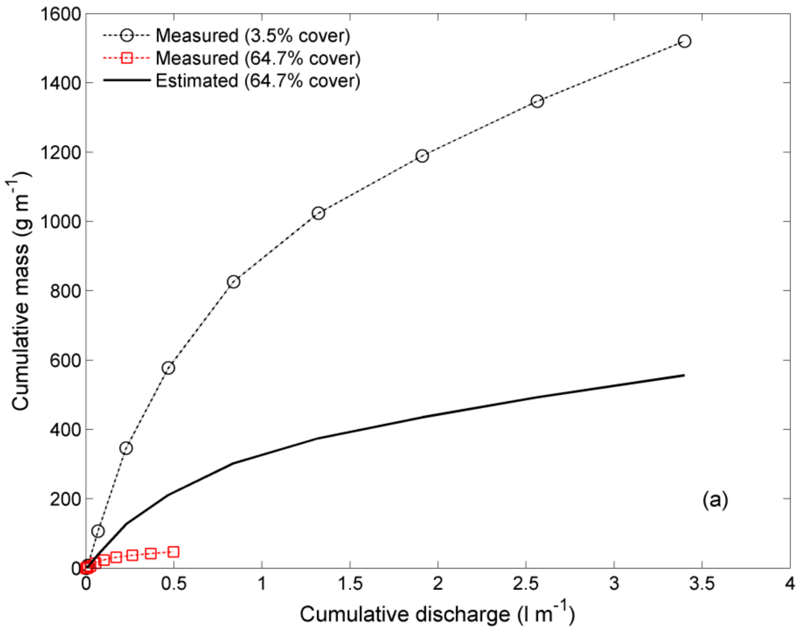
Supplementary material

Following are the complete results for the field studies of Cerdà (2001), Mandal et al. (2005) and Martinez-Zavala and Jordan (2008). First, details of three experiments conducted by Mandal et al. (2005) are presented. Second, results from Cerdà (2001) are shown. This experiment was quite different to the other field datasets (Mandal et al., 2005; Martinez-Zavala and Jordan, 2008), as summarized in Table 2. Third, the results of Martinez-Zavala and Jordan (2008) are reported. These results behave consistently. In all field cases, the estimation of erosion based on exposed soil alone over-predicts the cumulative eroded mass as a function of cumulative runoff.

In terms of the magnitude of erosion reported in these experiments, Martinez-Zavala and Jordan (2008) performed experiments on small flume (area of 0.25 m^2) and used a rainfall simulator generating precipitation with low kinetic energy (4 J m^{-2} mm^{-1}), explaining the order-of-magnitude difference compared with the results of Mandal et al. (2005).



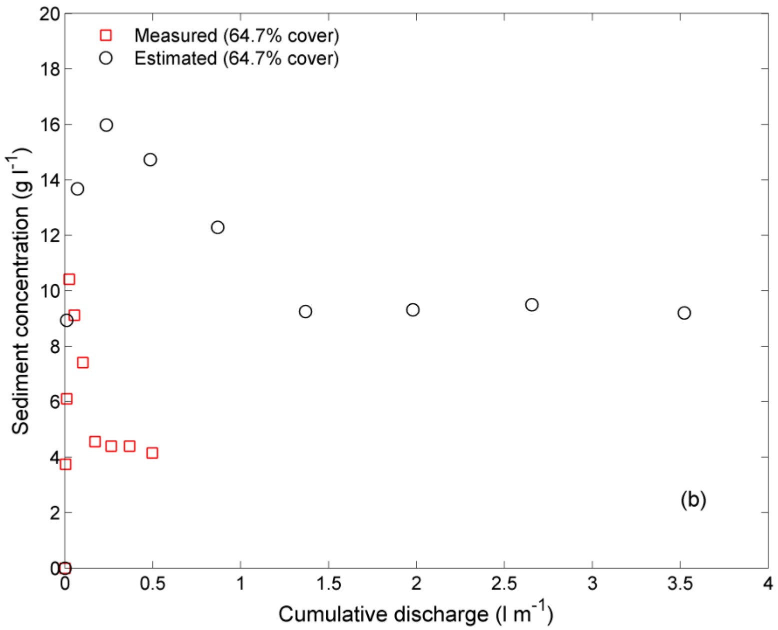


Fig. S1. Cumulative eroded mass as a function of cumulative discharge and sediment concentration for one of the field experiments of Mandal et al. (2005) are illustrated in panels (a) and (b), respectively. This experiment was conducted using a precipitation rate of 89.2 mm h^{-1} and rock fragment coverage of 64.7%. The numbers in parentheses indicate the rock fragment coverage (%) of the soil. Two of the experiments that were performed with the same precipitation, but with lower rock fragment coverages (17.6% and 41.7%) are presented in the main text (Fig. 5). The estimated sediment concentration using the area-based concept overestimates the measured sediment concentration. In contrast to the laboratory experiments, the eroded mass is not proportional to discharge, even at steady state.

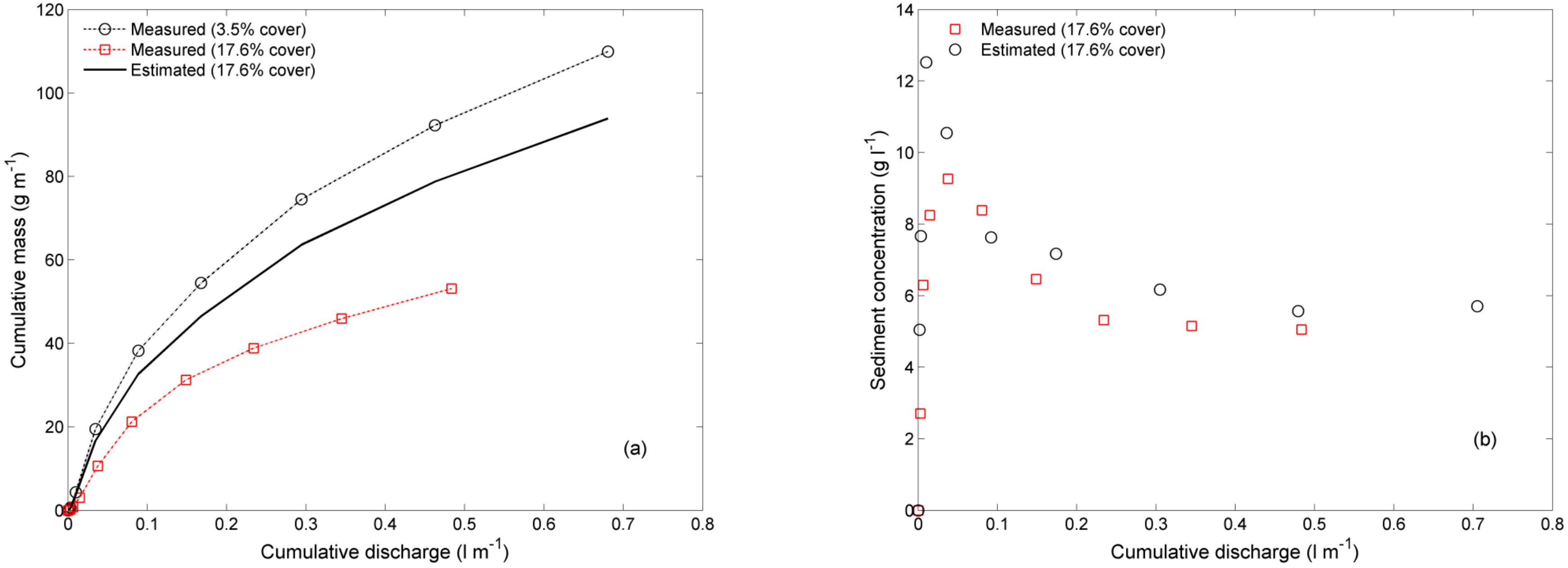


Fig. S2. Cumulative eroded mass as a function of cumulative discharge for one of the field experiments of Mandal et al. (2005). In this case the rainfall intensity and the rock fragment coverage were 48.5 mm h^{-1} and 17.6%, respectively. The estimates overshoot the measurements in this case, although the steady-state values with low rock fragment cover are comparable to the estimations (panel (b)). Differences between estimates and experiments were attributed to the effect of soil roughness and soil sealing.

