Channel bed particle size distribution procedure used to evaluate watershed cumulative effects for range permit re-issuance on the Santa Fe National Forest

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Abstract.-Personnel on the Santa Fe National Forest used methodologies adapted from Bevenger and King (1995) to collect base line particle size data on streams within grazing allotments currently scheduled for permit reissuance. This information was used to determine the relative current health of the watersheds as well as being used in the development of potential alternatives to current grazing practices, where deemed necessary.

INTRODUCTION

Two recent studies (Bevenger and King, 1995 and Potyondy and Hardy, 1994) have documented the successful use of channel bed particle size distribution as an indicator of watershed health. These studies adapted the Wolman pebble count methodology (Wolman, 1954) to study the effects of wildfire, timber harvest, and livestock grazing. Channels with higher percentages of fine particle sizes are considered more disturbed or impacted.

Personnel on the Santa Fe National Forest used methodologies adapted from Bevenger and King (1995) to collect base line particle size data on streams within grazing allotments currently scheduled for permit reissuance. This information was used to determine the relative current health of the watersheds as well as being used in the development of potential alternatives to current grazing practices, where deemed necessary.

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BACKGROUND

Considerable scientific literature exists regarding the effects of grazing on riparian and aquatic habitats. In 1982, William Platts (1982) presented a paper in which he reviewed 20 studies by fishery specialists. All but one study concluded that riparian-stream habitats had been degraded by livestock grazing (Platts, 1982). Grazing has been found to be the major contributor to surface water pollution in the State of New Mexico (NM Water Quality Control Commission, 1994).

Channel substrate has been found to be an important factor affecting microhabitat. Fine sediment in excessive amounts can change the structure of aquatic communities, reduce primary productivity, and reducing the suitable spawning areas for coldwater fish (Winget and Mangum, 1979, McNeil and Ahnell 1964, and Cooper 1965). The State of New Mexico has designated all of the streams and rivers on the Santa Fe National Forest as coldwater fisheries (NM Water Quality Control Commission, 1995). Because spawning of coldwater species in New Mexico is only successful over clean gravels (Sublette, Hatch and Sublette, 1990), protection of the channel substrate from excessive anthropogenic inputs of soil sized particles is necessary to protect this resource.

Streams adjacent to heavily grazed sites have been found to have higher percentages of fines (i.e., soil size particles less than 2 millimeters in diameter) and correspondingly lower percentages of gravels, cobbles, and boulders (Lusby, 1970). Thus, it was deemed to be necessary to develop and implement a monitoring program to determine the current health of these waters prior to reissuance of new grazing permits.

METHODS

To assess the effects of cattle grazing on selected streams on the Santa Fe National Forest, a field procedure for characterizing particle size distributions was adapted from methodologies developed by Bevenger and King op. **cif..** Bevenger and King modified the Wolman procedure, which randomly sampled bed material within a grid system, by using a zigzag pattern, progressing from **one** side of the active channel to the edge of the other side.

In our analysis the particle directly under the tip of the right boot was measured on every other step. To avoid a possibility of sampler bias in particle collection, we decided that **the** sampler must consistently pick up **the** first particle felt at the boot tip. The intermediate diameter (i.e., neither the longest nor shortest axis) was then measured with a ruler and noted using Wentworth size notation form (Figure 1). Using the Wentworth size notation methodology, all particles less than two millimeters in diameter were classed as fines. At least 100 samples were collected on all streams sampled. Sample locations were noted and marked on the ground so that changes in particle size distribution could be monitored through time.

