Water Acquisition and Management Subcommittee Position Paper: Supplementing Middle Rio Grande flows through Active Watershed Management

Introduction

The Middle Rio Grande (MRG) Endangered Species Act Collaborative Program (Program) is exploring options for increasing flows in the MRG for endangered species. This paper discusses the possibility of obtaining higher, augmented river flows through active upland watershed management. Augmented river flows by riparian vegetation or invasive species management is the topic of other Program position papers and is not discussed herein.

Prolonged drought has led to increased concern over water yield and fire danger. Manipulating upland watersheds for multiple purposes including reducing fire threat from insect- and drought-devastated forests, increasing overall water yield, and improving water quality. When active watershed management is combined with cloud seeding to further increase total precipitation, the opportunities for increased water yield at a reasonable cost per acre become very attractive (Baker and Ffolliott, 2000). Current administrative and legal frameworks do not permit those investing in watershed management to take direct benefit of the increased water yield. This position paper explores active watershed management alternatives that could result in wet water benefits to the MRG through increased wet water flows and paper water rights that, when managed on behalf of the Program, could benefit MRG endangered species.

In the Rocky Mountains, there is a long history of manipulating watershed vegetation with resultant increases in watershed yield. However, the uncertainty in defining absolute year-to-year water yield rests in understanding complex and interrelated hydrologic, biogeochemical, geomorphic, and ecosystem interactions. While increased water yields are well documented (Megahan and Hornbeck, 2000), attention must be paid to potential unintended consequences of any Program-funded activities. Best management practices (BMPs) are already established by the timber industry to minimize many of the undesirable effects of watershed management including erosion and sediment management associated with land disturbance. Long-term and paired watershed monitoring should be required for any watershed manipulation activities funded by the Program to ensure that increased water yields do not result in adverse impacts on species caused by erosion, sediment, or water quality impediments.

Between the Colorado/New Mexico state line and the Otowi Gage, sub-alpine and alpine upland areas contribute snowmelt runoff to the Rio Grande system. Collaborative watershed management activities in the Rio Grande headwaters areas of southern Colorado have potential to increase overall water supply flowing to New Mexico across the Colorado/New Mexico state line. In New Mexico, upper elevation spruce/aspen forests and middle elevation mixed conifer forests offer the greatest potentials for increased water yield. Federal and state lands comprising upland watersheds surrounding the Heron, El Vado, Abiquiu, and Cochiti Reservoirs are also potential targets for active watershed management with downstream reservoirs potentially available to store increased water yields.

Background

Water yield from a watershed receiving average input precipitation will yield an average output streamflow. The difference between input precipitation and output streamflow is typically a function of evapotranspiration by vegetation growing in the watershed. If one can decrease the amount of water used by vegetation, more water should be available for streamflow or infiltration. In arid areas, as much as 90 percent of precipitation is lost to evapotranspiration. Therefore, upland watershed management could provide increased water yield by replacing deep-rooted or high water using plants with shallow-rooted, lower water using plants. Techniques used to reduce evapotranspiration include: decreasing stand density to reduce transpiration and interception; type conversion where in dominant vegetative cover is changed to another that uses less water; creating forest openings to accumulate, redistribute and concentrate snow in order to reduce evaporation, increase snowmelt efficiency, and enhance streamflow contributions; and establishing trees, shrubs, or fences to pile snow into drifts thereby reducing evaporative losses.

While increased water yield has been observed following catastrophic fires, the ancillary undesirable consequences of increased sedimentation, erosion, flash flooding and their impacts on water quality, following such fires preclude the use of fire as a watershed management tool (Farnes, et. al., 1989; Kunze and Stednick, 2003, Neary et. al., 2000).