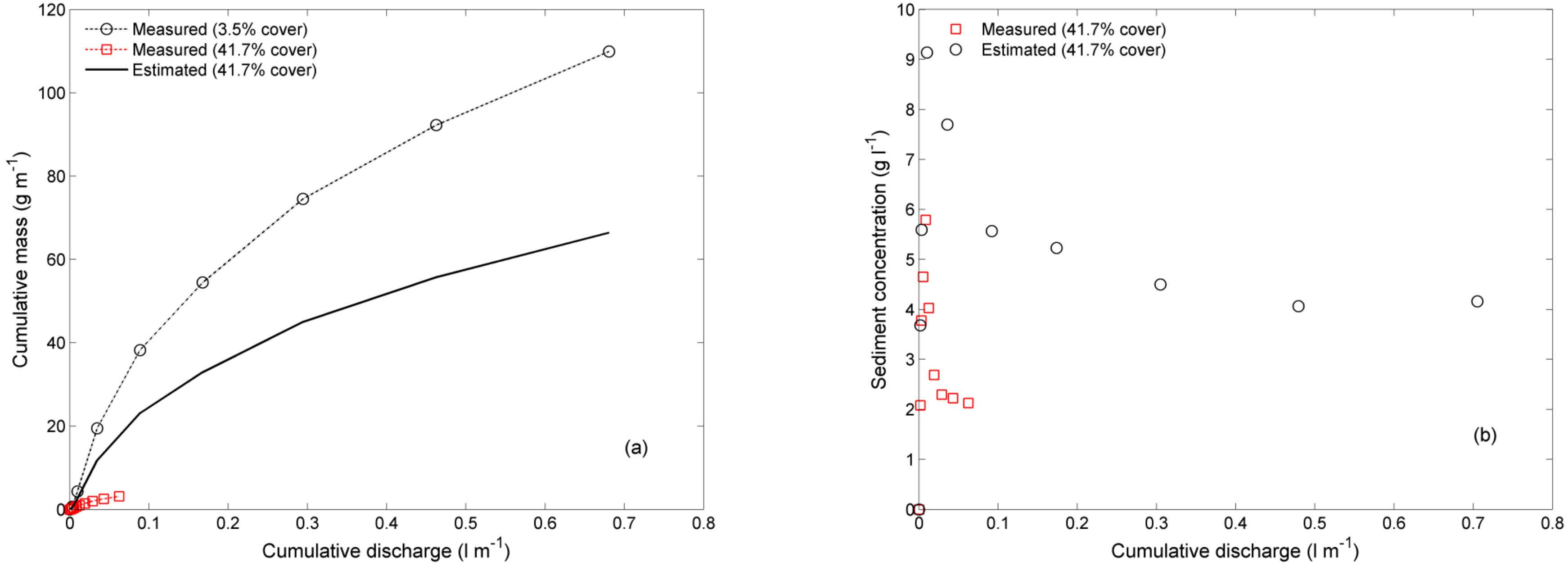


Fig. S3. Cumulative eroded mass as a function of cumulative discharge for the field experiment of Mandal et al. (2005) with a rainfall intensity of 48.5 mm h^{-1}. The eroded mass is not proportional to cumulative discharge, but the duration of the experiment (1 h) was short and sediment concentrations possibly did not reach steady state.

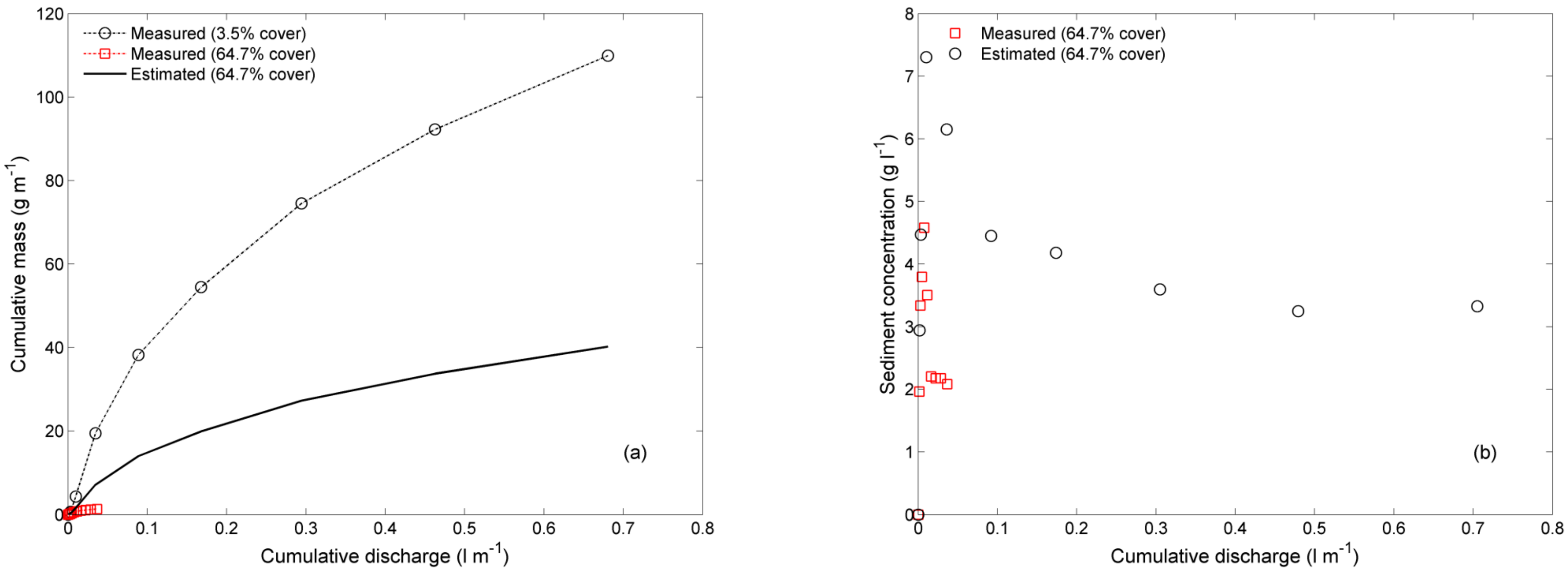


Fig. S4. Cumulative eroded mass as a function of cumulative discharge for the field experiment of Mandal et al. (2005) with rainfall intensity of 48.5 mm h^{-1} and 64.7% rock coverage. The eroded mass is not proportional to the cumulative discharge but again the experiment was very short and steady state was not reached. This reflects that using a low precipitation rate and high rock fragment cover (as in this experiment), 1h of experiment duration appears insufficient to achieve steady-state equilibrium. The difference compared to the laboratory experiments is attributed to the more pronounced effect of soil roughness and soil sealing in the field.

