DOES GRAY-TAILED VOLE ACTIVITY AFFECT SOIL QUALITY?

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Summary

Voles are well-known crop pests in grass seed cropping systems especially when post-harvest grass straw is chopped and remaining on the field, and particularly in years when peak populations are present. Their role in soil fertility and impacts on agricultural sustainability, however, are not well understood. We conducted a study in a perennial grass seed production system in the Willamette Valley, Oregon to better understand vole burrow structure and the impact that vole activity has on soil chemical properties. The study was performed in the spring of 2006, five months after the abrupt disappearance of a gray-tailed vole population in the valley following a significant vole irruption. This irruption was particularly noteworthy due to the millions of dollars of losses to the grass seed, plant nursery, and wine industries. Based on other fossorial mammals' impacts on nutrient cycling and carbon (C) and nitrogen (N) cycling, we hypothesized that concentrations of soil C, N-nutrients, trace elements, and moisture would be greater directly below vole burrows than above or away from the burrows. We also hypothesized that soil that had supported vole populations would have greater amounts of soil organic matter, greater concentrations of carbon and nitrogen, and greater soil moisture than soil with no vole activity. In this study we examined burrow structure, determined concentrations of trace elements, carbon and nitrogen in the soil immediately surrounding vole burrows, and compared soil chemical properties to a depth of 90 cm between areas with prior vole activity and areas of no activity. Vole tunneling activity was confined to the top 10 cm of the soil profile and was coincident with the majority of root biomass. Soil NH_4^+, NO_3^-, extractable organic carbon, and soil organic matter were greater below vole tunnels than above; however, due to small sample sizes, differences were not significant (Table 1). There were no differences in trace elements (Al, Ba, B, Ca, Cu, Fe, Mg, Mn, P, K, S, Si, Z) with respect to position around vole tunnels. Vole activity was associated with increased soil NO_3^- concentrations (Figure 1) and decreased soil pH (Figure 2) to a depth of 90 cm, indicating that nitrification might be enhanced by vole activity, and that this effect continues after vole populations crash.

Conclusions

- This study is the first to elucidate the signature of vole activity on soil in a perennial grassland ecosystem in the Willamette Valley of Oregon.
- Vole activity had the greatest impact on the production of NO_3^- in these soils.
- Greater concentrations of NO_3^- and decreased pH extended to soil depths of 60-90 cm in areas with previous burrowing activity, even though the burrows appeared to be largely confined to the top 10 cm of soil.
- Greater inorganic N could have long-term effects on ecosystem productivity.
- Changes in soil chemistry due to vole activity seem to outlast the population spikes that create the characteristic extensive burrow network.
- The effects voles have on soil processes that influence C and nutrient cycle requires further investigation.