Surrounding states are evaluating the potential for watershed management in increasing water yield and overall water supply. The costs for watershed thinning are often less, on a per-acre-foot basis, than imported water. Watershed management also offers synergistic benefits with fire reduction and cloud seeding programs. The value of watershed thinning was recognized early on – in 1983, the Denver Water Board estimated the value of incremental yields at $112 per acre-foot. Assuming an annual inflation rate of 3%, in today's dollars, that estimate would be about $210 per acre-foot. California (Turner, K.M, 1994), Texas (Texas State Soil and Water Conservation Board, 2002), Arizona, and Colorado are all evaluating and/or implementing watershed thinning projects in an attempt to increase water yields. It has been estimated that the surface water supply in the Colorado River Basin could be increased by as much as 33% if vegetation and snow on 16% of the basin were manipulated solely to increase water yield (Hibbert, 1979). Texas is evaluating woody vegetation and brush management in an attempt to increase watershed yields in the Edwards Plateau (Wu et. al., 2001; Walker et. al., 2000).

New Mexico has also made forays into recommending and implementing active watershed management for improved water yield.

- Section C.8 of the New Mexico 2003 State Water Plan addresses state support for watershed restoration projects with a high potential to increase the water supply or improve the quality of water. However, the Plan does not provide specific implementation strategies to support or enhance these activities (State of New Mexico, 2003).

- The Governor's Blue Ribbon Task Force on "Stewardship of New Mexico's Water" supports water-related funding for watershed restoration and management,

recommending that the State aggressively pursue such activities to: improve forest health; prevent catastrophic fires; increase water yield; and improve water quality (State of New Mexico, 2002).

- The Middle Rio Grande Water Assembly (MRGWA) evaluated watershed management as "Alternative 66: Watershed Plans". They emphasized the formation of local watershed groups coordinated by state, Tribal or Federal entities and estimated an average cost of $150 per acre foot of increased water over a 20-year timeframe. A legal analysis was also provided exploring pertinent Federal and state laws and provided a statement on Rio Grande Compact implications (MRGWA, 2003).

- The Jemez y Sangre Planning Council evaluated watershed management in their Regional Water Plan (Jemez y Sangre, 2002). They considered opportunities for forest, woodland and riparian systems management for increased water yield and evaluated the legal and administrative implications for implementation in New Mexico.

- Santa Fe is aggressively thinning woody vegetation in the steep terrain of the Santa Fe watershed at a cost of approximately $1,000 per acre (MacDonald, 2002). These costs did not include costs for slash management or reseeding with grasses. The goal of this thinning project is water quality protection in the event of a large crown fire. This program is participating in a paired basin study – attempts to quantify water yield will be made over the course of the thinning program (Carpenter, 2003 personal communication).

- The Rio Penasco Watershed Restoration Project is exploring a community-based watershed restoration project performed in conjunction with the USDA-Forest Service, U.S. Bureau of Land Management, Mescalero Apache Tribe, NM State Forest Service, Village of Cloudcroft, and other local partners. The goals of this project are to reduce catastrophic fire danger; restore ecological integrity and biodiversity; improve water supply and water quality; and create a sustainable economy based on diverse forest products and values. Actions include: thinning of small-diameter trees; reducing stand density with commercial timber sales; erosion management; providing slash disposal areas; and allowing for additional prescribed burns and pre-commercial thinning. Long-term restoration activities include: fuels reduction (Cloudcroft Estate); water quality improvement projects; and commercial small-diameter tree projects (Mescalero Mill). Other activities supported include community-based partnership workshops, educational outreach; and other public outreach activities (Doppelt et. al., 2002).

- The ZeroNet Water-Energy Initiative, a joint initiative between Los Alamos National Laboratory, the Electric Power Research Institute, and Public Service Company of New Mexico is also trying to quantify the costs and benefits of comprehensive pinon-juniper and upland forest vegetation management for increased water yield and biomass-based electricity generation (ZeroNet Water-Energy Initiative, 2003).