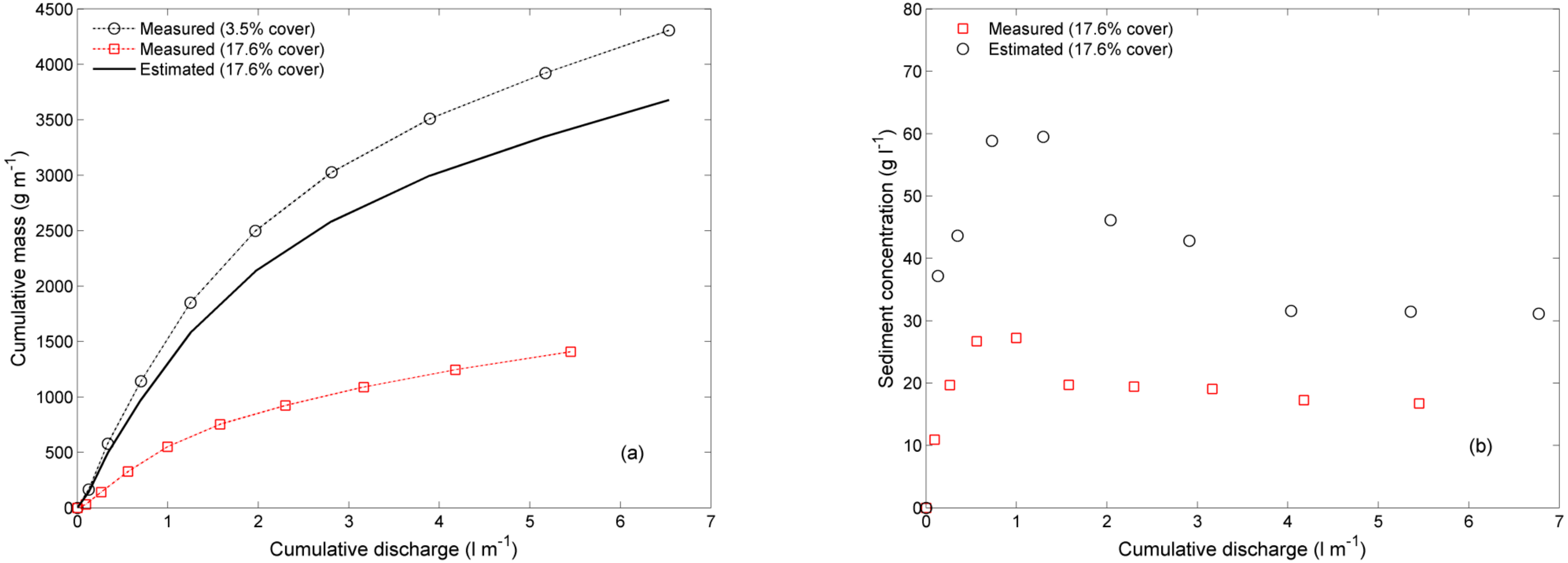


Fig. 5S. Cumulative eroded mass as a function of cumulative discharge for the field experiment of Mandal et al. (2005) with rainfall intensity of 136.8 mm h^{-1} and 17.6% rock coverage. The eroded mass is not proportional to the cumulative discharge despite the relatively low rock fragment coverage.

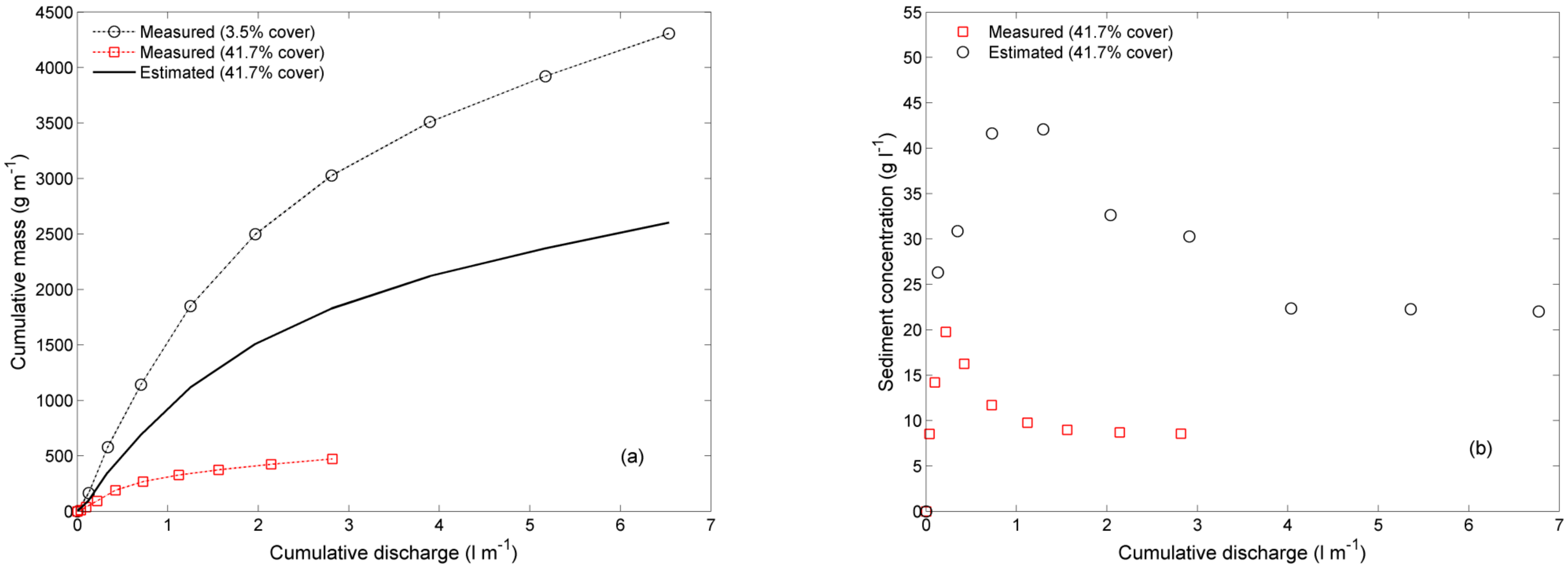


Fig. 6S. Cumulative eroded mass as a function of cumulative discharge for the field experiment of Mandal et al. (2005). This experiment was conducted with rainfall intensity of 136.8 mm h^{-1} and 41.7% rock fragment coverage. The eroded mass is not proportional to the cumulative discharge, as it was observed for controlled laboratory experiments.

