

IMPACTS OF INDIRECT AND DIRECT VISITATION ON MICROBIAL COMMUNITIES  
FROM LAVA CAVES IN LAVA BEDS NATIONAL MONUMENT, USA.

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**Abstract**

We compared indirect and direct impacts of human activity on bacterial diversity of overlying soils to microbial mats in lava caves in Lava Beds National Monument. We worked with LABE personnel to select seven lava caves to cover a range of parameters including the extent of human visitation. Bacterial communities are distinctly different between surface soils and caves, with only an 11.2% overlap, showing that the bacteria in the cave are not simply a subset of surface microbes infiltrating into the cave. There was little evidence of direct human impact in LABE caves. Two microbial mat samples with probable direct human impacts were distinctly different from the surface soil and microbial mat communities, and from each other. Bacteria usually associated with humans were very limited; only one *Staphylococcus* and *Streptococcus*, and 25 *Enterbacteriaceae* detected from any LABE cave or surface sample. Indirect effects of human visitation showed minimal differences in mat community richness among caves. Our high visitation (about 30,000 people a year) and low visitation (up to 10 visitors some years) caves are comparable in terms of alpha diversity and show no major differences in microbial community structure. In contrast, in Carlsbad Cavern, a karst cave, with over 400,000 visitors per year, studies showed differences in bacteria and fungi on and off the tourist trails. There was a general decrease with distance from the entrance, but with a peak in the Lunchroom where visitors rest,

eat, and wait for the elevator to return to the surface. The authors concluded that humans were important sources of non-indigenous microorganisms into Carlsbad Cavern, and recommended mitigation steps. What we may be seeing is a threshold of visitors before we see indirect human impacts; finding the threshold merits further study.