Effects of closing and decommissioning forest roads as determined with rainfall simulations

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Abstract. Sediment from unpaved forest roads is important because this can severely degrade water quality and aquatic habitat. Road closures and road decommissioning are being used to reduce road runoff and sediment delivery, but few studies have rigorously evaluated the effectiveness of these treatments. This study used rainfall simulations to: 1) quantify the differences in infiltration capacity and sediment production between undisturbed forest, closed roads, and two decommissioning treatments; and 2) quantify the effects of key site variables on infiltration, surface runoff, and sediment production. Sixteen rainfall simulations were conducted in summer 2014 on 1 m^2 plots west of Red Feather Lakes on the Arapaho-Roosevelt National Forest in northcentral Colorado. Four replicates were done for undisturbed forest, closed roads, and two decommissioning treatments (ripping only, and ripping plus wood strands and fertilization). Rainfall was applied at 44 mm hr^{-1} for 45 minutes using an oscillating nozzle. The mean bulk density was 1.28 g cm^{-3} in the undisturbed forest and 1.75 g cm^{-3} for closed roads. Ripping reduced the bulk density relative to closed roads by 13%, but the post-treatment bulk density of 1.53 g cm^{-3} was still 20% higher than the undisturbed forest. The mean infiltration rate for the last five minutes ("infiltration capacity") of 28 mm hr^{-1} for the undisturbed forest was lower than expected and highly variable, and this was attributed to soil water repellency. Closed roads and ripped roads had mean infiltration capacities of only 4 and 9 mm hr^{-1}, respectively. The combination of ripping and mulching was much more beneficial, as this more than doubled the mean infiltration capacity to 20 mm hr^{-1} compared to just ripping. Bulk density only explained 35% of the variability in infiltration capacity among the treatments as compared to 59% for ground cover. The mean sediment yield from the forested plots was only 3 g as compared to 43 g for the closed roads. The plots that were just ripped had the highest mean sediment yield of 72 g, or 40% higher than the closed roads, and this suggests that ripping greatly increased sediment availability. Mulching plus ripping reduced sediment yields to just 16 g or 22% of the mean value from the ripped plots. The results show that ripping alone can reduce runoff but increases sediment yields when compared to closed roads, while ripping plus mulching is much more effective in reducing surface runoff and especially sediment yields. The results can help calibrate and validate commonly-used road erosion models, and guide the design of future decommissioning treatments.