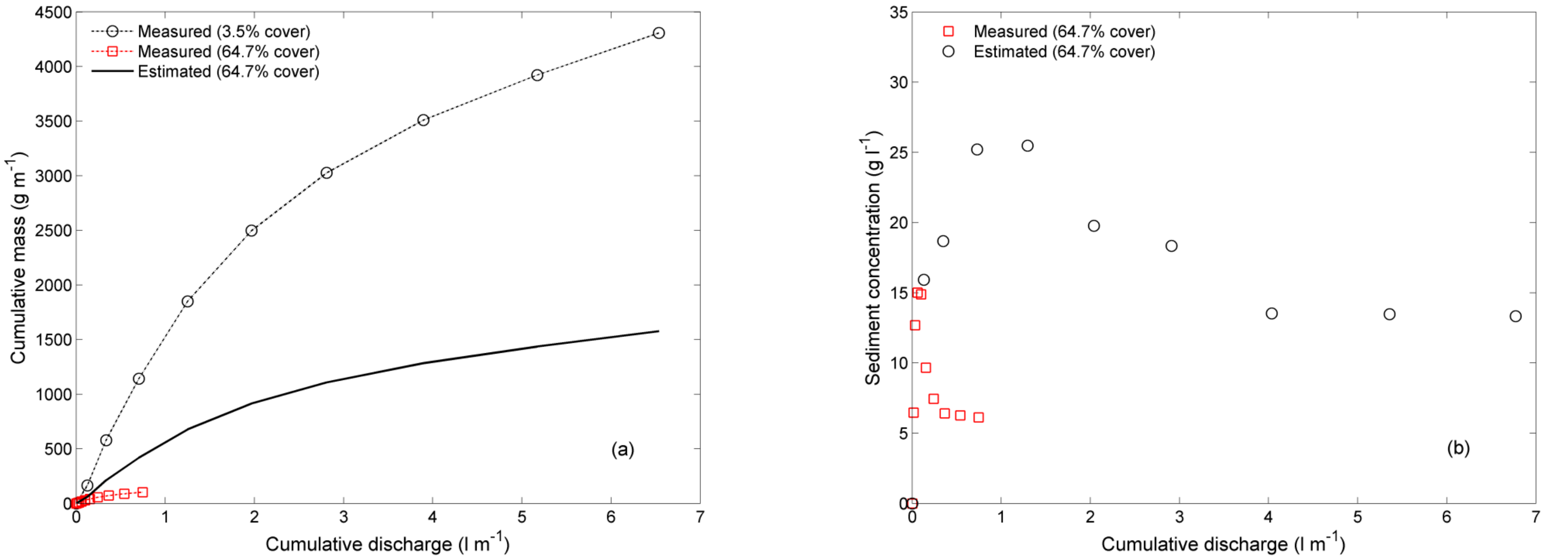


Fig. 7S. Cumulative eroded mass as a function of cumulative discharge and sediment concentration for the field experiment of Mandal et al. (2005) with a rainfall intensity of 136.8 mm h^{-1} and 64.7% rock fragment coverage. Also in this dataset the eroded mass is not proportional to the cumulative discharge.

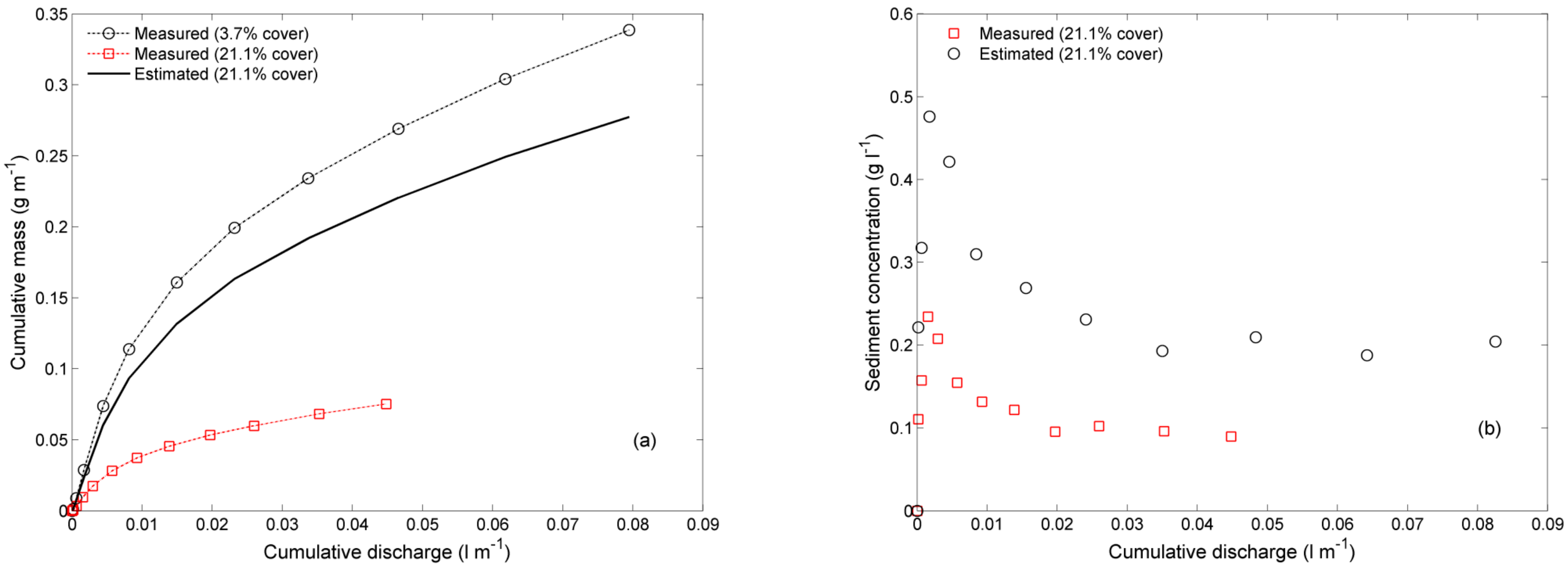


Fig. 8. The cumulative eroded mass as a function of the cumulative discharge collected from experiment conducted by Martinez-Zavala and Jordan (2008). This experiment was performed with precipitation rate of 50 mm h^{-1} and 21.1% rock fragment coverage. It is observed that sediment concentrations and erosion rates did not reduce proportionally to the fractions of exposed surface area.