Watershed Management:

From a hydrologic perspective, watershed management refers to managing the balance between inflow of water as precipitation and outflow of water as evapotranspiration, groundwater discharge, and streamflow. The basic water balance equation is as follows (Fetter, 1980):

$$\text{Inflow} = \text{Outflow} \pm \text{Changes in Storage}$$

When written in terms of watershed processes, the equation becomes the following.

$$P = (ET + SF + GWD) \pm (SMC \pm GWS)$$

Where:
P = Precipitation (gain) = inflow
ET = Evapotranspiration (loss) = outflow
SF = Streamflow (loss) = outflow
GWD = Groundwater discharge (loss) = outflow (subsurface baseflow)
SMC = Soil moisture content (gain or loss) = change in storage
GWS = Groundwater storage (gain or loss) = change in storage

Active watershed management is often performed for reasons other than increasing water yield – reduction in fuel load to reduce the magnitude and frequency of wildfires; forest health; insect infestation management, and improving forest health/drought resistance. However, the potential water yields versus the cost of watershed management justify examining watershed management as an alternative source of reasonably priced water. Watershed management for increased water yield becomes even more cost-effective where synergistic benefits can be achieved – e.g., fuel reduction with enhanced water yield and/or performed in conjunction with cloud seeding to enhance total precipitation.

Clear cutting and vegetation conversion are the two techniques most commonly cited for water yield; however, even limited vegetation thinning can provide significant (2-5% increases) in water yield (Baker and Ffolliott, 2000). The cheapest water (based on costs to produce) are typically associated with commercial forestry activities, where timber yields can pay for part of the treatment cost. Thinning combined with cloud seeding can further increases total precipitation in the watershed and the overall magnitude of water yielded to streamflow and aquifer recharge.

Typical vegetation manipulation at the watershed scale involves removing woody vegetation to provide increased streamflow or infiltration. However, unintended consequences must also be managed – e.g., cheat grass invasion, compaction from increased grazing, and soil erosion in water-stressed systems. Sub-alpine spruce, aspen, and mixed conifer forest zones have the greatest water yield potentials. However, even ponderosa, pinon-juniper and lowland vegetation management programs have shown increased water yields. The duration of increased yields ranges from 15 to 45 years (Troendle and Nankervis, 2000).

Early water balance studies were performed on two paired watersheds at Wagon Wheel Gap on the headwaters of the Rio Grande in southwestern Colorado (Bates and Henry, 1928). Streamflow was measured from 1911 to 1919, then one watershed was clearcut. Of 530 mm annual precipitation falling on these watersheds, about 150 mm was returned as streamflow, with an estimated 380 mm lost to evapotranspiration. Following clearcutting, water yield, as measured by streamflow, increased an average of about 25 mm. Reduced overstory transpiration was offset by increased understory transpiration and ground evaporation.

Studies performed in the Fraser Experimental Forest in north-central Colorado also demonstrated the potential for increased water yield associated with timber harvesting and weather modification (Leaf, 1975). Later studies in this area (Alexander, et. al, 1987, Troendle, et. al., 1987) indicated good potential for increasing water yield in sub-alpine forests by creating forest openings to reduce snow redistribution and transpiration with attendant water yield increases of 25 to 75 mm. The authors recommend patch cuts to create forest openings, rather than clear cutting. Patch cuts are considered ecologically sound and help maintain ecosystem diversity. Harvest procedures recommended for lodgepole pine forests include path cuts of 5 to 8 tree heights in diameter exposing about 1/3 of the area, with cuts made at 30-year intervals over a planning period of 120 years. Periodic thinning is proposed in regenerating stands. Spruce fir forests have similar recommendations, except that patch cuts are made at 50-year intervals.

Work done on mixed conifer forests at Workman Creek on the Sierra Ancha Experimental Forest in central Arizona demonstrated that increases in streamflow could be obtained by replacing trees with grass cover or by greatly reducing overstory densities (Baker, 1999). Results indicate that treatment of mixed conifer forests can result in water yield increases that remain consistent for 13 years or more. Treatments included both moist and dry-site clearcuts and single-tree selection. Minor changes were observed in sediment yields, but significantly less than sediment mobilization resulting from wildfire thinning. Patch thinning estimated an average 40 mm increase where 33% of the area is cleared on sites where streamflow normally averages 100 to 125 mm. Increases in water yield of 75 to 100 mm were possible where clearcutting was used.

