

## Wilderness, Water, and Quality of Life in the Bitterroot Valley

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***Abstract**—The Bitterroot Valley is located in western Montana, USA. Most of the Bitterroot Range above the Bitterroot Valley is protected as wilderness, and is a source of much of the water that flows down and through the valley floor. With an annual precipitation of only 12.3 inches, the Bitterroot Valley is classified as a high desert environment. Today the quality of life in the Bitterroot Valley is high, and it is deeply connected to the water resources and naturalness of the mountain landscape. To provide water for orchards, food crops, and hay, farmers constructed dams in the Bitterroot Mountains in the late 1800s and early 1900s. They were built to capture spring runoff from snow melt and store it until late July and August when flows in the Bitterroot River and its tributaries are usually too low to support irrigation and water-based recreation. In 1964, 251,443 acres (101,755 ha) of the Bitterroot Range were classified as wilderness. Special provisions in the Wilderness Act allowed continued operation and maintenance of these dams for existing uses. When dam repairs are undertaken periodically, there is intense discussion on the appropriateness of using heavy equipment, the type of repair to be implemented, and, sometimes, even whether to do the repair at all. The dams have substantial influence, both upstream and downstream, on the biological integrity of this wilderness ecosystem, but the influences may be considered tradeoffs with human needs for the same resource. This study attempted to develop an understanding of the ecological, economic, social and cultural values associated with wilderness dams in the Bitterroot Valley.*

Humans rely on freshwater for a number of reasons, including in our homes, agricultural uses, and for recreational use. At our homes we use water for drinking, bathing, cleaning, watering the lawn, and draining wastes. In fact, the “average per capita consumption of water in this country is about 100 gallons (379 liters) per day...” (Finstick 1986). However, household systems are not the only systems dependent on freshwater. The natural environment also requires freshwater to maintain ecosystems. The amount of water we rely on to continue our lifestyles increases when we consider the amount that is required to produce the food that we eat. When combined with our household use of water, the total amount of water required to sustain our livelihoods is quite extensive. To supply this demand for water, humans have regulated the flow of many rivers and streams. As the human population increases, the need to control freshwater resources also continues to increase.

Water is also an important component of recreation in the U.S. Rivers provide resources for rafting, kayaking, fishing and swimming. Lakes and reservoirs created by the placement of dams provide for recreational opportunities. Additionally, lakes and rivers provide picturesque scenery for hiking and picnicking, and are often sought after for camping locations when traveling through backcountry areas.

The natural world is also dependent on water abundance to sustain freshwater ecosystems. In an ideal situation the freshwater resource would be adequate to provide

for each use, whether it is for humans or for the environment. However, the freshwater resource is finite (Naiman and others 1995). Freshwater is most often derived from precipitation and therefore is a function of the area's geographic location.

The human population continues to increase, and because we are not the only species that rely on the freshwater resource, decisions must often be made about how the water is managed and which user, the environment or humans, will receive the most benefits from that water. Most often, the competition between users favors humans. Since the early ages, humans have diverted water to irrigate lands and grow crops to feed people (Postel 1999). Ward and Stanford (1979) conclude that today most of the mainstream rivers are effectively manipulated for anthropogenic purposes. Until recently, flow regulation from impoundments and diversions has proceeded without due consideration of the ecological consequences on the environment.

What has often been overlooked, and is now becoming of increasing interest, is what the effects are to the ecosystem from the regulation of streams and rivers for human uses and how those human uses affect the larger ecosystem. Therefore, the purpose of this paper is to provide an understanding of the ecological and human connections between the freshwater resource and the ecosystems and people that it supports; and, to explore the effects of human alterations (diversions, dams, and irrigation) on those connections through a case study of the history of dams in the Selway-Bitterroot Wilderness (SBW) in western Montana.

The connection between ecosystems and the water resource has been termed 'hydrologic connectivity,' and is defined as "the movement of matter, energy, and/or organisms within water and between elements of the hydrologic cycle" (Pringle 2001: 21). This paper also explores the "human connectivity" of future resources, defined here as human meanings or values ascribed to freshwater resources including, but not limited to, quality of life, safety, transportation, and survival.

