	3	2	2
140801010402	Fish Creek	1	0	5	6	3	1	7
140801010308	San Juan River-Eightmile Mesa	4	1	1	6	3	5	4
140801010307	Echo Canyon Reservoir	4	0	1	5	3	5	4
140801010306	Mill Creek	3	0	2	5	3	4	4
140801010305	McCabe Creek	4	0	2	6	3	5	4
140801010304	Upper Pagosa Springs	5	0	2	7	3	4	3
140801010303	Laughlin Park	2	0	4	6	3	5	1
140801010301	Turkey Creek	2	0	4	6	3	2	2
140801010203	Wolf Creek	5	0	2	7	3	1	7
140801010202	Beaver Creek	1	0	4	5	3	1	7
140801010102	Quartz Creek	2	0	4	6	3	1	7
140300036101	Naturita Creek	5	0	1	6	3	5	4

6th Level HUB	6th Level HUB Name	Cumulative Road Class	Cumulative Rail Class	Cumulative Trail Class	Total Transportation Categories	Cumulative Transportation Class	Riparian Cluster	Wetland Cluster
140300020605	Dolores Canyon-Joe Davis Hill	5	0	1	6	3	4	3
140300020604	Dolores Canyon-Lake Canyon	5	0	0	5	3	4	3
140300020603	Dolores Canyon-Cabin Creek	5	0	0	5	3	4	3
140300020602	Narraguinnep Canyon Natural Area	5	0	1	6	3	4	4
140300020511	Disappointment Valley-Wild Horse Reser	5	0	2	7	3	6	3
140300020510	Upper Disappointment Valley	4	0	1	5	3	6	6
140300020509	Pine Arroyo	5	0	2	7	3	4	3
140300020507	Dawson Draw	5	0	2	7	3	4	3
140300020506	Brumley Valley	3	0	2	5	3	6	4
140300020504	Ryman Creek	4	0	2	6	3	5	4
140300020502	Disappointment Creek Headwaters	5	0	1	6	3	5	1
140300020403	Middle Lost Canyon	4	2	1	7	3	4	3
140300020402	Spruce Water Canyon	4	0	1	5	3	4	3
140300020303	Calf Creek	4	3	0	7	3	5	4
140300020301	Upper Beaver Creek -McPhee	4	1	1	6	3	5	1
140300020206	Bear Creek	3	0	4	7	3	2	1
140300020205	Roaring Forks Creek	5	0	2	7	3	2	1
140300020201	Dolores River Headwaters-Tin Can Basin	3	3	1	7	3	2	1
140300020105	Lower West Dolores River	4	0	3	7	3	5	3
140300020103	Upper West Dolores River	2	0	3	5	3	2	1
140300020101	El Deinte Peak	2	0	3	5	3	2	1
140802020201	Upper Yellow Jacket Canyon	2	0	2	4	2	4	3
140801040801	Florida River Headwaters	0	0	3	3	2	8	9
140801040604	Animas River-Spring Creek	3	0	0	3	2	6	5
140801040602	Upper Lightner Creek	3	0	1	4	2	5	3

6th Level HUB	6th Level HUB Name	Cumulative Road Class	Cumulative Rail Class	Cumulative Trail Class	Total Transportation Categories	Cumulative Transportation Class	Riparian Cluster	Wetland Cluster
140801040404	Middle Hermosa Creek	1	0	3	4	2	2	1
140801040203	Needle Creek	0	0	3	3	2	8	9
140801040104	Animas River-Cunningham Creek	0	0	4	4	2	2	8
140801020503	Piedra River-Navajo Reservoir Inlet	1	0	2	3	2	6	3
140801020403	Stollsteimer Creek-Dyke Valley	3	0	1	4	2	4	4
140801020201	Upper Weminuche Creek	0	0	4	4	2	1	8
140801011703	Ute Creek	3	0	0	3	2	6	4
140801011503	Los Pinos River-Bayfield	3	0	0	3	2	5	4
140801011502	Bear Creek	3	0	1	4	2	5	4
140801011402	Middle Vallecito Creek	1	0	3	4	2	2	8
140801011401	Upper Vallecito Creek	0	0	3	3	2	2	8
140801010604	Upper Cat Creek	2	0	2	4	2	4	3
140801010601	San Juan River-Trujillo	3	0	1	4	2	6	3
140801010503	Navajo Peak	3	0	0	3	2	2	1
140801010401	Rio Blanco Headwaters	1	0	3	4	2	1	7
140801010204	Lower West Fork San Juan River	2	0	2	4	2	2	7
140801010201	Upper West Fork San Juan River	0	0	3	3	2	2	8
140801010104	East Fork San Juan River-The Clamshell	1	0	3	4	2	1	7
140801010103	Sand Creek	1	0	3	4	2	1	7
140801010101	Headwaters East Fork San Juan River	2	0	2	4	2	1	7
140300020505	Upper Disappointment Creek	3	0	1	4	2	5	4
140300020302	Upper Plateau Creek	3	0	1	4	2	5	4
140300020104	Groundhog Creek	4	0	0	4	2	2	1
140801040102	Cement Creek	2	0	0	2	1	3	8
140300020503	Sheep Camp Valley	0	0	1	1	1	5	4

6th Level HUB	6th Level HUB Name	Cumulative Road Class	Cumulative Rail Class	Cumulative Trail Class	Total Transportation Categories	Cumulative Transportation Class	Riparian Cluster	Wetland Cluster
140300020501	Bear Creek-Disappointment Creek	0	0	2	2	1	5	4
140801040101	Animas River above Howardsville	0	0	0	0	0	2	8

Chapter 4
Recreation Category
Management Scale

Key Findings

1. 90.5% of dispersed sites within the San Juan National Forest were within 800 meters of a road and over 89% were within 700 meters of a valley bottom. There is a direct correlation between dispersed recreation sites and their proximity to lakes.
2. Developed recreation sites are relatively uncommon in the San Juan Forest with the highest ratio of number of developed recreational sites per valley bottom stream mile being 0.11 or 4 sites per 37.27 miles of stream.
3. The Upper Florida River – Transfer Park, Vallecito Reservoir, and Piedra River – O'Neal Creek 6th level HUB's have the highest number of developed recreation sites per valley bottom.
4. 130 of the watersheds had some potential for dispersed recreation sites, most of which will be located in the valley floor.
5. The Stoner Creek, East Fork Hermosa Creek, East Mancos / Middle Mancos Rivers 6th Level HUBs have the highest density of potential dispersed recreation sites in the valley bottom
6. Only 2 6th level HUBs within the management scale have percentages of more than 33% for the percentage of stream mile downstream of ski areas/ total stream mile/ 6th level HUB.
7. Only 7 6th Level HUBs within the management scale have more than 15% of their stream length downstream from Nordic ski areas.
8. The additive effects analysis revealed that 33 of the 6th level HUBs were relatively uninfluenced by recreational activities.
9. 3 6th level HUBs had the highest values for all measured recreational activities except for being downstream of ski areas. 2 6th level HUBs had the highest values for being downstream of ski areas and were influenced to a lesser degree by other recreational influences.
10. The cumulative ranking of influences from recreational activities revealed a broad distribution throughout the San Juan National Forest.

Influence of Developed Recreation

Management Scale

Developed Recreation: Developed recreation tends to concentrate human activity in a localized area and generally requires infrastructure to support that activity. Infrastructure may include parking lots, restrooms, and shower facilities. Examples of developed recreation include camping or picnicking in established areas, downhill ski areas or resorts, and interpretive centers.

GIS analysis indicates that there are approximately 167 developed recreation sites which occur across the San Juan National Forest (Figure 4.1). These sites include family campgrounds, trailheads, boating and fishing sites, and trailheads.

They are generally located along existing travel ways, including the San Juan Skyway.

The Skyway is recognized as both a National Forest Scenic Byway and Colorado Scenic and Historic Byway. Interpretive services are provided at Chimney Rock Archaeological Area and Andrews Lake, near Molas Pass and the Weminuche Wilderness area.

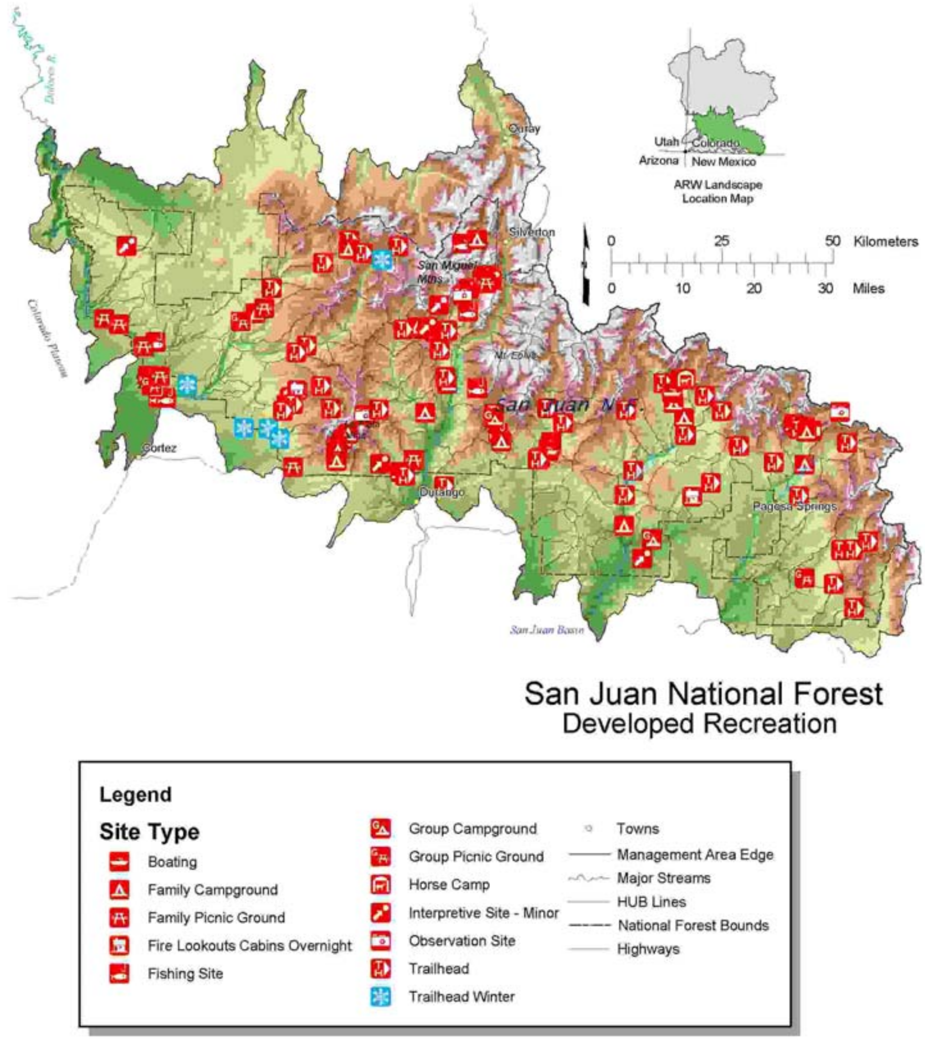

Figure 4.1 Recreation sites and principal roads in the San Juan National Forest.

Recreational uses vary seasonally, but their influences on and wetland resources can persist through out the year. Hydrologic effects include modification of peak runoff and non-point source pollution related to roads and parking lots, which have impervious surfaces. Additional sources of non-point pollution may be found in association with restrooms and shower facilities, which may contaminate surface and groundwater resources.

Common contaminates include fecal material household cleaner, detergents, garbage, oil and petroleum products, road salts, heavy metals derived from automobile exhaust, and landscaping chemicals. Water quality also may be altered as riparian vegetation is removed from streams, increasing solar ration and stream temperatures.

With this loss of riparian vegetation summer and winter water temperatures may exceed water quality criteria (USDA Forest Service 2003).

Riparian zones associated with developed recreation sites tend to be more susceptible to damage in these areas. Research has shown that largest amount of degradation occurs during periods of initial use (Cole, 1979, 1987; Marion and Cole 1996). Although degradation will occur with use in the riparian zone it should be noted that these effects will be less than those which are associated with logging, livestock grazing, and mining (Clark and Gibbons, 1991).

Effects in the riparian zone, associated with developed recreation include vegetation trampling, stream bank shearing, soil compaction, root exposure, reduction in organic matter available to the stream and to the soil profile, and decrease soil moisture. The degree to which these effects will play a role in the health of the riparian zone is also a function of the zone's width. If a riparian area is 50 ft wide impacts would generally be lower than compared to a 2 ft wide zone (USDA Forest Service, 2003). Clark and Gibbons, 1991, note that the greatest amount of disturbance is likely to occur within 5 m (16 ft) of the streams edge.

Stream bank and channel effects vary depending on the proximity of a developed recreation site to a stream channel and the intensity of its use. When activity is concentrated along the stream bank trampling may lead to stream bank collapse, which in turn can lead to degradation of aquatic habitat and an increase in levels of sediment introduction to the creek.

Channel morphology may also be degraded as a result of a decrease in vegetation, along with a decrease in root and plant vigor. Loss of root strength and integrity can lead to increased bank erosion and collapse. Also associated with concentrated use along stream backs is alteration of channel substrate and disruption of the streams natural pool/riffle ratios. Channel widening may also occur.

In addition, recreational activities may exert a strong influence on fisheries resources. The magnitude of associated effects, and the intensity threshold, will vary with the fish species and the specific characteristics of the water body, the type of recreational activity, and the number and timing of the recreationists (USDA Forest Service, 2003).

In order to evaluate the potential for developed recreational influences on aquatic, riparian, and wetland resources two metrics were analyzed. The first metric determined the ratio of developed recreational sites located in valley bottoms compared to a HUBs total number of developed recreational sites. The second metric determined the number of developed recreation sites per valley bottom stream mile.

60 out of 153 HUBs, or 39%, on the Forest have developed recreation sites located within them (Table 4.1). Of the 60 sites with HUBs only 10 of them have all their developed recreation sites located in valley bottom areas. Since so few HUBs forest wide have a preponderance of developed recreation sites located in valley bottom areas it is expected that any effects would be localized to areas adjacent to, and downstream of, the developed recreation site.

Table 4.1 Distribution of developed recreation sites among 6th level HUBs and comparison with valley bottom sites. Watersheds highlighted in light green are located entirely within the forest boundary.

HUB6	HUB6NAME	# Valley Bottom Sites	Total # Sites per HUB
140300020209	Upper Dolores River-Taylor Creek	1	1
140300020401	Upper Lost Canyon	1	1
140300020604	Dolores Canyon-Lake Canyon	1	1
140801010402	Fish Creek	1	1
140801010504	Navajo River-Weisel Flat	1	1
140801020102	Middle Fork Piedra River	1	1
140801020104	Piedra River-O'Neal Creek	2	2
140801020301	Upper Devil Creek	1	1
140801020401	Martinez Creek-Dutton Creek	1	1
140801040802	Upper Florida River-Transfer Park	4	4
140801010204	Lower West Fork San Juan River	2	3
140801011404	Vallecito Reservoir	4	8
140801020404	Middle Stollsteimer Creek	1	2
140801040303	Lower Cascade Creek	1	2
140801050102	Mayday Valley	1	2
140801010203	Wolf Creek	1	3
140801070102	West Mancos River	1	3
140801040402	East Fork Hermosa Creek	1	5
140801050101	La Plata River headwaters	1	6
140801020103	Williams Creek	1	7
140801070104	Chicken Creek	1	7
140300020408	McPhee Reservoir-Dolores River	1	15
140300020101	El Deinte Peak	0	3
140300020103	Upper West Dolores River	0	1
140300020105	Lower West Dolores River	0	7
140300020201	Dolores River Headwaters-Tin Can Basin	0	1

Table 4.1 continued

HUB6	HUB6NAME	# Valley Bottom Sites	Total # Sites per HUB
140300020202	Upper Dolores River-Cayton Valley	0	3
140300020206	Bear Creek	0	1
140300020207	Dolores River-Priest Gulch	0	1
140300020306	McPhee Reservoir-Beaver Creek Inlet	0	1
140300020406	Upper Dolores River-Italian Creek	0	1
140300020601	Dolores River-Salter Canyon	0	1
140300020603	Dolores Canyon-Cabin Creek	0	4
140801010104	East Fork San Juan River-The Clamshell	0	2
140801010301	Turkey Creek	0	1
140801010302	Fourmile Creek	0	1
140801010303	Laughlin Park	0	1
140801010403	Rio Blanco River-Blanco Basin	0	2
140801010404	Middle Rio Blanco	0	4
140801011306	East Creek	0	2
140801011403	Lower Vallecito Creek	0	3
140801020101	East Fork Piedra River	0	1
140801020202	Lower Weminuche Creek	0	1
140801020203	Sand Creek	0	1
140801020204	First Fork	0	1
140801020205	Upper Piedra River-Box Canyon	0	1
140801020206	Upper Piedra River-Indian Creek	0	1
140801040103	Mineral Creek	0	4
140801040202	Animas River-Tenmile Creek	0	1
140801040301	Upper Cascade Creek	0	1
140801040302	Lime Creek	0	12
140801040405	South Fork Hermosa Creek	0	3
140801040407	Lower Hermosa Creek	0	2
140801040501	Upper Animas Valley-Canyon Creek	0	1
140801040502	Elbert Creek	0	7

Table 4.1 Continued Distribution of developed recreation sites among 6th level HUBs and comparison with valley bottom sites. Watersheds highlighted in light green are located entirely within the forest boundary.

HUB6	HUB6NAME	# Valley Bottom Sites	Total # Sites per HUB
140801040504	Upper Animas Valley-Trimble	0	2
140801040601	Junction Creek	0	3
140801040603	Lower Lightner Creek	0	1
140801040604	Animas River-Spring Creek	0	1
140801040803	Lemon Reservoir	0	4
140801050105	Upper Cherry Creek	0	2
	TOTALS	**30**	**167**

Figure 4.2 and Table 4.2 summarize the results for evaluating the ratio of developed recreational sites located in valley bottoms compared to a HUBs total number of developed recreational sites. Four watersheds were found to be within the 80-100 percentile range for this metric (Table 4.2).

All four of the watersheds had 1 developed recreation site located within their valley bottom areas. Three of the watersheds are located in the western half of the forest (Figure 4.2). The developed recreation sites associated with the valley bottom areas of these three watersheds are the Bear Creek Trailhead, the Jersey Jim Fire Lookout and overnight cabins, and the Fish Creek Trailhead.

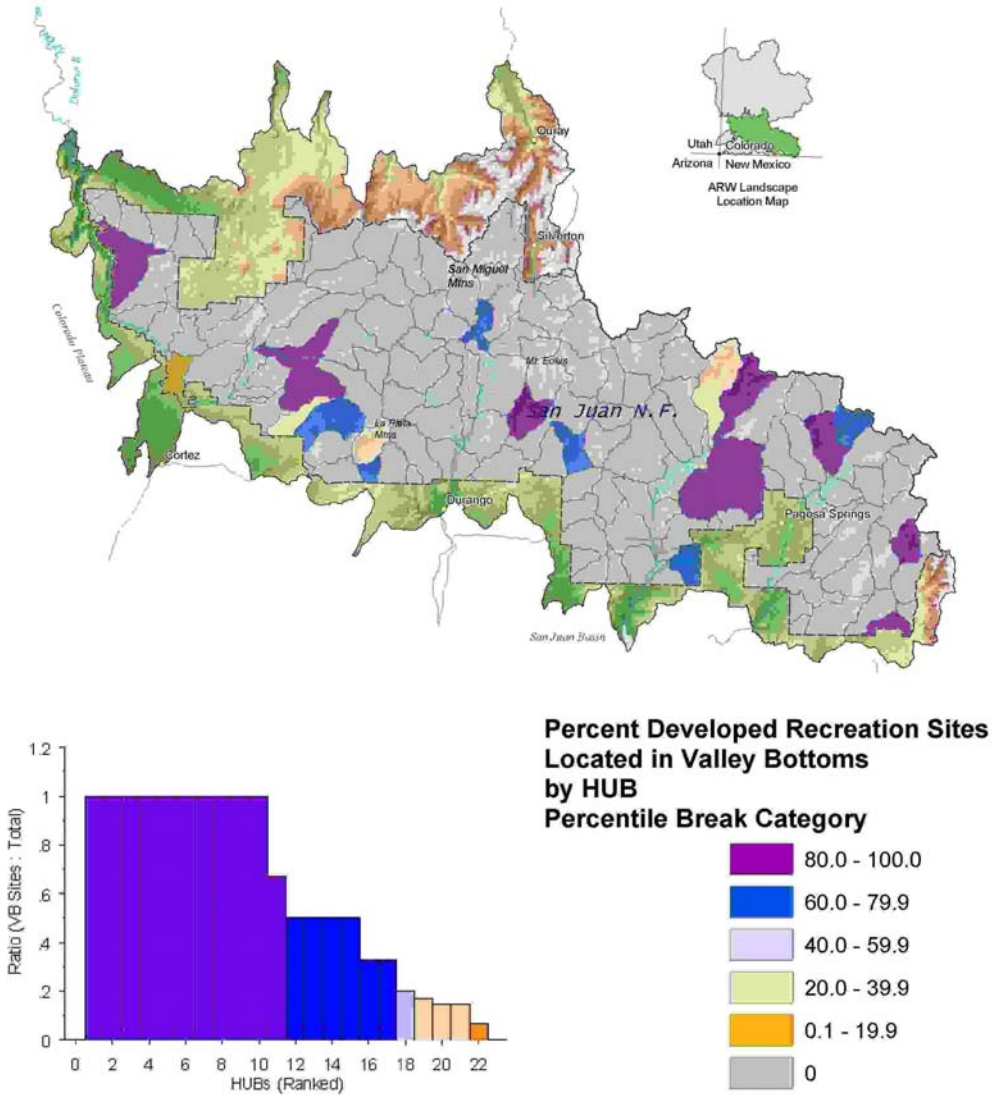

Figure 4.2 Rank and distribution of watersheds, within the 80-100 percentile range, for the ratio of valley bottom developed recreational sites compared to the total number of sites per HUB, management scale, San Juan National Forest.

Table 4.2 Summary of HUBs within the 80-100 percentile range, for the ratio of valley bottom developed recreational sites compared to the total number of sites per HUB, management scale, San Juan National Forest.
Watersheds highlighted in light green are located entirely within the forests boundary.

HUB6	HUB6NAME	# Valley Bottom Sites	Total # Sites per HUB	Ratio of # Valley Bottom Sites to Total # per HUB
140300020209	Upper Dolores River-Taylor Creek	1	1	1
140300020401	Upper Lost Canyon	1	1	1
140300020604	Dolores Canyon-Lake Canyon	1	1	1
140801010402	Fish Creek	1	1	1

The number of developed recreation sites per valley bottom stream mile was calculated in order to provide a more in-depth analysis of which HUBs and areas had the highest potential influences on aquatic resources. Four watersheds were found to have high potential for effects under this metric. All four watersheds are found in the eastern half of the Forest (Figure 4.3). The results of the analysis are summarized in Table 4.3.

All four watersheds are located entirely within the forests boundary. As a result, the high potential for the effects developed recreation is primarily found on-forest. However, Vallecito Reservoir (HUB140801011404) and Upper Florida River-Transfer Park (HUB 140801040802) watersheds which have the two highest ratios are located near southern border of the forest, near Vallecito and Lemon Reservoirs. For these two watersheds there is the potential for off-forest effects, especially for the Florida River-Transfer Park (HUB 140801040802) watershed which is immediately adjacent to the forest boundary.

Fish Creek (HUB 140801010402) watershed is found within the South San Juan Wilderness. Although its ratio of sites per valley bottom stream mile at 0.06 is the lowest of those watersheds featured in Table 4.3, the fact that it is in a wilderness area elevates the level of concern regarding the potential for effects on aquatic resources. The developed recreation sites are associated with the Fish Creek trailhead.

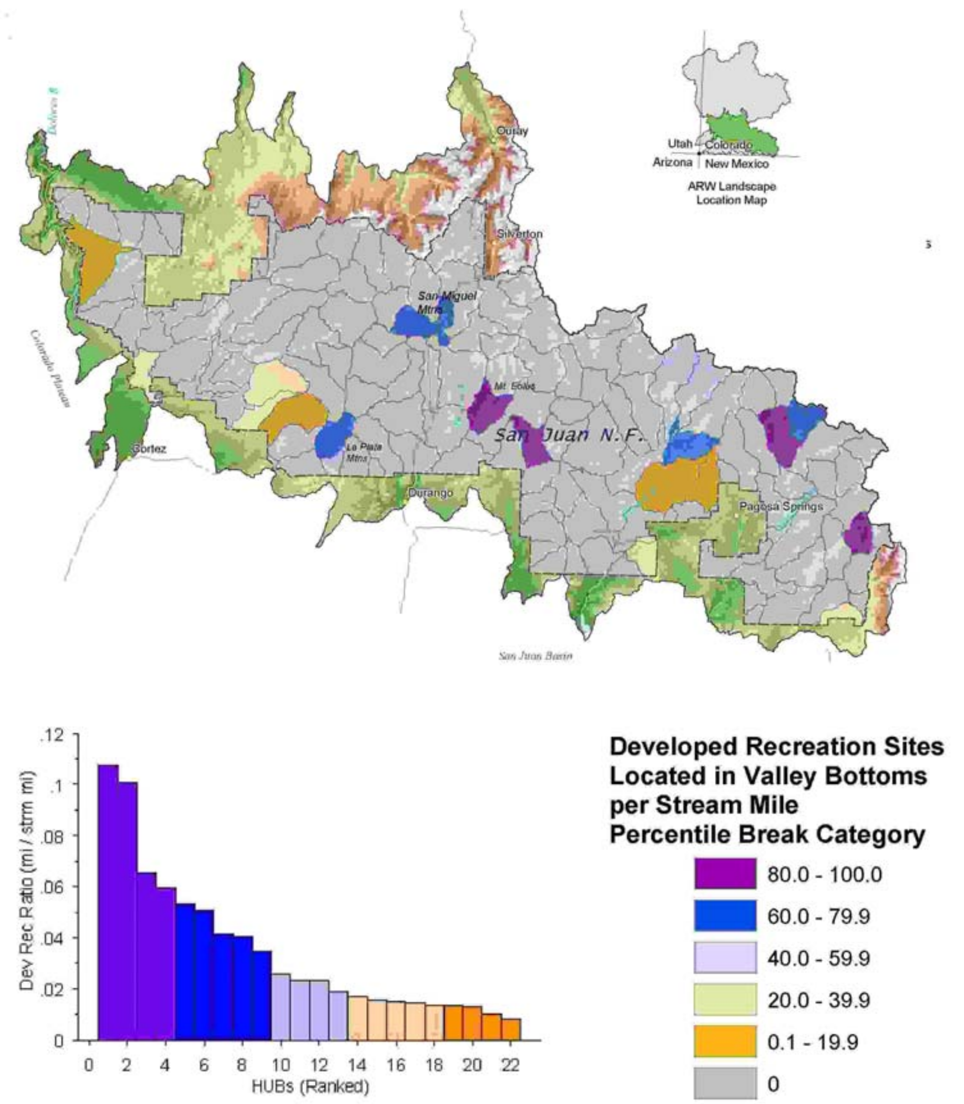

Figure 4.3 Rank and distribution of the number of developed recreation sites per valley bottom stream mile, 80-100 percentile range, management scale, San Juan National Forest.

Table 4.3 Summary of watersheds within the 80-100 percentile range for the number of developed recreation sites per valley bottom stream mile, management scale, San Juan National Forest.

HUB6	HUB 6 NAME	Miles of Stream per HUB	# of Sites Per HUB	Ratio
140801011404	Vallecito Reservoir	37.27	4	0.11
140801040802	Upper Florida River-Transfer Park	39.82	4	0.10
140801010204	Lower West Fork San Juan River	30.37	2	0.07
140801010402	Fish Creek	16.84	1	0.06

6th Level HUB Information Needs

Developed Recreation:

- **Ask Kelly and Dave Baker**

Management Implications at the 6th HUB Level – Developed Recreation

Information for this section is derived from the Ecological Driver Analysis (Report 1 of 3) and the Synthesis (Report 3 of 3), in the 2006 San Juan Aquatic, Riparian, and Wetland Ecosystem Assessment. When developing or evaluating proposed projects Reports 1 of 1 and 3of 3 should referred to obtain detailed information on the sensitivity of fisheries, riparian vegetation, aquatic productivity, and benthic macroinvertebrate responses changes in hydrology, sediment, thermal regime, nutrients, and biota.

The Upper Florida River-Transfer Park (HUB# 140801040802), East Fork Hermosa Creek (HUB# 140801040402), Fish Creek (HUB#140801010402), Piedra River-O'Neal Creek (HUB# 140801020104), and the Upper Dolores River-Taylor Creek (HUB# 140300020209) watersheds all had a score of 5 for their cumulative percentile rank, the highest rank possible, indicating the high likelihood of there being impacts to aquatic health associated with developed recreation. (Table 4.19).

These watersheds are dominated by riparian clusters 1r and 5r and wetlands clusters 3w, 4w, and 7w. Riparian clusters 1r and 5r are moderately to highly sensitive to changes in hydrology, sediment, and thermal regime (USDA Forest Service, 2006, Report 1of 1, Report 3 of 3). Wetland clusters 3w, 4w, and 7w are all highly sensitive to changes in hydrology with low to moderate sensitivities to sediment fluctuations, and low sensitivity to thermal modification.

Increased sediment loads can result from roads being too close to streams and riparian areas or the degradation of stream banks and vegetation due to concentrated foot traffic. Clusters 1r and 7w are both dominated by high and moderate gradient streams. As a result, the importance of low gradient streams for riparian\ vegetation and aquatic and fisheries habitat is magnified. Temporary storage of additional sediment could result in degrading habitat in the low gradient streams. Degradation or removal of riparian cover, associated with developed recreation sites or roads, could result in increased stream temperatures. As a result of increased stream temperature, production could increase while decreasing or eliminating cold-adapted, high elevation aquatic species.

In riparian cluster 2r fisheries, riparian vegetation, and aquatic productivity and benthic macroinvertebrate resources have a high susceptibility to alterations in hydrology and thermal conditions, as the regime is largely dependent upon snowmelt contributions to streamflow. As a result, increased use of water associated with developed recreation sites could exacerbate this sensitivity. Fisheries and riparian vegetation within this cluster are moderately to highly sensitive to sediment due to associated volcanic rock. However, aquatic productivity and benthic macroinvertebrates are rated as having a low sensitivity to sediment due to the dominance of high gradient channels. Cluster 2r is moderately sensitive to nutrient increases.

These watersheds also scored a cumulative total of 4 for all or some of the following anthropogenic uses: vegetation management, transportation, dispersed recreation, and water uses. These uses also result in hydrologic modification, water quality contamination, increased erosion and sediment generation, nutrient influxes, and riparian vegetation degradation or loss are effects associated with developed recreation sites.

Based on the above information the following general management recommendations are made:

- Do not implement additional developed recreational opportunities in those watersheds receiving a cumulative percentile rank of "5", especially where these watersheds score a cumulative percentile rank of "4" or "5" for all other anthropogenic categories.
- For watersheds ranked with a cumulative percentile total score of "4" any proposed developed recreation projects must: evaluate potential impacts in context of the sensitivity to change for the fisheries, riparian vegetation, aquatic production, and benthic macroinvertebrates in the riparian and wetlands cluster sensitivities within the proposed project area. Evaluation would include determining what levels of activity, for other anthropogenic factors within the project area, have received for their cumulative percentile ranks.

Ensure discussion of these other influences, especially where an anthropogenic factor has received scores of "5" and "4". Require mitigation measures proven effective in preventing or minimizing change to hydrology, sediment, and thermal regimes for riparian clusters 1r and 5r and wetlands clusters 3w, 4w, and 7w.

- In any future proposed developed recreation projects involving Cluster 1r should avoid areas with low gradient reaches containing riparian vegetation, aquatic plants and animals, as these channels are scare in this riparian cluster. These clusters are characterized by high elevation and relatively low potential productivity. As a result, avoiding damage to these channels is more cost effective than attempting mitigation and restoration.
- Cluster 5r is one of the most productive of the riparian clusters due to its association with calcareous geology and is affected by only moderate levels of anthropogenic activity. As this cluster is sensitive avoidance of impacts is recommended however if the potential for influence is moderate or high mitigation should be required.
- Wetland clusters 3w and 4w represent opportunities for restoration of individual wetlands in associated with existing or proposed developed recreation projects.
- 93% of watersheds found within wetland cluster 7w are located on-forest. Mitigation efforts with proposed developed recreation projects should be required to ensure functionality and monitoring is strongly recommended.

Direction for Reach/Site Scale Analysis

Developed Recreation: Inventories should be conducted at the reach/site scale anytime that developed recreation sites are located near water. A primary concern at the reach/site scale is septic system and outhouse locations, as these may be sources of water contamination. Recording visitor use at these sites may also be useful to identify locations where existing septic systems and outhouse facilities may be over taxed and have the potential for failure. In addition, the aerial extent and surface composition of parking areas could be measured because they have the potential to affect hydrology and speed the delivery of sediments and contaminants to streams that may affect water quality. In addition runoff may supply additional flow volume to the stream.

It is recommended that inventories be conducted at the reach/site scale when developed recreation sites are located within 300 ft of water.

The following items are recommended for when an inventory is conducted:

- Determine if hydrology has been altered. If so, how?
- Have there been unacceptable changes in water quality caused by non-point source pollution and or point source pollution? Recording the amount of visitor use at the septic system and outhouse locations. Data would be used to identify locations where existing septic systems and outhouse facilities may be overtaxed and have the potential to fail.

- Has sediment yield and delivery to streams been increased due to the developed recreation site? Identify measure and record the surface composition and aerial extent of parking areas. This data would be used to help assess the potential for sediment and contaminant delivery to streams.
- Has channel morphology been altered? Does there appear to be elevated levels of sediment being delivered either due to runoff from roads, parking lots, or bank degradation due to trampling and over use or the loss of vegetation?
- Has riparian habitat been modified? If so, how and to what extent? Is there the potential for loss of shade and supply of organic matter to the stream affecting habitat health and stream temperatures?
- What is the degree and extent of soil compaction?
- What types of recreational activities appear to be the cause of any observed damage? Develop recommendations, if needed for the restriction of recreational activity or modification of the developed site itself.

Influence of Ski Area Development

Management Scale- Downhill Ski Areas

At present almost 60% of all downhill ski resorts in the United States are located on National Forests (ARWA, Report 2 of 2, 2003). Currently many ski areas are trying to develop facilities for summer outdoor recreation activities, which expands their period of active operation.

The influence of ski areas on the dynamics of streams, aquatic organisms, and riparian areas or wetlands can be considerable. Ski areas are typically located in high elevation sites, which are often glaciated with relatively high precipitation. Often, these areas are characterized by large tracts of riparian and wetland ecosystem types. Slopes are often steep with thin soils, with the subsurface containing high proportions of cobbles and gravels. With the development and operation of ski resorts extensive portions of these fragile landscapes are disturbed.

Due to the complex and fragile nature of these ecosystems there is high potential for effects on hydrologic, aquatic, and riparian resources, related to the development and operation of a ski resort. One of the most significant concerns is related to the alteration of local hydrology. When ski area facilities are constructed and operated there is the potential for modification of water quality and alteration of the areas natural hydrologic processes. This includes shortages or dramatic fluctuations in water quantity (Ibarra and Zipperer 2001). These potential impacts are due to consumptive use of water and snowmaking. Other resort related actions may contribute salts, hydrocarbons, and nutrients to water supplies. Salt may be used to melt snow on roads, while the hydrocarbons come from roads or parking lots. During winter waste disposal systems function at slower rates and microbes can survive longer in the water and soil (US EPA, 1999). As a result there may be increases in nutrients related to actual sewage and fertilizers. Channel modifications may also occur due to water withdrawals for snowmaking. Water withdrawals can reduce flow volume and alter the timing of peak flows. Additional sediment from vegetation removal and other soil disturbance can result in increased sediment and alteration of a channel's morphology.

Within the San Juan National Forest, there is only one ski area, the Durango Mountain Resort, formerly known as Purgatory. The resort is approximately 25 miles north of Durango, Colorado (Figure 4.4). It encompasses approximately 2,400 acres located in portions of four different watersheds. 54% of the ski resort is found in the East Fork of Hermosa Creek watershed (HUB 140801040402) and 47% is in the Lower Cascade Creek watershed (HUB 140801040303). The other 3% of the area is found in the Elbert Creek (HUB 140801040502) and Upper Animas Valley-Canyon Creek (HUB 140801040501) watersheds.

This acreage distribution is reflected in the analysis on which HUB has the most potential for being influenced by ski resort related effects (Figure 4.5). The East Fork of Hermosa Creek watershed (HUB 140801040402) was the only watershed to be ranked in the 80-100 percentile range and is highlighted in light purple in Table 4.4. With twelve percent of the watershed, found within the ski area boundary, it has the most potential for reflecting ski area related effects. However, Lower Cascade Creek has 10% of its watershed within the ski area boundary. As Elbert Creek and Upper Animas Valley-Canyon Creek have less than 1% of their area within the ski area they have little potential for being influenced by the resorts activities. All four watersheds are located entirely on-forest.

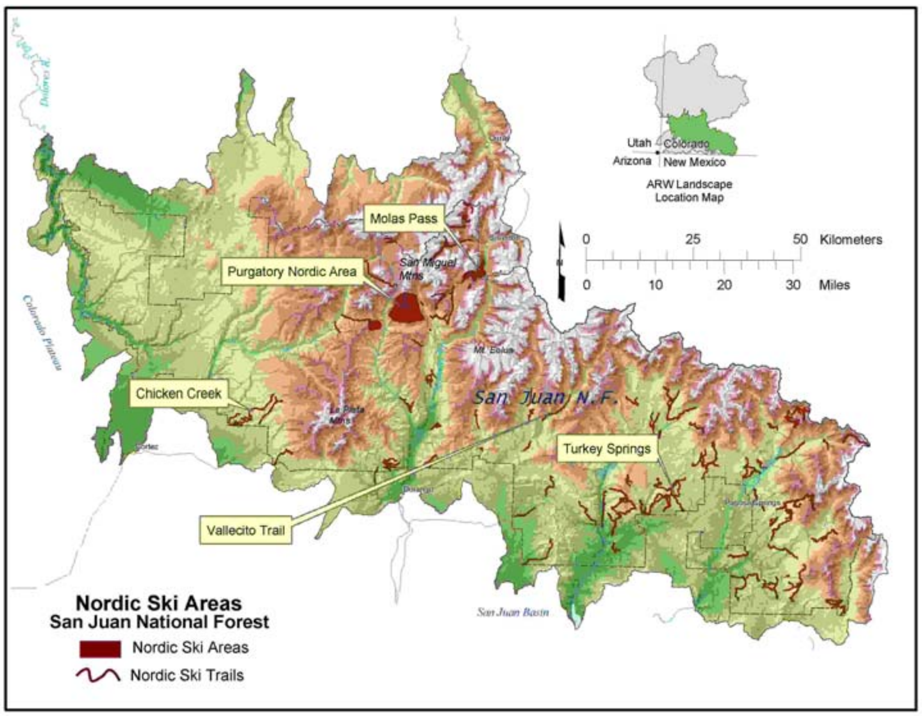

Figure 4.4 Location map of downhill and Nordic ski areas located on the San Juan National Forest, management scale.

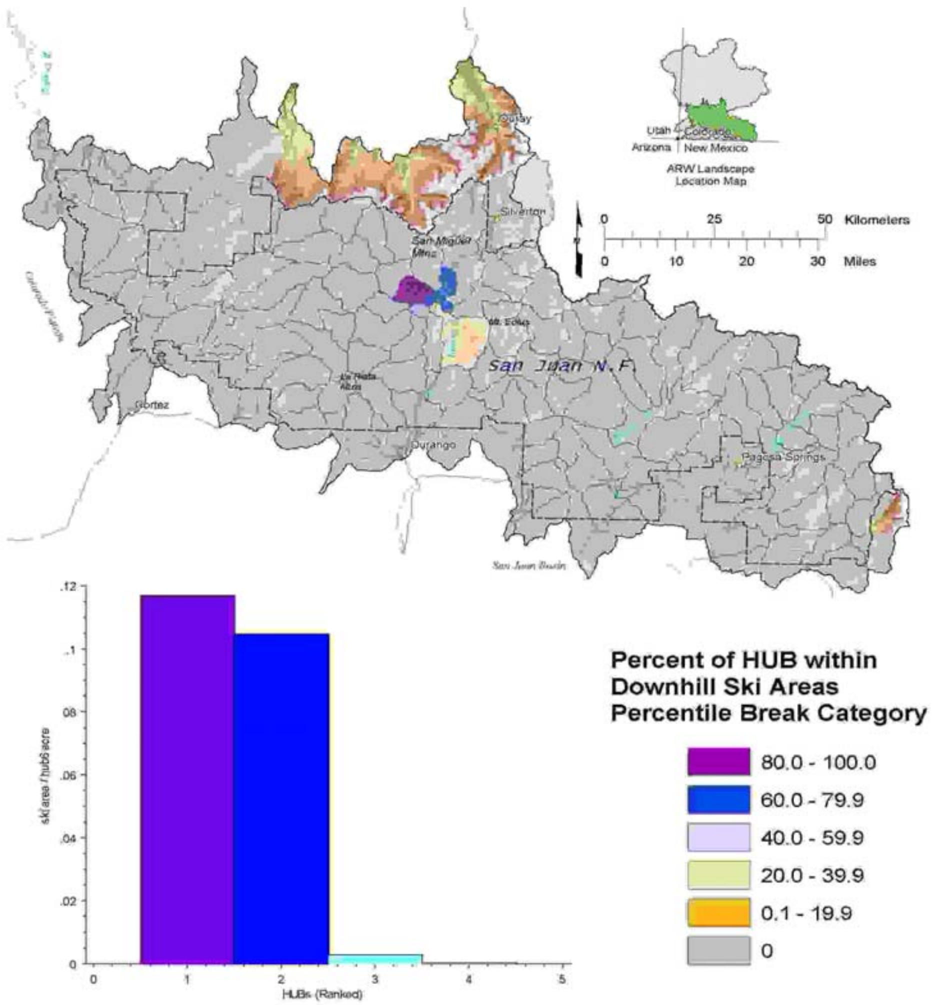

Figure 4.5 The rank and distribution of HUBs involved in the Durango Mountain Ski Resort (Purgatory), San Juan National Forest, management scale.

Table 4.4 Summary of the percent of a HUB within the Durango Mountain Resort Ski Area Boundary, management scale, San Juan National Forest.

HUB Number	HUB NAME	% of HUB Within Ski Area Boundary
140801040402	East Fork Hermosa Creek	12
140801040303	Lower Cascade Creek	10
140801040502	Elbert Creek	<1
140801040501	Upper Animas Valley-Canyon Creek	<1

Analysis also determined what percentage of each HUB's valley bottom was within the ski area. This metric was calculated in order to provide a more focused evaluation for potential effects as valley bottom areas typically include riparian and wetlands areas, which are susceptible to the effects of erosion, sedimentation, and alteration of hydrologic cycles. The East Fork of Hermosa Creek watershed (HUB 140801040402) again was the only watershed to be ranked in the 80-100 percentile range and is highlighted in light purple in Table 4.5. The valley bottoms in this watershed have the most potential for experiencing deleterious effects related to the ski area. However, valley bottoms in the other three watersheds only have 0-4% of their valley bottoms involved. As a result, it is very unlikely that these valley bottoms would experience degradation of water quality, quantity and hydrologic function.
The rank and distribution of watersheds in this analysis are shown in Figure 4.6.

Table 4.5 Summary of HUB's percent valley bottom within the Durango Mountain Ski Resort boundary, San Juan National Forest, management scale.

HUB6	NAME	%HUB's Valley Bottom Within Ski Area Boundary
140801040402	East Fork Hermosa Creek	19
140801040303	Lower Cascade Creek	4
140801040502	Elbert Creek	<1
140801040501	Upper Animas Valley-Canyon Creek	0

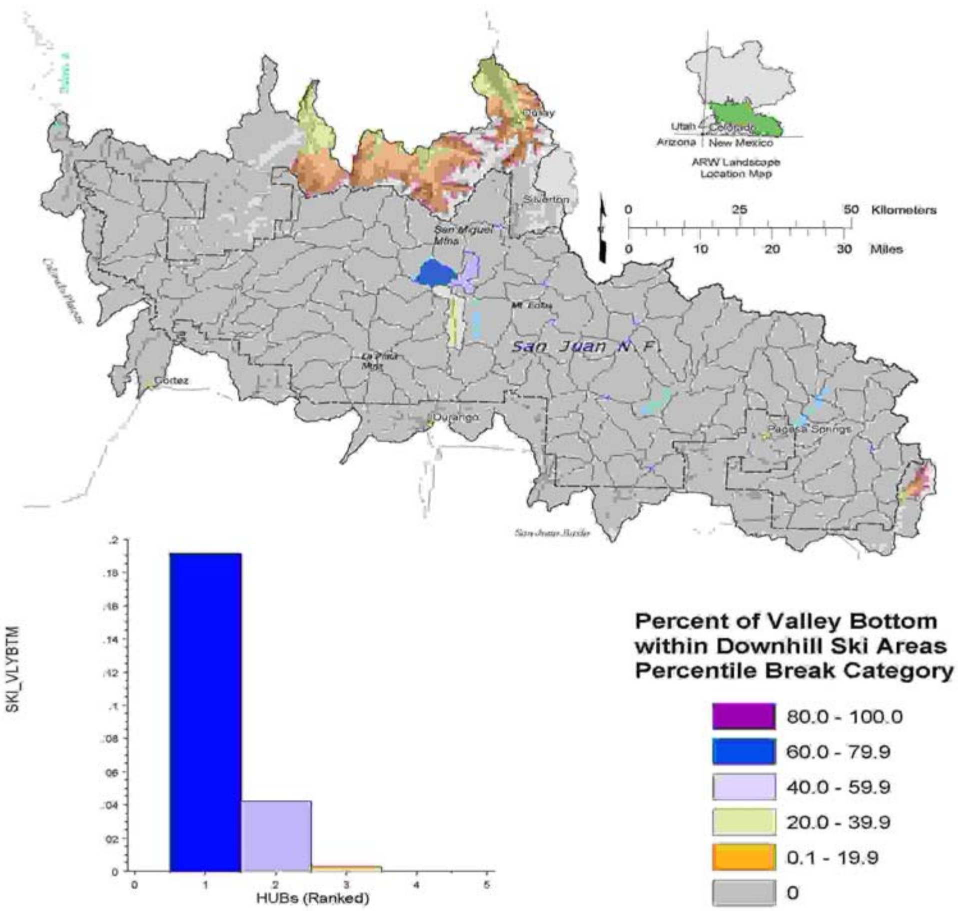

Figure 4.6 The rank and distribution of HUBs with valley bottom areas within the boundaries of the Durango Mountain Ski Resort (Purgatory), management scale, San Juan National Forest.

Effects on aquatic resources, located downstream of ski resorts, have been documented by Gosz, 1977, Behnke, 1992, and Molles and Gosz, 1992. As a result, the number of miles of permanent stream potentially affected below Durango Mountain Resort, to where these streams intersect the 6th level HUB boundary, per total stream miles for each HUB, was calculated. The results of this analysis are displayed in Figure 4.7 and Table 4.6. Only the East Fork of Hermosa Creek and Lower Cascade Creek watersheds had permanent streams below the ski area boundary. Analysis results indicates that only the East Fork of Hermosa Creek watershed is within the 80-100 percentile range, indicating that it has the highest potential for permanent streams, downstream of the ski area, to be influenced by the ski resort. It is highlighted in light purple in Table 4.6. However, examination of Table 4.6 does not show a large numeric difference between the two watersheds in terms of total stream miles and miles of stream downstream of the ski area. As a result, although statistically the East Fork of Hermosa Creek has the most potential for effects Lower Cascade Creek likely would experience similar effects.

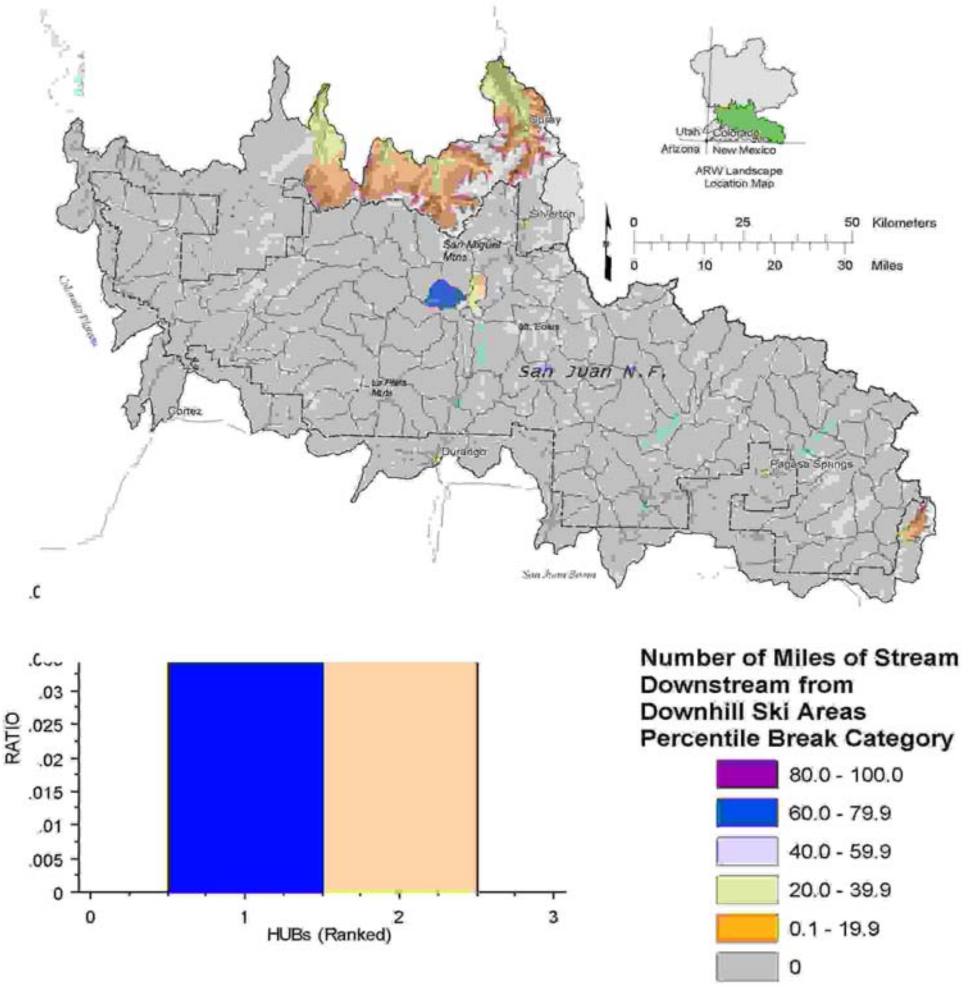

Figure 4.7 The rank and distribution of HUBs within the 80-100 percentile range for the ratio of miles of stream downstream of Downhill Ski Areas compared to total stream miles per HUB, management scale, San Juan National Forest.

Table 4.6 Summary of HUBs, Total Stream Miles in a HUB, and Miles of Stream Downstream from Durango Mountain Ski Resort, management scale, San Juan National Forest.

HUB #	HUB Name	Total Miles of Stream in HUB	# Miles of Stream Downstream of Ski Area	Ratio of # Miles Downstream/Total Stream Miles in HUB
140801040402	East Fork Hermosa Creek	39.2	1.7	0.043
140801040303	Lower Cascade Creek	40.8	1.6	0.042

Management Scale- Nordic Ski Areas

Nordic ski areas and centers are found across the forest. The forest's brochure entitled "Where to Go in the Snow on San Juan Public Lands" lists 29 designated areas for Nordic skiing, which includes both trails and Nordic ski areas. Figure 4.8 displays the location of the major Nordic areas on the forest and the trails and areas are summarized in Table 4.7.

The densities of Nordic ski centers/designated Nordic trails were analyzed at the 6th HUB level in order to define any areas that would occur within the 80-100 percentile range, as any watersheds occurring within this range would have the highest potential for being influenced by Nordic skiing related effects. Analysis indicates that 16 watersheds fall within the 80-100 percentile range. Table 4.8 lists these watersheds and the percentage of each HUB that is found within the Nordic area. Their rank and distribution throughout the forest are shown in Figure 4.9.

The East Fork of Hermosa Creek (HUB 140801040402), Hermosa Creek headwaters (HUB 1401040401), and Upper Cascade Creek (HUB 140801040301) watersheds have the three highest percentages of their HUBs involved with Nordic skiing. The elevated percentages for these three watersheds are associated with the Nordic center at Durango Mountain Resort (DMR). DMR was formerly known as Purgatory ski area. The Scotch Creek trail, which is also used for cross-country skiing is also located in the Upper Hermosa Creek.

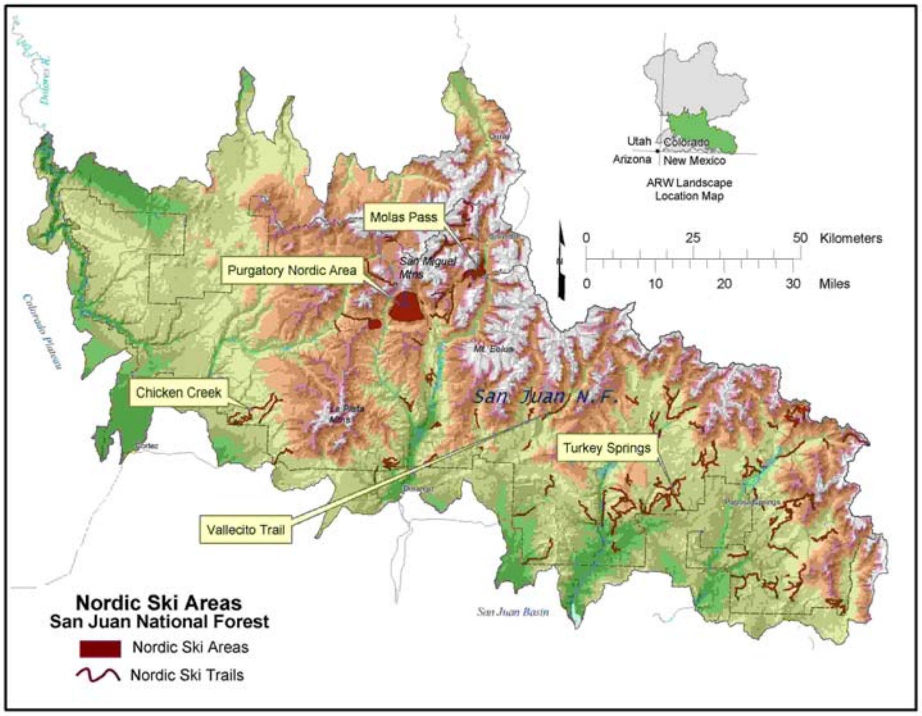

Figure 4.8 Location Map of Select Nordic Areas within the San Juan National Forest

Table 4.7 Summary of Designated Nordic Trails and Centers within the San Juan National Forest*

Dolores Ranger District	Columbine Ranger District	Pagosa Ranger District
Boggy Draw	Beaver Meadows and First Notch Loop	Wolf Creek Pass
House Creek	East Vallecito Cross-Country Ski Trails	Wolf Creek Trail
Beaver Creek	Middle Mountain	Fall Creek Trail
Chicken Creek Cross-Country Ski Area	Vallecito Trail	West Fork Trail
West Mancos	Lemon Reservoir	East Fork Trail
Echo Basin	Missionary Ridge	Plumtaw Trail
Roaring Forks	Haviland Lake and Chris Park	Williams Reservoir Area
Scotch Creek	Old Lime creek Road	Turkey Springs Hut and Trail System
Barlow Creek	Molas Pass Winter Recreation Area	
Lizard Head	South Mineral	
	La Plata Canyon	

Table 4.8 Summary of watersheds within the 80-100 percentile range for the percentage of each HUB located within Nordic ski areas or centers, management scale, San Juan National Forest. All watersheds highlighted within light green are located entirely within the forest boundary.

HUB6	HUB6NAME	Percentage of HUB located within Nordic ski areas or centers
140801040402	East Fork Hermosa Creek	46
140801040401	Hermosa Creek headwaters	16
140801040301	Upper Cascade Creek	15
140801040403	Upper Hermosa Creek	10
140801020302	Lower Devil Creek	5
140801010203	Wolf Creek	5
140801010405	Rito Blanco	5
140801040202	Animas River-Tenmile Creek	4
140801070104	Chicken Creek	4
140801020401	Martinez Creek-Dutton Creek	3
140801040103	Mineral Creek	3
140801040302	Lime Creek	3
140801040303	Lower Cascade Creek	3
140801010406	Lower Rio Blanco-San Juan River	3
140801010304	Upper Pagosa Springs	3
140801020301	Upper Devil Creek	2

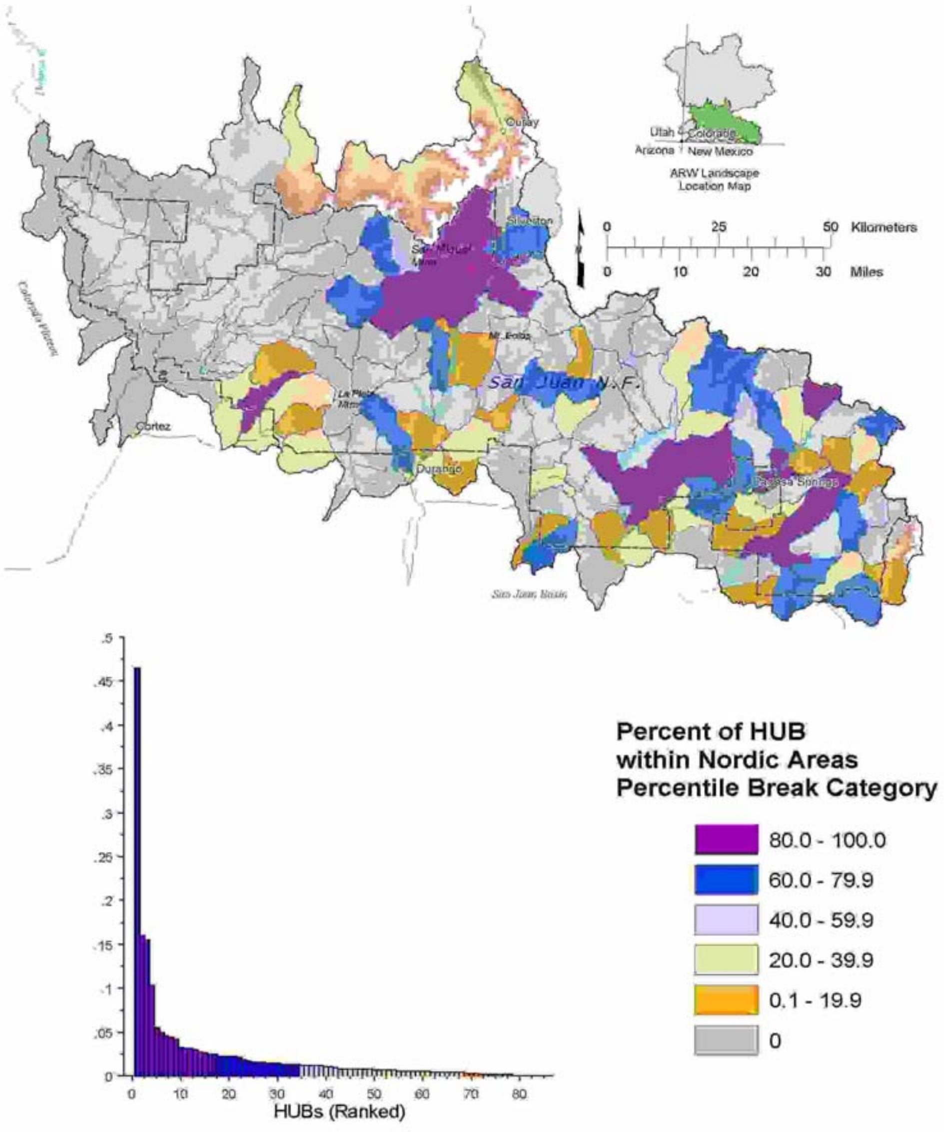

Figure 4.9 Rank and distribution of watersheds within the 80-100 percentile range for the percentage of each HUB involved with a Nordic ski area or designated trail, management scale, San Juan National Forest.

To obtain a more in-depth assessment, of what watersheds have a high potential for effects, two other metrics were also analyzed. First, the ratio of the number of miles of stream, downstream of an area or center, compared to total HUB stream miles was calculated. This helped define the potential for downstream effects, both on and off-forest. The last metric calculated determined the percentage of each HUBs valley bottom area associated with a Nordic ski trail/ designated trail.

Figure 4.10 displays the distribution of the watersheds found within the 80-100 percentile range, for the number of downstream miles metric. The majority of these watersheds are located in the eastern half of the forest. Table 4.14 shows that 11 watersheds fall within the 80-100 percentile range. Ratios range from a high of 0.28 for the Elbert Creek (HUB 140801040502) watershed to a low of 0.15 for the East Fork San Juan River-The Clamshell (HUB 140801010104), Lower Beaver Creek (HUB 140801011603), Upper Hermosa Creek (HUB 140801040403), and Lower Devil Creek (HUB 140801020302) watersheds.

Elbert Creek Watershed (HUB 140801040502) has the highest ratio because it has the most downstream miles relative to total miles. The total stream miles for this watershed are the lowest of all the watersheds on the forest. Chris Park designated ski trail is the major trail within the watershed. A developed parking lot is present. McCabe Creek watershed has fewer downstream stream miles its overall total for stream miles is higher than Elbert Creek. Associated with the Wolf Creek watershed (HUB 140801010203) are the Wolf Creek and Fall Creek trails. Only the Wolf Creek trail has a designated parking lot. Middle Rio Blanco trails are un-named and do not have supporting services such as vault or pit toilets or parking lots that may result in affects to aquatic resources.

On forest downstream effects in any of the watersheds listed in Table 4.14 are expected to be small. The amount of development associated with areas designated for Nordic use is very limited. Designated trails may or may not have a defined parking lot and pit toilets are relatively few and many are pre-existing roads or OHV trails. If on-forest effects do occur, they would be localized and of low magnitude. Off-forest effects are expected to be negligible for the above reasons.

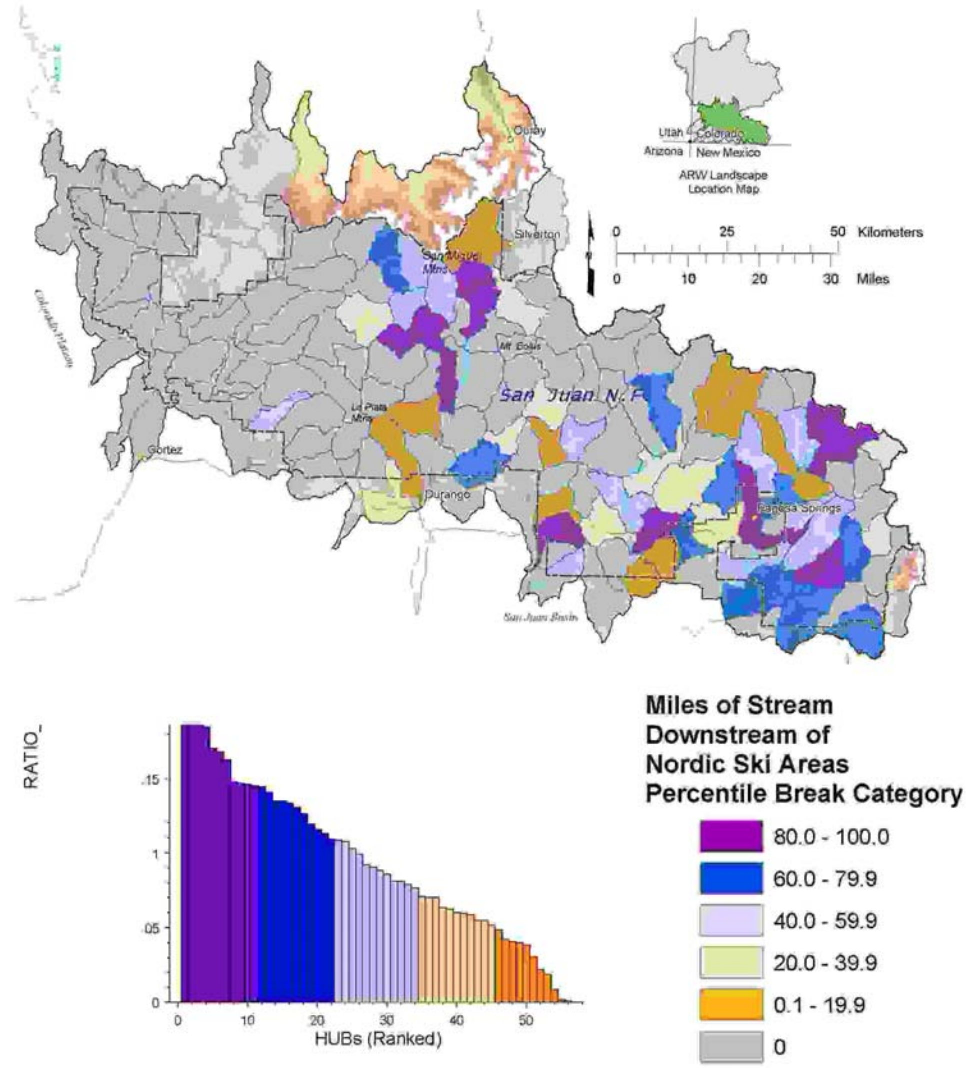

Figure 4.10 The rank and distribution of HUBs within the 80-100 percentile range for the ratio of miles of stream downstream of Nordic ski centers and designated trails compared to total stream mile per HUB, management scale, San Juan National Forest.

Table 4.9 Summary of HUBs within the 80-100 percentile range for the ratio of miles of stream downstream of Nordic ski centers and designated trails compared to total stream mile per HUB, management scale, San Juan National Forest. Watersheds highlighted in green are located entirely with the forest boundary.

HUB6	HUB6NAME	Ratio of miles of stream downstream of Nordic area compared to total stream miles by HUB
140801040502	Elbert Creek	0.28
140801010305	McCabe Creek	0.21
140801010203	Wolf Creek	0.19
140801010404	Middle Rio Blanco	0.18
140801010307	Echo Canyon Reservoir	0.17
140801040402	East Fork Hermosa Creek	0.17
140801040302	Lime Creek	0.16
140801010104	East Fork San Juan River-The Clamshell	0.15
140801011603	Lower Beaver Creek	0.15
140801040403	Upper Hermosa Creek	0.15
140801020302	Lower Devil Creek	0.15

Figure 4.11 and Table 4.10 summarize the results of analysis for determining which HUBs are most at risk for potential effects on aquatic resources, related to Nordic skiing and associated facilities. 14 HUBs were found to be within the 80-100 percentile range for this metric. These HUBs are found in the middle and eastern thirds of the forest (Figure 4.11). The East Fork of Hermosa Creek had by far the highest percentage of its valley bottom involved Nordic recreation at 0.29 or 29%. The high percentage is the result of the watershed having the highest total number of valley bottom acres involved and having one of the smaller totals for total number of valley bottom acres. Hermosa Creek headwaters (HUB 140801040401) is ranked third, with 0.13 (13%) of the HUBs' valley bottom involved in Nordic trails. The percentages for both these watersheds are related to the presence of the Nordic ski area portion of the Durango Mountain Resort.

Effects associated with Nordic areas in valley bottoms may include vegetation disturbance and loss of nutrients to soil, soil compaction, disruption of groundwater flow, and water quality degradation associated with pit toilets. However, there is only 16km of groomed trail. No additional trail construction, clearing and grading is currently supposed.

Although the watershed is at risk for potential effects related to existing Nordic skiing it is likely that any of these effects would be masked those associated with the downhill skiing portion of the resort.

The other 13 values ranged from 0.13(13%) down to 0.05 (5%). Although the Animas River-Tenmile Creek (HUB 140801040402), Mineral Creek (HUB 140801040401), and Lower Devil Creek (HUB 140801020302) watersheds are not highlighted in green, indicating that they are entirely within forest boundaries. However, very large portions are within forest boundaries. As a result, the percent involvement of their valley bottoms forms a reliable ranking of their risk for potential effects.

Runoff from petroleum products from parking lots likely poses the greatest on-forest risk. However the level of that risk would be dependent on proximity to streams and if they are fish bearing, as petroleum products are known to affect aquatic health and productivity (Crabtree, 2004). Additional effects could be related to soil compaction, disruption of groundwater flow, contamination of ground and/or surface water due to pit toilets. If additional trails are proposed and constructed then related effects would be dependent on the trails location, soils, and topography.

Off-forest effects due to existing Nordic development are probably minimal due to the limited amount of development associated with the Nordic areas within these watersheds. In addition, with the lower magnitude any effects would likely be masked by effects from more predominant land management activities such as road construction, timber harvest, and grazing.

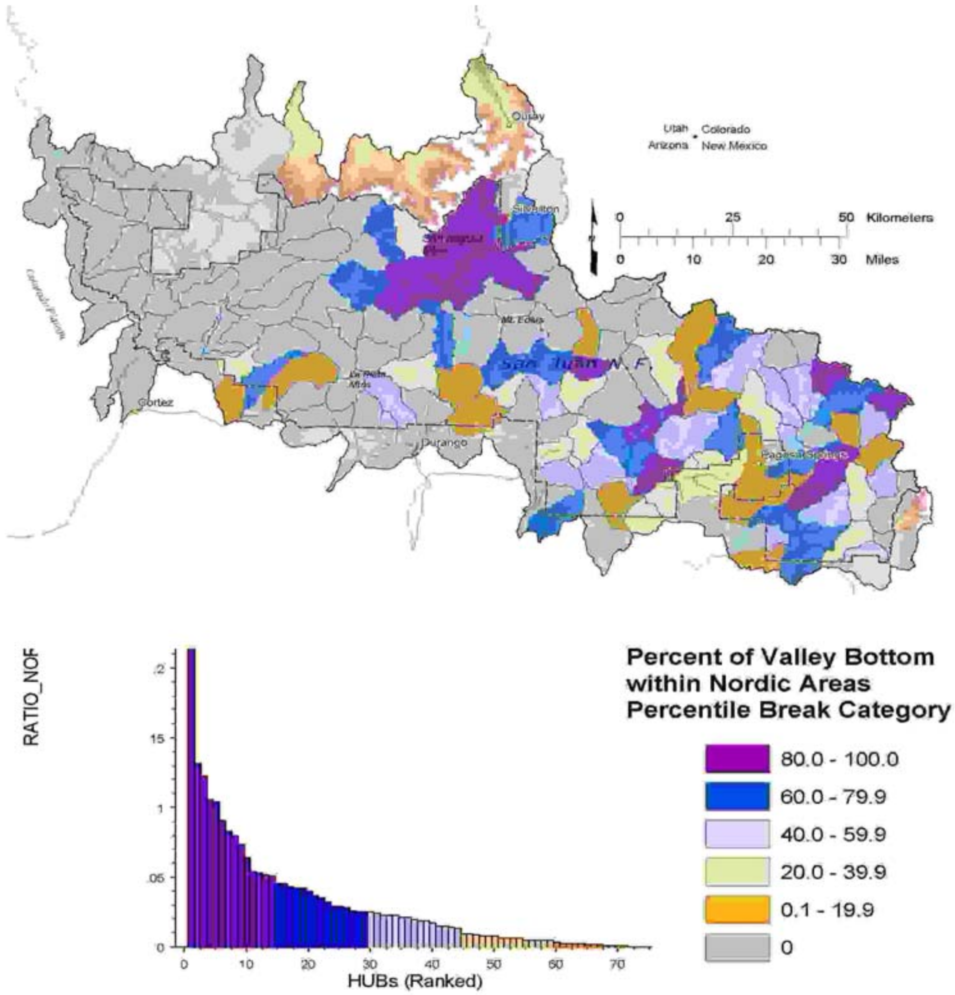

Figure 4.11 The rank and distribution of HUBs within the 80-100 percentile range for the percentage of the HUBs valley bottom involved in a Nordic ski center or designated trail, management scale, San Juan National Forest.

Table 4.10 HUBs within the 80-100 percentile range for the percentage of the HUBs valley bottom involved in a Nordic ski center or designated trail, management scale, San Juan National Forest. Summary of Watersheds highlighted in green are located entirely with the forest boundary.

HUB6	HUB6NAME	Percentage of Valley Bottom Involved in Nordic ski center/designated trail by HUB
140801040402	East Fork Hermosa Creek	0.29
140801040202	Animas River-Tenmile Creek	0.13
140801040401	Hermosa Creek headwaters	0.12
140801040103	Mineral Creek	0.11
140801010101	Headwaters East Fork San Juan River	0.10
140801040403	Upper Hermosa Creek	0.09
140801010203	Wolf Creek	0.08
140801011305	Indian Creek	0.08
140801040301	Upper Cascade Creek	0.07
140801040302	Lime Creek	0.06
140801020205	Upper Piedra River-Box Canyon	0.05
140801040303	Lower Cascade Creek	0.05
140801020302	Lower Devil Creek	0.05
140801010405	Rito Blanco	0.05

6th Level HUB Information Needs

Although the downhill ski area density relative to San Juan National Forest is low at the landscape and management scales. However, effects can be apparent at the management scale. Specific measurements that can be used to determine effects are:

1. Timing and magnitude of high-flow events in ski areas compared to adjacent unaffected stream reaches either upstream or in an adjacent comparable watershed.
2. Area of wetlands drained or flooded by ski area development.
3. Site attributes (e.g., slope, geology) of disturbed areas within ski areas.
4. Particle size distribution or other methods of analysis that can determine changes in stream sediment composition (e.g., siltation).
5. Identify areas of high compaction and or bare ground that are accessible to streams and may provide localized areas of increased yield to streams.
6. The number of stream channels crossed by ski runs.
7. Location and type of wetlands in or near ski area developments.
8. Size, location, and surfacing of parking lots, roads, or other impervious surfaces.
9. Amount of water use (snowmaking, direct consumption, waste water treatment).
10. Amount of area where there is concerned about lake or stream reduction related to snow making.
11. Abundance and diversity of: a) aquatic invertebrate and fish communities downstream from ski area developments; and b) flora and fauna in wetlands adjacent to and downstream from ski area developments.

Management Implications at the 6th HUB Level Ski Areas (Nordic and Downhill)

As previously discussed under management implications for developed recreation information for this section is derived from the Ecological Driver Analysis (Report 1 of 3) and the Synthesis (Report 3 of 3), in the 2006 San Juan Aquatic, Riparian, and Wetland Ecosystem Assessment. These reports should be used when developing or evaluating proposed projects.

The following watersheds have the highest potential for impacts to aquatic health related to nordic and downhill ski areas combined: the East Fork of Hermosa Creek (HUB# 140801040402), Lower Cascade (HUB# 140801040303), Wolf Creek (HUB# 140801010203), Upper Hermosa Creek (HUB# 140801040403), Lime Creek (HUB# 140801040302), and Lower Devil Creek (HUB# 140801040302). All of these watersheds had a cumulative percentile rank of 5 for ski areas, which is the maximum possible score (Table (4.18).

Riparian clusters associated with both of these categories are clusters 1r, 2r, 5r, and 6r. Associated wetland clusters are 1w, 3w, 7w, and 8w (Table 4.18).

Clusters 1r, 2r, and 5r are all moderately to highly sensitive to changes in hydrology, sediment, and thermal regime; Cluster 6r varies in sensitivity from low to high (USDA Forest Service, 2006, Report 1 of 1, Report 3 of 3). Clusters 1r, 5r, and 6r have a dominance of calcareous geology, however cold water temperatures in Cluster 1r are a limiting factor in fisheries production. Aquatic productivity and benthic macroinvertebrate populations vary in their sensitivity to thermal fluctuations in water temperature from moderate to high. Clusters 5r and 6r are highly sensitive to changes in hydrologic regimes.

Wetland clusters are 1w; 3w, 7w, and 8w all have a high sensitivity to fluctuations in hydrology.

However their sensitivity to fluctuations in sediment load is variable, with Clusters 7w and 8w highly sensitive to variations in sediment loads. Cluster 1w is moderately sensitive and cluster 3w has the lowest sensitivity to alterations to sediment loads. Clusters 1w and 3w are not influenced by thermal fluctuations while clusters 7w and 8w show some sensitivity to temperature modifications. Nutrient modification in clusters 7w and 8w will have a moderate influence on wetlands, while wetlands in clusters 1w and 3w are not influenced by alterations in nutrients. Biota in clusters 3w and 4w are very sensitive to environmental change (USDA Forest Service, 2006, Report 1 of 1).

These five watersheds which had the highest potential for aquatic, riparian, and wetland influences, due to downhill and nordic ski areas, also scored a cumulative total of "5" or "4" overall for recreation. Lower Cascade Creek and Lower Devil Creek watersheds also scored a cumulative total of "4" for transportation and vegetation management categories, while Wolf Creek and the East Fork Hermosa Creek watersheds scored a cumulative total of "4" for vegetation management. Transportation and vegetation management can also result in increased erosion and sediment generation, and riparian zone degradation or alteration.

Based on the information available for the riparian and wetland clusters associated with ski areas the following recommendations are made:

- The status of existing nutrient levels in surface and groundwaters should be well established before approving any additional ski area activities that would result in changes to nutrient influxes to wetlands Clusters 7w and 8w. This recommendation applies to all watersheds containing these two clusters but especially to the Lower Cascade Creek watershed which has received an overall cumulative score of "5" for recreation overall.
- For Lower Cascade Creek, Wolf Creek and the East Fork Hermosa Creek watersheds future projects should evaluate the potential impacts of any proposed project, in context to the sensitivity of fisheries, riparian vegetation, aquatic productivity, and benthic macroinvertebrates resources, to changes in hydrology, sediment, thermal regime, nutrients, and biota, for riparian and wetlands Clusters 1r, 1w 2w, and 7w.
- Emphasize conservation and preservation of riparian vegetation in Clusters 1r, 2r, and 5r. Cluster 1r as it is considered less responsive to restoration and mitigation due to high elevation and low potential productivity. Low gradient reaches are especially important for preserving and maintaining riparian vegetation in riparian Clusters 1r and 2r due to their scarcity within these clusters. Riparian vegetation is particularly important in Cluster 2r and most watersheds containing this Cluster are located entirely within the Forest boundary.
- Cluster 5r is one of the most productive for aquatic and riparian systems and is present in the Upper Hermosa Creek watershed. These areas should be considered for mitigation efforts under the watershed improvement program.
- Lower Devil Creek Cluster 6r is especially sensitive to anthropogenic activities altering subsurface and surface water hydrology. Additional requests for water withdrawal or other activities should be prohibited or significantly limited as water diversions reduce fish habitat, possibly to critically low levels in drought years, and would exacerbate the potential for thermal fluctuations.