Ponderosa forests were examined in pilot watersheds at the Beaver Creek Watershed (Brown et al, 1974 and Baker and Ffolliott, 1998, Gary 1975). Ponderosa forest water yield is less than that obtained from other commercial forest types. Short-term (3 to 10-year) increases of 25 to 75 mm are expected from clearcutting ponderosa pine. Long-term increase of 2 to 25 mm is more realistic using a 33% patch clearing technology. No meaningful increases in total sediment production occurred with patch treatments; clear-cutting increased sediment by about 170 kg/ha (Brown, et. al., 1974). An average water yield of 30% remained stable for 20 years after treatment, with the initial increase attributed to reduced evapotranspiration and increased snow accumulation in forest openings (Alexander, 1987).

Additional information is available for lowland vegetation management; however the land management obstacles for the patchwork of land ownership within the MRG valley at lower elevations renders active watershed management more impractical at these elevations.

Given widely documented increases in annual water yield resulting from active watershed management, what is the nature of the enhanced hydrograph? Both increased peak and flood

flows have been observed following thinning. Peak flows are the maximum flows resulting from a runoff event. Flood flows are peakflows that exceed channel capacity as defined by bankfull levels. With forest thinning, it was generally found that most increases in water yield occur at low flow levels – as augmented baseflow or delayed flow resulting from improved infiltration and groundwater recharge. Peak flow yield increases tended to occur primarily during the growing season. Flood flows were also increased due to larger overland flow rather than channel flow – these were evidenced as increased snowmelt and earlier ascending limbs on the spring flood hydrograph (Harr, 1979 and Troendle, et. al, 1988).

Surface erosions was found to be largely confined to areas of severe disturbance and compaction – primarily limited to skid trails, log landings, and roads (Megahan and Kidd, 1972). Disturbance can be limited by employing BMPs standard in the timber industry. Sedimentation is complementary to erosion – increased sedimentation can cause problems for fisheries because high concentrations of suspended sediments can damage the gills of aquatic insects and fish. Bedload sediments can interfere with fish spawning and rearing success. Fine organic and clay-sized lithic sediments can be vectors for downstream transport of sorbed pollutants such as pesticides, organic chemicals, radionuclides, or heavy metals. Sediment impacts are typically observed in the first five years of landscape alteration and will require long-term monitoring. Sediment impacts from patch cuts are much less than clear-cut areas. Implementation of BMPs is essential to protect water quality and minimize unintended consequences of increasing water yield by forest thinning.

Administrative Issues:

Watershed Management Authorities

The United States provides various authorities for the establishment and management of national forests. Implementation and oversight for various aspects of watershed health are divided among federal land, resource and water management agencies. Primary agencies offering watershed management funding support include the U.S. Department of Agriculture (USDA) – Forest Service (USFS), the USDA-Natural Resource Conservation Service (NRCS), and the Environmental Protection Agency (EPA). Of the agencies with primary responsibility in watershed management, only the USFS is a current Program signatory.

Sample federal authorities are cited below.

- The Organic Act of 1879 (16 USCA 475) states that “No national forest shall be established, except to improve and protect the forest within the boundaries, or for the purpose of securing favorable conditions of waterflows”.

- The 1911 Weeks Law further reinforced this concept by stating that “The Secretary of Agriculture is authorized and directed to examine, locate, and recommend for purchase such forest, cutover or denuded lands within the watersheds of navigable streams as in his judgment may be necessary to the regulation of the flow of navigable streams or for the production of timber.”

