FACT SHEET: ***ACCOUNTING FOR WATERSHED AND OTHER RESOURCE VALUES – CONSIDERATION IN THE NEPA ANALYSIS***

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The value of the wood products and the costs to administer, prepare, and complete the work are typically the sole economic factors studied in a NEPA analysis of forest restoration proposals or fuels reduction projects. Normally, watershed protection or restoration is part of the purpose and need for action and as such necessitates some level of disclosure in NEPA documentation. In some cases, such as a municipal watershed, water yield can be an extremely important attribute to carry through the analysis. The goals of this fact sheet are to 1) provide practitioners with some scientific literature they can use as a reference in their NEPA analysis on watershed outputs, 2) show some methods to determine watershed and other resource outputs, and 3) identify some basic technique that practitioners may consider to value these variables.

Much of the research used in this report comes from long-term experiments conducted in the Central Arizona Highlands (Table 1). These include sites on the Sierra Ancha Experimental Forest; Three-Bar Experimental watershed, the Whitespar, Mingus, and Battle Flat Experimental watersheds; Beaver Creek; and the White Mountain watersheds (Castle Creek, Willow Creek, Thomas Creek, and Seven Springs). Information has also been used from an unpublished data set collected on Burro Creek--another mixed conifer watershed in the White Mountains. Most of the studies began in the early1950s and were discontinued by the 1980s in response to a shift in research priorities.[1]

Table 1. Central Arizona Highlands Long-term Study Sites

Study Site	Terrestrial Ecosystem	Study Objectives
Sierra Ancha	Chaparral, Riparian, Ponderosa Pine, and Mixed Conifer	Three study areas were established with the research focusing on water use by native plants, grazing impacts, soil erosion/sedimentation, and water yield.
Three-Bar	Chaparral	Determine effects of chaparral-to-grass conversion in terms of increasing water yields, dissolved chemicals, and sediment. The effects of fire/herbicide applications to control shrub re-growth.
Whitespar	Chaparral and Riparian	Water yield and sedimentation.
Mingus	Chaparral	Water yield, soil erosion and sedimentation.
Battle Flat	Chaparral	Nutrient cycling, wildlife habitat, and fuels reduction.
Beaver Creek	Ponderosa Pine and Pinyon-Juniper	Water yield, soil erosion/sedimentation, wildlife habitat, and forage responses.
White Mountains	Ponderosa Pine and Mixed Conifer	Water yield, soil erosion, wildlife impacts, and snow fall accumulation in cutting units.

[1] Baker, Jr., M.B., compiler. 1999. History of watershed research in the Central Arizona Highlands. General Technical Report RMRS-GTR-29. USDA Forest Service, Rocky Mountain Research Station, Fort Collins, CO. 56p.

Study Site	Terrestrial Ecosystem	Study Objectives
Burro Creek	Mixed Conifer	Water yield and understory forage responses

The results of these studies indicate that increased water-yield will occur in most Central Arizona Highlands ecosystems, although the overall amounts and length of residence time will vary. For the most part, the ponderosa pine type had water yield values that ranged from a low of 0.5 inches at Castle Creek to a high of between 1 and 2 inches for Beaver Creek. However, one watershed associated with Beaver Creek had a water yield response of 5.6 inches or 103 percent the first year after treatment.[2]

Not surprisingly, the highest values were associated with large basal area and canopy cover reductions and the lower values with more conservative overstory removals. When other multiple use concerns are factored in, an increase of 0.6 inch is possible on the more productive sites. The length of time these increases manifested themselves for the ponderosa pine type in Sierra Ancha, Beaver Creek, and Castle Creek were 21, 13 years, and 10 years, respectively.

Three-Bar and Whitespar, both chaparral ecosystems, had reported water yield increases of 5.8 inches and 5.0 inches, respectively (this represents the high end of the reported values for the Whitespar with the range going from a low of 1.5 inches to a high of 5.0 inches). The Mingus study area noted water yield values going from 0.3 inches for those portions burned to 0.2 inches for herbicide-treated areas. Studies conducted at Sierra Ancha reported a 22-percent increase, or 0.4 inches, with herbicide treatments. The length of time these water yield increases could be expected were reported from a low of seven years for Whitespar to a high of 11 years at Three-Bar.

The reason for this wide variation of reported water yields was tied to the amount of existing canopy cover prior to treatment. Those sites that were inventoried with moderately high (40 to 60 percent) to high (more than 60 percent) canopy cover also had the highest water yield increases, whereas those sites with less than 40 percent cover had the lower values. The higher crown cover densities are also associated with annual precipitation in excess of 18 inches.

The mixed conifer ecosystems also demonstrated water yield gains following treatments. Both Willow and Thomas Creeks reported a 3.8 and 2.0 inch increase. Although the length of time these increases manifested themselves was not reported, it would appear that if the average annual runoff found by Rich and Thompson (1974)[3] is correct (4.7 inches), then the increases in the mixed conifer type would last about ten years. This is based on the calculated decline of .08 area inches per year determined for Burro Creek during the 25-year record.

Researchers determined that mechanical methods (cabling and felling) in the pinyon-juniper woodland community cannot be expected to increase water yield, although the herbicide treatments did demonstrate a water yield increase of 0.6 inches per

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[2] Brown, H.E., M.B. Baker, Jr., J.J. Rogers, W.P. Clary, J.L. Kovner, F.R. Larson, C.C. Avery, and R.E. Campbell. 1974. Opportunities for increasing water yield and other multiple use values on ponderosa pine forest lands. USDA Forest Service Research Paper RM-129. Rocky Mountain Forest and Range and Experiment Station, Fort Collins, CO. 36 p.