- Wetlands Cluster 1w is present in the East Fork Hermosa, Lower Cascade Creek, and Upper Hermosa Creek watersheds and provides important area for restoration and protection.
- Cluster 3w is relatively rare, but is considered less important than the other wetland clusters. These wetlands are opportunities for restoration in the Lower Devil Creek watershed due to their rarity.
- Wetlands Cluster 7w is located primarily on-forest and its involvement with ski areas occurs in the Wolf Creek watershed. It is also heavily influenced by transportation and vegetation management activities. As a result, it is an excellent opportunity to implement mitigation efforts.

Direction for Reach/Site Scale Analysis

Inventory and monitoring at the reach/site level is important to understand the influence of ski area development on aquatic, riparian, and wetland resources. Monitoring would also ensure that project level analyses are in accordance with Federal Land Policy and Management Act (FLPMA). Its directives concern species viability, ecological sustainability, and the Clean Water Act of 1972.

The potential for changes in water quality, stream channel morphology, and to terrestrial and aquatic vegetation and biota, must be evaluated at the reach level in order to assess to what degree, if any, that ski areas affect these resources. In evaluating any effects in the Forest the fundamental requirements and sensitivity to change for both aquatic and vegetative systems must be taken into consideration.

To help determine to what degree aquatic, riparian, and wetland resources may have been affected by ski areas, specific questions related to resource values include, but are not limited to:

1. How does operation of current ski area facilities:
    a. Alter hydrology (e.g., increased runoff from ski runs, water use for snowmaking) in the involved watersheds?
    b. Affect water quality (e.g., point and nonpoint pollution)
    c. Result in increased sediment yield and what are the associated effects (e.g., fine sediment deposition)?
    d. Result in alternation of stream channel morphology and function (e.g., degrading stream banks via ski run crossings)?
    e. Result in degradation of valley bottom/riparian habitat (e.g., direct removal of vegetation to maintain ski runs, draining of wetlands)?
2. Will future ski area development or expansion illicit changes listed above in number 1 (a-e) above?

Influences of Dispersed Recreation

Key Findings

- Correlation of 3,037 known dispersed recreation sites in the San Juan and GMUG Forests to roads, streams, slope, aspect, vegetation and ownership allows the creation of a predictive model in the San Juan management scale.
- There are 302,678 acres (472.9 square miles) of lands with high potential for dispersed recreation sites in the San Juan management scale.
- Using a ratio of 7.4 sites per square mile of high potential site area, there is a potential for about 3,500 sites in the San Juan management scale, distributed across the Forest, mostly in upland valleys.
- Dispersed recreation site average barren area is about 45 square feet per site (about 7 x 7 feet). Overall disturbed area is about 905 square feet per site (about 30 x 30 feet).
- Just over 130 out of 154 HUBs have some level of dispersed recreation site potential.
- Overall, the maximum potential site density is 3.7 sites per square mile (HUB 140300020208, Stoner Creek) to a minimum of .001 sites per square mile (HUB 140802020106, Mouth of Alkali Canyon-Narraguinnep Canyon) with an average of 0.90 sites per square mile.
- Overall, the maximum valley bottom site density is 5.58 sites per square mile (HUB 140300020208, Stoner Creek) to a minimum of .0002 sites per square mile (HUB 140300020404, Dolores River-Stapleton Valley) with an average of 1.73sites per valley bottom square mile among the 130 HUBs with site densities greater than zero.
- Research and validation is required to develop a more robust statistically valid model. The existing model is only qualitative and rests on some important assumptions.
- Apparent correlation of sites to streams indicates a high potential for influence on ARW systems from dispersed recreation.

Introduction

The influence of dispersed recreation on both terrestrial and aquatic systems is an emerging issue as levels of recreational use increase on public lands. Typical sites include disturbance features such as fire rings, tent sites, and areas of congregation, parking and automobile tracks. Repeated use of sites and abusive practices can disturb important communities and lead to increased levels of sedimentation and contamination of aquatic systems.

The distribution of dispersed recreation sites throughout the management scale has only been partially defined by field survey. To date there are 1,220 survey points in the management scale. These points are confined mostly to upland areas along the north and eastern bounds of the Forest (Fig. 4.17) and they represent only a fraction of existing sites in the Forest.

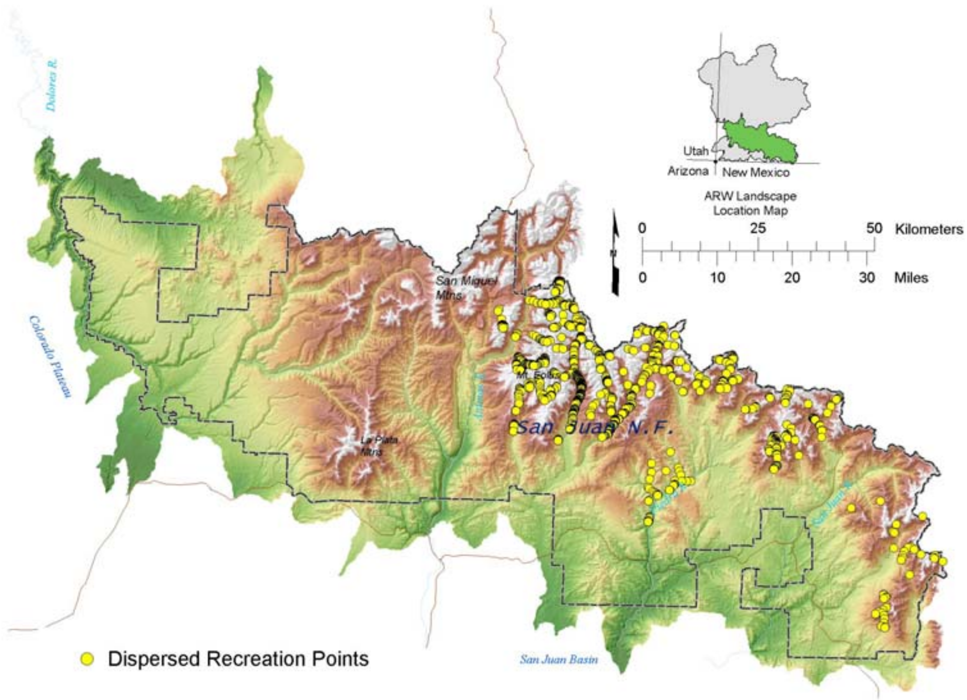

Figure 4.17 1750 identified dispersed recreation sites in the San Juan ARW management scale area.

Many more sites occur through out the management scale and have yet to be identified. Moreover, as levels of use continue to expand, the number of new sites will rise along with levels of disturbance at existing sites. Overall, extrapolation of existing data suggests that ***there is a potential for 3,499 sites in the management scale area.***

Potential is determined by evaluation of landscape characteristics at known sites and selection of areas across the management area where similar characteristics occur. This modeling was completed as part of a larger assessment of the current landscape condition (CLC) assessment ecological subregion for both the San Juan and GMUG Forests. Key elements of the model are described below.

Two types of metrics have been measured to assess the potential influence of these predicted 3,499 sites and ARW values. These metrics include predicted site density by sixth level HUB and site density in valley bottom settings. In general, these metrics have the highest values in upland valleys throughout the forest. Additionally, measures of disturbance have been estimated, based on the estimated number of sites and average barren and disturbance figures in existing inventories. These disturbance metrics are described in greater detail below.

Description of the Model

Geographic data depicting existing dispersed recreation sites were obtained from both the San Juan and GMUG Forests. These inventories of sites include 3,037 point locations. Among these 3,037 sites, 2,909 fall inside the CLC sub-region. These 2,909 sites are well distributed among a variety of landscape settings. These settings include alpine, upland and lowland sites. Sites are well distributed among both forests and provide a good basis for extrapolation.

Correlation of the 2,909 inventoried sites to roads, streams, slope, vegetation, aspect and ownership provides a method to extrapolate into un-inventoried areas. Very strong relationships are evident in measures of point distances to roads and streams. Evident relationship to slope, vegetation and aspect naturally correspond to user selection of sites. Finally, selection by ownership reflects social and legal constraints on site selection.

The method described here was applied over the entire CLC sub-region. A subset of this regional model was built by clipping to the edges of the San Juan management scale.

We begin the breakdown and description of the model by relating roads and trails to the existing sites. In the model, roads and trails of all classes, including trails were used. Over 90 percent of all sites in the sub-region fall within 800 meters of roads and trails (Fig. 4.18). Sixty-three percent are found within 100 meters.

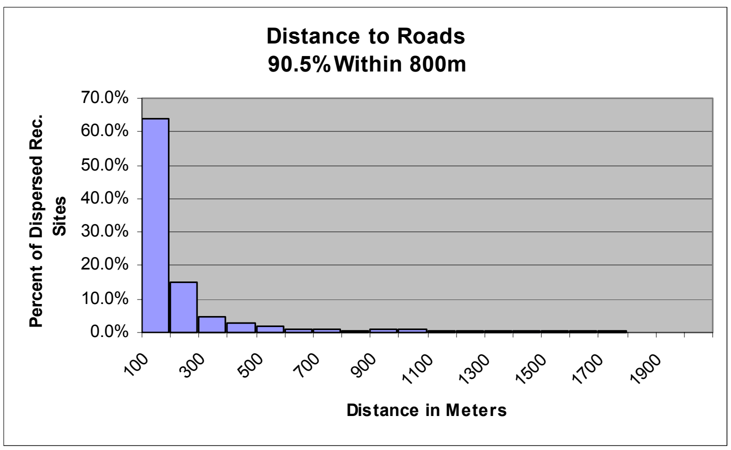

Figure 4.18 Just over 90 percent of CLC sub-region sites fall within 800 meters of a road.

Similarly, almost 60 percent of all sites are found within 100 meters of a stream. Nearly 90% of sites are located within 700 meters of a stream (Fig. 4.19).

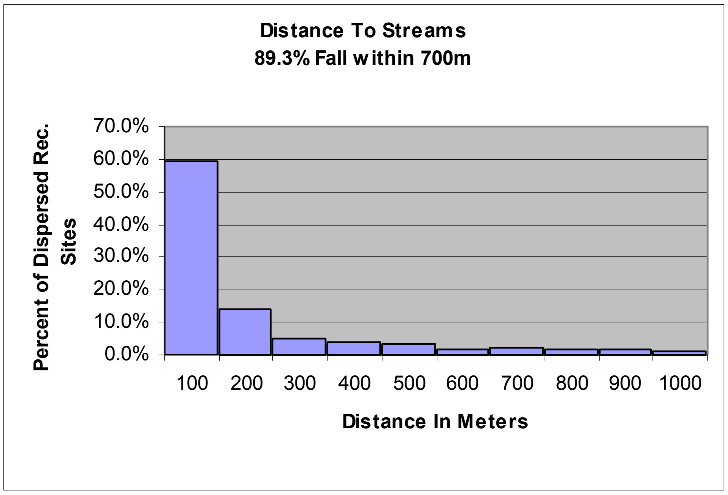

Figure 4.19 Just under 90 percent of CLC sub-region sites fall within 700 meters of a stream.

Slope

Naturally, slope would seem to be a strong limiting factor in selection of dispersed recreation sites for camping and/or day use. A slope model based on subregion-wide 100 meter DEM was used. In the subregion, ninety percent of dispersed recreation sites are found on slopes of 17 degrees or less (Fig. 4.20).

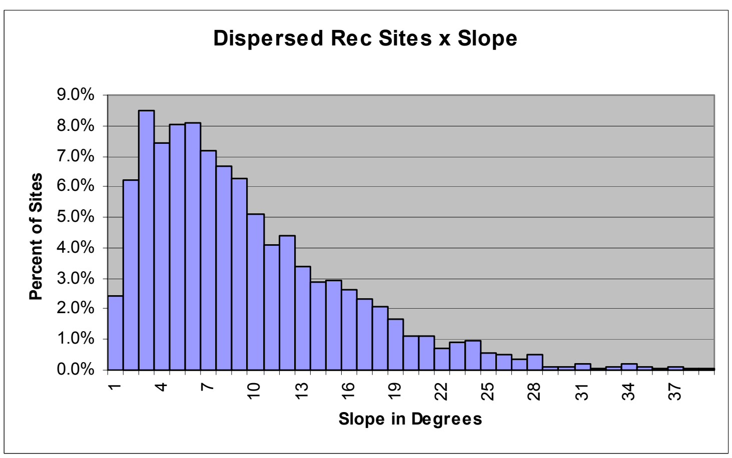

Figure 4.20 Ninety percent of CLC sub-region sites fall in areas with slopes of 17 degrees or less.

Aspect

Similar to slope, it would seem that aspect might be a strong limiting factor in selection of dispersed recreation sites for camping and/or day use. It might be expected that users would tend to select sites with southerly, warm and sunny, sites. This assumption seems to be weakly so – i.e. it is less evident in the data than slope (Fig. 4.16).

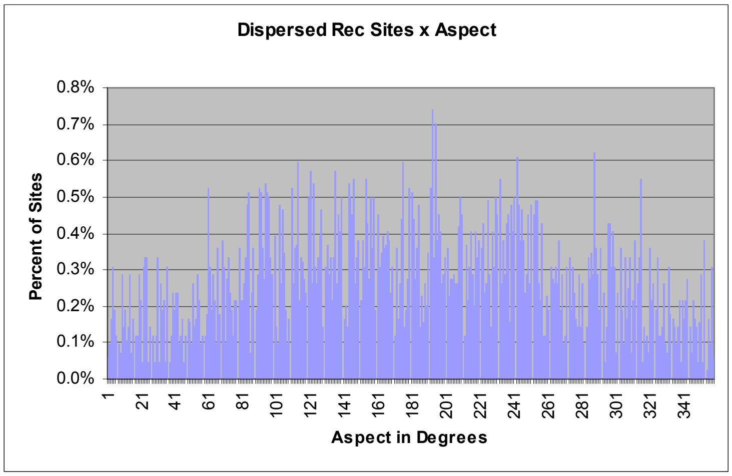

Figure 4.16 Ninety percent of CLC sub-region sites fall in areas with an aspect in the range from 35 to 325 degrees. A minor trend seems to be evident in the data, centered on 180 degrees.

Vegetation

Almost 90% percent of sites fall within three generalized GAP vegetation classes. These include Spruce-Fir, Alpine and Aspen, suggesting an upland preference. Just over 50% percent of sites are found in the Spruce-fir GAP class (Fig. 4.17).

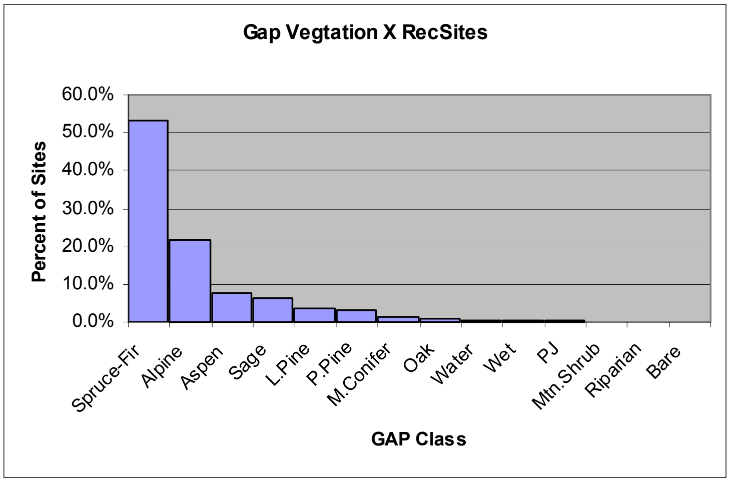

Figure 4.17 Just under ninety percent of sites occur in three GAP vegetation classes: Spruce-fir, Alpine and Aspen.

Ownership

Almost 97% percent of sites are found on Forest Service lands. This is no surprise as the surveys were deliberately aimed at Forest Service lands. Thus, a correlation to ownership is not directly evident in the sample data.

Even so, the model includes ownership under the assumption that the majority of dispersed recreation sites are naturally located public lands. While some level of dispersed recreation activity may occur on non-public lands, it is assumed to be actively discouraged on other lands while most public lands remain largely open to it. So, the model is applied within BLM and Forest Service lands throughout the sub-region. As a consequence the model includes all BLM and Forest lands throughout the San Juan management scale.

These six layers, roads, streams, slope, aspect, vegetation and ownership are joined and selected to build the dispersed recreation model. Selections are made in each category where attributes values fall within ranges where over 90% percent of the sites occur. These values are summarized in Table 4.11.

Table 4.11 The six layers used to define the dispersed recreation potential model.

Layer	Selection Attributes
Roads	Within 800 meters
Streams	Within 700 meters
Slope	0 to 17 degrees
Aspect	35 to 325 degrees
Vegetation	Spruce/Fir, Alpine, Aspen
Ownership	BLM and Forest Service

In the San Juan management scale there are 302,678 acres (472 square miles) of lands that fall within the dispersed recreation potential model criteria (Fig. 4.18). In general, the areas of the model that have been surveyed have a ***site density of 7.40*** sites per square mile. Applying this multiplier across the management scale **yields an estimated 3,499 sites**. The actual number existing may vary somewhat but the model allows determination of potential disturbance and may be helpful in targeting future systematic surveys

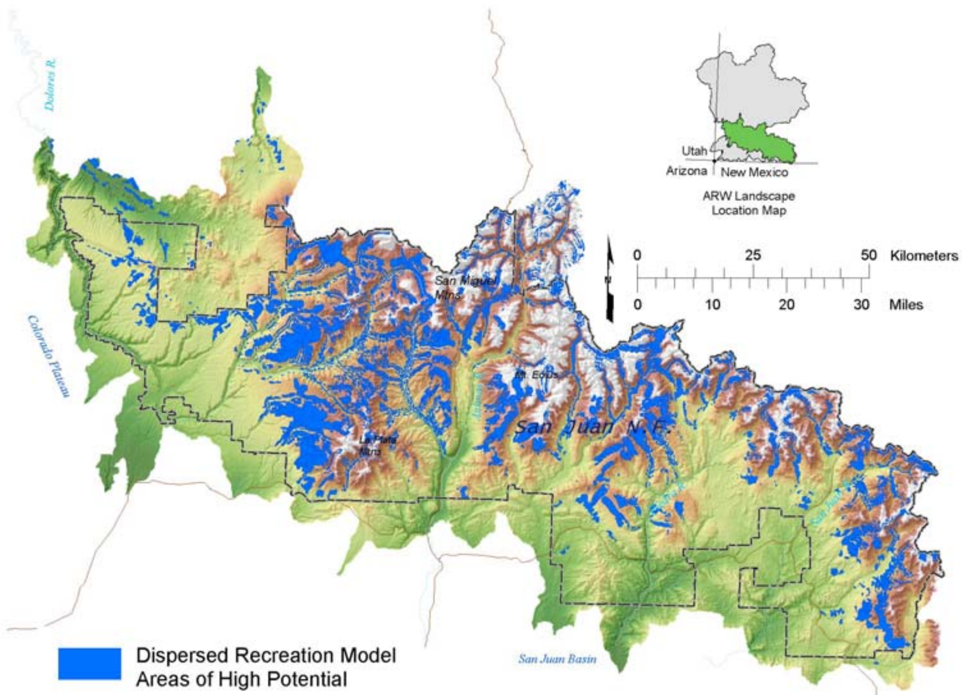

Figure 4.18 There are 302,678 acres of lands with high potential for dispersed recreation sites in the San Juan management scale.

Estimation of Disturbance

Of the 3,037 data for actual surveyed sites, provided by the San Juan and GMUG National Forests, 353 points include attribute information indicating barren area per site as well as total disturbed area per site. These data allow the estimation of potential disturbance resulting from dispersed recreation.

Table 4.12 illustrates how an estimate of ***45.04*** square feet of barren area has been derived from the 353 points having barren area values. Table 4.13 illustrates the same for the 357 points leading to an estimate of overall disturbed area per site of ***905.3*** square feet.

Table 4.12 In the existing site data, 353 sites provide a way to estimate average barren area per site.

Number of Sites	Class	Barren Area Sq. Feet	Number of Sites x Area
240	1	0	0
68	2	50	3,400
30	3	100	3,000
11	4	500	5,500
4	5	1,000	4,000
353 Average Barren Area	= 15900 / 353	= 45.04 SqFt	15,900

Multiplying this estimate of **45.04** square feet per site times the **3,499** sites in the management scale yields an estimated 1,236,117 square feet, or **28.4** acres of potential barren area in the management scale.

Table 4.13 In the existing site data, 357 sites provide a way to estimate average total area per site.

Number of Sites	Class	Area SqFeet	Approx Sum Area
27	1	500	13,500
26	2	2000	52,000
11	3	5000	55,000
134	a	50	6,700
45	b	100	4,500
61	c	500	30,500
26	d	1000	26,000
027	e	5000	135,000
357 Total Area = 323,200 / 357 = 905.32			323,200

Multiplying this estimate of **905.32** square feet per site time's **3,499** sites yields an estimated potential **68.02** acres of total disturbed area in the management scale.

Dispersed Recreation Potential Influence on ARW Values

The influence of dispersed recreation can be characterized at the management scale by evaluating the dispersed recreation potential model to determine: 1) the potential numbers of sites per 6th level

HUB per square mile; and 2) number of sites per valley bottom square mile per HUB.

1) Number of Sites per HUB Mile

One hundred and thirty-two 6th level HUBs in the management scale have some level of potential for dispersed recreation. Overall, the maximum site density is 3.7 sites per square mile (HUB 140300020208, Stoner Creek) to a minimum of .001 sites per square mile (HUB 140802020106, Mouth of Alkali Canyon-Narraguinnep Canyon) with an average of 0.90 sites per square mile.

There are 27 HUBs in the 80 to 100 percentile class with densities ranging from 3.74 down to 1.43 with an average of 2.20 sites per square mile. Twenty-three of these 27 fall completely within the San Juan Forest area (Table 4.14).

Comment [JF1]: Shouldn't the word "potential" be inserted here?

Table 4.14 Potential number of sites per HUB square mile.; Twenty-seven sites fall in the top percentile class (80 to 100). HUBs falling completely in the San Juan Forest area are highlighted

HUB	HUB Name	Potential Number	Number Per Sq. Mile
140300020208	Stoner Creek	172.34	3.74
140801040402	East Fork Hermosa Creek	59.16	3.53
140801070101	East Mancos/Middle Mancos Rivers	83.20	3.41
140300020401	Upper Lost Canyon	111.06	3.07
140801070102	West Mancos River	125.51	2.92
140801011301	Los Pinos River-Ricon La Vaca	54.48	2.75
140801040303	Mouth of Cascade Creek	35.90	2.40
140801040406	Hermosa Creek-Dutch Creek to South Fork	51.38	2.36
140300020102	Fish Creek	86.03	2.34
140801040802	Florida River-Virginia Gulch	59.34	2.32
140801010403	Rio Blanco-Blanco Basin	58.58	2.23
140300020105	Mouth of West Dolores River	89.23	2.21
140801040401	Hermosa Creek Headwaters	43.21	2.17
140300020201	Dolores River Headwaters-Tin Can Basin	53.17	2.00
140801011302	Los Pinos River-Flint Creek	76.09	1.97
140300020209	Dolores River-Taylor Creek	55.25	1.94
140300020205	Roaring Forks Creek	37.13	1.89
140801010101	Headwaters East Fork San Juan River	31.53	1.83
140300020101	West Dolores River Headwaters	54.10	1.78
140801011601	Upper Beaver Creek	34.83	1.76
140801010203	Wolf Creek	34.20	1.68
140801020203	Sand Creek	47.27	1.64
140801070104	Chicken Creek	40.53	1.63
140300020202	Dolores River-Cayton Valley	45.91	1.59
140801010405	Rito Blanco	65.54	1.44
140801010506	Little Navajo River	33.68	1.43
140801020204	First Fork	78.88	1.43
	Average:	63.61	2.20
	Sum:	1,717.50	

Those areas where site potential per square mile is greatest fall in high valleys and upland areas. Six HUBs stand out. Of these, five are located west of the Animas River on the western flanks of the La Plata Mountains and south of the San Miguel Mountains. The fifth HUB is located east of the Animas River along the northern edge of the Forest (Fig. 4.19).

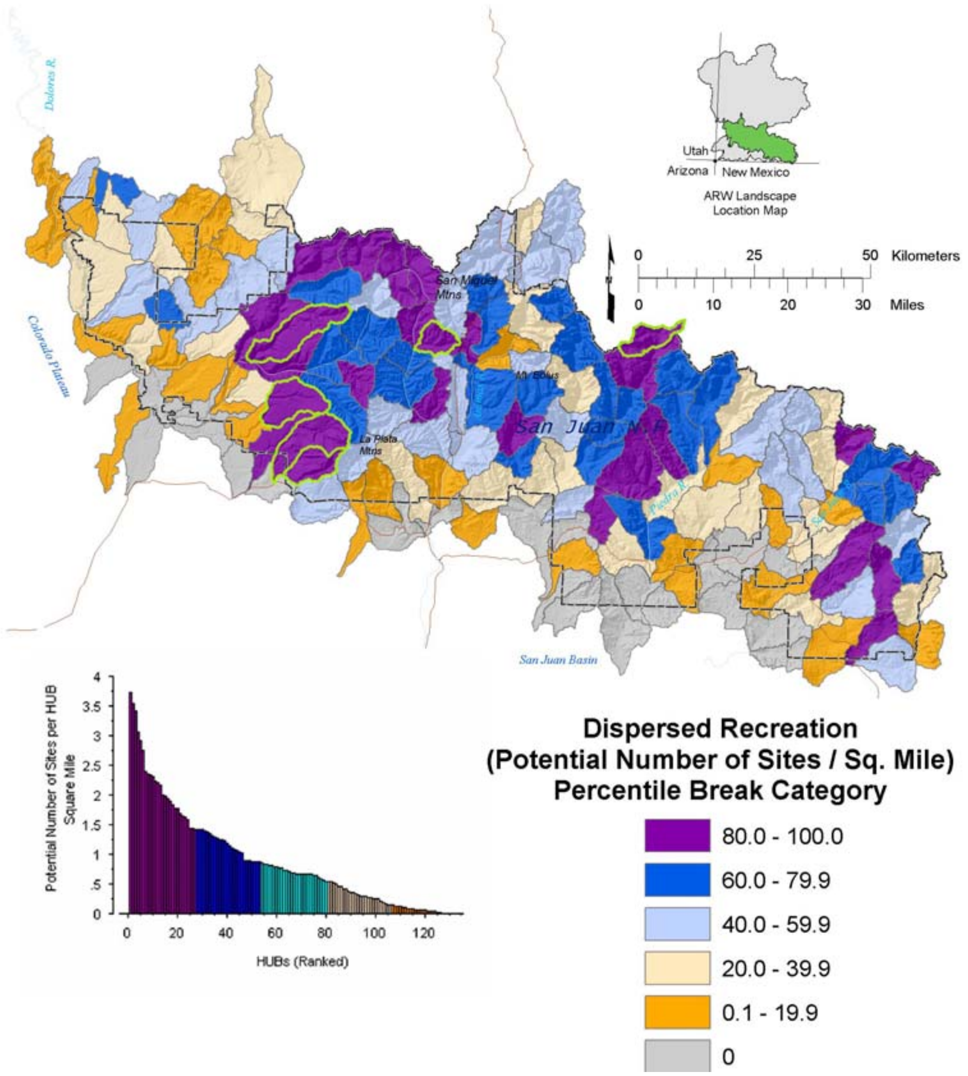

Figure 4.19 HUBs classified by potential number of sites per HUB square mile estimates. The top six stand out in the ranked graph and are shown by a brighter green outline in the figure.

2) Number of Sites per Valley Bottom Square Mile

One hundred and thirty 6th level HUBs in the management scale have some level of potential for dispersed recreation in valley bottom settings.

Overall, the maximum valley bottom site density is 5.58 sites per square mile (HUB 140300020208, Stoner Creek) to a minimum of .0002 sites per square mile (HUB 140300020404, Dolores River-Stapleton Valley) with an average of 1.73sites per valley bottom square mile among the 130 HUBs with site densities greater than zero.

There are 27 HUBs in the top percentile class with densities ranging from 5.58 down to 3.29 with an average of 4.06 sites per square mile. Twenty-four of these 27 fall completely within the San Juan Forest area (Table 4.15).

Comment [JF2]: Shouldn't the word "potential" be inserted here?

Table 4.15 Potential numbers of sites per Valley Bottom square mile; Twenty-seven sites fall in the top percentile class (80 to 100). HUBs falling completely in the San Juan Forest area are highlighted

HUB	HUB Name	PotNumSites	NumPerVB Sq Mi
140300020208	Stoner Creek	28.85	5.584
140801011304	Los Pinos River-Three Sisters	4.31	5.344
140801011301	Los Pinos River-Ricon La Vaca	12.55	5.301
140801020201	Upper Weminuche Creek	7.18	5.127
140801011302	Los Pinos River-Flint Creek	15.63	5.104
140801040402	East Fork Hermosa Creek	7.98	4.729
140801040401	Hermosa Creek Headwaters	5.23	4.639
140801011303	Lake Creek	6.97	4.618
140801050101	La Plata River Headwaters	3.93	4.530
140801010402	Fish Creek	3.96	4.064
140801040406	Hermosa Creek-Dutch Creek to South Fork	4.49	3.964
140300020102	Fish Creek	10.36	3.927
140801010103	Sand Creek	2.38	3.722
140801010102	Quartz Creek	3.67	3.711
140801070101	East Mancos/Middle Mancos Rivers	9.48	3.671
140801040103	Mineral Creek	10.73	3.625
140801010101	Headwaters East Fork San Juan River	3.82	3.605
140300020202	Dolores River-Cayton Valley	7.17	3.573
140801040303	Mouth of Cascade Creek	6.59	3.560
140801040101	Animas River above Howardsville	8.54	3.559
140300020105	Mouth of West Dolores River	18.39	3.528
140801040201	Elk Creek	5.13	3.493
140300020101	West Dolores River Headwaters	7.52	3.429
140801010201	Headwaters West Fork San Juan River	3.58	3.383
140300020203	Dolores River-Rico Valley	3.09	3.328
140801020203	Sand Creek	4.54	3.291
140801040403	Hermosa Creek-Big Lick Creek to East Fork	2.17	3.288
		7.71	4.063
		208.23	

Those areas where site potential per square mile is greatest fall in high valleys and upland areas. Among these, ten HUBs stand out. The ten are evenly distributed east to west with drainages contributing to the Animas, Dolores, San Juan and Piedra Rivers. These watersheds are highlighted below in (Fig. 4.20).

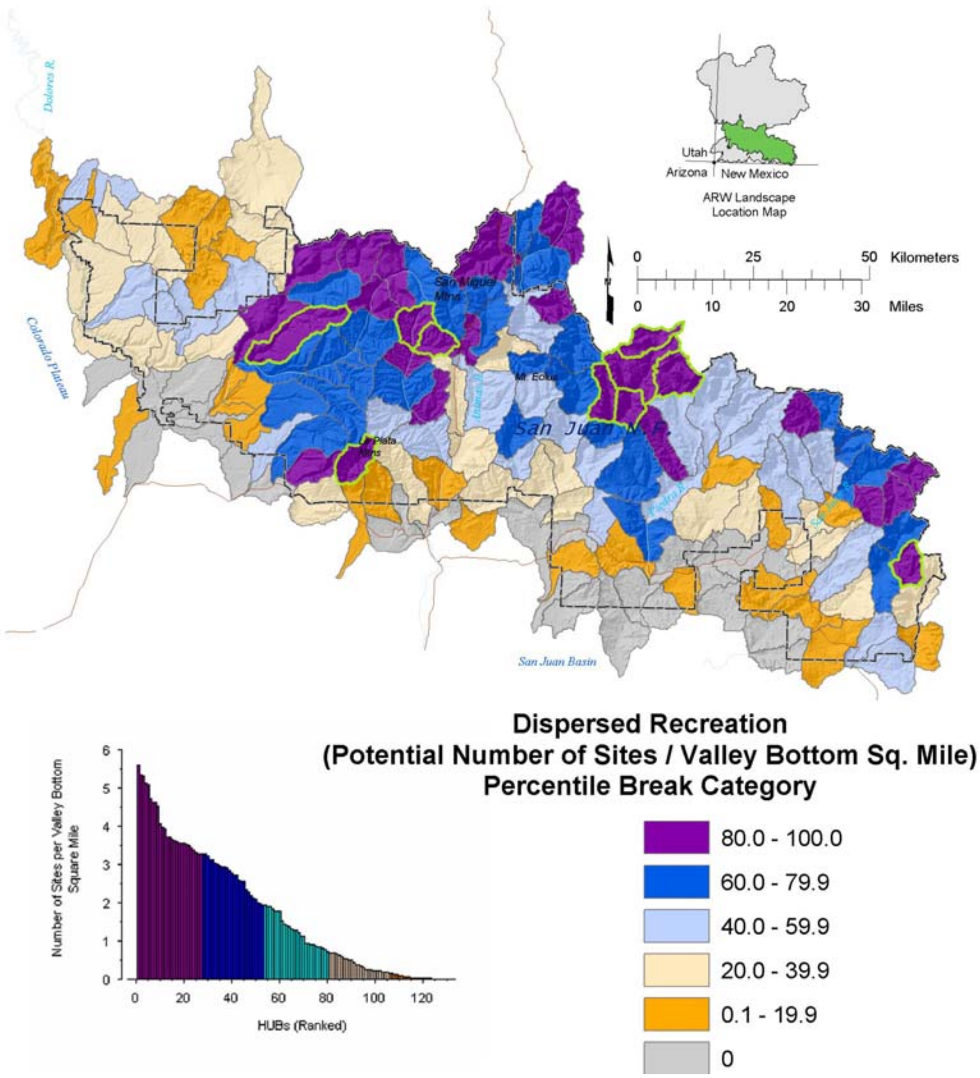

Figure 4.20 HUBs classified by potential number of sites per valley bottom square mile estimates. The top ten stand out in the ranked graph and are shown by a brighter green outline in the figure.

Information Needs

Forest inventories developed to date have provided a baseline to extrapolate potential densities used here. Inventories should continue to refine estimates and ultimately directly characterize the actual setting in the field.

While methods to develop estimates continue to be used more systematic, statistically robust, sampling methods should be used to ensure that the observed relationship of existing sites to roads is a valid correlate and not a bias introduced because the primary method to access sites is by roadway. Also, the method used to calculate an overall site density of 7.4 sites per model square mile should be evaluated. At the same time, the existing model may also be useful in the development of study plans and target areas for sampling.

Sampling systems should also be developed that develop estimates in the rate of growth or expansion in site location along with trends in site selection.

Reach Site Scale

A host of issues and questions could be addressed at the reach/site scale in order to determine the influence of dispersed recreation activities in the San Juan National Forest.

Generally, dispersed recreation site use and occupancy can lead to local increases in contaminates, loss of vegetation, compaction and increased sediment levels. Site proximity to streams increases the likelihood that these influences can directly affect aquatic systems. Petroleum products from vehicles and other uses can infiltrate near surface aquatic systems. Runoff from these sites can also carry these products along with debris and sediments into local surface waters. Loss of vegetation can lead to erosional pattern that leads to changes in channel geometry, negatively affecting channel function.

Building on this awareness, specific questions related to dispersed recreation site management and its influence on reach/site scale values include, but are not limited to:

1. Will current dispersed recreation site levels, or increased levels result in:
    a. Altered hydrology,
    b. Unacceptable changes in water quality from point and/or non-point sources,
    c. Increased sediment load,
    d. Increased channel alteration,
    e. Degradation of riparian habitat,
    f. Higher fishing pressure that results in population level effects on game species or sensitive native species,
    g. Introduction or exotic or invasive species.
2. What are the ranges of influences that can result from dispersed recreation activities. Of those, what activities have the greatest potential for negative outcomes?
3. Should certain types of activities be restricted?

Management Implications at the 6th HUB Level

21%, or 32 out of 154 watersheds on the San Juan National Forest, had a total cumulative score of “five” for dispersed recreation. These watersheds have the highest potential for impacts on aquatic, riparian and wetland health, related to dispersed recreation. These watersheds are summarized below in Table 4.16, along with the riparian and wetlands clusters found associated with these watersheds.

Table 4.16 Summary of Watersheds with a Cumulative Dispersed Recreation Total Score of Five, management scale, San Juan National Forest; Watersheds highlighted in light green are located entirely on-forest

6th Level HUB #	Watershed Name	Riparian Cluster	Wetlands Cluster
140801040802	Upper Florida River-Transfer Park	1	7
140801040402	East Fork Hermosa Creek	1	1
140801040303	Lower Cascade Creek	2	1
140801020401	Martinez Creek-Dutton Creek	5	4
140801010204	Lower West Fork San Juan River	2	7
140801010203	Wolf Creek	1	7
140801020202	Lower Weminuche Creek	2	2
140801011306	East Creek	2	1
140801011305	Indian Creek	2	2
140801010601	San Juan River-Trujillo	6	3
140300020401	Upper Lost Canyon	2	1
140300020209	Upper Dolores River-Taylor Creek Canyon	5	3
140300020202	Upper Dolores River-Cayton Valley	2	1
140801010602	Montezuma Creek	4	4
140801010503	Navajo Peak	2	1
140801010401	Rio Blanco Headwaters	1	7
140801010303	Laughlin Park	5	1
140801010102	Quartz Creek	1	7
140801010101	Headwaters East Fork San Juan River	1	7
140300020403	Middle Lost Canyon	4	3
140801040405	South Fork Hermosa Creek	5	7
140801040404	Middle Hermosa Creek	1	2
140801020204	First Fork	2	1
140801010604	Upper Cat Creek	4	3

Table 4.16 Continued Summary of Watersheds with a Cumulative Dispersed Recreation Total Score of Five, management scale, San Juan National Forest; Watersheds highlighted in light green are located entirely on-forest

6th Level HUB #	Watershed Name	Riparian Cluster	Wetlands Cluster
140801010201	Upper West Fork San Juan River	2	8
140300036101	Naturita Creek	5	4
140300020605	Dolores Canyon-Joe Davis Hill	4	3
140300020603	Dolores Canyon-Cabin Creek	4	3
140300020507	Dawson Draw	4	3
140300020301	Upper Beaver Creek-McPhee	5	1
140300020208	Stoner Creek	2	1
140300020206	Bear Creek	2	1

Associated with these watersheds are riparian clusters 1r, 2r, 4r, 5r and 6r and wetland clusters 1w, 2w, 3w, 4w, 7w, and 8w.

Aquatic productivity and benthic macroinvertebrates in Riparian Clusters 1r, 2r, and 4r are all sensitive to changes in thermal regime, with Cluster 2r being among the most sensitive to change. Cluster 5r is somewhat sensitive to modifications in thermal regime while aquatic productivity and benthic macroinvertebrates are relatively unresponsive to thermal fluctuations. However, for fisheries water removal in Clusters 1r, 2r, 4r, 5r, 6r, would reduce summer flows and fisheries habitat, especially during years with low summer rainfall. As a result, this could create thermal regime issues for cold-water native fisheries. In addition, additional sediment would be stored temporarily during low flows resulting in additional degradation of local biotic conditions (USDA Forest Service, 2006, Report 1 of

While water withdrawal may not be a relevant issue for dispersed recreation it is for developed recreation and ski areas. The Upper Florida River-Transfer Park, Lower West Fork San Juan River, and the Upper Dolores River-Taylor Creek watersheds also score a cumulative total of "5" for developed recreation. The East Fork Hermosa Creek, Lower Cascade Creek, and the Wolf Creek watersheds score a total of "5" for ski areas. No single watersheds scores a "5" in ski areas, developed recreation and dispersed recreation. Modifications to sediment loads are of concern in riparian Clusters 1r, 2r, and 4r for fisheries and riparian resources, especially in the low gradient reaches of Cluster 2r. However for macroinvertebrates Clusters 1r, 2r, 4r, and 5r exhibit low sensitivities to sediment load increases, with Cluster 6r predicted to be relatively unresponsive to alterations in sediment regime(USDA Forest Service, 2006, Report 1 of 1).

Wetlands Clusters 3w and 4w has already been affected by ditches, diversions, and other types of water use, which has modified the natural spatial distribution of water and wetlands. Wetlands Clusters 1w, 2w, 7w, and 8w are all sensitive to modifications in hydrology. However, they vary in their sensitivity to sediment load fluctuations. Cluster 4w is the least sensitive to alterations in sediment load while Cluster 8w is the highest. The other clusters have been rated as having a moderate sensitivity to changes in sediment loading (USDA Forest Service, 2006, Report 1 of 1).

As discussed earlier the influence of dispersed recreation on aquatic systems is an emerging issue as public lands experience ever-increasing levels of dispersed recreational use on Forest Service administered, and other, public lands. Typical sites include disturbance features such as fire rings, tent sites, trails through, and use of, riparian vegetation, areas of congregation, parking and automobile tracks. With concentration of these activities soil compaction and the potential for increased runoff, erosion, and the contamination of aquatic systems increases, especially as the distance to a riparian zone, wetland, and/or stream increases. Already the average site density is 1.73 sites per valley bottom stream mile with the maximum density ratio of 5.58 sites per square mile, which is associated with the Stoner Creek watershed. When considering that the average barren area at these sites is 45 sq. ft per site with a total overall disturbed area of 905 sq. ft the significance of impacts associated with, or the potential for impacts, dispersed recreation becomes very clear. Recommendations for management include:

- The Upper Florida River-Transfer Park, East Fork Hermosa Creek, Lower Cascade Creek and Martinez Creek-Dutton Creek watersheds all have an additional recreational category with a cumulative total score of "5" or "4", indicating a high potential for impacts to aquatic, riparian, and wetland resources due to more than one type of recreational activity.
- The potential impacts to watershed health in the Martinez-Dutton Creek watershed related to dispersed recreation have the most potential to be exacerbated due to the high cumulative total score for ski areas and for the entire categories of transportation, vegetation management, and water uses. These three activity categories received cumulative total scores for "4" for transportation and vegetation management and the highest possible cumulative total score of "5" for water uses. Riparian Cluster 5r and wetlands Cluster 4w associated with this watershed. Fisheries, riparian vegetation, and aquatic productivity and benthic macroinvertebrates for this cluster range from moderate to high sensitivity to changes in hydrology, while sensitivity to changes in sediment loads range from moderate to low for macroinvertebrates. Wetlands Cluster 4w is also has a high sensitivity to changes in hydrology and moderate sensitivity to alterations in sediment loads. Due to the high overall potential for influence in this watershed efforts to implement mitigation measures addressing hydrologic alterations and sediment should be emphasized to reduce the influence of impacts on riparian and wetland health and function.
- The Upper Florida River-Transfer Park also scored a cumulative total of "5" in vegetation management, while the East Fork Hermosa Creek watershed also had a cumulative total of "4" for vegetation management. Lower Cascade Creek watershed is the most impacted of these watersheds by anthropogenic activities as it also scored cumulative totals of "4" for transportation and vegetation management. Protection and mitigation efforts on the existing low gradient reaches for riparian vegetation in the Upper Florida River-Transfer Park and East Fork Hermosa Creek watersheds should be high priority, due to the scarcity of these channels in this cluster and the high elevation and relatively low overall production potential of these watersheds. Category 7w wetlands within the Upper Florida River-Transfer

Park watershed are located entirely within the Forest boundary, representing an ideal opportunity for mitigation or restoration efforts, depending on the degree of impact at candidate sites.

- The San Juan River-Trujillo watershed is involved in ski area activity as well as dispersed recreation and vegetation management. Both the wetlands and riparian clusters within it are highly sensitive to alterations in surface hydrology with the riparian cluster 6r also being highly sensitive to alterations in groundwater flow. Implementation of anthropogenic activities that may alter the Clusters hydrology should be carefully evaluated in context of what activities are being proposed and existing levels of anthropogenic impacts in that particular watershed where the activity is being proposed.
- Wetlands Cluster 3w has agricultural activities within these watersheds which has disturbed wetlands. Since dispersed recreation often occurs away from these agricultural areas there may be restoration opportunities in these individual, smaller wetlands in the Upper Cat Creek Dolores River-Joe Davis Hill watersheds where disturbances to hydrology are minimized as there are no other anthropogenic activities have dominating influences with total cumulative scores of “4” or “5”.
- Additional opportunities for wetland restoration exist in those watersheds with wetlands Cluster 4w, where the dispersed recreation cumulative total score is “3” or less indicating limited management influences. However, when considering these sites for restoration, anthropogenic influences from other categories will need to be determined to ensure management activity influences for the proposed restoration site are limited.

Recreation Overall Cumulative Percentile Ranking

In determine the total combined effects of developed and dispersed recreation, the results of all metrics, for both types of recreation, were combined, re-ranked, and a cumulative percentile ranking was determined. These metrics are summarized in Table 4.17. This analysis is relative only to the portion of the 6th level HUBs surface area within the San Juan National Forest boundary, and is intended to provide the reader with the additive rankings at this scale. Unlike the previous methodology, the results are evenly distributed across the total number of HUBs at this scale.

This analysis was performed at the management scale, with data existing for all portions of the 154 HUBs within the San Juan National Forest boundary. Ranking these watersheds delineates which watersheds are the most susceptible to recreation-related impacts on aquatic and riparian health. Rankings were divided into five differing groups, each with a 20 percentile ranges. Watersheds within the 100-80 percentile range have the most susceptibility to impacts on aquatic health while those falling within the 19.9-0.1 percentile range have the lowest potential for being influenced. The results of the cumulative ranking process for all recreation metrics, in all watersheds associated with the San Juan National Forest are summarized in Table 4.19 at the end of this section. This table also summarizes which riparian and wetland clusters are associated with each watershed on the forest. Essentially this table will function as a "look up" table, so at a glance one can determine which recreation activities are affecting each watershed, as well as have a reference to watershed sensitivity. The table also indicates which watersheds are located entirely on-forest.

The sum of the percentile ranks of the 9 criteria of the recreation category was calculated to identify the additive effects of this activity on aquatic, riparian, and wetland resources.

The cumulative percentile ranking for the 100-80 percentile range is summarized in Table 4.18 and displayed in map format in Figure 4.21.

Ten watersheds in the recreation synthesis analysis were within the 100-80 percentile range. The maximum cumulative ranking for recreation was 15. Five watersheds had a cumulative total of 13; two watersheds had a cumulative total of 12 and three watersheds had a cumulative total of 11. These watersheds are found in the eastern three-quarters of the Forest. These watersheds reflect high levels of skiing and recreation activity for both dispersed and developed recreation. None of the three categories had a cumulative ranking of less than three (Table 4.19).

Upper Florida River-Transfer Park (HUB#140801040802), East Fork Hermosa Creek (HUB# 140801040402), Lower Cascade Creek (HUB# 140801040303), Lower West Fork Juan River (HUB# 140801010204), and Wolf Creek (HUB# 140801010203) have the highest cumulative totals. All of these watersheds are located on-forest and have the potential for recreation related effects on aquatic, riparian, and wetland resources. However, the Upper Florida River-Transfer Park and Vallecito Reservoir watersheds have the potential to impact resources located downstream and off-forest.

Table 4.17 Summary of criteria used in Recreation cumulative analysis, management area, San Juan National Forest

Metric	Explanation
Developed Recreation	
Percent Developed Recreation Sites in Valley Bottom by HUB	What percentage of developed recreations sites are located in valley bottoms by 6th level HUB
# of Developed Recreation Sites per Stream Mile6th level HUB	How many developed recreation sites are there per stream mile by 6th level HUB
Percent of 6th level HUB Within a Downhill Ski Area	What percentage of a 6th level HUB is found within a downhill ski area by 6th level HUB
Percent Valley Bottom Within a Downhill Ski Area	What percentage of valley bottom area is located within a Downhill Ski area by 6th level HUB
# of Miles of Stream Downstream of a Downhill Ski Area	How many miles of stream are located downstream between a downhill ski area and the watersheds boundary, by 6th level HUB
Percent of 6th level HUB Within a Nordic Ski Area	What percentage of a 6th level HUB is found within a nordic ski area by 6th level HUB
Percent Valley Bottom Within a Nordic Ski Area	What percentage of valley bottom area is located within a nordic Ski area by 6th level HUB
# of Miles of Stream Downstream of a Nordic Ski Area	How many miles of stream are located downstream between a nordic ski area and the watersheds boundary, by 6th level HUB
Dispersed Recreation	
Potential # of sites per sq. mile of 6th level HUB	What is the potential number of dispersed recreation sites per square mile of 6th level HUB
Potential # of sites per sq. mile of valley bottom by 6th level HUB	What is the potential number of dispersed recreation sites per square mile of valley bottom by 6th Level HUB

Table 4.18 Summary of the Recreation Cumulative Percentile Ranking 100-80 Percentile Ranking, management scale, San Juan National Forest; Watersheds highlighted in light green are located entirely within the Forest boundary

HUB6	HUB6NAME	Ski Cumulative Percentile Rank	Developed Recreation Cumulative Percentile Rank	Dispersed Recreation Cumulative Percentile Category	Recreation Total	Cumulative Recreation Category	Riparian Cluster	Wetlands Cluster
140801040802	Upper Florida River-Transfer Park	3.00	5.00	5.00	13.00	5	1	7
140801040402	East Fork Hermosa Creek	5.00	3.00	5.00	13.00	5	1	1
140801040303	Lower Cascade Creek	5.00	3.00	5.00	13.00	5	2	1
140801020401	Martinez Creek-Dutton Creek	4.00	3.00	5.00	12.00	5	5	4
140801020102	Middle Fork Piedra River	3.00	4.00	4.00	11.00	5	2	7
140801011404	Vallecito Reservoir	3.00	5.00	3.00	11.00	5	5	3
140801010504	Navajo River-Weisel Flat	4.00	3.00	4.00	11.00	5	4	3
140801010402	Fish Creek	3.00	5.00	4.00	12.00	5	1	7
140801010204	Lower West Fork San Juan River	3.00	5.00	5.00	13.00	5	2	7
140801010203	Wolf Creek	5.00	3.00	5.00	13.00	5	1	7

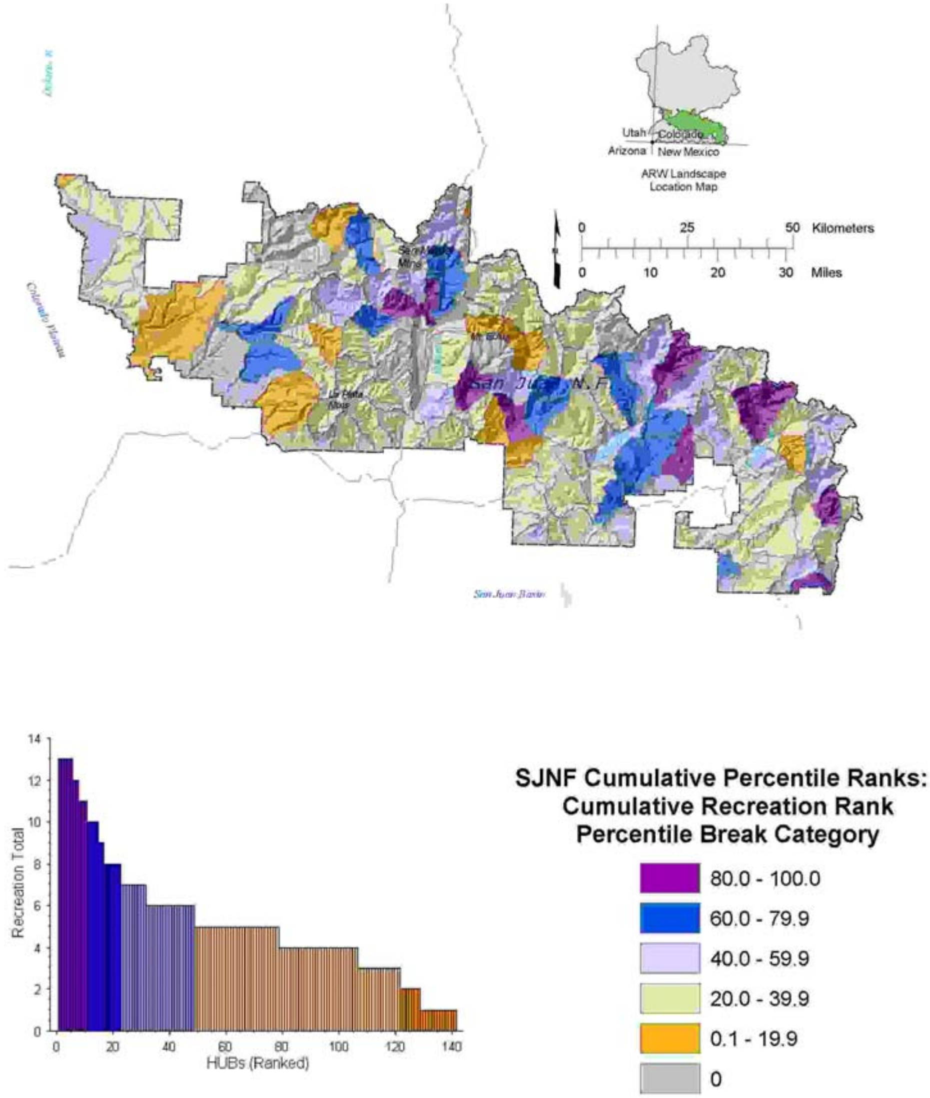

Figure 4.21 Recreation Categories, Cumulative 80-100 Percentile Ranking for 6th level watersheds, management scale, San Juan National Forest

Martinez Creek-Dutton Creek (HUB# 140801020401) and Fish Creek (HUB# 140801010402) both received cumulative totals of 12. Both watersheds have the potential for on-forest effects, but Martinez Creek-Dutton Creek also has the potential for downstream off-forest impacts.

Middle Fork Piedra River (HUB# 140801020102), Vallecito Reservoir (HUB# 140801011404), and the Navajo River-Weisel Flat (HUB# 140801010504) watersheds have cumulative totals of 11. All three watersheds have the potential for on-forest impacts. The Vallecito Reservoir and the Navajo River-Weisel Flat watersheds also have the potential for off-forest downstream impacts to aquatic, riparian, and wetland resources.

Watersheds in the 79.9-60 and 59.9-40 percentile ranges are found across the entire forest. There is the potential for both on and off-forest effects. These watersheds are dominated by ski area and dispersed recreational activities.

Watersheds falling within the 20-39.9 percentiles, which correspond to a cumulative recreation category of 2, dominated the rankings and are found predominantly in the western half of the Forest (See Figure 4.21). There is the potential for both on and off-forest impacts. These watersheds are dominated by dispersed recreational activities.

There are 20 watersheds within the 19.9-0.1 percentile range and are located primarily in the western half of the Forest, and the potential for impacts, as with the other percentile ranges, is for both on and off-forest effects. This percentile range is dominated only be dispersed recreational activities.

There are 13 watersheds where there is no recreational activity recorded. Seven of these watersheds are located entirely on the Forest.

Figure 4.19 Transportation Category, Cumulative Percentile Ranking for all watersheds; Watersheds located entirely with the forest boundary are highlighted in light green

HUB6	HUB6NAME	Ski Cumulative Percentile Rank	Developed Recreation Cumulative Percentile Rank	Dispersed Recreation Cumulative Percentile Category	Recreation Total	Cumulative Recreation Category	Riparian Cluster	Wetlands Cluster
140801040802	Upper Florida River-Transfer Park	3.00	5.00	5.00	13.00	5	1	7
140801040402	East Fork Hermosa Creek	5.00	3.00	5.00	13.00	5	1	1
140801040303	Lower Cascade Creek	5.00	3.00	5.00	13.00	5	2	1
140801020401	Martinez Creek-Dutton Creek	4.00	3.00	5.00	12.00	5	5	4
140801020102	Middle Fork Piedra River	3.00	4.00	4.00	11.00	5	2	7
140801011404	Vallecito Reservoir	3.00	5.00	3.00	11.00	5	5	3
140801010504	Navajo River-Weisel Flat	4.00	3.00	4.00	11.00	5	4	3
140801010402	Fish Creek	3.00	5.00	4.00	12.00	5	1	7
140801010204	Lower West Fork San Juan River	3.00	5.00	5.00	13.00	5	2	7
140801010203	Wolf Creek	5.00	3.00	5.00	13.00	5	1	7
140801040403	Upper Hermosa Creek	5.00	0.00	3.00	8.00	4	5	1
140801040302	Lime Creek	5.00	0.00	4.00	9.00	4	2	8
140801020302	Lower Devil Creek	5.00	0.00	3.00	8.00	4	6	3
140801020301	Upper Devil Creek	3.00	3.00	4.00	10.00	4	5	3
140801020202	Lower Weminuche Creek	3.00	0.00	5.00	8.00	4	2	3
140801020104	Piedra River-O'Neal Creek	1.00	5.00	4.00	10.00	4	5	4
140801011306	East Creek	3.00	0.00	5.00	8.00	4	2	1
140801011305	Indian Creek	3.00	0.00	5.00	8.00	4	2	2
140801010601	San Juan River-Trujillo	3.00	0.00	5.00	8.00	4	6	3
140300020401	Upper Lost Canyon	1.00	4.00	5.00	10.00	4	2	1
140300020209	Upper Dolores River-Taylor Creek	0.00	5.00	5.00	10.00	4	5	3
140300020202	Upper Dolores River-Cayton Valley	4.00	0.00	5.00	9.00	4	2	1
140801070104	ChiCreeken Creek	4.00	1.00	2.00	7.00	3	4	3
140801050102	Mayday Valley	0.00	3.00	4.00	7.00	3	7	3
140801040503	Upper Animas Valley-Stevens Creek	2.00	0.00	4.00	6.00	3	4	4
140801040502	Elbert Creek	5.00	0.00	2.00	7.00	3	5	3

HUB6	HUB6NAME	Ski Cumulative Percentile Rank	Developed Recreation Cumulative Percentile Rank	Dispersed Recreation Cumulative Percentile Category	Recreation Total	Cumulative Recreation Category	Riparian Cluster	Wetlands Cluster
140801040401	Hermosa Creek headwaters	4.00	0.00	2.00	6.00	3	2	1
140801040301	Upper Cascade Creek	4.00	0.00	3.00	7.00	3	2	8
140801040103	Mineral Creek	4.00	0.00	2.00	6.00	3	2	8
140801020404	Middle Stollsteimer Creek	2.00	3.00	1.00	6.00	3	6	3
140801020403	Stollsteimer Creek-Dyke Valley	3.00	0.00	3.00	6.00	3	4	4
140801020402	Upper Stollsteimer Creek	3.00	0.00	3.00	6.00	3	5	4
140801020205	Upper Piedra River-Box Canyon	3.00	0.00	3.00	6.00	3	5	3
140801020103	Williams Creek	1.00	2.00	3.00	6.00	3	2	2
140801020101	East Fork Piedra River	3.00	0.00	4.00	7.00	3	1	7
140801011704	Upper Spring Creek	4.00	0.00	2.00	6.00	3	6	4
140801011403	Lower Vallecito Creek	3.00	0.00	4.00	7.00	3	1	2
140801010602	Montezuma Creek	1.00	0.00	5.00	6.00	3	4	4
140801010506	Little Navajo River	2.00	0.00	4.00	6.00	3	2	3
140801010503	Navajo Peak	1.00	0.00	5.00	6.00	3	2	1
140801010401	Rio Blanco Headwaters	1.00	0.00	5.00	6.00	3	1	7
140801010303	Laughlin Park	1.00	0.00	5.00	6.00	3	5	1
140801010302	Fourmile Creek	3.00	0.00	3.00	6.00	3	2	3
140801010102	Quartz Creek	2.00	0.00	5.00	7.00	3	1	7
140801010101	Headwaters East Fork San Juan River	4.00	0.00	2.00	6.00	3	1	7
140300020604	Dolores Canyon-Lake Canyon	0.00	3.00	3.00	6.00	3	4	3
140300020403	Middle Lost Canyon	2.00	0.00	5.00	7.00	3	4	3
140300020204	Upper Dolores River-Scotch Creek	3.00	0.00	4.00	7.00	3	2	1
140801070103	Upper Mancos Valley	1.00	0.00	4.00	5.00	2	5	4
140801050105	Upper Cherry Creek	1.00	0.00	3.00	4.00	2	5	4
140801050101	La Plata River headwaters	0.00	3.00	1.00	4.00	2	2	8
140801040901	Lower Florida River-Ticalotte	1.00	0.00	2.00	3.00	2		
140801040804	Upper Florida River-Red Creek	3.00	0.00	0.00	3.00	2		
140801040803	Lemon Reservoir	2.00	0.00	1.00	3.00	2		

HUB6	HUB6NAME	Ski Cumulative Percentile Rank	Developed Recreation Cumulative Percentile Rank	Dispersed Recreation Cumulative Percentile Category	Recreation Total	Cumulative Recreation Category	Riparian Cluster	Wetlands Cluster
140801040604	Animas River-Spring Creek	1.00	0.00	2.00	3.00	2	5	3
140801040603	Lower Lightner Creek	3.00	0.00	2.00	5.00	2	2	1
140801040602	Upper Lightner Creek	0.00	0.00	4.00	4.00	2	1	7
140801040601	Junction Creek	3.00	0.00	1.00	4.00	2	8	9
140801040504	Upper Animas Valley-Trimble	1.00	0.00	3.00	4.00	2	6	5
140801040501	Upper Animas Valley-Canyon Creek	1.00	0.00	3.00	4.00	2	2	3
140801040407	Lower Hermosa Creek	2.00	0.00	3.00	5.00	2	5	5
140801040405	South Fork Hermosa Creek	0.00	0.00	5.00	5.00	2	5	7
140801040404	Middle Hermosa Creek	0.00	0.00	5.00	5.00	2	1	2
140801040204	Animas River-Needleton	0.00	0.00	3.00	3.00	2	2	8
140801040202	Animas River-Tenmile Creek	4.00	0.00	1.00	5.00	2	2	8
140801040201	Elk Creek	0.00	0.00	4.00	4.00	2	3	8
140801040104	Animas River-Cunningham Creek	3.00	0.00	2.00	5.00	2	2	8
140801020503	Piedra River-Navajo Reservoir Inlet	0.00	0.00	4.00	4.00	2	6	3
140801020502	Piedra River-Stollsteimer	1.00	0.00	4.00	5.00	2	6	4
140801020501	Yellowjacket Creek	3.00	0.00	1.00	4.00	2	4	4
140801020405	Lower Stollsteimer Creek	2.00	0.00	1.00	3.00	2	6	4
140801020206	Upper Piedra River-Indian Creek	4.00	0.00	1.00	5.00	2	5	3
140801020204	First Fork	0.00	0.00	5.00	5.00	2	2	1
140801020203	Sand Creek	0.00	0.00	4.00	4.00	2	2	1
140801011703	Ute Creek	1.00	0.00	4.00	5.00	2	6	4
140801011603	Lower Beaver Creek	4.00	0.00	1.00	5.00	2	5	4
140801011602	Middle Beaver Creek	2.00	0.00	2.00	4.00	2	5	4
140801011601	Upper Beaver Creek	2.00	0.00	2.00	4.00	2	5	4
140801011401	Upper Vallecito Creek	0.00	0.00	3.00	3.00	2	2	8
140801011304	Three Sisters	0.00	0.00	3.00	3.00	2	8	9

HUB6	HUB6NAME	Ski Cumulative Percentile Rank	Developed Recreation Cumulative Percentile Rank	Dispersed Recreation Cumulative Percentile Category	Recreation Total	Cumulative Recreation Category	Riparian Cluster	Wetlands Cluster
140801011303	Lake Creek	1.00	0.00	4.00	5.00	2	2	8
140801011302	Upper Los Pinos River-Flint Creek	0.00	0.00	4.00	4.00	2	2	8
140801011301	Upper Los Pinos River-Ricon La Vaca	0.00	0.00	3.00	3.00	2	2	8
140801010604	Upper Cat Creek	0.00	0.00	5.00	5.00	2	4	3
140801010507	Coyote Creek	4.00	0.00	0.00	4.00	2	4	3
140801010502	West Fork Navajo River	0.00	0.00	3.00	3.00	2	1	7
140801010406	Lower Rio Blanco-San Juan River	4.00	0.00	1.00	5.00	2	4	4
140801010405	Rito Blanco	4.00	0.00	0.00	4.00	2	5	4
140801010404	Middle Rio Blanco	4.00	0.00	0.00	4.00	2	4	3
140801010403	Rio Blanco River-Blanco Basin	3.00	0.00	2.00	5.00	2	2	2
140801010308	San Juan River-Eightmile Mesa	2.00	0.00	3.00	5.00	2	5	4
140801010307	Echo Canyon Reservoir	3.00	0.00	1.00	4.00	2	5	4
140801010306	Mill Creek	3.00	0.00	2.00	5.00	2	4	4
140801010305	McCabe Creek	3.00	0.00	2.00	5.00	2	5	4
140801010304	Upper Pagosa Springs	4.00	0.00	1.00	5.00	2	4	3
140801010301	Turkey Creek	3.00	0.00	2.00	5.00	2	2	2
140801010202	Beaver Creek	0.00	0.00	4.00	4.00	2	1	7
140801010201	Upper West Fork San Juan River	0.00	0.00	5.00	5.00	2	2	8
140801010104	East Fork San Juan River-The Clamshell	4.00	0.00	1.00	5.00	2	1	7
140300036101	Naturita Creek	0.00	0.00	5.00	5.00	2	5	4
140300020605	Dolores Canyon-Joe Davis Hill	0.00	0.00	5.00	5.00	2	4	3
140300020603	Dolores Canyon-Cabin Creek	0.00	0.00	5.00	5.00	2	4	3
140300020602	Narraguinnep Canyon Natural Area	0.00	0.00	4.00	4.00	2	4	4
140300020601	Dolores River-Salter Canyon	0.00	0.00	4.00	4.00	2	4	3
140300020510	Upper Disappointment Valley	0.00	0.00	4.00	4.00	2	6	6
140300020509	Pine Arroyo	0.00	0.00	3.00	3.00	2	4	3
140300020507	Dawson Draw	0.00	0.00	5.00	5.00	2	4	3
140300020506	Brumley Valley	0.00	0.00	4.00	4.00	2	6	4

HUB6	HUB6NAME	Ski Cumulative Percentile Rank	Developed Recreation Cumulative Percentile Rank	Dispersed Recreation Cumulative Percentile Category	Recreation Total	Cumulative Recreation Category	Riparian Cluster	Wetlands Cluster
140300020505	Upper Disappointment Creek	0.00	0.00	4.00	4.00	2	5	4
140300020504	Ryman Creek	0.00	0.00	3.00	3.00	2	5	4
140300020503	Sheep Camp Valley	0.00	0.00	4.00	4.00	2	5	4
140300020303	Calf Creek	0.00	0.00	4.00	4.00	2	5	4
140300020302	Upper Plateau Creek	0.00	0.00	3.00	3.00	2	5	4
140300020301	Upper Beaver Creek -McPhee	0.00	0.00	5.00	5.00	2	5	1
140300020208	Stoner Creek	0.00	0.00	5.00	5.00	2	2	1
140300020207	Dolores River-Priest Gulch	0.00	0.00	4.00	4.00	2	2	1
140300020206	Bear Creek	0.00	0.00	5.00	5.00	2	2	1
140300020203	Rico Valley	0.00	0.00	4.00	4.00	2	2	1
140300020201	Dolores River Headwaters-Tin Can Basin	3.00	0.00	1.00	4.00	2	2	1
140300020105	Lower West Dolores River	0.00	0.00	3.00	3.00	2	5	3
140300020104	Groundhog Creek	0.00	0.00	3.00	3.00	2	2	1
140802020106	Lower Alkali Canyon-Narraguinnep Canyon	0.00	0.00	1.00	1.00	1	6	6
140801070105	East Fork of Mud Creek	1.00	0.00	0.00	1.00	1	4	4
140801070102	West Mancos River	1.00	1.00	0.00	2.00	1	2	1
140801070101	East Mancos River-Middle Mancos River	1.00	0.00	0.00	1.00	1	2	1
140801040203	Needle Creek	0.00	0.00	1.00	1.00	1	8	9
140801040102	Cement Creek	0.00	0.00	1.00	1.00	1	3	8
140801040101	Animas River above Howardsville	0.00	0.00	2.00	2.00	1	2	8
140801011502	Bear Creek	0.00	0.00	1.00	1.00	1	5	4
140801011501	Middle Los Pinos River-Red Creek	0.00	0.00	2.00	2.00	1	5	3
140801011402	Middle Vallecito Creek	0.00	0.00	1.00	1.00	1	2	8
140801010103	Sand Creek	1.00	0.00	0.00	1.00	1	1	7
140300020511	Disappointment Valley-Wild Horse Reservoir	0.00	0.00	2.00	2.00	1	6	3

HUB6	HUB6NAME	Ski Cumulative Percentile Rank	Developed Recreation Cumulative Percentile Rank	Dispersed Recreation Cumulative Percentile Category	Recreation Total	Cumulative Recreation Category	Riparian Cluster	Wetlands Cluster
140300020408	McPhee Reservoir-Dolores River	0.00	1.00	0.00	1.00	1	4	4
140300020407	House Creek	0.00	0.00	2.00	2.00	1	4	3
140300020405	Lower Lost Canyon	0.00	0.00	1.00	1.00	1	4	3
140300020306	McPhee Reservoir-Beaver Creek Inlet	0.00	0.00	2.00	2.00	1	4	3
140300020305	Beaver Creek-Trail Canyon	0.00	0.00	1.00	1.00	1	4	3
140300020304	Lower Plateau Creek	0.00	0.00	2.00	2.00	1	5	4
140300020205	Roaring Forks Creek	0.00	0.00	1.00	1.00	1	2	1
140300020101	El Deinte Peak	0.00	0.00	1.00	1.00	1	2	1
140802020201	Upper Yellowjacket Canyon	0.00	0.00	0.00	0.00	0	4	3
140802020103	Hartman Canyon	0.00	0.00	0.00	0.00	0	6	6
140801040801	Florida River Headwaters	0.00	0.00	0.00	0.00	0	5	4
140801040406	Hermosa Creek-Dutch Creek	0.00	0.00	0.00	0.00	0	5	2
140801020201	Upper Weminuche Creek	0.00	0.00	0.00	0.00	0	1	8
140801011503	Los Pinos River-Bayfield	0.00	0.00	0.00	0.00	0	5	4
140300020502	Disappointment Creek Headwaters	0.00	0.00	0.00	0.00	0	5	1
140300020501	Bear Creek-Disappointment Creek	0.00	0.00	0.00	0.00	0	5	4
140300020406	Upper Dolores River-Italian Creek	0.00	0.00	0.00	0.00	0	4	3
140300020404	Stapleton Valley	0.00	0.00	0.00	0.00	0	4	3
140300020402	Spruce Water Canyon	0.00	0.00	0.00	0.00	0	4	3
140300020103	Upper West Dolores River	0.00	0.00	0.00	0.00	0	2	1
140300020102	Fish Creek	0.00	0.00	0.00	0.00	0	2	1

Chapter 5
Mineral Extraction Category
Management Scale

Key Findings

- Just over 2% percent of solid minerals sites are classified as *recent*. Much of the ongoing influence of minerals development emerges from a historic legacy of precious metals (i.e. locatable minerals) development.

- Silverton, Rico, La Plata Mountains and the Dolores area have historically and currently the highest level of locatable minerals development.

- Mining claim density mapping provides a qualitative measure of interest for locatable minerals in undeveloped frontier areas.

- 303d listed streams and TMDL candidate streams resulting from locatable minerals mining include reaches of the Animas River from above Silverton downstream to Durango and the Dolores River from Rico (Horse Creek) downstream to Bear Creek.

- Over 80% percent of oil and gas wells in the management scale occur in 15 6th level HUBS. None of these HUBs fall fully inside the Forest.

- The Florida River-Lemon Reservoir, Los Pinos River-Bayfield, Lower Beaver Creek, Ute Creek 6th level watersheds have high levels of current oil and gas activity. Wells outside these HUBs are largely inactive.

- About 75% percent of oil and gas wells in the management scale are abandoned.

- Six coal mines in the management scale area are currently, or have been recently active. Another 40 sites are now abandoned; most of those are historic prospects and smaller scale sites.

- There are about 115 miles of 303d/TMDL listed streams in the management scale that result from mining.

Introduction

This chapter characterizes the influence of mineral extraction at the management scale and summarizes levels of disturbance for the 154 6th level HUBs that comprise the San Juan Forest management scale (Figure 5.1).

Like the landscape scale, the San Juan management scale area itself is particularly well endowed with a wide variety of mineral resources. Significant deposits occur both within and outside the National Forest bounds.

Mineral commodities occurring and developed in the San Juan management scale area include precious and base metals, coal, sand, gravel, stone and oil and gas. Precious metals, naturally, include gold, silver and copper. Base metals include metals such as iron, zinc and uranium. Administratively, precious and base metals along with some less common minerals are considered to be *locatable minerals* and are subject to *mining claim* on federal lands. The regulations governing locatable minerals grow out of the Mining Law of 1872. At its inception, the law was deliberately permissive in order to encourage development in the West. And today, the historic success of the law is evident in the emergence of the Silverton, Rico and La Plata mining areas. However, the negative consequences of the permissiveness of the law are now recognizable in a legacy of abandoned mines, Forest in-holdings, roads, toxic drainage and ongoing cleanup efforts.

Furthermore, coal, petroleum and gas are subject to *leasing* on federal lands while sand, gravel and other common variety mineral materials are subject to *sales*. While the boom in metals mining is long passed, the development of coal, petroleum and gas, along with sand and gravel continues in the region.

While local and regional communities benefit from the rich mineral endowment found in the management scale area, the Forest and local communities also face challenges resulting from both historic and current mineral extraction activities. Sedimentation and contamination from mining areas near Silverton, Rico and in the La Plata Mountains continue to strongly influence ARW resources in downstream watersheds. High intensity oil and gas development in the San Juan Basin generates significant sedimentation loads and strongly affects the capacity and composition of aquifers in the Basin. Development of alluvial deposits for sand and gravel in valley bottom settings alters floodplain aquatic systems and disturbed areas increase sediment loads.

Broadly speaking, minerals fall into two categories: solid and fluid. Summary by these two categories is useful to characterize distribution of mineral sites and activity throughout the San Juan management scale area. In the area there are more than 2350 mineral sites recorded in the combined lists of U. S. Geological Survey Mas/Mils (Minerals Availability System/Minerals Industry Location System) (Causey, 1997) data and State of Colorado oil and gas well records (COGCC, 2004) (Figure 5.1)

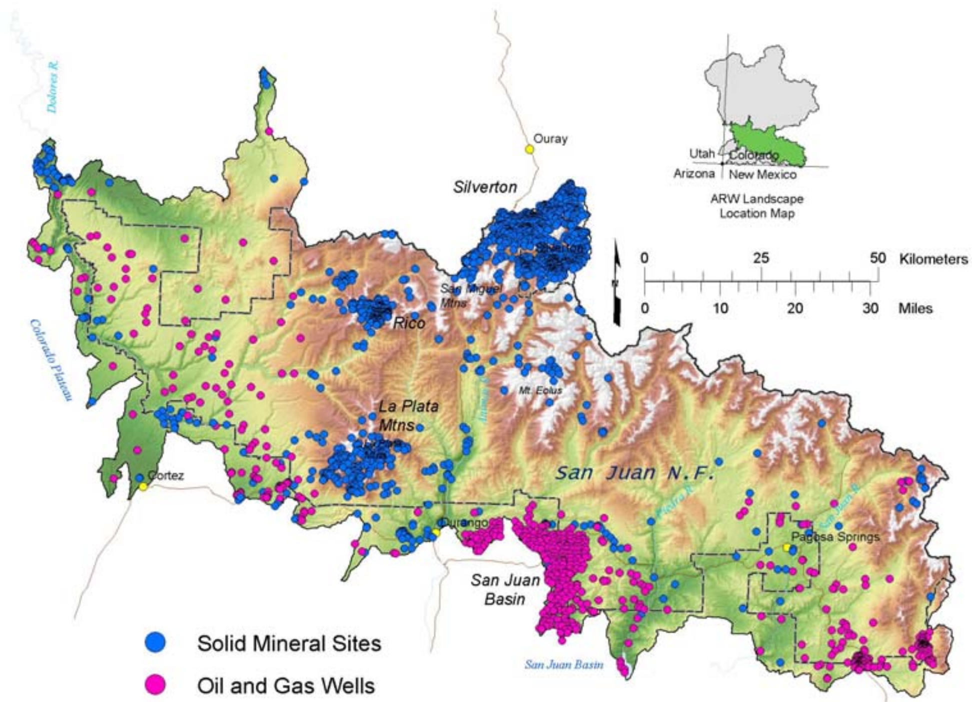

Figure 5.1 There are over 2350 (*historic and current*) solid mineral, oil and gas sites in the San Juan management scale area. These are largely taken from the U.S. Geological Survey Mas/Mils database and State of Colorado oil and gas wells database.

About 70% percent of the historic and current mineral sites in the management scale area are comprised of solid minerals. The greater proportion of these sites include mostly historic prospects and mines for the development of precious metals (e.g. gold and silver) from deposits in upland areas of Silverton, Rico and the La Plata Mountains. Otherwise, the remaining solid mineral sites are comprised of coal, sand and gravel. The remaining 30% percent of sites are comprised of oil and gas wells, mostly recent in the northern margin of the San Juan Basin. Each category, along with its influences is more fully elaborated in the following sections.

Mas/Mils Mining Sites – Status

First, we examine the historic and current setting of solid minerals in the management scale. We establish the sites, mineralogical and geological setting. Then we examine the patterns of watershed influenced by development of these different mineral groups – locatable, leasable and mineral materials. Mas/Mils is tells us where we find precious metals, some coal and mineral materials sites.

Within the ARW management scale there were 1,634 solid mineral development sites recorded in the MAS/MILS database as of 1997. The database includes all types of solid minerals. These may be categorized into four status classes. These four are:

1) *Historic* – indicative of mineral development in the past;
2) *Prospect* – a site with prospecting but no development;
3) *Recent* – indicating active development currently or recently;
4) *Unknown* – indicating the possibility of prospecting and/or development. Likely to be historical.