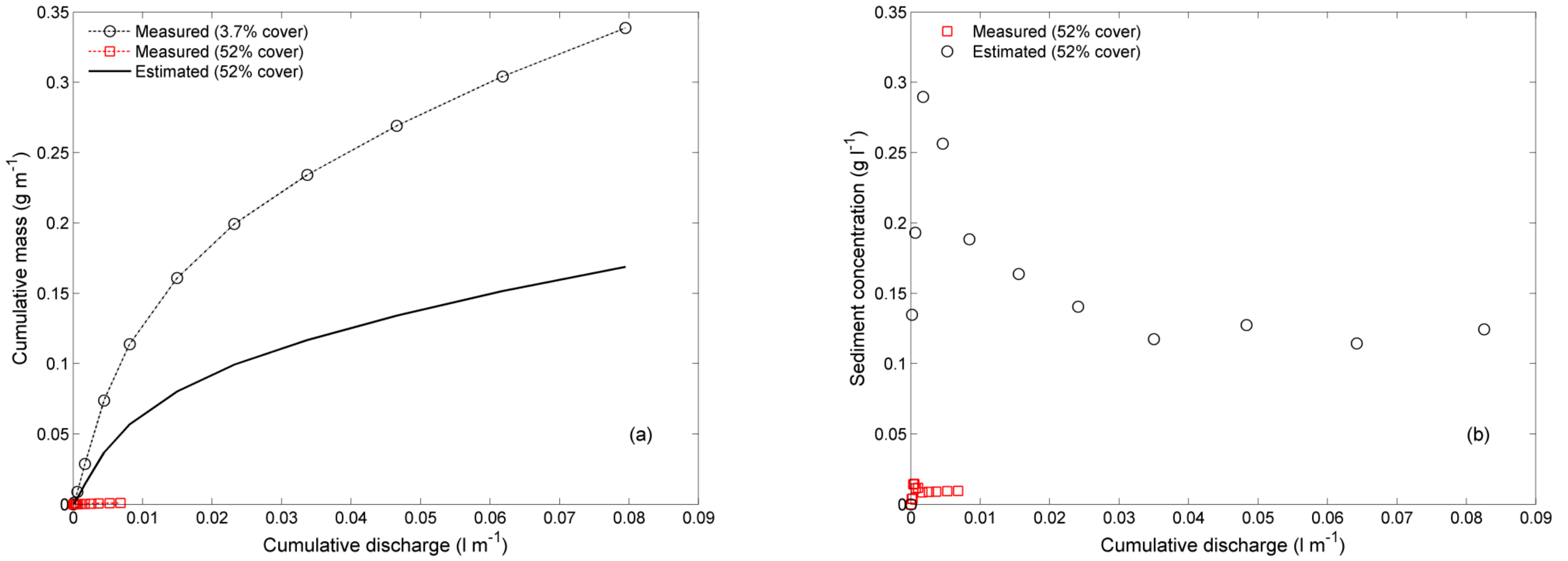


Fig. 9. Cumulative eroded mass as a function of cumulative discharge and sediment concentration for the field experiment of Martinez-Zavala and Jordan (2008) (the precipitation rate was 50 mm h^{-1} and the rock cover 52%). Also in this dataset the eroded mass is not proportional to the cumulative discharge and the steady-state concentration was not reached.

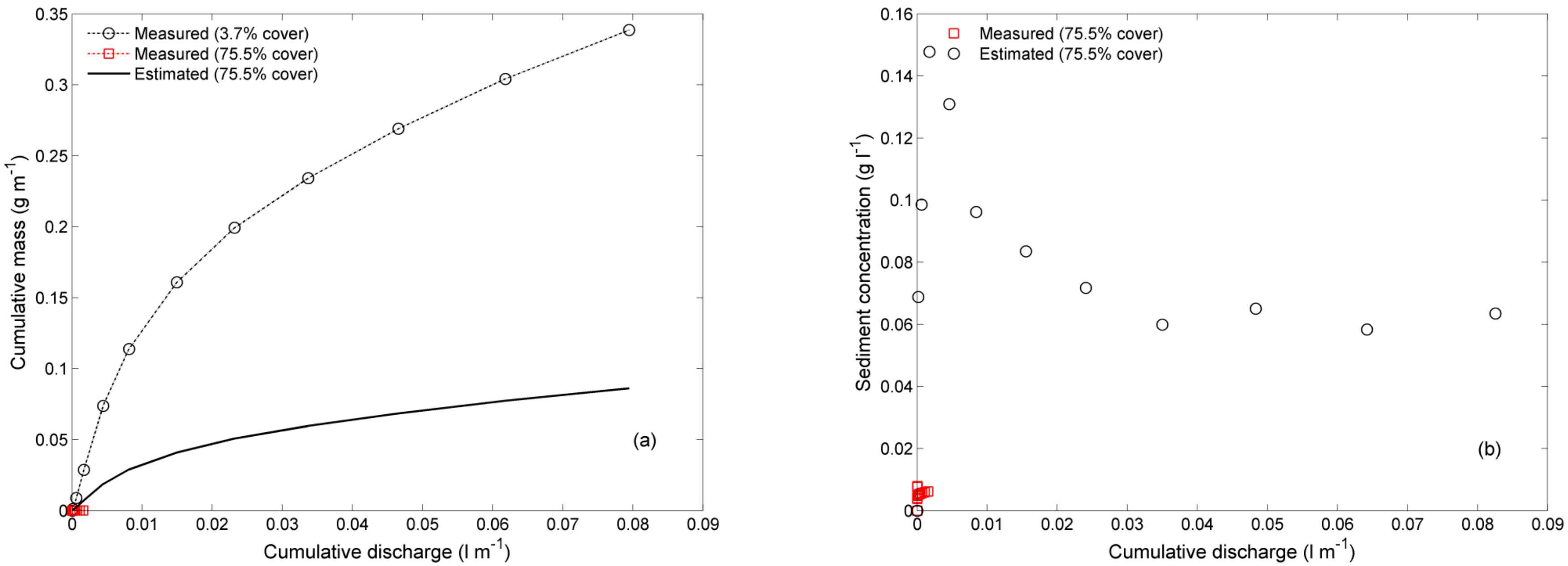


Fig. 10S. Cumulative eroded mass as a function of cumulative discharge and sediment concentration for the field experiment of Martinez-Zavala and Jordan (2008) (the precipitation rate was 50 mm h^{-1} and the rock cover 75.5%). Using low precipitation rate and high rock fragment coverage, 1 h of experiment duration was not enough to reach steady state.