[3] Rich, L.R. and J.R. Thompson. 1974. Watershed management in Arizona's mixed conifer forests: The status of our knowledge. USDA Forest Service Research Paper RM-130. Rocky Mountain Forest and Range and Experiment Station, Fort Collins, CO. 15p.

acre. Once the dead overstory trees were removed, however, streamflow was reduced to pretreatment levels.

Effects on other watershed variables, such as erosion and water quality, were also studied although a tie between increased erosion/sedimentation and declines in site productivity or water quality are not made. For example, even though a five-fold increase in soil erosion occurred on the heavily grazed plots within Sierra Ancha in the chaparral, the study did not identify soil erosion that surpassed any threshold loss. Researchers did note that sediment-free water invariably results from areas with good grass cover and soil erosion is highest where vegetation densities are decreased. The same can be said for the studies at Three-Bar, Whitespar and Battle Flat, where the authors reported increases in nitrate nitrogen, soil erosion and sediment, but did not relate those findings to exceeding any soil or water quality standard or declines in site quality.

Results from ponderosa pine and mixed conifer sites in Sierra Ancha, Beaver Creek, and Thomas Creek indicate that sediment delivery increases after harvesting were low with no meaningful changes in total sediment yield as a result of the treatments applied.

Forage/herbage production increases were noted at Three-Bar (chaparral), Beaver Creek (ponderosa pine and pinyon-juniper woodland[4]), and Burro Creek (mixed conifer). These increases range from a low of 300 pounds per acre (Beaver Creek, ponderosa pine) to a high of 1,400 pounds per acre (Beaver Creek, pinyon-juniper woodlands).

What can practitioners conclude from these studies that will help them when creating their NEPA effects analysis?

- Moderate to high levels of overstory removal (40 percent or more) in ponderosa pine or mixed conifer will lead to a water yield increase that averages between 1 to 3 inches per acre per year, and can possibly last up to ten years after treatment. Within the dense mixed chaparral, water yield increases could be as high as 5 inches per acre per year, although the average is probably closer to 3 inches. The longevity of treatments in this vegetation type, as with the ponderosa pine/mixed conifer, is roughly ten years. Neither low-density chaparral nor pinyon-juniper has any substantial water yield potential.
- Except for clearcutting, none of the other treatments (manual or mechanical) within the pinyon-juniper, ponderosa pine, or mixed conifer had any substantial influence on increased soil erosion or sedimentation. However, the use of herbicides within chaparral ecosystems may lead to elevated concentrations of nitrate nitrogen.
- Forage and herbage production will increase with reductions in overstory canopy.

MacDonald (2003)[5] noted several other resource considerations that land managers need to be aware of concerning water yield including:

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[4] Brown, H.E. 1971. The Beaver Creek Evaluation Project. USDA Forest Service, Rocky Mountain Forest and Range and Experiment Station. Flagstaff, AZ. 126p.

[5] MacDonald, L.H. 2003. Effects of forest harvesting on water yields in water resources of the Lower Pecos Region, New Mexico. Decision Makers Field Conference. New Mexico Bureau of Geology and Mines. Santa Fe, NM. 5p.

1. In snowmelt-dominated watersheds (ponderosa pine, mixed conifer, and spruce/fir), summer precipitation has little effect on summer stream flows.
2. Little or no water yield increases can be expected in areas where annual precipitation is less than 18 inches.
3. The greatest potential for increased water yield is in higher-elevation fir and spruce.
4. At least 15 to 20 percent of a watershed must be treated in order to detect any change in runoff.
5. Most of this increase will occur in the winter or spring.

Using some of the outputs reported in the research above, it is possible to demonstrate what practitioners might consider when disclosing restoration effects on watershed variables. Take the following scenario, for example:

> In this situation, one thousand acres of ponderosa pine are treated with a strict restoration prescription on 60 percent of the area or 600 acres. This results in an increase of 600 acre-inches (one inch increase per acre) or 50 acre-feet (600 acre inches ÷ 12) per year. Assuming this increase will last for ten years, the resulting water yield will be 500 acre-feet and, using a value of $250 per acre-foot (Snider unpublished literature review),[6] will result in a total increased value of $125,000. If either mixed conifer or chaparral are found within the watershed, then water yield values of 2 acre-inches or 3 acre-inches per acre would be appropriate based on the amount of acres treated and the level of overstory removal in those vegetation types.

Another example that practitioners could considered is the value of forage increases. Using the same example, if the anticipated increase is 500 pounds per acre (air dried biomass), then an increase of 1,000 animal unit months over the 10-year planning horizon could be realized (500 lbs/acre * 600 acres * 10 years * .30 [allowable use factor] ÷ 900 lbs [forage requirement per AUM] = 1,000 AUMs). Bartlett et al. (2002)[7] concluded that the value of an AUM was $9.30. Multiplying this amount by the AUMs produced in this example results in a value of $9,300.

This is not an all inclusive list of value considerations. Others could be analyzed and used (e.g., losses of property or wildlife values) but only if federal land managers can support these values and costs with credible scientific and documentary evidence.

Using information like that displayed in the example above, practitioners will be able to demonstrate that there is a positive relationship between ecological restoration activities/expenditures and the provision of ecosystem services valued by society.

Reviewers: Charlie Denton, Geneen Granger, Bruce Higgins
Editor: Dave Egan

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[6] Water value from unpublished literature review by G.B. Snider. Value estimate for good and services by stream/riparian systems. Northern Arizona University. This table uses a $250 per acre-foot, which is the mid-range estimate.
[7] Bartlett, E.T., L.A. Torell, N.R. Rimbey, L.W. Van Tassel, and D.W. McCollum. 2002. Valuing grazing use on public land. *Journal of Range Management* 55(5):426-438.