Of the 1,634 sites, nearly 40% percent may be considered to be *Historic* (Table 5.1). Nearly 10% percent are classified as *Prospects.* 47% percent are of *Unknown* status leaving **just over 2% percent classified as *recent***.

Historical sites tend to cluster in upland areas known for precious metals mining; notably these include the Silverton and La Plata areas (Figure 5.2). Deposits in these areas include volcanic-associated massive sulfide deposits, poly-metallic vein deposits, and poly-metallic replacement deposits. These modes of deposition are often associated with Tertiary volcanic rocks along with Paleozoic and Mesozoic sediments.

In those areas both prospects and sites classified as *unknown* can be considered to be historic as-well. Overall, a relatively small number of sites can be considered to be currently active ("*recent*"). As a consequence, a greater proportion of influences on aquatic resources, from mining**,** are due to the legacy of historic booms.

Table5.1 Mils/Mas Mine site status in San Juan ARW Management Scale

Status	Number of Sites	Percent
Historic	674	41.2%
Prospect	156	9.5%
Recent	34	2.1%
Unknown	770	47.1%
	1,634	100.0%

Recent sites, making up a small percentage of the total Mils/Mas sites, more widely distributed throughout the management scale area. Coal sites follow margins of sedimentary basins while common variety (sand and gravel) tend to correlate to an association between roadways combined with valley bottom alluvium.

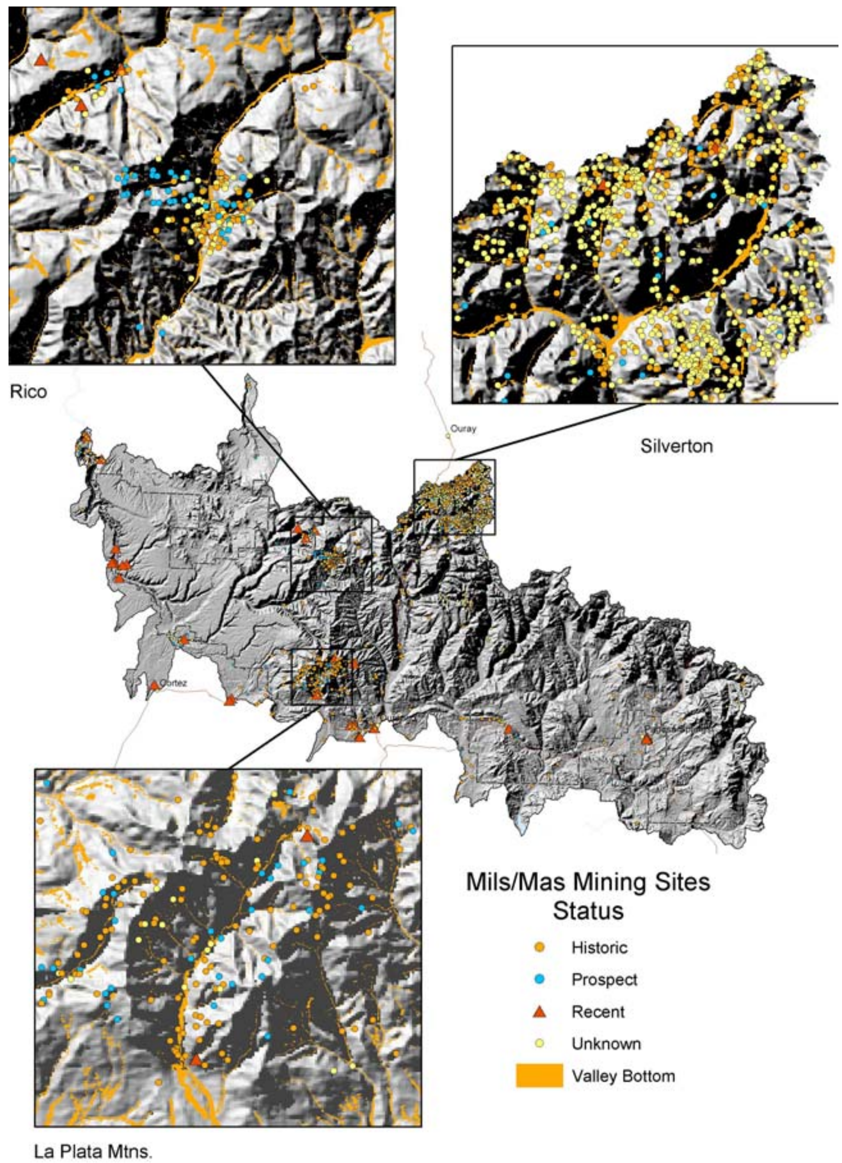

Figure 5.2 San Juan ARW Management Scale – Mils/Mas mine sites by status.

Mining Sites – Mineral/Commodity Type

Nearly half of the 1,634 Mas/Mils sites in the San Juan Management scale may be clearly identified as *locatable minerals* (Table 5.2). These categories include gold, silver, lead, base-metal and uranium.

Deposits are often associated with Tertiary volcanic rocks and intrusive bodies in a variety of structural and stratigraphic settings. These settings are

too complex to fairly characterize in this summary.
Most of these 1,634 sites are historical and located in upland areas most notably Silverton, Rico and the La Plata Mountains (Figure 5.3). Those sites that are classified as 'Unknown' are located mostly in these mining districts and generally may also be considered to be *locatable* too.

While many of these locatable sites fall within the bounds of private land, the result of mineral patenting, they are of particular concern to Forest management. The bulk of these lands are in-holdings surrounded by Forest Lands. As a result, streams influenced by mining on these lands carry sedimentation and contamination downstream across Forest lands and beyond.

Table 5.2 Mas/Mils mine sites by commodity in San Juan ARW Management Scale. "Common Variety" minerals include sand and gravel and building stone.

Commodity	Number of Sites	Percent
Unknown	562	34.4%
Gold	279	17.1%
Other	229	14.0%
Silver	209	12.8%
Lead	121	7.4%
Base Metal	72	4.4%
Common Variety	60	3.7%
Uranium	57	3.5%
Coal	45	2.8%
	1,634	100.0%

The following sections examine the potential influence of locatable minerals for 926 sites in the management scale. Common variety minerals, coal and petroleum are examined in subsequent sections.

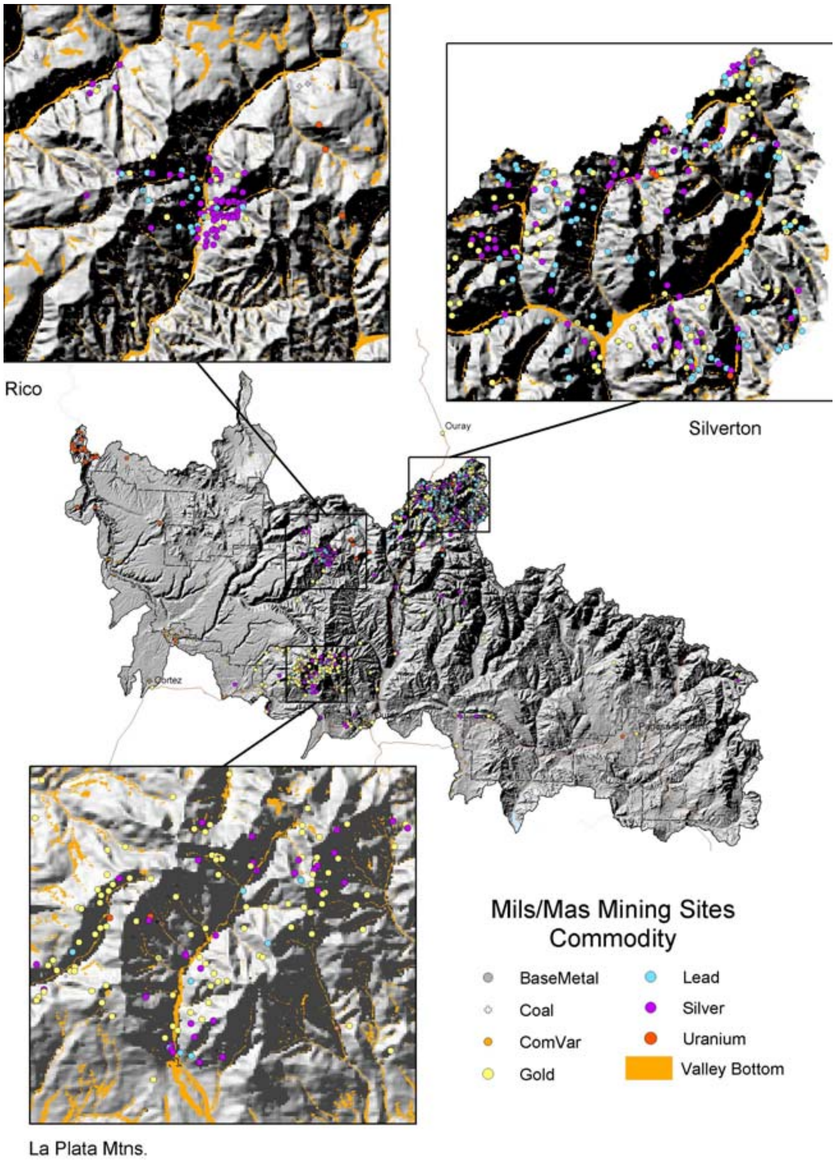

Figure 5.3 San Juan ARW Management Scale – Mils/Mas mine sites by commodity. All except Coal and Common Variety ("ComVar") are locatable minerals.

Locatable Minerals Site Density – Number of Sites Per HUB Acre

At the management scale, fifty-six of 154 watersheds are influenced directly by historic and recent locatable mineral mining activity. In these 56 watersheds, there are 926 sites contributing to site densities from 0.0078 sites per HUB acre to 0.00002 sites per HUB acre.

Twelve watersheds are most strongly influenced on the basis of this simple measure of site density and fall in the 80th to 100th percentiles of all HUBS. In addition, almost 85% percent (784 sites) of 926 sites fall in these twelve HUBs (Table 5.3). And, among these top twelve, over 50% percent of all 926 sites are in five HUBS. These five HUBS, in order of descending density are: Dolores River – Rico Valley, Cement Creek, La Plata River Headwaters and the Animas River above Howardsville (Figure 5.4).

Table 5.4 Mas/Mils Locatable mine sites in 80th to 100th percentile for site density as Number per HUB Acre. Highlighted HUBs fall completely inside the San Juan Forest Boundary.

HUB	Name	Number of Sites	Number of Sites Per Hub Acre	Percent Of Total
140300020203	Dolores River-Rico Valley	120	0.0078	12.96%
140801040102	Cement Creek	79	0.0061	8.53%
140801050101	La Plata River Headwaters	64	0.0045	6.91%
140801040101	Animas River above Howardsville	115	0.0042	12.42%
140801040103	Mineral Creek	129	0.0038	13.93%
140801040104	Animas River-Cunningham Creek	100	0.0036	10.80%
140801070101	East Mancos/Middle Mancos Rivers	36	0.0023	3.89%
140801050102	La Plata River-Mayday Valley	24	0.0017	2.59%
140300020204	Dolores River-Scotch Creek	33	0.0013	3.56%
140801040604	Animas River-Dry Fork	10	0.0012	1.08%
140300020605	Dolores River Canyon-Joe Davis Hill	45	0.0012	4.86%
140801040601	Junction Creek	29	0.0012	3.13%
		784		84.67%

Mine site densities are highest in watersheds near Silverton, Rico, La Plata Mountains and along the Dolores River. Mining in the Silverton, Rico and La Plata mountains includes prospects, pits, tunnels, shafts, mills and other mine works developed mostly for the extraction of precious metals. Most of the mines in these areas are closed and abandoned. Mines in the Dolores River area are also mostly closed and abandoned and were developed for the extraction of uranium and vanadium. The remaining locatable sites, scattered throughout the Forest are historic sites now closed and abandoned.

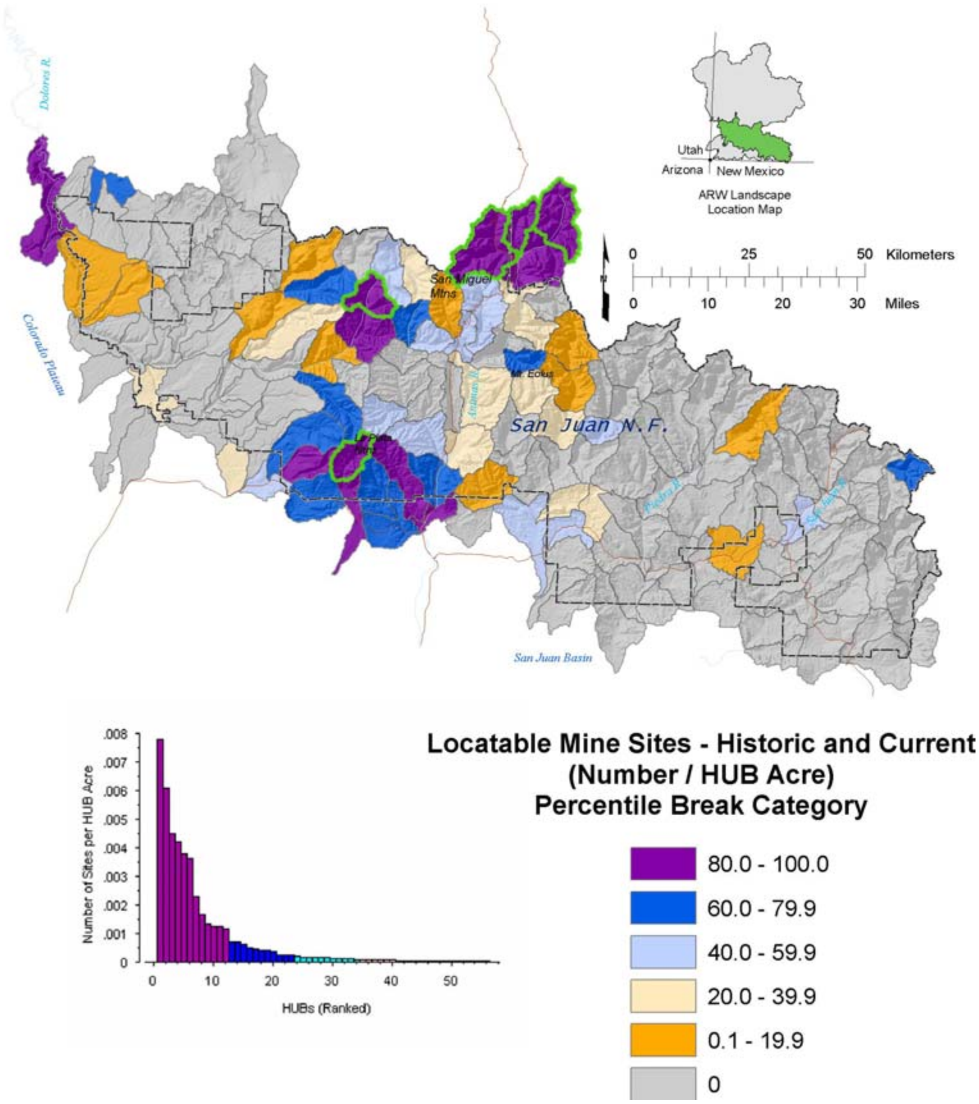

Figure 5.4 HUBs ranked by combined historic and current locatable mine site density. Over 50% percent of all 926 locatable sites are found in the five HUBS outlined in green.

Number of Locatable Sites Per Stream Mile

The ratio of number of locatable mine sites per HUB stream mile among all 154 management scale HUBs varies from 1.9933, in the Dolores River-Rico Valley (140300020203) HUB, to 0.0065 in the Dolores River Canyon-Lake Canyon (140300020604) HUB. Nearly perfectly mirroring the density of sites per HUB ratio (above), five HUBs, containing over 50% percent of all sites also exhibit the highest ratios (Table 5.4). These HUBs, in order of descending density are: Dolores River – Rico Valley, Animas River above Howardsville, Cement Creek, La Plata River Headwaters and the Animas River Cunningham Creek (Figure 5.5).

On the basis of site density and stream density, it is particularly important that these HUBS continue to be monitored and be evaluated as candidates for mine site mitigation.

Table 5.4 Mas/Mils Locatable mine sites in 80 to 100th percentile for number of sites per HUB stream mile. Highlighted HUBs fall completely inside the San Juan Forest Boundary.

Hub6	HUB6NAME	Number of Sites	Number of Stream Miles	Percent Of Total
140300020203	Dolores River-Rico Valley	120	1.9933	12.96%
140801040101	Animas River above Howardsville	115	1.6506	12.42%
140801040102	Cement Creek	79	1.5359	8.53%
140801050101	La Plata River Headwaters	64	1.2773	6.91%
140801040104	Animas River-Cunningham Creek	100	1.1856	10.80%
140801040103	Mineral Creek	129	1.1130	13.93%
140801070101	East Mancos/Middle Mancos Rivers	36	0.5476	3.89%
140801050102	La Plata River-Mayday Valley	24	0.5376	2.59%
140300020605	Dolores River Canyon-Joe Davis Hill	45	0.4471	4.86%
140801040604	Animas River-Dry Fork	10	0.3827	1.08%
140300020204	Dolores River-Scotch Creek	33	0.2840	3.56%
140801040601	Junction Creek	29	0.2223	3.13%
		784		84.67%

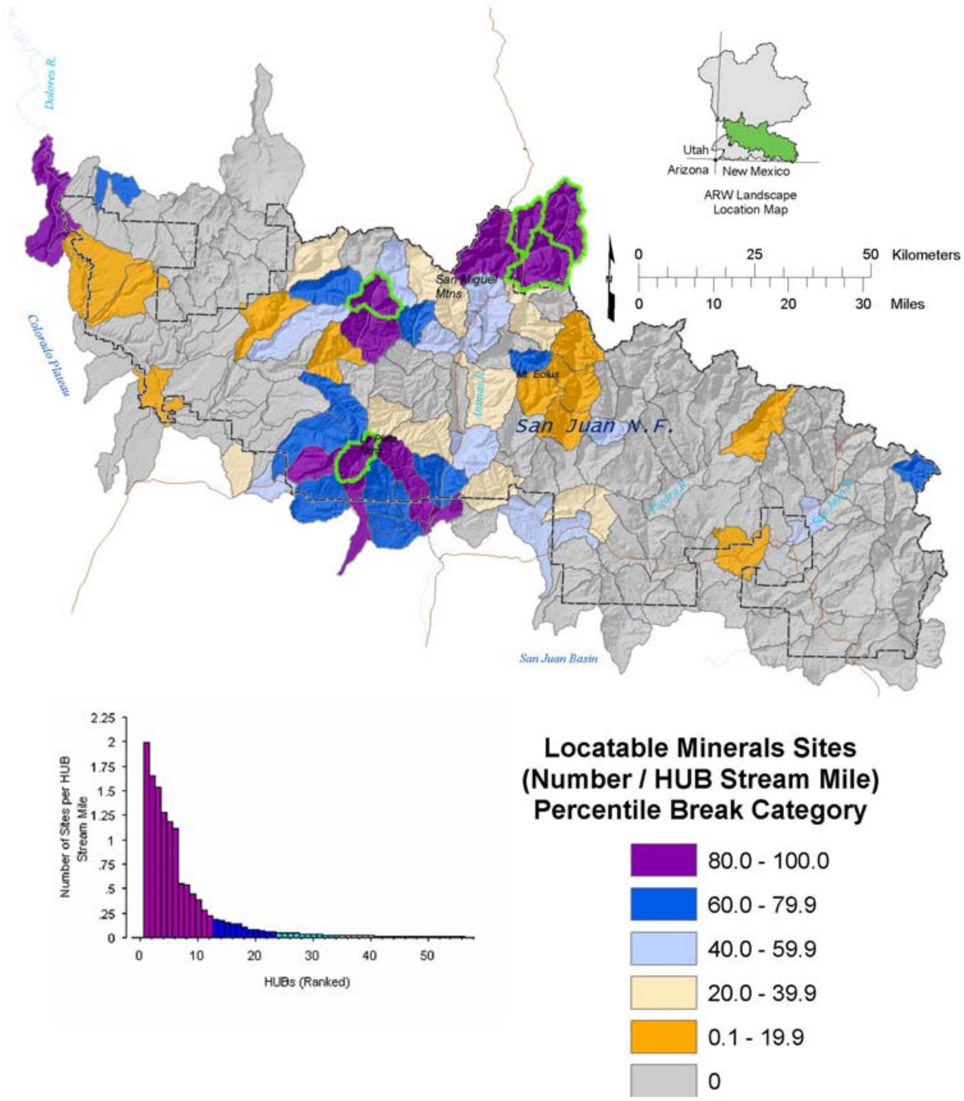

Figure 5.5 Distribution of sixth level HUBS ranked by the number of locatable mining sites per stream mile**.** Over 50% percent of all 926 locatable sites are found in the five HUBS outlined in green

Number of Locatable Sites per Valley Bottom Acre

Ninety-one locatable mine sites are found in valley bottom settings in 22 watersheds of the management scale. These represent about 10% of all locatable sites in the management scale. Five HUBs contain 57 valley bottom mine sites or about 62% of the total (Table 5.5). Most notable among these is the Dolores River-Rico Valley HUB (140300020203) which contains 33 sites, well beyond the same measure for any other HUB. These sites are mostly concentrated near the Rico town site along Silver Creek and Horse Creek and only one site is considered to be recently open, the remainders are generally historic.

Table 5.5 Ninety-one of 926 locatable mineral sites are found in Valley Bottom settings for 22 watersheds. Highlighted HUBs fall completely inside the San Juan Forest Boundary.

HUB	HUB Name	VB Sites	VBAcres	NumPer VBAcre
140300020203	Dolores River-Rico Valley	33	595	0.0555
140801050101	La Plata River Headwaters	5	555	0.0090
140801040101	Animas River above Howardsville	8	1,536	0.0052
140300020204	Dolores River-Scotch Creek	6	1,167	0.0051
140801040104	Animas River-Cunningham Creek	5	1,643	0.0030
140801040103	Mineral Creek	5	1,894	0.0026
140801040102	Cement Creek	1	500	0.0020
140300020510	Upper Disappointment Valley-Spring Creek to Brumley Valley	6	3,878	0.0015
140300020103	West Dolores River-Fish Creek to Cold Creek	2	1,361	0.0015
140801040302	Lime Creek	2	1,700	0.0012
140801040301	Cascade Creek Headwaters	1	984	0.0010
140300020206	Bear Creek	1	1,052	0.0010
140300020202	Dolores River-Cayton Valley	1	1,284	0.0008
140300020605	Dolores River Canyon-Joe Davis Hill	4	5,499	0.0007
140801010304	San Juan River-Upper Pagosa Springs	2	3,103	0.0006
140801070101	East Mancos/Middle Mancos Rivers	1	1,653	0.0006
140801040503	Animas River-Canyon Creek	1	1,781	0.0006
140801040603	Mouth of Lightner Creek	2	3,584	0.0006
140801070102	West Mancos River	2	4,019	0.0005
140801040801	Florida River Headwaters	1	2,354	0.0004
140801011503	Los Pinos River-Bayfield	1	5,880	0.0002
140801070105	East Fork Mud Creek	1	6,435	0.0002
		91.0	52,456	0.0017

Again, the five HUBs that constitute the 80^{th} to 100^{th} percentile class for the number of mine sites per valley bottom acre mirror the over all site distribution. The principal areas are Silverton, Rico and the La Plata Mountains (Figure 5.6).

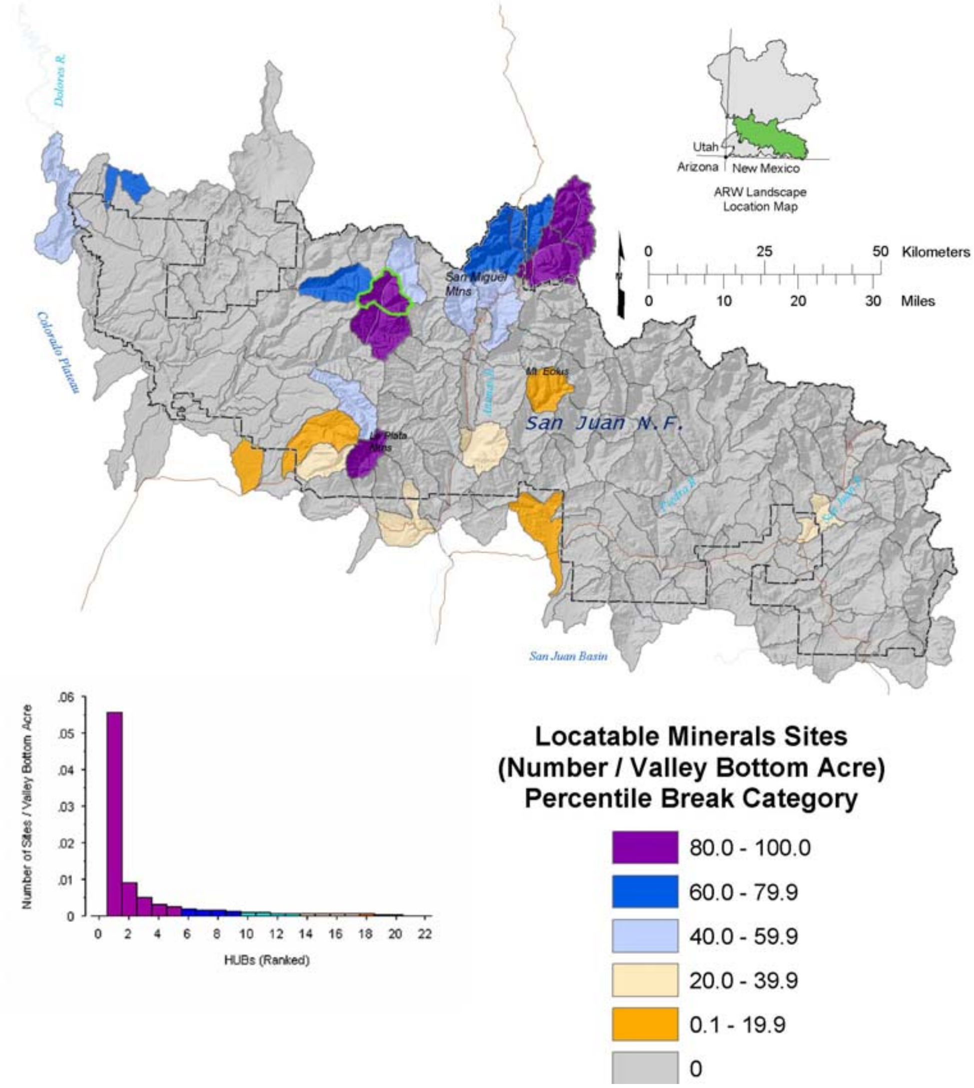

Figure 5.6 The distribution of sixth level HUBS ranked by the number of valley bottom locatable mining sites per valley bottom acre. The Dolores River-Rico Valley HUB, with the highest rating is shown in green outline.

Mining Claims Density

Under federal law and regulation mining claims provide a method to establish, maintain and exchange property rights for certain minerals. These minerals include precious metals such as gold, silver, copper, zinc and uranium on federally owned land, including both Forest and BLM lands. There are a number of procedures and precedents that affect the "staking" of claims that are beyond the scope of this report. However, claims, appropriately established and maintained are considered "Open". When claims are allowed to lapse or are administratively terminated they are deemed "Closed".

Mine claim density provides an important measure of historic and current interest in areas having potential for both lode and placer minerals. The staking of claims often represents an active interest in an area and is representative of areas with both potential for mineralization and potential for disturbance. Geographic pattern is therefore a useful qualitative indicator of both historic and likely future disturbance.

Placer Claims

First we look at the distribution of open placer claims. With some exceptions, unconsolidated gravels and sands containing particulate precious minerals are the object of *placer claim location*.

Claim distributions are indicative of areas and stream reaches most at risk from placer mining disturbance. While claims need not necessarily be located in valley bottom settings, most are associated with alluvial deposits along stream channels and valley bottoms. Large scale development of alluvium can have profound affects on ground and surface water hydrology as well as valley bottom morphology.

Disturbance on placer claims can range from small prospects to large open pits. Disturbance includes, in addition to extraction, development of tracks and roads, processing and storage areas. Naturally, significant elevation of sedimentation can result from activities in these areas. Contamination from machinery and processing chemicals can significantly alter downstream water quality and damage plant and animal communities.

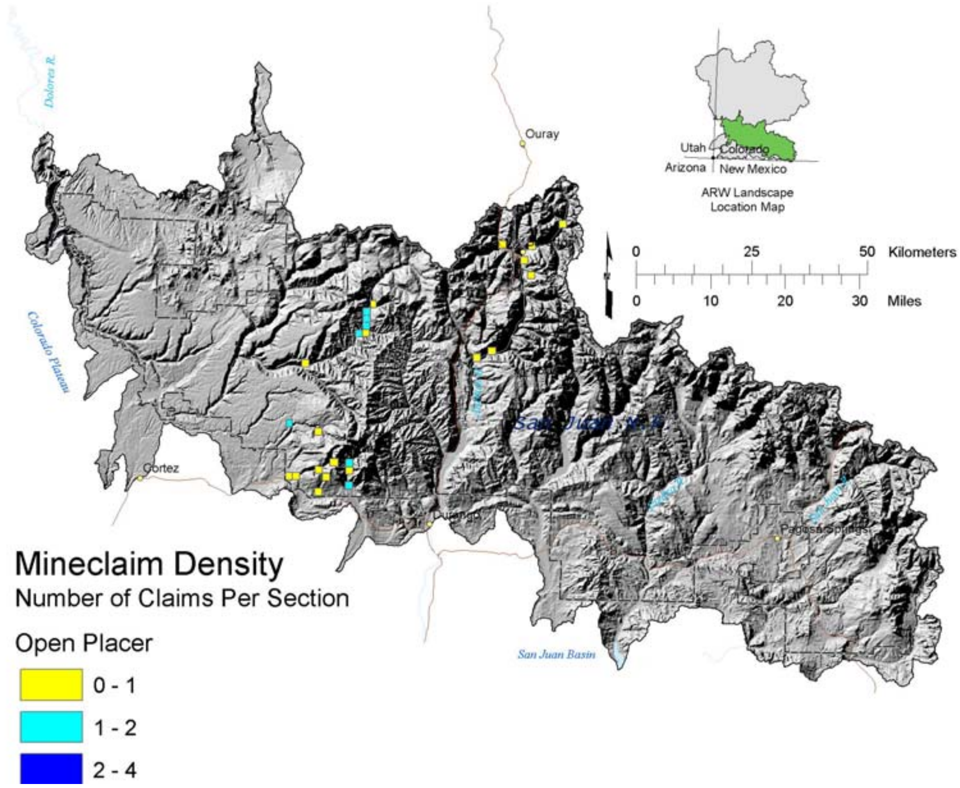

Figure 5.7 Open Placer claims density. These densities reflect current levels of interest in areas downstream from the Silverton, Rico and La Plata mountains.

There are 38 open placer claims among 27 sections concentrated in settings downstream from Silverton, the La Plata Mountains and Rico (Figure 5.7). These sections intersect about 1821 acres of valley bottoms along the Animas River, Cascade Creek, Dolores River and Mineral Creek.

Closed placer claims maps depict lands of interest where claims have been relinquished. Closed placer claims density maps reveal patterns over larger areas than currently open claims because they are cumulative over time (Figure 5.8).

These maps of closed claim density are more gradational than open claim density maps, suggestive of suggestive of overall historic interest and mineral potential.

In the management scale there are 655 closed placer claims among 216 public land survey sections. These placer claims generally follow the same geographic trends as the open placer claims above with the highest concentrations of closed claims corresponding to areas currently open.

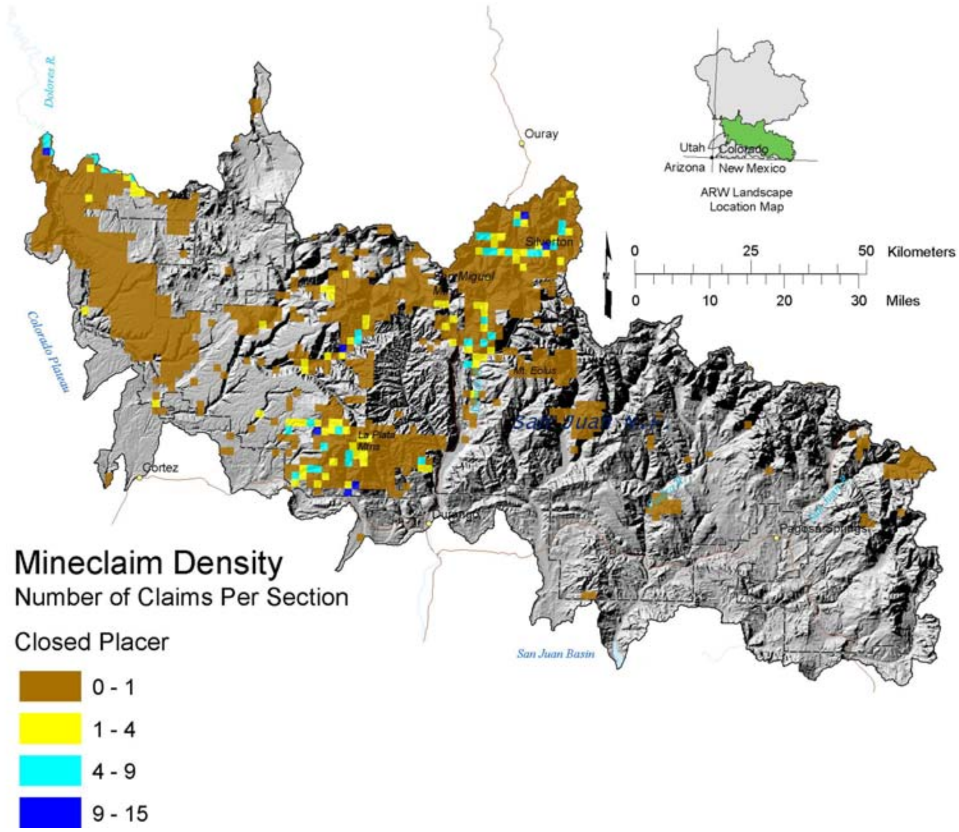

Figure 5.9 Closed Placer claims density. Claims in upland areas, downstream from the Silverton, Rico and La Plata areas tend to be located in glacial outwash and alluvial materials.

Lode Claims

Lode claims provide access to "in-place" mineralization. Here minerals are part of the rock matrix as veins, pods and diffuse particles and crystals. Lode claim distributions, like placer claim distributions, are strong indicators of historic and potential interest and mining activity. Here, claim locations may be associated with a variety of geological settings and mineral types.

In the San Juan management scale, 486 open lode claims are distributed among 102 sections (Figure 5.9). One-half of these 486 claims occur in 16 public land survey sections where claim density ranges from 9 to 49 claims per section.

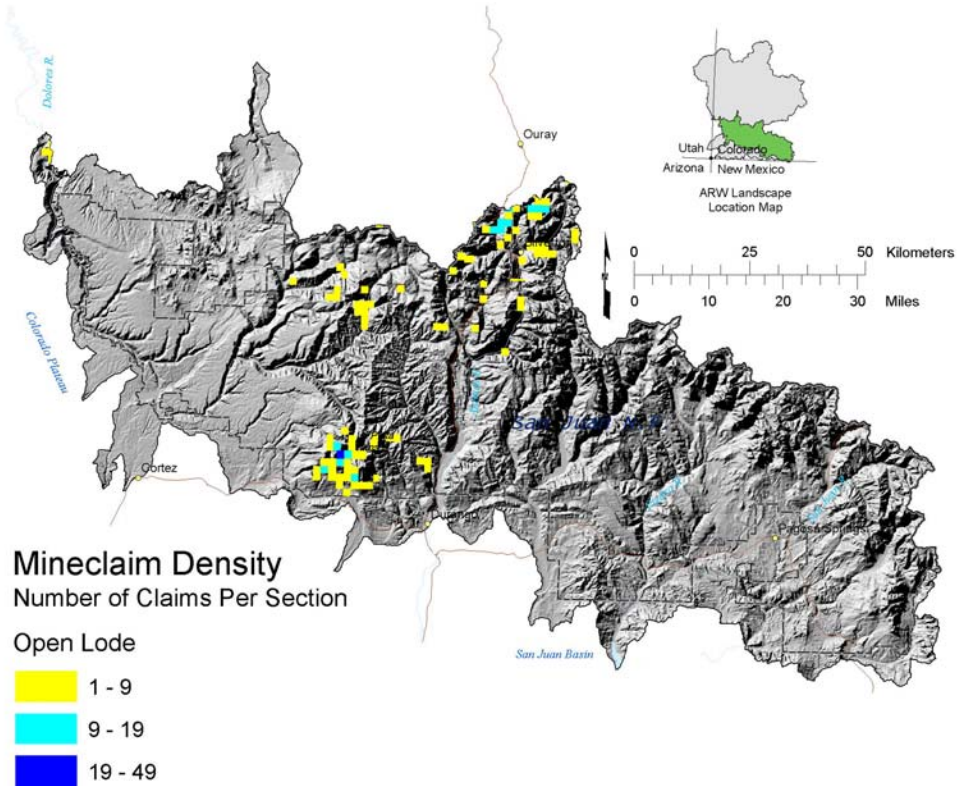

Figure 5.9 Open lode claims density. These densities reflect current interest in Silverton; Rico and La Plata mountains mineralized areas.

There are 24,882 closed lode claims distributed among 1027 sections (Fig 5.10). Half of these (i.e. 12,441) are distributed among 252 public land survey sections. The geographic distribution of these claims corresponds to patterns observed in the Mas/Mils data, to geological trends. Within these areas there is an increased likelihood of disturbance from prospecting, exploration and mining.

Disturbance in developed areas, as discussed above, can include full scale sites including pits, tunnels, shafts, mills, processing areas, buildings, roads and parking areas. Importantly, prospecting and exploration can include less pronounced sites with small pits, trenches and perhaps shallow workings.

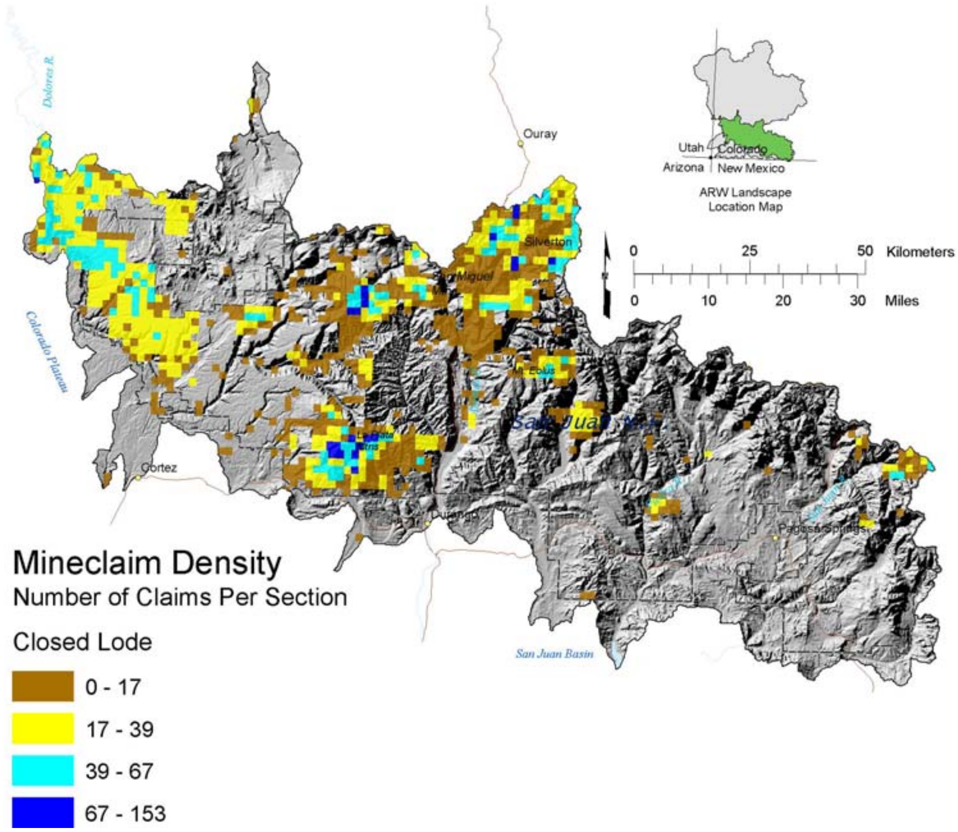

Figure 5.10 Closed lode mining claims density. The overall distribution is indicative of historic interest in the Silverton, Rico and La Plata and Dolores areas.

Combined Lode and Placer Claims Density per HUB

It is evident that placer and lode claim density distributions follow significant mineralogical trends and thus characterize the potential for mineral exploration and development. Combining both placer and lode claim distribution, for both open and closed status provides a useful measure of overall potential for influence by 6th level watershed.

Of the 154 6th level HUBs in the management scale, 107 HUBs contain mining claims. Claim counts by HUB among all HUBs range from 27 claims per section up to 82 claims per section.

Twenty-two watersheds fall in the 80th to 100th percentiles and 53.5% percent of claims occur in these 22 sixth level HUBS. These 22 watersheds are centered on the upland areas around Silverton, Rico and the La Plata mountains along with the western lowlands and foothills.

In particular, eight watersheds stand out (Figure 5.11). These watersheds are: Dolores River Canyon-Joe Davis Hill, Mineral Creek, Dolores River Canyon-Lake Canyon, Animas River above Howardsville, Animas River-Cunningham

Creek, Lime Creek, Narraguinnep Canyon Natural Area, West Mancos River.

Potential mining activities in the three western HUBs generally would be and have been directed to the extraction of uranium and vanadium. In the remaining HUBs potential mining would be aimed at precious metals.

As discussed above, these higher levels of claim density indicate high levels of public interest in these lands, recognizing the elevated mineral potential on these lands. This adjunct to mine site mapping is useful because it extents our view of disturbance potential away from historically developed into frontier areas. These frontier areas are where there is the greatest likelihood for future disturbance. HUBs with the greatest densities therefore may be considered to have the greatest potential for disturbance from mining in the future.

Table 5.6 Twenty-two HUBs in the 80th to 100th percentile on the basis of claim counts per hub. The top 8 stand out with counts from 40 to 82. HUBs completely within the Forest are highlighted in green.

HUB	Name	Claim Count
140300020605	Dolores River Canyon-Joe Davis Hill	82
140801040103	Mineral Creek	74
140300020604	Dolores River Canyon-Lake Canyon	67
140801040101	Animas River above Howardsville	62
140801040104	Animas River-Cunningham Creek	62
140801040302	Lime Creek	54
140300020602	Narraguinnep Canyon Natural Area	42
140801070102	West Mancos River	40
140801050101	La Plata River Headwaters	34
140300020204	Dolores River-Scotch Creek	33
140300020510	Upper Disappointment Valley-Spring Creek to Brumley Valley	33
140801040102	Cement Creek	33
140300020203	Dolores River-Rico Valley	33
140300020601	Dolores River-Salter Canyon	32
140300020103	West Dolores River-Fish Creek to Cold Creek	32
140300020306	McPhee Reservoir-Plateau/Beaver Creek Inlets	30
140300020509	Pine Arroyo	30
140300020511	Disappointment Valley-Wild Horse Reservoir	30
140801040202	Animas River-Tenmile Creek	30
140300020201	Dolores River Headwaters-Tin Can Basin	28
140801040601	Junction Creek	27
140801070101	East Mancos/Middle Mancos Rivers	27
		915

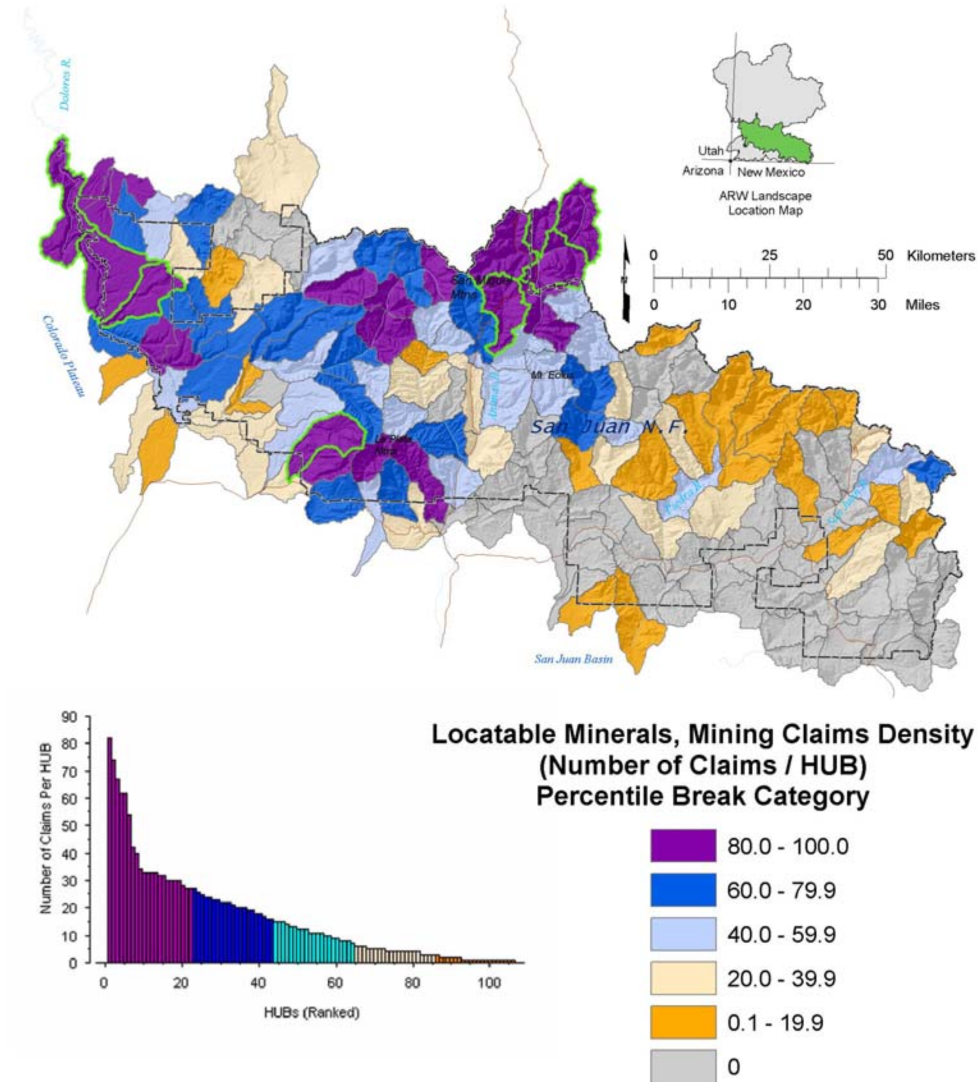

Figure 5.11 The pattern of HUBs classified by overall mining claim density. Eight HUBs stand out and are highlighted in green.

303D and TMDL Streams

There are 14 reaches classified as TMDL or 303d as a result of mining in the management scale (Table 5.7). These streams are impaired as the result of both anthropogenic sources and natural sources. Listed streams are highly influenced by locatable minerals mining including, mine drainage and leaching from mine tailings. Source reaches are found in historic mining areas, most notably Silverton, Rico and the La Plata Mountains.

Table 5.7 Reaches designated as TMDL or 303d as a result of locatable minerals mining.

Reach Description	Impairment	Source	Reach Miles
Animas R. & Tribs., Denver Lk to Maggie Gulch	Al, Cd, Cu	tmdl	9.9
Animas R., Cement Crk. to Mineral Crk	Al, Cd, Cu	tmdl	0.8
Animas R., Elk Crk. to Junction Crk	Zn	tmdl	43.4
Animas R., Mineral Crk. to Elk Crk	pH, Cu, Fe	tmdl	6.6
Cement Crk., source to Animas R	Al, Cd, Cu	tmdl	10.0
Dolores R., Horse Crk to Bear Crk	Mn	tmdl	16.3
Mineral Crk, source to S Mineral Crk	Al, Cd, Cu	tmdl	6.5
Mineral Crk, S Fk Mineral Crk. to Animas R	pH, Cu, Fe	tmdl	3.5
Tribs. to Dolores R above W. Dolores	Cd, Mn, Zn	tmdl	3.3
			100.3
Mancos River and tributaries above HWY 160	Cu	303d	9.0
Silver Creek from Rico DW diversion to Dolores R	Cu, Zn	303d	1.4
Tributaries to Dolores River and West Dolores R	Cd, Zn	303d	3.4
			13.8
			114.1

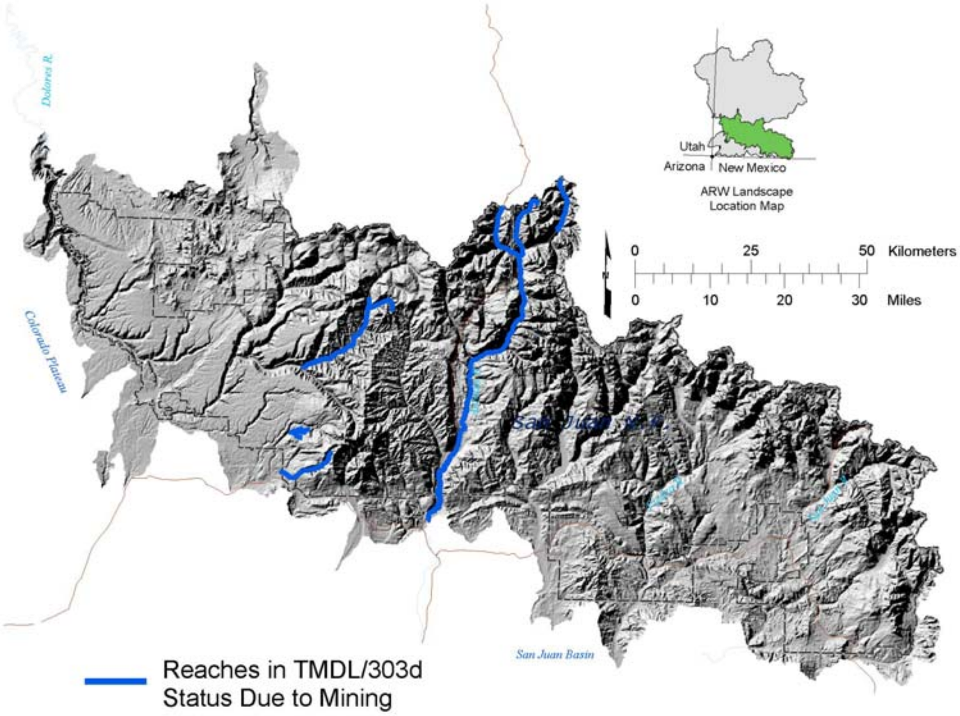

Figure 5.12 TMDL/303d reaches resulting from mining.

Direction for Reach/Site Scale Analysis

Mining influences and impacts generally depend on the specific type of mining activity. For example, gravel mining and suction dredging have direct effects on aquatic, riparian and wetland resources by removing vegetation and disturbing stream substrate. In addition, this type of mining can lead to wetland habitat loss through stripping, compaction and infill along with increased sedimentation in streams. Hard-rock mining can disrupt both surface and groundwater and water quality. Degradation of water quality can be severe and with the resulting impacts being found for significant distances downstream. In addition, impacts may also affect adjacent wetland ecosystems.

The first step in addressing mining related influences at the reach/site scale is to identify the type of activity, what influences are associated with it, and which resources are being affected. Specific questions that should be addressed for mining influences on aquatic, riparian, and wetland resources include:

1. What types of mining activities are being conducted?
2. Are groundwater and/or surface water being influenced and how?
3. What biological and aquatic communities are being influenced and which one have the potential for being affected by these influences?
4. What trophic levels (e.g., periphyton, benthic macroinvertebrates) are being affected? What is the best way to monitor changes in population dynamics?
5. How far downstream are influences being realized?
6. What is the aerial extent of influence on groundwater resources?
7. What aquatic, riparian, and wetland habitats are being modified as a result of sedimentation, removal and deposition of soils and bedrock?
8. How is water quality affected, and how do these changes influence life-history characteristics of plants and animals? Are Clean Water Act standards being met?

Determination of groundwater related impacts may require detailed evaluation and monitoring. In order to accurately evaluate and determine degradation of surface or groundwater samples for the presence of heavy metals will require extensive preparation and the use of "clean sampling collection and analysis methods" (EPA, 1995, U.S. Geological Survey, 1994, U.S. Forest Service, 1995). The use of these methods does cost more; however, without the use of these methods, accurate, uncontaminated samples can not be obtained. Before undertaking ground or surface water sampling or monitoring consultation with the Forest hydrologist should be undertaken.

Information Needs

Mas/Mils mine site data may not fully reflect the full range of sites present in the Forest and management scale area. The data is likely a good record of historic and major mining sites, many prospects and recent exploration and developments may not be recorded in these data.

Mining claim density data provide a qualitative measure of the likelihood for disturbance in frontier areas. This measure should be validated with actual field survey data.

Levels of disturbance per exploration site and mine site are known for only a handful of mines. Only general statements about potential disturbance are possible with the existing data.

Management Implications for Locatable Minerals

Areas of high locatable mine site and mining claim density require special attention at the Forest level. Managers should be aware that historic and current mining areas continue to influence aquatic systems, especially by mine drainage and those mitigation efforts will often require the active involvement of the Forest.

Oil and Gas Development

Oil and gas exploration and development in the region reach significant levels, especially in the San Juan Basin, east and south of Durango and in the Paradox Basin, west and north of Cortez. While the principal levels of activity occur in these basins outside the management scale area, significant numbers of wells have been drilled and continue to be drilled within the management scale area at the margins of these two basins.

According to well data obtained from the Colorado Oil and Gas Commission, there are 710 wells in the management scale area. Of these, 190 are currently open and just under half fall within the Forest (Table 5.8). All 710 wells, both historic and currently active are found concentrated in the San Juan Basin (Figure 5.13).

Table 5.8 Summary table showing status of wells in the management scale area

Forest	Status	Number of Wells	Pct
Outside	Unknown	5	0.7%
	Closed	245	34.5%
	Open	130	18.3%
	Subtotal:	380	53.5%
San Juan	Unknown	4	0.6%
	Closed	266	37.5%
	Open	60	8.5%
	Subtotal:	330	46.5%
	Total:	710	100.0%

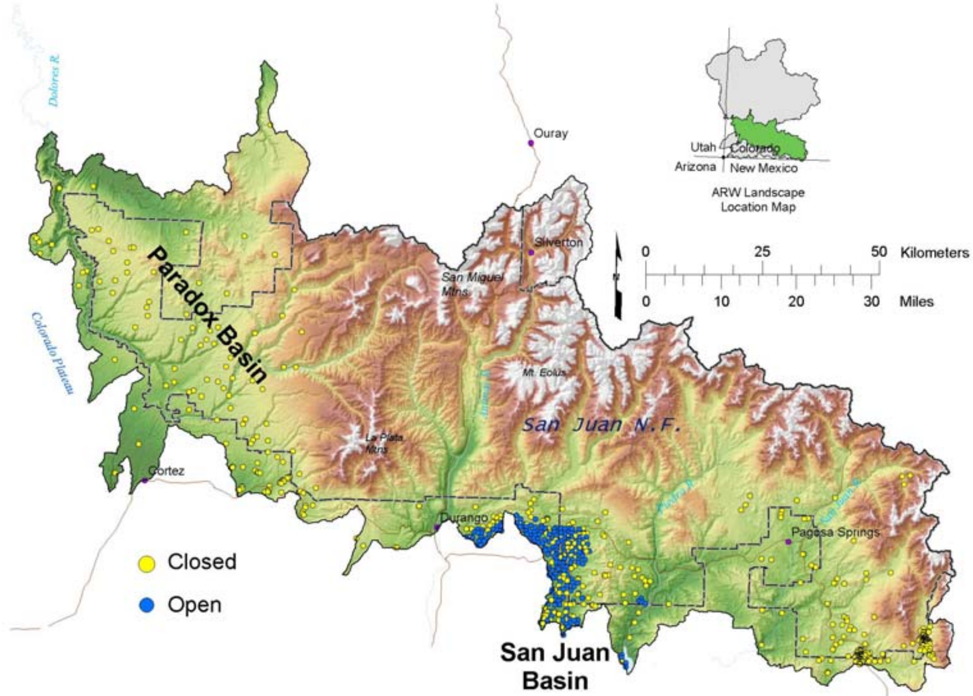

Figure 5.13 Location of oil and gas wells on the San Juan National Forest; There are 710 oil and gas wells in the management scale area. Open wells are largely concentrated in the San Juan Basin and producing coal bed methane.

Number of Wells per HUB Stream Mile

Oil and gas development occurs in 72 sixth level HUBs in the management scale area. Over 80 percent of all wells are distributed among 15 HUBS that constitute the top percentile break category (80.0 to 100.0). Here, the ratio of number of wells to HUB stream mile range from 0.12 to 1.75 with an average of 0.62 (Table X5.9).

Six HUBs, where stream mileage ratios are the highest, contain over 50% percent of all wells. These six HUBS are located in the San Juan Basin, east of Durango and in two HUBs south of Pagosa Springs further to the east (Figure 5.4). Of greatest importance are those HUBS that include open/active wells. These are Florida River-Lemon Reservoir, Los Pinos River-Bayfield, Lower Beaver Creek, and Ute Creek.

These wells are largely aimed at extraction of coal-bed methane gas from the San Juan Basin. Well density levels are high leading to significant disturbance from roads, transmission lines, and storage and well pads. Penetration of aquifers and dewatering associated with drilling is affecting local hydrologic patterns.

Table 5.9 Over 80% percent of wells in the management scale occur in 15 6th level HUBS; None of these HUBs fall fully inside the Forest.

HUB	Name	Wells Count	# / Stream Mile
140801010503	Navajo River-Navajo Peak	89	1.75
140801010506	Little Navajo River	72	1.59
140801011603	Lower Beaver Creek	67	0.98
140801011503	Los Pinos River-Bayfield	82	0.90
140801011703	Ute Creek	39	0.86
140801040901	Florida River-Lemon Reservoir	39	0.62
140801011704	Spring Creek Headwaters	49	0.59
140801011602	Middle Beaver Creek	36	0.56
140801070103	Mancos River-Upper Mancos Valley	20	0.46
140801010504	Navajo River-Weisel Flat	15	0.20
140801010507	Coyote Creek	18	0.20
140801070105	East Fork Mud Creek	13	0.18
140801020502	Piedra River-Stollsteimer	13	0.15
140801050105	Cherry Creek Headwaters	9	0.13
140801020503	Piedra River-Navajo Reservoir Inlet	11	0.12
		572	0.62

There are two HUBS (Navajo River-Navajo Peak and the Little Navajo River) that have markedly higher ratios of number per stream mile than all the others. These HUBs, southeast of Pagosa Springs, are dominated by wells on private lands that are largely no longer active and concentrated in two locations on the Navajo River. Only two wells were recorded as open in the 2004 Colorado oil and gas commission (COGCC) source data applied in this assessment.

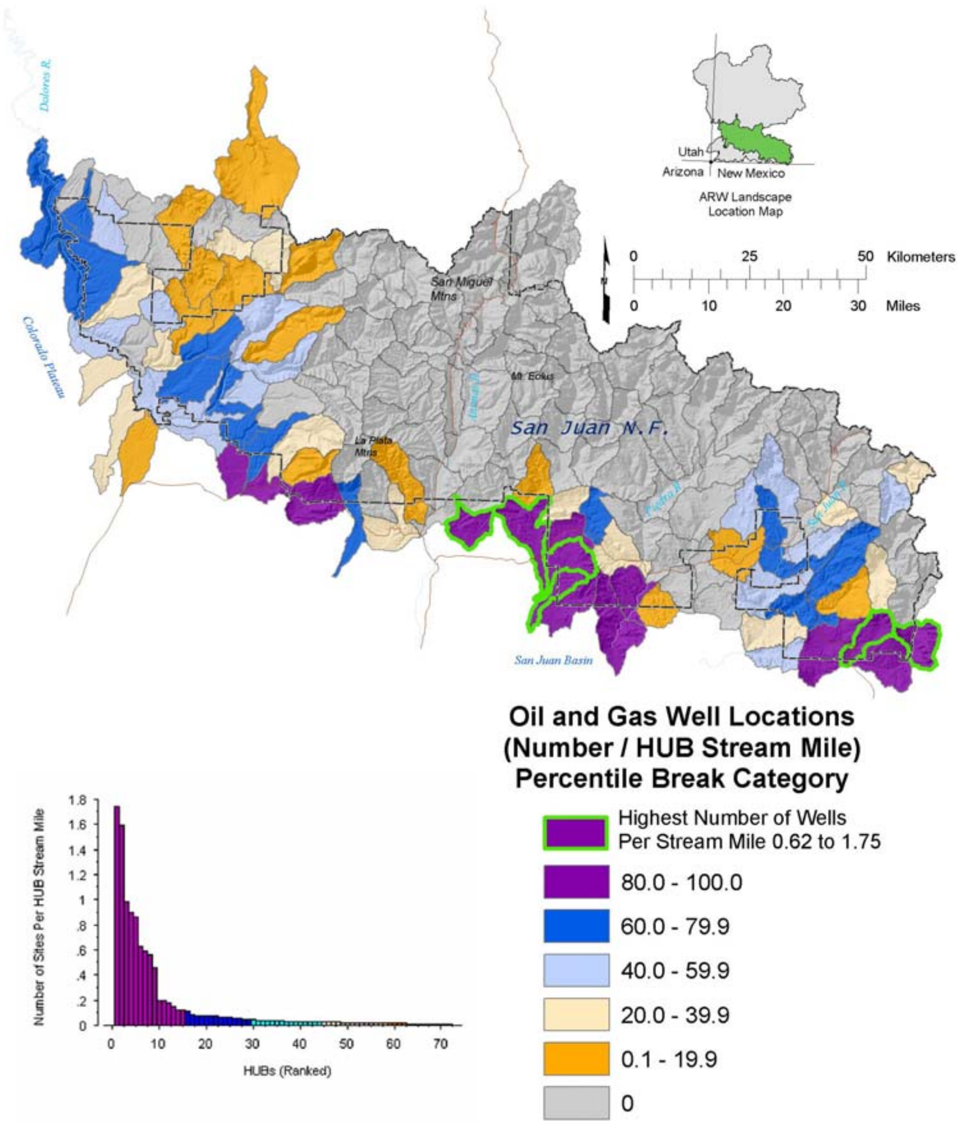

Figure 5.154 Oil and Gas locations, ratio of number of HUB wells / HUB stream mile

Number of Wells per Valley Bottom Acre

Oil and gas wells are located in valley bottom settings within 43 sixth level HUBs in the management scale area. There are 198 wells in these 43 HUBs. Of these, there are 139 wells in nine HUBs that constitute the 80th to 100th percentile as a measure of the number of wells per valley bottom acre. These 139 wells represent just over 70% percent of the 198 wells. Here, the ratio of number of wells to HUB valley bottom acreage range from 0.0022 to 0.0122 with an average of 0.0049 (Table 5.10).

Six HUBs, where stream mileage ratios are the highest, contain over 50% percent of all wells. These six HUBS are located in the San Juan Basin, east of Durango and in two HUBs south of Pagosa Springs further to the east (Figure 5.15).

Table 5.10 Nine HUBs in the 80th to 100th percentile as a measure of number of wells per valley bottom acre. All 9 HUBS include lands beyond the Forest bound.

HUB	Name	Wells Count	# / VB Acre
140801010503	Navajo River-Navajo Peak	20	0.0122
140801010506	Little Navajo River	16	0.0077
140801011704	Spring Creek Headwaters	22	0.0045
140801011503	Los Pinos River-Bayfield	24	0.0041
140801011603	Lower Beaver Creek	17	0.0037
140801011703	Ute Creek	11	0.0035
140801040901	Florida River-Lemon Reservoir	12	0.0034
140801011602	Middle Beaver Creek	10	0.0031
140801070103	Mancos River-Upper Mancos Valley	7	0.0022
		139	0.0049

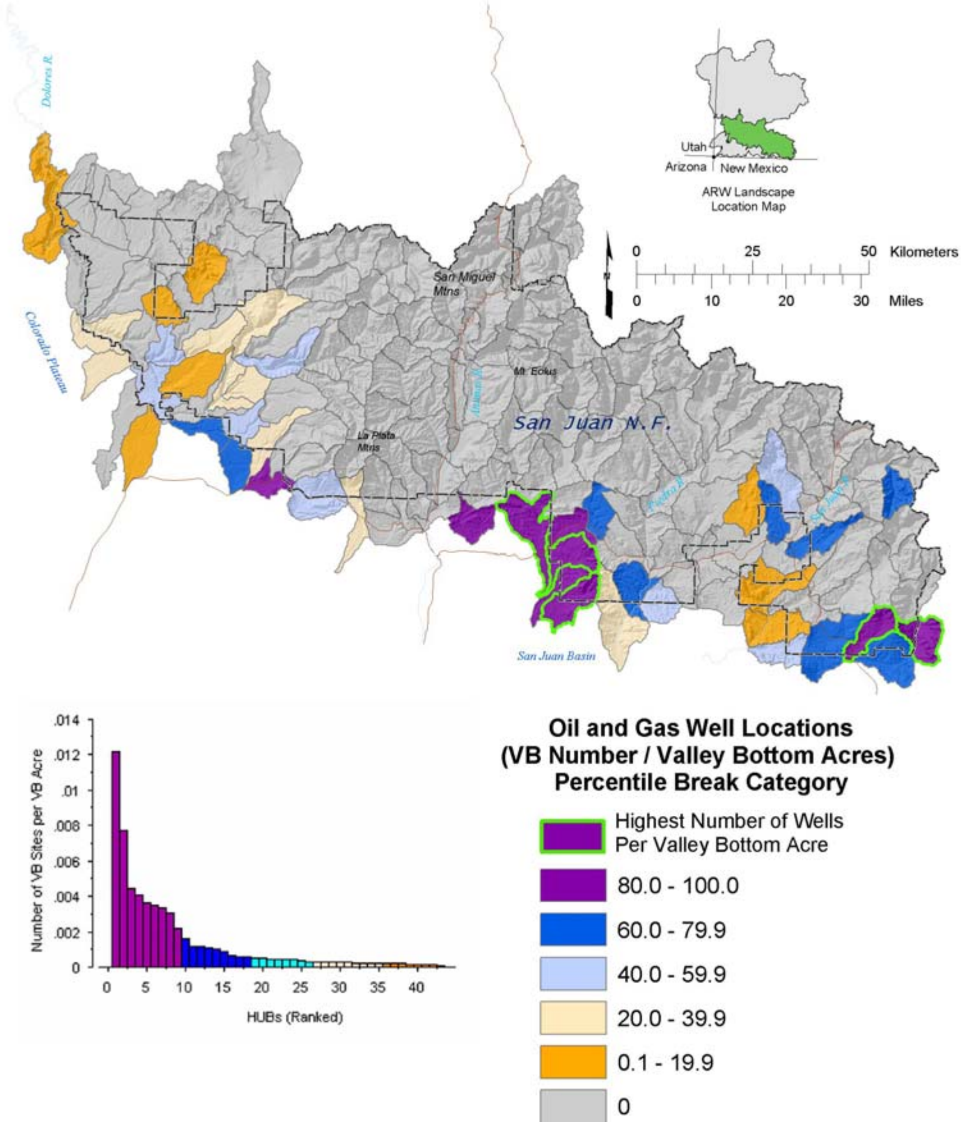

Figure 5.15 Oil and Gas locations, ratio of number of Valley Bottom Wells per HUB Valley Bottom Acres; The five highlighted HUBS have the highest values and over half of all valley bottom wells fall in these HUBS.

Direction for Reach/Site Scale Analysis

Oil and gas influences and impacts can directly affect aquatic, riparian and wetland resources by vegetation removal. Exploration, drilling, pad, transmission line and road construction can lead to wetland habitat loss through stripping, compaction and infill along with increased sedimentation in streams.

Degradation of water quality can be severe and with the resulting impacts being found for significant distances downstream. In addition, impacts may also affect adjacent wetland ecosystems.

The first step in addressing oil and gas related influences at the reach/site scale is to identify the type of activity, what influences are associated with it, and which resources are being affected. Specific questions that should be addressed for mining influences on aquatic, riparian, and wetland resources include:

1. What types of activities are being conducted?
2. Are groundwater and/or surface water being influenced and how?
3. What biological and aquatic communities are being influenced and which one have the potential for being affected by these influences?
4. What trophic levels (e.g., periphyton, benthic macroinvertebrates) are being affected? What is the best way to monitor changes in population dynamics?
5. How far downstream are influences being realized?
6. What is the aerial extent of influence on groundwater resources?
7. What aquatic, riparian, and wetland habitats are being modified as a result of sedimentation, removal and deposition of soils and bedrock?
8. How is water quality affected, and how do these changes influence life-history characteristics of plants and animals? Are Clean Water Act standards being met?
9. How are drilling activities affecting subsurface aquifers through depletion/dewatering and/or contamination?

Information Needs

More comprehensive information about oil and gas activities would include: disturbance rates by activity – e.g. average well pad area, number of miles of road and transmission line per well.

Inventories and field examinations of abandoned well sites in the management scale area are required to identify sites and facilities requiring further reclamation and/or mitigation.

Management Implications for Oil and Gas

The opportunity to mitigate the over all affects of drilling and extraction from wells is limited as most sites are located outside areas of Forest jurisdiction. At the same time cooperative efforts with other agencies such as the BLM could be explored.

Coal

Coal beds crop out along the margins of the Paradox and San Juan basins in the management scale area. These outcrops are of late Cretaceous age including the Dakota Sandstone, Menefee Formation and Fruitland Formation (Murray, 1980).

Historically, small mines have been developed to support local markets. These mines and related prospects are largely abandoned. More recently, large scale mines have been developed in the region.

The most significant of these modern mines are located outside the management scale area.

According to the U.S. Geological Survey there are 46 mines in the management scale area (Kirschbaum et al, 2000). Of these, 28 are located outside the Forest and 18 are inside. Six are classified as recent (Table 5.11). Four of these recent mines are located immediately west of Durango, outside of the Forest. Another two are located within the Forest immediately between Durango and the Piedra River (Figure 5.16).

Active operations have significant potential to influence aquatic and riparian systems. Large areas can be converted by mining operations, facilities, spoils piles, storage, transmission lines and roads. Run off can carry significant levels of sediments into local drainages. Acid mine drainage from abandoned sites can contaminate local ground waters and streams. An information need for this assessment is a compilation of measures of all of these influences.

Table 5.11 Coal mines summary table from U.S. Geological Survey data.

San Juan NF	Status	Number of Sites
Outside	Historic	19
	Prospect	3
	Recent	4
	Unknown	1
	Subtotals:	28
Inside	Historic	10
	Prospect	4
	Recent	2
	Unknown	3
	SubTotal:	18
	Total:	46

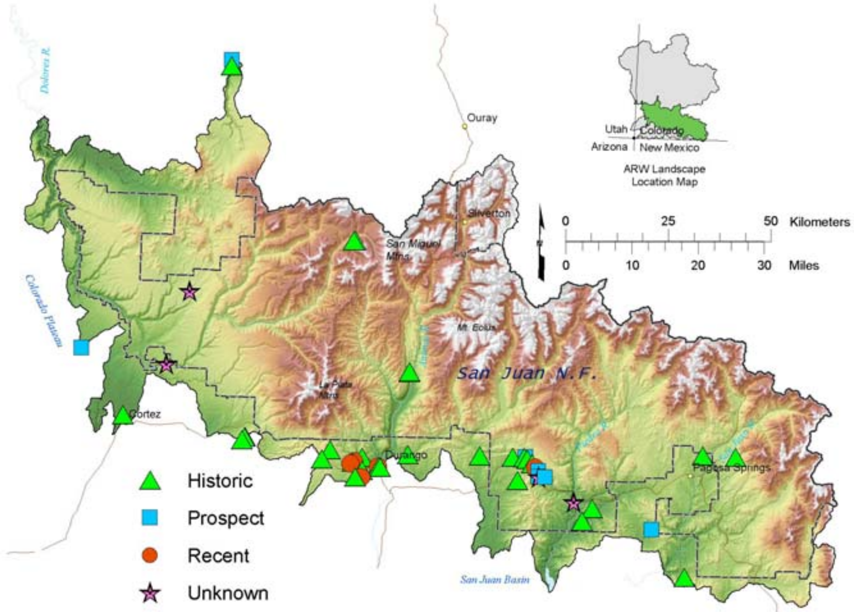

Figure 5.16 Coal mine locations in the management scale area.

Number of Coal Mines to HUB Stream Mile

Coal mines are found in 24 sixth level HUBs in the management scale area. Over 50% percent of all mines are distributed among five HUBS. Here, the ratio of the number of mines to HUB stream mile range from 0.06 to .15 with an average of 0.62 (Table 5.12). Those HUBS with the highest ratios are found along the southern margin of the management scale area (Figure 5.17)

Table 5.12 Over 50% percent of coal mines in the management scale occur in five 6th level HUBS. These mines have an average number per HUBs stream mile of 0.0914. Highlighted HUBs are completely in the Forest.

HUB	Name	Mine Count	# / Stream Mile
140801040604	Animas River-Dry Fork	4	0.1531
140801011601	Upper Beaver Creek	5	0.0952
140801040603	Mouth of Lightner Creek	7	0.0800
140801070103	Mancos River-Upper Mancos Valley	3	0.0685
140801020501	Piedra River-Yellowjacket Creek	5	0.0602
		24	0.0914

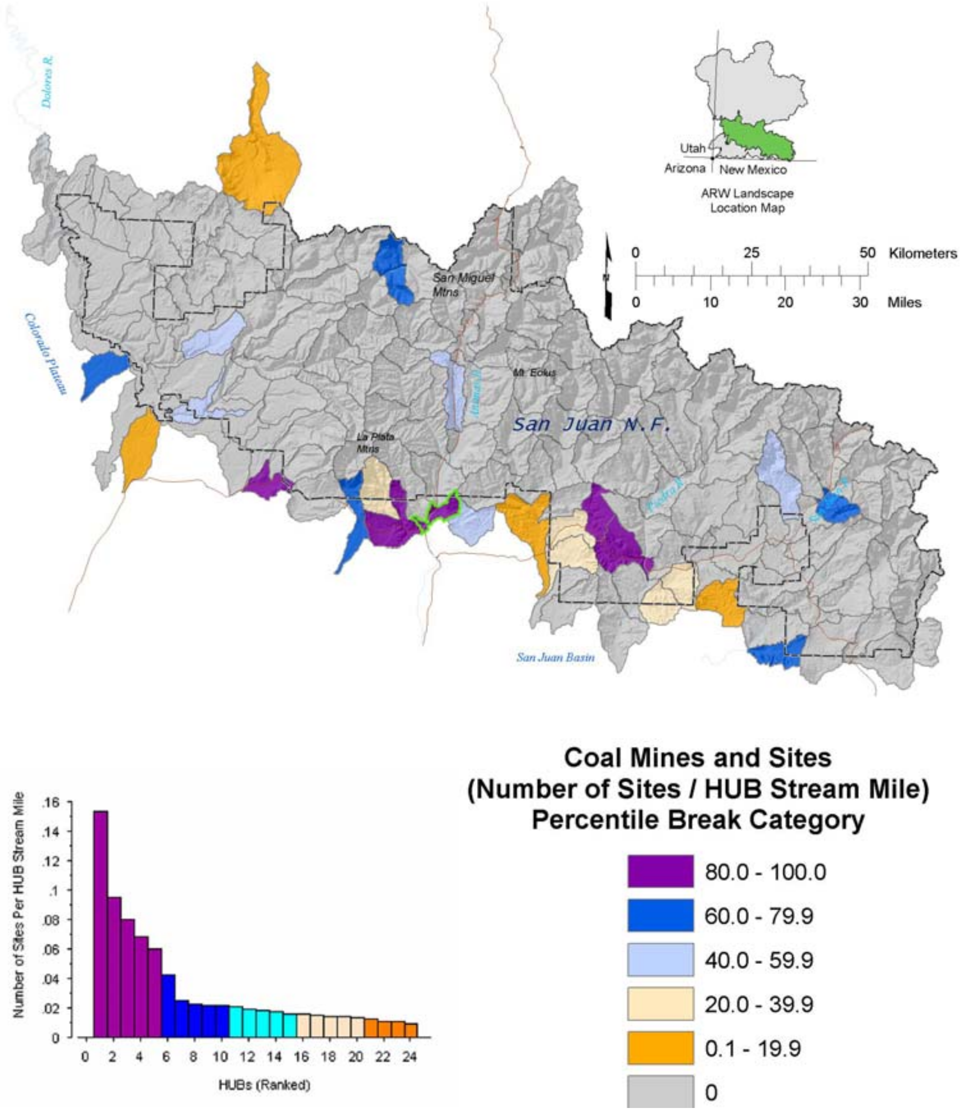

Figure 5.17 Coal Mines, ratio of number of HUB sites/ HUB stream mile. The HUB highlighted in green (Animas River-Dry Fork) has the highest ratio of .1531 per stream mile.

Streams and aquatic systems in the Animas River-Dry Fork (140801040604) and Mouth of Lightner Creek (140801040603) HUBs have the greatest potential to be influenced by coal mining. These HUBs are among those in the top percentile and have a number of currently or recently active mines.

Number of Coal Mines to HUB Valley Bottom Acre

Thirty-four coal mine sites overlay valley bottom settings in the management scale area. Fourteen of these sites, in six HUBs have number of sites per valley bottom acre ratios from 0.00084 to 0.00168 with an average of 0.00116 (Table 5.13). Those HUBS with the highest ratios are found along the southern margin of the management scale area (Figure 5.18)

Table 5.13 Over 50% percent of coal mines in the management scale occur in 5 6th level HUBS comprising the 80th to 100th percentiles. Highlighted HUBs are completely in the Forest.