## **DAMS IN THE SELWAY-BITTERROOT WILDERNESS**

The Bitterroot Valley is nestled between two mountain ranges on the western edge of Montana. The Bitterroot Valley is 25 miles (40 km) wide and 96 miles (154 km) long covering 2,383 square miles (6,172 km<sup>2</sup>). Average rainfall is 12 to 15 inches per year (Bitterroot Chamber of Commerce 2004). The Bitterroot Valley would be very arid without the water produced on the east face of the Bitterroot Range. The Forest Service estimates that this slope produces 70 percent of the water for the Bitterroot River (USDA Forest Service 1963). The Bitterroot Mountain Range forms the western boundary of the Bitterroot National Forest and over 70 percent of the land in the Bitterroot Valley is part of the Bitterroot National Forest. According to the 2002 population census there are 37,730 residents living in Ravalli County in the Bitterroot Valley.

Ravalli County, which includes most of the Bitterroot watershed, experienced a 43 percent increase in population during the 1990s and was the fastest growing county in Montana (Swanson 2001). The quality of life in the Bitterroot Valley is high, and it is deeply connected to the water resources and naturalness of the mountain landscape. Prosperity of some economic sectors, aesthetic beauty, and sense of place are all believed to be somewhat dependent upon the water and other natural resources of the Bitterroot National Forest.

## **Cultural/Historical Resources**

Archaeological surveys revealed prehistoric occupations at some sites in the Bitterroot Mountains, including a possible Early Archaic presence (5000 – 3000 B.C.). Aboriginal campsites have been surveyed although many artifacts have been destroyed around dams constructed in the late 1800s.

The primary legislation governing modern heritage resource management is the National Historic Preservation Act (NHPA) of 1966 (amended in 1976, 1980, and 1992). All other heritage resource management laws and regulations support, clarify, or expand on the National Historic Preservation Act. The Forest Service is required to consider the effects of dams, as pre-existing structures and requests for maintenance and reconstruction by dam owners, on cultural resources that are determined eligible for the National Register of Historic Places or on heritage resources not yet evaluated for eligibility. Resources include such things as campsites, artifacts, historic cabins and bridges, and other cultural objects. These laws and regulations guide the Forest Service in identifying, evaluating, and protecting heritage resources on National Forest System lands (USDA Forest Service 2002a).

Long before they arrived in the Bitterroot Valley, the Salish were one of several tribes living in the Columbia Plateau. By 1805/1806, the Lewis and Clark expedition observed that the Salish were two distinct tribes: the coastal Salish, who had migrated west to the Pacific slope, and the inland Salish, the group that included the small tribe who followed the Clearwater River and eventually made their home in the Bitterroot Valley (Malone and others 1991; Stevensville Historical Society 1971).

Events occurring between 1812 and 1841 altered the lives of the Salish people (Malone and others 1991). The Salish learned about the “Black Robes” through Iroquois Indians who were traveling across the West with fur trappers. Big Ignace LaMouse, an Iroquois Indian, led a band of his tribe west eventually settling among the Salish in the Bitterroot Valley. He assured them with the “Black Robes” pointing the way that “all men could enjoy the fruits of heaven” (Stevensville Historical Society 1971: 38).

Even though the Salish survived quite well in a nomadic life of hunting, fishing, and collecting “bitter roots,” the Jesuit missionaries considered agriculture as the better alternative to the itinerant native lifestyle. The Jesuit priests successfully planted and irrigated a crop of potatoes, oats, and wheat at St. Mary’s Mission in the summer of 1842. “Thus, by appropriation, the first water right in the state of Montana was established” (Stevensville Historical Society 1971: 141).

Six years after the first successful crops were harvested by priests at St. Mary’s Mission, the British ceded a large portion of its Northwest Territories to the United States and the Bitterroot Valley was placed under the jurisdiction of the Oregon Territory. Five years later, the Bitterroot was incorporated into the Washington Territory. One of the first priorities of Territorial Governor, Isaac I. Stevens, was to solidify the land claim by resolving “the Indian question,” developing transportation networks and opening the land to homesteaders (Malone and others 1991). Governor Stevens’ solution to the “Indian difficulties” was cession of their aboriginal lands and removal to reservations, where clear, established boundaries would protect both the settlers and natives from squabbles over the white concept of property (Zeisler 1982). Stevens negotiated the Hellgate Treaty with the Salish, Kootenai, and Pend Oreille tribes in 1855 that established the Flathead

Reservation in the Jocko Valley. As a result of the treaty, the Salish own federal reserved water rights, and they were also given fairly broad rights in the Hellgate Treaty, including hunting and fishing rights through the Upper Clark Fork Basin. The Hellgate Treaty was ratified in 1859. Twelve years later, as more and more settlers came to the valley seeking land, the remaining natives' presence was perceived to hinder white settlement, so President Grant issued an executive order requiring all of the Salish to move. By 1891, all of the Indians had moved to the Jocko Indian Reservation, which freed the Bitterroot Valley of one obstacle to white settlement (Malone and others 1991). Scarcity of water and productive soil were the barriers that remained.