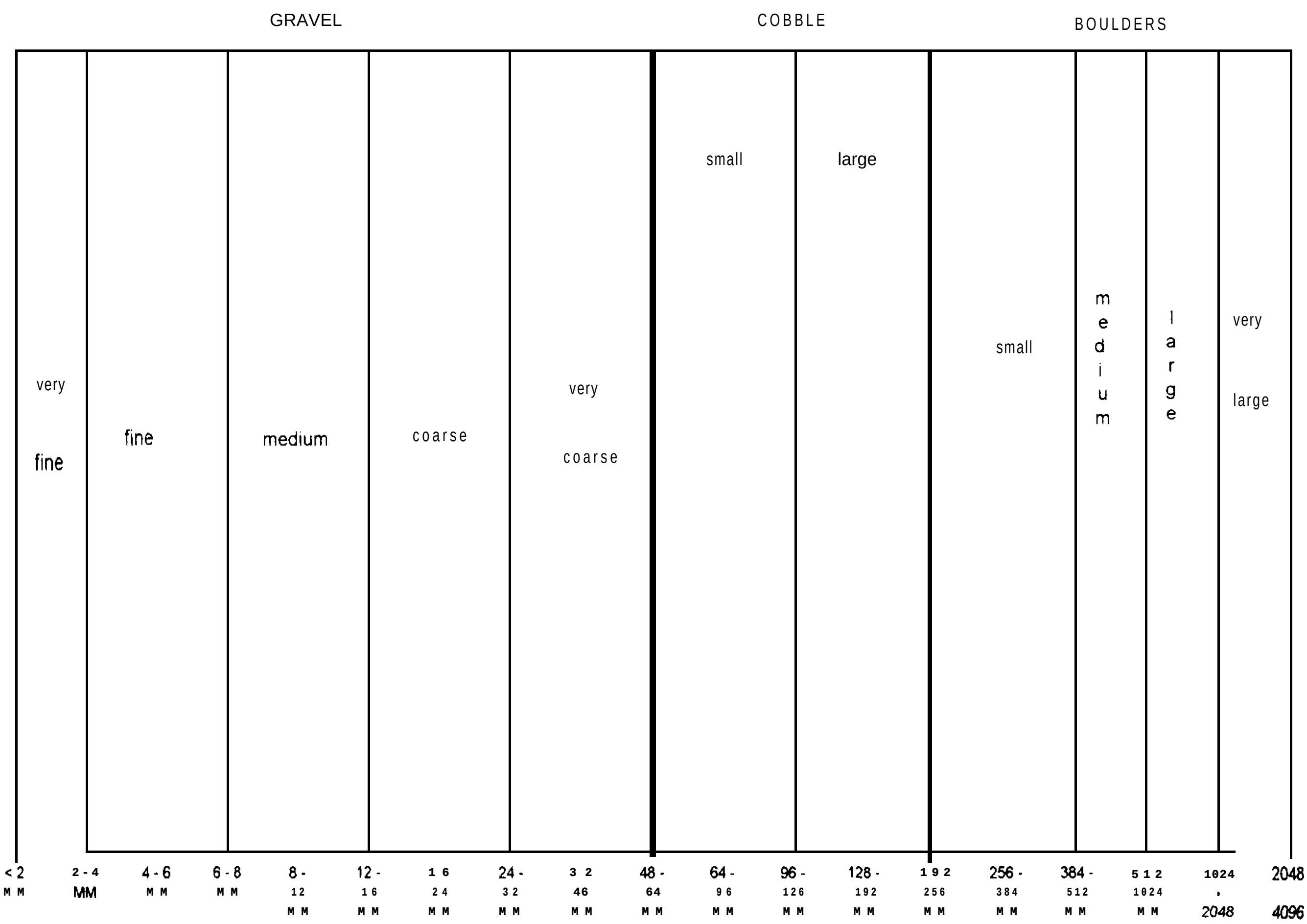


FIgure 1. Wentworth particle size classes.

STUDY SITES, MONITORING, AND RESULTS

Measurements were made on forty streams on the Santa Fe National Forest during the 1995 field season. In this paper we discuss results from several streams that we feel show the strengths and weaknesses of this technique. To determine if pebble count distribution provided results which were useful and could be explained, cursory watershed condition evaluations were done for each study site.

Particle size data analysis indicated a wide range of variability between streams (Figure 2). This was expected as natural variables such as volume of flow, channel geometry, channel slope, geology and soil types could affect the measured distribution as could many land management practices, such as grazing, within the watershed. Fine particle sizes ranged from almost 39 percent to only one percent with an average of 14.7 percent. Similarly, significant variability was noted in the total gravel fraction (maximum - 90%, minimum - 35%, average - 67%), cobble fraction (maximum - 51%, minimum - 8%, average - 28.4%) and boulder (maximum - 18%, minimum - 0%, average - 4.7%). However, when two adjacent watersheds with