HUB	Name	Number of Sites	Num / VB Acre
140801040604	Animas River-Dry Fork	4	0.2981%
140801011601	Upper Beaver Creek	5	0.2099%
140801040603	Mouth of Lightner Creek	7	0.1953%
140801020501	Piedra River-Yellowjacket Creek	5	0.1601%
140300020202	Dolores River-Cayton Valley	2	0.1557%
		23	0.2038%

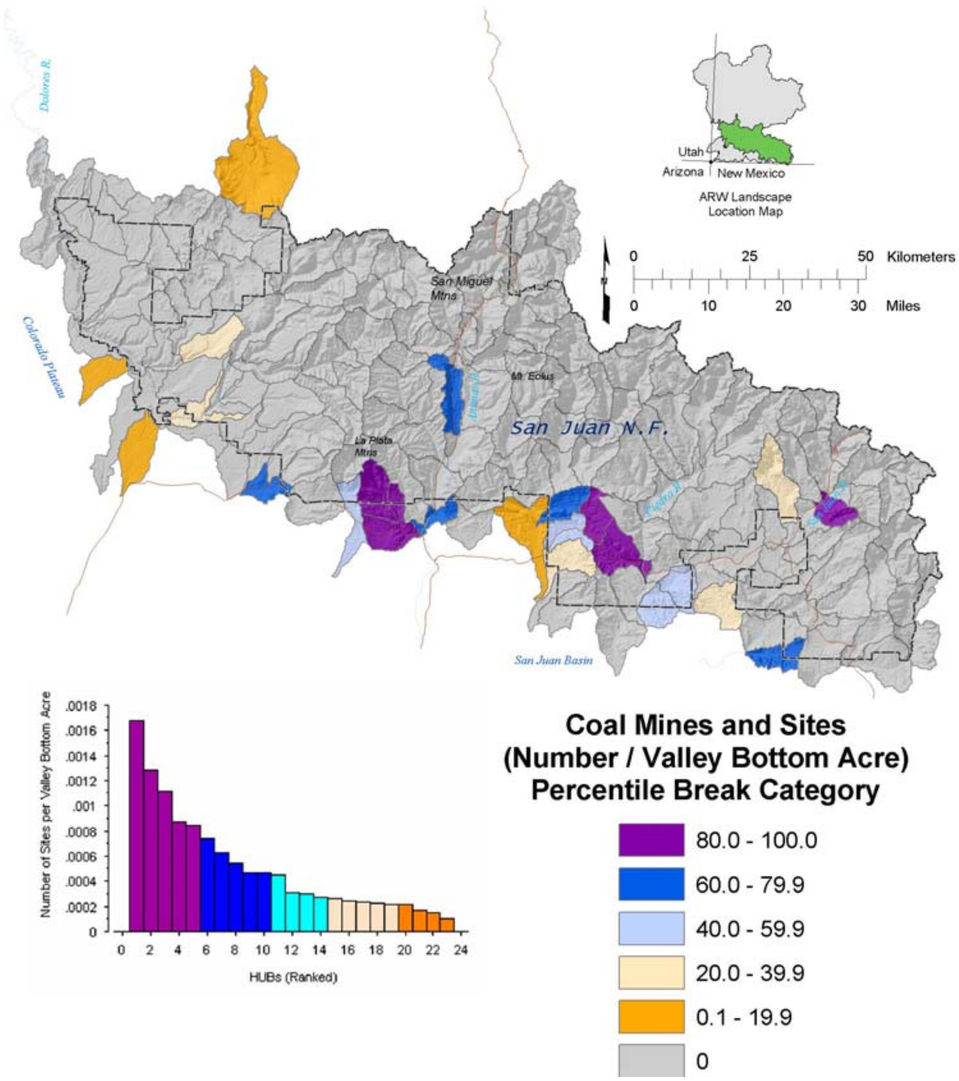

Figure 5.18 Coal Mines, ratio of number of HUB sites/ HUB Valley Bottom Acreage.

Valley bottom aquatic systems in the Mouth of Lightner Creek (140801040603) HUB has the greatest potential to be influenced by coal mining. This Hub is among those in the top percentile and has a number of currently or recently active mines.

Direction for Reach/Site Scale Analysis

Coal mining influences and impacts generally depend on the specific type and scope of mining activity. Small - scale pits trenches and tunnels are orders of magnitude less disturbing than modern large scale underground and surface operations. Field surveys to inventory the current reach scale influence of historic mines and safety concerns are required.

Large scale operations, currently active are outside the jurisdiction of the Forest. These operations are generally located downstream from Forest watersheds or at the margins of the management scale. Few opportunities exists for interaction, analysis and mitigation directly by the Forest at the reach scale.

The first step in addressing mining related influences at the reach/site scale is to identify the type of activity, what influences are associated with it, and which resources are being affected. Specific questions that should be addressed for mining influences on aquatic, riparian, and wetland resources include:

1. What types of mining activities are being conducted?
2. Are groundwater and/or surface water being influenced and how?
3. What biological and aquatic communities are being influenced and which one have the potential for being affected by these influences?
4. What trophic levels (e.g., periphyton, benthic macroinvertebrates) are being affected? What is the best way to monitor changes in population dynamics?
5. How far downstream are influences being realized?
6. What is the aerial extent of influence on groundwater resources?
7. What aquatic, riparian, and wetland habitats are being modified as a result of sedimentation, removal and deposition of soils and bedrock?
8. How is water quality affected, and how do these changes influence life-history characteristics of plants and animals? Are Clean Water Act standards being met?

Determination of groundwater related impacts may require detailed evaluation and monitoring. In order to accurately evaluate and determine degradation of surface or groundwater samples for the presence of heavy metals will require extensive preparation and the use of "clean sampling collection and analysis methods" (EPA, 1995, U.S. Geological Survey, 1994, U.S. Forest Service, 1995). The use of these methods does cost more; however, without the use of these methods, accurate, uncontaminated samples can not be obtained. Before undertaking ground or surface water sampling or monitoring consultation with the Forest hydrologist should be undertaken.

Information Needs

USGS mine site data may not fully reflect the full range of historic coal sites present in the Forest and management scale area. The data is likely a good record of historic and major mining sites, many prospects and recent exploration and developments may not be recorded in these data.

Existing sites should be inventoried, in cooperation with State agencies, to identify sites with safety or environmental problems.

Field surveys are required to fully measure how much large scale coal mining has displaced aquatic, riparian and wetland systems – i.e. how many acres have been covered or filled in.

More comprehensive information is required to document actual disturbance area from coal historic an existing coal mining, facilities and roads.

Management Implications for Coal

The opportunity to mitigate the over all affects of coal mining is limited as current sites are located outside areas of Forest jurisdiction.

Mineral Materials

Mineral materials constitute an administrative class largely made up of sand and gravel borrow pits and large scale operations. These operations are typically correlated to roadways and valley bottom settings with alluvial deposits.

In the management scale area there are 67 identified sand and gravel sites (Table 5.14). Because of the informal nature of many borrow pits and lack of reporting, it is likely that a number of historical sites are missing from this summary. Most of the 67 recorded sites are located in middle elevations on lands beyond the southern edge of the Forest (Figure 5.19).

Table 5.14 Mineral materials summary table from U.S. Geological Survey data

Forest	Status	Number of Sites	Pct
Outside	Historic	21	31.3%
	Prospect	9	13.4%
	Recent	18	26.9%
	Unknown	5	7.5%
	SubTotal:	53	79.1%
San Juan	Historic	3	4.5%
	Prospect	1	1.5%
	Recent	3	4.5%
	Unknown	7	10.4%
	SubTotal:	14	20.9%
	Total:	67	100.0%

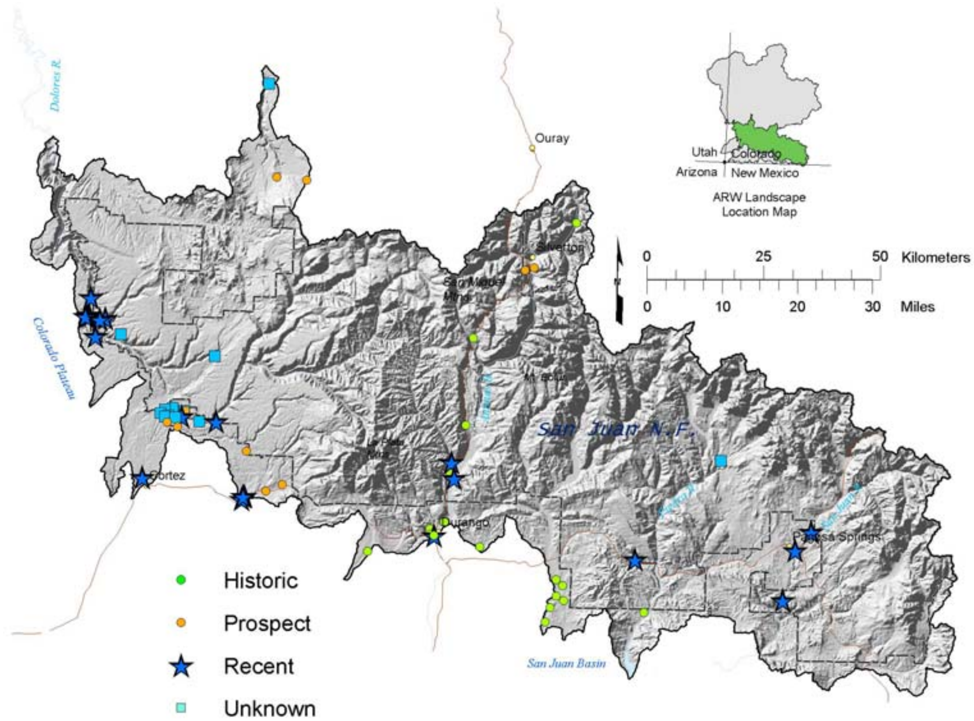

Figure 5.19 In the management scale area, there are 67 sand and gravel sites. About 80% percent of these are located outside the Forest. There are 21 sites classified as "Recent".

Sand and gravel sites are found in 30 sixth level HUBs in the management scale area. Almost 50% percent of all sites are distributed among six HUBS. Here, the ratio of the number of sites to HUB stream mile range from 0.045 to .34 with an average of 0.1162 (Table 5.15).

Materials from mineral materials sites are critical to road development and maintenance along with other infrastructure and building. HUBS with the highest ratio of sites per stream mile mark the presence of materials but more importantly, the high level of demand due to proximity to growing communities. Those HUBS with the highest ratios are found along the southern margin of the management scale area (Figure 5.20) near these communities, especially Dolores, Cortez, Durango and Pagosa Springs.

Table 5.15 Mineral materials sites, number per stream mile per HUB; These are the six HUBs in the top percentile. None of these HUBs falls fully within the Forest.

HUB	Name	Site Count	# / Stream Mile
140801040604	Animas River-Dry Fork	9	0.3444
140300020408	Dolores River-McPhee Reservoir	9	0.1099
140801011703	Ute Creek	4	0.0887
140801070105	East Fork Mud Creek	4	0.0547
140300020406	Dolores River-McPhee Reservoir to Italian Creek	3	0.0540
140801070103	Mancos River-Upper Mancos Valley	2	0.0457
		31	0.1162

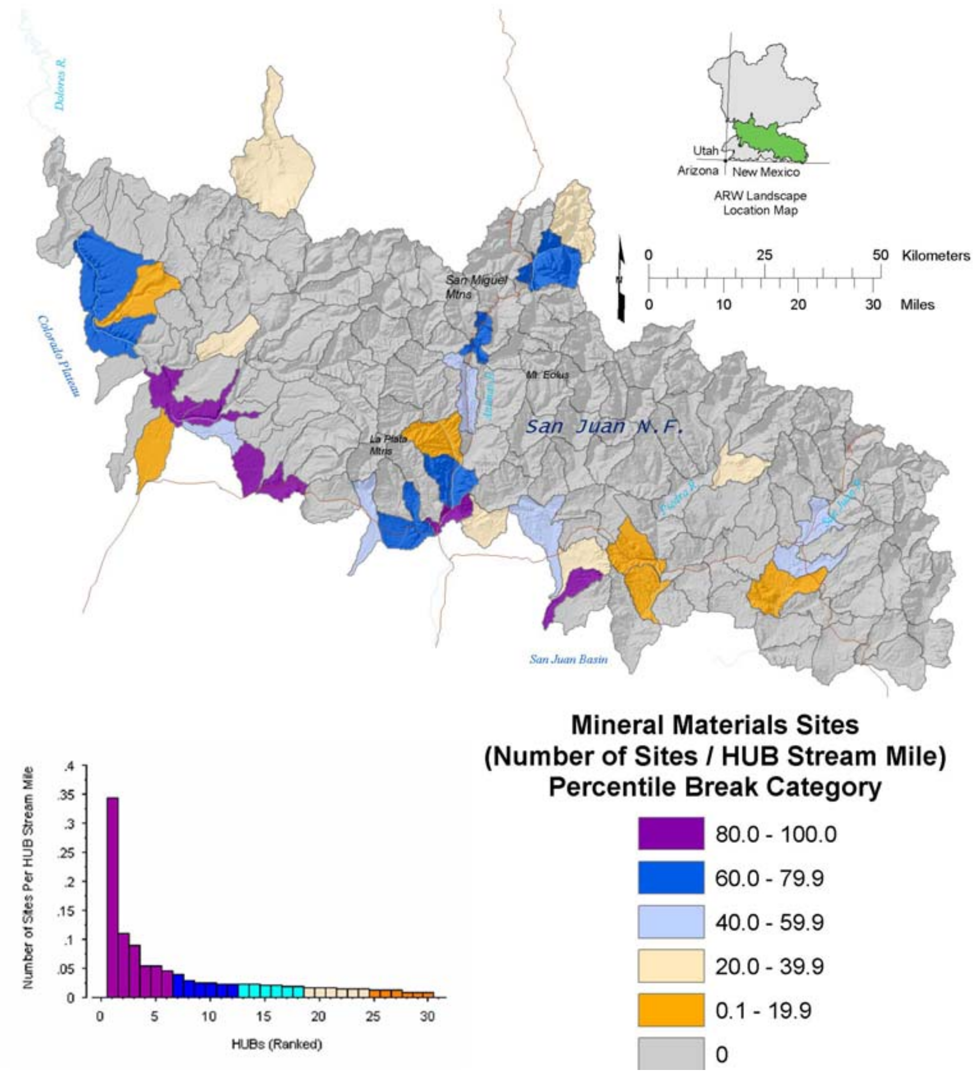

Figure 5.20 Almost 50% percent of all mineral materials sites occur in the six 6th level HUBS that constitute the top Percentile Break Category (80.0 to 100.0). Note the overall association with existing roads.

Sixteen mineral materials sites overlay valley bottom settings in the management scale area. This is to be expected as the largest deposits are associated with outwash deposits comprising these valley bottoms.

These 16 sites are distributed among 14 HUBs having a number of sites per valley bottom acre ratio from 0.00007 to 0.0006 with an average of 0.0002 (Table 5.16). Ute Creek, the Animas River and San Juan River above Pagosa Springs have the highest ratios (Figure 5.21).

Table 5.16 Mineral materials sites, number per valley bottom acre per HUB; None of these HUBs falls fully within the Forest

HUB	Name	Num Sites	# / VB Acre
140801011703	Ute Creek	2	0.000635
140801040504	Animas River below Hermosa Creek	1	0.000453
140801010304	San Juan River-Upper Pagosa Springs	1	0.000322
140801070103	Mancos River-Upper Mancos Valley	1	0.000316
140801070105	East Fork Mud Creek	2	0.000311
140801010307	San Juan River-Echo Canyon Reservoir	1	0.000296
140801020502	Piedra River-Stollsteimer	1	0.000288
140300020408	Dolores River-McPhee Reservoir	2	0.000284
140801050102	La Plata River-Mayday Valley	1	0.000270
140300020406	Dolores River-McPhee Reservoir to Italian Creek	1	0.000224
140801010308	San Juan River-Eightmile Mesa	1	0.000189
140801011503	Los Pinos River-Bayfield	1	0.000170
140300036101	Naturita Creek Headwaters	1	0.000074
		16	0.000295

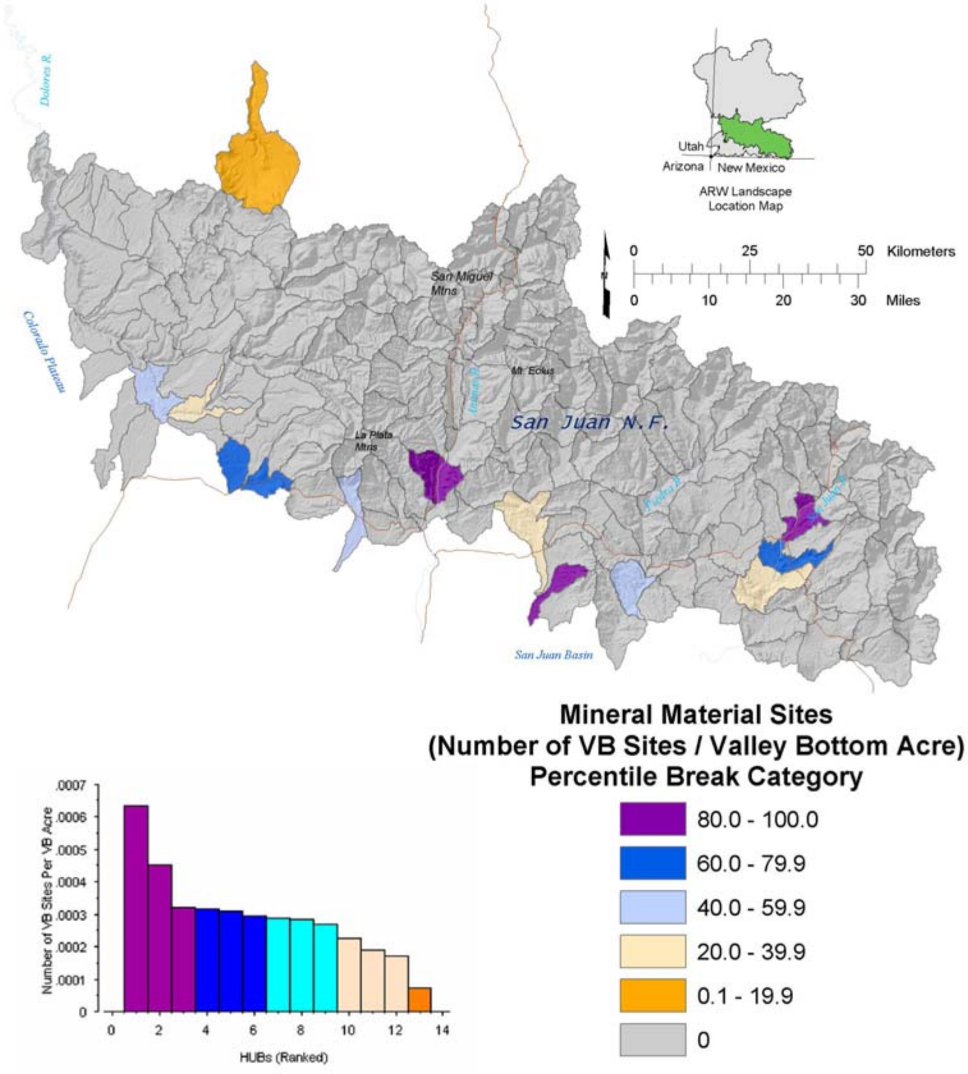

Figure 5.21 Thirteen HUBs in the management scale area have mineral materials sites in valley bottom settings.

Direction for Reach/Site Scale Analysis

Sand and Gravel development occurs most often directly in flood plain settings where the potential influence on aquatic systems is very high. Excavations can significantly alter hydrologic pattern and channel geometry. Compaction from roads and processing areas can also alter flow pattern. Removal of vegetation can lead to changes in aquatic communities, diminished filtration and increased sedimentation. Leakage and spills from equipment fuel storage, lubrication and lubrication materials can lead to significant contamination.

The first step in addressing mineral materials mining related influences at the reach/site scale is to identify the type of activity, what influences are associated with it, and which resources are being affected. Specific questions that should be addressed for mining influences on aquatic, riparian, and wetland resources include:

1. What types of mining activities are being conducted? What is their scale and scope? What will be the duration of operations?
2. Are groundwater and/or surface water being influenced and how?
3. What biological and aquatic communities are being influenced and which one have the potential for being affected by these influences?
4. What trophic levels (e.g., periphyton, benthic macroinvertebrates) are being affected? What is the best way to monitor changes in population dynamics?
5. How far downstream are influences being realized?
6. What is the aerial extent of influence on groundwater resources?
7. What aquatic, riparian, and wetland habitats are being modified as a result of sedimentation, removal and deposition of soils and bedrock?
8. How is water quality affected, and how do these changes influence life-history characteristics of plants and animals? Are Clean Water Act standards being met?

Determination of groundwater related impacts may require detailed evaluation and monitoring. In order to accurately evaluate and determine degradation of surface or groundwater samples for the presence of heavy metals will require extensive preparation and the use of "clean sampling collection and analysis methods" (EPA, 1995, U.S. Geological Survey, 1994, U.S. Forest Service, 1995). The use of these methods does cost more; however, without the use of these methods, accurate, uncontaminated samples can not be obtained. Before undertaking ground or surface water sampling or monitoring consultation with the Forest hydrologist should be undertaken.

Information Needs

Studies to evaluate flood plain function are needed to identify reclamation priorities to re-establish flood plain biological community function in flood plains affected by mineral material extraction.

Studies to evaluate future development scenarios and demands would be important to ensure maintenance of flood plain function.

Field surveys are required to fully measure how much large scale mining has displaced aquatic, riparian and wetland systems – i.e. how many acres have been covered or filled in?

Management Implications for Mineral Material Deposits

The widespread occurrence of mineral material deposits, especially sand and gravel, along with increasing demand will call for continued management awareness of both opportunity and risk – i.e. what sites offer the most accessible deposits that will be in greatest public demand? Of these, what sites are most suitable?

Management Implications at the 6th Level HUB for All Minerals

Out of 154 watersheds on the San Juan National Forest five had a total cumulative score of "five", the highest possible score, which indicates that that there is very probable that aquatic, riparian and wetland resources are influenced by impacts associated with some type of mining activity (Table 5.18). These watersheds are the Upper Beaver Creek (HUB # 140801011601), the Upper Mancos Valley (HUB # 140801070103), the East Fork of Mud Creek (HUB # 140801070105), Mayday Valley (HUB # 140801050102), and Lower Lightner Creek (HUB # 140801040603) watersheds. The Upper Beaver Creek is the only one of these watersheds to also total cumulative score of "5" in the three activity categories. The other two are vegetation management and water uses. The East Fork of Mud Creek also totaled a cumulative score of "5" for urbanization. The Upper Mancos Valley, Mayday Valley, and Lower Lightner Creek only scored a cumulative rating of "5" in the minerals activity category.

All the watersheds except for Mayday Valley had wetlands classified as 4w. Wetlands in this watershed are classified as 3w.

Riparian Clusters 4r, 5r, 6r and 7r and wetland Clusters 3w and 4w are associated with the Upper Beaver Creek, the East Fork of Mud Creek, and Upper Mancos Valley, Mayday Valley, and Lower Lightner Creek watersheds.

Wetlands Cluster 4w has already been affected by ditches, diversions, and other types of water use. Wetlands within this category dominate watersheds in the 100-80 percentile range for the minerals category. They have been rated as high in their sensitivity to changes in hydrology but low in sensitivity to alterations in sediment loads. Wetlands Cluster 3w has the same characteristics for hydrology and sediment, and it also has been influenced by anthropogenic water uses. Cluster 3w however has considerably less influence due to a lesser percentage of calcareous geologic bedrock.

Water removal in Clusters 4r, 5r, 6r, and in 7r would reduce summer flows, especially during years with low summer rainfall, with would in turn worsen any problems with fisheries habitat and stream temperatures. However, the sensitivity of aquatic productivity and benthic macroinvertebrates, to thermal fluctuations, is generally low, with Cluster 6r the least responsive to changes in hydrology, water temperature, and sediment. However, fisheries resources in Cluster 6r are sensitive to sediment load increases, as would be Clusters 4r, 5r and 7r. Increases in sediment load would be temporarily stored during low flow periods, degrading biotic habitat in these three clusters (USDA Forest Service, 2006, Report 1 of 1).

Recommendations for watersheds with these riparian and wetland clusters are listed below:

- Watersheds with moderate to high levels of anthropogenic activities in Cluster 4wetlands would be candidates where mitigation measures could be implemented. Watersheds with low levels of anthropogenic activity in Cluster 4w represent locations where restoration would be more appropriate as these wetlands are relatively rare.
- Wetlands Cluster 3w is typically smaller and more isolated than other wetland Clusters. Mitigation measures for management activities may be the most

reasonable means of managing these systems. However, wetlands in Cluster 3w are also relatively rare, as are those classified as 4w. Due to the rarity of Cluster 3w restoration may also be utilized to improve wetland health and function.

Riparian Cluster 4r is generally found in watersheds having moderate to high potential for impacts to aquatic health due to anthropogenic activities. It is recommended that any disturbances, which would increase sediment production in low gradient reaches, be prevented or mitigated. This would deflect degradation of fisheries habitat.

- Riparian Cluster 5r is one of the most productive for riparian and aquatic systems, due to the high percentage of underlying calcareous bedrock. Most of the watersheds in this Cluster have moderate levels of anthropogenic activity. High percentages of canopy cover should be maintained to moderate stream temperature fluctuations. Where anthropogenic influence is high mitigation efforts should be considered. Where these activities are considered to be low, restoration may be a more suitable choice.
- Riparian Cluster 6r is sensitive to alterations of surface and subsurface hydrology due to a combination of low elevation, rainfall, and mixed precipitation flow events. Implementation of anthropogenic activities that may alter the Clusters hydrology should be carefully evaluated in context of what activities are being proposed and existing levels of anthropogenic impacts in that particular watershed where the activity is being proposed.
- There is only one watershed within riparian Cluster 7r, Mayday Valley. This watershed is highly influenced by minerals activity and moderately so by other anthropogenic activities. Production potential for aquatic and riparian systems is limited by the associated non-calcareous geology.

Minerals Overall Cumulative Percentile Ranking

The resulting metric's data for locatable minerals, oil and gas, coal, and sand and gravel, were combined, re-ranked, and a cumulative percentile ranking was generated. The information was used to determine which watersheds had the highest potential for impacts to aquatic, riparian, and wetland resources related to minerals management activity.

This analysis is relative only to the portion of the 6th level HUBs surface area within the San Juan National Forest boundary, and is intended to provide the reader with the additive rankings at this scale. Unlike the previous methodology, the results are evenly distributed across the total number of HUBs at this scale. This analysis was performed at the management scale, with data existing for all portions of the 154 HUBs within the San Juan National Forest boundary.

Ranking these watersheds delineates which watersheds are the most susceptible to recreation-related impacts on aquatic and riparian health. Rankings were divided into five differing groups, each with a 20 percentile ranges. Watersheds within the 100-80 percentile range have the most susceptibility to impacts on aquatic health while those falling within the 19.9-0.1 percentile range have the lowest potential for being influenced.

The results of the cumulative ranking process for all recreation metrics, in all watersheds associated with the San Juan National Forest are summarized in Table 5.18 at the end of this section. This table also summarizes which riparian and wetland clusters are associated with each watershed on the forest. Essentially this table will function as a "look up" table, so at a glance one can determine how minerals activities are affecting each watershed, as well as have a reference to watershed sensitivity. The table also indicates which watersheds are located entirely on-forest.

The sum of the percentile ranks of the 12 criteria of the minerals category was calculated to identify the additive effects of this activity on aquatic, riparian, and wetland resources. The 12 criteria used in this analysis are summarized in Table (5.17).

The cumulative percentile ranking for the 100-80 percentile range is summarized in Table 5.18 and displayed in map format in Figure 5.21. Seven watersheds in the recreation synthesis analysis were within the 100-80 percentile range. The maximum cumulative ranking for recreation was 40. The cumulative mineral category values, for the 100-80 percentile range, varied from a high of 30 to a low of 18. These watersheds are concentrated in the vicinity of the LaPlata Mountains, west of Durango, and northwest of the Chimney Rock Archeological Area (Figure 5.21). These watersheds have the highest combined influences of minerals activity. The potential for effects to aquatic, riparian, and wetland resources is largely off-forest as all but the Upper Beaver Creek (HUB# 140801011601) watershed are only partially located within the forest boundary. This watershed has the potential for both on and off-forest impacts.

Table 5.17 Summary of criteria used in minerals cumulative analysis, management scale, San Juan National Forest

Metric	Explanation
Sand/Gravel Site VF Density (# / VF Acre)	Number of sand or gravel sites per valley floor acre per 6th level HUB
Claim VF Density (# / VF Acre)	Number of mining claims per valley floor acre per 6th level HUB
# Coal Sites per Stream Mile	Number of coal sites per stream mile per 6th level HUB
Coal Site VF Density (# / VF Acre)	Number of coal sites per valley floor acre per 6th level HUB
Total # Mining Claims	The total number of mining claims per 6th level watershed
# Oil/Gas Sites per Stream Mile	Number of oil/gas sites per stream mile per 6th level HUB
Oil/Gas VF Density (# / VF Acre)	Number of oil/gas sites per valley bottom acre per 6th level HUB
# Sand/Gravel Sites per Stream Mile	Number of sand/gravel sites per stream mile per 6th level HUB

Table 5.18 Minerals Category, Cumulative 80-100 Percentile Ranking for 6th level Hubs, management scale, San Juan National Forest

HUB6	HUB6NAME	Cumulative Mineral Category Value	Mineral Additive Category	Riparian Cluster	Wetlands Cluster
140801070105	East Fork of Mud Creek	21	5	4	4
140801070103	Upper Mancos Valley	30	5	5	4
140801050102	Mayday Valley	22	5	7	3
140801040603	Lower Lightner Creek	20	5	4	4
140801011703	Ute Creek	20	5	6	4
140801011601	Upper Beaver Creek	18	5	5	4
140801011503	Los Pinos River-Bayfield	18	5	5	4

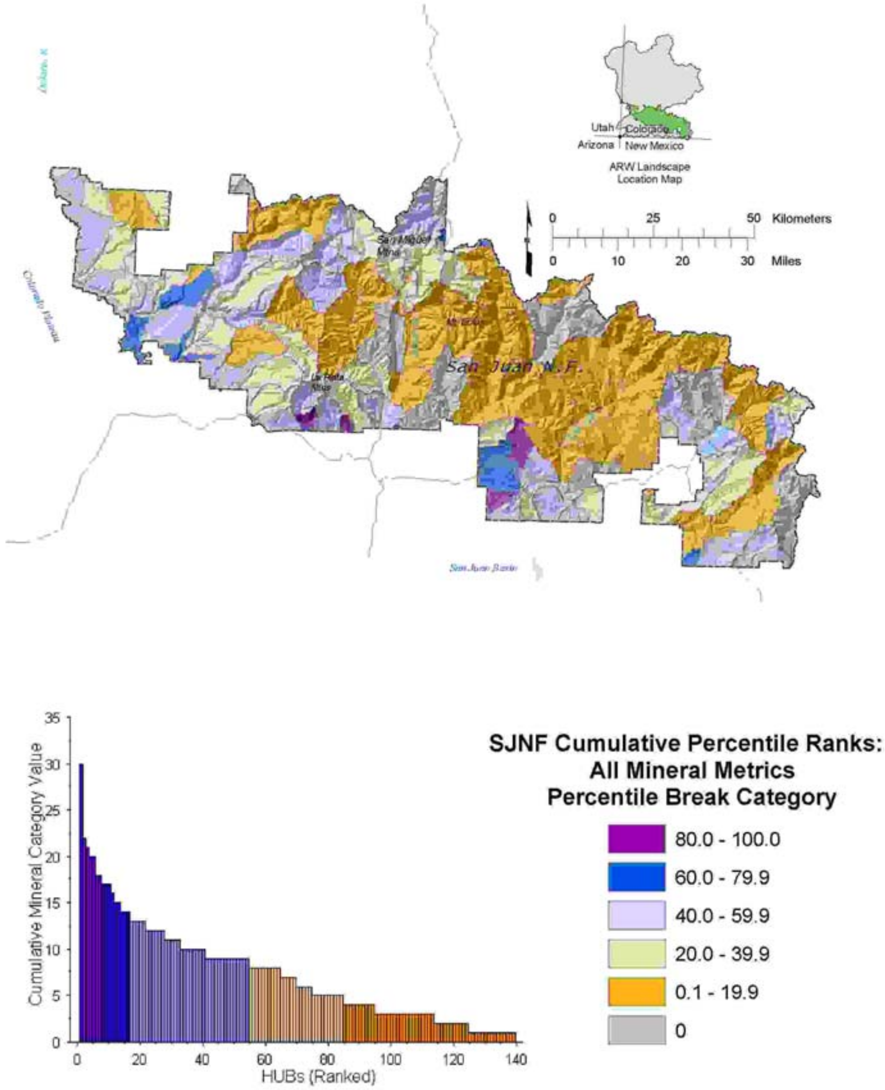

Figure 5.21 Ranking and Distribution of cumulative percentiles, for all mineral categories, 6th level HUBs, management scale, San Juan National Forest.

Analysis shows that there are 9 watersheds within the 79.9-60 percentile range, which corresponds to mineral additive category "4". Only one of these watersheds is located entirely on-forest (Table 5.19). These watersheds are found along the southwest border of the western half of the Forest, along the northern tip of the Forest near the San Miguel Mountains, and along the southern boundary of the eastern half of the Forest (Figure 5.19).

For all the watersheds in the 79.9-60 percentile range all of them but the Lower Florida-Ticalotte (HUB# 140801040901), Animas River-Spring Creek (HUB# 140801040604), and Animas River-Cunningham Creek (HUB# 140801040104) watersheds have the potential for both on and off-forest effects to aquatic resources. The Lower Florida-Ticalotte and Animas River-Spring Creek watersheds are located primarily off-forest and there is likely little impact, due to mining related activities, to on-forest resources.

The Animas River-Spring Creek watershed is unusual in that most of the watershed is located off-forest, with the drainage flowing onto the Forest. In this case, the large majority of mining activities are located off-forest, but with the potential for downstream effects occurring on Forest land.

There are 38 watersheds, or 25% of the Forest's watersheds, within the 59.9-40 percentile range. This percentile range corresponds to a mineral additive category of "3" (Table 5.17). Watersheds have the potential for both on and off-forest effects.

19% of the Forest's watersheds, which equates to 30 watersheds, are within the 39-.9-20.0 percentile range. This percentile range corresponds to a mineral additive category of "2" (Table 5.17). Watersheds have the potential for both on and off-forest effects.

The majority of the Forest's watersheds are within the 19.9-0.1 percentile range, reflecting a fairly low level of mining activity. This percentile range corresponds to a mineral additive category of "1". These watersheds are found across the San Juan National Forest (Figure 5.21). Most of these watersheds are located entirely on Forest. The potential for impacts to aquatic resources is fairly low overall, and is probably even less for those resources located off-forest.

Only 15 watersheds, or 9% of the watersheds found on the San Juan, have no influence due to minerals activities on aquatic resources (Table 5.19 and (Figure 5.21).

Table 5.19 Minerals Cumulative Percentile Ranking, 6th Level HUBs, management scale, San Juan National Forest

HUB6	HUB6NAME	Cumulative Mineral Category Value	Mineral Additive Category	Riparian Cluster	Wetlands Cluster
140801070105	East Fork of Mud Creek	21	5	4	4
140801070103	Upper Mancos Valley	30	5	5	4
140801050102	Mayday Valley	22	5	7	3
140801040603	Lower Lightner Creek	20	5	4	4
140801011703	Ute Creek	20	5	6	4
140801011601	Upper Beaver Creek	18	5	5	4
140801011503	Los Pinos River-Bayfield	18	5	5	4
140801040901	Lower Florida River-Ticalotte	15	4	5	4
140801040604	Animas River-Spring Creek	14	4	6	5
140801040104	Animas River-Cunningham Creek	14	4	2	8
140801011603	Lower Beaver Creek	16	4	4	4
140801011602	Middle Beaver Creek	15	4	5	3
140801010602	Montezuma Creek	14	4	4	4
140300020408	McPhee Reservoir-Dolores River	17	4	4	4
140300020406	Upper Dolores River-Italian Creek	17	4	4	3
140300020305	Beaver Creek-Trail Canyon	17	4	4	3
140802020201	Upper Yellowjacket Canyon	10	3	4	3
140801070104	Chicken Creek	9	3	4	3
140801050105	Upper Cherry Creek	12	3	5	4
140801050101	La Plata River headwaters	10	3	2	8
140801040602	Upper Lightner Creek	11	3	5	3
140801040504	Upper Animas Valley-Trimble	12	3	5	5
140801040502	Elbert Creek	12	3	5	7
140801040103	Mineral Creek	9	3	2	8
140801040102	Cement Creek	9	3	3	8
140801040101	Animas River above Howardsville	12	3	2	8
140801020502	Piedra River-Stollsteimer	13	3	6	4
140801020501	Yellowjacket Creek	13	3	4	4
140801020405	Lower Stollsteimer Creek	9	3	6	4
140801011704	Upper Spring Creek	11	3	6	4
140801010507	Coyote Creek	9	3	4	3
140801010506	Little Navajo River	10	3	2	3
140801010504	Navajo River-Weisel Flat	9	3	4	3
140801010503	Navajo Peak	10	3	2	1
140801010307	Echo Canyon Reservoir	11	3	5	4
140801010304	Upper Pagosa Springs	10	3	4	3
140801010303	Laughlin Park	11	3	5	1
140801010302	Fourmile Creek	12	3	2	3
140801010102	Quartz Creek	9	3	1	7
140300020605	Dolores Canyon-Joe Davis Hill	13	3	4	3
140300020604	Dolores Canyon-Lake Canyon	13	3	4	3
140300020603	Dolores Canyon-Cabin Creek	13	3	4	3
140300020510	Upper Disappointment Valley	9	3	6	6

HUB6	HUB6NAME	Cumulative Mineral Category Value	Mineral Additive Category	Riparian Cluster	Wetlands Cluster
140300020509	Pine Arroyo	9	3	4	3
140300020407	House Creek	9	3	4	3
140300020405	Lower Lost Canyon	12	3	4	3
140300020403	Middle Lost Canyon	9	3	4	3
140300020306	McPhee Reservoir-Beaver Creek Inlet	10	3	4	3
140300020209	Upper Dolores River-Taylor Creek	9	3	5	3
140300020204	Upper Dolores River-Scotch Creek	10	3	2	1
140300020203	Rico Valley	10	3	2	1
140300020202	Upper Dolores River-Cayton Valley	11	3	2	1
140300020105	Lower West Dolores River	9	3	5	3
140300020103	Upper West Dolores River	9	3	2	1
140802020103	Hartman Canyon	6	2	6	6
140801070102	West Mancos River	8	2	2	1
140801070101	East Mancos River-Middle Mancos River	8	2	2	1
140801040601	Junction Creek	6	2	2	3
140801040407	Lower Hermosa Creek	5	2	5	1
140801040303	Lower Cascade Creek	8	2	2	8
140801040302	Lime Creek	8	2	2	8
140801040301	Upper Cascade Creek	7	2	2	8
140801040202	Animas River-Tenmile Creek	5	2	2	8
140801020503	Piedra River-Navajo Reservoir Inlet	8	2	6	3
140801020404	Middle Stollsteimer Creek	5	2	6	3
140801011502	Bear Creek	6	2	5	4
140801010405	Rito Blanco	6	2	4	4
140801010308	San Juan River-Eightmile Mesa	7	2	1	7
140801010306	Mill Creek	8	2	4	4
140801010305	McCabe Creek	8	2	5	4
140801010101	Headwaters East Fork San Juan River	6	2	1	7
140300036101	Naturita Creek	8	2	5	4
140300020602	Narraguinnep Canyon Natural Area	8	2	4	4
140300020601	Dolores River-Salter Canyon	5	2	4	3
140300020511	Disappointment Valley-Wild Horse Reservoir	5	2	6	3
140300020507	Dawson Draw	7	2	4	3
140300020505	Upper Disappointment Creek	5	2	5	4
140300020404	Stapleton Valley	7	2	4	3
140300020402	Spruce Water Canyon	5	2	4	3
140300020304	Lower Plateau Creek	5	2	5	4
140300020303	Calf Creek	8	2	5	4
140300020208	Stoner Creek	5	2	2	1
140300020206	Bear Creek	7	2	2	1
140300020201	Dolores River Headwaters-Tin Can Basin	5	2	2	1
140802020106	Lower Alkali Canyon-Narraguinnep Canyon	4	1	6	6
140801040801	Florida River Headwaters	4	1	8	9
140801040503	Upper Animas Valley-Stevens Creek	4	1	5	2
140801040501	Upper Animas Valley-Canyon Creek	3	1	1	2

HUB6	HUB6NAME	Cumulative Mineral Category Value	Mineral Additive Category	Riparian Cluster	Wetlands Cluster
140801040405	South Fork Hermosa Creek	3	1	2	1
140801040404	Middle Hermosa Creek	2	1	2	1
140801040403	Upper Hermosa Creek	1	1	2	1
140801040402	East Fork Hermosa Creek	3	1	2	1
140801040401	Hermosa Creek headwaters	3	1	2	1
140801040204	Animas River-Needleton	3	1	2	8
140801040203	Needle Creek	3	1	8	9
140801040201	Elk Creek	3	1	3	8
140801020402	Upper Stollsteimer Creek	1	1	5	4
140801020401	Martinez Creek-Dutton Creek	4	1	5	4
140801020301	Upper Devil Creek	2	1	5	3
140801020206	Upper Piedra River-Indian Creek	2	1	5	3
140801020205	Upper Piedra River-Box Canyon	3	1	5	3
140801020204	First Fork	1	1	2	1
140801020203	Sand Creek	2	1	2	1
140801020202	Lower Weminuche Creek	1	1	2	3
140801020104	Piedra River-O'Neal Creek	3	1	5	4
140801020103	Williams Creek	1	1	2	2
140801020102	Middle Fork Piedra River	1	1	2	7
140801020101	East Fork Piedra River	1	1	1	7
140801011501	Middle Los Pinos River-Red Creek	1	1	5	3
140801011404	Vallecito Reservoir	1	1	5	3
140801011403	Lower Vallecito Creek	4	1	1	2
140801011402	Middle Vallecito Creek	4	1	2	8
140801011401	Upper Vallecito Creek	3	1	2	8
140801011306	East Creek	2	1	2	1
140801011305	Indian Creek	3	1	2	2
140801011303	Lake Creek	2	1	2	8
140801011301	Upper Los Pinos River-Ricon La Vaca	1	1	2	8
140801010604	Upper Cat Creek	3	1	4	3
140801010601	San Juan River-Trujillo	3	1	6	3
140801010406	Lower Rio Blanco-San Juan River	4	1	1	7
140801010404	Middle Rio Blanco	1	1	5	4
140801010403	Rio Blanco River-Blanco Basin	2	1	4	3
140801010401	Rio Blanco Headwaters	1	1	1	7
140801010203	Wolf Creek	2	1	1	7
140801010202	Beaver Creek	1	1	1	7
140801010201	Upper West Fork San Juan River	1	1	2	8
140801010104	East Fork San Juan River-The Clamshell	3	1	1	7
140801010103	Sand Creek	1	1	1	7
140300020506	Brumley Valley	3	1	6	4
140300020504	Ryman Creek	2	1	5	4
140300020501	Bear Creek-Disappointment Creek	2	1	5	4
140300020401	Upper Lost Canyon	3	1	2	1
140300020302	Upper Plateau Creek	3	1	5	4

HUB6	HUB6NAME	Cumulative Mineral Category Value	Mineral Additive Category	Riparian Cluster	Wetlands Cluster
140300020301	Upper Beaver Creek -McPhee	3	1	5	1
140300020207	Dolores River-Priest Gulch	4	1	2	1
140300020205	Roaring Forks Creek	3	1	2	1
140300020104	Groundhog Creek	2	1	2	1
140300020102	Fish Creek	4	1	2	1
140300020101	El Deinte Peak	4	1	2	1
140801040804	Upper Florida River-Red Creek	0	0	5	3
140801040803	Lemon Reservoir	0	0	2	1
140801040802	Upper Florida River-Transfer Park	0	0	1	7
140801040406	Hermosa Creek-Dutch Creek	0	0	1	1
140801020403	Stollsteimer Creek-Dyke Valley	0	0	4	4
140801020302	Lower Devil Creek	0	0	6	3
140801020201	Upper Weminuche Creek	0	0	1	8
140801011304	Three Sisters	0	0	8	9
140801011302	Upper Los Pinos River-Flint Creek	0	0	2	8
140801010502	West Fork Navajo River	0	0	1	7
140801010402	Fish Creek	0	0	2	2
140801010301	Turkey Creek	0	0	2	2
140801010204	Lower West Fork San Juan River	0	0	2	7
140300020503	Sheep Camp Valley	0	0	5	4
140300020502	Disappointment Creek Headwaters	0	0	5	1

Bibliography

BLM. 2004. Federal Lands Mining Claim Records. BLM LR2000 Lands and Minerals Records Databases, Denver, CO.

Causey, J. Douglas. 1998. MAS/MILS mineral location database information. MAS/MILS Arc/Info point coverage for the Western U.S. (excluding Hawaii). Open-File Report 98-512. U.S. Department of Interior, U.S. Geological Survey. Spokane, WA. Online: http://geo-nsdi.er.usgs.gov/cgi-bin/publication?open-file/98-512/

COGCC. 2004. Online Oil and Gas Well Locations Dataset. Colorado Department of Natural Resources, Colorado Oil and Gas Conservation Commission. Online: http://oil-gas.state.co.us/

Kirschbaum, M.A., L. Roberts and L. Biewick. 2000. Geologic Assessment of Coal in the Colorado Plateau. Professional Paper 1625-B. U.S. Department of Interior, U.S. Geological Survey. Denver Colorado. Online: http://greenwood.cr.usgs.gov/energy/coal/PP1625B/

Murray, Keith D. 1980. Coal in Colorado. Rocky Mtn. Assoc. of Geologists. Harry C. Kent, Karen W. Porter, Eds.

Chapter 6
Vegetation Management Category
Management Scale

Key Findings

1. The percentage of clear-cut boundaries (conducted within the last 40 years) in 6th level HUBs ranged from 11.26% (62 HUBs with some clear-cut harvest) to 0% (92 HUBs). The percentage of valley bottoms within clear-cut boundaries shows 10% of clearcut acres were in valley bottoms.
2. Twelve watersheds are within the 100-80 percentile range for the amount of valley bottom acres involved in clearcuts. The percentages varied from 2.36 to 0.40. The highest percent of stream miles in a watershed, involved with clearcuts in the valley floor ranged from 8.0% to 3.4%.
3. A total of 16 watersheds were found to be in the 100-80 percentile range for total acres burned in the last 30 years. However, the number of total acres burned does not translate to having the highest percentage of the watershed burned since 1976.
4. Data for fire area by decade and by total acres are dominated by the Missionary Ridge fire of 2002.
5. Since 1976 the number of acres burned by watershed, for the 100-80 percentile range, varied from 79% to 3%. The number of valley floor acres burned ranged from 950-260 acres, which translates to 96.5 to 6.7% of the valley floor area.
6. For the 100-80 percentile range for number of acres burned since 1991, the total acres burned ranged from 700-190 acres, which equates to 56.1-4.7% of valley floor area.
7. 201, 188 acres are of high preference for cattle grazing on the San Juan National Forest. That represents 19.61% of the available preference acreage. 141, 867 acres are rated as high preference for sheep, which equates to 12.06% of the acreage suitable for sheep grazing.
8. The percent of National Forest valley floor area that is in high density allotment varies from 100-76.63%. For watersheds in the 100-80 percentile ranges, the percent of valley floor area in high preference grazing areas for cattle varies from 42.5 to 35.4%. In valley floor areas that are rated as high preference for sheep the percentage involved, for watersheds in the 100-80 percentile range, varies from 66.2% to 55.3%.

Influence of Commercial Timber Harvest

Timber harvest played a large part in the development of the western United States. By the mid-1850's commercial lumber was needed for railroad ties, charcoal, and mine supports (Wohl, 2001; Walcott, 1899). This led to harvest in many parts of the Rocky Mountains, which was largely un-regulated. The effects of unregulated harvest, and associated activities such as tie drives and road construction, are still influencing aquatic related resources in many areas of the Rockies today (USDA Forest Service 2003).

Chamberlin et al. (1991) summarized the five major cumulative effects of logging on aquatic environments or systems as changes in: 1) timing or magnitude of small or large runoff events, 2) modifications of stream bank stability, 3) modification of sediment supply to channels, 4) alteration of sediment storage and structure in channels (e.g., large woody debris), and 5) alteration of energy relationships such as water temperature, snowmelt, and freezing. As a result, timber harvest can have a profound influence on aquatic systems if it leads to modification of biophysical processes and/or physical structure. This includes hydrology, water quality, riparian and wetland health and function as well as channel and biotic conditions.

Through timber harvest the reduction of Forest canopy may alter snow accumulation, rate of snow melt, and reduce the amount of evapotransporation. This typically leads to increased water yields which may result in increased erosion, sedimentation, and modification of channel morphology.

Water temperature, the amount of suspended sediment, and nutrients, are the three main water quality components that may be modified as a result of timber harvest activities. As riparian or streamside vegetation is removed summer water temperatures generally increase. The increase is in direct proportion to the amount of increased sunlight striking the waters surface. Increases in stream temperature may result in a competitive advantage for warm-water species, increased chance of disease, and increased food production. In addition, forested waters are typically lower in nutrients than un-forested land (USDA Forest Service, 2003). With harvest, natural nutrient cycles may be disrupted and can lead to increased concentrations of nitrogen, phosphorous, potassium, and calcium in the water (Stednick, 2000).

Road construction, tractor skidding, and intensive site preparation are the three practices with the highest potential for generating erosion and stream sedimentation, especially where these actions occur in relation to alluvial channels and riparian areas (USDA Forest Service, 2003).In alluvial channels the channel is typically widened, and its depth decreased, when riparian vegetation is removed and the sediment supply to the channel is increased. As a result the channel becomes shallower, has fewer pools, and the number of riffles increases (Chamberlin et al. 1991). With these modifications come changes in habitat quality, productivity, and a decrease in macrobiotic diversity.

Forest management activities may also result in large woody debris being removed from a stream as well as introducing additional sediment or degrading its banks. Alteration of a channel's natural large woody debris load may result in un-intentional modifications to stream habitat for native or non-native species. Chamberlin et al. (1991) demonstrated that differing components of habitat, such as a pool, riffle, or glide, are selectively affected by timber management activities.

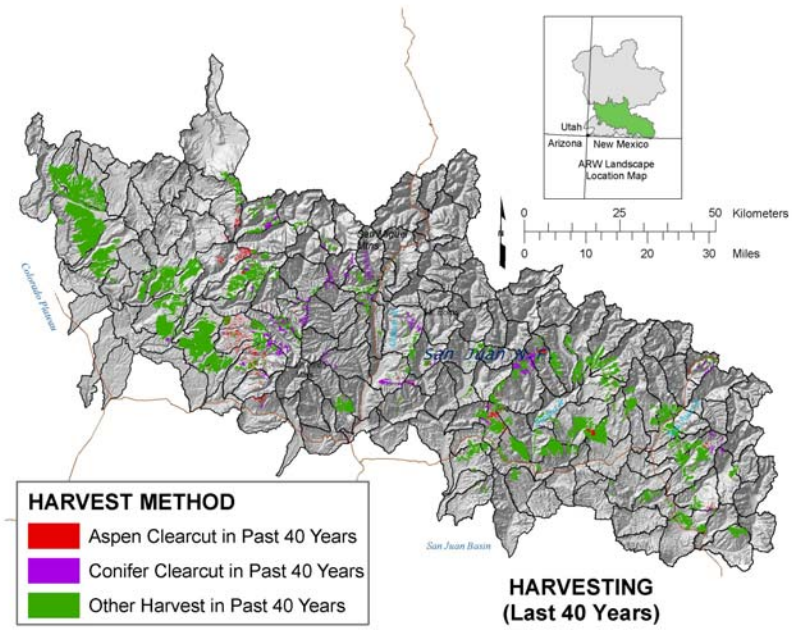

Figure 6.1 Location Map of Harvest, by Type, on the San Juan National Forest, management scale

At the management scale, the most important questions to ask concerning commercial timber harvest in relation to aquatic, riparian, and wetland resources are: 1) what is the extent of past harvest, 2) where has most of the past timber harvest occurred, and 3) where would future harvest be predicted to occur?

Within the past 40 years, timber harvest has been moderate on the San Juan National Forest and rare on BLM Lands, but a number of watersheds have had relatively extensive harvest. A number of harvest methods and silvicultural prescriptions were used; some of the logging during this period has involved clearcutting, a trend that peaked in the 1960s and 70s (Figure 6.1). Other harvest methods included various types of selective harvest which generally removed less than 25% of the overstory stand in each entry. Overall timber sale volume harvested annually on the San Juan National Forest has decreased from a high of 98 million board feet in 1969 to a low of 2.9 million board feet in 1995, with an annual average of 12.7 million board feet over the last decade.

Harvest on BLM lands is generally limited to fuelwood, and post/pole sales. Some commercial harvest occurred on BLM lands over the last 40 years; however most of those lands were recently exchanged with the San Juan National Forest.

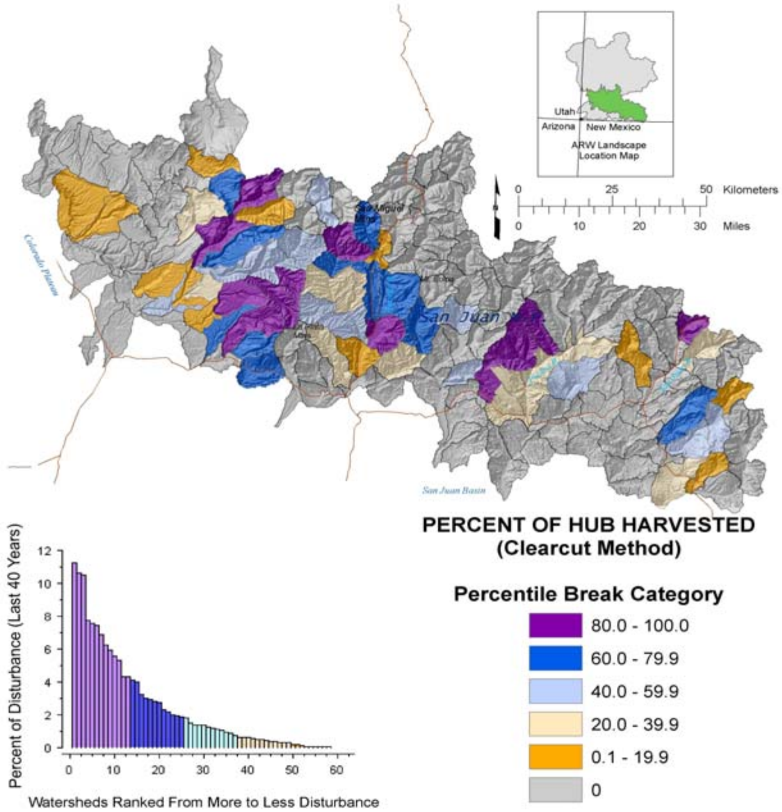

Figure 6.2 Percent of 6th level HUB area clearcut within 40 years (e.g., recent clearcut) in San Juan National Forest, management scale.

Approximately one-third (62 of 153 HUBs; Figure 6.2) of the 6th level HUBs intersecting the Forest have had some clearcut timber harvest, which is generally regarded as the timber harvest strategy most damaging to aquatic, riparian, and wetland resources (Chamberlin et al. 1991). HUBs listed within the 100-80 percentile range are considered to have the highest potential for effects on these resources. Watersheds within this percentile range are summarized in Table 6.1

Clearcutting is no longer used within the analysis area, except for aspen harvest. A more precise term for the type of aspen harvest used would be coppice rather than Clearcut since aspen regenerates almost immediately following the removal of the overstory via sprouts from the root system. Due to the rapid regeneration watershed effects are limited in scope and very short term. 34% of the acres clearcut in the last 40 years was aspen coppice harvest.

Table 6.1 Summary of HUBs within the 100-80 percentile range, Percent of HUB Harvested by the Clearcut Method, management scale, San Juan National Forest. Watersheds highlighted in light green are located entirely within the Forest boundary.

HUB6	HUB6NAME	Percentage of HUB Harvested by the Clearcut Method
140300020205	Roaring Forks Creek	11.26
140300020401	Upper Lost Canyon	10.61
140801011601	Upper Beaver Creek	10.52
140801040401	Hermosa Creek headwaters	7.76
140801070102	West Mancos River	7.55
140300020206	Bear Creek	7.43
140801040402	East Fork Hermosa Creek	6.88
140801020203	Sand Creek	6.24
140801010203	Wolf Creek	5.91
140300020105	Lower West Dolores River	5.55
140801020204	First Fork	5.34
140801040503	Upper Animas Valley-Stevens Creek	4.34
140300020102	Fish Creek	4.33

The amount of clearcutting varied widely among the 62 HUBs that have had this activity. For example, in the 100-80 percentile range up to 11.26% of the total area in the Roaring Forks Creek watershed (HUB 140300020205) was clearcut, while the minimum was 4.33% in the Fish Creek watershed (HUB 140300020102). When all 62 HUBs with clearcut disturbance are considered, three HUBs had clearcuts of at least 10% of their area, but the average was around 2% (Figure 6.2).Past clearcut activity has occurred both in uplands and near, or in, riparian areas. This activity is summarized in Table 6.2. Clearcutting of aspen and conifers in valley floor areas represent 10% of the total acreage which has been clearcut.

49 of the 62 HUBs with measurable clearcutting had some valley bottom harvest (Figure 6.3). 12 of these 49 HUBs were found to be within the 100-80 percentile range and are summarized in Table 6.3. Upper Lost Canyon watershed (HUB 140300020401) had the highest percentage of clearcuts with 2.4 of its valley floor area. The Hermosa Creek headwaters watershed (HUB 140801040401) and the East Fork Hermosa Creek watershed (HUB 140801040402) had the lowest percentages of their valley bottoms clearcut at 0.4.

Table 6. 2 Summary of Clearcut Acres by Slope Position, management scale, San Juan National Forest

Type of Harvest	Slope Position	Acres
Aspen Clearcut	Upland	8,373
	Valley Floor	1,279
Conifer Clearcut	Upland	17,447
	Valley Floor	1,507
Other Harvest	Upland	178,891
	Valley Floor	41,889
Total Harvest	Upland	204,712
	Valley Floor	44,674
	Total	249,386

Table 6. 3 Summary of watersheds within the 100-80 percentile range, Percent of Clearcut Valley Floor, By HUB, management scale, San Juan National Forest; Watersheds highlighted in light green are located entirely within the Forest boundary.

HUB6	HUB6NAME	Percentage of Valley Floor in Clearcuts
140300020401	Upper Lost Canyon	2.4
140801011601	Upper Beaver Creek	1.4
140801020301	Upper Devil Creek	0.8
140801070102	West Mancos River	0.7
140300020205	Roaring Forks Creek	0.6
140300020406	Upper Dolores River-Italian Cr	0.6
140801040802	Upper Florida River-Transfer P	0.5
140801020203	Sand Creek	0.5
140801070101	East Mancos River-Middle Mancos	0.5
140300020206	Bear Creek	0.4
140801040402	East Fork Hermosa Creek	0.4
140801040401	Hermosa Creek headwaters	0.4

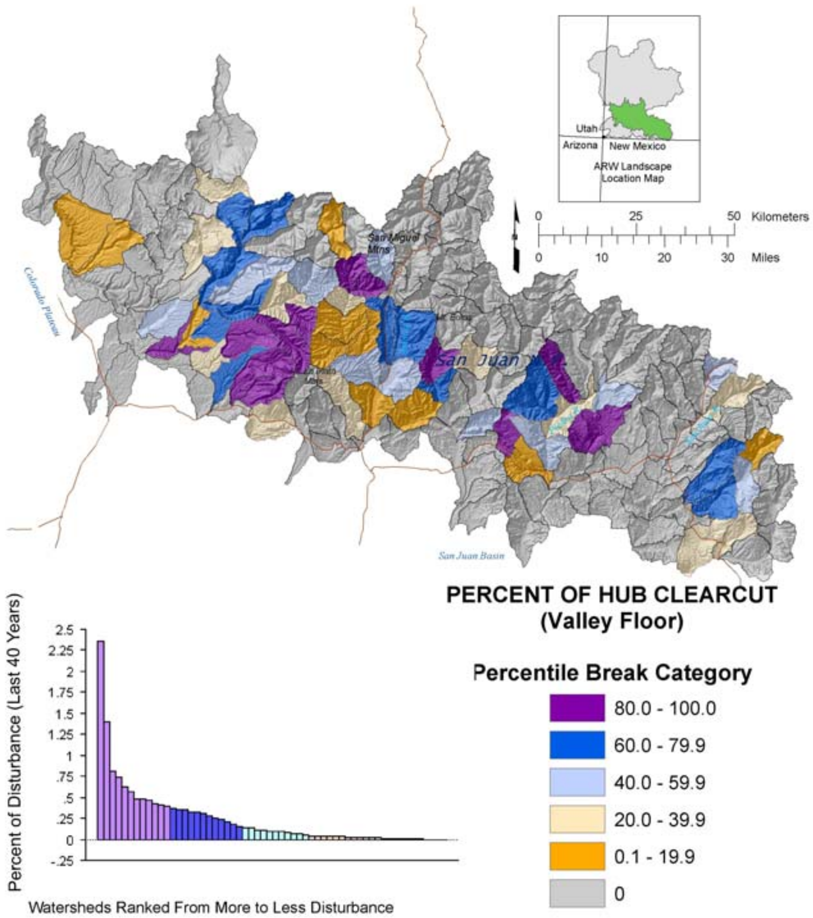

Figure 6.3 Trends in timber harvest clearcuts, located in valley floor areas, for 6th level HUBs, management scale in the San Juan National Forest

To provide a more focused evaluation of potential impacts on aquatic, riparian, and wetland resources, the percentage of HUB stream miles located in clearcuts, was calculated. Overall, it was determined that a total of 38 miles of stream are found within clearcut harvest units (Table 6.4).

Based on percentile range, it was determined that 11 watersheds had the highest potential for being impacted by effects associated with timber harvest near streams. Figure 6.4 shows the rank and distribution of these watersheds. Table 6.5 summarizes those watersheds that occur within the 100-80 percentile range.

Roaring Forks Creek watershed (HUB 140300020205) has the highest percentage of it's streams involved with clearcut units at 8.0% while Bear Creek watershed (HUB 140300020206) has only 3.4% of its streams involved with clearcuts. It is interesting to note that both watersheds have a stream density of 2.3 miles of stream per sq. mile of HUB.

Table 6.4 Summary of Miles of Stream Associated with Harvest Units, management scale, San Juan National Forest.

HARVESTING IN VALLEY BOTTOMS	MILES OF STREAMS IN HARVEST UNITS
Aspen Clearcuts	11
Conifer Clearcuts	27
Partial Harvesting	468
Total Harvesting	**506**

Clearcutting in HUBs with low gradient stream reaches does not appear to be widespread. Low gradient stream reaches are defined using the Rosgen system of channel typing. Based on the definition low gradient reaches vary from 0% to 3.9%, which is the upper gradient range for a "C" channel type. Only one of 153 Forest HUBs had any recent clearcutting where low gradient stream reaches were present. Clearcut areas within this watershed totaled only 0.025 miles/ mile^{2}. Low gradient stream habitats may be rare in these watersheds, and may contain pools and pool-riffle transitions which can be critical rearing and spawning habitats for resident fishes (Reiser and Wesche 1977; Bisson et al. 1992).

In the Rocky Mountains, low-gradient stream reaches also tend to have higher biomass of native cutthroat trout compared to higher-gradient reaches (Herger et al. 1996). Thus, despite the small aerial extent of this clearcutting in these specific locations, the effects on aquatic biota may still be important.

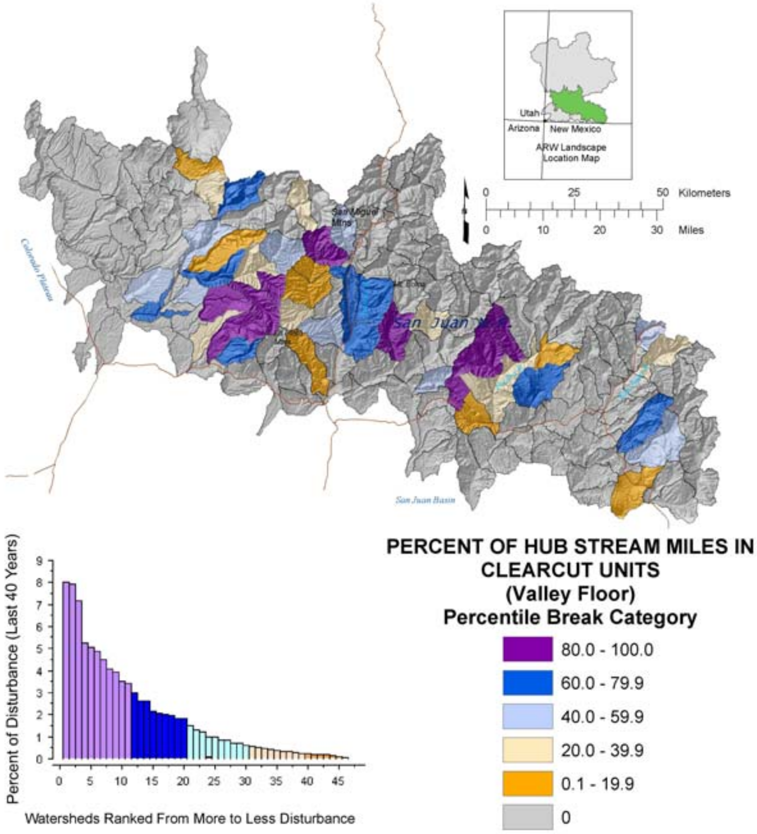

Figure 6.4 Percent of HUB stream within clearcut harvest units on the San Juan National Forest, management scale.

Table 6.5 Summary of Percent of HUB Stream Miles in Clearcut Units within Valley Floor Areas, management scale, San Juan National Forest. Watersheds highlighted in light green are located entirely within the Forest boundary.

HUB6	NAME	Percent of HUB Stream Miles in Clearcut Units within the Valley Floor	Stream Density
140300020205	Roaring Forks Creek	8.0	2.3
140801011601	Upper Beaver Creek	7.9	2.7
140801020203	Sand Creek	7.2	2.0
140300020401	Upper Lost Canyon	5.2	2.3
140801040401	Hermosa Creek headwaters	5.	2.7
140801020204	First Fork	4.9	1.8
140801040402	East Fork Hermosa Creek	4.5	2.3
140801070102	West Mancos River	4.05	2.7
140801040802	Upper Florida River-Transfer Park	3.95	3.2
140801040803	Lemon Reservoir	3.55	3.3
140300020206	Bear Creek	3.4	2.3

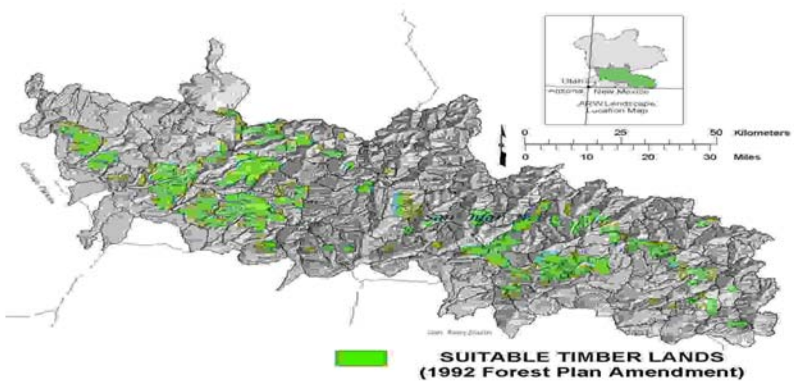

Figure 6.5 Summary of Suitable Timber Lands within the San Juan National Forest, management scale.

The current extent of timber suitable for commercial harvest suggests that logging may continue to be a significant land use activity in the San Juan National Forest (Figure 6.5). Most of the timber in the high-elevation stands consist of Engelmann spruce and subalpine fir. Most of the commercial timber sales on the San Juan National Forest over the last decade or so have been restoration-based individual tree or group selection harvest, located in mixed conifer and ponderosa pine types at lower elevations. These restoration treatments are generally thinning from below, which are designed to improve forest health and reduce the potential For uncharacteristically intense wildfire. Aspen coppice harvests have also been common over the past decade and are expected to continue at about the current level of 300 to 500 acres per year. Approximately 22% of the current suitable timber lands on the San Juan National Forest fall within roadless areas. Harvest within the roadless portion of the suitable base in the near future is very unlikely.

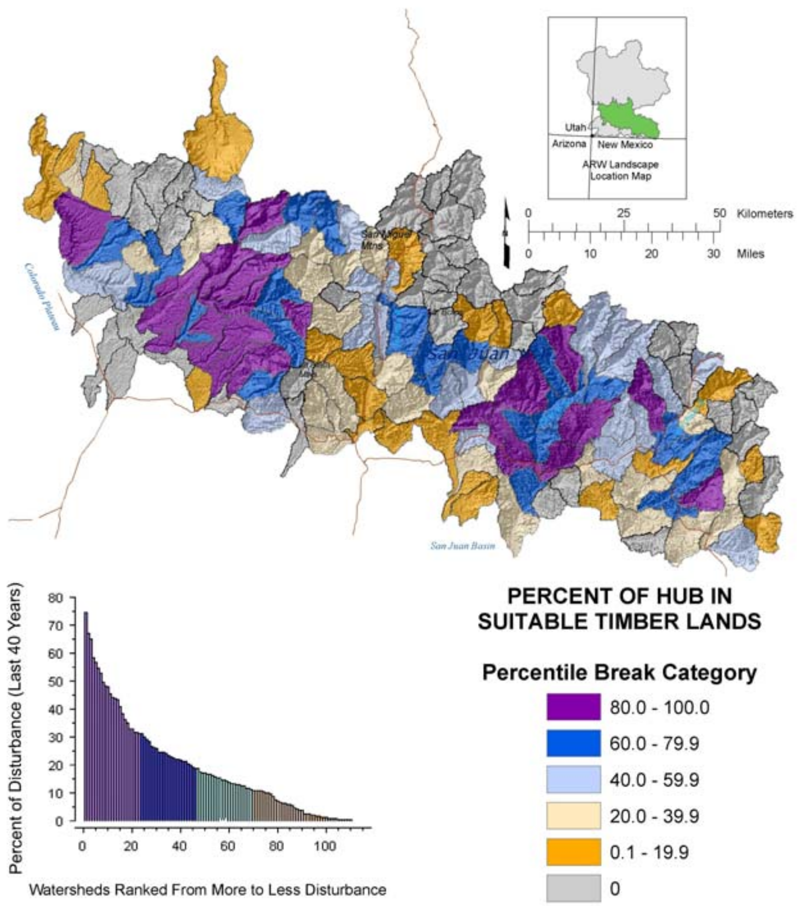

Figure 6.6 Rank and distribution of the percentage of a HUB containing suitable timber lands, management scale, San Juan National Forest

HUBs were also analyzed to determine the percentage of suitable timber within each watershed. 73% (112 of 153) of 6th level HUBs include "suitable" timber acres and are found primarily in the western and eastern thirds of the Forest (Figure 6.6). 23 HUBs are within the 100-80 percentile range. Of the 23 HUBs seven of them have over 50% of the HUB in "suitable" timber lands (Table 6.6).

Upper Lost Canyon (HUB 140300020401), Beaver Creek-Trail Canyon (HUB 140300020305), and Upper Beaver Creek (HUB 140801011601) have the three highest percentages of suitable timber lands. Their percentages are 74.4%, 67.2%, and 65.1% respectively.

Table 6.6 Summary of the percentage of suitable timber lands, by HUB, management scale, San Juan National Forest; Watersheds highlighted in light green are located entirely within the Forest boundary

HUB6	HUB Name	Percent of HUB in Suitable 6.16.1Timber Land
140300020401	Upper Lost Canyon	74.4
140300020305	Beaver Creek-Trail Canyon	67.2
140801011601	Upper Beaver Creek	65.1
140300020208	Stoner Creek	58.3
140300020407	House Creek	56.7
140300020402	Spruce Water Canyon	54.7
140300020205	Roaring Forks Creek	53.0
140300020403	Middle Lost Canyon	49.5
140801011502	Bear Creek	48.1
140300020102	Fish Creek	47.8
140801020302	Lower Devil Creek	45.6
140801070104	Chicken Creek	44.2
140801070102	West Mancos River	43.6
140801020301	Upper Devil Creek	43.2
140300020604	Dolores Canyon-Lake Canyon	40.9
140801020204	First Fork	38.1
140801010404	Middle Rio Blanco	36.2
140300020406	Upper Dolores River-Italian Creek	34.8
140801020501	Yellowjacket Creek	33.1
140801010302	Fourmile Creek	33.0
140300020105	Lower West Dolores River	31.7
140801020202	Lower Weminuche Creek	31.6
140300020209	Upper Dolores River-Taylor Creek	31.3

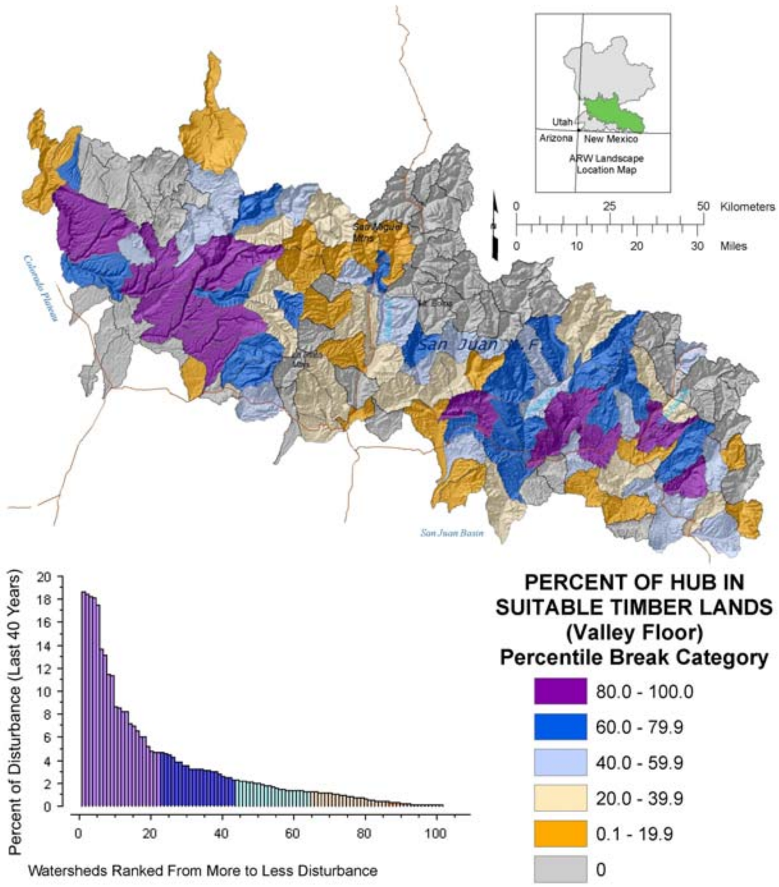

Figure 6.7 Rank and distribution of watersheds showing the percentage of suitable timber lands within valley floor areas, by HUB, management scale, San Juan National Forest

The percent of suitable timber lands, within valley floor areas, was calculated for each HUB on the Forest. This metric was calculated to provide a more focused review of future potential timber harvest effects on aquatic resources. 22 HUBs were found to be within the 100-80 percentile range, indicating that they had the highest amounts of suitable timber lands within valley floor areas. Figure 6.7 displays the rank and distribution of these watersheds for all percentile ranges. Table 6.7 summarizes these watersheds.

Beaver Creek-Trail Canyon (HUB 140300020305), Upper Lost Canyon (HUB 140300020401), Spruce Water Canyon (HUB 140300020402), and Middle Lost Canyon (HUB 140300020403) have the four highest percentages of suitable timber lands within their valley floor areas. Although Middle Lost Canyon is not entirely within the Forest'soundary the percentage of the valley floor area involved in suitable timber is probably a good estimate. 87% of the watershed is located within the Forest boundary.

Table 6.7 Summary of Percentage of Valley Floor Areas Containing Suitable Timber Lands, by HUB, management scale, San Juan National Forest. Watersheds highlighted in light green are located entirely within the Forest boundary.

HUB6	NAME	Percentage of HUBs Valley Floor in Suitable 6.16.1Timber Lands
140300020305	Beaver Creek-Trail Canyon	18.6
140300020401	Upper Lost Canyon	18.4
140300020402	Spruce Water Canyon	18.2
140300020403	Middle Lost Canyon	18.1
140300020407	House Creek	17.5
140300020406	Upper Dolores River-Italian Creek	13.6
140801070104	Chicken Creek	13.2
140300020604	Dolores Canyon-Lake Canyon	11.5
140300020404	Stapleton Valley	11.3
140801011601	Upper Beaver Creek	8.7
140801020301	Upper Devil Creek	8.5
140300020208	Stoner Creek	8.2
140300020306	McPhee Reservoir-Beaver Creek Inlet	8.2
140801020302	Lower Devil Creek	7.1
140300020304	Lower Plateau Creek	7.0
140300020602	Narraguinnep Canyon Natural Area	6.6
140801010404	Middle Rio Blanco	6.0
140801010304	Upper Pagosa Springs	6.0
140801011502	Bear Creek	5.2
140801020402	Upper Stollsteimer Creek	4.7
140801010306	Mill Creek	4.7
140300020105	Lower West Dolores River	4.7

Ultimately, management emphasis and land allocation within a watershed will be essential to the integrity and sustainability of aquatic ecosystems (McIntosh et al. 2000). Although all of the watersheds listed in Table 6.6 have a high potential for influencing aquatic, riparian, and wetland resources, effects can be prevented or reduced to acceptable levels through the application of Best Management Practices Handbook (FSH 2509.25 Watershed Conservation Practices Handbook). In addition, rstoration harvests within suitable lands may reduce the risk of stand replacement wildfire and the severe watershed effects associated with stand replacement fire in ponderosa pine and dry mixed conifer types.

6th Level HUB Information Needs

Streams within watersheds that have high amounts of timber harvest should be evaluated at the reach/site level to fully understand the influence that they have had on aquatic, riparian, and wetland resources. Some streams in these areas can be expected to have higher than average sediment loads and channel modifications due to accelerated runoff.

The following variables can be used to assess the conditions of streams that: a) have been influenced by past timber harvest (e.g., by comparing logged streams to similar unlogged streams); or b) may be in watersheds subjected to future logging (e.g., compare variables pre- and post-logging within a reach).