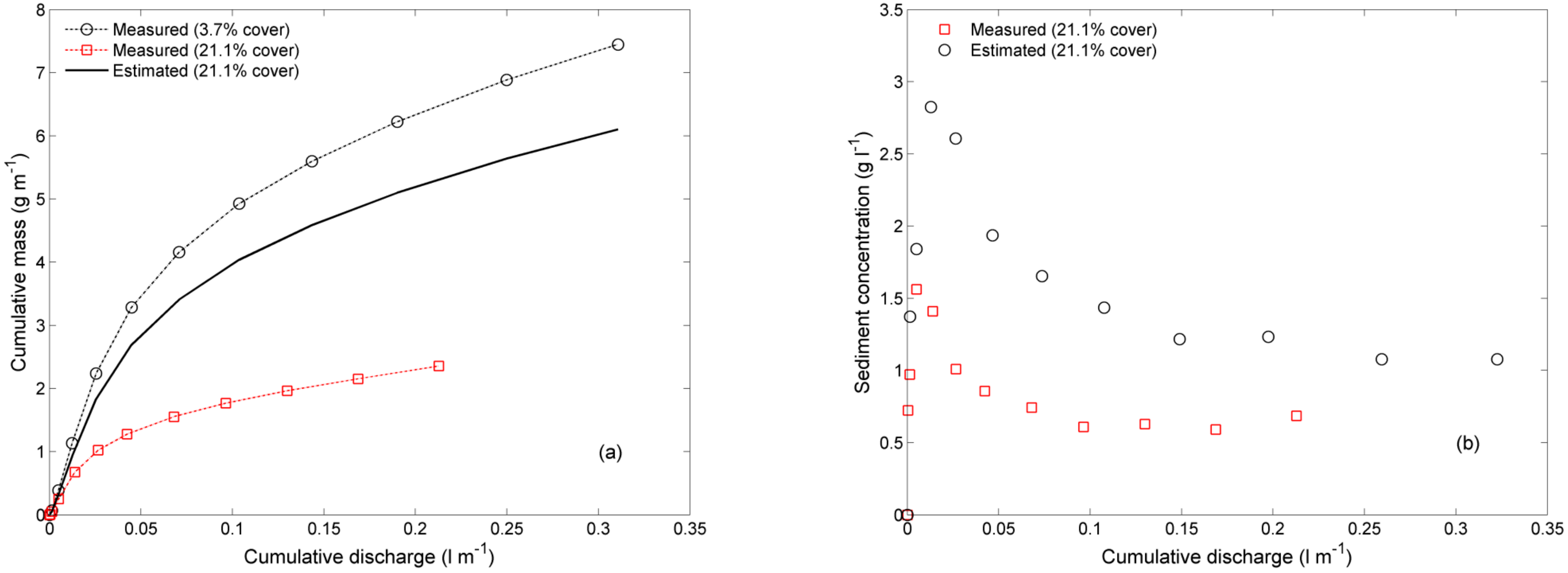


Fig. 11S. Cumulative eroded mass as a function of cumulative discharge and sediment concentration for the field experiment of Martinez-Zavala and Jordan (2008), where 100 mm h^{-1} as a precipitation rate was used. The eroded mass is not proportional to the cumulative discharge.

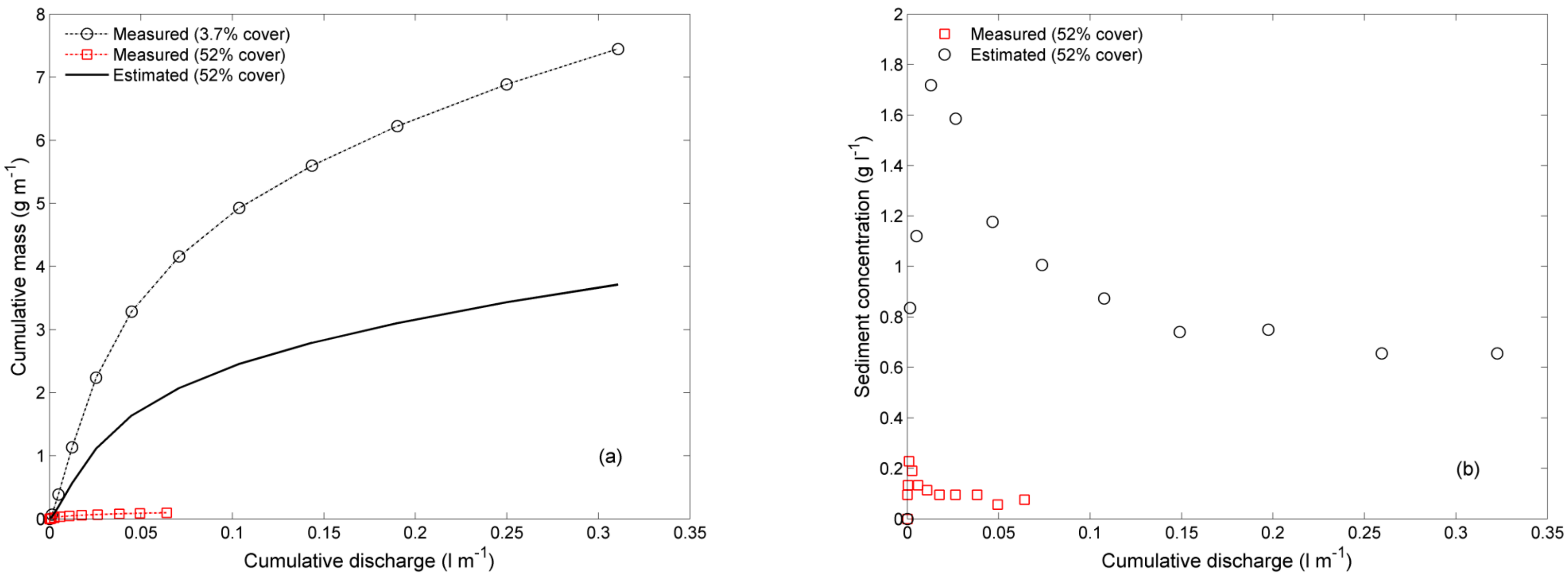
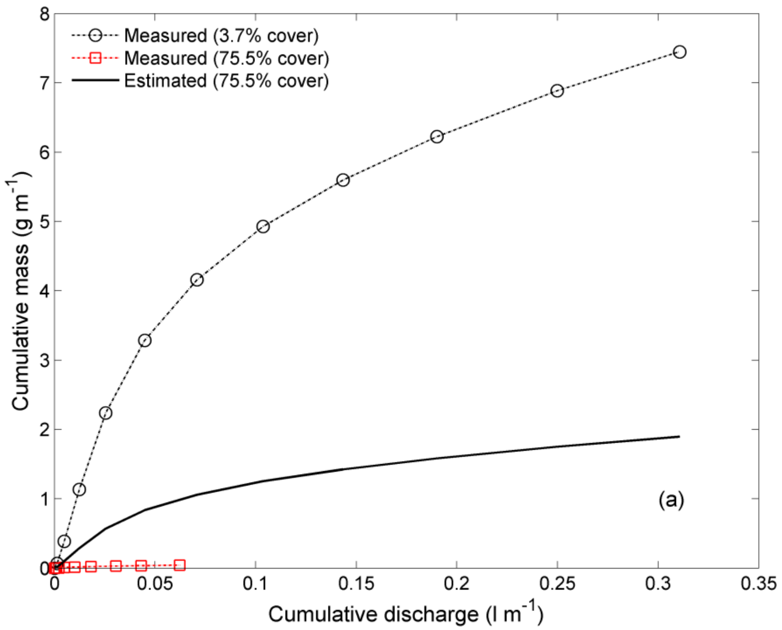


Fig. 12S. Cumulative eroded mass as a function of cumulative discharge and sediment concentration for the field experiment of Martinez-Zavala and Jordan (2008), where 100 mm h^{-1} as a precipitation rate was used. Also in this dataset the eroded mass is not proportional to the cumulative discharge.