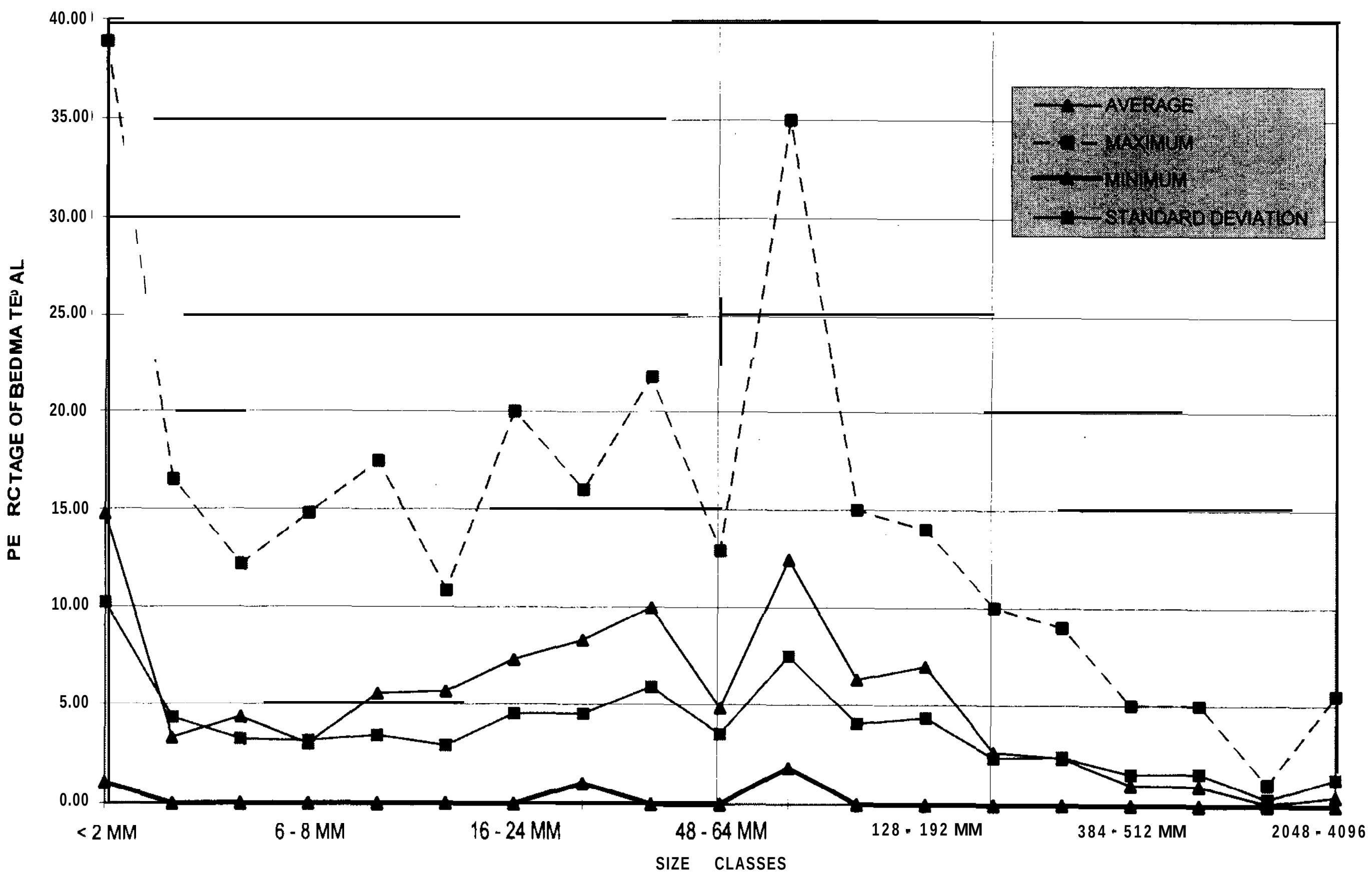


Figure 2. Descriptive statistics: Percentage composition by particle size class.

similar natural features and land use are compared, particle size distribution is very similar (Figure 3). This figure shows a cumulative plot of channel bed particle size distribution for Tecolote and Blue Canyon Creeks located in the Sangre de Cristo Mountains southwest of Las Vegas, New Mexico.

When an upstream particle size distribution is compared against a downstream distribution, in the largely undisturbed Tecolote Watershed (Figure 4), we note that the upstream station exhibits a larger percentage of smaller gravel sized particles even when the percentage of fines is essentially identical. In that channel gradient and geology are unchanged from the upstream sample point, we believe that this result is probably due to increased stream power as the watershed becomes larger.

In a disturbed watershed, the particle size distribution changes very differently in a downstream direction (Figure 5). The Vallecitos Creek Watershed located southeast of Jemez Springs in the Jemez Mountains contains a high road density, and unsurfaced roads parallel the stream for miles. The percentage of fine particles at the downstream sample point is approximately 300 percent higher than that found at the upstream sample site. Percentages of cobbles and boulders are similar at