1. Timing and magnitude of high-flow events or debris torrents
2. V*
3. D50 particle size or other measures to determine changes in stream sediment composition (e.g., siltation)
4. Distribution, frequency, and volume of large woody debris (LWD)
5. Percent cover
6. Stream width and depth
7. Pool/Riffle ratio
8. Changes in pool frequency and volume
9. Annual temperature regime/solar radiation
10. Primary production (chlorophyll a standing stock)
11. Diversity of aquatic invertebrates sensitive to environmental stressors (e.g., Ephemeroptera-Plecoptera-Trichoptera or EPT)
12. Diversity and biomass of resident fishes
13. Comparative abundance and diversity of wetland fauna in clearcut versus unlogged watersheds

Management Implications at the 6th HUB Level

The discussion and recommendations presented below regarding management implications focus on those watersheds with the highest levels of timber harvest (a clearcut score of “5”), as they have the highest potential for related effects on aquatic, riparian, and wetland resources. However, Table 6.36 ummarizes the total clearcut scores for all watersheds on the Forest.

The information presented below is based on the Ecological Driver Analysis (Report 1 of 3) and the Synthesis (Report 3 of 3), in the 2006 San Juan Aquatic, Riparian, and Wetland Ecosystem Assessment. When planning a site specific land management activity or restoration project, these documents should be referred to for detailed information on the sensitivity of fisheries, riparian vegetation, aquatic productivity, and benthic macroinvertebrate responses changes in hydrology, sediment, thermal regime, nutrients, and biota.

17 watersheds have scored the maximum total of “5” for clearcuts, which is the timber harvest activity having the most potential for affecting the health of aquatic, riparian, and wetland resources. 11 of these watersheds are found within the Forest’s boundaries. An additional 11 watersheds scored a “4”, the second highest possible score, with nine of these watersheds located entirely on-Forest. All totaled there are 28 watersheds, or 18% of the watersheds on the Forest have a high to very likely potential for impacts to water quality. As discussed earlier in this chapter, alterations include yield, increased erosion and sedimentation, soil nutrients, and compaction are the most likely associated impacts with subsequent effects on aquatic, riparian, and wetland resources.

The 17 watersheds with a clearcut total score of “5” are summarized in Table 6.36 along with their associated riparian and wetland clusters. Riparian Clusters 8r and 5r were most commonly associated with these watersheds, with riparian Cluster 4r and 1r less common.

Wetland Clusters 1w and 6w were by far most commonly associated with the watersheds experiencing high levels of timber harvest. Wetland Clusters 4w and 7w were associated with these watersheds only several times.

Watersheds with Riparian Cluster 2r are likely less sensitive alterations in water yield as the hydrology is driven by a snowmelt flow regime while watersheds with Riparian Cluster 5r are rated as moderately sensitive to changes in flow as this cluster reflects a mixed precipitation regime. Cluster 2r is the more sensitive to influxes of sediment into riparian areas, however increased sediment loads is of concern to both Clusters 2r and 5r as low gradient channels are scarce. Fish and channel morphology are moderately sensitive to changes in sediment, while benthic macroinvertebrates are relatively insensitive. Cluster 2r is probably the most sensitive of the Clusters to changes in water temperature, which can be related to sediment load and alteration of flow regime (USDA Forest Service, 2006, Report 1 of 3).

Wetland Clusters 3w and 1w dominate those watersheds scoring a "5" for clearcutting. Cluster 3w is the most prevalent wetlands cluster found on the Forest, while Cluster 1w is the second most dominating cluster within the Forest. Both clusters are highly sensitive to changes in hydrology. Cluster 1w though is rated as moderately sensitive to increases in sediment regimes, while Cluster 3w is ranked as relatively insensitive (USDA Forest Service, 2006, Report 1 of 3).

The majority of the recommendations below are based upon information in Reports 1of 3 and 3of 3 from this aquatic assessment.

- Six watersheds which scored a five for clearcutting also scored a "5" for at least one other vegetation management activity, further elevating the potential modifications of hydrology, erosion, and sedimentation.
- The majority of watersheds containing riparian Cluster 2r are located on-Forest. As a result, restoration and management strategies implemented for this cluster may be particularly effective in mitigating impacts and restoring riparian health and function.
- Mitigation and restoration of riparian areas within Cluster 2r may be especially efficient and effective in improving aquatic and riparian health as riparian vegetation is especially important in this cluster. In riparian Cluster 5r restoring canopy covers should moderate fluctuations in thermal regime.
- Mitigation efforts are recommended for watersheds containing Cluster 5r where anthropogenic activity levels are high to moderate.
- 14 out of 17 watersheds score a "5" for clearcutting contain Wetlands Clusters 1w and 3w. Four watersheds scored a "5" in at least two anthropogenic activities. These watersheds present both mitigation and restoration opportunities for improving biologic and habitat diversity as they are influenced by calcareous geology, which promotes productivity.

Direction for Reach/Site Scale Analysis

Aquatic, riparian, and wetland values include changes in water quality, stream channel maintenance and sediment input. Additional values include the requirements and sensitivity of terrestrial, riparian, and aquatic vegetation, and the potential for direct and indirect effects on aquatic biota. In order to effectively determine the influence of timber harvest practices in the San Juan National Forest, and that project level analyses are in accordance with Federal Land Policy and Management Act (FLPMA) directives concerning species viability and ecological sustainability, these values and legal requirements should be evaluated at the reach/site level.

When these evaluations are being conducted at the reach/site level the legacy of past timber harvest activities must be fully considered, as they influence the existing structure and function of aquatic, riparian, and wetland systems. By doing so cumulative effects from past harvest is considered conjunction with current and future proposed actions and future resource needs (Beschta et al. 1995; McIntosh et al. 2000)

Specific questions related to resource values include, but are not limited to:

1. Are effects of past timber harvest still influencing resources due to:
    a. Altered hydrology (e.g., frequency, distribution, timing, and magnitude of high flow events)?
    b. Changes in water quality (e.g., suspended fine particles, nutrient input, and temperature regime)?
    c. Increased sediment yield (e.g., deposition of fines, mass wasting)?
    d. Channel alteration (e.g., degrading stream banks)?
    e. Degradation of riparian habitat (e.g., direct removal of vegetation, skidding, yarding)?
    f. Stream habitat simplification (e.g., loss of woody debris or overhead cover)?
2. Will future timber harvest cause similar changes listed above in number 1 (a-f) above?
3. Will future timber harvest occur in watersheds containing particularly significant plant or animal populations, such as sensitive Yellowstone cutthroat trout?
4. What is the Cumulative Vegetation Management Total score for the watershed which is being studied or contains the area of a proposed action?
5. What other anthropogenic activity categories have received a rank of "5" or "4" for these same watersheds which are being studied or contain the area of a proposed action? With this combined information, what are the cumulative effects on aquatic, riparian, and wetland resources?

Influences of Fire

The affects of fire on aquatic, riparian and wetland resources is most likely a product of several factors: habitat context (such as low or high elevation forest), climate, and human activity, such as fire suppression and land management activities (USDA Forest Service, 2004). These elements come into play and influence the location, extent and intensity of fires. Another key factor is fire severity. As it increases, the potential for impacts to aquatic, riparian, and wetlands resources also increases.

When considering the impacts of fire on aquatic, riparian and wetland ecosystems, several key components of these systems may be affected, depending upon fire severity. These are: hydrology, sediment regimes and channel morphology and substrate composition, water quality, and the riparian zone. The riparian zone plays a role in influencing water quality, and supplying large woody debris, as well as providing organic matter for food and aquatic and fisheries habitat.

If riparian vegetation is burned extensively enough during a fire increased exposure to the sun can produce elevated stream temperatures, which may exceed state water quality criteria and standards. Large woody debris, both in-stream, and adjacent to the stream may be consumed, modifying habitat and eliminating future supplies of woody debris.

Heating from the fire, if hot enough, may kill important bacteria and vegetation roots, that are needed to maintain soil productivity and help ensure slope stability. Some soils develop a "hydrophobic" nature or become water-repellent after a fire, which exacerbates soil erosion and landslides. Increased erosion of slopes and stream banks can result in dramatic shifts in stream sediment load, altering channel morphology, degrading fisheries and other aquatic habitats. The lack of vegetation and other surface materials may also contribute to increased surface runoff, altering the stream discharge and the frequency and magnitude of high-flow events.

A total of 3,314 fires have been recorded in the San Juan National Forest since 1960, when recording fire data began. Figure 6.8 shows that fires have occurred across the Forest, with most of the fire activity concentrated in the Durango to Vallecito Reservoir area. Since 1990 there has been a dramatic increase in the total fire area burned by decade. This is primarily due to one fire, the large Missionary Ridge fire of 2002. The total fire area burned by year shows a similar jump in fire activity (Figure 6.9 and Figure 6.10).

For this analysis fires were assigned to one of two categories: smaller than 10 acres or greater than 10 acres. Since fire recording activity began fires smaller than 10 acres have dominated fire activity on the Forest. Since 1960 there have been relatively few fires over 10 acres in size. However between 1994 and 2003 the numbers of fires per year that are over 10 acres in size has increased. Although 1998 had the most fires over 10 acres in size, the total acres burned is small compared to the number of fires over 10 acres compared to 2002 and 2003 (Table 6.8).

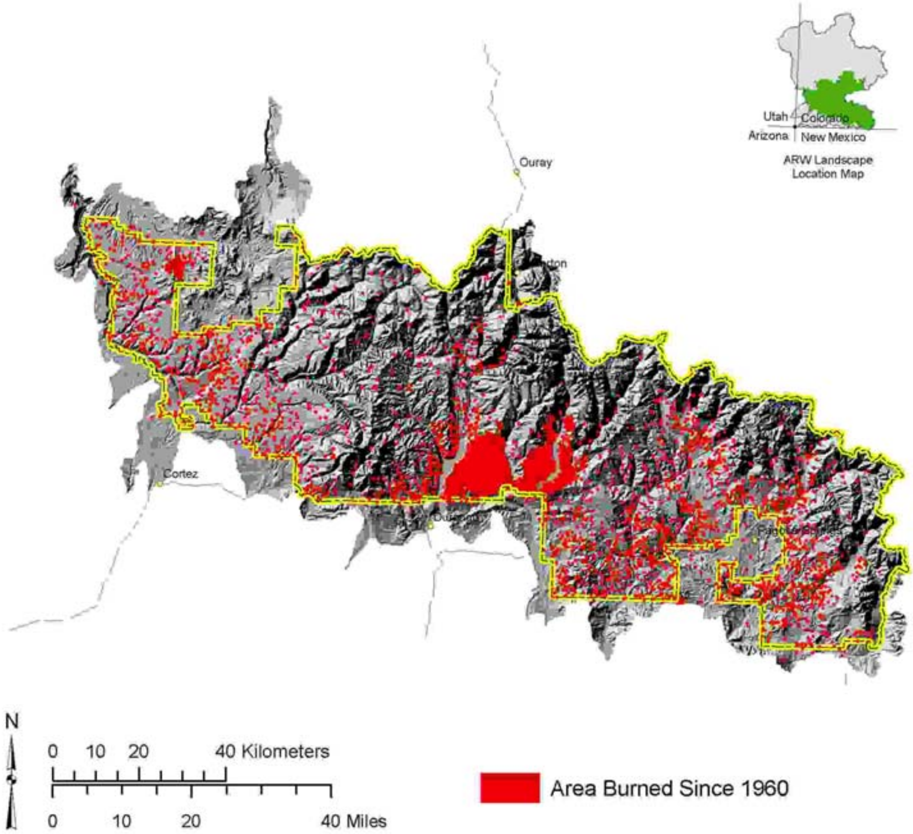

Figure 6.8 Total fire area burned since 1960

Figure 6.9 Total Fire Areas by Decade, in Acres, for the San Juan National Forest Since 1960

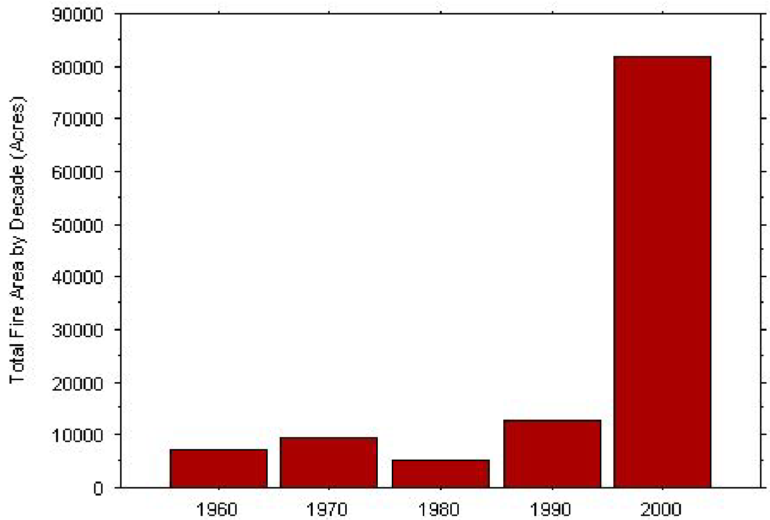

Figure 6.10 Total Fire Area by Year, in Acres, for the San Juan National Forest Since 1960

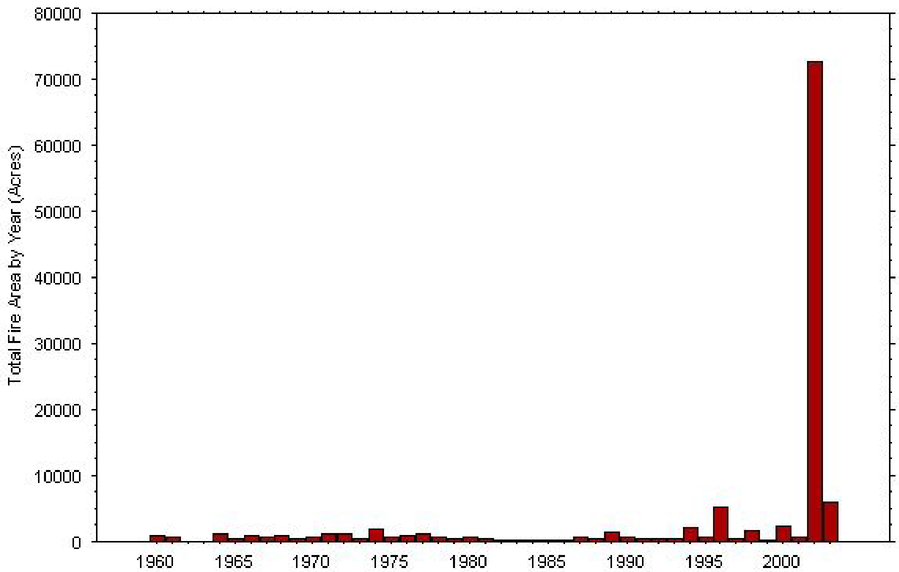
Total Fire Area by Year (Acres)
80000
70000
60000
50000
40000
30000
20000
10000
0
1960
1965
1970
1975
1980
1985
1990
1995
2000

Table 6.8 Summary of Fire Activity by Year & Acreage on the San Juan since 1960

Fire Year	Number of Fires < 10 Acres	Area of Fires < 10 Acres (Acres)	Number of Fires > 10 Acres	Area of Fire > 10 Acres (Acres)	Total # of Fires	Total Area of Fires (Acres)
1960	87.0	870.0	0.0	0.0	87.0	870.0
1961	129.0	1290.0	0.0	0.0	129.0	1290.0
1964	119.0	1190.0	0.0	0.0	119.0	1190.0
1965	54.0	540.0	0.0	0.0	54.0	540.0
1966	101.0	1010.0	0.0	0.0	101.0	1010.0
1967	61.0	610.0	0.0	0.0	61.0	610.0
1968	67.0	670.0	1.0	317.8	68.0	987.8
1969	57.0	570.0	0.0	0.0	57.0	570.0
1970	62.0	620.0	0.0	0.0	62.0	620.0
1971	125.0	1250.0	0.0	0.0	125.0	1250.0
1972	112.0	1120.0	0.0	0.0	112.0	1120.0
1973	48.0	480.0	0.0	0.0	48.0	480.0
1974	156.0	1560.0	1.0	309.6	157.0	1869.6
1975	70.0	700.0	0.0	0.0	70.0	700.0
1976	88.0	880.0	0.0	0.0	88.0	880.0
1977	129.0	1290.0	0.0	0.0	129.0	1290.0
1978	78.0	780.0	0.0	0.0	78.0	780.0
1979	54.0	540.0	0.0	0.0	54.0	540.0
1980	58.0	580.0	1.0	114.7	59.0	694.7
1981	56.0	560.0	0.0	0.0	56.0	560.0
1982	33.0	330.0	0.0	0.0	33.0	330.0
1983	28.0	280.0	0.0	0.0	28.0	280.0
1984	28.0	280.0	0.0	0.0	28.0	280.0
1985	35.0	350.0	0.0	0.0	35.0	350.0
1986	23.0	230.0	0.0	0.0	23.0	230.0
1987	41.0	410.0	1.0	294.4	42.0	704.4
1988	54.0	540.0	0.0	0.0	54.0	540.0
1989	140.0	1400.0	0.0	0.0	140.0	1400.0
1990	60.0	600.0	0.0	0.0	60.0	600.0
1991	45.0	450.0	0.0	0.0	45.0	450.0
1992	47.0	470.0	0.0	0.0	47.0	470.0
1993	40.0	400.0	0.0	0.0	40.0	400.0
1994	142.0	1420.0	2.0	812.1	144.0	2232.1
1995	51.0	510.0	1.0	193.7	52.0	703.7
1996	142.0	1420.0	1.0	3825.1	143.0	5245.1
1997	48.0	480.0	0.0	0.0	48.0	480.0
1998	63.0	630.0	11.0	1130.2	74.0	1760.2
1999	30.0	300.0	0.0	0.0	30.0	300.0
2000	161.0	1610.0	1.0	796.2	162.0	2406.2
2001	71.0	710.0	1.0	115.9	72.0	825.9
2002	117.0	1170.0	3.0	71430.4	120.0	72600.4
2003	177.0	1770.0	3.0	4234.8	180.0	6004.8
Totals	**3287.0**	**32870.0**	**27.0**	**83574.8**	**3314.0**	**116444.8**

To begin focusing in on which watersheds have been affected most by fire, the first metric analyzed evaluated the number of acres burned by HUB, since 1976. 24 of the Forest's 154 HUBs have no fire activity in the last 30 years (Table 6.9). The remaining 130 HUBs had various amounts of activity, ranging from a total of 10 acres burned to 14,829 acres. Those watersheds that were found to be within the 80-100 percentile range for the number of acres burned since 1976 are summarized in Figure 6.11 and Table 6.10. Fire activity by HUB, earlier than 1976, was not evaluated as cumulative effects analysis procedures on the San Juan National Forest assume a 30 year hydrologic recovery curve for cumulative effects.

A total of 16 watersheds were found to be in the 100-80 percentile range for total acres burned in the last 30 years. Fire activity associated with this 30 year summary is found to be concentrated in the eastern half of the Forest from Durango east to Pagosa Springs; and also in the far-western portion of the Forest northwest of Cortez, around the Dolores Canyon area, and in the Pine Creek area.

Eight of the 16 watersheds that were found to be within the 100-80 percentile range are located entirely on-Forest. These watersheds, which are found primarily along the southern border of the Forest from Durango east to the Vallecito Reservoir, have the potential for both on and off-Forest effects. The other eight watersheds have variable potential for impacting aquatic, riparian, and wetland resources, both on and off-Forest.

All but the Upper Animas Valley-Stevens Creek (HUB # 140801040503), Upper Florida River-Red Creek (HUB #140801040804), and Middle Los Pinos River-Red Creek (HUB# 140801011501) watersheds had less than 10, 000 acres burned in the last 30 years. The large number of burned acres for the Upper Florida River-Red Creek, and Middle Los Pinos River-Red Creek watersheds were due to the 2002 Missionary Ridge fire. In the Upper Animas Valley-Stevens Creek watershed the Missionary Ridge fire burned the majority of acres in this watershed, but 400 acres were burned in 1994 in the Mitchell Lakes fire (Table 6.11).

The amount of total acres burned does not translate to having the highest percentage of the watershed burned since 1976 (Figure 6.12 and Table 6.12). Although the Middle Los Pinos River-Red Creek watershed had third highest acreage total burned it had the highest percentage of watershed acres burned since 1976. The Upper Animas Valley-Stevens Creek which had the highest total number of acres burned since 1976 had the third highest percentage of it its watershed affected by fire. For the other watersheds there is not a persistent and direct correlation between the total number of acres burned and the percentage of the watershed burned since 1976. This is due to the number of acres burned relative to the total number of watershed acres.

Table 6.9 Watersheds with No Fires Since 1976, 6th level HUC's, management scale, San Juan National Forest; Watersheds highlighted in light green are located entirely within the Forest's boundary

Watershed #	Watershed Name	Total Number of Acres Burned Since 1976
140300020201	Dolores River Headwaters-Tin Can Basin	0
140300020203	Rico Valley	0
140300020204	Upper Dolores River-Scotch Creek	0
140300020302	Upper Plateau Creek	0
140300020405	Lower Lost Canyon	0
140300020501	Bear Creek-Disappointment Creek	0
140300020503	Sheep Camp Valley	0
140300020510	Upper Disappointment Valley	0
140300020605	Dolores Canyon-Joe Davis Hill	0
140300036101	Naturita Creek	0
140801010101	Headwaters East Fork San Juan River	0
140801010202	Beaver Creek	0
140801010502	West Fork Navajo River	0
140801010506	Little Navajo River	0
140801011303	Lake Creek	0
140801011304	Three Sisters	0
140801011401	Upper Vallecito Creek	0
140801040101	Animas River above Howardsville	0
140801040102	Cement Creek	0
140801040201	Elk Creek	0
140801040404	Middle Hermosa Creek	0
140801040801	Florida River Headwaters	0
140802020103	Hartman Canyon	0
140802020201	Upper Yellowjacket Canyon	0

The probability, extent, and intensity of future fires in the San Juan National Forest will be a function of elevation, climatic conditions and the history of fire suppression and management. Due to historic fire suppression high intensity fuels have increased. In the San Juan National Forest, fire frequency has likely been reduced by fire suppression, so more intense stand-replacing fires should be more frequent that under historical conditions. Future effects of fire on aquatic, riparian and wetland resources will depend on the location, extent, and intensity of the fires.

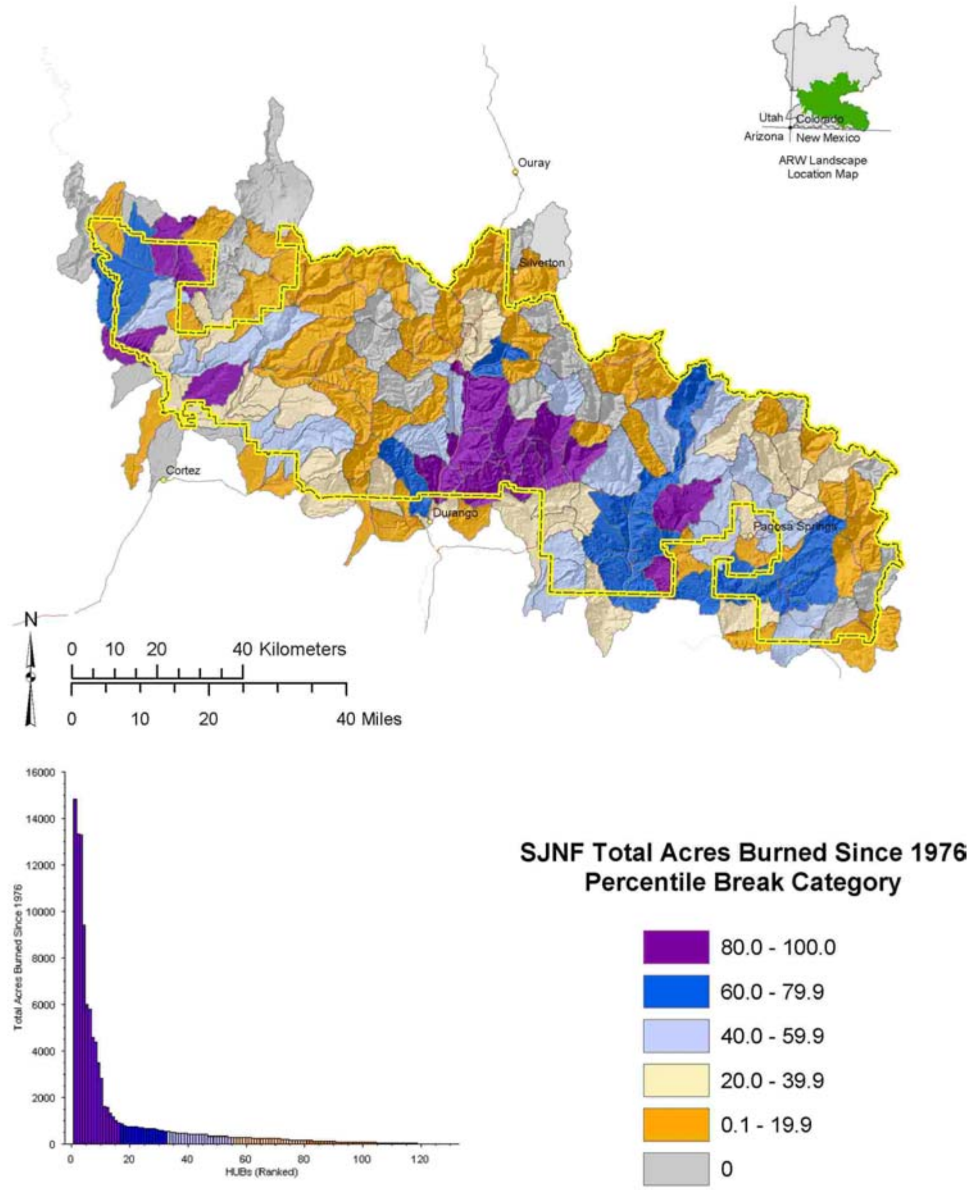

Figure 6.11 Summaries of Total Acres Burned Since 1976 by HUB, 100-80 Percentile Range, San Juan National Forest

Table 6.10 Summary of Total Acres Burned Since 1976 by HUB, 100-80 Percentile Range, San Juan National Forest, Watersheds located entirely on-Forest highlighted in light green

6th Level HUB	6th Level HUB Name	Total Acres Burned Since 1976
140801040503	Upper Animas Valley-Stevens Creek	14829
140801040804	Upper Florida River-Red Creek	13352
140801011501	Middle Los Pinos River-Red Creek	13289
140801011404	Vallecito Reservoir	9410
140801040504	Upper Animas Valley-Trimble	5985
140801011403	Lower Vallecito Creek	5784
140801011306	East Creek	4573
140801040802	Upper Florida River-Transfer Park	4373
140801040803	Lemon Reservoir	3511
140300020504	Ryman Creek	2852
140801020404	Middle Stollsteimer Creek	1631
140300020407	House Creek	1584
140300020506	Brumley Valley	1313
140801040501	Upper Animas Valley-Canyon Creek	1180
140801020301	Upper Devil Creek	985
140300020603	Dolores Canyon-Cabin Creek	924

Table 6.11 (Summary of Watersheds with the Highest Total Acres Burned Since 1976, and Associated Fires 80-100 Percentile Range), San Juan National Forest

Watershed Name	Missionary Ridge Fire 2002	Mitchell Lakes Fire 1994
Upper Animas Valley-Stevens Creek	13438.5	400.7
Upper Florida River-Red Creek	12871.8	
Middle Los Pinos River-Red Creek	13048.8	
Grand Total	39359.1	400.7

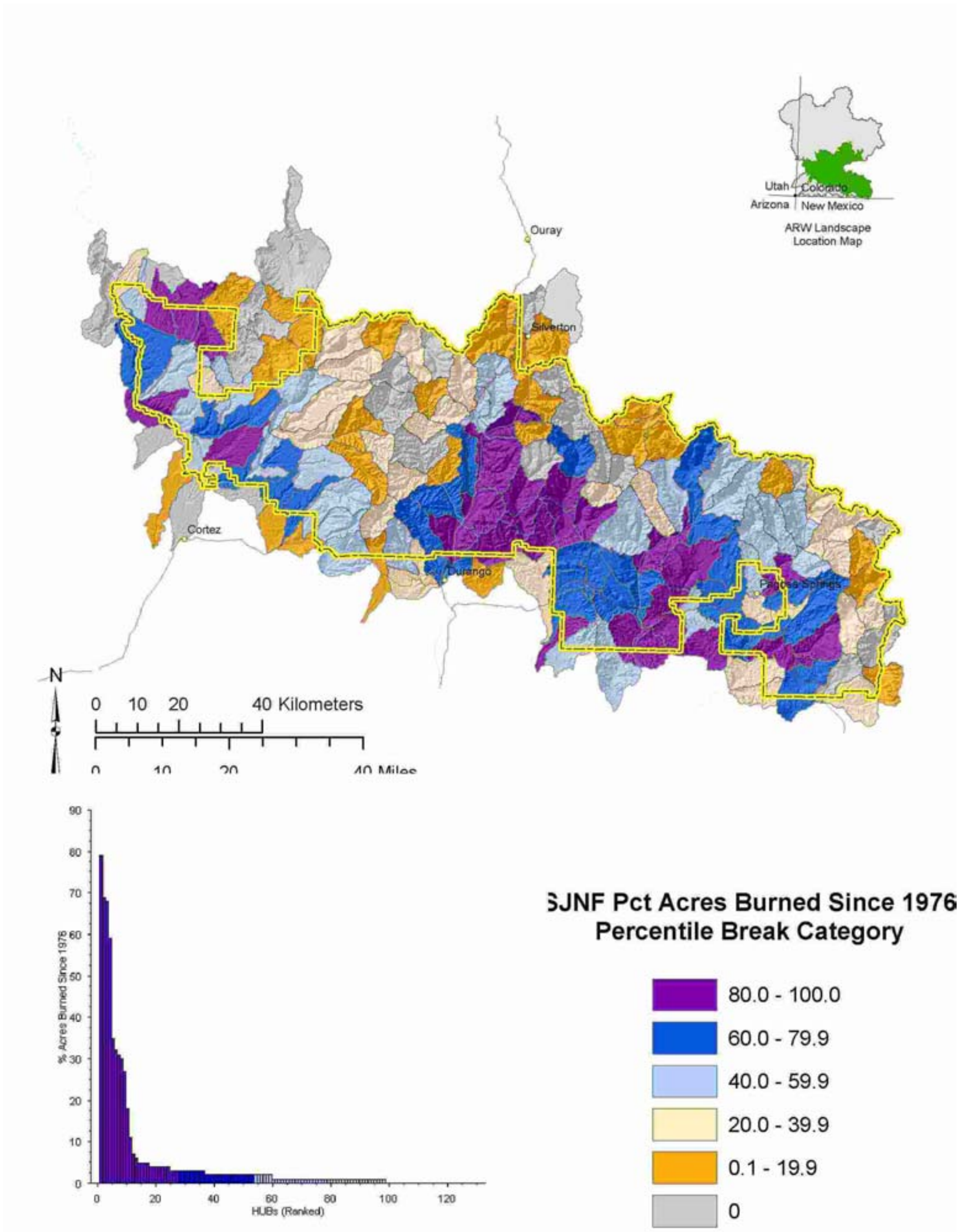

Figure 6.12 Summaries of the Percent Acres Burned Since 1976, by HUB, San Juan National Forest

Table 6.12 Summary of the Percent Acres Burned Since 1976, by HUB, San Juan National Forest, watersheds located entirely on-Forest highlighted in light green

6th Level HUB	6th Level HUB Name	% Acres Burned Since 1976
140801011501	Middle Los Pinos River-Red Creek	79
140801011404	Vallecito Reservoir	69
140801040503	Upper Animas Valley-Stevens Creek	68
140801040804	Upper Florida River-Red Creek	59
140801040803	Lemon Reservoir	35
140801011403	Lower Vallecito Creek	32
140801040504	Upper Animas Valley-Trimble	31
140801011306	East Creek	30
140801040802	Upper Florida River-Transfer Park	27
140300020504	Ryman Creek	18
140801020404	Middle Stollsteimer Creek	11
140300020407	House Creek	7
140300020506	Brumley Valley	6
140801020405	Lower Stollsteimer Creek	5
140801040204	Animas River-Needleton	5
140801011703	Ute Creek	5
140801020302	Lower Devil Creek	5
140801020502	Piedra River-Stollsteimer	4
140300020603	Dolores Canyon-Cabin Creek	4
140801010406	Lower Rio Blanco-San Juan River	4
140801010404	Middle Rio Blanco	4
140300020507	Dawson Draw	4
140801040501	Upper Animas Valley-Canyon Creek	4
140801020205	Upper Piedra River-Box Canyon	4
140801010604	Upper Cat Creek	3
140801010304	Upper Pagosa Springs	3
140801020301	Upper Devil Creek	3

All the watersheds found in Tables 6.10 and 6.11 have the highest potential for the indirect effects associated with fire (e.g., debris flows, sedimentation, etc.) to impact aquatic, riparian and wetland resources. However since the Middle Los Pinos River-Red Creek Vallecito Reservoir, Upper Animas Valley-Stevens Creek, and Upper Florida River-Red Creek watersheds have between 79% to 59% of their area burned, these drainages are at even higher risk.

Since the Forest assumes a 30 year recovery curve for cumulative effects, watersheds more recently burned may have a higher potential for exhibiting any impacts on aquatic, riparian and wetland resources. As a result, the next metric analyzed which watersheds had the highest number of acres burned since 1991 and which watersheds had the highest percentage of their area burned since 1991. 1991-2006 represents the first fifteen years of a 30 year cumulative effects recovery curve.

As such, this metric would display which watersheds have most recently experienced fire activity, and which may have the highest potential for fire-related impacts.

The results of these two metrics are displayed below in Tables 6.13 and 6.14 and in Figures 6.13 and 6.14.

Table 6.13 San Juan National Forest total Acres Burned Since 1991; Watersheds located entirely on-Forest highlighted in light green

6th Level HUB	6th Level HUB Name	Total Acres Burned Since 1991
140801040503	Upper Animas Valley-Stevens Creek	14829
140801040804	Upper Florida River-Red Creek	13352
140801011501	Middle Los Pinos River-Red Creek	13289
140801011404	Vallecito Reservoir	9410
140801040504	Upper Animas Valley-Trimble	5985
140801011403	Lower Vallecito Creek	5784
140801011306	East Creek	4573
140801040802	Upper Florida River-Transfer Park	4203
140801040803	Lemon Reservoir	3511
140300020504	Ryman Creek	2682
140801020404	Middle Stollsteimer Creek	1631
140300020407	House Creek	1584
140300020506	Brumley Valley	1313
140801040501	Upper Animas Valley-Canyon Creek	1180
140801020301	Upper Devil Creek	985
140300020604	Dolores Canyon-Lake Canyon	868

Table 6.14 San Juan Percent Acres Burned by Watershed Since 1991, Watersheds located entirely on-Forest highlighted in light green

6th Level HUB	6th Level HUB Name	% Acres Burned Since 1991
140801011501	Middle Los Pinos River-Red Creek	79
140801011404	Vallecito Reservoir	69
140801040503	Upper Animas Valley-Stevens Creek	68
140801040804	Upper Florida River-Red Creek	59
140801040803	Lemon Reservoir	35
140801011403	Lower Vallecito Creek	32
140801040504	Upper Animas Valley-Trimble	31
140801011306	East Creek	30
140801040802	Upper Florida River-Transfer Park	26
140300020504	Ryman Creek	17
140801020404	Middle Stollsteimer Creek	11
140300020407	House Creek	7
140300020506	Brumley Valley	6
140801020405	Lower Stollsteimer Creek	5
140801011703	Ute Creek	5
140801020302	Lower Devil Creek	5
140801020502	Piedra River-Stollsteimer	4
140801010406	Lower Rio Blanco-San Juan River	4
140801010404	Middle Rio Blanco	4
140300020507	Dawson Draw	4
140801040501	Upper Animas Valley-Canyon Creek	4
140801020205	Upper Piedra River-Box Canyon	4

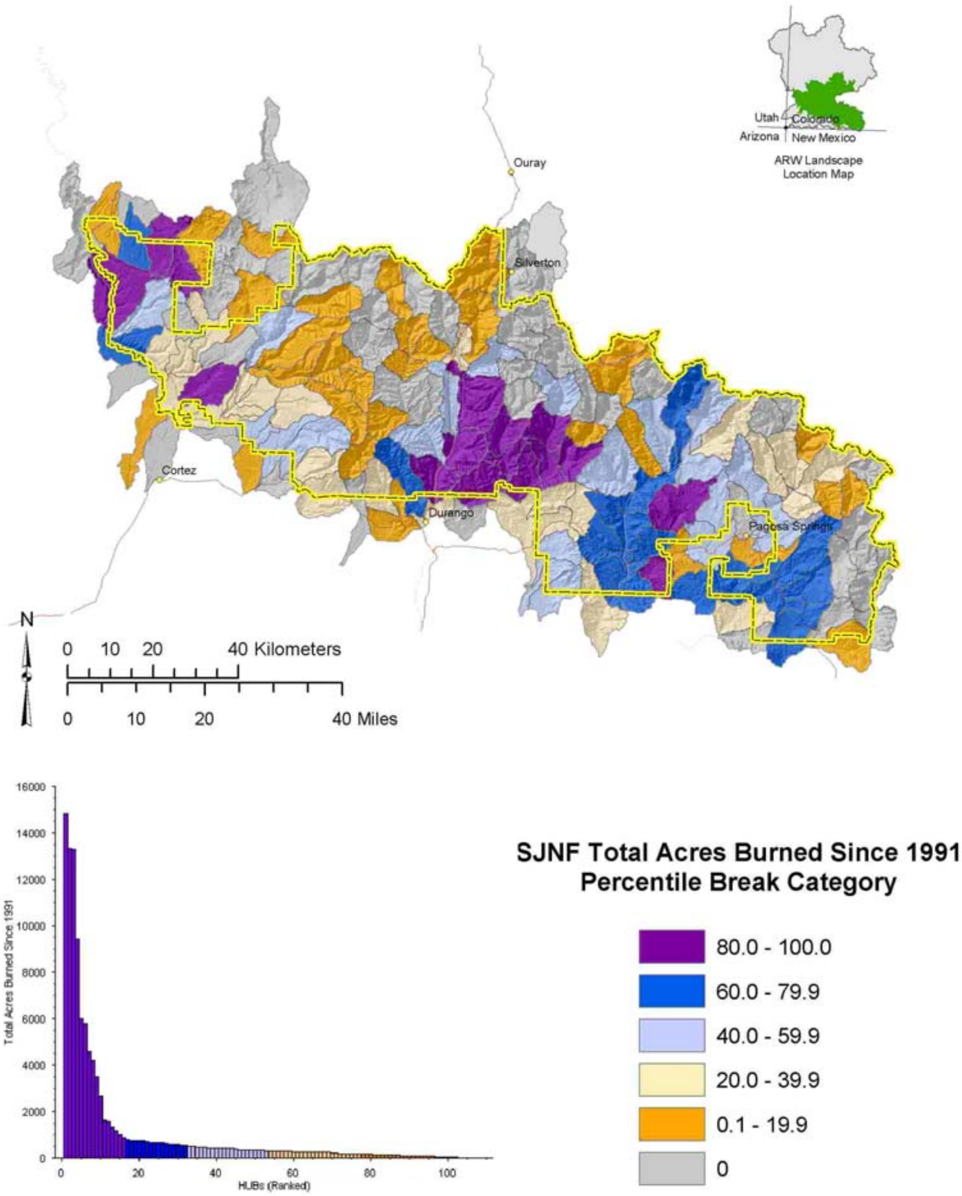

Figure 6.13 San Juan National Forest total Acres Burned Since 1991, management scale, San Juan National Forest

As with the previous two metrics, the Upper Animas Valley-Stevens Creek (HUB # 140801040503), Upper Florida River-Red Creek (HUB #140801040804), and Middle Los Pinos River-Red Creek (HUB# 140801011501) watersheds had the three highest totals for total acres burned since 1991, due to the dominating influence of the 2002 Missionary Ridge fire (Tables 6.11 and 6.14). As before, the total number of acres burned since 1991 does not directly correlate with the highest percentages of a watersheds area that has been burned (Tables 6.13 and 6.14). Although this lack of correlation may be due to the number of acres burned compared to each watersheds individual size, it is probably more related to the uncharacteristically large size of the Missionary Ridge Fire.

The first four metrics focused analysis on the overall watershed picture. The next four metrics focus on the potential for fire related impacts to the valley floor. The valley floor has been defined as a stable environment containing dynamic components such as perennial and intermittent streams, primary and secondary stream channels, and active terraces and floodplains (Bighorn ARWEA, 2004). It is also where riparian and wetland areas dominate a watershed. As a result, it is important to evaluate the degree to which fire has played a role in influencing these areas. It should be noted that GIS data for wetlands was not available for this analysis.

The results of the analysis for these four metrics are summarized in Tables 6.15 and 6.16, and Figures 6.15 and 6.16.

The Upper Animas Valley-Steven Creek (HUB# 140801040503), House Creek (HUB# 1402300020407), and Animas River-Needleton (HUB# 14080101040204) have the three highest total number of valley floor acres burned since 1976. Although the Animas River-Needleton watershed has had 280 fewer valley floor acres burned than the Upper Animas Valley-Steven Creek watershed, the 670 acres burned in the Animas River-Needleton watershed translates to a whopping 96.5% of the valley floor. The Animas River-Needleton is located well within the Forest's boundary, confining effects to Forest Service land. The Upper Animas Valley-Steven Creek watershed has had 53.4% of its valley floor acres burned since 1976 while House Creek has had only 12% of its valley floor acres burned. Both of these watersheds have the potential for both on and off-Forest effects, although House Creek has the most potential for impacting aquatic resources off-Forest.

The potential for House Creek to have off- effects is likely mitigated by the fact that only 9.7% of the valley floor acres have burned since 1991. The potential for on-Forest effects, both in the watershed, and downstream, of the Upper Valley-Stevens Creek and Animas River-Needleton watersheds is further indicated by the fact that 29.8 and 56.1%, respectively of these valley floor acres have been burned since 1991 (Tables 6.17 and 6.18).

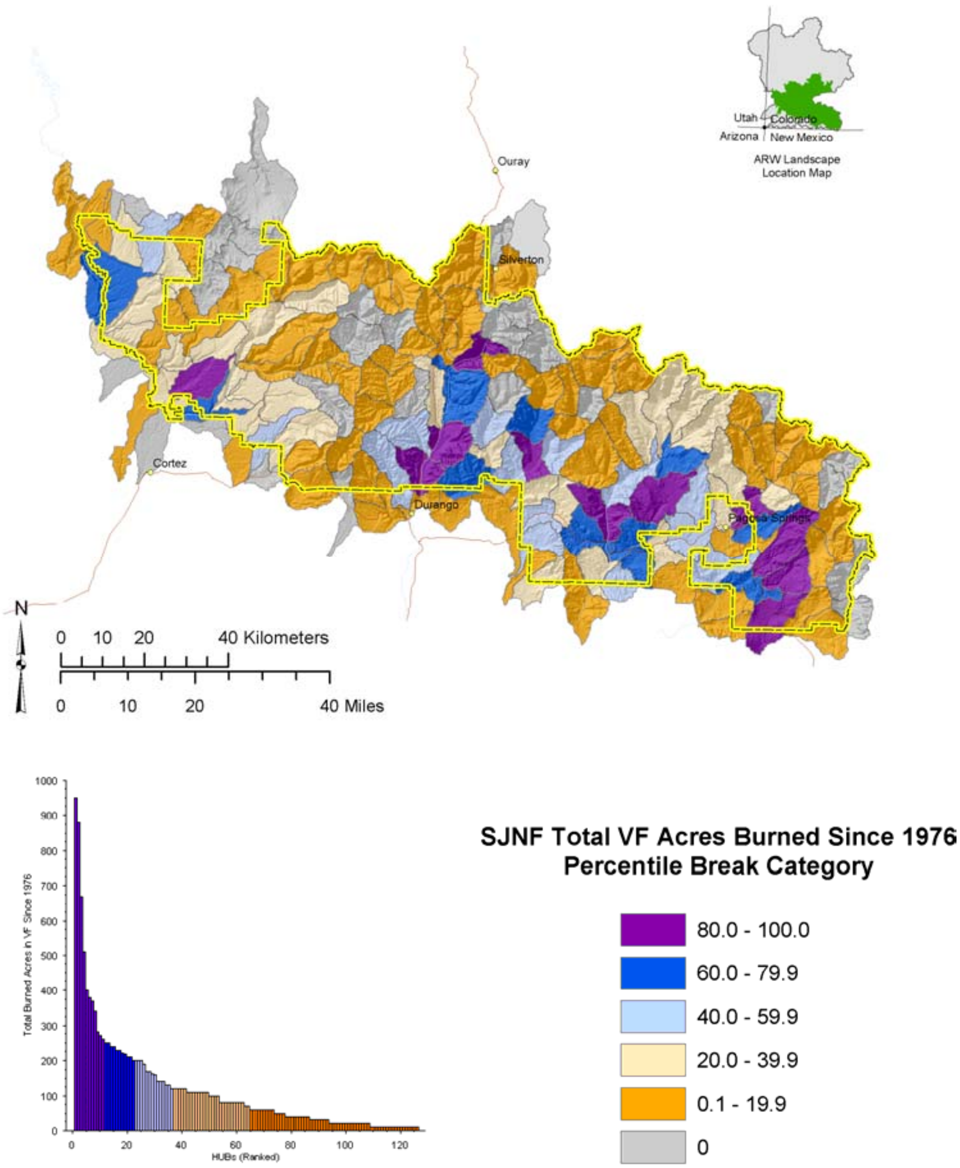

Figure 6.14 Total Valley Floor Acres Burned Since 1976, management scale, San Juan National Forest

Table 6.15 Total Valley Floor Acres Burned Since 1976, Watersheds located entirely on-Forest highlighted in light green

6th Level HUB	6th Level HUB Name	Total Burned Acres in VF Since 1976*
140801040503	Upper Animas Valley-Stevens Creek	950
140300020407	House Creek	880
140801040204	Animas River-Needleton	670
140801011404	Vallecito Reservoir	510
140801020301	Upper Devil Creek	400
140801040504	Upper Animas Valley-Trimble	380
140801020206	Upper Piedra River-Indian Creek	370
140801010507	Coyote Creek	340
140801010405	Rito Blanco	280
140801010404	Middle Rio Blanco	270
140801010304	Upper Pagosa Springs	260

* Rounded to nearest whole acre.

Figure 6.16 Percent Valley Floor Burned Since 1976, San Juan National Forest, Watersheds located entirely on-Forest highlighted in light green

6th Level HUB	6th Level HUB Name	% VF Burned Since 1976
140801040204	Animas River-Needleton	96.5
140801040503	Upper Animas Valley-Stevens Creek	53.4
140801011404	Vallecito Reservoir	18.9
140801040504	Upper Animas Valley-Trimble	17.2
140801020205	Upper Piedra River-Box Canyon	16.6
140801020206	Upper Piedra River-Indian Creek	15.1
140801011306	East Creek	12.2
140300020407	House Creek	12.1
140801040804	Upper Florida River-Red Creek	11.4
140801040407	Lower Hermosa Creek	11.2
140801040601	Junction Creek	10.6
140801011403	Lower Vallecito Creek	10.6
140801010406	Lower Rio Blanco-San Juan River	9.9
140801010404	Middle Rio Blanco	9.5
140801011501	Middle Los Pinos River-Red Creek	9.0
140801010304	Upper Pagosa Springs	8.4
140801020302	Lower Devil Creek	7.8
140801020404	Middle Stollsteimer Creek	7.4
140801010103	Sand Creek	7.3
140801020405	Lower Stollsteimer Creek	7.2
140801050101	La Plata River headwaters	7.2
140801010306	Mill Creek	7.2
140801040501	Upper Animas Valley-Canyon Creek	7.1
140801010405	Rito Blanco	7.0
140801010303	Laughlin Park	6.9
140801020501	Yellowjacket Creek	6.7

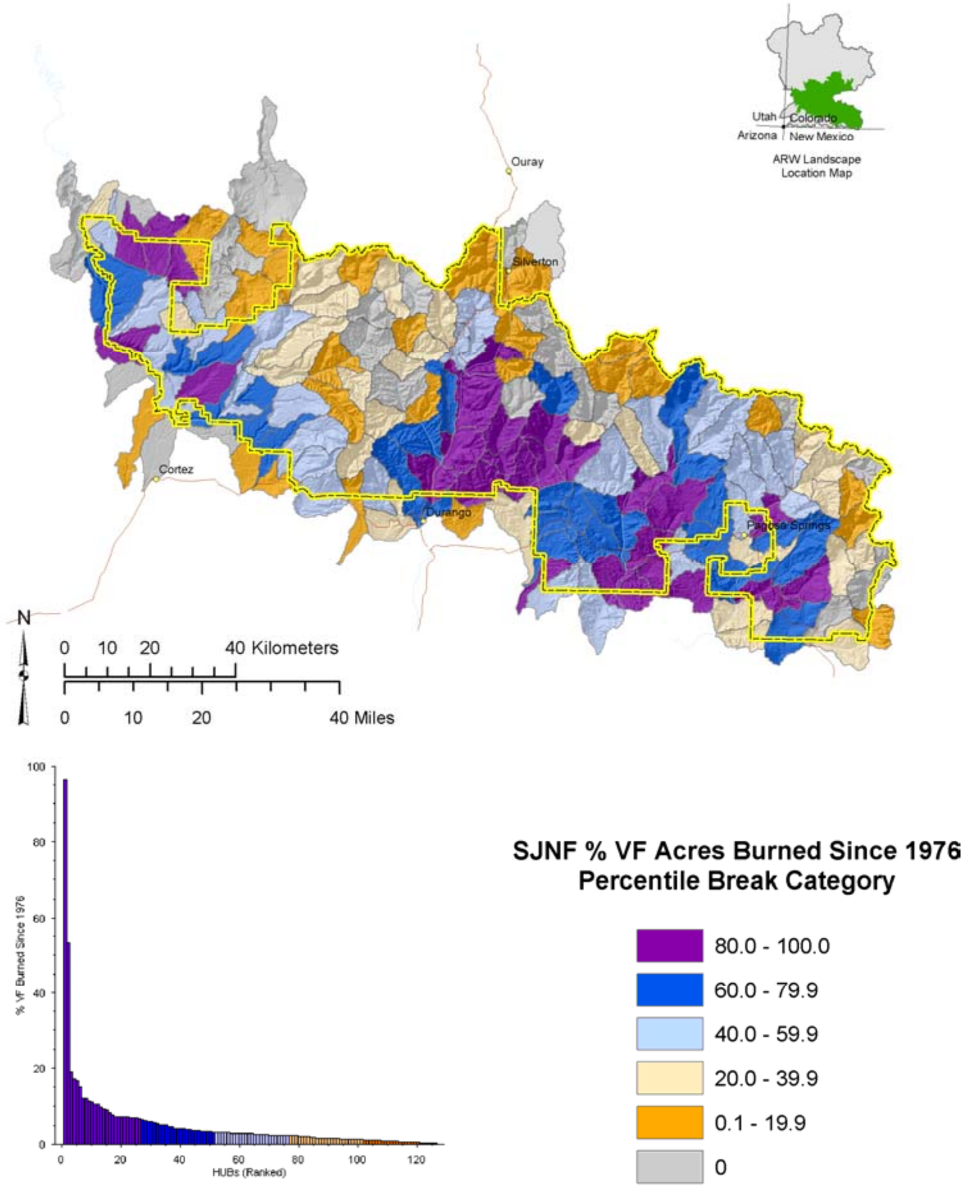

Figure 6.15 Rank and distribution of the percentage of valley floor acres burned since 1976, management scale, San Juan National Forest

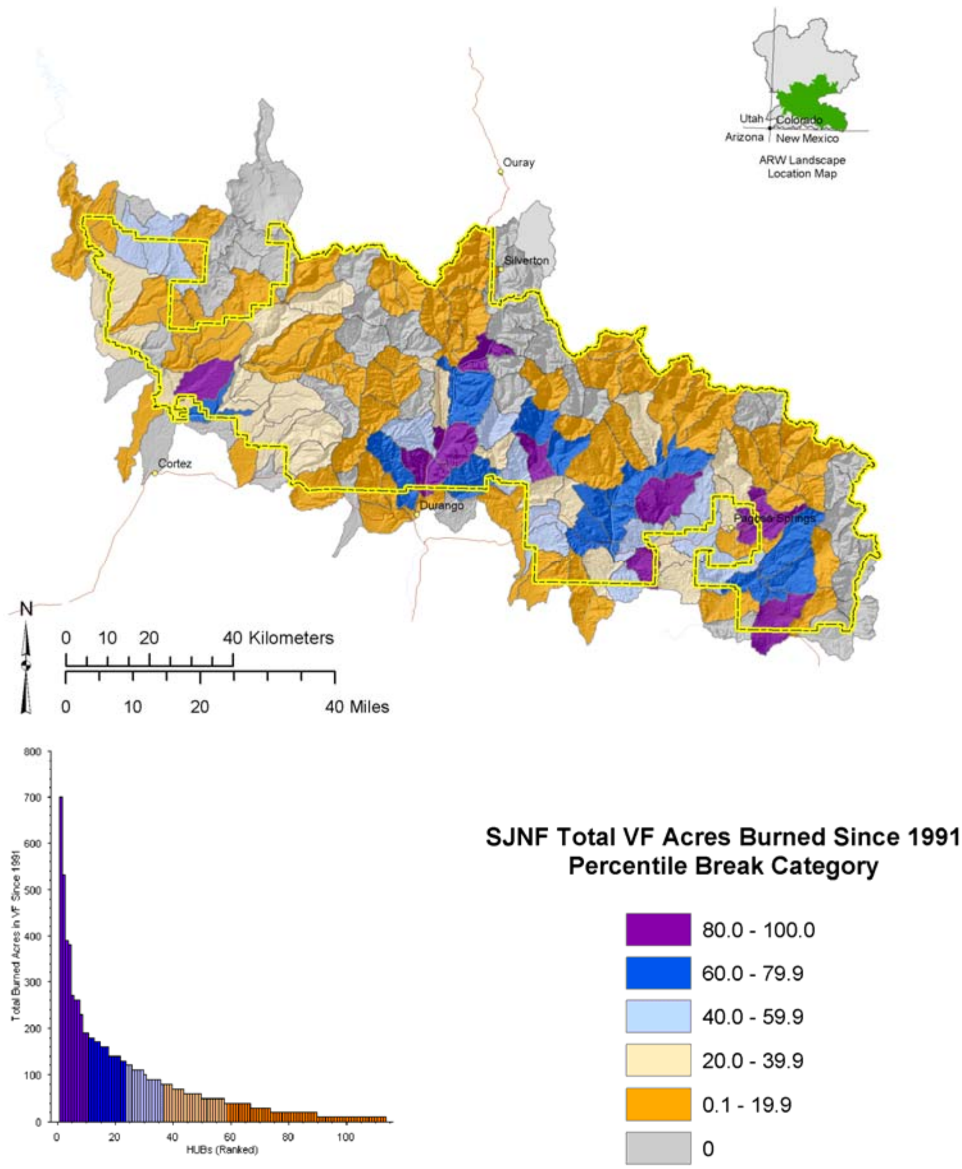

Figure 6.16 Rank and distribution of the percentage of valley floor acres burned since 1991, management scale, San Juan National Forest

Table 6.17 Total Burned Acres in the Valley Floor by 6th Level HUB Since 1991, San Juan National Forest, watersheds located entirely on-Forest highlighted in light green

6th Level HUB	6th Level HUB Name	Total Burned Acres in VF Since 1991
140300020407	House Creek	700.0
140801040503	Upper Animas Valley-Stevens Creek	530.2
140801040204	Animas River-Needleton	390.0
140801011404	Vallecito Reservoir	380.2
140801010507	Coyote Creek	270.0
140801040504	Upper Animas Valley-Trimble	260.1
140801020301	Upper Devil Creek	260.0
140801010304	Upper Pagosa Springs	230.0
140801020404	Middle Stollsteimer Creek	190.0
140801010306	Mill Creek	190.0

Table 6.18 Percentage of Burned Acres in the Valley Floor by 6th Level HUB Since 1991, San Juan National Forest, Watersheds located entirely on-Forest highlighted in light green

6th Level HUB	6th Level HUB Name	% VF Burned Since 1991
140801040204	Animas River-Needleton	56.1
140801040503	Upper Animas Valley-Stevens Creek	29.8
140801011404	Vallecito Reservoir	14.1
140801040504	Upper Animas Valley-Trimble	11.8
140801020205	Upper Piedra River-Box Canyon	11.6
140300020407	House Creek	9.7
140801011306	East Creek	9.3
140801011403	Lower Vallecito Creek	8.7
140801040601	Junction Creek	8.5
140801040804	Upper Florida River-Red Creek	7.9
140801010406	Lower Rio Blanco-San Juan River	7.6
140801010304	Upper Pagosa Springs	7.4
140801040407	Lower Hermosa Creek	7.2
140801020206	Upper Piedra River-Indian Creek	6.9
140801011501	Middle Los Pinos River-Red Creek	6.8
140801010306	Mill Creek	5.7
140801020404	Middle Stollsteimer Creek	5.6
140801040802	Upper Florida River-Transfer Park	5.2
140801010507	Coyote Creek	5.2
140801020405	Lower Stollsteimer Creek	5.0
140801010404	Middle Rio Blanco	4.9
140801010103	Sand Creek	4.9
140801020302	Lower Devil Creek	4.7

6th Level HUB Information Needs

Information needs have been defined as follows for the fire section:

1) Obtain wetlands GIS layers to evaluate the impacts of fire on wetlands.
2) Integrate fire severity data with the results of the fire section to further delineate which watersheds, or portions of watersheds, have the highest potential for fire-related impacts.
3) In certain situations, it may be necessary to model sediment and water yield predictions to determine on site and downstream risks and appropriate mitigation measures.

Management Implications at the 6th Level HUB

Naturally occurring fires are an important process for aquatic, riparian, and wetland resources (Bisson et al. 2003). While aquatic, riparian, and wetland ecosystems maybe resilient to the effects of fire, past fire management and suppression efforts have created "unnatural" fuel and aquatic, riparian, and wetland conditions in many areas for many years. Road crossings and culverts, water diversions and reservoirs, grazing activities, and a variety of other activities have created artificial conditions where the ability to respond to the effects of natural fires (resiliency) has been compromised.

In order to respond to natural (and prescribed fire) in a way that is ultimately beneficial to aquatic, riparian, and wetland resources, management of other activities should be considered. Activities that fragment stream and riparian species such as roads, culverts, reservoirs etc. should be considered when addressing the ability of aquatic, riparian, and wetland resources to recover within a normal time period following natural fire. The ability of fish to move back into watersheds, which were severely burned, is in large part a result of their ability to migrate into an area without barriers.

The above analyses only ascertain the potential for impacts related to wildfire. While prescribed fire is meant to minimize the potential effects of larger natural fires, the resiliency of aquatic, riparian, and wetland resources should also be addressed. If cumulative influences within a watershed have already significantly been compromised, the aquatic, riparian, and wetland resources in that watershed may be further impacted by prescribed fire, and not be able to respond in a positive fashion. The result is aquatic, riparian, and wetland resources that are constantly in a "poor condition", with little resiliency left and little habitat for those species that rely on them.

Sediment production is a common result of fires, both natural and prescribed. The intensity of the fires, steepness of hill slopes, local climatic conditions and local geology all influence the amount sediment that is transported to aquatic, riparian, and wetland ecosystems. Wohl (USDA Forest Service, 2004, Chapter 2 in Report 1) notes that sensitivity to changes in sediment supply increases at lower stream gradients where pool-riffle channel morphology is more likely to be present. Rahel (USDA Forest Service, 2004, Chapter 2 in Report 1) also identified these low gradient stream channels are the most "productive" for fish.

As discussed in Report 1of 3, in this aquatic assessment, it is important to remember that headwater streams are disproportionately important, relative to their spatial extent, in their role of supplying water and sediment to downstream reaches. This is especially true on the San Juan National Forest where only three out of the eight riparian clusters have greater than 5% of their reach lengths rated as "low" gradient. Clusters 4r, 5r, and 6r contain greater than 5% of their reach length classified as "low" at 12.7%, 12.9%, and 16.8% respectively, which is still a minority for these clusters. As a result, the importance of managing sediment regime increases, due to fire, becomes even more important.

When examining the watersheds most affected by fire (Table 6.35) riparian clusters 4r and 5r are frequently involved, along with Cluster 2r. Cluster 2r has 4.7% of its reach length classified as "low" gradient. Although all three clusters are sensitive to changes in sediment loads and changes in hydrology Cluster 2r has been characterized as the most sensitive to changes in sediment load in its low gradient reaches. Both riparian vegetation and aquatic productivity and benthic macroinvertebrates have been characterized as highly sensitive to changes in both sediment and hydrology.

Many of the watersheds containing Cluster 4r also have high potential for anthropogenic disturbance related to other vegetation management activities and to mineral activities. As a result, watersheds containing Cluster 4r are candidates for mitigation efforts to improve habitat for fisheries in low gradient reaches. Canopy cover in Cluster 5r is required to limit thermal fluctuations. Where fire, grazing, or timber harvest have decreased canopy cover these watersheds present mitigation opportunities, where watersheds with low potential for anthropogenic activities present restoration opportunities. Restoration of surface and groundwater hydrology is an important element regarding watersheds containing Cluster 6r, where there have been high levels of anthropogenic influence.

In this same group of watersheds wetland Clusters 1w and 7w occurred most commonly. Although both are described as sensitive hydrologic change, 7w is highly sensitive to alterations in sediment loads. Cluster 1w is valuable from a wetland ecosystem standpoint, as the high elevation areas within this Cluster may contain a high density of wetlands. A large portion of this Cluster is contained by the San Juan National Forest. As a result, any mitigation or restoration efforts would have a large influence in improving aquatic and wetland health.

The variability in anthropogenic activity level that is found in this Cluster suggests 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, strategic management of this Cluster may be the most proactive approach.

Cluster 7w is considered to have high potential for wetland productivity. As a consequence restoration and mitigation efforts may have a high chance of success in watersheds containing this cluster. Clusters experiencing low or little anthropogenic activity may serve well as reference areas.

<u>Direction for Reach/Site Scale Analysis</u>

Although the area burned by fires at the management scales may be comparatively small, site impacts from fires can be considerable. When monitoring or evaluating conditions at the reach or site scale, specific questions to consider at this level of analysis include the items listed below. Wherever possible, data collected post-fire should be compared to pre-fire conditions.

1. Has the hydrology been altered resulting in an increased frequency and magnitude of high flow events?
2. If fire retardant was used near streams and wetlands, what were the short term impacts?
3. Has the water quality been altered for analytes relating to sediment, nutrients, and stream temperature?
4. Has sediment yield increased resulting in channel modification, loss of fisheries habitat, and degradation of stream banks?
5. Can modifications to channel substrates be determined using the D50 particle size or other measures to determine how substrate has been modified? If so, what are the changes?
6. What are the post-fire stream widths, depths, and pool/riffle ratios?
7. What is the post-fire annual stream temperature and solar radiation regimes?
8. What is the timing and magnitude of high-flow events and/or debris torrents?
9. Has there been loss of riparian and wetland habitat through the direct removal of vegetation by fire? What is the post-fire percent cover of riparian vegetation?

10. Determine post-fire abundance and distribution of large and large key woody debris.
11. Conduct a stream survey to evaluate diversity and biomass of resident amphibians and fisheries; If possible monitoring over both the short and long term to evaluate impacts to, and trends in, populations.
12. Over time what are the changes observed in riparian and wetland areas that have been burned?
13. What is the potential for future fires causing changes similar to questions 1-4?
14. Will future fires occur in watersheds containing particularly significant plant or animal populations such as Colorado River cutthroat trout?"

Actively monitoring the ecological effects of wildfires will provide the opportunity to learn how a significant natural disturbance influences the flora and fauna of aquatic, riparian, and wetland habitats. Fires will continue to occur on the Forest. If funding is available it would be extremely useful to establish long term survey locations in watersheds prone to fire so pre and post-fire evaluations may be implemented.

Influences of Livestock Grazing

This section provides an evaluation of the influence of domestic livestock management activities on the San Juan National Forest and associated aquatic, riparian and wetland ecosystems.

Livestock grazing has the potential to have a significant influence on riparian, wetland, and aquatic resources if it is not managed properly (Binkley and Brown, 1993). There are numerous references to document these potential influences although most references discuss impacts from improperly managed livestock grazing rather than from proper management (Kauffman and Krueger 1984; Buckhouse 1981; Meehan and Platts 1978; Binkley and Brown 1993; Larson et al. 1998).

Livestock grazing may also be used to positive effect when managed properly and when it is focused on meeting well defined interdisciplinary objectives. Grazing can: stimulate new growth of both herbaceous and woody species, increase total production and provide increased palatability and nutrient quality to other animal grazers. It also can increase herbaceous plant density, and alter habitat structure and composition to meet specific species objectives, such as managing for specific threatened or endangered species habitats or alteration of habitat relationships to favor certain species (Krueger and Anderson 1985).

Management has intensified over time on the San Juan National Forest, although not uniformly across the landscape. The result being that some allotments are well and intensively managed and others continue to need improvement. There are a few active sheep allotments still remaining although many sheep allotments are vacant. Most of these vacant allotments (e.g., there is no permit currently in effect but the allotment remains available for grazing upon appropriate decision) and closed allotments (the allotment is no longer available for permitting of livestock use) came into that status for economic reasons. Today, most of the San Juan National Forest permitted use is by cattle.

Currently 52% (963,607 acres) of the total area of the Forest is suitable for cattle grazing and 59% (1,107,158 acres) of the total Forest area is suitable for sheep grazing. Reports from the Forest indicate that of the 1,321,192 acres currently identified with rangeland management objectives, 929,937 acres (70%) are meeting or moving toward Land and Resource Management Plan (LRMP) objectives, 37,673 acres (3%) are not meeting or moving toward objectives and 353,582 acres (27%) are of undermined status (USFS Allotment Status data). This by no means represents the total allotment acres but is presented as an indication of current management status. Note that a significant portion of the landscape does not have current data to indicate status.

The effect of unmanaged livestock grazing in riparian zones is well known: trampling decreases vegetation both in-stream and within the riparian zone, increases soil compaction, and erosion and sedimentation are increased. As a result, knowing the current status of riparian conditions, in conjunction with the results of analyzed grazing metrics, is important to having an understanding of the complete picture of grazing impacts on the Forest.

In terms of riparian conditions, current reporting indicates that there is a total of 54,404 riparian acres identified to date. Of this, 35,808 acres (66%) are shown as meeting or moving toward LRMP objectives, 2,559 acres (4%) are not meeting or moving toward objectives and 16,037 acres (30%) are of undetermined status. This information for 'percent meeting' is likely to be low, as many of the riparian areas that are less accessible to livestock, have not yet been evaluated and many of these would likely be found to be meeting or moving toward objectives. However, it should be noted that the numbers for acres of riparian area meeting Forest objectives are open to some degree of interpretation, as riparian areas are subject to a wide variety of influences. This means that in most instances, a less than satisfactory condition is the result of a number of past and present activities. Livestock grazing may be one factor but it is seldom the sole factor. Often roads are major impacts and in some areas, recreational activities, large wild ungulates, and past activities such as tie drives may be the major continuing influence.

During analysis GIS grazing related data was clipped to the Forest boundary for all metrics except for sheep and cattle preferences. For all metrics watershed boundaries are shown to extend beyond the Forest boundary to help clearly delineate watersheds. For metrics relating to preferences GIS data was clipped to watershed boundaries.

Data analysis defined the amount of vacant or closed grazing allotments, within the San Juan National Forest boundary, as 741,435.7 acres, or 35.4%. This number includes allotments for both cattle and sheep. 62.6% of the area within the Forest boundary is within active grazing allotments for both sheep and cattle.

The percentage of each watershed that is involved in active allotments for both sheep and cattle is summarized in Figure 6.17 and in Table 6.19.

58 watersheds on the Forest are within the 100-80 percentile range, indicating that they have the highest potential for influence on aquatic, riparian and wetland resources, as a result from influences related to grazing by cattle and sheep. These watersheds are located across the Forest. However, the area associated with the Weminuche Wilderness Area is the largest area within the Forest that is not involved with grazing allotments. The area immediately west of the Animas River, although involved with grazing, is noticeably lower than the rest of the Forest, excluding the Weminuche Wilderness area (Figure 6.17). 34 of watersheds are located entirely on the Forest The percentage of watershed, or HUB, in active allotment for the 100-80 percentile range varies from 100% to 92.61%. For the watersheds contained in this percentile range the vast majority, if not all of the areas for each listed watershed are involved in active grazing allotments for sheep and cattle (Table 6.19).

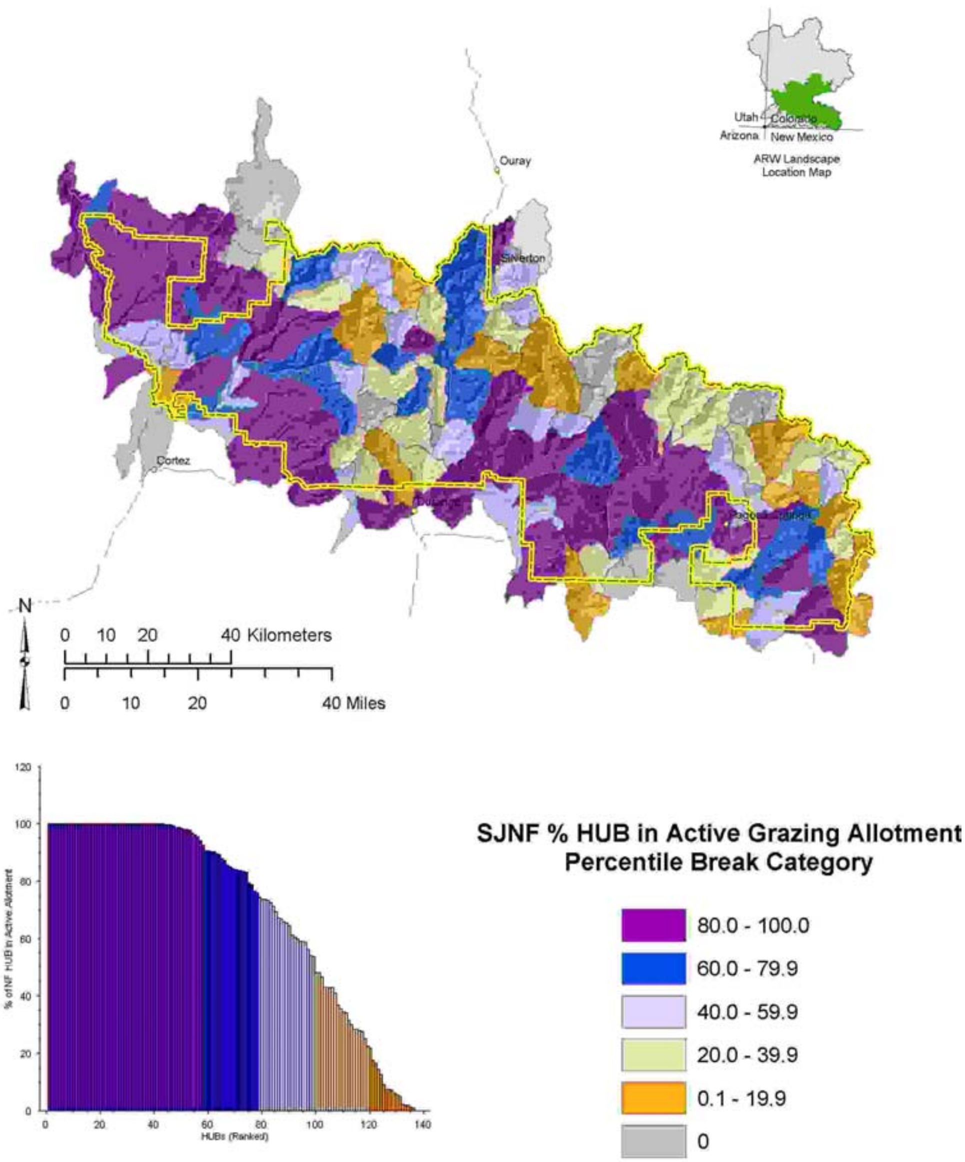

Figure 6.17 Percent HUB in Active Grazing Allotment), management scale, San Juan National Forest

Table 6.19 100-80 percentile ranges, % of NF HUB in active grazing allotment, management scale, San Juan National Forest; Watersheds highlighted in green are located entirely within Forest boundaries.

6th Level HUB	6th Level HUB Name	% of HUB, within National Forest Boundary, in Active Allotment	Category	6th Level HUB	6th Level HUB Name	% of HUB, within National Forest Boundary, in Active Allotment	Category
140300020509	Pine Arroyo	100.00	5	140801010307	Echo Canyon Reservoir	100.00	5
140300020507	Dawson Draw	100.00	5	140801010404	Middle Rio Blanco	100.00	5
140300020506	Brumley Valley	100.00	5	140801050105	Upper Cherry Creek	100.00	5
140300020504	Ryman Creek	100.00	5	140801010305	McCabe Creek	100.00	5
140801011703	Ute Creek	100.00	5	140801020501	Yellowjacket Creek	100.00	5
140300020301	Upper Beaver Creek -McPhee	100.00	5	140801040901	Lower Florida River-Ticalotte	99.99	5
140300020602	Narraguinnep Canyon Natural Area	100.00	5	140801011404	Vallecito Reservoir	99.99	5
140300020510	Upper Disappointment Valley	100.00	5	140802020201	Upper Yellowjacket Canyon	99.99	5
140300020505	Upper Disappointment Creek	100.00	5	140801040603	Lower Lightner Creek	99.98	5
140300020401	Upper Lost Canyon	100.00	5	140801040802	Upper Florida River-Transfer Park	99.97	5
140801020401	Martinez Creek-Dutton Creek	100.00	5	140801070103	Upper Mancos Valley	99.97	5
140300020503	Sheep Camp Valley	100.00	5	140801011502	Bear Creek	99.96	5
140801020301	Upper Devil Creek	100.00	5	140801011704	Upper Spring Creek	99.96	5

Table 6.19 100-80 percentile ranges, % of NF HUB in active grazing allotment, management scale, San Juan National Forest; Watersheds highlighted in light green are located entirely within the Forest boundaries.

6th Level HUB	6th Level HUB Name	% of HUB, within National Forest Boundary, in Active Allotment	Category	6th Level HUB	6th Level HUB Name	% of HUB, within National Forest Boundary, in Active Allotment	Category
140300020403	Middle Lost Canyon	100.00	5	140801011306	East Creek	99.92	5
140801070104	Chicken Creek	100.00	5	140801040102	Cement Creek	99.84	5
140801070101	East Mancos River-Middle Mancos River	100.00	5	140300020605	Dolores Canyon-Joe Davis Hill	99.78	5
140801020205	Upper Piedra River-Box Canyon	100.00	5	140801011603	Lower Beaver Creek	99.72	5
140801020206	Upper Piedra River-Indian Creek	100.00	5	140801040801	Florida River Headwaters	99.28	5
140801020104	Piedra River-O'Neal Creek	100.00	5	140801010504	Navajo River-Weisel Flat	98.84	5
140801020403	Stollsteimer Creek-Dyke Valley	100.00	5	140300020407	House Creek	98.77	5
140801011501	Middle Los Pinos River-Red Creek	100.00	5	140801040402	East Fork Hermosa Creek	98.32	5
140801011601	Upper Beaver Creek	100.00	5	140300020208	Stoner Creek	98.23	5
140801070102	West Mancos River	100.00	5	140300020303	Calf Creek	98.14	5
140801040803	Lemon Reservoir	100.00	5	140300020604	Dolores Canyon-Lake Canyon	97.96	5
140801020203	Sand Creek	100.00	5	140300020402	Spruce Water Canyon	96.82	5
140300020302	Upper Plateau Creek	100.00	5	140801010506	Little Navajo River	96.38	5
140801040804	Upper Florida River-Red Creek	100.00	5	140801020202	Lower Weminuche Creek	95.78	5
140801070105	East Fork of Mud Creek	100.00	5	140300020105	Lower West Dolores River	93.96	5
140801040604	Animas River-Spring Creek	100.00	5	140801010306	Mill Creek	92.61	5

Livestock Preference Model

Domestic livestock are not randomly distributed across the landscape. In order to assess the possible distribution of permitted livestock across the land, and to allow for an assessment of areas most likely to experience livestock grazing influences, an existing model was used to assess livestock preferences. The parameters of this model were adapted to reflect conditions on the San Juan National Forest.

The model first used the Land and Resources Management Plan (LRMP) suitability and capability process to identify areas across the landscape where livestock grazing may be appropriate (e.g., the land is determined to be both suitable and capable for livestock grazing). This process included elements which accounted for the long-term health and sustainability of the Forest's ecosystems. Areas where livestock grazing have been determined to be inappropriate for any of a variety of reasons have been discounted. As mentioned earlier in this document, GIS data for the preference metrics were clipped to watershed boundaries, not the Forest boundary.

The model overlayed the suitability determination on to allotment status (active, vacant, or non-allotment), and permitted livestock type (cattle or sheep). The model assessed livestock preference in terms of three key factors which together indicates livestock preference (slope, distance to water, and canopy cover). Although other factors could be locally important, the model was run using these three components as a reasonable means of arriving at a general assessment of conditions at the watershed level.

The model was used to analyze data for the metric of how many acres of predicted preference (High, medium, or low) for grazing by cattle and sheep there are in each watershed on the Forest. Where actual use mapping is available, this would be a preferable alternative to the preference model; however, this information is not generally available for most areas. In addition, it should be noted that there is variability inherent in this model. This variability will be magnified at the site scale. Additional validation will need to occur in order to determine its utility at localized scales.

Privately owned lands comprise 11% of the area in the San Juan National Forest. Grazing related information for private lands within the Forest was not available. As a result, it was not possible to assess the potential effects of grazing on private lands within the Forest boundary. Typically private lands tend to be managed more intensively for specific uses. With that in mind it is expected that private lands managed for livestock production, or for rural home sites with associated livestock use, would show greater potential for effects than would be expected on lands managed by the Forest. As a result, the information summarized in this chapter represents a "minimum" of impacts to aquatic, riparian and wetland resources, as data for grazing on private lands is not available.

Data was available from the Bureau of Land Management (BLM) and was included in the analysis. However, BLM lands located within the Forest's boundary comprise less than one percent of the Forest area.