References

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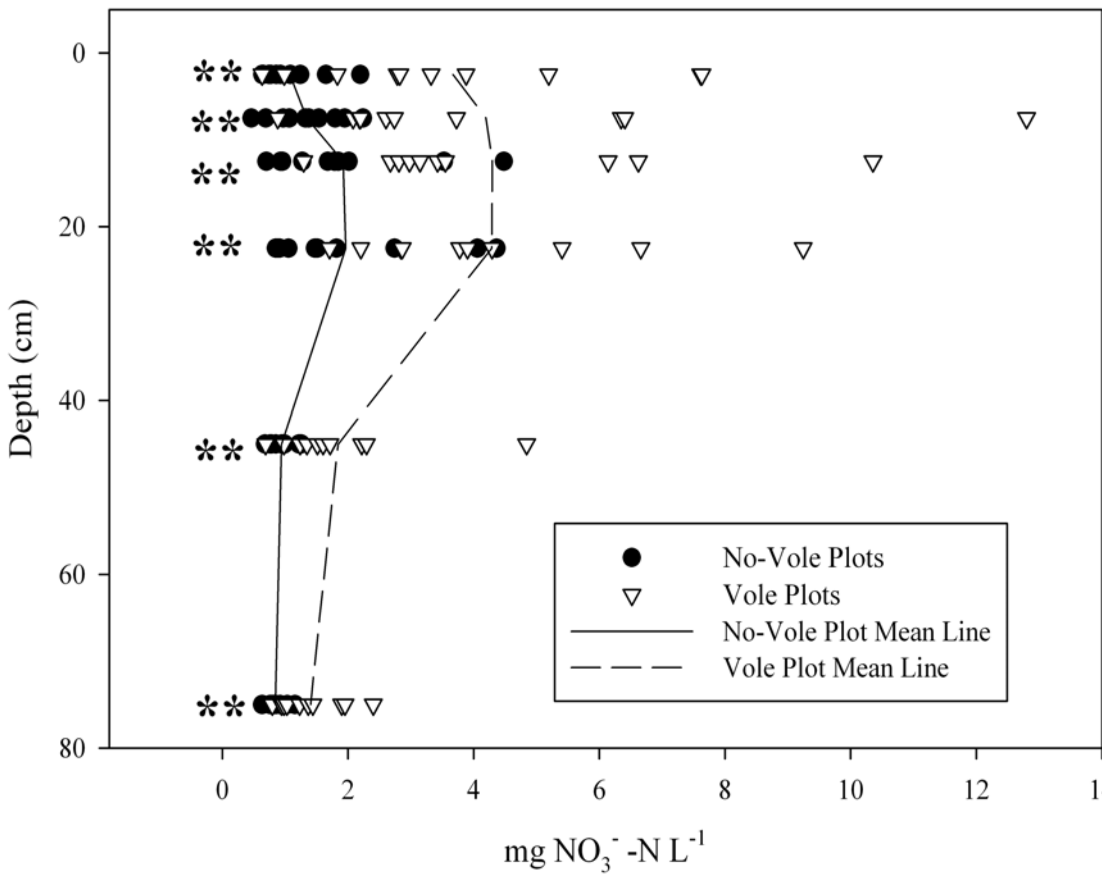

Figure 1. Relationship between soil depth and soil NO_3^- in plots with and without vole activity in the Willamette Valley, Oregon in May 2005 Lines connect means for each soil depth class (0-5, 5-10, 10-15, 15-30, 30-60, and 60-90 cm). Differences between no-vole and vole plots were significant at all depths ($P \leq 0.10$). The untransformed raw data are presented. Significance is denoted at $P \leq 0.10$ by * and at $P \leq 0.05$ with **.

Table 1. Geometric means and 90% confidence limits (in parentheses) of soil parameters from the vole burrow vicinity study. "Above" refers to soil samples taken within 5 cm above burrows, "below" refers to soil samples taken from within 5 cm below burrows, samples from "above away" were taken 25cm above a burrow and "below away" were taken 25 cm below a burrow. Units are mg N kg^{-1} dry soil for nitrate (NO_3^-), ammonium (NH_4^+), and extractable total nitrogen (ETN), mg C kg^{-1} dry soil for extractable organic carbon (EOC) and percentages for soil organic matter (SOM) and gravimetric soil moisture (GSM).

Soil Parameter	Above (n=4)	Below (n=5)	Above Away (n=1)	Below Away (n=2)
pH	5.34 (5.17-5.52)	5.55 (5.27-5.83)	5.60	5.67 (4.33-7.01)
NH_4^+ (mg/kg)	1.32 (0.84-1.81)	13.1 (-10.8-37.0)	1.36	1.10 (1.00-1.20)
NO_3^- (mg/kg)	0.84 (0.70-0.99)	1.17 (0.69-1.65)	0.96	0.90 (0.24-1.55)
ETN (mg/kg)	8.49 (6.84-10.2)	18.0 (-1.58-37.6)	8.42	7.71 (5.94-9.48)
EOC (mg/kg)	54.3 (49.0-59.7)	67.5 (48.1-86.9)	60.6	54.2 (42.6-65.8)
SOM (%)	3.64 (2.1-4.47)	3.91 (3.38-4.44)	3.28	3.19 (2.21-4.18)
GSM (%)	16.1 (15.1-17.2)	21.5 (19.7-23.3)	14.7	16.3 (13.0-19.6)