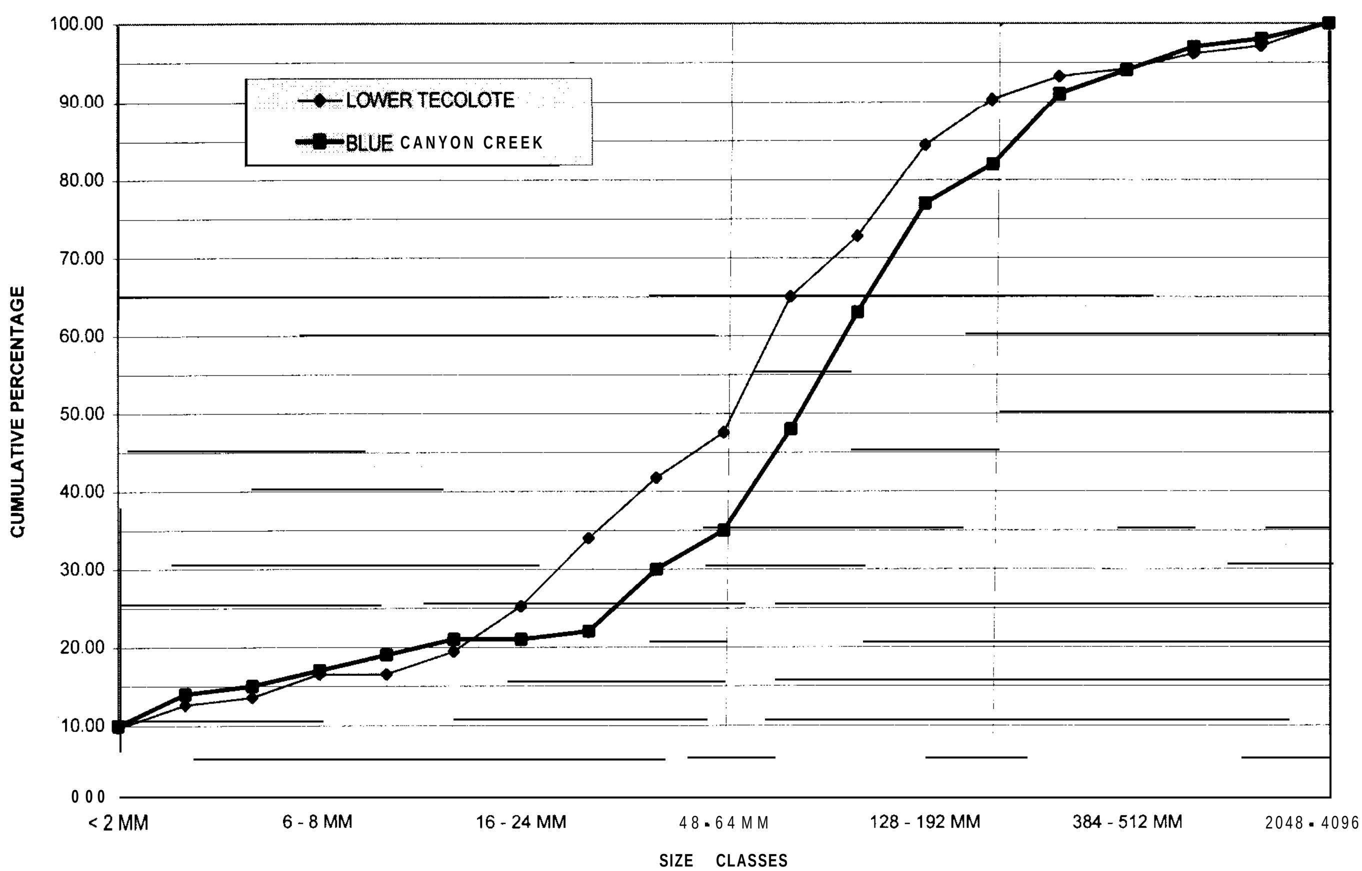


Figure 3. Comparison of particle size distribution of Tecolote Creek with its largest tributary.

both sites. Though channel gradient and geology are similar at both locations, the road that parallels the stream has been closed and seeded in the location of the upper sample site reducing input of fines to that portion of the stream.

In a second disturbed watershed, the East Fork of the Jemez River, we found very different conditions and results (Figure 6). The upstream station was located just below private lands and showed higher concentrations of fines than did a downstream station (10 percent vs 3 percent). The private land upstream is intensively grazed and streams and their attendant riparian areas are not protected. Though the downstream site located on National Forest land is also grazed and receive heavy recreation use, the relative effects of these activities on fine particles percentages appear to be less.

Single sample points on disturbed watersheds can help quantify observed watershed conditions (Figure 7). On San Pablo Creek located in the Nacimiento Mountains southeast of Cuba, New Mexico, eroding roads drain directly into the stream at several locations. A particle size distribution sample was taken downstream of such an eroding road. This sample showed that 30 percent