### **History of Water Rights in the Bitterroot Valley**

Soon after the Hellgate Treaty was ratified, new immigrants arrived in the Bitterroot Valley. With a growing number of homesteaders, Montana became a territory in 1864. By 1865, there were approximately one hundred white inhabitants in the Bitterroot Valley, most of whom were engaged in agricultural pursuits (Baumgartel 1923).

One of the earliest acts of the newly established Montana Territorial Legislature was to establish a system of water rights. On January 11, 1865, the legislature ratified the doctrine of riparian rights resulting from English common law and practiced throughout the eastern states. The riparian rights system gives individuals rights to water flowing on their property, allowing them to use that water however they please so long as the water stays in its channel and continues downstream substantially "undiminished in quantity or quality" (Deuel 1999: 29). Miners and ranchers protested against the riparian doctrine so the legislature approved the fundamentals of prior appropriation as well.

Mining and agriculture interests provided the impetus for construction of some of the earliest dams in the Bitterroot Range. The steady expansion of agriculture and settlement was reflected in the continual filing for water rights and concurrent construction of irrigation ditches.

In the 1870s, the Bass brothers planted the valley's first successful commercial fruit orchard and initiated an experimental station that operated for 20 years (Zeisler 1982). In 1871, the Etna Mutual Ditch Company was founded as the earliest recorded cooperative irrigation project in the valley, to divert water from the main stem of the Bitterroot River. The trend towards group irrigation projects initiated by Etna Mutual in the early 1870s gathered momentum in the 1880s with the formation of several small ditch companies comprised of groups of neighbors sharing the costs and labor required to build and maintain ditches.

The Organic Administration Act of 1897 provided a formal system for managing the forest reserve system. The Bitterroot Forest Reserve was one of the first forest preserves, established in 1897. The importance of stored water for agriculture and economics of the Bitterroot Valley was emphasized by the U.S. Geological Survey. The survey report notes that "nearly all the canyons of the western watershed offer good opportunities for creation of small storage reservoirs" and "small scale dams have been constructed on some small streams on the west side of the Bitterroot Range that hold back a portion of surplus water" and their construction has been "a matter of local enterprise" (USDI Geological Survey 1899: 261). As of 1899, residents of the Bitterroot Valley had constructed 75 small dams within the Forest Reserve (Bitter Root Water

Forum 2003). In 1905, the Bitterroot National Forest was established and boundaries were adjusted. Because of the agricultural character, some land along the East and West Forks of the Bitterroot River was removed from the original Forest Reserve status.

### **Wilderness Considerations**

In 1964 there were 144 dams within the initial 9.1 million acres (3,682,639 ha) designated as wilderness within the National Wilderness Preservation System (NWPS) (USDA Forest Service 1963). Many of the dams required routine maintenance, replacement or removal.

Most of the dams in the Selway-Bitterroot Wilderness (SBW) typically have earth and rock-filled log crib cores with native rock facings. They are approaching (or in some cases, exceed) 100 years old. The log cribs have rotted, the fill has settled, and the facings have deteriorated after a century of use and exposure to naturally occurring events like windstorms and avalanches (USDA Forest Service 2003a). Inclusion in the wilderness presents unique challenges for repair, maintenance and reconstruction. Routine maintenance usually involves access by foot, saddle horses and pack mules, or helicopter (by special authority on a case-by-case basis). The dams are located at high alpine elevations and are only accessible from July until October of each year. These dams require a certain level of annual maintenance, including removal of woody debris that falls into the reservoirs and floats up to the face of the dam. This debris must be removed periodically to keep the spillway from becoming blocked with the resulting danger of the dam being over-topped (USDA Forest Service 1991a). The normal sequence of operation of dams in the SBW is to leave the irrigation gate open August through late June/early July, at which time the gate is closed to impound the remaining spring snowmelt. The gate is opened in August to provide late season irrigation water.