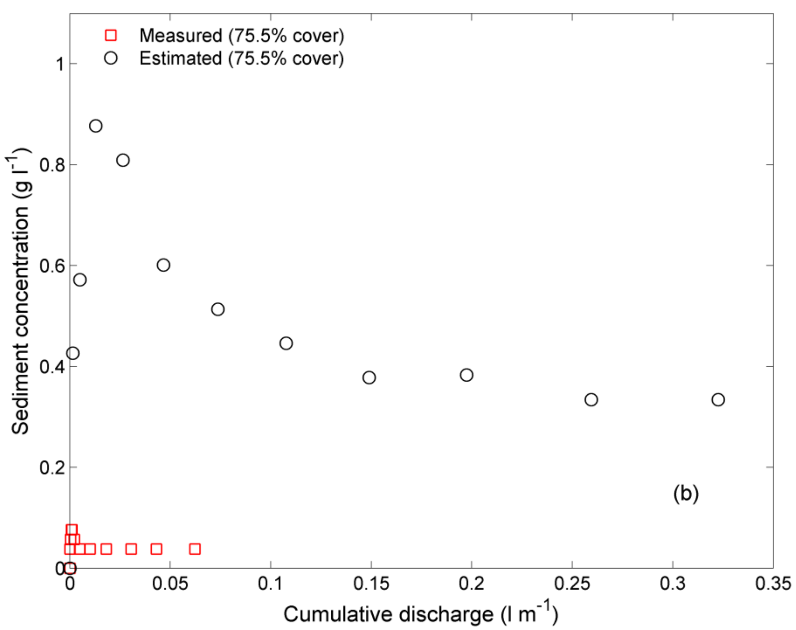


Fig. 13S. Cumulative eroded mass as a function of cumulative discharge and sediment concentration for the field experiment of Martinez-Zavala and Jordan (2008). This experiment was performed with a precipitation rate of 100 mm h^{-1} and using high rock fragment coverage (75.5%). The eroded mass is not proportional to the cumulative discharge.

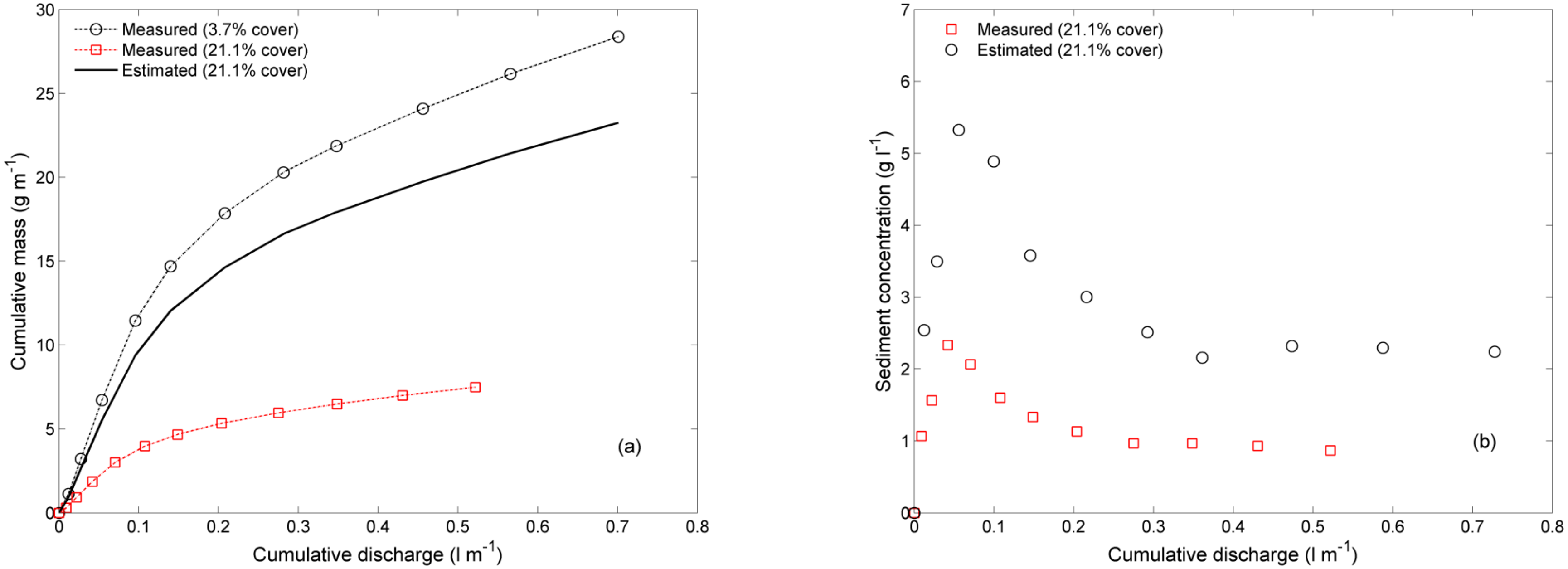


Fig. 14S. Cumulative eroded mass as a function of cumulative discharge and sediment concentration for the field experiment of Martinez-Zavala and Jordan (2008). This experiment was performed with a precipitation rate of 150 mm h^{-1}. The eroded mass is not proportional to the cumulative discharge.

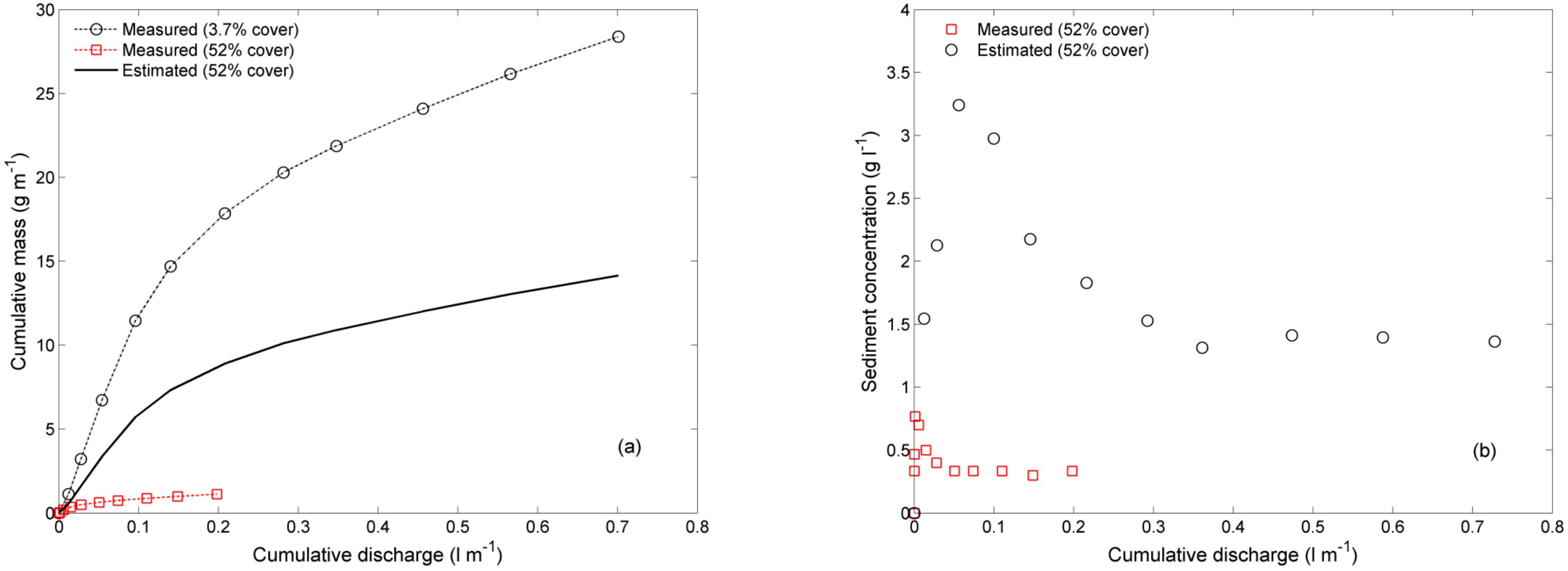
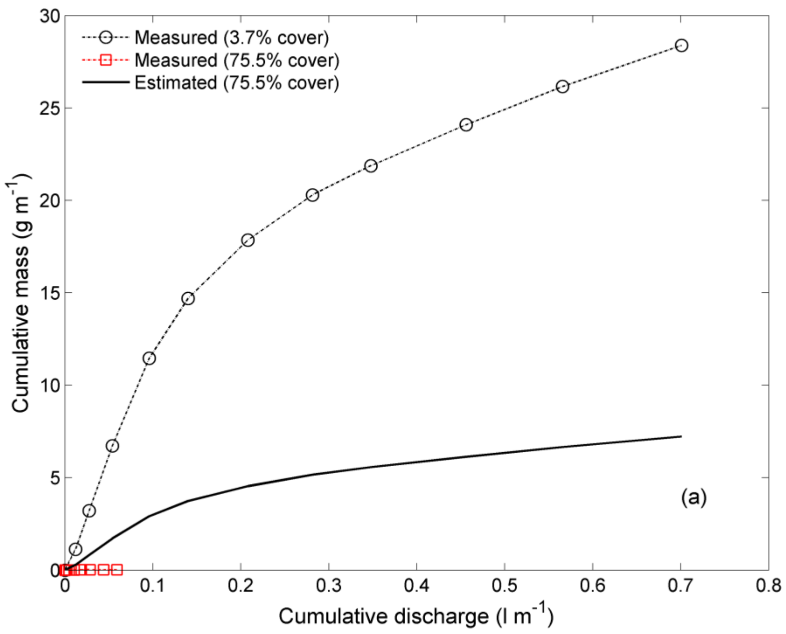