Other important acts for managing watersheds include: Multiple Use Sustained Yield Act, the Forest and Rangeland Renewable Resources Planning Act, and the National Forest Management Act (NMFA) all including protection of soil and water resources. Additional legislation with watershed protection themes includes: Watershed Protection and Flood Prevention Act, the Federal Water Pollution Act, the Clean Water Act (CWA), the National Environmental Policy Act (NEPA), and the National Historic Preservation Act (NHPA) (Jemez y Sangre 2002 and MRGWA, 2003). For example, the Multiple Use Sustained Yield Act of 1960 provided that national forests "shall be administered for watershed purposes". However, the NMFA limits the methods and locations of logging and road building; the ESA may limit any actions in designated critical habitats for threatened or endangered species; the CWA may limit the amount of sediment; and the NHPA may limit land disturbance near sites of religious, cultural or historical significance.

While the USDA-FS, USDA-NRCS, and the EPA are the lead agencies with active watershed management programs, a myriad of other federal agencies are involved with aspects of watersheds including: the Bureau of Land Management (BLM), the U.S. Army Corps of Engineers (Corps), the Bureau of Reclamation (Reclamation), and the Fish and Wildlife Service (FWS). Some of these agencies are Program signatories and could assist in leveraging Federal funding for implementation. The Catalog of Federal Domestic Assistance lists at least 29 federal funding sources for watershed-related activities (General Services Administration, 2003).

The State of New Mexico has equivalent resource and management agencies (State of New Mexico – Forestry Division, New Mexico Interstate Stream Commission (NMISC), New Mexico Office of the State Engineer (OSE), New Mexico Environment Department (NMED), New Mexico Department of Game and Fish, New Mexico Department of Agriculture, etc.), some of whom are also signatories to the Program. The ISC regulates surface waters of the state subject to interstate and international agreements. The OSE has authority over the appropriation of surface waters and groundwaters of the state. The New Mexico Water Trust Board has indicated its willingness to fund watershed restoration projects that stand to increase available water supply (State of New Mexico, 2002). Thus, sources of state funding for watershed improvements yielding wet water are also available and could be used to show in-kind contributions and better leverage federal investments.

Operational Authorities

If active watershed management can increase water supply, reservoir storage is recommended to best leverage the wet water resource to meet multi-year and year-round species water demands. Operational authorities associated with the storage and management of waters related to the Program are discussed in the WAM position paper, "Storage and Management of Program Water". Alternatively, benefits to MRG species and habitat may also be realized without storage, by letting a larger water pulse move downriver through riparian habitat.

New Mexico water law asserts a legal right to waterflows derived from lands within the state. Any additional water created by active watershed management would become part of the public water supply and be subject to the prior appropriation system. If thinning and management produced excess water, the Program might secure that water under existing law by filing an application to appropriate with the OSE.

However, the priority of this appropriation would be junior to the rights of more senior water rights holders who would retain the first right to divert any additional supplies.

Conclusions

- Opportunities for increased or enhanced river flows through active watershed management should be explored by the Program with possible benefits in additional wet water supply benefiting endangered species in the MRG.

- Watershed management alone has the potential to increase watershed yield ranging from 5 to 25 percent. When performed in conjunction with cloud seeding (the topic of a separate position paper), the potential water yield increase by an additional 5 to 15 percent.

- The cost of water gained through active watershed management appears attractive when compared to the cost of other water sources. However, well-documented costs for NEPA compliance, environmental permitting, and paired watershed monitoring were not available and further economic analysis should be undertaken to evaluate implementation costs relative to wet augmented water and paper water rights yields.

- The Program should encourage appropriate land management agencies to provide an assessment estimating increases in water yield to the MRG possible through active watershed management activities. Information of interest includes a compilation of public and private watershed acreages potentially suitable for forest thinning, and a compilation and review of results from similar watershed management efforts in the region producing results potentially applicable to the MRG.

- The Program should identify opportunities to cooperate with, or actively involve watershed land management agencies in the ESA Collaborative Program, to advance watershed management for improving water yield, water quality, and forest heath supported by multiple sources of funding and to the benefit of Program activities.

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