Federal agencies charged with managing wilderness are faced with challenges of dam management when interpreting the intent of the Wilderness Act and other resource protection policies regarding pre-wilderness water and property rights, reasonable access, dam safety, recreation, cultural resources, and fisheries considerations.

The SBW consists of lands that were within the Selway-Bitterroot Primitive Area established by the Forest Service in 1936 under the L-20 Regulation. When the primitive area was established there were 45 irrigation reservoirs in use on the east face of the Bitterroot Mountains within the boundaries. Most of these dams were constructed around the turn of the century using hand or horse labor and utilizing on-site materials. Twenty-nine of the original 45 dams have been abandoned by the original owners. Difficult access, costs to maintain and operate dams, and no actual need for water are some reasons for abandoning these reservoirs.

The L-20 Regulation, which was replaced by Regulation U-1 in 1939, was more permissive than Regulation U-1 and permitted certain improvements and developments in Primitive Areas such as logging and road construction, that are now prohibited in wilderness areas (USDA Forest Service 1963). U Regulations prohibited timber cutting and road construction but allowed grazing and water resource development (Hendee and Dawson 2002; Roth 1995).

In 1961, the U.S. Senate overwhelmingly approved legislation similar to Senator Humphrey's 1956 Wilderness Act legislation. During the 1961 Senate debate on the legislation concerning the issue of protection of "existing private rights," Senator Metcalf

of Montana expressed that “private rights are protected, and the intention is to protect them as these areas are converted into wilderness” (U.S. Congress 1961: 3).

In 1963, Secretary of Agriculture, Orville F. Freeman, recognized the importance of the eastern face of the Bitterroot Divide draining into the Bitterroot Valley. Some of the areas under consideration for wilderness designation were excluded “because it is needed for irrigation reservoirs.” These areas were deemed “more valuable for water storage purposes than for wilderness.” The interests of the Bitterroot Valley residents in water produced on the east face of the range were recognized in the decision by guaranteeing that “individuals or organizations holding special-use permits for irrigation structures ... shall be entitled to access to such structures and to repair or enlarge such structures by any means which shall not be unduly destructive of other natural resources in the area” (USDA Forest Service 1963: 19).

The SBW was designated by the Wilderness Act of 1964 (PL 88-577, 78 Stat. 890). Facilities for water storage, such as dams and reservoirs, are permitted by the 1964 Wilderness Act. Currently, there are 16 privately owned dams within the SBW, all existing prior to wilderness designation. Five of the dams were built before the establishment of the Bitterroot National Forest in 1905 and are authorized by virtue of recognized outstanding rights (USDA Forest Service 2003a). Remaining dams are authorized under Forest Service special use permits, with several qualifying for permanent easements to be issued under authority of the Colorado Ditch Bill (Ditch Bill, PL 99-545). Special use dams are shown in figure 1.

Section 4(c) of the Wilderness Act of 1964 states prohibited uses and actions in wilderness “except as necessary to meet minimum requirements for the administration of the area for the purpose of this Act...” In this section Congress acknowledges that even though the activities are prohibited there are times that exceptions will need to be made.

From Section 4 (c), the minimum requirements decision guide (MRDG), formerly referred to as the “minimum tool rule,” was derived to assist managers in assessing both the minimum work that is necessary and the minimum tools to implement the action that will result in the least impact to wilderness. Use of the MRDG is not required by law or Forest Service policy. The interpretation of the MRDG is to be used when the proposed action is generally prohibited by the Wilderness Act and/or policy (USDA Forest Service 2004). Forest Service wilderness policy requires a minimum tool analysis for dam maintenance and reconstruction proposals when motorized tool use or mechanical transport in wilderness is requested.

Until the late 1960s, the Forest Service had a permissive policy regarding the use of mechanized and motorized means to maintain the dams. The Wilderness Act placed restrictions on the use of motorized equipment and mechanical transport. The Bitterroot National Forest responded to those restrictions by scrutinizing each request for use of motorized equipment or mechanical transport. A comprehensive review of dam management policies was undertaken in 1991 leading to further restrictions on the use of mechanized and motorized means for dam maintenance and reconstruction.

