COMMENTS ON SILVERMAN'S EVALUATION OF THE KERN RIVER PROGRAM

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I am skeptical about Silverman's (2008) approach of taking point estimates of a seeding effect (in this case, from the Kern River program) at face value, as in the interpretation of his Fig.1, and viewing a variation in those estimates with increasing length of record as an indication of a time trend in the seeding effect. A point estimate is just that: An estimate. There is a 10% chance that the "true value" of the effect does not even lay within the 90% confidence interval. I question whether small variations of the point estimate, within a confidence interval that does not substantially narrow with increasing sample size (no plot of the variation of the confidence intervals appears in Silverman 2008, but see Fig. 3 of Silverman 2007 for an example), indicate anything other than simple statistical variations of the point estimate.

(a) Problems with the Point Estimates

Examination of some of the data and Silverman's results provides a suggestion of the kind of problems that can occur with taking the point estimates at face value. The term *flow* as used herein designates the annual "Full Natural Flow" (FNF) values calculated from data obtained from the California Data Exchange Center (CDEC) as employed in Silverman's analysis. These comments consider values of the flow at three stations: The Kern River below Isabella (KRI), the primary target station in Silverman (2008) and representing runoff from an upper drainage area of 2407 mi^2; the Kern River at Bakersfield (KRB), a second downriver target station incorporating an additional lower drainage area of 333 mi^2; and (later) Success Dam (SCC), the control station showing the strongest correlation with the flow at KRI.

Table 1 shows some of the relevant mean flow values from the KRI and KRB stations. The "difference" column shows the increment contributed by the lower drainage area. Values in the bottom row were calculated by taking the point estimates at face value and dividing the mean-seeded-flow values by the appropriate factor; *e.g.* for KRI 762,467/1.122 = 679,561.

The values in the last column of the table raise an interesting question. The mean flow at both target stations was higher during the seeded years, but the increment contributed by the lower drainage area was actually *lower* during those years. This suggests that the seeding may have *decreased* the contribution from the lower drainage area. A possible explanation for this would be that the seeding effects moved the precipitation higher up the terrain, but that does not seem compatible with any seeding conceptual model that involves accelerated development of precipitation. Moreover, according to the last row in the table taking the point estimates at face value would exacerbate the problem by suggesting that

Table 1: Summary of key flow information for Kern River program

Variable	Units	KRB	KRI	Difference
Mean flow in 22 historical years	AF	707,677	656,571	51,106
Mean flow in 28 seeded years	AF	794,488	762,467	32,021
Point estimate of seeding effect	%	+8.4	+12.2	--
Estimate of mean flow in 28 seeded years in absence of seeding	AF	732,922	679,561	53,362

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the increment from the lower drainage should have increased by 4% in the absence of seeding (in contrast to the observed 37% decrease).

A more likely interpretation is that the point estimates should *not* be taken at face value. This does not negate the statistical evidence of a positive seeding effect, but it does appear that the two point estimates are incompatible. One or the other, and perhaps both, probably misrepresent the true seeding effect. They nevertheless stand as the best estimates available pending accumulation of further data. But any time trend in those estimates as data are accumulated should not be viewed as a definitive indication of a time variation in the seeding effect.

(b) Evidence of Seeding Effect Mainly in High-flow Years

Sifting through the data revealed another interesting aspect that warrants further study. As noted above, the mean flows at the two target stations were higher during the seeded years. Moreover, the frequency of high flows (> 10^6 AF) at both stations increased from about 18% (4 of 22) during the historical years to 32% (9 of 28) in the seeded years. Yet the *median* flow at both stations was actually substantially *lower* during the seeded years. The mean flow at the SCC control station was also higher during the seeded years, and the median flow decreased only slightly. This suggests that the positive effects of the seeding were mainly realized during high-flow years.

Figure 1 compares cumulative frequency distributions of the flows at KRI for the two sets of years; the values have been normalized by dividing by the respective median values. The plot highlights a distinct shift in the seeded years toward higher relative values in flows greater than the median. A similar plot of the SCC control station flow values in Fig. 2 shows little difference between the historical and seeded years, except for a couple of extreme cases, suggesting that this shift is a feature of the seeded flows.

The only hypothesis to account for this observation that comes readily to mind is that the seeding effect may not be a simple multiplicative factor. In any case, the observed behavior seems at least as worthy of further investigation as Silverman's hypothesis about temporal variations in the seeding effects.

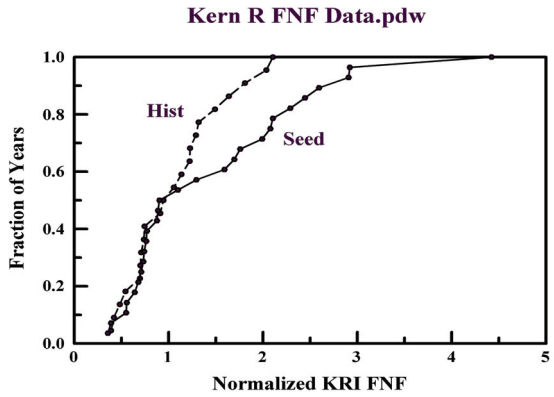

Fig. 1: Cumulative frequency distributions of flow at KRI target station; Hist denotes historical years and Seed denotes seeded years. Flow values normalized by dividing by the median value for the period.

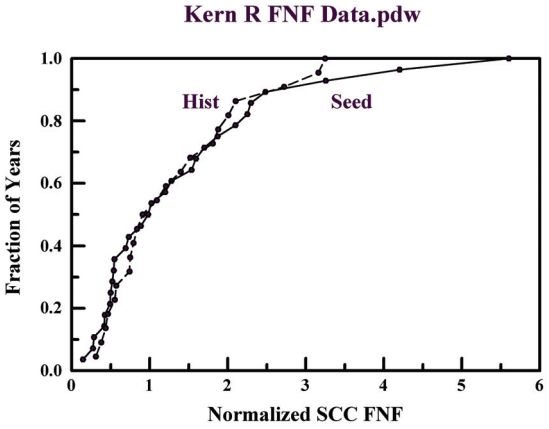

Fig. 2: Cumulative frequency distributions of flow at SCC control station; Hist denotes historical years and Seed denotes seeded years. Flow values normalized by dividing by the median value for the period.

REFERENCES

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