Existing allotments for both cattle and sheep are summarized in Figure 6.18. 328,971 acres or 32.1% of suitable acres for grazing were determined to be of low preference for cattle grazing. Moderate cattle preference acreage had the highest number of acres and percentage at 495,704 acres or 48.3%. Only 201, 188 acres were determined to be of high preference for cattle (Table 6.20). The distribution by preference of those lands suitable for cattle grazing is shown in Figure6.19.

The percentile of each watershed within the high cattle preference category was determined. A total of 31 watersheds were within the 100-80 percentile range for this metric with ten of the watersheds being located entirely on the Forest.

These watersheds tend to occur along the Forest's boundary and are concentrated in the western half of the Forest (Figure 6.21). As the majority of watersheds in this percentile range only have a portion of their area both on-Forest, it is expected that these watersheds have the highest potential for both on and off-Forest impacts to aquatic, riparian and wetlands resources (Table 6.22).

The percentage of HUBs involved in the moderate and low cattle preferences were also calculated.

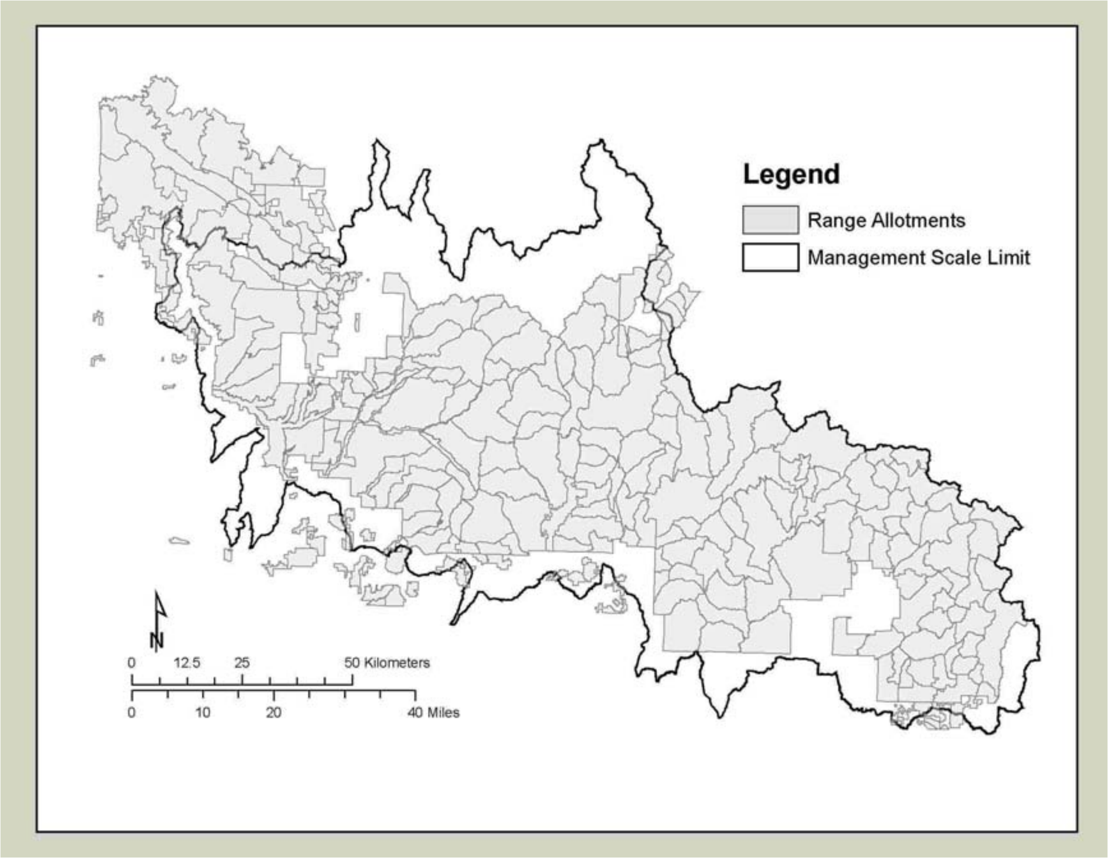

Figure 6.18 Current Livestock Allotments, management scale, San Juan National Forest

Table 6.20 Cattle Allotment Preference Rating, management scale, San Juan National Forest

	Low	Moderate	High	Total
Area (Acres)	328971	495704	201188	1025863
Area (% of Suitable)	32.07	48.32	19.61	100

Table 6.21 Sheep Allotment Preference Rating, management scale, San Juan National Forest

	Low	Moderate	High	Total
Area (Acres)	597402	437426	141867	1176695
Area (% of Suitable)	50.77	37.17	12.06	100.00

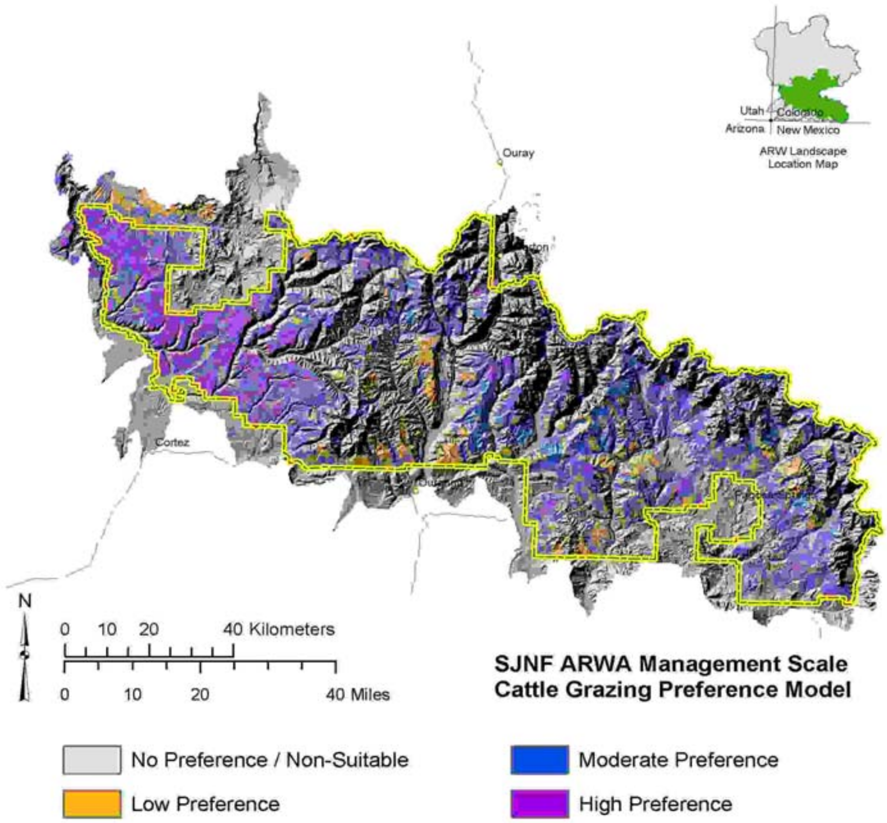

Figure 6.19 Cattle Grazing Preference Model, management scale, San Juan National Forest

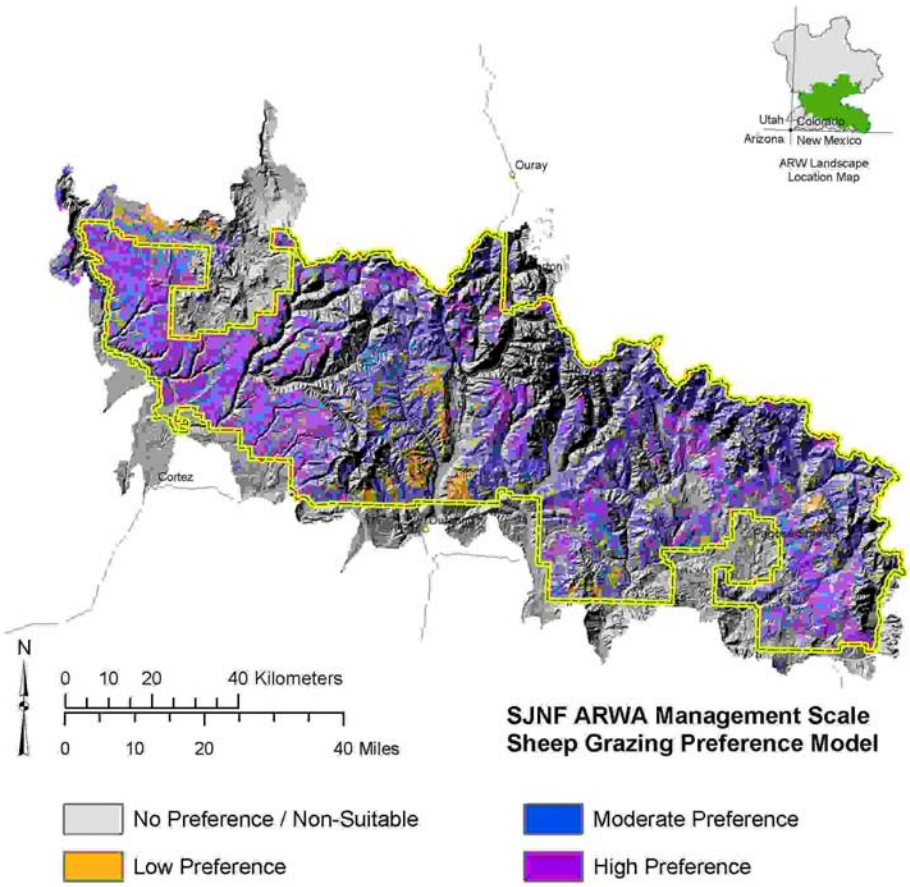

Figure 6.20 Sheep Grazing Preference Model, management scale, San Juan National Forest

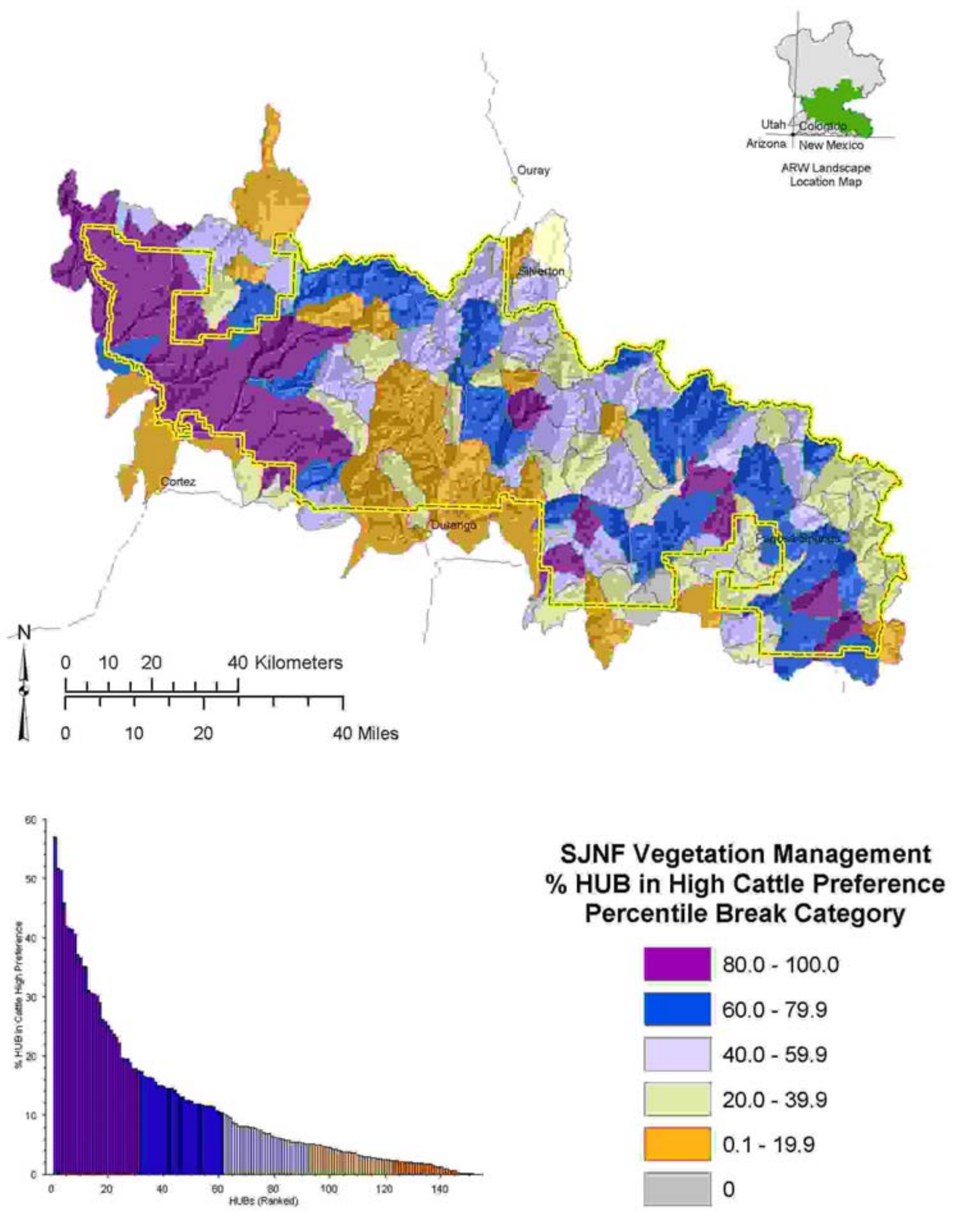

Figure 6.21 Percent of HUB in High Cattle Preference, management scale, San Juan National Forest

Table 6.22 100-80 percentile range, Percent HUB in High Cattle Preference, management scale, San Juan National Forest

6th Level HUB	6th Level HUB Name	% Watershed in Cattle High Preference	Category	6th Level HUB	6th Level HUB Name	% Watershed in Cattle High Preference	Category
140300020305	Beaver Creek-Trail Canyon	57.0	5	140300020304	Lower Plateau Creek	29.0	5
140300020402	Spruce Water Canyon	51.7	5	140300020504	Ryman Creek	26.3	5
140300020407	House Creek	51.5	5	140300020208	Stoner Creek	25.8	5
140300020507	Dawson Draw	46.0	5	140300020506	Brumley Valley	25.2	5
140300020509	Pine Arroyo	41.9	5	140801010404	Middle Rio Blanco	24.3	5
140300020403	Middle Lost Canyon	41.6	5	140300020511	Disappointment Valley-Wild Horse Reservoir	23.8	5
140300020601	Dolores River-Salter Canyon	41.4	5	140300020105	Lower West Dolores River	23.1	5
140300020306	McPhee Reservoir-Beaver Creek Inlet	40.7	5	140801040801	Florida River Headwaters	22.2	5
140300020602	Narraguinnep Canyon Natural Area	37.2	5	140801011601	Upper Beaver Creek	19.6	5
140300020401	Upper Lost Canyon	36.5	5	140801011603	Lower Beaver Creek	19.5	5
140300020406	Upper Dolores River-Italian Creek	35.2	5	140801020401	Martinez Creek-Dutton Creek	19.5	5
140300020604	Dolores Canyon-Lake Canyon	35.1	5	140801070102	West Mancos River	18.9	5
140300020404	Stapleton Valley	31.1	5	140300020605	Dolores Canyon-Joe Davis Hill	17.8	5
140300020303	Calf Creek	30.6	5	140801020104	Piedra River-O'Neal Creek	17.8	5
140300020408	McPhee Reservoir-Dolores River	30.4	5	140801010506	Little Navajo River	17.4	5
140801070104	Chicken Creek	30.1	5				

151 watersheds, or 98% of the Forest's watersheds, had a percentage of their areas classified as moderate preference for cattle grazing. These watersheds are found concentrated in the east half of the Forest and along the northern and southern boundaries of the west half of the Forest. 31 of the watersheds are within the 100-80 percentile range and 22 of these watersheds are located entirely on Forest (Table 6.23 and Figure 6.22.

Lemon Reservoir (HUB# 140801040803) and the Upper Florida River-Transfer Park (HUB# 140801040802) watersheds had the highest percentage of their total watershed area identified as in moderate cattle preference at 401.5%. Both of these watersheds are located entirely on-Forest. Fish Creek (HUB# 140300020102) and Lower Cascade Creeks (HUB# 140801040303) have the lowest percentage of their watersheds designated as moderate cattle preference within the 100-80 percentile range at 27.2%.

Potential impacts to aquatic, riparian and wetland resources are expected both on and off-Forest, though the likelihood for potential impacts is somewhat lower than for the cattle high preference category.

The moderate and high preference categories combined total 68% of the acres suitable for cattle grazing. It is in the moderate and high preference acreages where livestock activity is most likely to occur and where the potential for livestock influence on aquatic, riparian and wetland resources is the greatest. The low preference acreage areas are expected to have only minimal livestock activity and would have limited potential for influences on watershed health.

A total of 147 watersheds, or 95%, of the Forest's watersheds, had a percentage of their areas classified as low preference for cattle grazing. 30 of these watersheds are within the 100-80 percentile range with 16 of these watersheds were located entirely within the Forest boundary. Figure 6.23 shows that watersheds within the 100-80 percentile range for low cattle preference are concentrated in the eastern two-thirds of the Forest. Potential impacts, either on or off-Forest, are expected to be minimal as these areas have a minimum of grazing activity and with that comes limited potential for influences on aquatic, riparian and wetland resources. Watersheds involved in this low cattle preference rating are listed in Table 6.24.

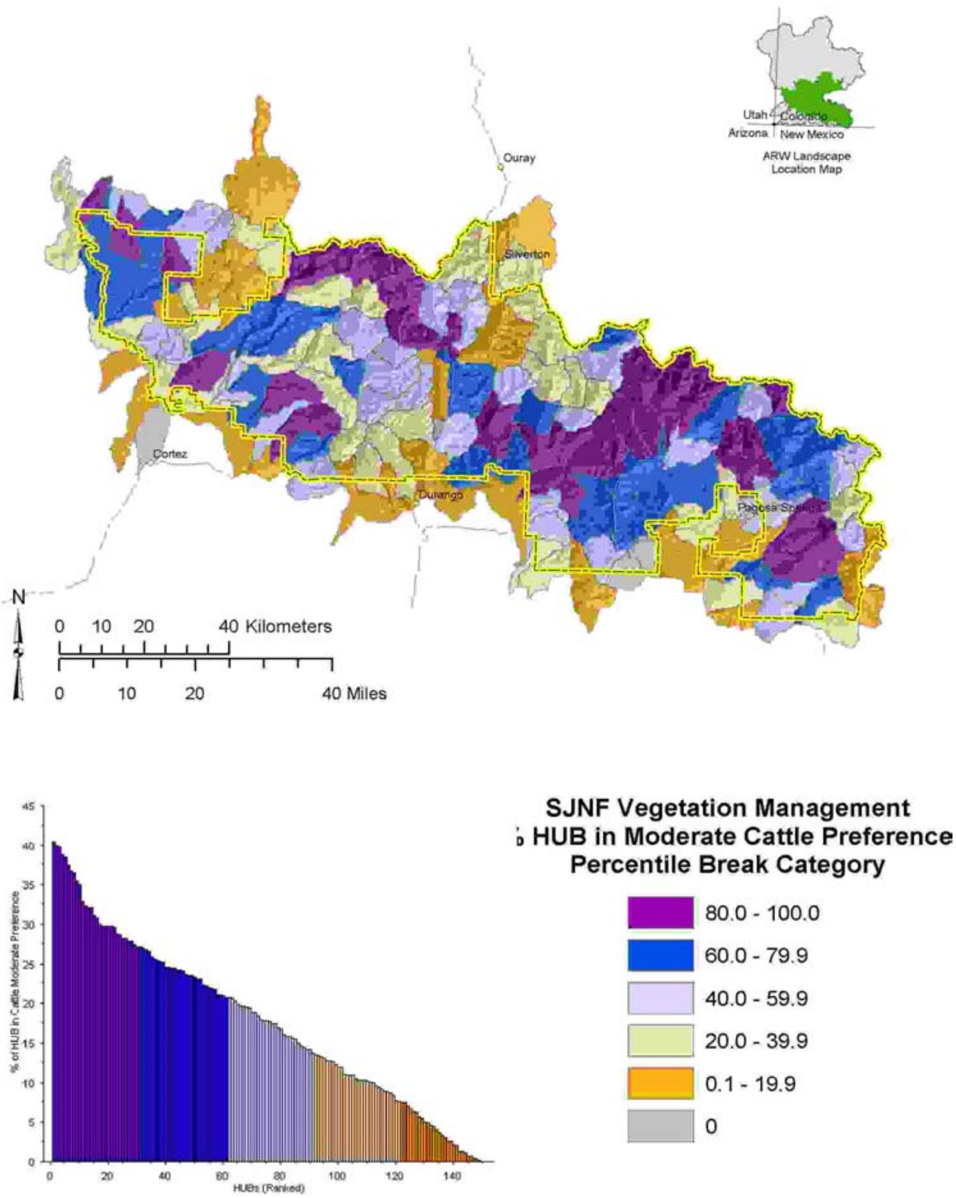

Figure 6.22 Percent HUB in Moderate Cattle Preference, management scale, San Juan National Forest

Table 6.23 100-80 percentile range for % HUB in Moderate Cattle Preference, management scale, San Juan National Forest; all watersheds within the Forest are highlighted in light green

6th Level HUB	6th Level HUB Name	% of Watershed in Cattle Moderate Preference	Category	6th Level HUB	6th Level HUB Name	% of Watershed in Cattle Moderate Preference	Category
140801040803	Lemon Reservoir	40.5	5	140801010301	Turkey Creek	30.8	5
140801040802	Upper Florida River-Transfer Park	40.0	5	140300020201	Dolores River Headwaters-Tin Can Basin	30.0	5
140801020204	First Fork	39.8	5	140300020511	Disappointment Valley-Wild Horse Reservoir	29.8	5
140801010404	Middle Rio Blanco	38.9	5	140801020102	Middle Fork Piedra River	29.8	5
140801040401	Hermosa Creek headwaters	38.6	5	140801010302	Fourmile Creek	29.7	5
140801011502	Bear Creek	37.5	5	140300020407	House Creek	29.7	5
140801020203	Sand Creek	36.8	5	140300020504	Ryman Creek	29.6	5
140801011601	Upper Beaver Creek	36.5	5	140801020201	Upper Weminuche Creek	28.8	5
140801040402	East Fork Hermosa Creek	35.5	5	140801010202	Beaver Creek	28.7	5
140300020202	Upper Dolores River-Cayton Valley	35.0	5	140801020103	Williams Creek	28.2	5
140801010403	Rio Blanco River-Blanco Basin	32.9	5	140300020507	Dawson Draw	28.2	5
140801020202	Lower Weminuche Creek	32.3	5	140801070102	West Mancos River	27.9	5
140300020401	Upper Lost Canyon	32.2	5	140300020101	El Deinte Peak	27.9	5
140801010405	Rito Blanco	32.1	5	140801011404	Vallecito Reservoir	27.5	5
140801011306	East Creek	31.1	5	140300020102	Fish Creek	27.2	5
				140801040303	Lower Cascade Creek	27.2	5

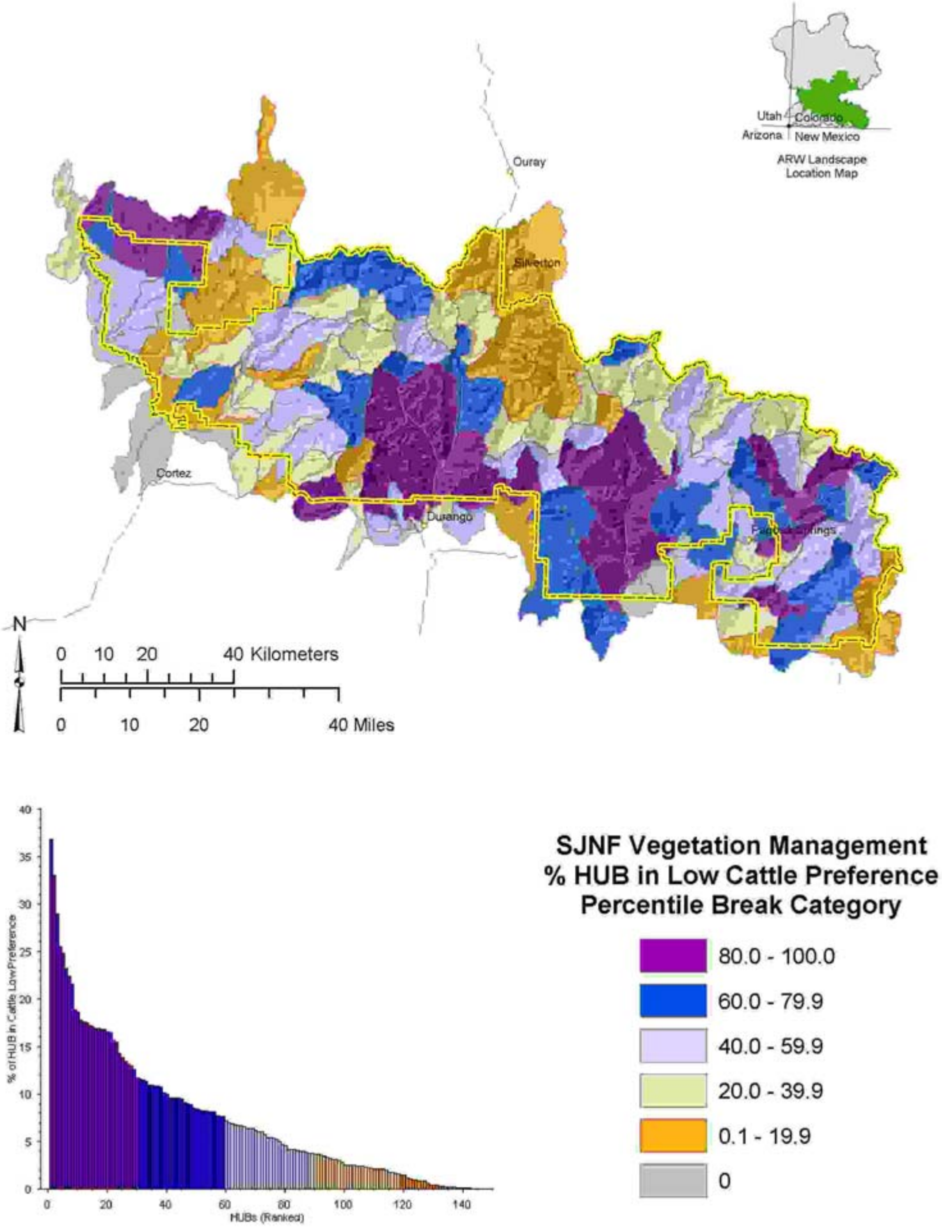

Figure 6.23 Percent of HUB in Low Cattle Preference, management scale, San Juan National Forest

Table 6.24 100-80 percentile range % HUB in Low Cattle Preference, management scale, San Juan National Forest

6th Level HUB	6th Level HUB Name	% of Watershed in Cattle Low Preference	Category	6th Level HUB	6th Level HUB Name	% of Watershed in Cattle Low Preference	Category
140300020510	Upper Disappointment Valley	36.8214573	5	140801010306	Mill Creek	16.8818035	5
140801040406	Hermosa Creek-Dutch Creek	33.0228103	5	140801020204	First Fork	16.8169101	5
140801020502	Piedra River-Stollsteimer	28.9486872	5	140300020507	Dawson Draw	16.7926624	5
140801020205	Upper Piedra River-Box Canyon	25.4765877	5	140801040405	South Fork Hermosa Creek	16.524967	5
140300020506	Brumley Valley	24.8279554	5	140801010104	East Fork San Juan River-The Clamshell	16.4416515	5
140801040502	Elbert Creek	23.2370031	5	140801050105	Upper Cherry Creek	15.5759833	5
140801040602	Upper Lightner Creek	22.3486237	5	140300020511	Disappointment Valley-Wild Horse Reservoir	15.3971342	5
140801010303	Laughlin Park	21.5304254	5	140801011501	Middle Los Pinos River-Red Creek	14.2540303	5
140801040804	Upper Florida River-Red Creek	18.8329941	5	140801020203	Sand Creek	13.8851811	5
140300020505	Upper Disappointment Creek	18.5991653	5	140801040601	Junction Creek	13.3965495	5
140801020501	Yellowjacket Creek	17.8220901	5	140801010301	Turkey Creek	13.1188715	5
140801040503	Upper Animas Valley-Stevens Creek	17.5868292	5	140801020206	Upper Piedra River-Indian Creek	12.954398	5
140801020302	Lower Devil Creek	17.5188201	5	140801040407	Lower Hermosa Creek	12.5850944	5
140801040504	Upper Animas Valley-Trimble	17.2136905	5	140801010406	Lower Rio Blanco-San Juan River	11.7116655	5
140801011306	East Creek	17.0853524	5				
140801040404	Middle Hermosa Creek	16.9032781	5				

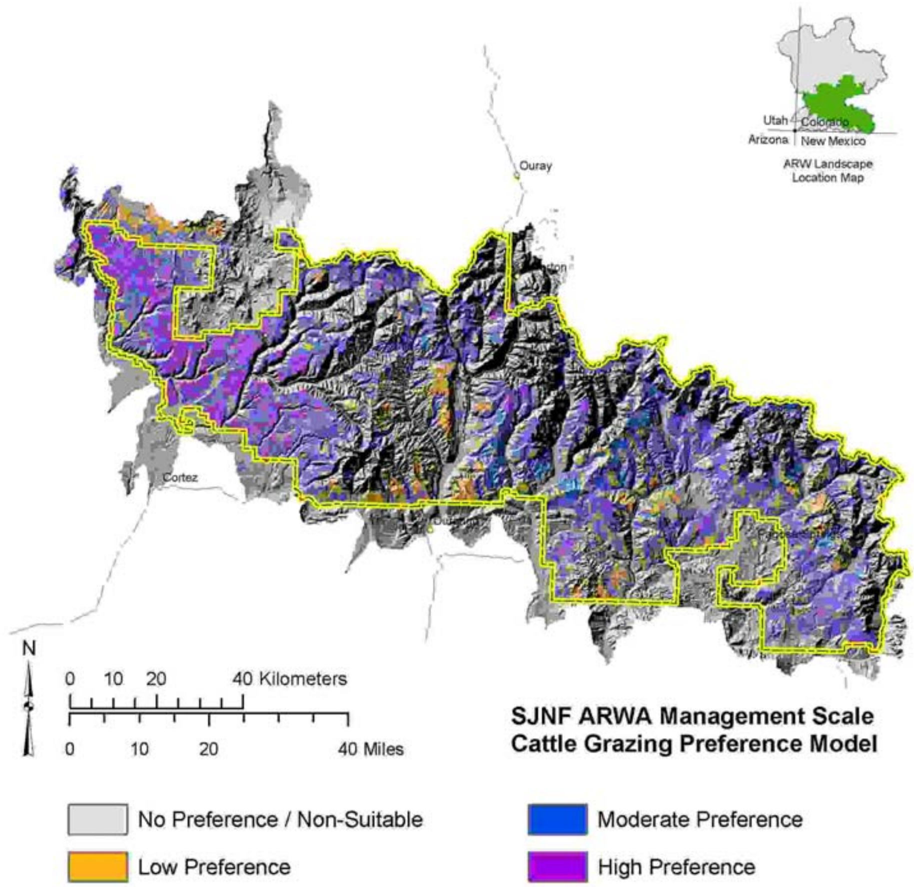

Figure 6.24 Cattle Grazing Preference Model, management scale, San Juan National Forest

Analysis indicates that a total of 1, 176,695 acres, or 56 % of the San Juan National Forest is suitable for grazing by sheep. 917,756 acres are not suitable for grazing by sheep, which is approximately 44 % of the Forest (Table 6.20). 50.8% of lands suitable for grazing by sheep, within the Forest boundary, are rated as low in preference. 37.2% of the suitable land is rated as moderate in preference, with only 12.1% of the lands qualifying as high preference for sheep (Table 6.21). The distribution of these lands, by preference, across the Forest is displayed in Figure 6.20.

The moderate and high preference categories combined total is 28% of the suitable acres. As with cattle grazing, it is in the moderate and high preference acreages where activity is most likely to occur and where the potential for influence on aquatic, riparian and wetland resources is the greatest. The low preference acreage areas are expected to have only minimal livestock activity and would have limited potential for influences on watershed health.

As with cattle, modeling analyzed available data to determine the percentage of watershed within high, moderate, and low preferences for sheep. 31 watersheds were found to be in the 100-80 percentile range for this metric. 15 of these watersheds are located entirely on-Forest (Table 6.25). Watersheds within this percentile range are concentrated in the western and eastern thirds of the Forest (Figure 6.26).

The Beaver Creek-Trail Canyon(HUB # 140300020305) watershed had the highest percentage of its total watershed area involved in high sheep preference at 66.9%, while the lowest recorded values were in Stapleton Valley (HUV# 140300020404) and El Deinte Peak (HUB# 140300020101) had 34.9% and 34.5% of their total area rated as high preference grazing land for sheep.

Watersheds within this percentile range have the highest potential for effects on aquatic, riparian and wetland resources. Based on the distribution of watersheds within this percentile range it is expected that there is potential for both on and off-Forest effects on aquatic, riparian and wetland resources.

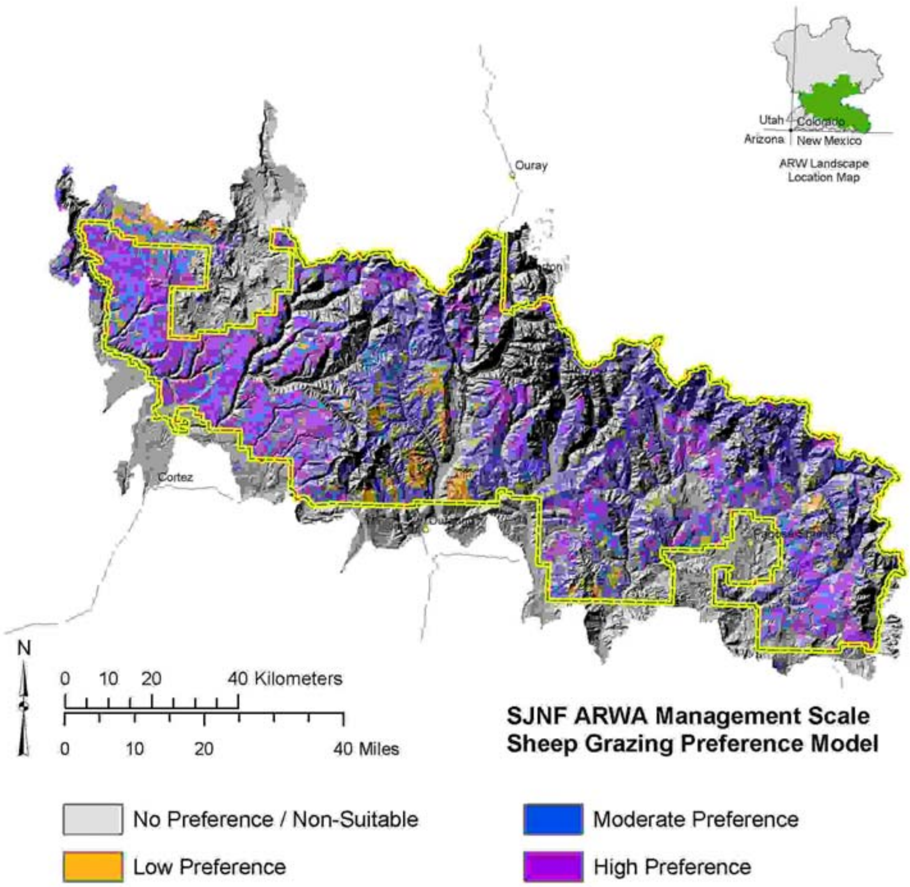

Figure 6.25 Sheep Grazing Preference Model, management scale, San Juan National Forest

Table 6.25 100-80 percentile range, Percent HUB in High Preference Sheep, management scale, San Juan National Forest

6th Level HUB	6th Level HUB Name	% Watershed in High Sheep Preference	Category	6th Level HUB	6th Level HUB Name	% Watershed in High Sheep Preference	Category
140300020305	Beaver Creek-Trail Canyon	66.9	5	140300020406	Upper Dolores River-Italian Creek	38.6	5
140300020407	House Creek	59.1	5	140300020604	Dolores Canyon-Lake Canyon	38.2	5
140300020402	Spruce Water Canyon	57.1	5	140801070104	Chicken Creek	37.9	5
140300020507	Dawson Draw	51.5	5	140300020504	Ryman Creek	37.7	5
140801010404	Middle Rio Blanco	50.7	5	140300020202	Upper Dolores River-Cayton Valley	37.0	5
140300020601	Dolores River-Salter Canyon	50.5	5	140801070102	West Mancos River	36.9	5
140300020401	Upper Lost Canyon	48.3	5	140300020408	McPhee Reservoir-Dolores River	36.9	5
140300020403	Middle Lost Canyon	47.1	5	140300020105	Lower West Dolores River	36.8	5
140801011601	Upper Beaver Creek	46.9	5	140801010506	Little Navajo River	36.7	5
140300020306	McPhee Reservoir-Beaver Creek Inlet	46.3	5	140801020103	Williams Creek	36.5	5
140300020509	Pine Arroyo	46.1	5	140801011502	Bear Creek	36.5	5
140300020602	Narraguinnep Canyon Natural Area	43.8	5	140300020208	Stoner Creek	36.5	5

Table 6.25 continued

6th Level HUB	6th Level HUB Name	% Watershed in High Sheep Preference	Category	6th Level HUB	6th Level HUB Name	% Watershed in High Sheep Preference	Category
140801040802	Upper Florida River-Transfer Park	39.7	5	140300020201	Dolores River Headwaters-Tin Can Basin	35.1	5
140801010405	Rito Blanco	39.4	5	140300020404	Stapleton Valley	34.9	5
140801040801	Florida River Headwaters	38.8	5	140300020101	El Deinte Peak	34.5	5
				140801040303	Lower Cascade Creek	34.4	5

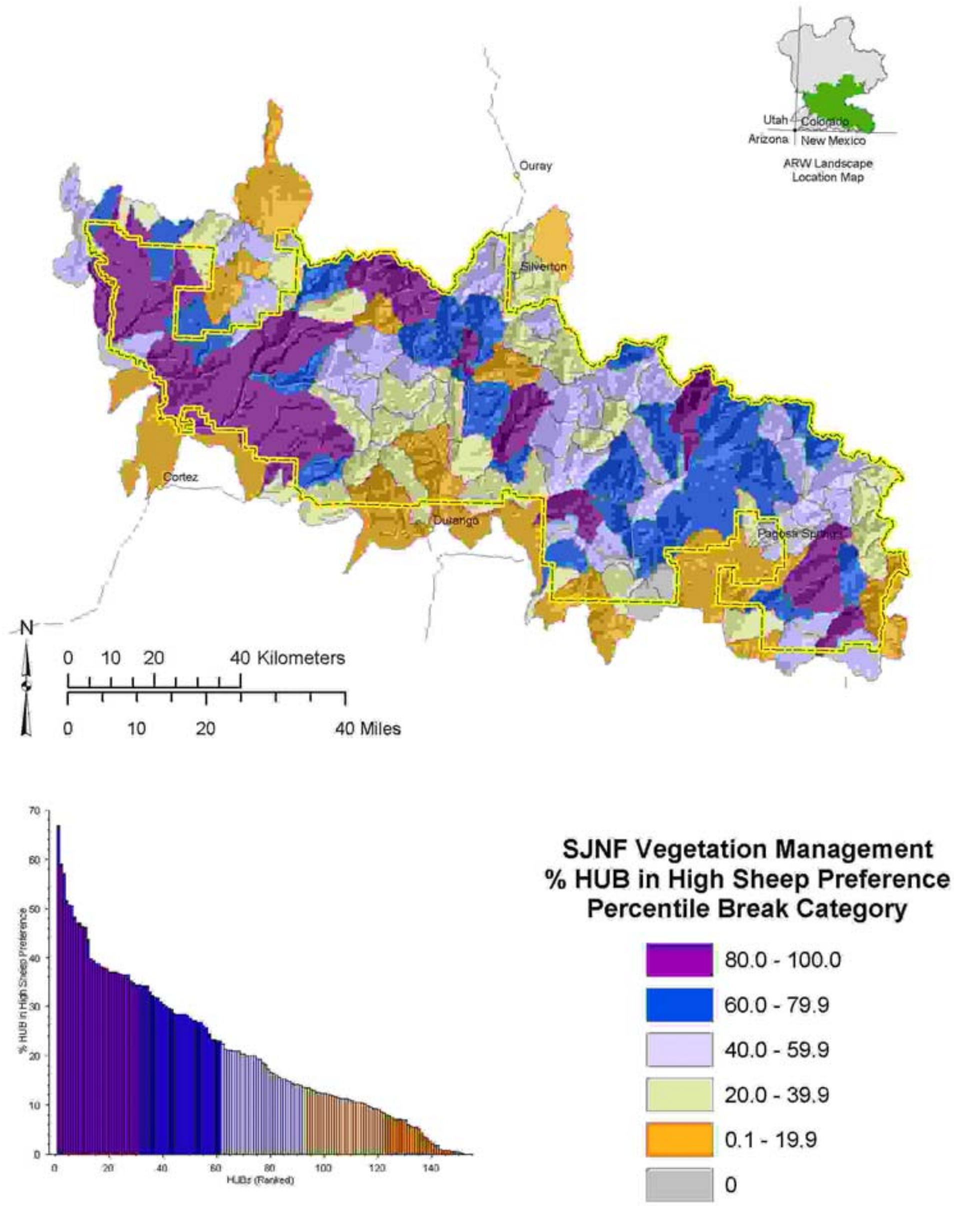

Figure 6.26 Percent HUB in High Sheep Preference, management scale, San Juan National Forest

32 watersheds were found to be in the 100-80 percentile range for the metric "Percent HUB in Moderate Sheep Preference". 23 of these watersheds are found entirely with the Forest's boundaries (Table 6.26). The Hermosa Creek (HUB# 140801040403) watershed had the highest percentages of its total area ranked as low sheep preference with a value of 45.6%, and is located entirely on-Forest. The lowest value within the 100-80 percentile range was located in the Quartz Creek (HUB# 140801010102) watershed, which also located entirely on-Forest.

Watersheds within the 100-80 percentile range for Moderate Sheep Preference are scattered across the Forest (Figure 6.27) As 23 out of 32 of the watersheds are located on Forest there is, in general, a higher potential for on-Forest effects relative to off-Forest downstream potential impacts. Downstream off-Forest impacts though are likely northeast and northwest of Cortez and immediately north of Durango (Figure 6.27).

30 watersheds ranked in the 100-80 percentile range for the metric "Percent HUB Low Sheep Preference". The majority of these watersheds are found in the eastern two-thirds of the Forest (Figure 6.28). 13 of these watersheds are located entirely on-Forest and are summarized in Table 6.27. The Hermosa-Dutch Creek (HUB# 140801040406) and Upper Disappointment Valley (HUB# 140300020510) watersheds had the highest percentage of their watersheds designated as low sheep preference grazing land with 33.4% and 33.1% respectively. The Hermosa-Dutch Creek watershed is located entirely on-Forest, the Upper Disappointment Valley watershed is not. The watershed with the lowest percentage of area designated as low sheep preference grazing land is the Lower Devil Creek (HUB# 140801020302) with only 7.8% of its land designated as low preference.

Based on the distribution and location of these watersheds there is potential for both on and off-Forest impacts to aquatic, riparian and wetland resources. However, as all watersheds with Low Sheep Preference ratings, the potential for impacts due to grazing by sheep is very low, as these areas have minimal activity.

Table 6.26 100-80 percentile ranges, Percent HUB Moderate Sheep Preference, management scale, San Juan National Forest; Watersheds highlighted in light green are located entirely within the Forest boundaries.

6th Level HUB	6th Level HUB Name	% Watershed in Moderate Sheep Preference	Category	6th Level HUB	6th Level HUB Name	% Watershed in Moderate Sheep Preference	Category
140801040403	Upper Hermosa Creek	45.6	5	140801020501	Yellowjacket Creek	28.3	5
140801040404	Middle Hermosa Creek	41.4	5	140300020506	Brumley Valley	27.6	5
140801040401	Hermosa Creek headwaters	40.9	5	140300020205	Roaring Forks Creek	27.6	5
140801040406	Hermosa Creek-Dutch Creek	38.1	5	140300020407	House Creek	27.5	5
140300020511	Disappointment Valley-Wild Horse Reservoir	33.3	5	140801040802	Upper Florida River-Transfer Park	26.6	5
140801040803	Lemon Reservoir	32.9	5	140801011501	Middle Los Pinos River-Red Creek	26.4	5
140801010103	Sand Creek	32.4	5	140801010404	Middle Rio Blanco	25.5	5
140801040405	South Fork Hermosa Creek	31.4	5	140300020509	Pine Arroyo	25.3	5
140801011404	Vallecito Reservoir	31.3	5	140801020302	Lower Devil Creek	25.2	5
140801011306	East Creek	30.5	5	140801040804	Upper Florida River-Red Creek	24.9	5
140300020507	Dawson Draw	30.3	5	140801010303	Laughlin Park	24.8	5
140801040402	East Fork Hermosa Creek	30.2	5	140801010204	Lower West Fork San Juan River	24.7	5
140801020201	Upper Weminuche Creek	29.2	5	140300020504	Ryman Creek	24.6	5
140300020204	Upper Dolores River-Scotch Creek	28.9	5	140801010202	Beaver Creek	24.4	5
140801010104	East Fork San Juan River-The Clamshell	28.4	5	140300020401	Upper Lost Canyon	24.4	5
				140801010102	Quartz Creek	24.2	5

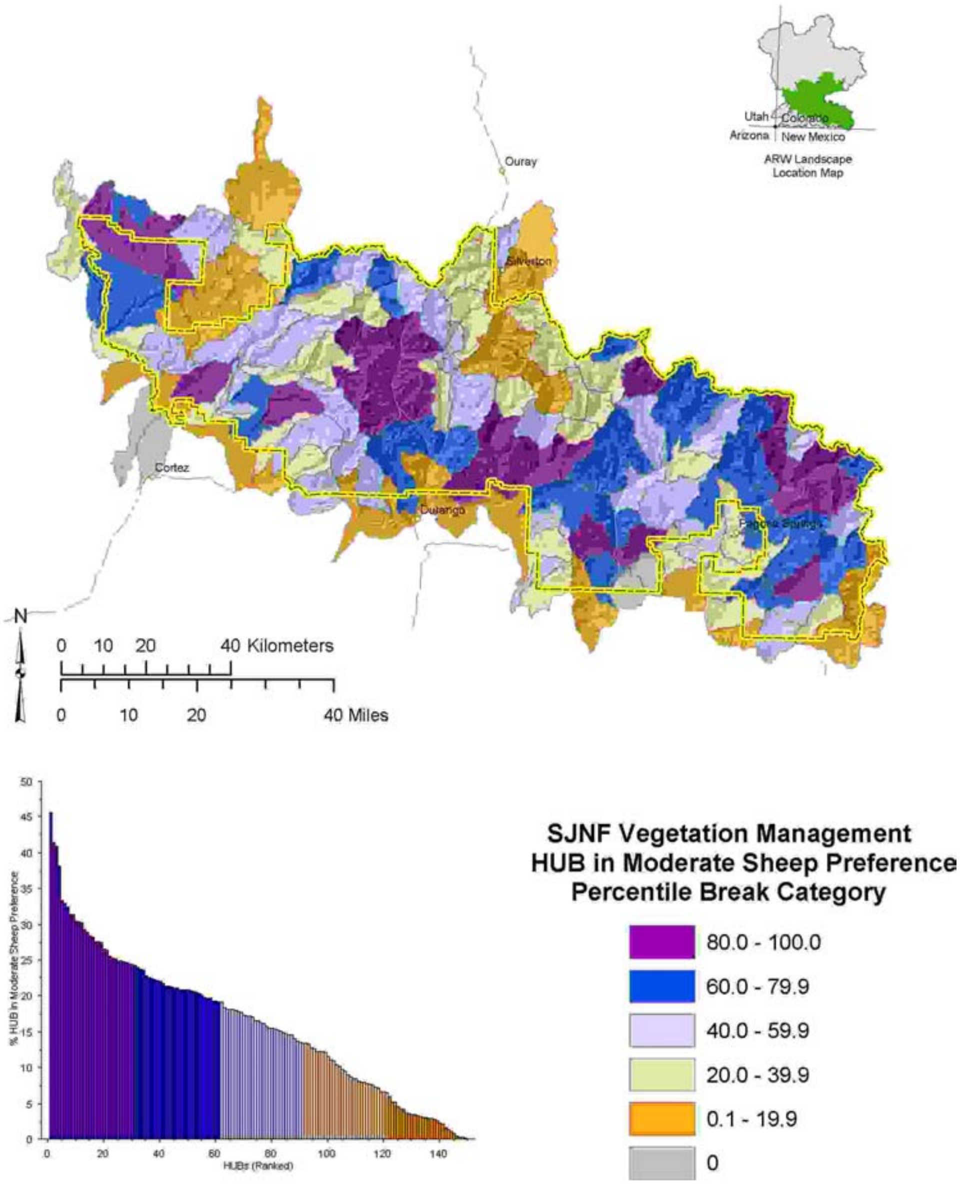

Figure 6.27 Percent HUB in Moderate Sheep Preference, management scale, San Juan National Forest

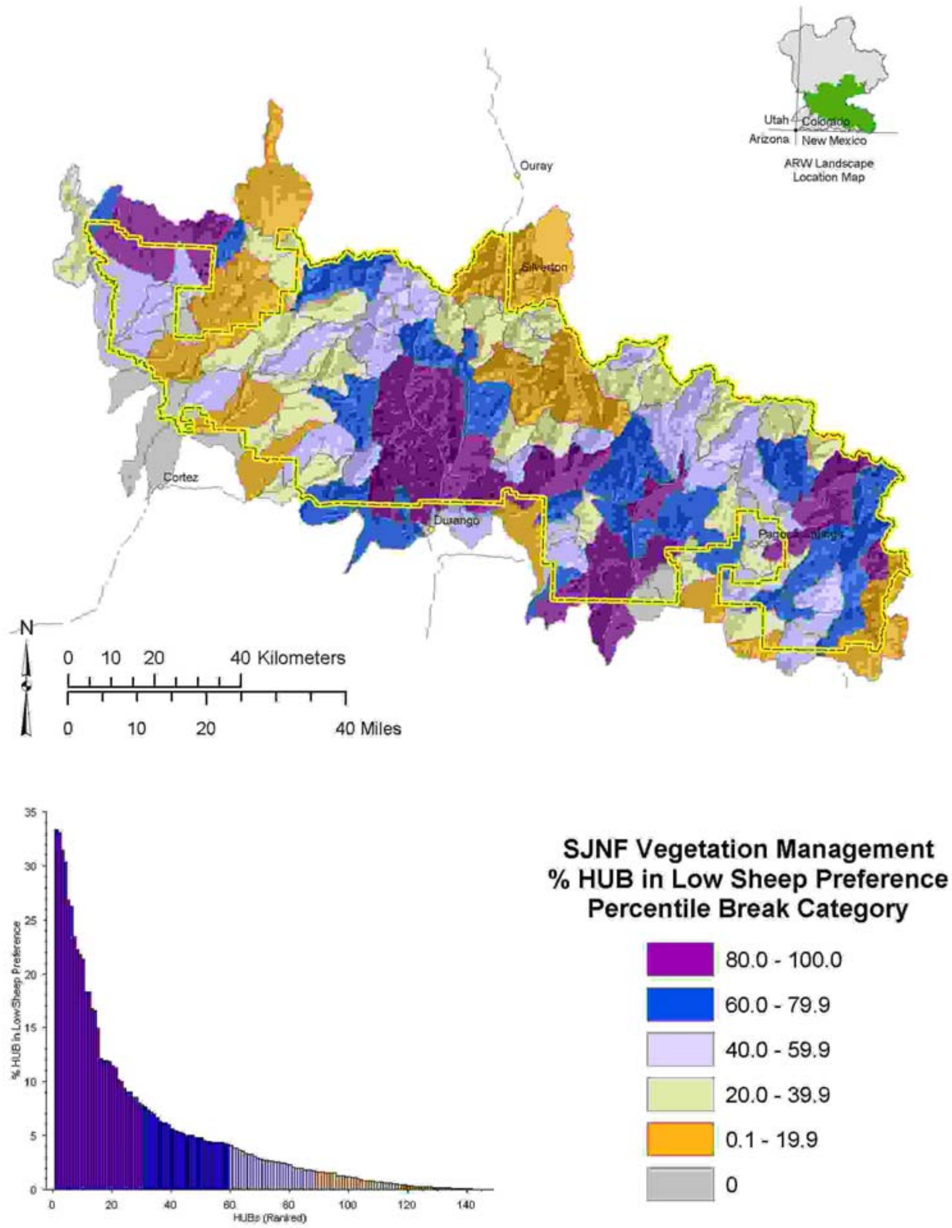

Figure 6.28 Percent HUB in Low Sheep Preference, management scale, San Juan National Forest

Table 6.27 100-80 percentile ranges, Percent HUB in Low Sheep Preference, management scale, San Juan National Forest; Watersheds highlighted in light green are located entirely with the Forest's boundaries

6th Level HUB	6th Level HUB Name	% Watershed in Low Sheep Preference	Category	6th Level HUB	6th Level HUB Name	% Watershed in Low Sheep Preference	Category
140801040406	Hermosa Creek-Dutch Creek	33.4	5	140801011501	Middle Los Pinos River-Red Creek	12.1	5
140300020510	Upper Disappointment Valley	33.1	5	140801020205	Upper Piedra River-Box Canyon	12.0	5
140801040504	Upper Animas Valley-Trimble	31.4	5	140801010103	Sand Creek	11.9	5
140801040405	South Fork Hermosa Creek	30.4	5	140801011306	East Creek	11.9	5
140801040404	Middle Hermosa Creek	26.8	5	140801040403	Upper Hermosa Creek	11.5	5
140801040502	Elbert Creek	26.2	5	140801040601	Junction Creek	11.3	5
140801040602	Upper Lightner Creek	23.5	5	140801010402	Fish Creek	10.2	5
140801040407	Lower Hermosa Creek	22.2	5	140300020507	Dawson Draw	10.0	5
140801040503	Upper Animas Valley-Stevens Creek	21.8	5	140801010306	Mill Creek	9.4	5
140300020506	Brumley Valley	21.4	5	140801011404	Vallecito Reservoir	9.1	5
140801020502	Piedra River-Stollsteimer	18.4	5	140801011704	Upper Spring Creek	9.0	5
140801010303	Laughlin Park	18.3	5	140801020503	Piedra River-Navajo Reservoir Inlet	8.6	5
140300020505	Upper Disappointment Creek	16.7	5	140300020509	Pine Arroyo	8.5	5
140801040804	Upper Florida River-Red Creek	16.6	5	140801020501	Yellowjacket Creek	8.0	5
140801010104	East Fork San Juan River-The Clamshell	14.9	5	140801020302	Lower Devil Creek	7.8	5

Stocking Density

The next step was to model permitted Animal Unit Months (AUMs) on active allotments separately for cattle and for sheep, and then by the number of valley bottom acres by HUB. This part of the assessment focuses on the potential influences of permitted livestock stocking densities on aquatic, riparian and wetland resources.

Greater stocking densities are expressed as a low number of suitable acres per AUM. These types of numbers are based on suitable acres in an allotment. 6th level HUBs with greater stocking densities are areas where the Forest Service needs to carefully assess whether or not the current stocking density is appropriate when considering the current or potential intensity of management.

Highly productive meadows and riparian areas would be expected to be capable of supporting a relatively high stocking density while maintaining long-term health and sustainability under proper management, for short periods of time only. On the other hand, low productivity grasslands on shallow soils or low productivity conifer types, would be expected to be capable of maintaining a relatively low stocking density (e.g., a larger number of acres per AUM) under proper management only if they are able to maintain their long term health and sustainability.

Figures 6.29, 6.30, 6.31 and their accompanying tables, summarize the potential for influence by watershed, due to high, moderate and low grazing allotment densities. In these figures and tables, both cattle and sheep are being referred to. In the tables, those watersheds located entirely on-Forest are highlighted in light green. Regardless how much of a given watershed is located on-Forest; the calculated numbers should be used with caution, as grazing information regarding stocking densities on non-National Forest Service lands was not obtainable. As a result, the numbers summarized in the tables, and the number of watersheds within the 100-80 percentile range, do not take into account the management of grazing on private land. As a result, the number of watersheds within the 100-80 percentile range represents a "minimum" for potential grazing-related influences on aquatic, riparian and wetland resources.

Data for these metrics have been clipped to the Forest boundary. Only ten watersheds, or 6% of the watersheds found on the Forest, are within the 100-80 percentile range for the metric "Percent HUB in High Density Allotment" (Figure 6.29 and Table 6.28). The Beaver Creek-Trail Canyon (HUB# 140300020305) watershed is the only one for the 100-80 percentile range located entirely within the Forest boundary. Upper Beaver Creek-McPhee (HUB# 140300020301) has 100% of its watershed area, located within the Forest boundary, in high density grazing allotments. The Dolores River-Salter Canyon (HUB# 140300020601) had only 58.7% area involved in high density grazing allotments.

As nine out of ten watersheds are located only partially on-Forest there is potential for both on and off-Forest impacts on aquatic, riparian and wetland resources. In the Beaver Creek-Trail Canyon watershed it is likely that there is a greater change for on-Forest versus off-Forest impacts.

29 watersheds are within the 100-80 percentile range for the metric "Percent HUB in Moderate Density Allotment". This equates to 19% of the Forest's total number of watersheds. 29 watersheds are more than the total number of watersheds summarized in the High or Low Density Allotment metrics, for the 100-80 percentile range. Nine watersheds though are located entirely on-Forest. Watersheds within the 100-80 percentile are mainly found in the western half of the Forest (Figure 6.30 and Table 6.29).

The Dawson Draw (HUB# 140300020507), Pine Arroyo (HUB# 140300020509), Brumley Valley (HUB# 140300020506), Ryman Creek (HUB# 140300020504), Upper Disappointment Creek (HUB# 140300020505), Sheep Camp Valley (HUB# 140300020503), and Middle Lost Canyon (HUB# 140300020403) all have 100% of their area within the Forest boundary, involved in moderate density allotments. These seven watersheds represent almost 25% of the watersheds found within the 100-80 percentile range for this metric. The lowest value recorded was for the Stoner Creek (HUB# 140300020208) watershed with 73.1% of its area involved in moderate density grazing allotments.

The potential exists for both on and off-Forest effects to aquatic resources, though the risk for these effects is somewhat lower compared to those watersheds with high grazing densities.

The numbers of watersheds involved in high and moderate stocking densities do not exceed 25% of the watersheds found on the Forest. If the high and moderate stocking densities are compounded by other factors such as high large wild ungulate use, or past impacts such as railroads, roads, or heavy logging these areas would likely be areas of elevated concern. This may indicate a need to focus management attention on those high and moderate stocking density allotments to determine if grazing intensity needs to be modified in order to ensure the long term health and sustainability of aquatic, riparian and wetland resources.

Watersheds within the 100-80 percentile range for the metric "Percent HUB in Low Density Allotment" are found in the eastern two-thirds of the Forest. No watersheds within this percentile range are found in the western-third of the Forest (Figure 6.31 and Table 6.30). Eight watersheds are found entirely on-Forest. The highest recorded value, for low density grazing allotments, was in Ute Creek (HUB# 140801011703), Sand Creek (HUB# 140801020203), Animas River-Spring Creek (HUB# 140801040604), Lower Florida-Ticalotte (HUB# 140801040901), and Upper Spring Creek (HUB# 1401011704). The lowest percentage of area involved in low density sheep grazing was in the Upper Piedra River-Box Canyon (HUB# 140801020205) at 69.8%.

Those watersheds within the 100-80 percentile range have the most potential for experiencing grazing related influences. However, all watersheds summarized under this metric reflect low levels of grazing use. The potential for, and magnitude of any effects, is probably very small.

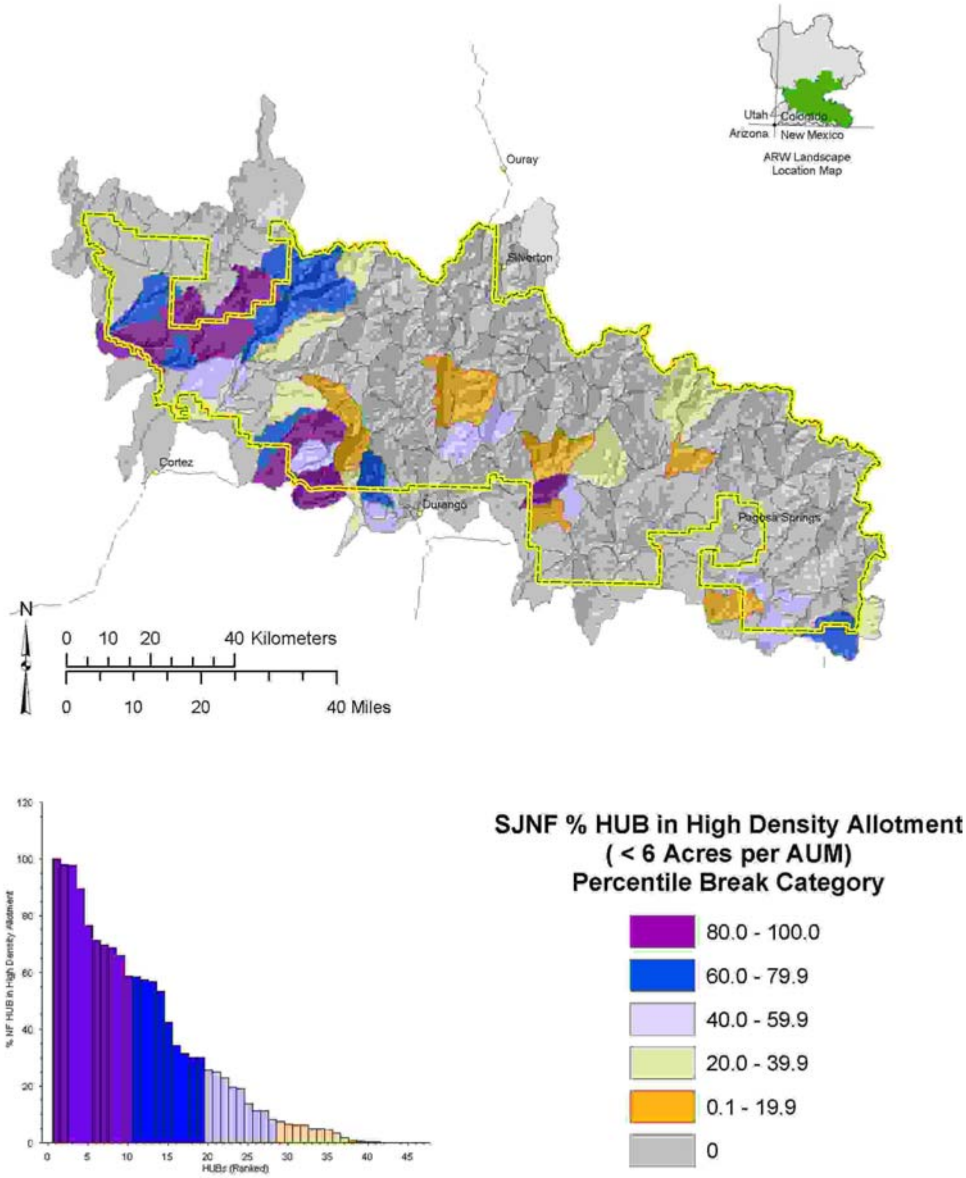

Figure 6.29 Percent of HUB in High Density Allotment, management scale, San Juan National Forest

Table 6.28 100-80 percentile range, Percent of HUB in High Density Allotment,

6th Level HUB	6th Level HUB Name	% of HUB, within National Forest Boundary, in High Density Allotment	Category
140300020301	Upper Beaver Creek - McPhee	100.0	5
140300020303	Calf Creek	98.1	5
140801050105	Upper Cherry Creek	97.7	5
140300020305	Beaver Creek-Trail Canyon	89.3	5
140300020304	Lower Plateau Creek	76.6	5
140300020603	Dolores Canyon-Cabin Creek	71.3	5
140801070103	Upper Mancos Valley	69.6	5
140801011502	Bear Creek	68.9	5
140801070102	West Mancos River	66.0	5
140300020601	Dolores River-Salter Canyon	58.7	5

Table 6.29 100-80 percentile range, Percent of HUB in Moderate Density Allotment

6th Level HUB	6th Level HUB Name	% of HUB, within National Forest Boundary in Moderate Density Allotment	Category	6th Level HUB	6th Level HUB Name	% of HUB, within National Forest Boundary in Moderate Density Allotment	Category
140300020507	Dawson Draw	100.0	5.0	140300020604	Dolores Canyon-Lake Canyon	98.0	5.0
140300020509	Pine Arroyo	100.0	5.0	140300020402	Spruce Water Canyon	96.8	5.0
140300020506	Brumley Valley	100.0	5.0	140300020401	Upper Lost Canyon	96.6	5.0
140300020504	Ryman Creek	100.0	5.0	140801020401	Martinez Creek-Dutton Creek	93.0	5.0
140300020505	Upper Disappointment Creek	100.0	5.0	140801040406	Hermosa Creek-Dutch Creek	90.6	5.0
140300020503	Sheep Camp Valley	100.0	5.0	140801020301	Upper Devil Creek	86.6	5.0
140300020403	Middle Lost Canyon	100.0	5.0	140300020209	Upper Dolores River-Taylor Creek	85.0	5.0

Table 6.29 continued

6th Level HUB	6th Level HUB Name	% of HUB, within National Forest Boundary in Moderate Density Allotment	Category	6th Level HUB	6th Level HUB Name	% of HUB, within National Forest Boundary in Moderate Density Allotment	Category
140801020403	Stollsteimer Creek-Dyke Valley	100.0	5.0	140801020402	Upper Stollsteimer Creek	83.6	5.0
140300020510	Upper Disappointment Valley	100.0	5.0	140801010404	Middle Rio Blanco	82.1	5.0
140801070105	East Fork of Mud Creek	100.0	5.0	140300020511	Disappointment Valley-Wild Horse Reservoir	78.7	5.0
140300020302	Upper Plateau Creek	100.0	5.0	140801020104	Piedra River-O'Neal Creek	77.7	5.0
140801010307	Echo Canyon Reservoir	100.0	5.0	140300020407	House Creek	76.1	5.0
140802020201	Upper Yellowjacket Canyon	100.0	5.0	140801040303	Lower Cascade Creek	75.9	5.0
140300020605	Dolores Canyon-Joe Davis Hill	99.8	5.0	140801040603	Lower Lightner Creek	74.3	5.0
				140300020208	Stoner Creek	73.1	5.0

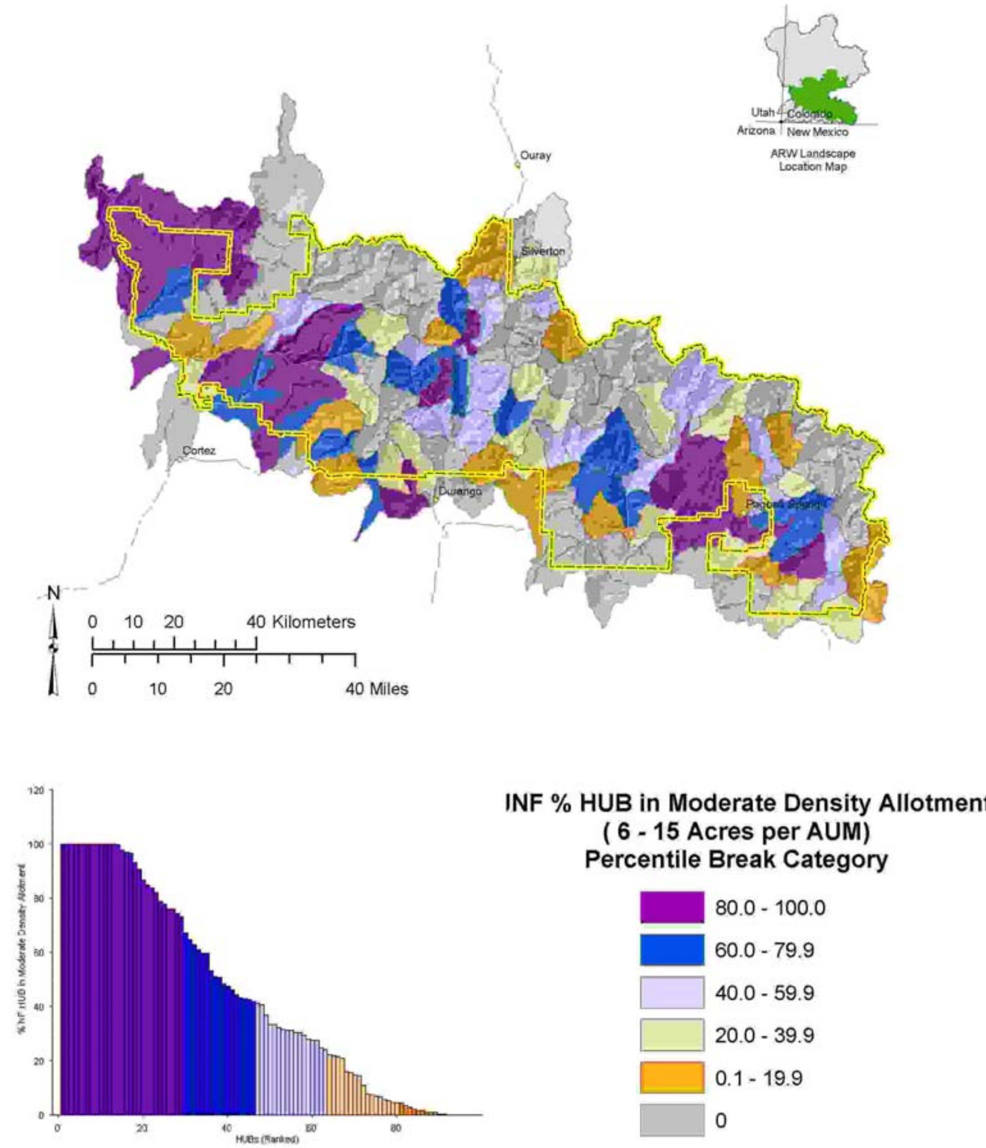

Figure 6.30 Percent of HUB in Moderate Density Allotment, management scale, San Juan National Forest

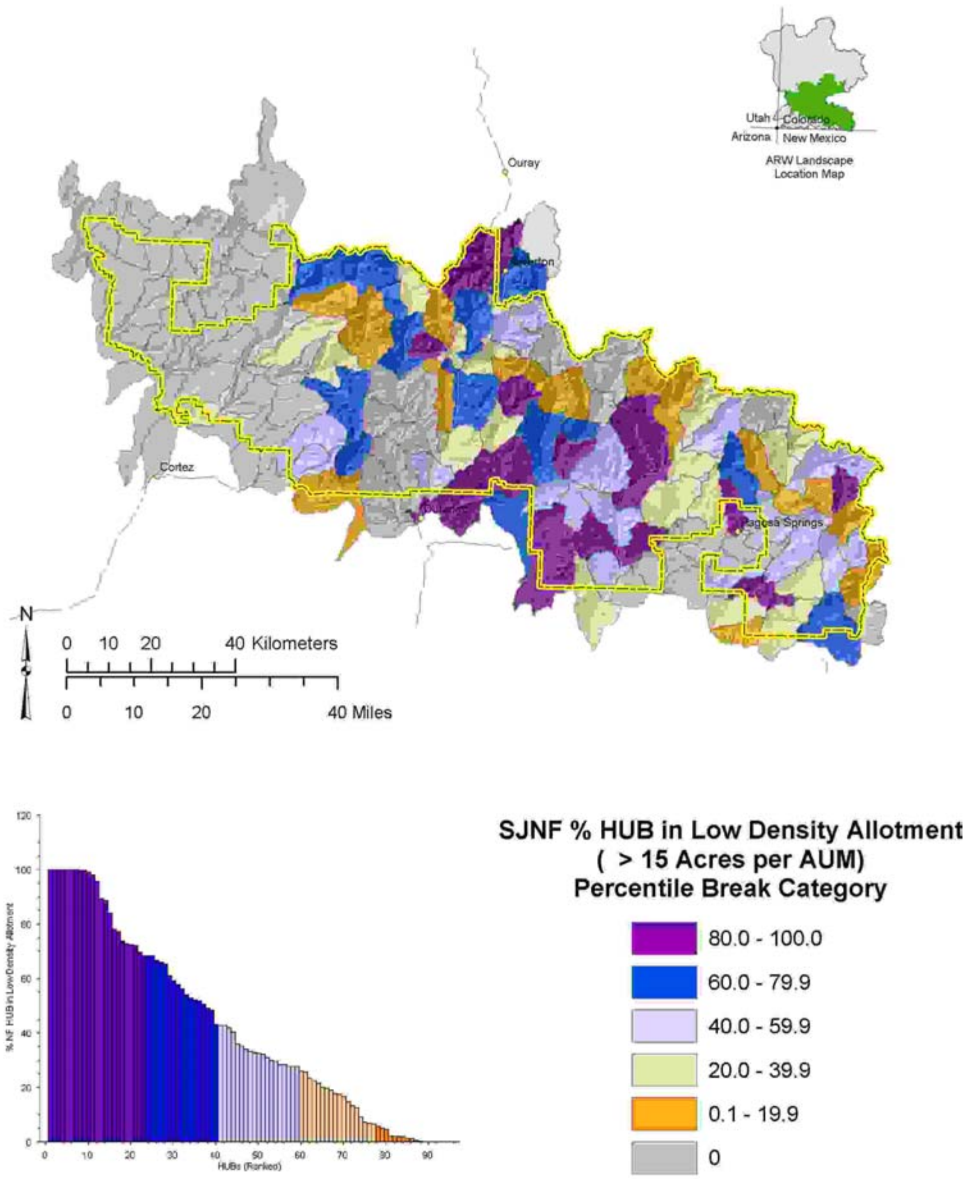

Figure 6.31 Percent of HUB in Low Density Allotment, management scale, San Juan National Forest

Table 6.30 100-80 percentile range, Percent of HUB in Low Density Allotment, management scale, San Juan National Forest

6th Level HUB	6th Level HUB Name	% of HUB, within National Forest Boundary in Low Density Allotment	Category	6th Level HUB	6th Level HUB Name	% of HUB, within National Forest Boundary in Low Density Allotment	Category
140801011703	Ute Creek	100.0	5.0	140801011501	Middle Los Pinos River-Red Creek	95.5	5.0
140801020203	Sand Creek	100.0	5.0	140801040103	Mineral Creek	89.5	5.0
140801040604	Animas River-Spring Creek	100.0	5.0	140801020202	Lower Weminuche Creek	88.8	5.0
140801040901	Lower Florida River-Ticalotte	100.0	5.0	140801040803	Lemon Reservoir	84.1	5.0
140801040804	Upper Florida River-Red Creek	100.0	5.0	140801010406	Lower Rio Blanco-San Juan River	78.1	5.0
140801011704	Upper Spring Creek	100.0	5.0	140801040801	Florida River Headwaters	77.2	5.0
140801010305	McCabe Creek	99.9	5.0	140801010102	Quartz Creek	73.9	5.0
140801040102	Cement Creek	99.8	5.0	140801020302	Lower Devil Creek	72.7	5.0
140801011603	Lower Beaver Creek	99.7	5.0	140801011602	Middle Beaver Creek	72.6	5.0
140801020501	Yellowjacket Creek	99.0	5.0	140801011306	East Creek	72.2	5.0
140801040402	East Fork Hermosa Creek	98.2	5.0	140801020205	Upper Piedra River-Box Canyon	69.8	5.0

In general, livestock prefer lower gradient areas near water. This is especially true for where the canopy is open and there is minimal rock with deep fine textured soil sites. It would be significantly less true for the steeper gradient rocky and/or dense canopy cover sites. Assessing the amount of high, moderate and low preference acreage within valley floor areas, allows analysis to focus in on valley bottom or wetland areas within individual watersheds. These areas may be especially susceptible to livestock influences. This metric evaluates potential at the watershed level. Site-specific assessments would be needed to determine local conditions.

There are 31 watersheds are within the 100-80 percentile zone for the metric "% of Valley Floor HUB within the Forest Boundary in High Density Allotment". These watersheds are found concentrated in the western quarter of the Forest and along its northern border in the east half of the Forest (Figure 6.32). 22 watersheds are found entirely on-Forest (Table 6.31). The percent of the valley floor within each watershed's boundary designated as high cattle preference ranges from a high of 68.3% to a low of 35.4% for the 100-80 percentile range. Beaver Creek-Trail Canyon (HUB# 140300020305) is substantially higher than any of the other watersheds in this percentile range. All of the watersheds in the 100-80 percentile range have high cattle preferences, in valley floor areas, exceeding 25%.

31 watersheds, or 20% of the Forest's watersheds, are within the 100-80 percentile range for metric "Percent Valley Floor in High Sheep Preference". Watersheds in this percentile range are found across the Forest (Figure 6.33). 27 watersheds, or 87% of the watersheds within the 100-80 percentile range, are located on-Forest (Table 6.32). Beaver Creek (HUB# 1401010202) had 81.0 % of its valley floor acres involved in high sheep preference. As a result, it is highly probable that riparian, aquatic and wetland resources in this watershed are experiencing effects related to grazing. The lowest value recorded for the percentage of valley floor acres, in a watershed, designated as high sheep preference was in the Upper West Fork San Juan River (HUB# 140801010201) with a value of 55.3%.