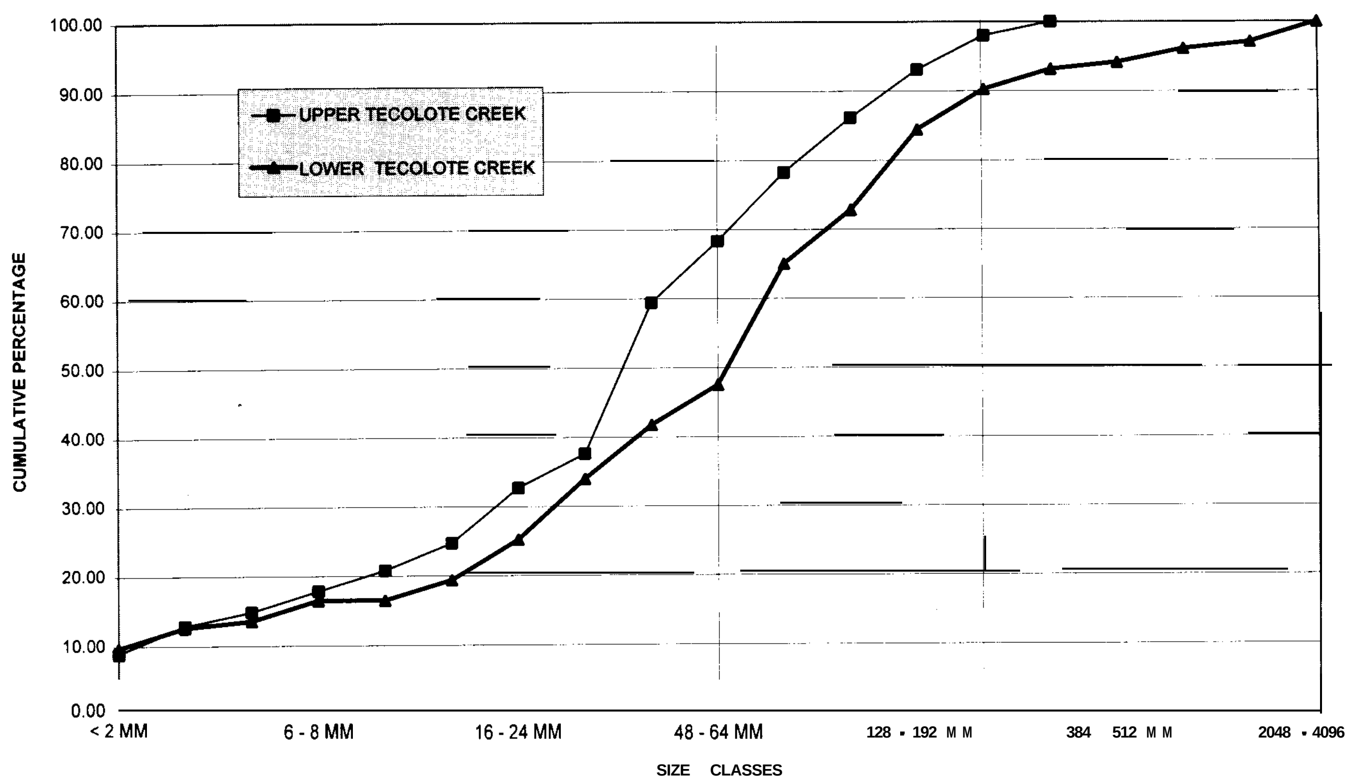


Figure 4. Comparison of particle size distributions at stations on Tecolote Creek.

of the channel bed particles were fines less than 2 mm in diameter. This was well in excess of the Forest average of about 15 percent fines found during our investigations. We anticipate that once road drainage problems are corrected the percent of fines within the channel bed will decrease through time, and that this decrease could be easily documented with this technique.

A single sample was also taken along San Jose Creek located northeast of Cuba, New Mexico (Figure 8). The headwaters of this stream are located in the San Pedro Parks Wilderness. This stream appears to have incised during the first half of the Twentieth Century probably as a result of overgrazing. Improvement in range management in the past few years has greatly improved headwater riparian conditions. Today, though incised, riparian vegetation is dense, and particle size distribution showed a very low percentage of fines. However, because of the absence of accessible flood plain in many stream reaches, a large magnitude flood is expected to create sufficient water velocities in the confined channel to damage riparian vegetation and reactivate active channel erosion. This example illustrates the importance of using a trained observer to evaluate the condition of the watershed as well