In a 1998 Region One supplement (2300-98-1) to the Forest Service Manual regarding maintenance of dams in wilderness, use of motorized/mechanized equipment for maintenance or reconstruction of dams in designated wilderness will be permitted if one or more of the following conditions apply:

1. Emergencies (immediate threat to life and property).
2. Where impacts to wilderness and/or resources therein would be greater using non-motorized/non-mechanical methods (includes duration of impacts).
3. When physically infeasible to use non-motorized methods.
4. When costs make the use of primitive methods infeasible.

The determinations required may be made and documented by the responsible Forest Service official through the National Environmental Policy Act (NEPA) process. Specific project level conditions apply to site-specific conditions and the situation at the dam. A "minimum tool" analysis may be required that can be incorporated into an environmental analysis.

A brief history of two dams located within the SBW is presented to illustrate the complexities of managing dams that were constructed long before the Wilderness Act was passed. The original Bass Lake Dam was built in 1887 to provide irrigation water for farmland in the Bitterroot Valley. The dam was reconstructed in 1918, 1952-1953, and most recently in 1996. A road was built in 1952 for heavy equipment access to the dam and was renovated again in 1996 so heavy equipment could be taken to the dam site (Bass Lake Reservoir Company 2003). When the equipment was removed the road was restored to trail conditions. Normal storage capacity of the dam is 3,600 acre-feet (4,441 cubic dekameters). In contrast, Big Creek dam was initially constructed in 1892 as a rock and timber structure. The original dam was in a 7ft (2m) cut with a hole in the logs of the dam for an outlet (USDA Forest Service 2002b). Significant repairs to the dam were done in 1942. Over the years much of the maintenance has been done using traditional hand tools. The dam was rebuilt in 1977 using heavy equipment and helicopters. No access road was built to the dam so all construction materials and equipment were transported by helicopter. Concrete was flown in to build a new dam at the site of the old dam (USDA Forest Service 1991b). Normal storage capacity of the dam is 3,261 acre-feet (4,022 cubic dekameters) (Big Creek Lakes Reservoir Association 2002). Both dams were originally constructed before the turn of the century using traditional tools, have been rebuilt more recently using mechanized and motorized equipment, and they have similar storage capacities. The contrast is that no road access was allowed for reconstruction of Big Creek dam and heavy equipment had to come in by helicopter transport.

### **Policy Considerations and Implications**

The National Historic Preservation Act requires consultation with the Salish Culture Committee of the Confederated Salish and Kootenai Tribes at sites within the Bitterroot National Forest that may have been occupied by the tribes. Consultation with the Montana State Historic Preservation Office is required for dams with Ditch Bill easements and special use permits, dam reconstruction, and other activities as needed. Ditch Bill easements date back to 1866 legislation, granting right-of-way for a ditch or canal that was constructed by the holder of a valid water right prior to inclusion of the land in the National Forest System.

The Forest Service also has oversight responsibilities on dams located on federal lands in Montana to ensure compliance with federal dam safety regulations. Federal regulations are very stringent (USDA Forest Service 2003b). A dam poses potential risks

to persons and property downstream, so the dam owner is legally obligated to maintain the dam in a safe condition (USDA Forest Service 2003a).

Federal and state dam safety requirements and oversight have increased significantly since the SBW was established. Examples include the Federal Dam Inspection Act of 1972 (PL 92-377); Presidential Memorandum of October 1979 and Federal Guidelines for Dam Safety of June 1979; the Water Resources Development Act of 1992; the Montana Dam Safety Act of 1993; the National Dam Safety Program act of 1996 (PL 104-303); and, the National Dam Safety and Security Act of 2003 (PL 107-310). The Montana Dam Safety Act eliminated the regulatory role of the state on dams located on federal lands, leaving the regulatory role of dam safety entirely with the Forest Service. Hazard ratings are applied to dams based on the potential for loss of life and/or property should the dam fail (USDA Forest Service 2003a).

Six of the dams in the SBW are high or moderate hazard and require Emergency Action Plans. The dams include Early Warning Systems, powered by solar panels, and installed below dam sites in the SBW or closer to the wilderness boundary or the trailhead to alert the downstream population at risk of dam failure.