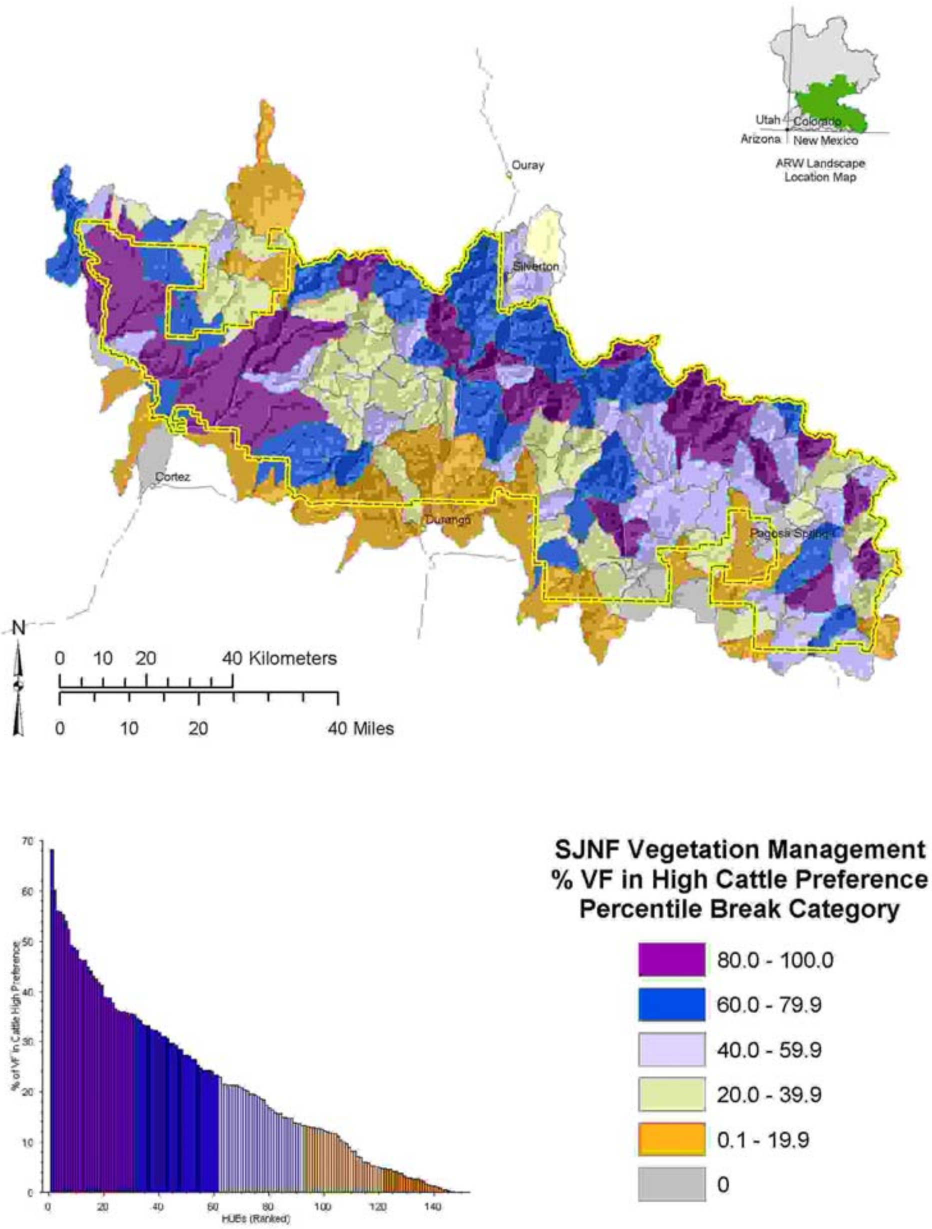

Figure 6.32 Percent Valley Floor in High Cattle Preference, management scale, San Juan National Forest

Table 6.31 100-80 percentile range, Percent Valley Floor in High Cattle Preference, management scale, San Juan National Forest

6th Level HUB	6th Level HUB Name	% of VF in Cattle High Preference	Category	6th Level HUB	6th Level HUB Name	% of VF in Cattle High Preference	Category
140300020305	Beaver Creek-Trail Canyon	68.1	5	140300020401	Upper Lost Canyon	42.5	5
140300020601	Dolores River-Salter Canyon	60.1	5	140801010102	Quartz Creek	41.8	5
140300020306	McPhee Reservoir-Beaver Creek Inlet	56.0	5	140801010402	Fish Creek	41.1	5
140300020602	Narraguinnep Canyon Natural Area	55.8	5	140801020206	Upper Piedra River-Indian Creek	38.9	5
140300020407	House Creek	55.2	5	140801020101	East Fork Piedra River	38.7	5
140300020402	Spruce Water Canyon	53.9	5	140300020406	Upper Dolores River-Italian Creek	38.6	5
140801040801	Florida River Headwaters	52.3	5	140801010203	Wolf Creek	37.7	5
140300020403	Middle Lost Canyon	49.3	5	140801010301	Turkey Creek	36.5	5
140300020509	Pine Arroyo	48.7	5	140300020404	Stapleton Valley	36.0	5
140300020507	Dawson Draw	48.1	5	140300020101	El Deinte Peak	36.0	5
140801020103	Williams Creek	46.5	5	140801011301	Upper Los Pinos River-Ricon La Vaca	35.9	5
140801010404	Middle Rio Blanco	46.1	5	140801040303	Lower Cascade Creek	35.8	5
140300020604	Dolores Canyon-Lake Canyon	46.1	5	140801040301	Upper Cascade Creek	35.6	5
140300020208	Stoner Creek	44.9	5	140801040204	Animas River-Needleton	35.5	5
140801020102	Middle Fork Piedra River	44.1	5	140801011402	Middle Vallecito Creek	35.4	5
140300020105	Lower West Dolores River	43.0	5				

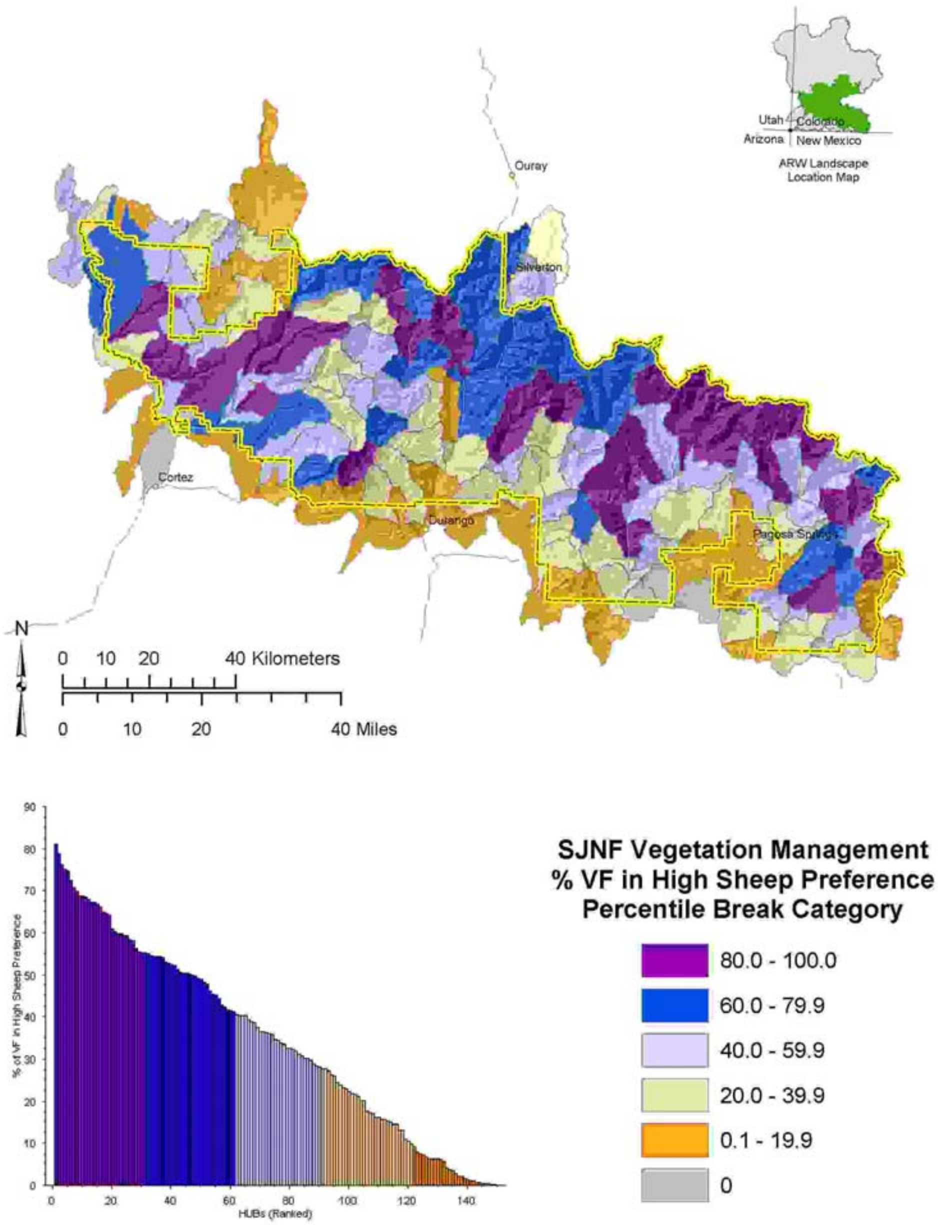

Figure 6.33 Percent Valley Floor in HUB in High Sheep Preference, management scale, San Juan National Forest

Table 6.32 100-80 percentile range, Percent Valley Floor in HUB in High Sheep Preference, management scale, San Juan National Forest

6th Level HUB	6th Level HUB Name	% of VF in High Sheep Preference	Category	6th Level HUB	6th Level HUB Name	% of VF in High Sheep Preference	Category
140801010202	Beaver Creek	81.0	5	140300020601	Dolores River-Salter Canyon	66.2	5
140300020305	Beaver Creek-Trail Canyon	78.8	5	140801020204	First Fork	65.0	5
140801020102	Middle Fork Piedra River	76.3	5	140801040303	Lower Cascade Creek	64.6	5
140801020201	Upper Weminuche Creek	75.0	5	140300020407	House Creek	64.1	5
140801010102	Quartz Creek	74.8	5	140801020206	Upper Piedra River-Indian Creek	60.8	5
140801020103	Williams Creek	72.5	5	140801040802	Upper Florida River-Transfer Park	60.3	5
140801010301	Turkey Creek	70.7	5	140300020202	Upper Dolores River-Cayton Valley	59.8	5
140801040301	Upper Cascade Creek	69.9	5	140300020306	McPhee Reservoir-Beaver Creek Inlet	59.7	5
140801020101	East Fork Piedra River	68.7	5	140300020402	Spruce Water Canyon	59.3	5
140801010402	Fish Creek	68.7	5	140300020602	Narraguinnep Canyon Natural Area	59.2	5
140801010404	Middle Rio Blanco	68.4	5	140801020203	Sand Creek	58.4	5
140801040801	Florida River Headwaters	68.1	5	140801050101	La Plata River headwaters	58.2	5
140801040401	Hermosa Creek headwaters	67.4	5	140801011402	Middle Vallecito Creek	56.3	5
140801010103	Sand Creek	67.3	5	140300020105	Lower West Dolores River	55.6	5
140801010203	Wolf Creek	66.8	5	140300020208	Stoner Creek	55.3	5
				140801010201	Upper West Fork San Juan River	55.3	5

To further investigate the relationship between grazing preference and watershed health, the amount of land located in valley floor areas involved with high density allotments, was evaluated. Only areas located on-Forest were studied. This metric was calculated on a "by watershed" basis and includes grazing by both cattle and sheep. Only nine watersheds were found in the 100-80 percentile. These nine watersheds are found primarily in the western half of the Forest (Figure 6.34). Out of these nine watersheds, only two are located on-Forest (Table 6.33).

Upper Cherry Creek (HUB # 140801050105) had 100% of its valley floor area, within the National Forest boundary, involved in high density grazing allotments. This watershed is not located entirely within the Forest. However, the McPhee Reservoir-Beaver Creek Inlet (HUB # 140300020306) has the lowest value at 76.6%.

Only Beaver Creek-Trail Canyon (HUB # 140300020305) watershed is found within the 100-80 percentile range for the percent of valley floor in high cattle and sheep preference. The other watersheds within the 100-80 percentile range for high density grazing allotments in valley floor areas do not correlate to those watersheds listed in the high preference 100-80 percentile ranges for cattle and sheep.

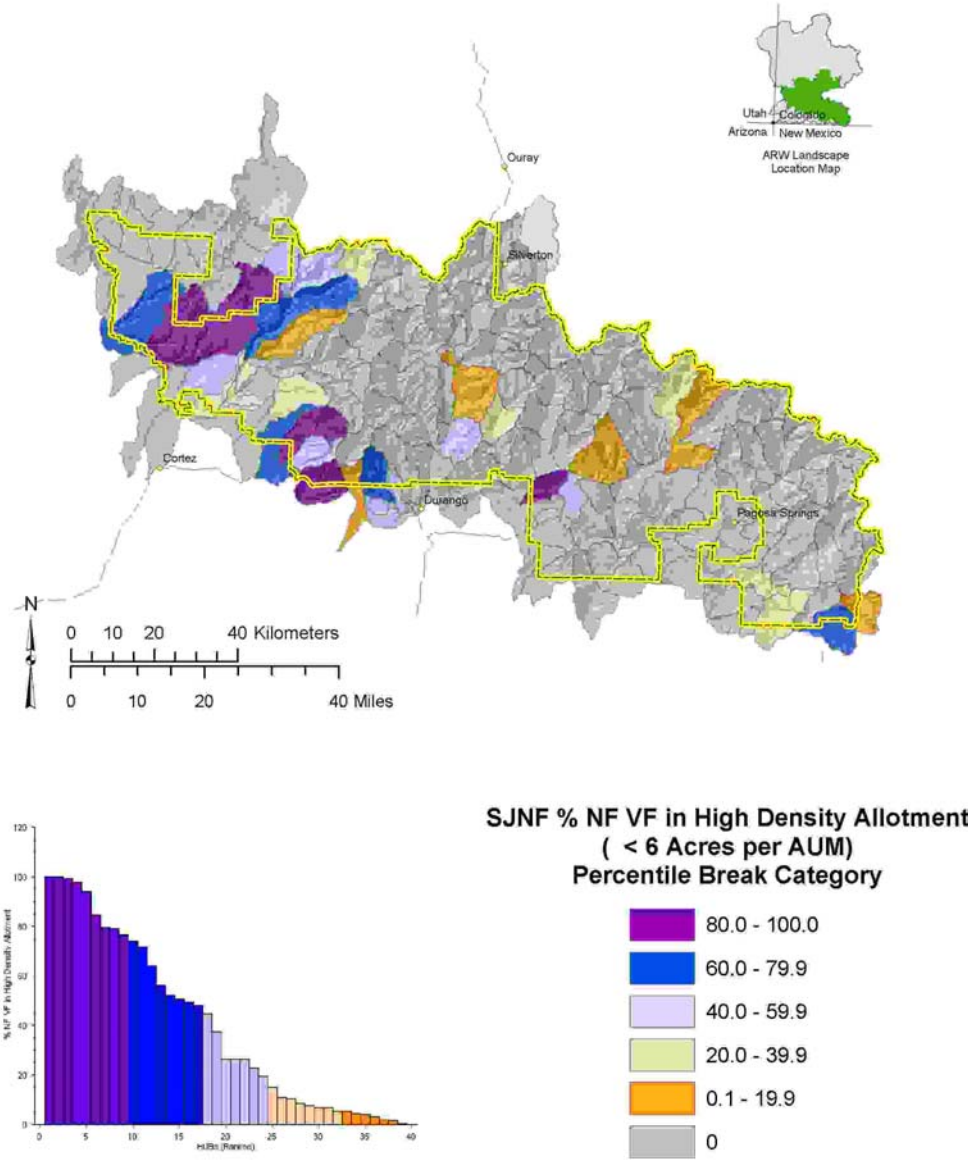

Figure 6.34 Percent National Forest Valley Floor in High Density Allotment, management area, San Juan National Forest

Table 6.33 Percent National Forest Valley Floor in High Density Allotment, management scale, San Juan National Forest, Watersheds located entirely on-Forest are highlighted in light green

6th Level HUB	6th Level HUB Name	% NF VF in High Density Allotment	Category
140801050105	Upper Cherry Creek	100.00	5
140300020301	Upper Beaver Creek - McPhee	100.00	5
140300020303	Calf Creek	99.48	5
140300020305	Beaver Creek-Trail Canyon	97.71	5
140300020304	Lower Plateau Creek	93.98	5
140801070102	West Mancos River	84.81	5
140801011502	Bear Creek	79.79	5
140300020601	Dolores River-Salter Canyon	78.92	5
140300020306	McPhee Reservoir-Beaver Creek Inlet	76.63	5

6th Level HUB Information Needs

An assessment of livestock effects is incomplete without data indicating long-term conditions and trends. Some of this data exists, much of it dating back for decades. Unfortunately this data is not in a format (electronic) that allows for ready access or management. This data should be moved to Terra (the current corporate database) as soon as feasible. Data needs to be collected across the landscape in order to allow adequate assessment of trends and effects of livestock grazing. In addition, new data collections should utilize the information contained in this document as a tool to improve monitoring efforts. Over time, this data should be examined in the context of validating the models and in determining conditions and trends for specific benchmark areas. Allotment management planning on a landscape scale would be an appropriate time to manage this data to provide needed answers.

In order to conduct a detailed evaluation, it is necessary to have detailed plant community mapping and data. This information is lacking for the non-conifer vegetative types. Future efforts need to focus on collection of site-specific plant community mapping and data for grasslands, shrub lands, riparian areas, and wetlands.

It would also be helpful to have a summary assessment of historical livestock grazing in terms of numbers (or AUMs) and the species of livestock grazing specific areas. This would allow for a better assessment of the historical context of livestock management.

Management Implications at the 6th HUB Level

Historically, improperly managed livestock grazing impacted many landscapes. In some cases these impacts are still present in the form of down-cut stream channels and altered plant communities, especially in low gradient riparian communities.

Livestock grazing tends to have the greatest influence on riparian and wetland areas that are low in gradient; fine textured soils with a minimal amount of rock, cobble, or boulders; open canopy or low shrub vegetation types; and, have available water, although there may be some avoidance of standing water areas. These factors are dependent on the timing of the use, the kind of livestock (sheep vs. cattle), the intensity of grazing use, the duration and frequency of grazing; and, the associated management practices, including especially the level of permittee interest and involvement.

The potential for livestock influences is dependent upon which riparian and wetland clusters are involved. Relative to livestock grazing, none of the management scale riparian clusters are dominated by low gradient systems; however they are present to a limited extent in Cluster 4r, 5r, and 6r. The dominance of non-calcareous geology is also important in determining a cluster's sensitivity to grazing impacts. Riparian Clusters 2r, 3r, 4r, 7r and 8r have very little influence from calcareous geology. Cluster 6r has slightly more of an influence due to calcareous geology but the Cluster is still calcareous-limited. These factors combined would determine which watersheds would be the most sensitive to grazing influences on hydrology and sediment.

Cluster 4r is found primarily in the southeastern most portion of the Forest around Pagosa Springs and in the northwestern most portion of the Forest along its southwestern border. Several locations for this cluster also occur outside of the Forest. Where clusters of 4r are found in the western half of the Forest, many of them are within watersheds considered as high preference for both cattle and sheep. However, only several of these watersheds have been ranked out as high density grazing for sheep or cattle.

Numerous watersheds containing Cluster 5r are rated as being in the 100-80 percentile range for the percent of HUB involved in an active grazing allotment. However, when comparing the locations of this cluster's occurrences, there is not a strong correlation between cluster occurrence and those watersheds that have been ranked as in the high preference category for either sheep or cattle. There is a fairly good correlation to watersheds with a high number of springs.

Only a few of the watersheds rated as being in the 100-80 percentile range for the amount of HUB within in active grazing allotment also contain riparian Cluster 6r. This lack of correlation also exists between those watersheds that are categorized as high preference for both sheep and cattle and the occurrence of this riparian cluster (USDA Forest Service, 2006, Report 2of 2).

When allotments are up for renewal, and/or the potential effects of proposed projects are being ascertained, the specialist should refer to the information found in the Ecological Driver Analysis Chapter regarding the characteristics of each cluster. This information can be used in conjunction with the sheep and cattle preference models and the stocking density model to focus administrative attention on those cluster area most likely to experience the greatest potential for hydrological or sediment influences by livestock.

Nine wetland clusters were identified for the San Juan Assessment area. Out of these nine wetland clusters only 3w, 4w, and 6w were characterized as having low sensitivities to changes in sediment load. All the remaining clusters had sensitivities ranging from moderate to high.

Clusters 3w and 4w are found primarily along the southern and southwestern margins of the Forest, and along the northern border of the northwestern portion of the Forest. Watersheds containing these two wetland clusters are often rated as having a high percentage of their watershed in an active grazing allotment. However, only in the western third of the Forest do watersheds contain clusters 3w and 4w, which are also rated as high preference for both sheep and cattle.

Wetlands Cluster 6w is located off-Forest.

All wetland Clusters found on the San Juan have been rated as having a high sensitivity to changes in hydrology. However, only 7w, 8w and 9w have also been characterized as having high sensitivities to changes in sediment regime. All three clusters are associated with glaciated areas.

Wetland Cluster 7w is found primarily along the northeastern rim, north of Pagosa Springs, with the majority of these watersheds falling in designated wilderness areas. 8w is found in the north central portion of the Forest and extends past Silverton to the north. In general the watersheds containing this cluster are not within the 100-80 percentile range for having a high percentage of the watershed in active grazing allotments. The watersheds containing this cluster appear to approximately to be within the 40-79.9 percentile range for high preference sheep and cattle. Only three watersheds contain wetland cluster 9w and are located north and slightly east of Durango. Watersheds involving Cluster 9w have a high percentage of their area involved in active grazing allotments and rank high for preference by sheep and cattle. As a result, these three wetland clusters will be very sensitive to both changes in hydrology and sediment regimes that are associated with land management activities. It should be noted that there is not a strong correlation between where wetlands Clusters 7w, 8w, and 9w occur and watersheds within the 100-80 percentile range for having a high number of springs.

Where sensitivities to changes in sediment and hydrologic regimes are high and sheep preference ratings are moderate or high, these areas represent an opportunity. Sheep tend to be more effectively managed in these kinds of areas than do cattle, and are less likely to have significant influences under proper management. These opportunities for wetland clusters 7w and 8w are located outside of these areas designated as wilderness.

From a fisheries management standpoint, livestock grazing primarily influences populations indirectly through habitat modification rather than directly such as through mortality. Fisheries resources in Clusters 4r and 5r are both highly sensitive to changes in sediment regime, with increases in low gradient streams especially detrimental. Aquatic productivity and benthic macroinvertebrates are highly sensitive to changes in thermal regime. Although both are sensitive to introductions of nutrients, this sensitivity is somewhat less in Cluster 5r as there is more calcareous bedrock geology found in this cluster. Although Cluster 6r is also highly sensitive to sediment increases from a fisheries standpoint and its responsive to nutrient additions, it is the least sensitive to changes in hydrology, sediment, and thermal fluctuations.

Clusters 1r, 2r, 7r, and 8r are less sensitive to changes in hydrologic and sedimentologic regimes from a fisheries standpoint. However, aquatic productivity and macroinvertebrates in Cluster 1r, 2r, 3r, and 8r are highly sensitive to hydrologic and thermal alterations. Thermal alteration could be the result of decreased flow or loss of riparian vegetation.

Recommendations include:

- In the 13 clusters with the greatest potential for livestock influences, which have a total grazing score of "5", management must carefully control the timing, intensity, duration, and frequency of the grazing.

This will ensure that soils are dry enough to withstand hoof effects; preferred forage species are able to provide for replenishment of root reserves and to complete life cycles including seed set or other reproduction. Timing involves not only ensuring that the turn out date considers forage species phenological stage and soil moisture but also that these same tenants are provided for throughout the grazing season. It also involves ensuring that plants have a periodic opportunity for re-growth and photosynthesis following defoliation by grazing. Intensity involves ensuring that the amount of plant material harvested or impacted is managed to levels that will ensure that the plant is able to meet its life cycle requirements with no long-term negative effects. Frequency involves ensuring that individual plants are not grazed repeatedly throughout the season in order to allow those specific plants the opportunity to recover from the influence of harvest of a portion of the leaf area. Duration is closely related to both intensity and frequency but is also focused on ensuring that the grazing animal is not allowed to remain on a given area for a period of time such that excessive compaction or disturbance of the soil occurs.

- Even though grazing impacts due to big game was not analyzed in this assessment, management needs to remember that grazing and browsing by both big came livestock both follow the same basic tenants of management. As a result, both activities need to be accounted for in assessing impacts.
- Overall, management must provide for long term monitoring as a means of ensuring that the influences of grazing are managed in such a manner that the long term health and sustainability of the plants or soil are not compromised.
- Restoration and mitigation in wetlands Cluster 3w provides a unique opportunity for improving watershed health on the Forest as it is the second largest cluster type on the San Juan. Cluster 3w was the most common cluster involved with grazing in watersheds scoring a "5".
- Riparian Cluster 4w was the cluster most commonly associated with watersheds scoring a "5". Restoration and mitigation opportunities will assist improvement in fish populations in low gradient reaches. Restoration and/or mitigation of damage in the riparian zone will moderate fluctuations in thermal regime, improving fisheries and benthic macroinvertebrate habitat.

Direction for Reach/Site Scale Analysis

When evaluating the influences of livestock grazing at the reach/site scale, the following data collection methods should be considered:

1. Determine residual stubble height over time.
2. Conduct an invasive species inventory relative to livestock grazing influences.
3. Determine EPA stream bank stability rating relative to livestock influences.
4. Conduct a proper functioning condition assessment as the findings relates to livestock management practices.
5. Monitor channel morphology changes relative to livestock influences. If possible, set up established long term monitoring cross-sections and photo points.
6. Establish water quality and/or macroinvertebrate indexes and monitor the findings and relate them to livestock management practices.
7. Conduct implementation monitoring and determine the degree to which terms and conditions from the grazing permit (and associated plans or instructions - such as allowable use, pasture timing requirements, etc.) are met.

Vegetation Management Cumulative Percentile Ranking

Vegetation management consists of grazing, timber harvest, and fire. To determine the total combined effects of vegetation management on aquatic health, the results of all metrics for fire and timber harvest were combined, along with some of the metrics from grazing. Not all the grazing metrics could be included in the synthesis as there was significant overlap between some measures. For example the percentage of the watershed in high, moderate, and low density grazing allotment were calculated in the grazing section. However if all of these metrics were included in the synthesis, all watersheds would receive at least one high ranking.

As the high density grazing allotment metric provides the highest potential for influence on aquatic, riparian, and wetland ecosystems, only this measure was included in the synthesis analysis. As a result the following metrics were not included in this cumulative percentile ranking process: the percent of HUB in moderate density grazing allotment, the percent of HUB in low density grazing allotment, the percent of HUB in moderate preference area (both cattle and sheep), and the percent of HUB in low preference area (cattle and sheep). All metrics that were defined and analyzed grazing can be found in the individual grazing section write up.

All the metrics that were determined suitable for inclusion in the cumulative analysis were then combined and re-ranked, and a cumulative percentile ranking was determined. Rankings were divided into five differing groups, each with a 20 percentile ranges. Watersheds within the 100-80 percentile range have the most susceptibility to impacts on aquatic health while those falling within the 19.9-0.1 percentile range have the lowest potential for being influenced. The combined ranking of the selected vegetation management metrics within the involved watersheds delineates which ones will have the most potential for related impacts on aquatic, riparian, and wetland resources.

This analysis was performed at the management scale, with data existing for all federally administered lands within the 154 HUBs found on the San Juan National Forest. This analysis is relative only to the portion of the 6th level HUBs surface area within the San Juan National Forest boundary, and is intended to provide the reader with the additive rankings at this scale. Unlike the previous methodology used in the individual topic sections, the results are evenly distributed across the total number of HUBs at this scale.

The results of the cumulative ranking process for all recreation metrics, in all watersheds associated with the San Juan National Forest are summarized in Table 6.36 at the end of this section. This table also summarizes which riparian and wetland clusters are associated with each watershed on the Forest. Essentially this table will function as a "look up" table, so at a glance one can determine which water use activities affect each watershed, as well as have a reference to watershed sensitivity.

The table also indicates which watersheds are located entirely on-Forest. The three metrics used in this analysis are summarized in Table 6.34.

The cumulative percentile ranking for the 100-80 percentile range is summarized in Table 6.35 and displayed in map format in Figure 6.35. 17 watersheds in the vegetation management analysis were within the 100-80 percentile range. The maximum cumulative ranking for water uses is 15.

Cumulative totals for water uses, in the 100-80 percentile range, varied from the maximum of 15 to a low of 12. These watersheds are found in the far west and eastern half of the Forest Figure 6.35. These watersheds reflect high levels of use for grazing, fire and clearcutting of timber.

The Upper Florida-Transfer Park (HUB# 140801040802) received the highest total score of 15, reflecting maximums in all three component categories. This watershed is located entirely within the Forest's boundaries. On-Forest effects to aquatic resources almost certainly are present and there is a strong likelihood off of-Forest downstream impacts as well, as the watersheds southern most boundary is only 4.5 miles from the Forest's boundary. There are three watersheds with a cumulative total of 14, six watersheds with a cumulative total of 13, and six watersheds with a cumulative total of 12.

Out of all 17 watersheds ten of them are located entirely on-Forest. As with the Upper Florida-Transfer Park watershed, the remaining 16 watersheds have the both the potential for on and off-Forest effects on aquatic, riparian, and wetland resources.

Table 6.34 Summary of criteria used in Vegetation Management cumulative analysis.

Metric	Explanation
% of NF HUB in Active Allotment	Percentage of 6th HUB involved in an active grazing allotment. All HUBs listed have all or a portion of their area located within the San Juan National Forest boundary
% NF HUB in High Density Allotment	Percentage of 6th HUB involved in a high density grazing allotment
% NF VF in High Density Allotment	Percentage of 6th HUB involved in a high density grazing allotment and located with the valley floor area
% HUB in Cattle High Preference	Percentage of 6th HUB involved in a grazing allotment with a high cattle preference
% of VF in Cattle High Preference	Percentage of 6th HUB involved in a grazing allotment with a high cattle preference and located in a valley floor area
% HUB in High Sheep Preference	Percentage of 6th HUB involved in a grazing allotment with a high sheep preference and located in a valley floor area
% of VF in High Sheep Preference	Percentage of 6th HUB involved in a grazing allotment with a high sheep preference and located in a valley floor area

42 watersheds on the Forest fell within the 79.9-60 percentile range, which corresponds to a cumulative water uses total of "4". This total number of watersheds represents the 2nd highest total number of watersheds within a percentile range. 24 of these watersheds are located entirely on-Forest Table 6.36. These watersheds are found across the Forest. Watersheds in this group are dominated by grazing, fire and clearcutting. 24 of these watersheds are located on-Forest Table6.36. There is potential for both on and off-Forest downstream impacts.

Table 6.35 Vegetation Management Cumulative Percentile Ranking 100-80 Percentile Ranking; Watersheds located entirely on-Forest highlighted in light green

6th Level HUB	6th Level HUB Name	Fire Total	Clearcut Total	Grazing Total	Cumulative Vegetation Management Totals	Vegetation Management Category Cumulative Rank	Riparian Cluster	Wetlands Cluster
140801070104	Chicken Creek	3	5	4	12	5	4	3
140801070102	West Mancos River	3	5	5	13	5	2	1
140801070101	East Mancos River-Middle Mancos River	3	5	5	13	5	2	1
140801040803	Lemon Reservoir	4	5	3	12	5	2	1
140801040802	Upper Florida River-Transfer Park	5	5	5	15	5	1	7
140801040501	Upper Animas Valley-Canyon Creek	5	4	4	13	5	1	2
140801020301	Upper Devil Creek	5	5	3	13	5	5	3
140801020206	Upper Piedra River-Indian Creek	5	4	3	12	5	5	3
140801020204	First Fork	3	5	4	12	5	2	1
140801011601	Upper Beaver Creek	3	5	4	12	5	5	4
140801011502	Bear Creek	3	4	5	12	5	5	4
140801010405	Rito Blanco	5	5	3	13	5	5	4
140801010404	Middle Rio Blanco	5	5	4	14	5	4	3
140300020407	House Creek	5	4	5	14	5	4	3
140300020406	Upper Dolores River-Italian Creek	4	5	5	14	5	4	3
140300020401	Upper Lost Canyon	2	5	5	12	5	2	1
140300020105	Lower West Dolores River	3	5	5	13	5	5	3

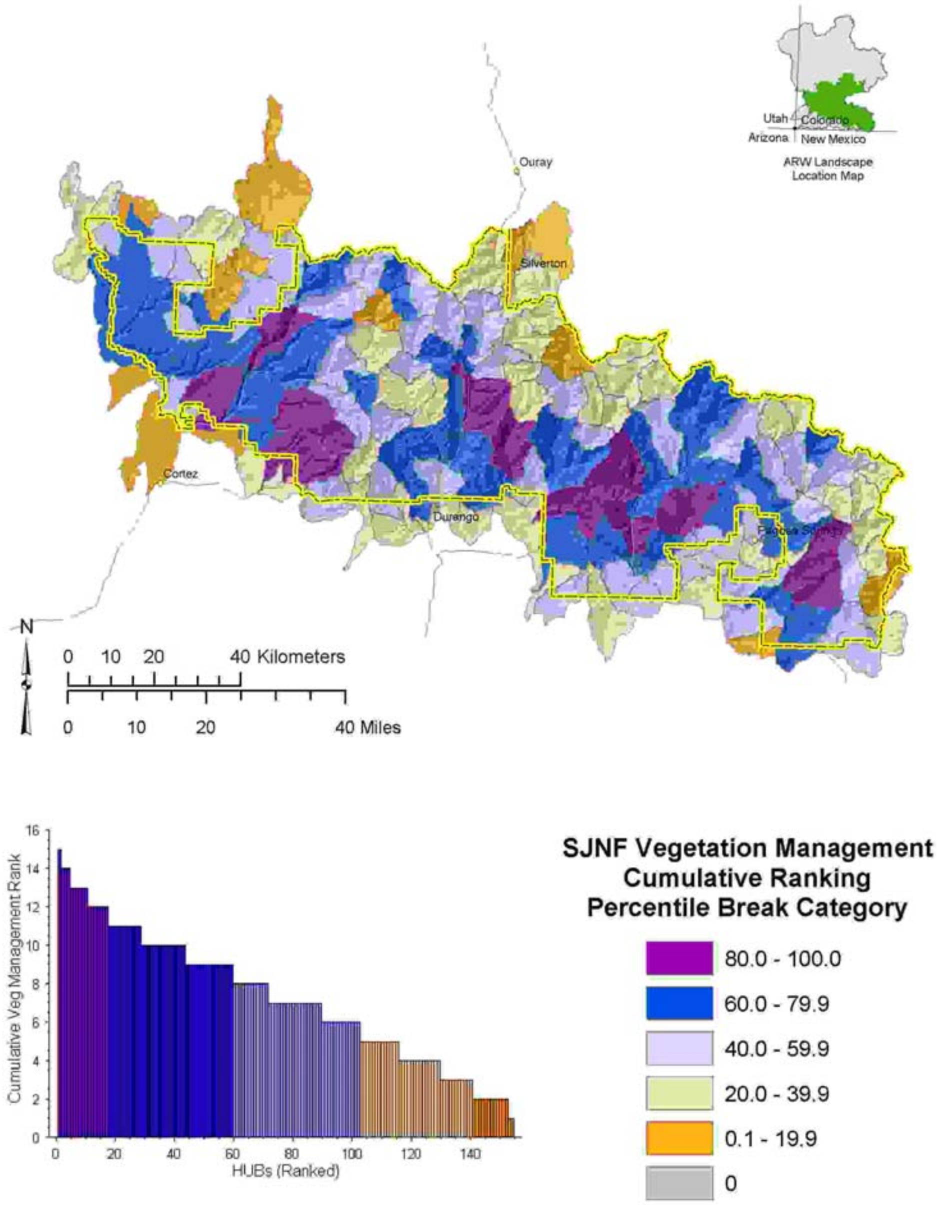

Figure 6.35 Vegetation Management Category, Cumulative 100-80 Percentile Ranking, management scale, San Juan National Forest

43 watersheds were found to be within the 59.9-40 percentile range. This percentile range corresponds to a water uses cumulative total of “3”. This percentile range contains the largest number of watersheds associated with the Forest. These watersheds are found across the Forest. 20 of these watersheds were located entirely on-Forest (Table 6.36). Again the potential for impacts to aquatic, riparian, and wetland resources is both on and off-Forest. Grazing, fire and clearcutting activities still all occur within this percentile range.

38 6th level HUBs have cumulative totals placing them in the 39.9-20.0 percentile range. This percentile range corresponds to the water uses cumulative total of “2” (Table 6.36). This is the third highest total number of watersheds for any of the five percentile ranges. These watersheds are found primarily along the Forest’s entire boundary although there are 18 watersheds found entirely within the Forest’s boundary. Although there is still potential for both on and off-Forest impacts to aquatic resource exists, an examination of vegetation cumulative totals indicates that cumulative totals by category range from “0” to “3”.

The 19.9-0.1 percentile range is comprised of 14 watersheds. This percentile range is denoted by a “1” under the cumulative water uses total column (Table 6.36). These watersheds are found scattered across the western, northern, and southeastern most portions of the Forest (Figure 6.35. Only two of these watersheds are located entirely on-Forest. Cumulative totals by water use category are very low ranging from a total of 2-0. This percentile range is dominated by fire and grazing. The influences of clearcuts are largely absent. As although there is little overall potential for impacts to aquatic, riparian, and wetland resources, most of the potential is off-Forest as the watersheds not found entirely on-Forest have large portions of their area located off-Forest.

There are no watersheds that don’t have any fire, grazing or clearcut activity.

Table 6.36 Water Uses Category-Cumulative Percentile Ranking of Watersheds on the San Juan National Forest; Watersheds located entirely with the Forest boundary are highlighted in light green

6th Level HUB	6th Level HUB Name	Fire Total	Clearcut Total	Grazing Total	Cumulative Vegetation Management Totals	Vegetation Management Category Cumulative Rank	Riparian Cluster	Wetlands Cluster
140801070104	Chicken Creek	3	5	4	12	5	4	3
140801070102	West Mancos River	3	5	5	13	5	2	1
140801070101	East Mancos River-Middle Mancos River	3	5	5	13	5	2	1
140801040803	Lemon Reservoir	4	5	3	12	5	2	1
140801040802	Upper Florida River-Transfer Park	5	5	5	15	5	1	7
140801040501	Upper Animas Valley-Canyon Creek	5	4	4	13	5	1	2
140801020301	Upper Devil Creek	5	5	3	13	5	5	3
140801020206	Upper Piedra River-Indian Creek	5	4	3	12	5	5	3
140801020204	First Fork	3	5	4	12	5	2	1
140801011601	Upper Beaver Creek	3	5	4	12	5	5	4
140801011502	Bear Creek	3	4	5	12	5	5	4
140801010405	Rito Blanco	5	5	3	13	5	5	4
140801010404	Middle Rio Blanco	5	5	4	14	5	4	3
140300020407	House Creek	5	4	5	14	5	4	3
140300020406	Upper Dolores River-Italian Creek	4	5	5	14	5	4	3
140300020401	Upper Lost Canyon	2	5	5	12	5	2	1
140300020105	Lower West Dolores River	3	5	5	13	5	5	3
140801040804	Upper Florida River-Red Creek	5	2	2	9	4	5	3
140801040601	Junction Creek	5	2	2	9	4	2	3
140801040503	Upper Animas Valley-Stevens Creek	5	4	2	11	4	5	2
140801040502	Elbert Creek	4	4	2	10	4	5	7

Table 6.36 Continued

6th Level HUB	6th Level HUB Name	Fire Total	Clearcut Total	Grazing Total	Cumulative Vegetation Management Totals	Vegetation Management Category Cumulative Rank	Riparian Cluster	Wetlands Cluster
140801040407	Lower Hermosa Creek	4	3	2	9	4	5	1
140801040402	East Fork Hermosa Creek	1	5	3	9	4	2	1
140801040303	Lower Cascade Creek	3	2	4	9	4	2	8
140801020501	Yellowjacket Creek	5	3	3	11	4	4	4
140801020401	Martinez Creek-Dutton Creek	4	2	3	9	4	5	4
140801020302	Lower Devil Creek	5	3	3	11	4	6	3
140801020205	Upper Piedra River-Box Canyon	5	3	3	11	4	5	3
140801020203	Sand Creek	2	5	3	10	4	2	1
140801020104	Piedra River-O'Neal Creek	4	3	3	10	4	5	4
140801020103	Williams Creek	4	2	4	10	4	2	2
140801020102	Middle Fork Piedra River	3	2	4	9	4	2	7
140801011603	Lower Beaver Creek	4	2	3	9	4	5	4
140801011602	Middle Beaver Creek	4	2	3	9	4	5	4
140801011404	Vallecito Reservoir	5	2	2	9	4	5	3
140801011403	Lower Vallecito Creek	5	3	3	11	4	1	2
140801011306	East Creek	5	1	3	9	4	2	1
140801010507	Coyote Creek	5	3	3	11	4	4	3
140801010406	Lower Rio Blanco-San Juan River	5	2	4	11	4	4	4
140801010306	Mill Creek	5	2	3	10	4	4	4
140801010304	Upper Pagosa Springs	5	2	3	10	4	4	3
140801010302	Fourmile Creek	3	3	3	9	4	2	3
140801010203	Wolf Creek	2	4	4	10	4	1	7
140300020604	Dolores Canyon-Lake Canyon	4	3	4	11	4	4	3
140300020603	Dolores Canyon-Cabin Creek	4	2	4	10	4	4	3

Table 6.36 Continued

6th Level HUB	6th Level HUB Name	Fire Total	Clearcut Total	Grazing Total	Cumulative Vegetation Management Totals	Vegetation Management Category Cumulative Rank	Riparian Cluster	Wetlands Cluster
140300020602	Narraguinnep Canyon Natural Area	3	3	5	11	4	4	4
140300020601	Dolores River-Salter Canyon	2	2	5	9	4	4	3
140300020507	Dawson Draw	4	1	4	9	4	4	3
140300020404	Stapleton Valley	3	3	4	10	4	4	3
140300020403	Middle Lost Canyon	3	3	4	10	4	4	3
140300020402	Spruce Water Canyon	3	4	4	11	4	4	3
140300020306	McPhee Reservoir-Beaver Creek Inlet	3	2	5	10	4	4	3
140300020305	Beaver Creek-Trail Canyon	2	3	5	10	4	4	3
140300020304	Lower Plateau Creek	2	2	5	9	4	5	4
140300020209	Upper Dolores River-Taylor Creek	2	5	3	10	4	5	3
140300020208	Stoner Creek	2	4	5	11	4	2	1
140300020205	Roaring Forks Creek	2	5	3	10	4	2	1
140300020202	Upper Dolores River-Cayton Valley	2	3	4	9	4	2	1
140300020102	Fish Creek	1	5	4	10	4	2	1
140801050105	Upper Cherry Creek	2	3	3	8	3	5	4
140801040602	Upper Lightner Creek	3	1	3	7	3	5	3
140801040504	Upper Animas Valley-Trimble	5	1	1	7	3	5	5
140801040405	South Fork Hermosa Creek	2	2	2	6	3	2	1
140801040403	Upper Hermosa Creek	2	2	2	6	3	2	1
140801040401	Hermosa Creek headwaters	1	4	3	8	3	2	1
140801040302	Lime Creek	2	1	4	7	3	2	8
140801040301	Upper Cascade Creek	1	3	4	8	3	2	8

Table 6.36 Continued

6th Level HUB	6th Level HUB Name	Fire Total	Clearcut Total	Grazing Total	Cumulative Vegetation Management Totals	Vegetation Management Category Cumulative Rank	Riparian Cluster	Wetlands Cluster
140801040204	Animas River-Needleton	5	0	2	7	3	2	8
140801020502	Piedra River-Stollsteimer	4	2	2	8	3	6	4
140801020405	Lower Stollsteimer Creek	5	0	1	6	3	6	4
140801020404	Middle Stollsteimer Creek	5	0	1	6	3	6	3
140801020403	Stollsteimer Creek-Dyke Valley	3	2	1	6	3	4	4
140801020402	Upper Stollsteimer Creek	4	2	2	8	3	5	4
140801020202	Lower Weminuche Creek	3	2	3	8	3	2	3
140801020101	East Fork Piedra River	2	2	3	7	3	1	7
140801011704	Upper Spring Creek	3	1	2	6	3	6	4
140801011501	Middle Los Pinos River-Red Creek	5	2	1	8	3	5	3
140801011402	Middle Vallecito Creek	3	1	3	7	3	2	8
140801011305	Indian Creek	2	2	2	6	3	2	2
140801010601	San Juan River-Trujillo	2	1	3	6	3	6	3
140801010506	Little Navajo River	1	2	4	7	3	2	3
140801010504	Navajo River-Weisel Flat	1	2	4	7	3	4	3
140801010403	Rio Blanco River-Blanco Basin	1	3	3	7	3	2	2
140801010308	San Juan River-Eightmile Mesa	4	1	1	6	3	5	4
140801010305	McCabe Creek	2	2	2	6	3	5	4
140801010303	Laughlin Park	3	1	2	6	3	5	1
140801010301	Turkey Creek	2	2	4	8	3	2	2
140801010204	Lower West Fork San Juan River	3	0	3	6	3	2	7

Table 6.36 Continued

6th Level HUB	6th Level HUB Name	Fire Total	Clearcut Total	Grazing Total	Cumulative Vegetation Management Totals	Vegetation Management Category Cumulative Rank	Riparian Cluster	Wetlands Cluster
140801010104	East Fork San Juan River-The Clamshell	3	2	2	7	3	1	7
140300020509	Pine Arroyo	2	2	4	8	3	4	3
140300020506	Brumley Valley	4	0	3	7	3	6	4
140300020504	Ryman Creek	4	0	3	7	3	5	4
140300020502	Disappointment Creek Headwaters	1	3	3	7	3	5	1
140300020408	McPhee Reservoir-Dolores River	3	0	3	6	3	4	4
140300020303	Calf Creek	1	2	4	7	3	5	4
140300020301	Upper Beaver Creek –McPhee	1	2	4	7	3	5	1
140300020207	Dolores River-Priest Gulch	1	3	3	7	3	2	1
140300020206	Bear Creek	1	5	2	8	3	2	1
140300020201	Dolores River Headwaters-Tin Can Basin	1	2	4	7	3	2	1
140300020104	Groundhog Creek	1	4	3	8	3	2	1
140300020103	Upper West Dolores River	3	2	3	8	3	2	1
140300020101	El Deinte Peak	1	2	4	7	3	2	1
140801070105	East Fork of Mud Creek	1	1	2	4	2	4	4
140801070103	Upper Mancos Valley	1	0	3	4	2	5	4
140801050102	Mayday Valley	1	0	2	3	2	7	3
140801050101	La Plata River headwaters	2	0	2	4	2	2	8
140801040901	Lower Florida River-Ticalotte	1	1	1	3	2	5	4
140801040801	Florida River Headwaters	0	0	4	4	2	8	9
140801040604	Animas River-Spring Creek	2	1	2	5	2	6	5
140801040603	Lower Lightner Creek	2	1	2	5	2	4	4
140801040406	Hermosa Creek-Dutch Creek	1	2	2	5	2	1	1
140801040404	Middle Hermosa Creek	1	2	2	5	2	2	1

6th Level HUB	6th Level HUB Name	Fire Total	Clearcut Total	Grazing Total	Cumulative Vegetation Management Totals	Vegetation Management Category Cumulative Rank	Riparian Cluster	Wetlands Cluster
140801040203	Needle Creek	1	0	2	3	2	8	9
140801040202	Animas River-Tenmile Creek	1	0	3	4	2	2	8
140801040201	Elk Creek	0	0	3	3	2	3	8
140801040104	Animas River-Cunningham Creek	1	0	2	3	2	2	8
140801040103	Mineral Creek	1	0	3	4	2	2	8
140801020503	Piedra River-Navajo Reservoir Inlet	2	1	1	4	2	6	3
140801020201	Upper Weminuche Creek	1	1	3	5	2	1	8
140801011703	Ute Creek	3	1	1	5	2	6	4
140801011503	Los Pinos River-Bayfield	2	1	1	4	2	5	4
140801011304	Three Sisters	0	0	3	3	2	8	9
140801011303	Lake Creek	1	1	3	5	2	2	8
140801011302	Upper Los Pinos River-Flint Creek	1	0	3	4	2	2	8
140801011301	Upper Los Pinos River-Ricon La Vaca	1	0	3	4	2	2	8
140801010604	Upper Cat Creek	3	1	1	5	2	4	3
140801010503	Navajo Peak	1	1	2	4	2	2	1
140801010402	Fish Creek	1	1	3	5	2	1	7
140801010401	Rio Blanco Headwaters	1	1	2	4	2	1	7
140801010307	Echo Canyon Reservoir	2	1	2	5	2	5	4
140801010202	Beaver Creek	0	0	3	3	2	1	7
140801010201	Upper West Fork San Juan River	1	0	2	3	2	2	8
140801010103	Sand Creek	2	0	2	4	2	1	7
140801010102	Quartz Creek	1	0	3	4	2	1	7
140801010101	Headwaters East Fork San Juan River	0	0	3	3	2	1	7
140300020605	Dolores Canyon-Joe Davis Hill	1	1	3	5	2	4	3

Table 6.36 Continued

6th Level HUB	6th Level HUB Name	Fire Total	Clearcut Total	Grazing Total	Cumulative Vegetation Management Totals	Vegetation Management Category Cumulative Rank	Riparian Cluster	Wetlands Cluster
140300020511	Disappointment Valley-Wild Horse Reservoir	1	1	3	5	2	6	3
140300020505	Upper Disappointment Creek	1	0	2	3	2	5	4
140300020503	Sheep Camp Valley	0	0	3	3	2	5	4
140300020204	Upper Dolores River-Scotch Creek	0	3	2	5	2	2	1
140802020201	Upper Yellowjacket Canyon	0	0	2	2	1	4	3
140802020106	Lower Alkali Canyon-Narraguinnep Canyo	1	0	1	2	1	6	6
140802020103	Hartman Canyon	0	0	1	1	1	6	6
140801040102	Cement Creek	0	0	2	2	1	3	8
140801040101	Animas River above Howardsville	0	0	2	2	1	2	8
140801011401	Upper Vallecito Creek	0	0	2	2	1	2	8
140801010602	Montezuma Creek	1	0	1	2	1	4	4
140801010502	West Fork Navajo River	0	0	2	2	1	1	7
140300036101	Naturita Creek	0	1	1	2	1	5	4
140300020510	Upper Disappointment Valley	0	0	2	2	1	6	6
140300020501	Bear Creek-Disappointment Creek	0	0	1	1	1	5	4
140300020405	Lower Lost Canyon	0	0	2	2	1	4	3
140300020302	Upper Plateau Creek	0	0	2	2	1	5	4
140300020203	Rico Valley	0	1	1	2	1	2	1

Chapter 7
Urbanization Category
Management Scale

Key Findings Management Scale

1. Both major oil and gas, and electrical lines are located within the San Juan National Forest. Analysis of ratios of miles of electrical transmission line per valley bottom stream mile show that there are 22 watersheds with high potential for effects on aquatic, riparian, and wetland resources. Analysis of the same ratio for pipelines shows that only five watersheds have a high potential for pipeline related effects to these resources.
2. Current and meaningful population statistics were not available at the time this report was written.
3. 11% of the land within the forest's boundary is privately owned. Analysis of private ownership in valley bottoms shows that 27 watersheds have a high potential for being influenced by land management activities on these lands. Only two of these watersheds are located entirely on-Forest. The majority of these privately owned lands are found in valley bottom areas
4. Adjacent to and within the San Juan National Forest five stream segments were found to be on the State of Colorado's 303(d) list for impaired water bodies. Only two watersheds were found to have a high potential for influences on aquatic, riparian, and wetland resources. Only one of these watersheds was located entirely on-Forest.
5. The highest potential for influences on aquatic, riparian, and wetland resources from increased urbanization would be increased water consumption and development or riparian and wetlands on private lands.

Influence of Major Transmission Corridors

Transmission corridors are swaths of land which have been cleared of vegetation for a variety of uses including electrical power lines and buried lines. Buried lines include oil and gas lines. These corridors may have a significant impact on aquatic, riparian, and wetland resources as indicated by Elliot, 2000 and France, 1997. Corridors are typically laid out in relatively straight lines. Sharp angles occur where changes of direction are needed and there is limited ability to by-pass areas of resource concern. Corridors often go up and down steep slopes and may cross aquatic, riparian, and wetland areas at near right angles (USDA Forest Service, 2003). Levels of disturbance associated with installation, maintenance, and use depend in part on existing vegetation types and the amount of area needed to be cleared.

Potential effects related to transmission corridors include: alteration of flow regimes related to road construction, modification of water quality due to increased sediment production related to road construction and vegetation removal, alteration of wetland and riparian conditions due to vegetation removal or construction activities directly within the aquatic resource itself. For example, the Trans-Co pipeline was buried under the Dolores River causing direct channel and water quality impacts. Additional potential effects include modification of channel morphology due to sediment derived from inadequately vegetated corridors and channel modification related to decreased bank stability (USDA Forest Service, 2003).

This chapter evaluates the effects of electrical and oil and gas corridors on aquatic resources. The locations of these corridors are displayed in Figure 7.1. The data analyzed for transmission corridors is found within, and outside of, the forest boundary. As both oil and gas pipeline and electrical transmission line data are located within and outside of the forest boundary, the results of calculated metrics are representative of on-the-ground conditions.

Analysis was conducted to determine which HUB's have the highest combined concentrations of both pipelines and electrical transmission lines. The results of this analysis are displayed in Figure 7.2 and Table 7.1. 23 HUBs were found within the 100-80 percentile range. These HUBs, which have the highest potential for influence on aquatic resources, due to the combined effects of pipelines and electrical transmission lines, are found in the southern half of the forest (Figure 7.2). Upper Stollsteimer Creek (HUB 140801020402) watershed had the highest combined electrical and pipeline mileage (80.9) and the highest ratio per valley bottom stream mile (0.87). The Ute Creek (HUB 140801011703) watershed had the lowest mileage total (10.0) and as well as the lowest ratio (0.23).

Although Upper Stollsteimer Creek (HUB 140801020402) has the highest total combined mileage and ratio, most of the potential effects would occur downstream and off-forest as that is where the lines are concentrated. There is some potential for effects in the watershed's headwaters, which are located on-Forest.

In the Hartman Canyon (HUB 140802020103), East Fork of Mud Creek (HUB 140801070105), and Lower Alkali Canyon-Narraguinepp Canyon (HUB 140802020106) watersheds any potential effects will be located off-forest and downstream. Only very small portions of these watersheds intersect the forest boundary.

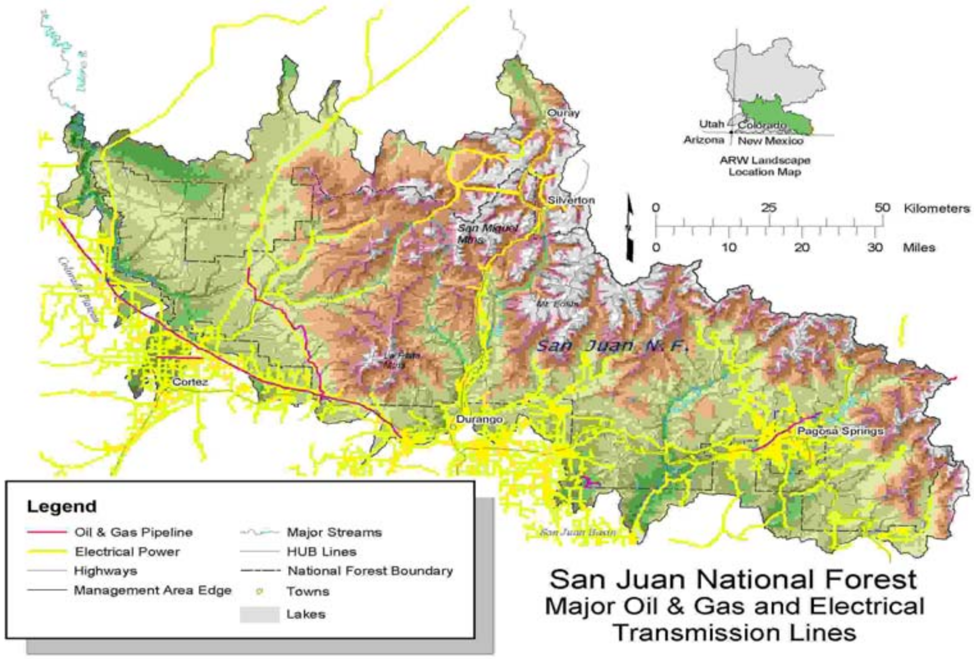

Figure 7.1 Location of Major Oil and Gas and Electrical Transmission Lines, management scale, San Juan National Forest.

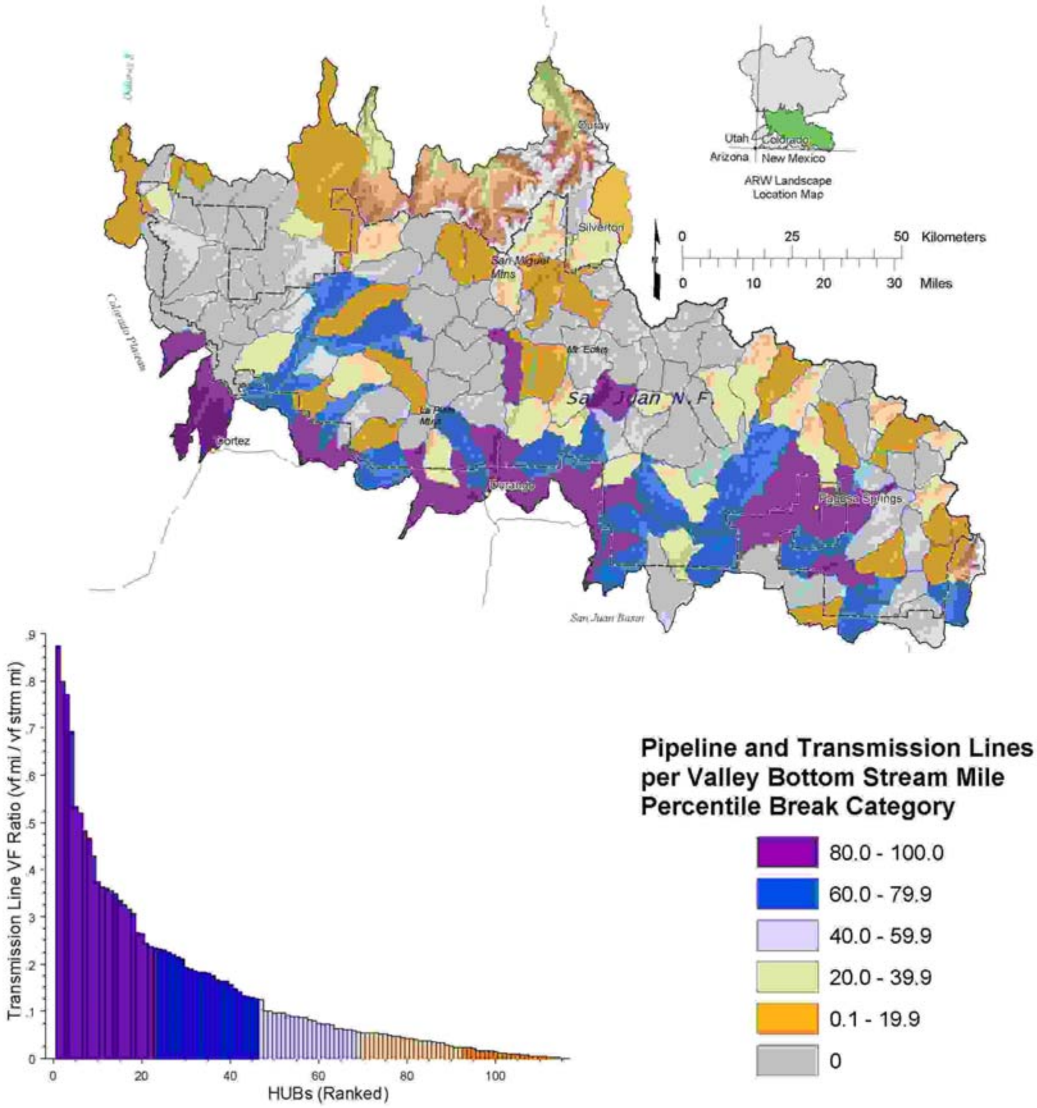

Figure 7.2 The rank and distribution of the combined total number of pipeline and electrical transmission corridor miles per stream mile, management scale, San Juan National Forest

Table 7.1 Summary of the combined total number of pipeline and electrical transmission corridor miles per stream mile, 100-80 percentile range, management scale, San Juan National Forest. Watersheds highlighted in green are entirely located within the National Forest Boundaries.

HUB6	HUB6NAME	Ratio of Total Miles Pipeline and Electrical Transmission Line to Miles of Valley Bottom Stream	Total Miles Pipeline and Electrical Transmission Line	Stream Density
140801020402	Upper Stollsteimer Creek	0.87	80.9	2.7
140801040604	Animas River-Spring Creek	0.80	16.2	2.1
140801070103	Upper Mancos Valley	0.77	31.0	2.6
140802020103	Hartman Canyon	0.69	73.2	3.1
140801070105	East Fork of Mud Creek	0.53	39.0	3.4
140801010307	Echo Canyon Reservoir	0.52	25.2	2.5
140802020106	Lower Alkali Canyon-Narraguinnep Canyon	0.48	49.9	3.3
140801010305	McCabe Creek	0.47	23.1	2.7
140801040901	Lower Florida River-Ticalotte	0.43	23.2	2.7
140801011503	Los Pinos River-Bayfield	0.37	29.7	2.2
140801050102	Mayday Valley	0.36	14.2	2
140801040502	Elbert Creek	0.36	12.3	1.9
140801011403	Lower Vallecito Creek	0.36	15.2	3.1
140801040504	Upper Animas Valley-Trimble	0.35	12.7	2.5
140801040603	Lower Lightner Creek	0.34	23.4	2.6
140801020401	Martinez Creek-Dutton Creek	0.33	23.9	2.9
140801011602	Middle Beaver Creek	0.32	17.3	3.3
140801020403	Stollsteimer Creek-Dyke Valley	0.31	13.7	2.7
140801010304	Upper Pagosa Springs	0.27	12.6	2.8
140802020201	Upper Yellowjacket Canyon	0.26	12.1	2.1
140801010406	Lower Rio Blanco-San Juan River	0.24	11.0	2.8
140801010306	Mill Creek	0.24	13.5	3.1
140801011703	Ute Creek	0.23	10.0	2.6

* All acreage data was generated using Arcview GIS and associated spreadsheets. All numbers rounded to nearest tenth of a mile.

Major electrical transmission lines are found across the forest (Figure 7.1). Lines are most common along the southern boundary of the forest and are also concentrated around Cortez and Pagosa Springs. Some electrical transmission lines do occur in the smaller headwater areas around Durango, but these do not comprise a major portion of the lines.

In order to evaluate potential effects related to electrical transmission corridors two specific types of analysis were conducted. The number of miles of transmission corridor per valley bottom stream mile was calculated. The numbers of corridor crossings per valley bottom stream mile were also calculated.

Analyses focused on valley bottom areas as they are most susceptible to land management related influences. For these analyses, valley bottoms are defined as a stable environment containing dynamic components such as perennial and intermittent streams, primary and secondary stream channels, and active terraces and floodplains (Bighorn ARWEA, 2004). As valley bottoms include riparian zones separate calculations for riparian zones were not conducted.

Analysis of the number of transmission corridor miles per valley bottom stream mile is displayed in Figures 7.3 and Table 7.2. 23 watersheds have been ranked within the 100-80 percentile range. Figure 7.3 shows the rank and distribution of the 23 watersheds within the 100-80 percentile range. These watersheds occur across the Forest and are found primarily in the southern half of the forest.

HUBs ranked in the 100-80 percentile range, will have the highest potential for transmission corridor related effects on hydrology, aquatic resources, and riparian zones. Upper Stollsteimer Creek (HUB 140801020402), Animas River-Spring Creek (HUB 140801040604), Upper Mancos Valley (HUB 140801070103), and Hartman Canyon (HUB 140802020103) watersheds have the four highest ratios listed in Table 7.1. The four watersheds have stream densities of 2.7, 2.1, 2.6 and 3.1 respectively.

Average watershed density for the forest is 2.3 miles. The higher stream density ratios in these watersheds are likely due to the underlying geology. The geology in these areas consists primarily of Cretaceous and Tertiary age shale's and sandstones. The watersheds are located on the edge of the Colorado Plateau. As a result, it is likely the higher drainage densities are due to geological structural control at the plateau edge. These three watersheds are located almost entirely outside of the forest boundary and two percent or less of their area is located within the forest boundary. Lower Yellowjacket Creek (HUB# 140802020201) is the only other watershed in this situation. Headwater areas are essentially at the edge of the forest border and do not flow into the forest. These drainages flow to the south and southwest away from the forest. As a result, potential transmission related effects on aquatic, hydrologic and riparian resources would be located off-forest. However, all the other watersheds are either located entirely on the forest or a substantial portion of the watershed is within the forest boundary. In general drainage patterns are from the continental divide on the north/northeast to the south/southwest. As a result there is potential for downstream effects related to transmission lines for those watersheds falling within the 100-80% percentile range.

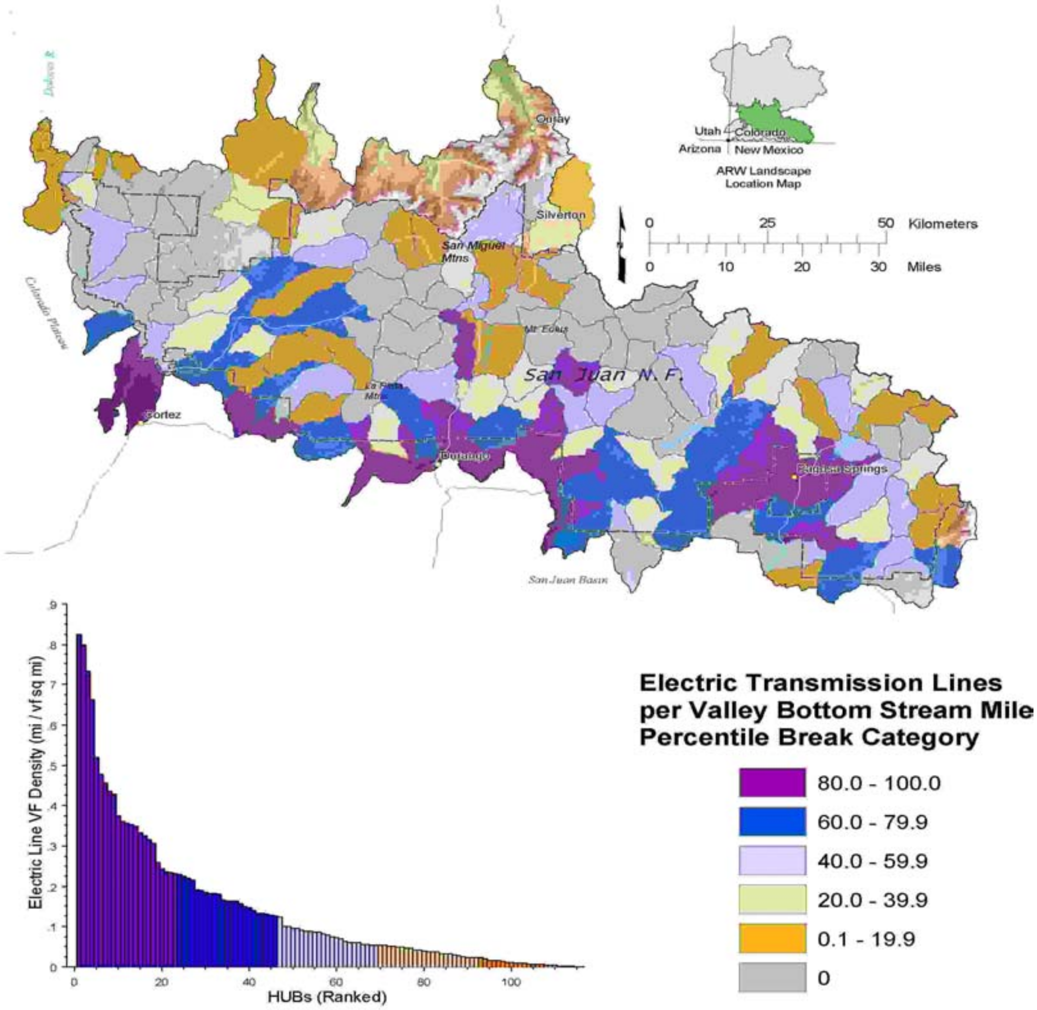

Figure 7.3 The rank and distribution of electrical transmission lines per valley bottom stream mile, management scale, San Juan National Forest.

Table 7.2 Summary of Electrical Transmission Line Ratios for the 100-80 percentile range, management scale, San Juan National Forest. Watersheds highlighted in green are wholly located within the National Forest Boundaries.

HUB6	HUB6NAME	Ratio of Electrical Transmission Line Per Valley Bottom Stream Mile	Stream Density
140801020402	Upper Stollsteimer Creek	0.83	2.7
140801040604	Animas River-Spring Creek	0.80	2.1
140801070103	Upper Mancos Valley	0.73	2.6
140802020103	Hartman Canyon	0.66	3.1
140801010307	Echo Canyon Reservoir	0.52	2.5
140801070105	East Fork of Mud Creek	0.48	3.4
140802020106	Lower Alkali Canyon-Narraguinnep Canyon	0.46	3.3
140801010305	McCabe Creek	0.44	2.7
140801040901	Lower Florida River-Ticalotte	0.43	2.7
140801011503	Los Pinos River-Bayfield	0.37	2.2
140801040502	Elbert Creek	0.36	1.9
140801011403	Lower Vallecito Creek	0.36	3.1
140801050102	Mayday Valley	0.35	2.0
140801040504	Upper Animas Valley-Trimble	0.35	2.5
140801040603	Lower Lightner Creek	0.33	2.6
140801020401	Martinez Creek-Dutton Creek	0.33	2.9
140801011602	Middle Beaver Creek	0.32	3.3
140801020403	Stollsteimer Creek-Dyke Valley	0.31	2.7
140801010304	Upper Pagosa Springs	0.26	2.8
140801010406	Lower Rio Blanco-San Juan River	0.24	2.8
140801010306	Mill Creek	0.24	3.1
140801011703	Ute Creek	0.23	2.6
140801011501	Middle Los Pinos River-Red Creek	0.23	0.23

Effects to hydrologic, aquatic, and riparian resources not only occur where a transmission corridor parallel drainages, but also where corridors cross the streams. Figure 7.4 displays the location of both electrical and pipeline transmission corridor stream crossings. Data analysis results for electrical transmission stream corridor crossings are summarized in Figure 7.5 and Table 7.3.

The 22 watersheds, which were found to be within the 100-80 percentiles ranking for electrical transmission line stream crossings, are distributed across the forest (Figure 7.5). The three HUBs located completely within forest boundary are highlighted in light green in Table 7.3. HUBs, which are not highlighted, have only a portion of their area located within the forest boundary. Animas River-Spring Creek watershed has the highest number of stream crossings and the largest ratio of the 22 watersheds in the 100-80 percentile range.

However, it does not have the largest number of electrical transmission corridor stream crossings per stream mile. The high watershed ratio due to the high number of power lines (16.2 miles of power line) relative to stream density (2.1mi/sq.mi). The high concentration of power lines in this watershed is related to the watersheds close proximity to Durango.

Only 336 acres of the Animas River-Spring Creek watershed is located on-Forest and within that area there is only 0.9 miles of electrical transmission However, there is the potential for electrical transmission corridor related effects on downstream off-forest aquatic resources due to the concentration of power lines and the number of stream crossings.

Animas River-Spring Creek (HUB 140801040604), Upper Stollsteimer Creek (HUB 140801020401), Upper Mancos Valley (HUB 140801070103), Hartman Canyon (HUB 140802020103) watersheds have only very minor portions of their watersheds within the forest boundary. In these watersheds there is very little potential for on-Forest effects related to the transmission corridors. The corridors are concentrated in the portions of the watersheds located outside of the forest boundary. As a result, there are no downstream effects in these watersheds originating on the forest. However, there is the potential for downstream effects to aquatic resources located on private land as these watersheds fall within the 100-80 percentile range.

Existing effects are predicted to remain constant as there are no plans at present for adding any new electrical transmission corridors (Powers, 2004, Pers. Comm.).

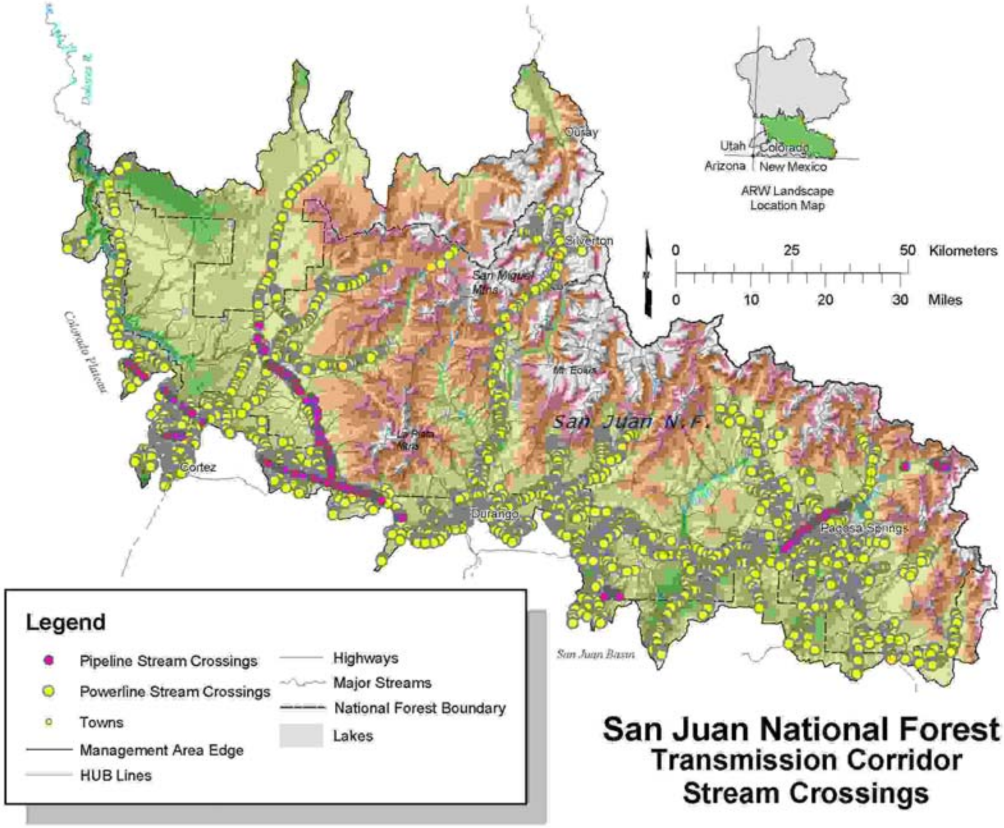

Figure 7.4 Location and Distribution of Electrical and Pipeline Transmission Corridor Stream Crossings, Management Scale, San Juan National Forest.

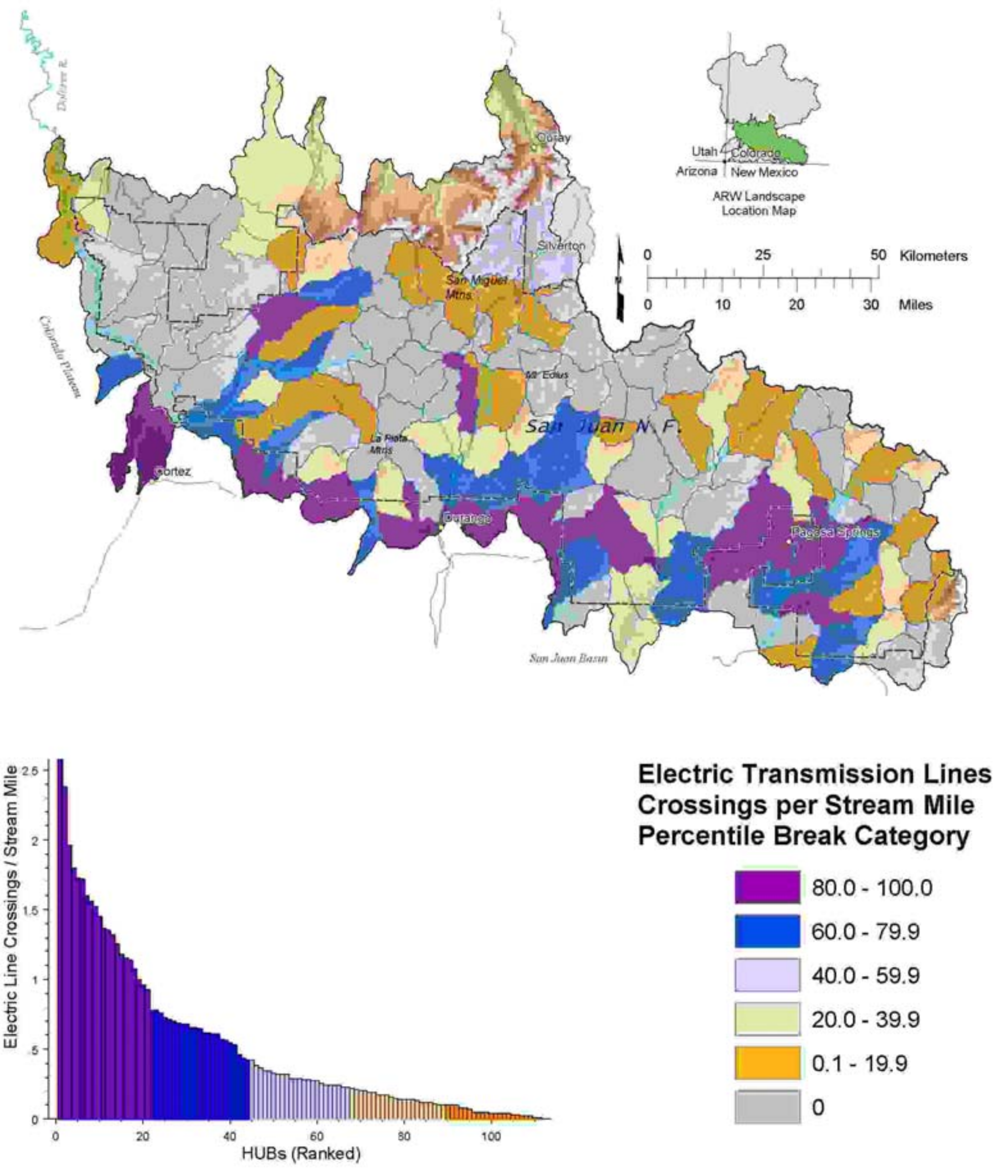

Figure 7.5 The rank and distribution of the number of electrical transmission corridor crossings per mile of valley bottom streams, management scale, San Juan National Forest.