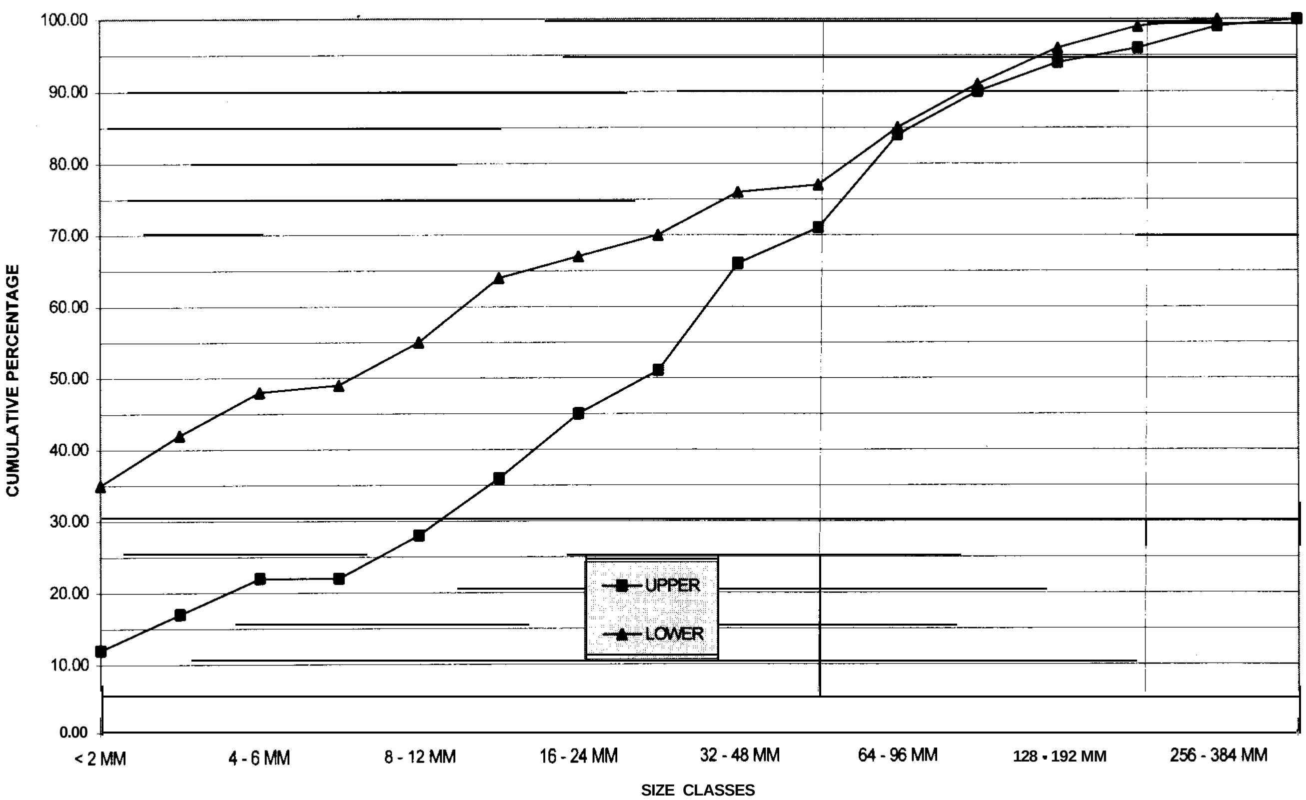


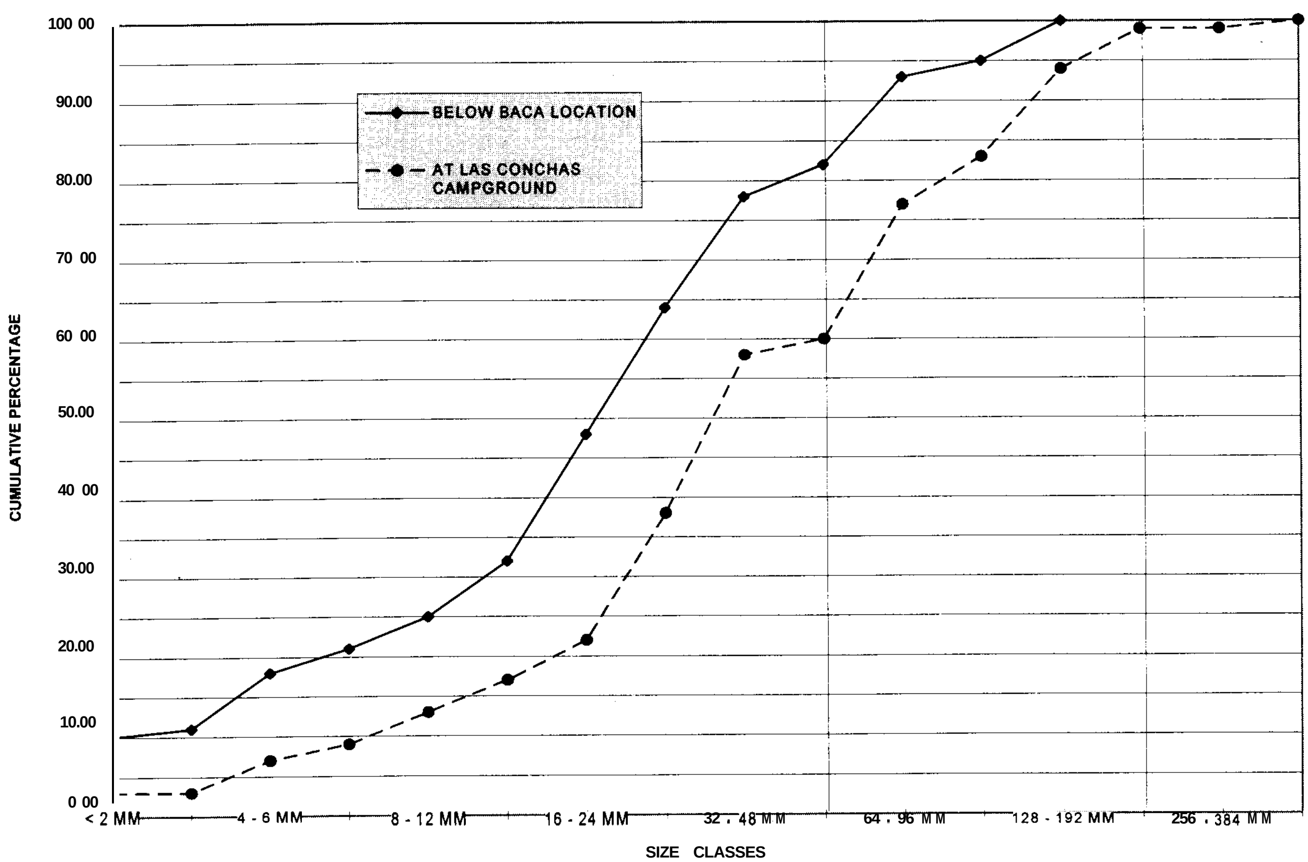
Figure 5. Comparison of particle size distributions at stations on Vallecitos Creek.

as a need to temper temptation to judge watershed condition based solely on a statistical basis.