Fig. 15S. Cumulative eroded mass as a function of cumulative discharge and sediment concentration for the field experiment of Martinez-Zavala and Jordan (2008). This experiment was performed with a precipitation rate of 150 mm h^{-1}. Also in this dataset the eroded mass is not proportional to the cumulative discharge.



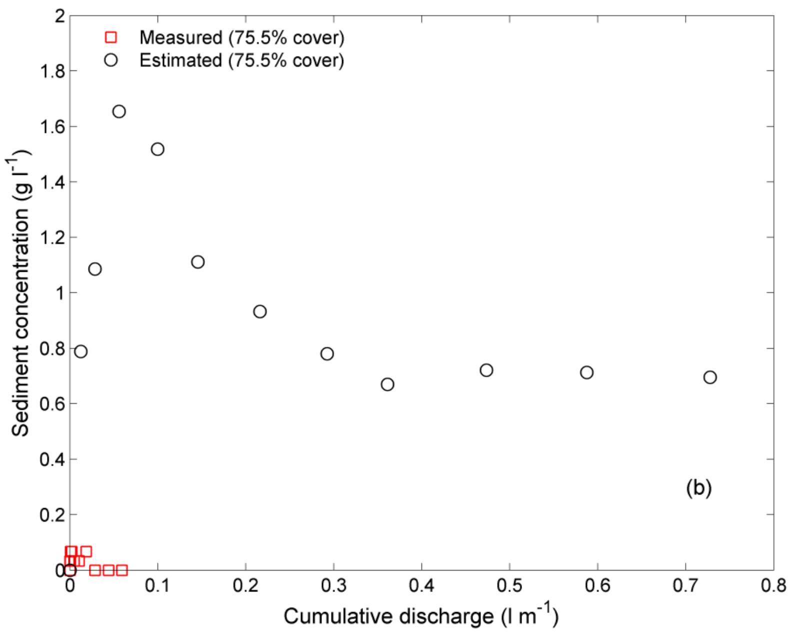


Fig. 16S. Cumulative eroded mass as a function of cumulative discharge and sediment concentration for the field experiment of Martinez-Zavala and Jordan (2008). This experiment was performed with a precipitation rate of 150 mm h^{-1}. The eroded mass is not proportional to the cumulative discharge.

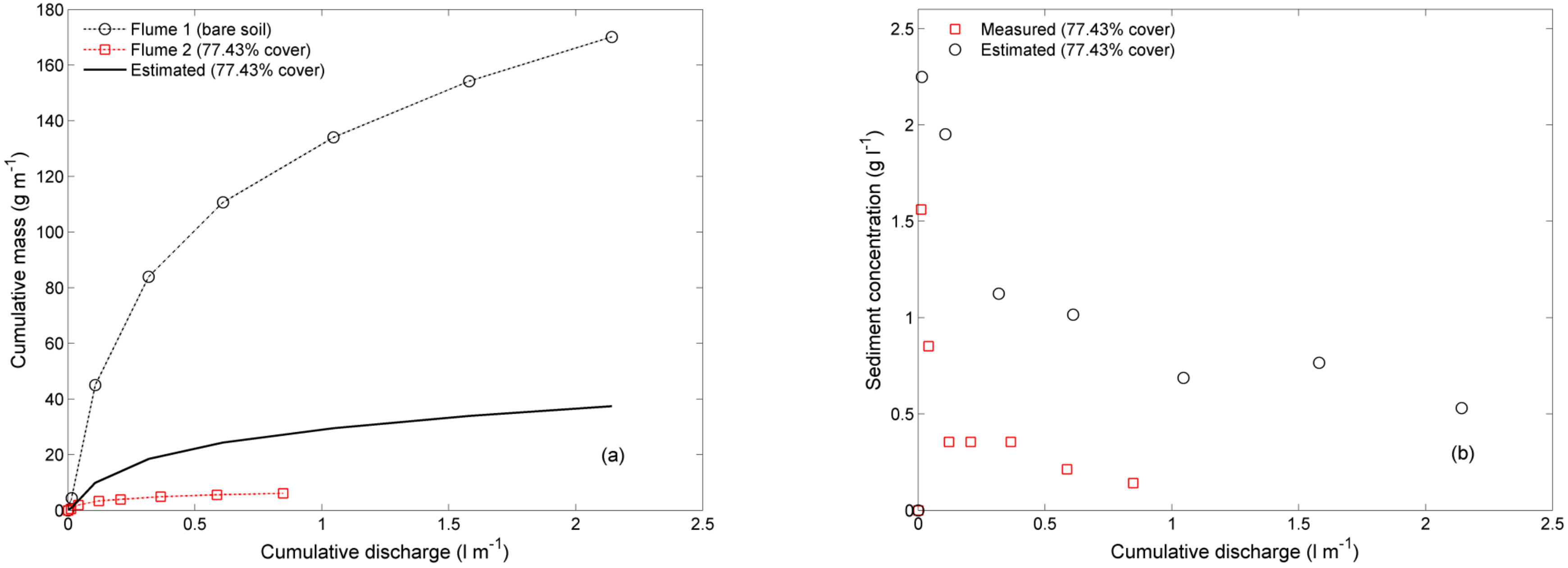


Fig. 17S. The cumulative eroded mass as a function of the cumulative discharge collected from experiment conducted by Cerdà (2001). This experiment was performed with a precipitation rate of 55 mm h^{-1}. The eroded mass is not proportional to the cumulative discharge.