## **CONTEMPORARY IMPLICATIONS FOR WILDERNESS, WATER, AND QUALITY OF LIFE IN THE BITTERROOT VALLEY**

Many of the dams in the SBW are old and pose a great challenge to meet standards set by state and federal dam safety regulations. Inclusion in the wilderness presents unique challenges for repair and maintenance of the dams. There are no roads to any of the dams and access is by foot, horseback, or helicopter (USDA Forest Service 2003b). Since the Wilderness Act was signed into law in 1964, different Forest Service personnel have interpreted the analysis and the definition of "reasonable access" differently, resulting in inconsistent treatment of similar requests. Section 5(b) of the Wilderness Act does not provide specific direction for access and appears to be in conflict with Forest Service dam safety policy (USDA Forest Service 2003a).

Today the Bitterroot Valley is characterized by an influx of new people with different values and economic means. The once very rural communities here are evolving into communities of commuters to the Missoula area, retirees, a growing service and high technology business center, as well as trying to maintain a strong relationship with agriculture. Ravalli County has no building restrictions along creek drainages outside of the Selway-Bitterroot Wilderness.

Many people living below the dams on the west side of the Bitterroot Valley, who are members of an irrigation district, pay a tax assessment for maintenance, operation, and rehabilitation of dams. In return, some landowners receive water to irrigate their crops, fields, or land. Not all landowners downstream from the reservoirs receive water, use it, or even know they have access to it until a dam needs repairs and they suddenly receive a sizeable bill. With the rapid population growth in the Bitterroot Valley (Swanson 2001), newcomers will continue to create increased demand on water resources.

The Bitterroot Water Cooperative was formed by many of the owners of the dams in the SBW who are working together to be informed on legal requirements and to resolve issues affecting the operation of dams in the SBW. In 2001, the Water

Cooperative decided to request Congressional legislative action to “alleviate the severe and perhaps insurmountable physical and financial strain placed on the dam owners whose reservoirs are located within the boundaries of the SBW” by asking that the wilderness boundary on the east face of the Bitterroot Mountains be moved to “cherry stem” the reservoirs and the canyons and trails leading to them so the result is that these areas would not be in the Wilderness” (T. Bumbarger, personal communication, letter to Lawrence Siroky, Montana Department of Natural Resources, October 12, 2001).

The Bitter Root Water Forum was started in 1995 as a collaborative, consensus-based group of people with diverse ideas who meet monthly to gather information on issues such as growth and water and then work towards change. According to Roxa French, former Project Coordinator for the Bitter Root Water Forum, “One by one, irrigation companies are facing the daunting task of reconstruction or at least serious maintenance on the aging structures. The Irrigation Company must decide whether the dam continues to be valuable and thus a worthy investment, or whether to simply breach it, rather than trying to secure funds for repairs. For any one of the dams, the decision of the irrigation company seems to affect only the company and its shareholders. Taken collectively, the potential loss of this much water storage capacity and late season flows might drastically affect the greater Bitterroot Valley in the physical setting we’ve become accustomed to, and perhaps the way in which our ecosystem has evolved.”

Wilderness Watch (WW), founded in 1989, is a national conservation organization dedicated solely to the preservation and proper stewardship of those lands and rivers included in the National Wilderness Preservation System (NWPS) and National Wild & Scenic Rivers System (<http://www.wildernesswatch.org/>). Dams in wilderness is one issue WW monitors throughout the NWPS. While WW agrees that dams are part of wilderness, and recognize them as cultural artifacts with valid water rights, they have taken a firm stand on the use of non-motorized primitive tools and access for operation, maintenance, and reconstruction. They argue that the original dams were built with primitive tools and that the intent of Congress was that they continue to be maintained with primitive tools, in accordance with the Wilderness Act of 1964 (W. Worf, personal communication, June 5, 2003).

The issue of dams in the SBW is complex and often divisive with many stakeholders in the Bitterroot Valley holding diverse viewpoints and interests, both social and economic. Bitterroot Valley residents want to protect their quality of life.

## **FUTURE RESEARCH QUESTIONS**

The key to understanding the concept of hydrologic connectivity is to focus on a large scale. The effects of regulating water are not limited to the immediate river or drainage in which they are located. Rather, these effects are often noticeable across an entire landscape. In the Bitterroot Valley of Montana, the effects of regulating water that originates within the Selway-Bitterroot Wilderness can be observed across the entire Valley. The regulation of these creeks also affects the biological integrity of the entire Columbia River drainage.