DISCUSSION AND CONCLUSIONS

We believe particle size distribution is a powerful cost-effective landscape evaluation and monitoring tool. Just as physicians can use a human blood test to indicate a medical problem, watershed scientists can use particle size distribution patterns to indicate watersheds that are out of adjustment. Both tests likewise can be used for long-term monitoring. Like any other tool it must be used by skilled individuals trained to evaluate watershed conditions but should not be considered to be the only evaluative tool necessary. Such monitoring will not allow us, for example, to determine the presence of chemical pollutants which may be of concern.

The method was found to produce consistent results when compared across similar watersheds. Results from streams whose watersheds had known management concerns clearly demonstrated the movement of fines into the aquatic environment. Yet, in watersheds with only limited anthropogenic impacts and uniform geology,



Flgure 6. Comparison of particle size distribution at stations on the East Fork of the Jemez River.

results were also able to document hydrologic phenomena such as increases in flow.

Potyondy and Hardy op. cit. found increases in fine particle-size percentage following high magnitude disturbances of wildfire and dam breaks. Our data suggest that lower magnitude watershed disturbances such as uncontrolled road drainage or overgrazing along a stream can be quantified using particle size distribution.

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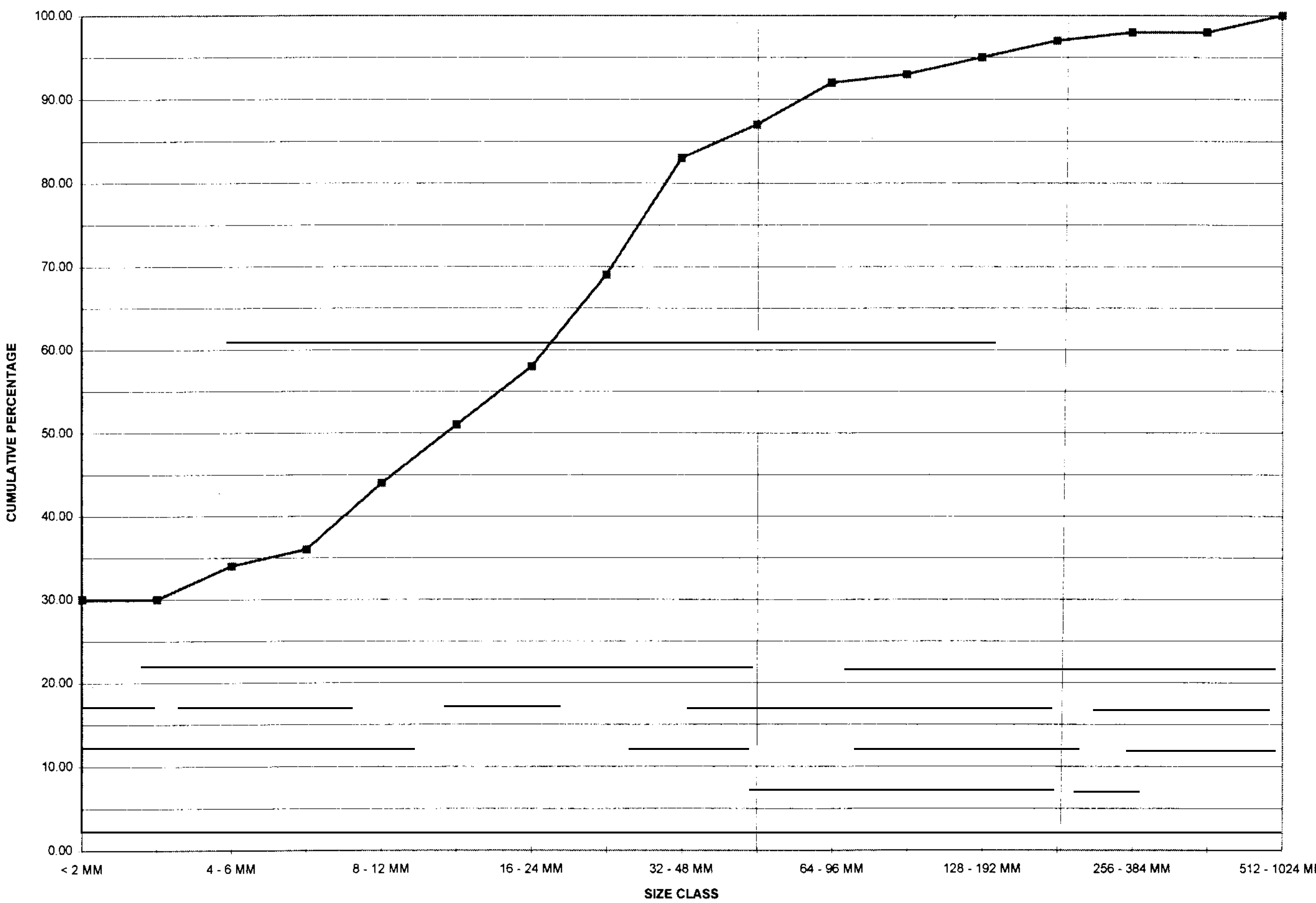