Table 7.3 Summary of Ratio of Number of Electrical Transmission Corridor Stream Crossings per valley bottom stream mile, Management Scale, San Juan National Forest.

HUB6	HUB6NAME	# Stream Crossings Per Stream mile	Ratio of # of Stream Crossings Per Stream Mile	Stream Density (mi./sq.mi)
140801040604	Animas River-Spring Creek	70	2.68	2.1
140801020402	Upper Stollsteimer Creek	238	2.38	2.7
140801070103	Upper Mancos Valley	86	1.96	3.1
140802020103	Hartman Canyon	193	1.8	3.1
140801040603	Lower Lightner Creek	151	1.73	2.6
140801011602	Middle Beaver Creek	110	1.72	3.3
140801010305	McCabe Creek	88	1.6	2.7
140801011503	Los Pinos River-Bayfield	142	1.56	2.2
140801040901	Lower Florida River-Ticalotte	95	1.52	2.7
140801020403	Stollsteimer Creek-Dyke Valley	76	1.45	2.7
140801040502	Elbert Creek	66	1.37	1.9
140801010307	Echo Canyon Reservoir	75	1.35	2.5
140801010306	Mill Creek	94	1.32	3.1
140801010406	Lower Rio Blanco-San Juan River	86	1.26	2.8
140802020106	Lower Alkali Canyon-Narraguinepp Canyon	125	1.18	3.1
140801070105	East Fork of Mud Creek	85	1.16	3.4
140801020401	Martinez Creek-Dutton Creek	92	1.14	2.9
140801020501	Yellowjacket Creek	90	1.08	2.6
140801050105	Upper Cherry Creek	72	1	1.8
140801010304	Upper Pagosa Springs	52	0.96	2.8
140801011601	Upper Beaver Creek	49	0.93	2.7
140300020105	Lower West Dolores River	63	0.78	2.0

* All acreage data was generated using Arcview GIS and associated spreadsheets. Information may not be statistically accurate.

Major oil and gas pipelines found within, and adjacent to, the forest boundary are displayed in Figure 7.1. The pipelines are buried along their entire length and transport natural gas and oil. The corridors are approximately 75-100 ft wide. Vegetation has been cleared and periodic surface facilities and access roads are present. The Durango-Cortez line runs from east to west between Durango and Cortez. The Trans-Colorado runs north south between these towns. The Pagosa Springs line is located just west of the town and trends northeast-southwest (Figure 7.1). All three major lines are transporting natural gas found off-forest to other locations.

For pipeline transmission corridors two metrics were calculated: the number of acres disturbed associated with a pipeline per square mile of valley bottom and the number of pipeline transmission corridor crossings per valley bottom stream mile. The first metric was calculated as a density measurement in order to have a better sense of the potential magnitude of surface disturbance associated with the development and maintenance of a pipeline corridor. In order to do this a buffer of 100 ft was used, based on discussions with San Juan National Forest personnel, familiar with the pipelines on the Forest. The results of these metric analyses are displayed in Figure 7.6 and Table 7.4.

At present, five watersheds are within the 100-80 percentile range for the number of acres disturbed per square mile of valley bottom (Table 7.4 and Figure 7.6). Two of these watersheds are located completely within the forest boundary and are highlighted in light green. Pipeline data, like the electrical transmission data, is found both within and outside of the forest boundary. As a result data was clipped to watershed boundaries and not to the forests boundary. Consequently calculated densities, for those watersheds not located entirely on the forest, have not been biased due to partial watershed areas being included into the calculations.

The Upper Cherry Creek has the highest ratio of miles of pipeline per valley bottom stream mile with a ratio of 0.057 (Table 7.4). It also has the highest number of disturbed acres of the five watersheds. Oil and gas pipelines cross drainages within the watershed 19 times but only 2% of the valley bottom is involved (Tables 3.5 and 3.6). Upper Stollsteimer Creek has the lowest number of acres disturbed per valley bottom square mile. This is best explained by the low number of stream crossings within the watershed. Analysis shows that there are only nine stream crossings in this watershed.

As for the Stapleton Valley, Upper Spring Creek, and Headwaters East Fork San Juan River watersheds the percentage of valley bottom disturbance appears to depend on the total amount of valley bottom for each HUB, the order of the streams crossed or closely paralleled by the pipeline.

Table 7.5 and Figure 7.7 summarize the results of analysis calculating the number of oil and gas pipeline stream crossing ratios. Four watersheds are found to be within the 100-80 percentile range for the number of oil and gas pipeline transmission corridor stream crossings. In Table 7.5 Stapleton Valley (HUB# 1403000020404) and Spruce Water Canyon (# 140300020402) is located within the forest boundary.

Figure 7.7 shows the location and distribution of the watersheds in the 100-80 percentile range. These watersheds are found along or near the southwestern border of the forest. Table 7.5 shows that the stream densities for these four watersheds range from a high of 2.7 miles of stream per square mile in the McCabe Creek watershed to a low of 1.8 in the Upper Cherry Creek watershed.

Both the Upper Cherry Creek and McCabe Valley watersheds have the potential for on and off forest (downstream) effects on aquatic resources as their headwater areas are located on forest. However, there is greater potential for these effects in the Upper Cherry Creek watershed. More of its headwaters are located on forest and there is a greater concentration of pipelines, and stream crossings, in this area.

Spruce Water Canyon and Stapleton Valley however are located within the forest boundary. Pipelines do cross stream within the forest boundary and as these two watersheds fall within the 100-80 percentile range there is the potential for both on forest and downstream off-forest effects.

In the future it is possible that there will be an additional oil and gas pipeline added to the existing north-south corridor that is located between Durango and Cortez (See Figure 3.1). The addition of this pipeline would be related to ongoing activity and development in northwest Colorado (Powers, 2004). The Northern Basin DEIS proposes to develop 300 new coal bed methane gas wells from east of Durango, east to Bayfield, and to west of Chimney Rock Archaeology area. As a consequence, future management decisions in these two areas will need to take into account any additional effects related pipeline and collector line installation. Resource issues to consider would include removal of vegetation, ground disturbance, and increased erosion. As drainages in both areas eventually flow off forest, downstream effects would need to be taken into consideration. The implementation of Best Management Practices (BMPs) is recommended in association with any projects that may result in ground disturbance, vegetation removal, and erosion, in order to maintain superior upstream water quality. This would prevent or minimize any downstream effects.

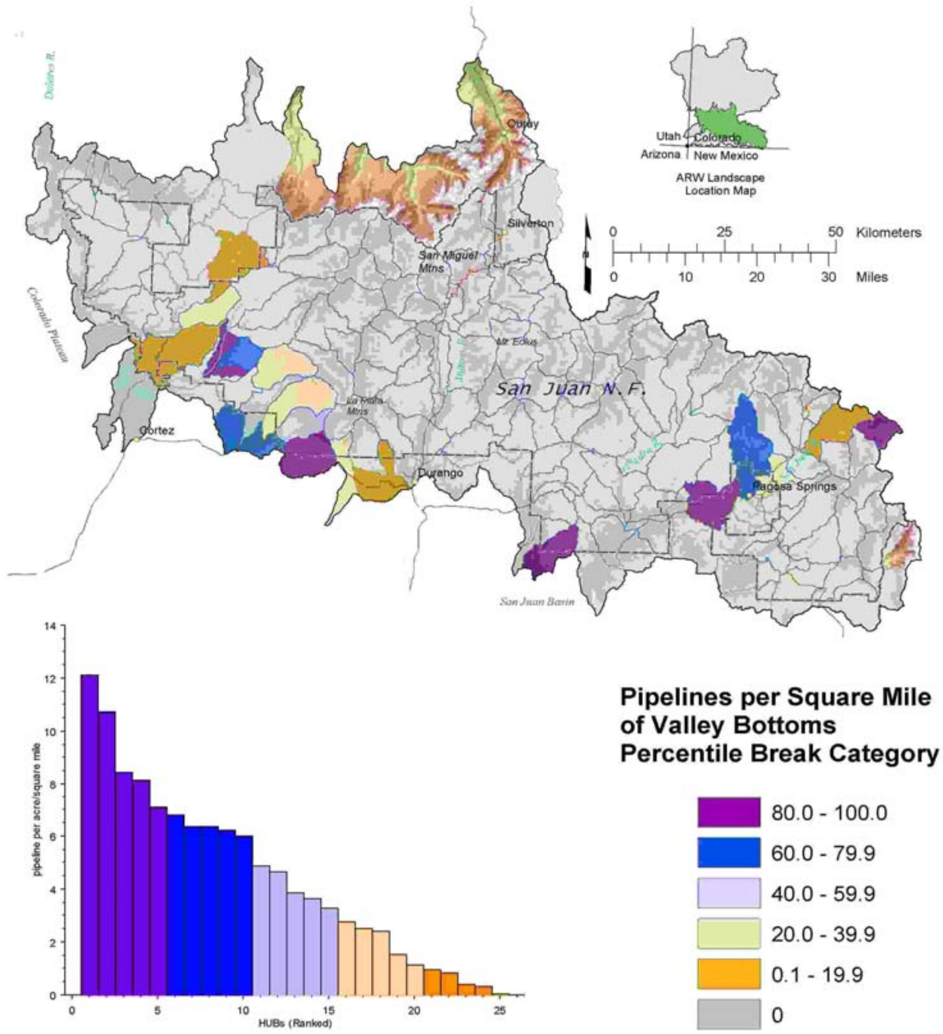

Figure 7.6 The rank and distribution of the ratios of acres disturbed in association with oil and gas pipeline transmission corridors per square mile of valley bottom, 100-80 percentile range, management scale, San Juan National Forest. Watersheds highlighted in light green are located entirely on the forest.

Table 7.4 Summary of HUB Numbers and Calculated Disturbance Densities (Acres/sq. mile valley bottom) within the 100-80 Percentile Range, San Juan National Forest. Watersheds highlighted in light green are located entirely on the forest.

HUB6	HUB Name	Ratio of Miles of Pipeline per Valley Bottom Stream Mile	Acres Disturbed/Valley Bottom Sq. Mi.	% of Valley Bottom Area In HUB Disturbed
140801050105	Upper Cherry Creek	0.057	12.1	2
140801010101	Headwaters East Fork San Juan River	0.047	10.7	2
140801011704	Upper Spring Creek	0.047	8.4	1.3
140300020404	Stapleton Valley	0.045	8.1	1.2
140801020402	Upper Stollsteimer Creek	0.044	7.1	1.1

Table 7.5 Summary of HUB Numbers and Number of Pipeline Transmission Corridor Stream Crossings (within the 100-80) Percentile Range, San Juan National Forest. Watersheds highlighted in light green are located entirely on the forest.

HUB 6	HUB Name	# of Crossings per Stream Mile	Ratio of Pipeline Stream Crossings Per Stream Mile	Stream Density (mi/sq.mi)
140801050105	Upper Cherry Creek	19	0.3	1.8
140300020402	Spruce Water Canyon	9	0.2	2.5
140300020404	Stapleton Valley	8	0.2	2.4
140801010305	McCabe Creek	9	0.2	2.7

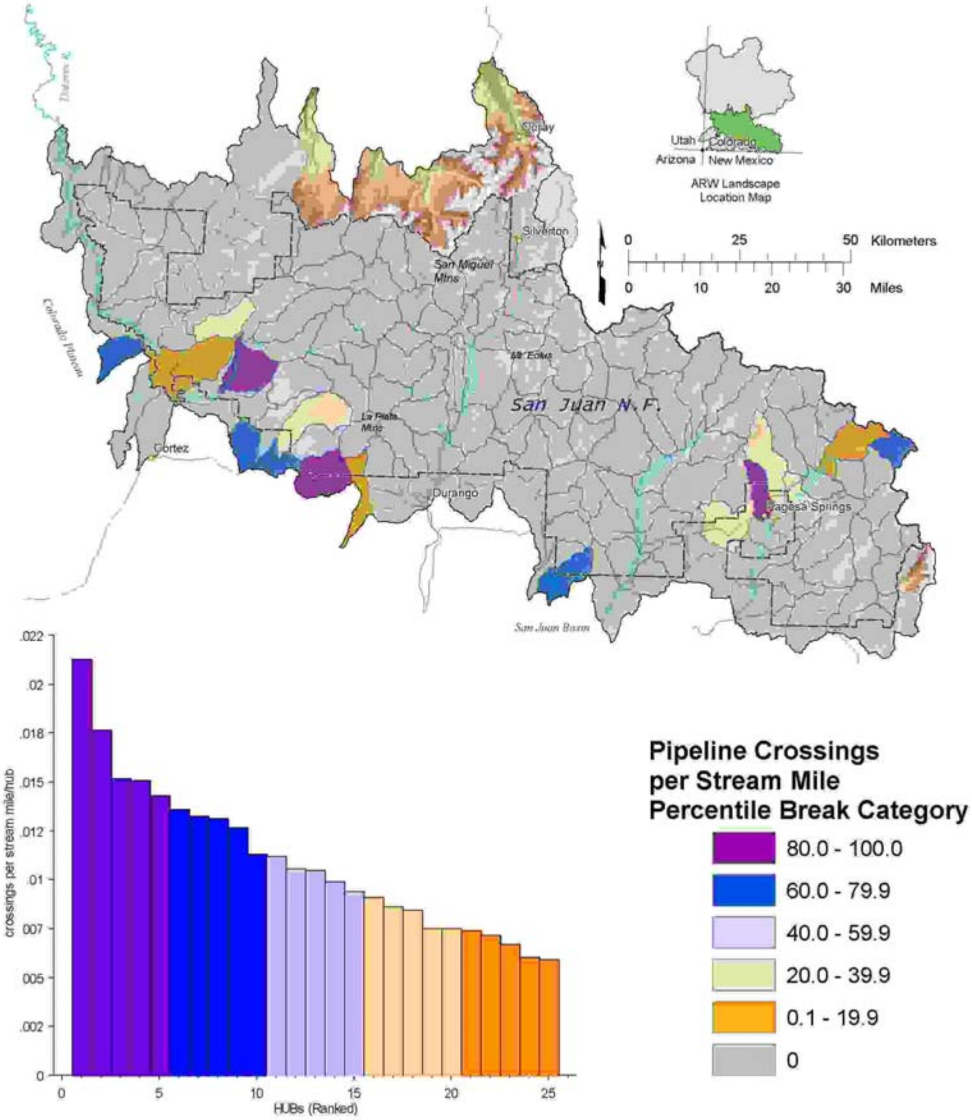

Figure 7.7 The rank and distribution of Pipeline Transmission Corridor Stream Crossing Ratios, 100-80 Percentile Range, Management Scale, San Juan National Forest.

Influence of Urbanization

Private Ownership

The San Juan National Forest is approximately 2.1 million acres in size. Additional land owners, within the forest boundary, include private in-holdings, and in-holdings managed by the Bureau of Land Management (BLM) and the State. Some tribally owned lands are also present. Land not owned by the Forest Service is found primarily along the southern border of the forest and in the eastern and western quarters of the forest (Figure 7.8). State, Private Citizen, BLM, and tribal lands comprise approximately 11 % of the land within the forest boundary. These in-holdings tend to be concentrated in valley floors where irrigable agricultural land exists.

Land ownership categories, and their percentage within the forest boundary, are summarized in Table 7.6. Within the Forest boundary ownership is fairly homogeneous. Land owned by public citizens, comprises 11 % of the land within the forest boundary. State, BLM, and Tribal lands comprise less than 1 % of the area within the forest. Table 7.7 summarizes those watersheds with no private in-holdings.

These HUB's could be ideal watersheds for native species management, due to the ability of state and federal agencies to implement necessary management actions throughout these watersheds. For example native trout management in watersheds with no private in-holdings would allow managers to apply a "metapopultation" approach where intermixing populations could be established. At the same time managers could avoid jurisdictional concerns that arise when management is made more complicated by mixed ownership lands.

This becomes especially important with mobile populations, such as native trout, where population movements may cross ownership or jurisdictional bounds. A detailed examination of ecological driver characteristics would be needed to prioritize These watersheds for this type of management activity.

However, other watersheds may be considered if the total amount of in-holdings within a watershed comprises only a small percentage of the watersheds overall size and if the holdings are low in the watershed they can still be managed for metapopulations.

As private in-holdings do occur on the forest it was important to determine where the greatest influences from activities not managed by the Forest Service would occur. The percent of privately owned land for each HUB was determined. 27 HUBs were found to be within the 100-80 percentile range for this metric. These HUBs are found primarily along the southern and western margins of the forest (Figure 7.9). The percentage of privately held land, within these HUBs, is summarized in Table 7.8.

Data on public land distribution is available both within and outside of the forest boundary. As a result, this means that the numbers displayed in Table 7.8 have not been biased by partial watershed acreages. The Piedra River-O'Neal Creek watershed, highlighted in light green, is the only watershed located entirely within the forest boundary.

Watersheds which are not highlighted at all, or those highlighted in dark olive green, are those watersheds which are not located entirely within the forest boundary. For those watersheds which are not highlighted at all, the vast majority of their acreage lies outside of the forest boundary. As a consequence these watersheds have a high percentage of private land. Drainages in these watersheds generally flow to the southwest and off the forest. Although these watersheds are found in the 100-80 percentile range, potential for effects related to private development are limited by the small amount of acreage within the forest.

However, all of the watersheds in Table 7.8, highlighted in dark olive green, have 40-90% of their total area located within the forest boundary. The amount of land, owned by private citizens, ranges from 79% in the McCabe watershed (HUB #140801010305) to a low of 30% in the Lower Beaver Creek (HUB #140801011603). In these watersheds there is the potential for on-Forest effects to aquatic resources due to private land development.

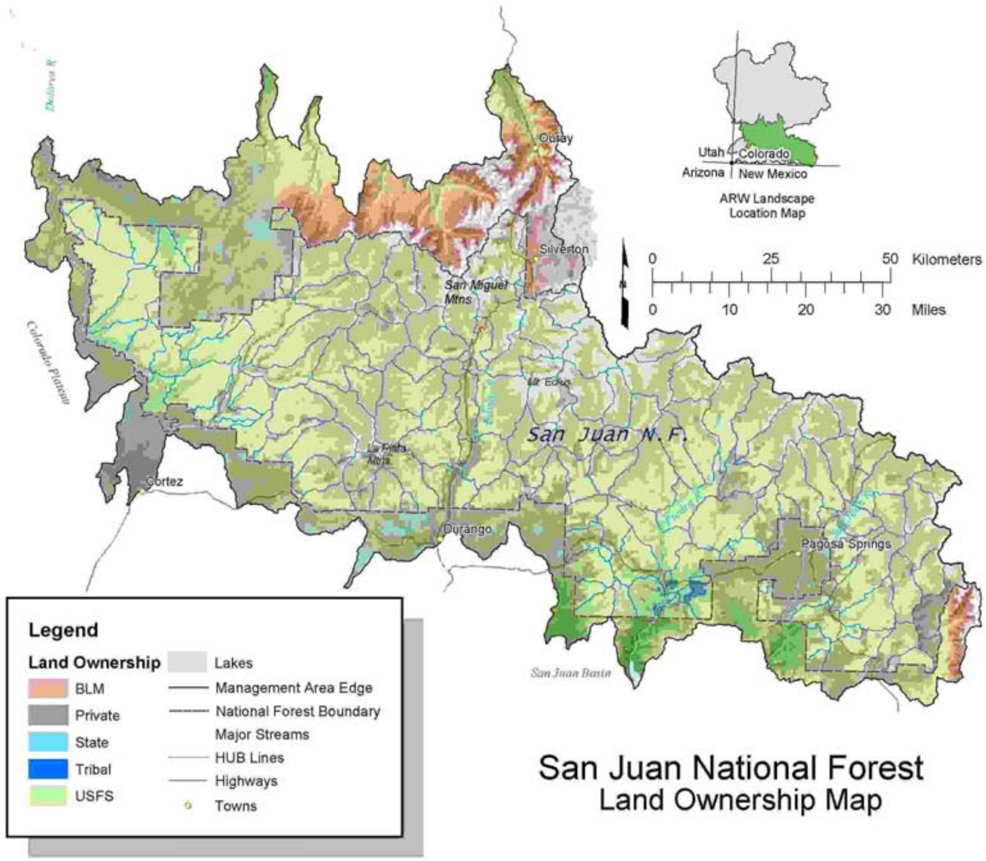

Figure 7.8 Land ownership and distribution, management scale, San Juan National Forest.

Table 7.6 Land ownership distribution by percentage within the San Juan National Forest boundary, management scale

6th Level HUB Code	Acres	Percentage of San Juan National Forest
Forest Service	1,858,442	89%
Tribal	5282	< 1%
State	7302	< 1%
BLM	332	< 1%
Owned by Private Citizen	223,194	11%
TOTAL	2,094,552	100%

Table 7.7 6th level HUBs inside the San Juan National Forest with no private in-holdings. Watersheds highlighted in light green are located entirely on the forest.

6^{th} Level HUB Code	6^{th} Level HUB Name
140801010103	Sand Creek
140801010201	Upper West Fork San Juan River
140801010202	Beaver Creek
140801011301	Upper Los Pinos River-Ricon La Vaca
140801011302	Upper Los Pinos River-Flint Creek
140801011303	Lake Creek
140801011304	Three Sisters
140801011401	Upper Vallecito Creek
140801020201	Upper Weminuche Creek
140801020203	Sand Creek
140801040403	Upper Hermosa Creek
140801040404	Middle Hermosa Creek
140801040406	Hermosa Creek-Dutch Creek

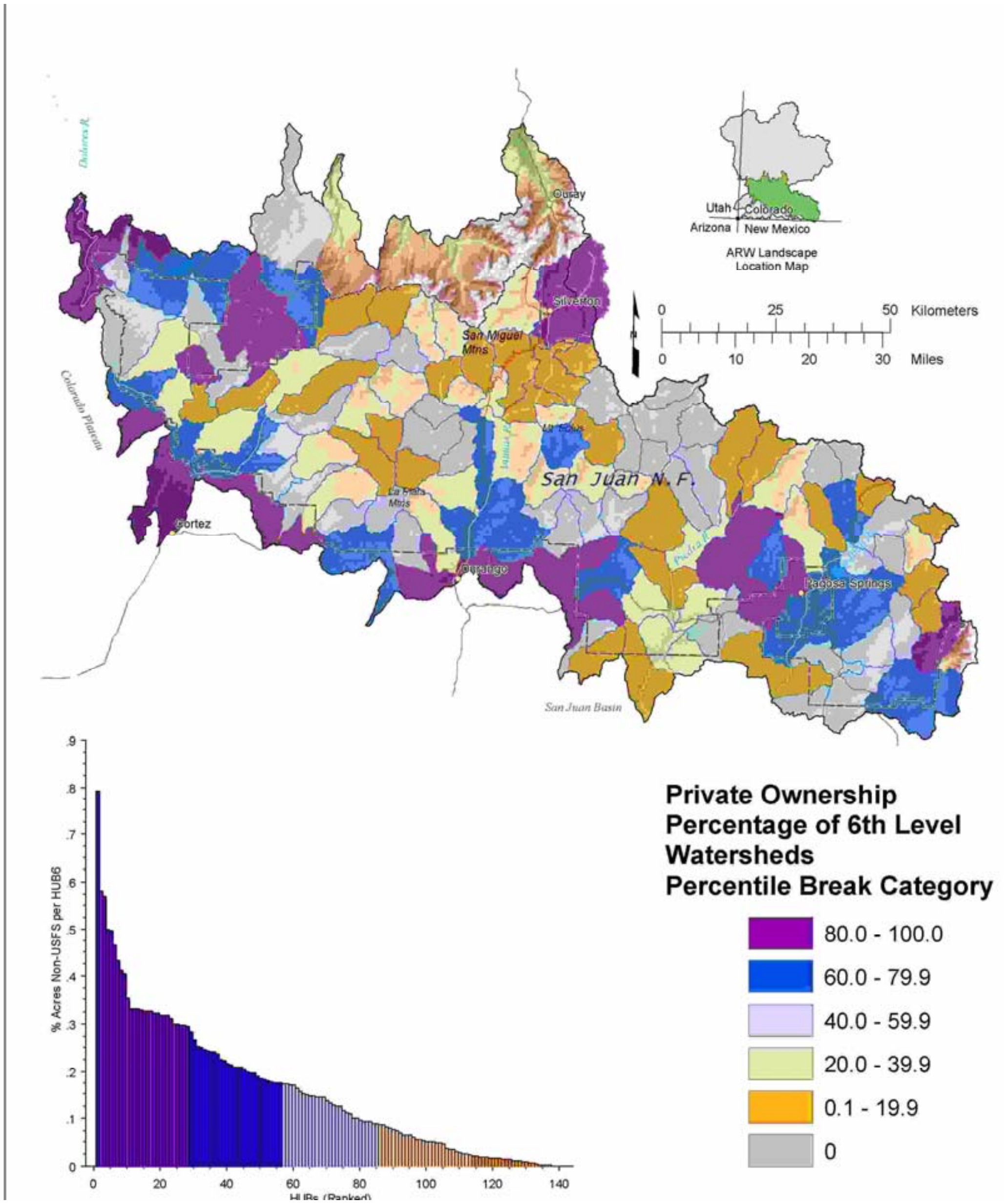

Figure 7.9 The rank and distribution of private ownership for individual HUBs, management scale, San Juan National Forest.

Table 7.8 Summary of private land ownership within HUB's, 100-80 percentile range, management scale, San Juan National Forest.

HUB 6	HUB Name	% HUB Not Forest Service
140801010305	McCabe Creek	79
140801010502	West Fork Navajo River	58
140801020104	Piedra River-O'Neal Creek	57
140801040101	Animas River above Howardsville	50
140802020201	Upper Yellowjacket Creek	50
140300020605	Dolores Canyon-Joe Davis Hill	47
140801040102	Cement Creek	43
140300020511	Disappointment Valley-Wildhorse Reservoir	41
140300020301	Upper Beaver Creek-McPhee	41
140801011502	Bear Creek	35
140300020501	Bear Creek-Disappointment Creek	33
140802020103	Hartman Canyon	33
140802020106	Lower Alkali Canyon-Narraguinepp Canyon	33
140801040901	Lower Florida-Ticalotte	33
140300020405	Lower Lost Canyon	33
140300020503	Sheep Camp Valley	33
140801070105	East Fork Mud Creek	33
140300020302	Upper Plateau Creek	32
140801020402	Upper Stollsteimer Creek	32

Table 7.8 Summary of private land ownership within HUB's, 100-80 percentile range, management scale, San Juan National Forest, Continued.

HUB 6	HUB Name	% HUB Not Forest Service
140801040604	Upper Cat Creek	32
140300020510	Upper Disappointment Valley	32
140300020303	Calf Creek	32
140801070103	Upper Mancos Valley	31
140801040603	Lower Lightner Creek	30
140801040104	Animas River-Cunningham Creek	30
140801011603	Lower Beaver Creek	30
140801020301	Upper Devil Creek	30

*All percentages calculated using ArcGIS. Numbers rounded to the nearest whole number.

Figure 7.10 shows that continuous private tracts of land are found along the valley bottom areas associated with the Dolores River, the West Dolores River (northeast of Cortez); along the Animas River and Electra Lake (north of Durango); and to the northwest of Pagosa Springs. As a result, the percentage of privately owned valley bottom area, for each HUB intersecting the forest boundary, was determined. The percent of private land ownership in valley bottoms was also evaluated. The results of this metric are displayed in Figure 7.11 and Table 7.9.

HUBs with high percentages of valley bottom ownership are found predominantly along the southern boundary of the forest and in the western most portion of the forest (Figure 7.11). This relationship is directly related to how much of a given watershed if found within the forest boundary.

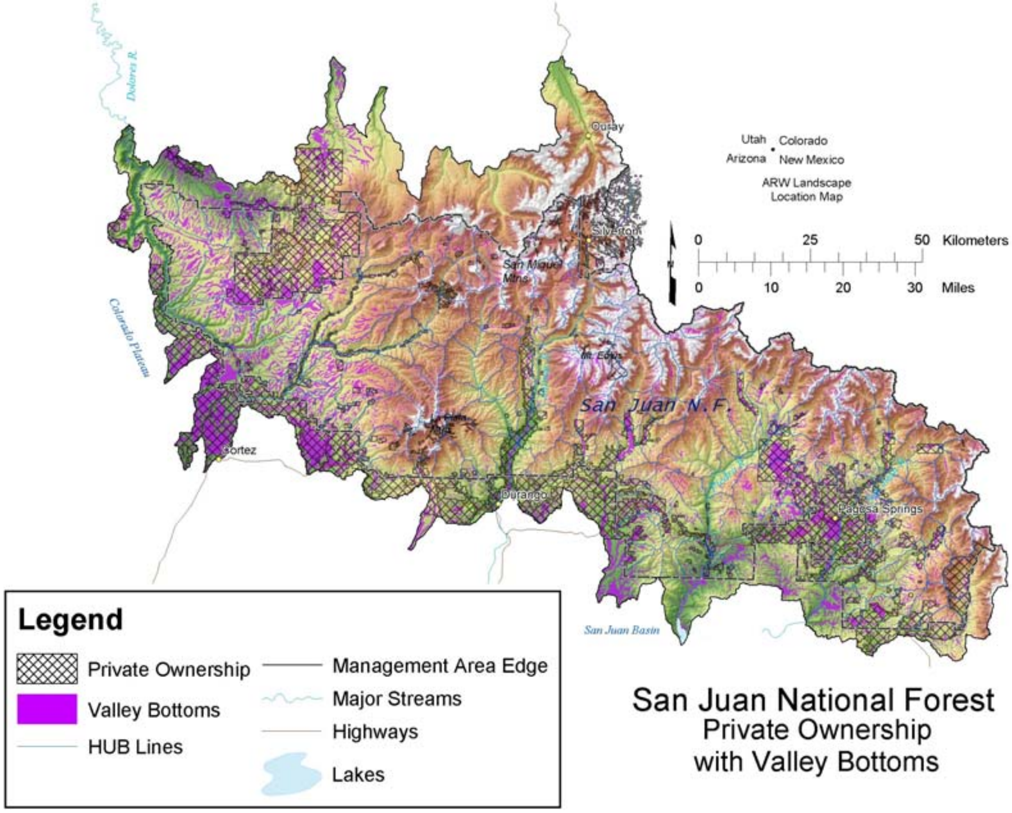

Figure 7.10 Distribution of Private land ownership, relative to valley bottoms, within the San Juan National Forest.

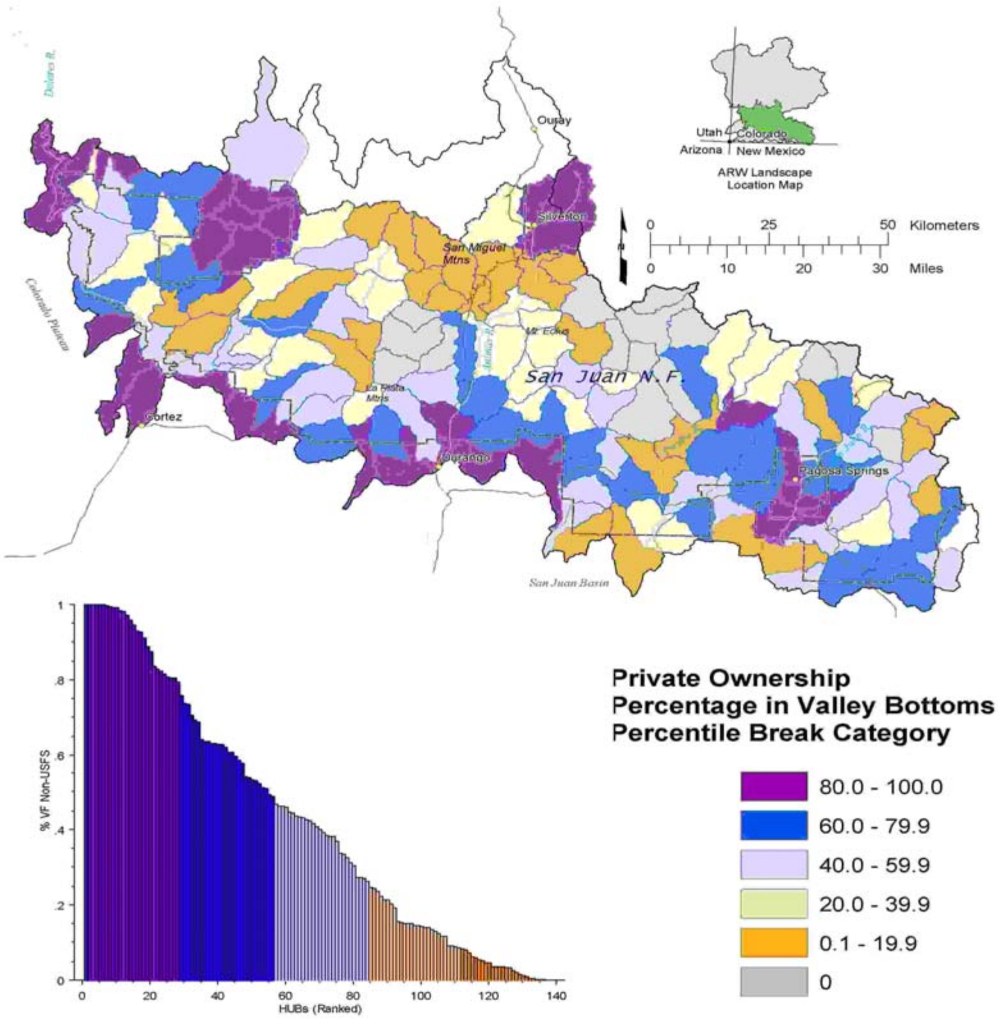

Figure 7.11 The rank and distribution of private land ownership in valley bottoms, by HUB, 100-80 percentile range, management scale, San Juan National Forest.

Table 7.9 HUB's with private land in valley bottoms, 100-80 percentile range, Management Scale, San Juan National Forest.

HUB6	HUB Name	% Non-Forest Land in Valley Bottom
140802020103	Hartman Canyon	1.00
140300020501	Bear Creek-Disappointment Creek	1.00
140300020405	Lower Lost Canyon	1.00
140300020503	Sheep Camp Valley	1.00
140801040101	Animas River above Howardsville	1.00
140801040901	Lower Florida River – Ticalotte	1.00
140801070105	East Fork of Mud Creek	1.00
140802020106	Lower Alkali Canyon-Narraguinepp Canyon	1.00
140802020201	Upper Yellowjacket Creek Canyon	0.99
140801040604	Animas River-Spring Creek	0.99
140300020510	Upper Disappointment Valley	0.99
140801070103	Upper Mancos Valley	0.98
140300020302	Upper Plateau Creek	0.97
140801040102	Cement Creek	0.96
140801010307	Echo Canyon Reservoir	0.95
140801040603	Lower Lightner Creek	0.93
140300020605	Dolores Canyon-Joe Davis Hill	0.93

Table 7.9 Continued HUB's with private land in valley bottoms, 100-80 percentile range, Management Scale, San Juan National Forest.

HUB6	HUB Name	% Non-Forest Land in Valley Bottom
140300020511	Disappointment Valley-Wild Horse Reservoir	0.91
140801010305	McCabe Creek	0.89
140300020104	Groundhog Creek	0.88
140300020502	Disappointment Creek Headwaters	0.84
140801050102	Mayday Valley	0.83
140801040504	Upper Animas Valley-Trimble	0.82
140801040104	Animas River-Cunningham Creek	0.81
140801010308	San Juan River – Eightmile Mesa	0.81
140300020301	Upper Beaver Creek-McPhee	0.80
140801020104	Piedra River-O'Neal Creek	0.80
140801011503	Los Pinos River-Bayfield	0.80

*All percentages determine using ArcGIS. Numbers may not be statistically valid. Numbers rounded to the nearest 10^{th} of a percent.

Un-highlighted watersheds listed in Table 7.9 have only a portion of their area located within the forest boundary. The watershed highlighted in light green is located entirely within forest boundaries.

Eight watersheds were found to have 100 % of their valley bottoms lands in private ownership. The Animas River above Howardsville (HUB# 140801040101) is located off-forest and its drainages flow on to the forest. As a result, there is the potential for on-Forest effects from off-forest activities.

The other seven watersheds have very little of their watershed area or drainages located on-Forest forest land. As a result, little potential influence on forest aquatic resources is expected.

Although each of the following HUBs have only a small portion of land within forest boundaries, drainages within these watersheds flow on to forest land. These watersheds are: Sheep Valley Camp (HUB 140300020503), Upper Plateau Creek (HUB# 140300020302), Cement Creek (HUB# 140801040102), Groundhog Creek (HUB# 140300020104), Disappointment Creek headwaters (HUB# 140300020502), Animas River-Cunningham Creek (HUB# 140801040104), and Upper Beaver Creek-McPhee (HUB# 140300020301).

As a result, these watersheds have the potential to influence downstream on-Forest aquatic resources, due to activities on privately owned land.

All other watersheds, except the Piedra River-O'Neal Creek (HUB 140801020104) have the potential for effects on aquatic resources, either on or off-forest. Only the Piedra River-O'Neal Creek watershed is located entirely within the forest.

80 % of this watershed is privately owned. As a result, there is a high potential for land management activities on privately owned land to affect aquatic resources, both on and off-forest.

303(d) Listed Streams

The EPA, under the Clean Water Act, requires states to enforce water quality standards for surface waters and provide a report to the EPA every two year's. Section 303 (d) of the Clean Water Act requires states to identify waters for which effluent limitations are not stringent enough to meet water quality standards (http://www.state.ma.us/mgis/mgic/10_00/dallaire/sld008.htm).

Adjacent to and within the San Juan National Forest seven stream segments were found to be on the 2004 303(d) list published by the State of Colorado Department of Public Health and Environment. In 2004, after the list was published an additional segment was proposed for listing on the 303(d) list. That segment is on the Dolores River, from McPhee Reservoir to Bradfield Ridge Ranch. The location of these streams, within the Forest, is shown in Figure 7.12. Table 7.10 summarizes which watersheds these streams occur in, the name of the impaired segment, and the reason for listing the stream are summarized in Table 7.10. The proposed Dolores River, from McPhee Reservoir to Bradfield Ridge Ranch stream segment has not yet received a designation code from Colorado Department of Public Health. It is listed in Table as "New 9/2004" and is highlighted in light yellow.

Streams may be listed as impaired due to "natural" causes but they may also be listed as a result of effects related to land management activities. Table 7.10 indicates that these streams are listed due to elevated levels of mercury, cadmium, zinc, and copper.

Two metrics were calculated for analysis: the number of 303(d) listed stream miles per HUB and the percent of stream miles listed for each HUB. Only two watersheds, located in the southwest corner of the forest, were found to be within the 100-80 percentile range for the number of 303d listed stream miles per stream mile per HUB (Figure 7.12). The watersheds are the McPhee Reservoir-Dolores River (HUB# 140300020408) and the McPhee Reservoir-Beaver Creek Inlet (HUB# 140300020306) (Table 7.11). The McPhee Reservoir-Dolores River watershed has a total of 30.2 mile of listed stream while the McPhee Reservoir-Beaver Creek Inlet watershed has 17.5 miles of listed streams. Both watersheds have stream segments listed for Mercury. Discussions with water quality division personnel at the Colorado Department of Public Health and Environment indicate that the elevated levels of metals are related to either mining activity or atmospheric deposition from coal fired power plants.

Historical mining activity has occurred since the late 1880's (upstream on the Dolores River near the present town of Rico. The first mine in the area was the Enterprise minehttp://rgsrr.home.comcast.net/rgs/tline1.html). Mercury from coal powered mines is thought to come from airborne coal dust. However, there is some controversy regarding this theory (Oppelt, 2004, Pers. Comm.).

Table 7.11 documents that the 303(d) listed streams comprise approximately 22% of the stream miles in the McPhee Reservoir-Dolores River (HUB# 140300020408). Approximately 29%, or almost one-third, of the stream miles in the McPhee Reservoir-Beaver Creek Inlet watershed (HUB#140300020306) are found on the 303(d) list.

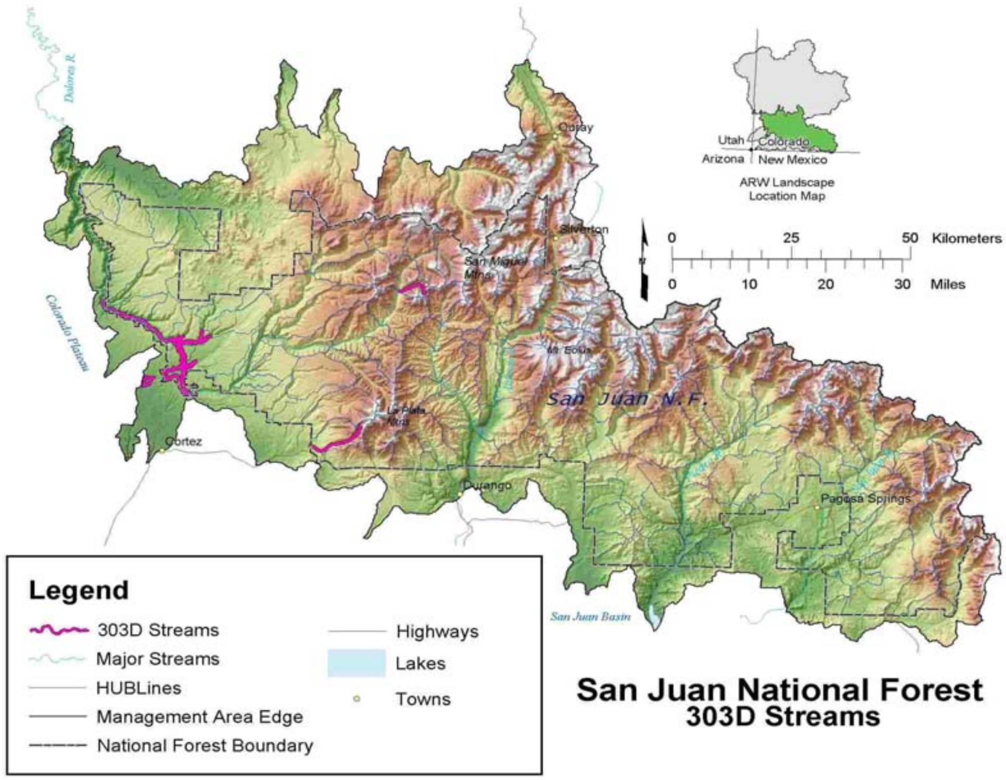

Figure 7.12 Location of 303(d) listed streams located within the assessment project area.

Table 7.10 Summary of 303(d) listed streams within the San Juan National Forest.

HUB #	HUB Name	Stream ID Code*	Stream Name	Portion of Stream Listed	Length of Listed Stream Portion (miles)	Reason Listed
140300020203	Rico Valley	COSJDO05	Tributaries to Dolores River and West Dolores River	Silver Creek above Rico DW diversion	3.4	Cadmium Zinc
140300020203	Rico Valley	COSJDO09	Silver Creek from Rico's diversion to Dolores River	All	1.4	Copper Zinc
140300020305	Beaver Creek-Trail Canyon	COSJDO04	Dolores River, Bear Creek to Bradfield Ranch Bridge	McPhee Reservoir	<0.1	Mercury
140300020306	McPhee Reservoir-Beaver Creek Inlet	COSJDO04	Dolores River, Bear Creek to Bradfield Ranch Bridge	McPhee Reservoir	17.4	Mercury
140300020306	McPhee Reservoir-Beaver Creek Inlet	NEW 9/2004	Dolores River, McPhee Reservoir to Bradfield Ranch Bridge	McPhee Reservoir	0.2	Mercury

*Stream code: the code assigned by the State of Department of Public Health and Environment

Table 7.10n Continued Summary of 303(d) listed streams within the San Juan National Forest.

HUB #	HUB Name	Stream ID Code*	Stream Name	Portion of Stream Listed	Length of Listed Stream Portion (miles)	Reason Listed
140300020405	Lower Lost Canyon	COSJDO04	Dolores River, Bear Creek to Bradfield Ranch Bridge	McPhee Reservoir	<0.1	Mercury
140300020406	Upper Dolores River-Italian Creek	COSJDO04	Dolores River, Bear Creek to Bradfield Ranch Bridge	McPhee Reservoir	<0.1	Mercury
140300020407	House Creek	COSJDO04	Dolores River, Bear Creek to Bradfield Ranch Bridge	McPhee Reservoir	6.7	Mercury
140300020408	McPhee Reservoir-Dolores River	COSJDO04	Dolores River, Bear Creek to Bradfield Ranch Bridge	McPhee Reservoir	30.2	Mercury
140300020601	Dolores River-Salter Canyon	COSJDO04	Dolores River, Bear Creek to Bradfield Ranch Bridge	McPhee Reservoir	0.1	Mercury
140300020601	Dolores River-Salter Canyon	NEW 9/2004	Dolores River, McPhee Reservoir to Bradfield Ranch Bridge	McPhee	6.2	Mercury
140300020603	Dolores Canyon-Cabin Creek	NEW 9/2004	Dolores River, McPhee Reservoir to Bradfield Ranch Bridge	McPhee	8.6	Mercury
140801070101	East Mancos River-Middle Mancos River	COSJLP04	Mancos River and tributaries above HWY 160	E. Mancos River	9.0	Copper
140801070103	Upper Mancos Valley	COSJLP04	Mancos River and tributaries above HWY 160	E. Mancos River	<0.1	Copper
140802020106	Lower Alkali Canyon-Narraquinepp Canyon	COSJLP11	Narraguinepp, Puett, and Totten Reservoir	Narraguinepp Reservoir	5.9	Mercury

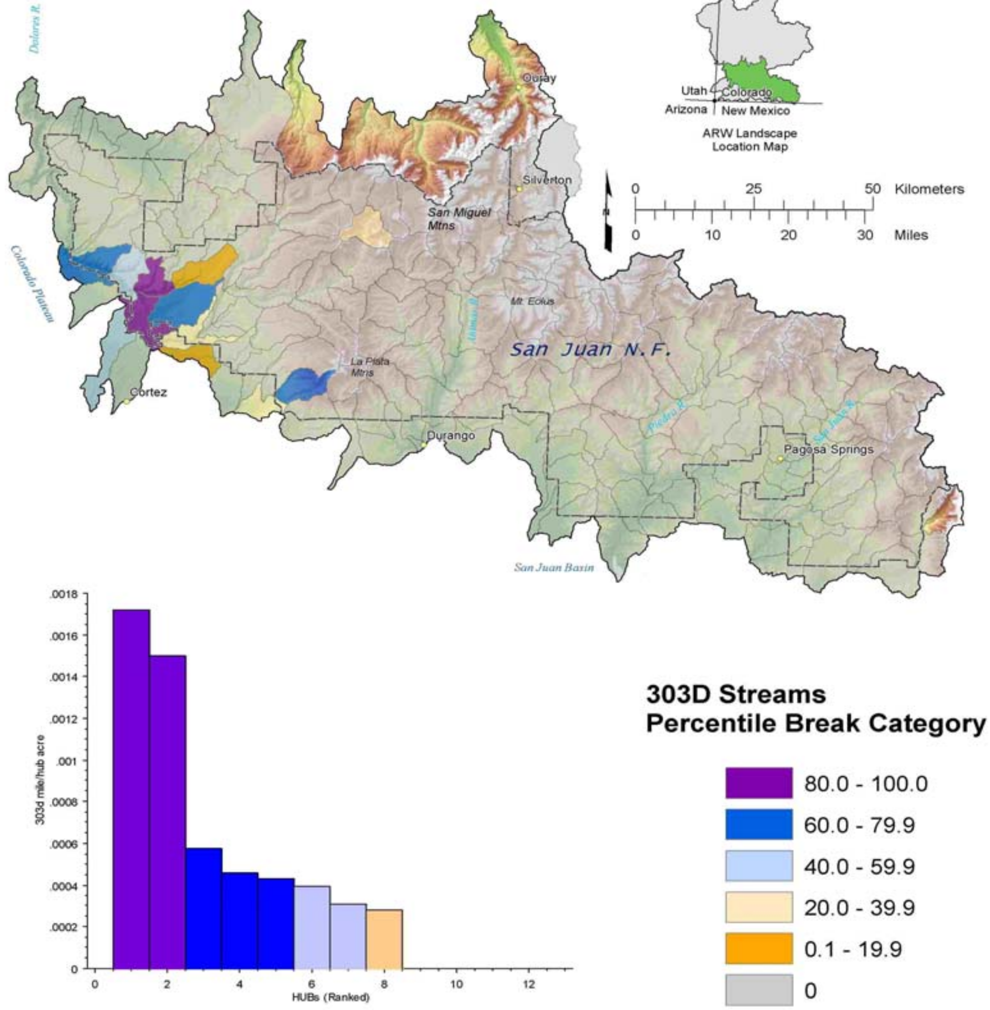

Figure 7.12 Summary of 303(d) listed stream lengths, by HUB, found within the San Juan National Forest, management scale.

Table 7.11 Length of 303(d) Streams, by HUB, within the 100-80 percentile range, management scale, San Juan National Forest.

HUB #	HUB Name	Ratio of Miles of 303d Stream per HUB acre	Total Length of Stream On 303(d) List	% of Stream Miles Per HUB on 303(d) List
140300020408	McPhee Reservoir-Dolores River	0.0017	30.2	22
140300020306	McPhee Reservoir-Beaver Creek Inlet	0.0015	17.5	29

6th Level HUB Information Needs

Information needs related to private in-holdings and related development is covered in detail in the water uses section. However, it should be noted that by knowing future water use development scenarios would improve our ability to assess the extent and magnitude of on forest impacts related to water availability and the downstream aquatic environment. Development of a data base that could summarize urbanization related activities by watershed, date of occurrence, number of acres involved, etc. facilitate assessing how these activities affect forest health.

As indicated in the discussion of 303(d) listed streams the source of mercury contamination is still up for debate. This situation represents a partnership opportunity to determine the mercury's source. Possible partners are other state, federal, and tribal agencies, and private business, such as mining or electric companies. Conventional methods for analyzing mercury are susceptible to contamination during sampling and laboratory analysis.

In order to accurately assess mercury levels, and to help determine the source, it is suggested that any studies undertaken use "clean methods". Clean methods are relatively new technique used to evaluate the levels of heavy metals in ambient surface and ground waters. The U.S. Geological Survey, 1994, and the E.P.A, in 1995, detail how to collect heavy metal samples, including mercury and copper (see Table 7.10), in such a way that contamination is prevented during sampling and laboratory analysis.

Existing data does not solve the question of source as data was collected and analyzed using conventional methods and detection limits. Detection limits in conventional methods typically can not be set low enough to determine mercury levels in ambient surface water conditions. As a result, the information that does exist will not be useable during the forest plan revision process.

EPA is working to address water quality issues related to abandoned mines on private land, which contribute to on-Forest water quality problems. It is recommended that the forest obtain water quality data as it is collected by the EPA. This will better help the forest assess existing conditions related to abandoned mines, rehabilitate abandoned mines on-Forest, and conduct cumulative effects analyses. However, data should be carefully evaluated as to quality and usability, especially in comparison with state water quality criteria and standards. The potential for data contamination, as discussed above, will need to be taken under consideration.

Management Implications at the 6th HUB Level

Management implications at the watershed, or 6th level HUB scale, will vary depending is the issue is transmission corridors, private inholdings, or 303(d) listed streams. Each of these activities, depending on the level of activity intensity, affects aquatic, riparian, and wetland health differently.

Potential effects related to transmission corridors include: alteration of flow regimes related to road construction, modification of water quality due to increased sediment production related to road construction and vegetation removal, and alteration of wetland and riparian conditions due to vegetation removal or construction activities directly within the aquatic resource itself. Additional potential effects include modification of channel morphology due to sediment derived from inadequately vegetated corridors and channel modification related to decreased bank stability (USDA Forest Service, 2003). As a result, riparian or wetland clusters, where the sensitivities of fisheries, riparian vegetation, or benthic macroinvertebrates are high, these watersheds would be most vulnerable to impacts associated with transmission corridors.

This is due to the nature of the primary impacts related to transmission corridors.

All of the riparian clusters found in the San Juan National Forest are dominated by moderate to high gradient streams, which to increased stream power and erosive capability. However, riparian clusters 4r, 5r, and 6r have higher percentage of their stream lengths classified as low gradient. As a result, low gradient reaches may receive more sediment than they should either where these reaches are crossed by a transmission corridor or where they are downstream of corridors where they are associated with moderate and high gradient streams. This increased sediment load can degrade fisheries habitat or impact riparian vegetation. Fisheries in riparian cluster 6r is highly sensitive to changes in hydrology and or sediment, while riparian vegetation in all 8 riparian clusters exhibits high sensitivity to fluctuations in hydrology and or sediment regimes. Benthic macroinvertebrates generally have a high sensitivity to changes in hydrology and/or sediment regimes. Reductions of flow and increases in sediment can lead to thermal fluctuations. Clusters 2r, 3r, and 4r may be impacted by these fluctuations.

Most wetlands are highly sensitive to any changes in hydrology but seem to vary in their sensitivity to sediment load is variable. Special attentions to alterations in sediment load are warranted for Clusters 7w and 8w which are characterized as having high sensitivity to sediment load alterations.

As discussed earlier in this chapter, State, Private Citizen, BLM, and tribal lands comprise approximately 11 % of the land within the forest boundary. These in-holdings tend to be concentrated in valley floors where irrigable agricultural land exists. Lands owned by private citizens tend to be managed more intensely, and for one activity, than do public lands. This factor, combined with the fact that data indicates that privately owned land is concentrated in valley bottoms, indicates an even higher likelihood of land use related impacts to aquatic health.

Data was not available delineating which land use activities in valley bottom-privately owned areas were most dominant. Almost all of the watersheds with large percentages of private ownerships are located only partially within the Forest boundaries. As a result, there is the potential for effects generated on private land to impact Forest resources.

Farming, irrigation, grazing, and perhaps development are likely candidates. Ground disturbance, erosion, bank and riparian vegetation degradation, water quantity and water quality modification are potential effects.

Specific recommendations for opportunities related to private land focus primarily on partnership opportunities as related to cluster type. These opportunities include:

- 80% of the Piedra River-O'Neal Creek watershed is privately owned and has the potential for both on and off-Forest impacts to aquatic, riparian, and wetland health. It represents a very good opportunity for working with other land owners to improve watershed health.
- The Sheep Valley Camp, Upper Plateau Creek, Cement Creek, Groundhog Creek, Disappointment Creek headwaters, Animas River-Cunningham Creek, and Upper Beaver Creek-McPhee watersheds have their headwaters located off Forest, but flow on to the San Juan National Forest. Working with land owners in these watersheds to improve aquatic health would help mitigate downstream effects that would occur on Forest administered lands.
- Cluster 1r is sensitive to thermal and sediment alterations. Due to the dominance of high gradient systems in this cluster, the importance of riparian vegetation

and aquatic animals is magnified. Where this cluster is located on BLM, Private, State, or Tribal lands, partnership opportunities for restoration or mitigation may exist. Improving canopy cover, reduction of sediment input, and aquatic habitat would be areas to emphasize.

- Cluster 2r locations on Private, State, Tribal, or BLM lands would provide opportunities to eliminate sediment source areas. In addition, if there were opportunities to eliminate sources of modifications to hydrology would be an additional opportunity.
- Cluster 6r is also sensitive to alterations of hydrology.
- Riparian areas within Cluster 5r require high amounts of canopy cover to regulate thermal modifications. Restoration efforts towards improving the quality of riparian vegetation are the primary opportunity for this cluster.

Discussions with water quality division personnel at the Colorado Department of Public Health and Environment indicate that the elevated levels of metals are related to either mining activity or atmospheric deposition from coal fired power plants. Historical mining activity has occurred since the late 1880's (upstream on the Dolores River near the present town of Rico. These sources of contaminants are not easily eliminated and mitigation and clean up is costly. For future mining opportunities, it will be important that effective and efficient water quality monitoring, and mining best management practices, be used from the time of project start-up through project completion, including post-project monitoring. As indicated in the discussion of 303(d) listed streams the source of mercury contamination is still up for debate. This situation represents a partnership opportunity to determine the mercury's source. Possible partners are other state, federal, and tribal agencies, and private business, such as mining or electric companies. As mercury may be related to coal fired power plants, opportunities may exist through air quality grants. Future water quality monitoring though should be done using the "clean" methods referred to earlier in the chapter and conducted on a frequency that will support appropriate statistical analysis.

As maintaining water quality is important for all riparian and wetland clusters, any mitigation or restoration efforts that eliminate sources of metal contaminants, will help to improve aquatic health for all clusters.

Direction for Reach/Site Scale Analysis

The influence of management activities on downstream aquatic, riparian, and hydrologic resources is best addressed at the reach/site scale. Many of the same influences of management activities found on Forest land, related to land disturbing activities, may also be observed on private in-holdings. However, influences on private lands may be even more pronounced in some cases, where there are fewer regulations. Some specific questions that should be asked when addressing the influences of private land management activities include:

1. What activities are most noticeably occurring or have occurred on the private land, which would potentially influence aquatic, riparian and hydrologic resources on Forest Service property? When did these activities occur?
2. Has a relationship been established between the Forest Service and Private land owners that emphasize a cooperative approach to ensure both upstream and downstream aquatic, riparian, and wetland resources are treated adequately during land management activities?

3. If so, when, where, and how? If new actions are being considered on private lands, does the Forest Service have the necessary monitoring information to identify change as a result of the action?
4. Does special use permit authority apply to activities that could influence aquatic, riparian, and wetland resources on Forest Service lands, or are their connected actions?
5. What aquatic, riparian, and wetland resource values are located downstream of the private lands that are important or should be addressed as a result of activities upstream on private lands?

Comment [JF3]: Kelly, you need to add what you want for reach/site scale for transmission corridors and for 303(d) streams. Just noticed that the Bighorn only addressed private ownership/

Urbanization Cumulative Percentile Ranking

In order to understand the total combined effects of urbanization, 303(d) listed streams, and transmission lines on watersheds, the results of these metrics were combined and re-ranked, and a cumulative percentile ranking was determined. This analysis is relative only to the portion of the 6th level HUBs surface area within the San Juan National Forest boundary, and is intended to provide the reader with the additive rankings at this scale. Unlike the previous methodology, the results are evenly distributed across the total number of HUBs at this scale.

This analysis was performed at the management scale, with data existing for all portions of the 154 HUBs within the San Juan National Forest boundary. Ranking these watersheds delineates which watersheds are the most susceptible to the combined effects of urbanization, transmission/pipelines, and 303(d) streams on aquatic and riparian health. Rankings were divided into five differing groups, each with a 20 percentile ranges. Watersheds within the 100-80 percentile range have the most susceptibility to impacts on aquatic health while those falling within the 19.9-0.1 percentile range have the lowest potential for being influenced.

The results of the cumulative ranking process for all three urban related metrics, in all watersheds on the forest, are summarized in Table 7.15 at the end of this section. This table also summarizes which riparian and wetland clusters are associated with each watershed on the forest. Essentially this table will function as a "look up" table, so at a glance one can determine the influence of urbanization, transmission/pipelines, and 303(d) streams as well as have a reference to watershed sensitivity.

The sum of the percentile ranks of the eight criteria of the three urban-related categories was calculated to identify the additive effects of these activities on aquatic, riparian, and wetland resources. The 8 criteria used in this analysis are summarized in Table 7.12.

The cumulative percentile ranking for the 100-80 percentile range is summarized in Table 7.13 and displayed in map format in Figure 7.13.

Only three watersheds in the urban-related category synthesis analysis fell within the 100-80 percentile range. The maximum cumulative ranking for Urban-related was 15. Fish Creek (HUB# 140300020102) had a cumulative rank of 13. The Dolores River Headwaters-Tin Can Basin (HUB# 140300020201) had a cumulative rank of 12 and the Rico Valley (HUB # 140300020203) had a cumulative rank of 11. All three watersheds are found along the northern border of the western third of the Forest. These watersheds reflect high levels of urbanization, transmission/pipeline, and 303(d) listed streams (Table 7.15).

All three watersheds are located entirely on the forest. As a result, they have the most potential for on-Forest urban-related impacts on aquatic, riparian and wetland resources (See Figure 7.14).

There are 12 watersheds with a cumulative rank of "4", placing them within the 60-79.9 percentile range. Their cumulative urban-related rank ranges from a total of ten to eight (See Table 7.14). These watersheds are found predominantly in the western half of the Forest (See Figure 7.14). Based on watershed location for this percentile range there is the potential for both on and off forest downstream impacts.

Watersheds falling within the 40-59.9 percentile range were the second largest group defined by the analysis. Watersheds within this range are found across the Forest (See Figure 7.15). Cumulative rank totals range from seven to six. The transmission/pipeline and urbanization categories dominate the 40-59.9 percentile group (See Table 7.15). As the watersheds are spread consistently across the Forest, both on and off-Forest effects are likely.

Those watersheds falling in the 20-39.9 percentile range have cumulative ranks ranging from five to three. This group is by far the dominant group on the Forest with 71 watersheds falling into this ranking. Transmission/pipeline and the urbanization category again dominate this percentile range. Watersheds in this range are found across the Forest and there is some potential for both on and off-Forest effects.

There are 28 watersheds within the 0.1-19.9 percentile range. These watersheds tend to be found along the Forest boundary. For all the watersheds except Upper Hermosa Creek (HUB#140801040403), Upper Vallecito Creek (HUB# 140801011401), Upper Los Pinos-Ricon La Vaca (HUB# 140801011301) and Upper Los Pinos River-Flint Creek (HUB# 140801011302) the watershed boundaries extend beyond the Forest boundary. However the potential for effects on aquatic, riparian, and wetland resources are low for all watersheds in this percentile range due to their low cumulative rank (See Table 7.15).

Two watersheds Lake Creek (HUB#1408011303) and Three Sisters (HUB # 140801011304) had no cumulative rank as no activity for transmission/pipelines, urbanization, or 303 (d) listed streams occur in these two watersheds. The two watersheds are within the Weminuche Wilderness.

Table 7.12 Summary of criteria used in urbanization cumulative analysis, management scale, San Juan National Forest

Metric	Explanation
Pipelines and Transmission Lines	
Valley Bottom Pipeline and Transmission Line Ratio	Miles of pipeline and transmission line per valley bottom stream mile
Valley Bottom Transmission Line Ratio	Miles of transmission line per valley bottom stream mile
Transmission Line Stream Crossing Ratio	Number of transmission line stream crossings
Valley Bottom Pipeline Ratio	Number of miles of pipeline per square mile of valley bottom
Pipeline Stream Crossing Ratio	Number of pipeline stream crossings
Urbanization	
Percentage of Private Ownership	Percentage of private land ownership by watershed
Percentage of Valley Bottom Private Ownership	Percentage of valley bottom areas under private land ownership
303(d) Listed Streams	
Length of 303(d) Listed Streams	Total length of 303(d) listed streams by watershed

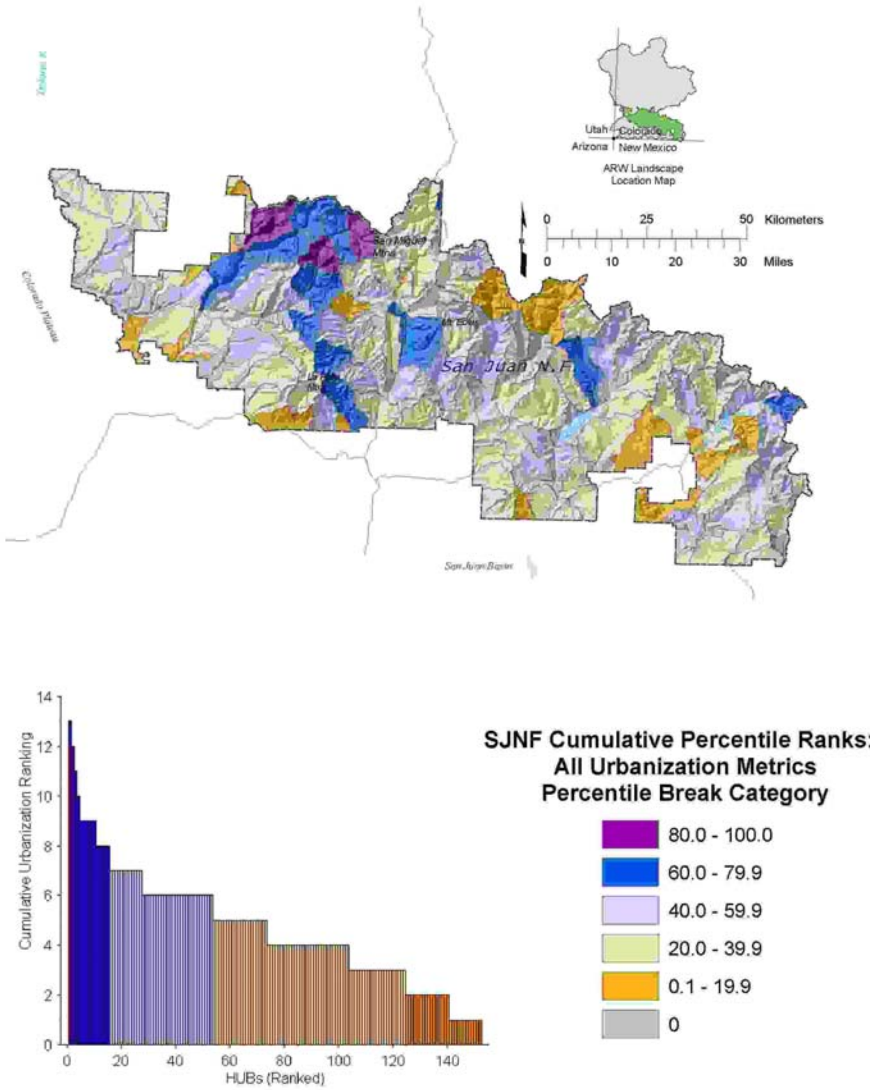

Figure 7.13 Urban-related Categories, Cumulative Percentile Ranking for 6th Level HUB's, management scale, San Juan National Forest

Table 7.14 Summary of Urban-related Cumulative 100-80 Percentile Ranking, management scale, San Juan National Forest; Watersheds located entirely with the forest boundary are highlighted in light green

HUB6	HUB6NAME	Transmission Line Category	303d Category	Urbanization Category	Urbanization Category
140300020102	Fish Creek	5	3	5	5
140300020201	Dolores River Headwaters-Tin Can Basin	5	2	5	5
140300020203	Rico Valley	3	4	4	5

Table 7.15 Urban-related Category-Overall Category Cumulative Percentile Ranking of Watersheds on the San Juan National Forest; Watersheds located entirely with the forest boundary are highlighted in light green

HUB6	HUB6NAME	Transmission Line Category	303d Category	Urbanization Category	Cumulative Urbanization Rank	Riparian Cluster	Wetland Cluster
140300020102	Fish Creek	5	3	5	13	2	1
140300020201	Dolores River Headwaters-Tin Can Basin	5	2	5	12	2	1
140300020203	Rico Valley	3	4	4	11	2	1
140300020101	El Deinte Peak	5	0	5	10	2	1
140801040601	Junction Creek	0	5	4	9	2	3
140801040501	Upper Animas Valley-Canyon Creek	5	0	4	9	1	2
140801040405	South Fork Hermosa Creek	2	4	3	9	2	1
140801040102	Cement Creek	2	4	3	9	3	8
140300020204	Upper Dolores River-Scotch Creek	5	0	4	9	2	1
140300020103	Upper West Dolores River	5	0	4	9	2	1
140801020202	Lower Weminuche Creek	5	0	3	8	2	3
140801010101	Headwaters East Fork San Juan River	3	0	5	8	1	7
140300020205	Roaring Forks Creek	3	0	5	8	2	1
140300020202	Upper Dolores River-Cayton Valley	3	0	5	8	2	1
140300020105	Lower West Dolores River	4	0	4	8	5	3

HUB6	HUB6NAME	Transmission Line Category	303d Category	Urbanization Category	Cumulative Urbanization Rank	Riparian Cluster	Wetland Cluster
140801040602	Upper Lightner Creek	3	1	3	7	5	3
140801040503	Upper Animas Valley-Stevens Creek	4	0	3	7	5	2
140801040407	Lower Hermosa Creek	2	1	4	7	5	1
140801040404	Middle Hermosa Creek	2	5	0	7	2	1
140801020205	Upper Piedra River-Box Canyon	2	0	5	7	5	3
140801020103	Williams Creek	2	0	5	7	2	2
140801010403	Rio Blanco River-Blanco Basin	4	0	3	7	2	2
140801010203	Wolf Creek	2	0	5	7	1	7
140801010102	Quartz Creek	2	0	5	7	1	7
140300020306	McPhee Reservoir-Beaver Creek Inlet	2	0	5	7	4	3
140300020208	Stoner Creek	2	0	5	7	2	1
140300020207	Dolores River-Priest Gulch	3	0	4	7	2	1
140801040803	Lemon Reservoir	2	0	4	6	2	1
140801040802	Upper Florida River-Transfer Park	2	0	4	6	1	7
140801040402	East Fork Hermosa Creek	1	0	5	6	2	1
140801040203	Needle Creek	1	0	5	6	8	9
140801040201	Elk Creek	1	0	5	6	3	8
140801040104	Animas River-Cunningham Creek	0	3	3	6	2	8
140801020501	Yellowjacket Creek	3	0	3	6	4	4
140801020206	Upper Piedra River-Indian Creek	1	0	5	6	5	3
140801020102	Middle Fork Piedra River	1	0	5	6	2	7
140801011404	Vallecito Reservoir	2	0	4	6	5	3
140801011403	Lower Vallecito Creek	2	0	4	6	1	2

HUB6	HUB6NAME	Transmission Line Category	303d Category	Urbanization Category	Cumulative Urbanization Rank	Riparian Cluster	Wetland Cluster
140801011402	Middle Vallecito Creek	1	0	5	6	2	8
140801010601	San Juan River-Trujillo	2	0	4	6	6	3
140801010503	Navajo Peak	3	0	3	6	2	1
140801010406	Lower Rio Blanco-San Juan River	3	0	3	6	4	4
140801010404	Middle Rio Blanco	2	0	4	6	4	3
140801010402	Fish Creek	1	0	5	6	1	7
140801010401	Rio Blanco Headwaters	1	0	5	6	1	7
140801010301	Turkey Creek	1	0	5	6	2	2
140801010104	East Fork San Juan River-The Clamshell	3	0	3	6	1	7
140300020602	Narraguinnep Canyon Natural Area	2	0	4	6	4	4
140300020601	Dolores River-Salter Canyon	2	0	4	6	4	3
140300020403	Middle Lost Canyon	3	0	3	6	4	3
140300020401	Upper Lost Canyon	2	0	4	6	2	1
140300020305	Beaver Creek-Trail Canyon	1	0	5	6	4	3
140300020104	Groundhog Creek	5	0	1	6	2	1
140801070104	Chicken Creek	3	0	2	5	4	3
140801070101	East Mancos River-Middle Mancos River	0	2	3	5	2	1
140801050101	La Plata River headwaters	1	0	4	5	2	8
140801040401	Hermosa Creek headwaters	0	0	5	5	2	1
140801040301	Upper Cascade Creek	0	0	5	5	2	8
140801040204	Animas River-Needleton	0	0	5	5	2	8
140801040202	Animas River-Tenmile Creek	0	0	5	5	2	8
140801040101	Animas River above Howardsville	2	0	3	5	2	8

HUB6	HUB6NAME	Transmission Line Category	303d Category	Urbanization Category	Cumulative Urbanization Rank	Riparian Cluster	Wetland Cluster
140801020502	Piedra River-Stollsteimer	1	0	4	5	6	4
140801020204	First Fork	2	0	3	5	2	1
140801010604	Upper Cat Creek	0	0	5	5	4	3
140801010502	West Fork Navajo River	3	0	2	5	1	7
140801010405	Rito Blanco	2	0	3	5	5	4
140801010204	Lower West Fork San Juan River	2	0	3	5	2	7
140300020507	Dawson Draw	0	0	5	5	4	3
140300020506	Brumley Valley	1	0	4	5	6	4
140300020504	Ryman Creek	2	0	3	5	5	4
140300020304	Lower Plateau Creek	3	0	2	5	5	4
140300020209	Upper Dolores River-Taylor Creek	2	0	3	5	5	3
140300020206	Bear Creek	0	0	5	5	2	1
140801070102	West Mancos River	1	0	3	4	2	1
140801040804	Upper Florida River-Red Creek	1	0	3	4	5	3
140801040801	Florida River Headwaters	0	0	4	4	8	9
140801040504	Upper Animas Valley-Trimble	2	0	2	4	5	5
140801040406	Hermosa Creek-Dutch Creek	2	2	0	4	1	1
140801040303	Lower Cascade Creek	0	0	4	4	2	8
140801040103	Mineral Creek	0	0	4	4	2	8
140801020404	Middle Stollsteimer Creek	0	0	4	4	6	3
140801020302	Lower Devil Creek	1	0	3	4	6	3
140801020301	Upper Devil Creek	2	0	2	4	5	3
140801020203	Sand Creek	4	0	0	4	2	1
140801020104	Piedra River-O'Neal Creek	3	0	1	4	5	4
140801020101	East Fork Piedra River	0	0	4	4	1	7
140801011704	Upper Spring Creek	1	0	3	4	6	4

HUB6	HUB6NAME	Transmission Line Category	303d Category	Urbanization Category	Cumulative Urbanization Rank	Riparian Cluster	Wetland Cluster
140801011703	Ute Creek	1	0	3	4	6	4
140801011603	Lower Beaver Creek	2	0	2	4	5	4
140801011602	Middle Beaver Creek	3	0	1	4	5	4
140801011601	Upper Beaver Creek	1	0	3	4	5	4
140801011502	Bear Creek	2	0	2	4	5	4
140801011305	Indian Creek	0	0	4	4	2	2
140801010507	Coyote Creek	2	0	2	4	4	3
140801010506	Little Navajo River	2	0	2	4	2	3
140801010504	Navajo River-Weisel Flat	2	0	2	4	4	3
140801010201	Upper West Fork San Juan River	4	0	0	4	2	8
140300020605	Dolores Canyon-Joe Davis Hill	1	0	3	4	4	3
140300020603	Dolores Canyon-Cabin Creek	2	0	2	4	4	3
140300020509	Pine Arroyo	0	0	4	4	4	3
140300020407	House Creek	0	0	4	4	4	3
140300020402	Spruce Water Canyon	1	0	3	4	4	3
140300020303	Calf Creek	3	0	1	4	5	4
140802020103	Hartman Canyon	2	0	1	3	6	6
140801040901	Lower Florida River-Ticalotte	2	0	1	3	5	4
140801040502	Elbert Creek	1	0	2	3	5	7
140801040302	Lime Creek	0	0	3	3	2	8
140801020405	Lower Stollsteimer Creek	0	0	3	3	6	4
140801020403	Stollsteimer Creek-Dyke Valley	1	0	2	3	4	4
140801020201	Upper Weminuche Creek	3	0	0	3	1	8
140801011503	Los Pinos River-Bayfield	2	0	1	3	5	4
140801011501	Middle Los Pinos River-Red Creek	1	0	2	3	5	3
140801011306	East Creek	0	0	3	3	2	1

HUB6	HUB6NAME	Transmission Line Category	303d Category	Urbanization Category	Cumulative Urbanization Rank	Riparian Cluster	Wetland Cluster
140801010602	Montezuma Creek	0	0	3	3	4	4
140801010307	Echo Canyon Reservoir	2	0	1	3	5	4
140801010303	Laughlin Park	0	0	3	3	5	1
140801010302	Fourmile Creek	0	0	3	3	2	3
140801010202	Beaver Creek	3	0	0	3	1	7
140300036101	Naturita Creek	1	0	2	3	5	4
140300020604	Dolores Canyon-Lake Canyon	0	0	3	3	4	3
140300020511	Disappointment Valley-Wild Horse Reservoir	0	0	3	3	6	3
140300020510	Upper Disappointment Valley	1	0	2	3	6	6
140300020505	Upper Disappointment Creek	1	0	2	3	5	4
140300020404	Stapleton Valley	1	0	2	3	4	3
140802020106	Lower Alkali Canyon-Narraguinnep Canyon	1	0	1	2	6	6
140801070105	East Fork of Mud Creek	1	0	1	2	4	4
140801070103	Upper Mancos Valley	1	0	1	2	5	4
140801050105	Upper Cherry Creek	0	0	2	2	5	4
140801050102	Mayday Valley	0	0	2	2	7	3
140801040603	Lower Lightner Creek	0	0	2	2	4	4
140801011401	Upper Vallecito Creek	2	0	0	2	2	8
140801010308	San Juan River-Eightmile Mesa	1	0	1	2	5	4
140801010306	Mill Creek	0	0	2	2	4	4
140801010305	McCabe Creek	1	0	1	2	5	4
140801010103	Sand Creek	2	0	0	2	1	7
140300020503	Sheep Camp Valley	0	0	2	2	5	4
140300020502	Disappointment Creek Headwaters	0	0	2	2	5	1

HUB6	HUB6NAME	Transmission Line Category	303d Category	Urbanization Category	Cumulative Urbanization Rank	Riparian Cluster	Wetland Cluster
140300020408	McPhee Reservoir-Dolores River	0	0	2	2	4	4
140300020405	Lower Lost Canyon	1	0	1	2	4	3
140300020301	Upper Beaver Creek -McPhee	1	0	1	2	5	1
140802020201	Upper Yellowjacket Canyon	0	0	1	1	4	3
140801040604	Animas River-Spring Creek	0	0	1	1	6	5
140801040403	Upper Hermosa Creek	1	0	0	1	2	1
140801020503	Piedra River-Navajo Reservoir Inlet	1	0	0	1	6	3
140801020402	Upper Stollsteimer Creek	0	0	1	1	5	4
140801020401	Martinez Creek-Dutton Creek	0	0	1	1	5	4
140801011302	Upper Los Pinos River-Flint Creek	1	0	0	1	2	8
140801011301	Upper Los Pinos River-Ricon La Vaca	1	0	0	1	2	8
140801010304	Upper Pagosa Springs	0	0	1	1	4	3
140300020501	Bear Creek-Disappointment Creek	0	0	1	1	5	4
140300020406	Upper Dolores River-Italian Creek	0	0	1	1	4	3
140300020302	Upper Plateau Creek	0	0	1	1	5	4
140801011304	Three Sisters	0	0	0	0	8	9
140801011303	Lake Creek	0	0	0	0	2	8