Regulation of rivers and creeks threatens the landscape’s biological integrity. As species of the ecosystem become lost or threatened as a result of loss in habitat, it sends a ripple through the entire food chain. At the local level, the loss of one species, perhaps an

insect, may be seen as irrelevant. However, when that loss is viewed from a landscape perspective, that one species may have been a vital food source for several species. As species are lost, the predator/prey continuum is altered. Most importantly, by simply altering the amount of sediments and organic material contained within the river, we can severely disrupt the biological integrity of the area.

The regulation of freshwater and its subsequent uses also affects the quality of life for the residents of the area, namely in the availability of groundwater. In the Bitterroot Valley, this is perhaps the most important connection between alpine lakes and people residing there. As Finstick (1986) indicates, the area's groundwater supply could not sustain the county's current population levels without the additional water added to the groundwater from irrigation. These irrigation waters recharge the area's aquifers, which provide water for domestic uses. If the irrigation practices within the Valley were discontinued, the availability of groundwater would be severely diminished.

This connection is important to note because the Bitterroot Valley is experiencing a rapid population increase. To accommodate the new residents, lands are being taken out of agriculture, and therefore, out of irrigation. If this practice continues, Valley residents' wells will likely go dry.

And lastly, a recurrent theme of this analysis is the inevitability of tradeoffs between water resources and the quality of life Bitterroot Valley residents enjoy. Due to the nature of this dilemma, with its foundation in human values, science alone cannot provide a solution. Science can provide information as to the effects of certain alternatives, but the solution can only come from mutual agreement on behalf of all stakeholders. If scholars are correct that "there is commonly a lack of data on hydrologic connections between wilderness resources and surrounding areas" then "the role of water, both aboveground and below the surface, must become a more integral consideration of wilderness integrity" (Pringle 2001: 21).

Based on this analysis, and reviewer comments, these are several research questions to consider for future research. The questions are divided into two subject areas: A) hydrological connectivity; and, B) human dimensions.

#### **A. Hydrological Connectivity**

1) Careful consideration of ecological and socioeconomic tradeoffs associated with altering hydrological connectivity require answers to this question:

- How can we balance long-term ecological and public health benefits associated with water supplies, with short-term economic gains?

2) Development of a more comprehensive understanding of hydrological connectivity is also needed.

- How does hydrological connectivity operate within different landscapes?
- How does hydrologic connectivity link different ecosystem types?
- What are the time lags between a given alteration in hydrologic connectivity and consequent ecological effects on biodiversity? Ecosystem function?
- How do alterations in hydrologic connectivity affect foodwebs? How do cascading ecosystem-level effects of foodweb alterations affect both aquatic and terrestrial ecosystems?

- How do interactions between anthropogenic and ‘natural’ disturbances affect hydrologic connectivity?
- How do cumulative effects of alterations in hydrologic connectivity operate at different spatial and temporal scales?

3) There is a need to develop a basic understanding of the ecosystem processes that are affected by dams and to understand how dams and their hydrologic connectivity have been influenced by past and present human activities. This can be achieved through a paired watershed (dam/non-dam) analysis in the SBW along the Bitterroot Front that estimates populations of key floral and faunal species to ascertain ecosystem changes from dams. This will assess the availability of biological data at the local level and the implementation of GIS and hydrographic modeling to estimate and display current and future ecosystem effects from dams. More specific comparisons are offered below:

- Compare August streamflows (on a per drainage acre basis) for selected westside drainages with and without dams.
- Compare stream and riparian conditions (fisheries, aquatic life, etc.) of selected westside drainages with and without dams.
- Compare irrigated land, land values, natural and aesthetic values for private lands at the lower end of selected westside drainages with and without dams.
- Compare the aggregate of drainages with dams and those without.

## **B. Human Dimensions**

Research could be accomplished to better understand the economic, social, historical and cultural role the dams play in providing water to the Bitterroot Valley.

### 1) Breaching of dams.

- Understand why some private dams within the SBW have been breached.  
Conduct interviews with dam owners to develop oral histories of individual dams.

### 2) Social values.

- Conduct research to define the ecological, economic, social and cultural values held by local residents regarding wilderness water resources.
- Determine if Bitterroot Valley residents recognize and comprehend the relationship between wilderness water resources and the quality of life they enjoy in the Bitterroot Valley.

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**Figure 1—Special use dams, Bitterroot River drainage.**