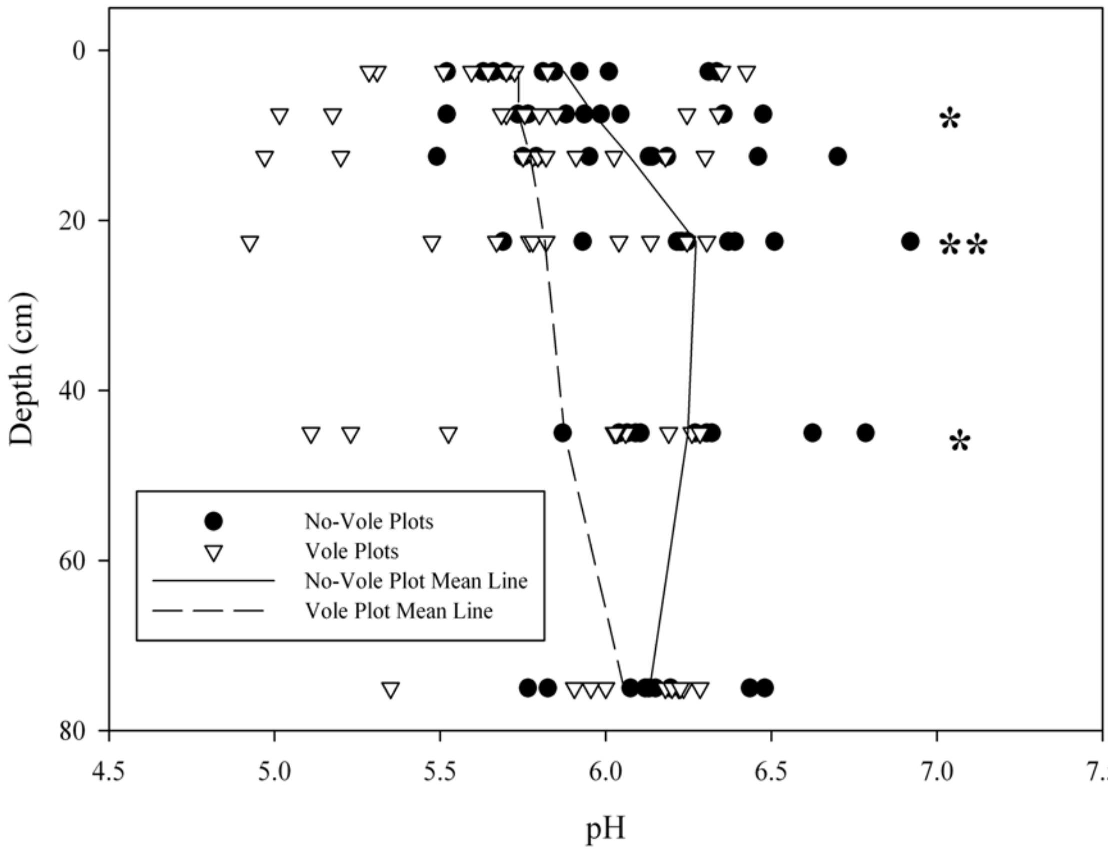

Figure 2. Relationship between soil depth and soil pH in plots with and without vole activity in the Willamette Valley, Oregon in May 2005. Lines connect means for each soil depth class (0-5, 5-10, 10-15, 15-30, 30-60, and 60-90 cm). Differences between no-vole and vole plots were significant at depths 15-30 cm and 5-10 cm and 30-60 cm ($P \leq 0.10$). The un-transformed raw data are presented. Significance is denoted at $P \leq 0.10$ by * and at $P \leq 0.05$ with **.