FIgure 7. Particle size distributin at San Pablo Creek.

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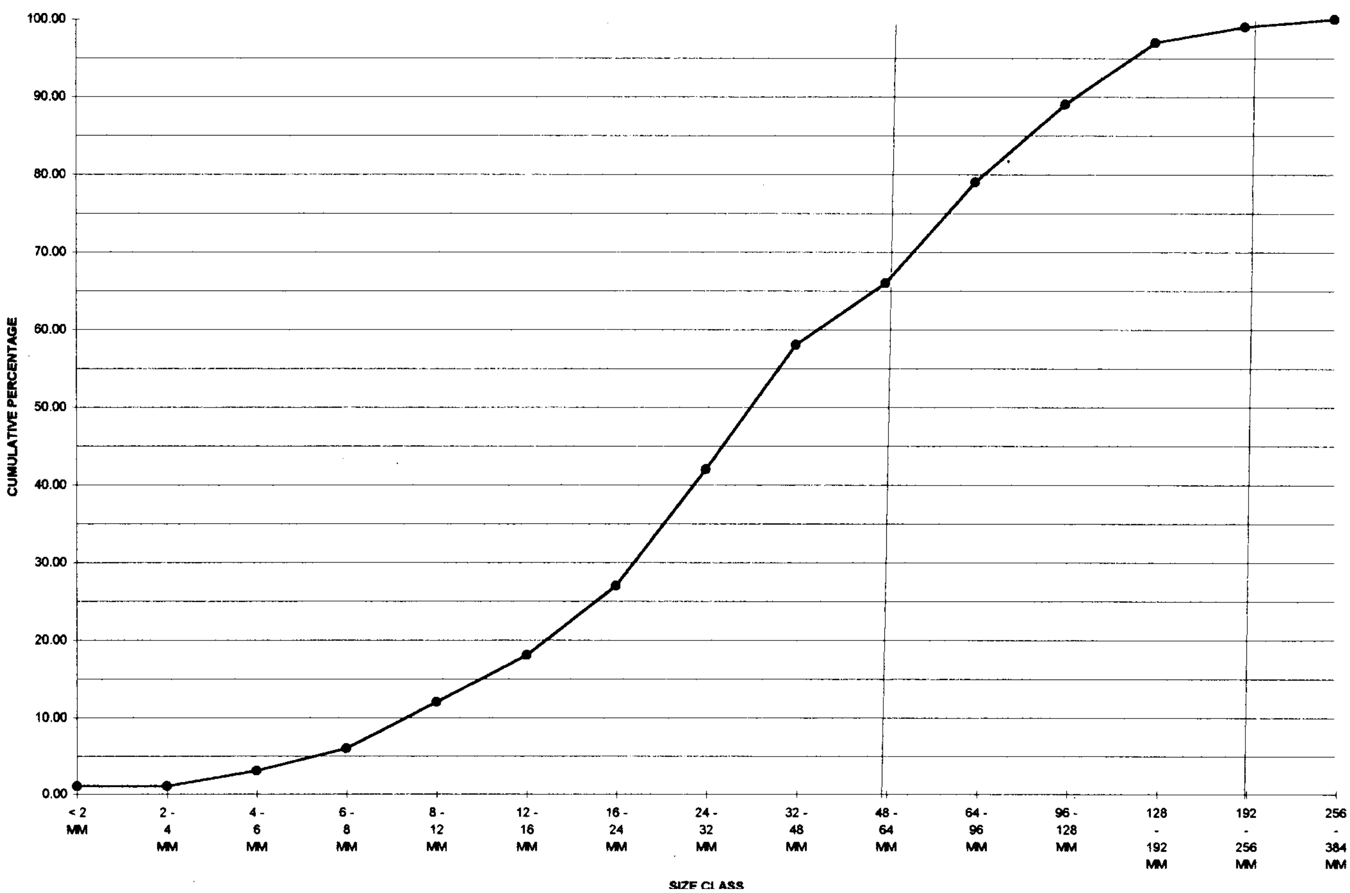

Figure 8. Particle size distribution at San Jose Creek.