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The Effects of Cape Ivy on Soil Microbial Populations

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Abstract

Cape Ivy (*Delairea odorata*) was introduced from South Africa to the United States in the 1850s and is now the primary threat to biodiversity along the central California coast. Although the decrease in plant diversity following Cape Ivy infestation has been documented, there is no published research on the effect of Cape Ivy on soil productivity. Soil microbes provide essential ecosystem services such as nutrient mineralization. Therefore, the purpose of our study is to determine whether Cape Ivy disrupts soil microbial ecology. We hypothesize that Cape Ivy is disrupting microbial populations, which disables native species or gives Cape Ivy a selective advantage. We are comparing soil microbial activity of Cape-Ivy infested areas with the native coastal scrub community. Soil samples were collected from depths of 0 to 30.5 cm. Community-level physiological profiling employing Biolog Ecoplates was used to compare catabolic activity in the microbial community in Cape-Ivy infested areas with that of the native coastal scrub community. Our preliminary results show that Cape Ivy does affect the function of soil microbial communities. At 12 cm, catabolic capabilities of the Cape-Ivy associated microbial communities are 7% greater than those of the coastal-scrub associated community. Functional diversity in Cape-ivy soil is 91.4%±7.0 compared to 82.8%±2.1 in the coastal-scrub soil at 12 cm. We are examining activities of nitrifying and denitrifying bacteria in the different soil samples. Our results and analysis of functional traits will contribute to understanding the mechanisms by which Cape Ivy maintains dominance and may help achieve long-term restoration goals.

Aim

To determine the effect of Cape Ivy on soil microbial ecology.

Background

- Cape Ivy (*Delaria odorata)* was introduced from South Africa as an ornamental vine in the late 1800s. It soon escaped and now infests coastal scrub and riparian communities on the California coast (9).
- Cape Ivy is an aggressive invader that displaces native plants and natural habitats. It is currently the primary threat to species diversity in California (10).
- Soil under Cape Ivy stores more moisture longer into the spring, giving Cape Ivy an advantage over drought-tolerant natives (6).
- Invasion by alien plants can alter ecosystem processes and soil properties. Increased productivity in communities invaded by alien exotic plants has been reported (8).
- Community Level Physiological Profiling (CLPP) involves the inoculation of environmental samples into Biolog Microplates, which contain 31 different carbon sources and a blank, After incubation for 2-7 days, color formation yields results that can be assessed to formulate patterns in microbial communities (3,4).
- Microbial nitrification and denitrification are critical for supplying nitrogen for plant growth (2).
- Biodiversity research is mainly focused on macroorganisms. However, bacteria mediate the biogeochemical cycles that maintain life and understanding their ecology and diversity is crucial.
- We did these investigations to determine whether Cape Ivy disrupts soil microbial ecology.

Figure 1. In California, invasive Cape Ivy grows year-round and reproduces through stolon production (5).

Methods

- Soil samples were collected at depths of 0, 15.24, and 30.48 cm. from grids laid out at each of three sites:
  - The test site was completely covered by Cape Ivy (**Figure 1**). The surrounding area has *Eucalyptus globulus*, *Foeniculum vulgare*, and *Urtica dioica*.
  - The control site is native coastal scrub, predominated by *Baccharis pilularis*.
  - Cape Ivy was growing near *Eucalyptus*, which secretes allelopathic and antimicrobial chemicals into the soil. Therefore, a second control site consisting of only *E. globulus* was used to account for any effect of the *Eucalyptus*.
- Community-Level Physiological Profiling
  - Soil samples were diluted 10^{-3} in Phosphate Buffered Saline (PBS) and vortexed for 30 sec. to suspend bacteria.
  - Each Biolog Ecoplate well was inoculated with 100 µL of one of the diluted samples.
  - Ecoplates were incubated at ambient temperature for 4 days. Indicator color change was determined by comparing the color of the wells to the control (water) well. Any slight appearance of purple was counted as a color change.
- Nitrification
  - 10 g soil was placed into 125-ml flasks with 50 ml PBS and 1 g $(NH_4)_2SO_4$.
  - Flasks were incubated in a shaking water bath at 37°C for 2 hr.
  - The filtered supernatant was tested for NO_2^- by the Griess-Ilosvay method with the addition of sulfanilamide and naphthylamine.
  - Absorbance was measured at 543 nm and compared to a standard curve to determine the NO_2^- concentration.
- Denitrification
  - 100 g soil, 0.10 g KNO_3, and 100 ml water were placed in flasks.
  - The stoppered flasks were incubated at room temperature for 1 week.
  - NO_2^- was determined by the Griess-Ilosvay method.

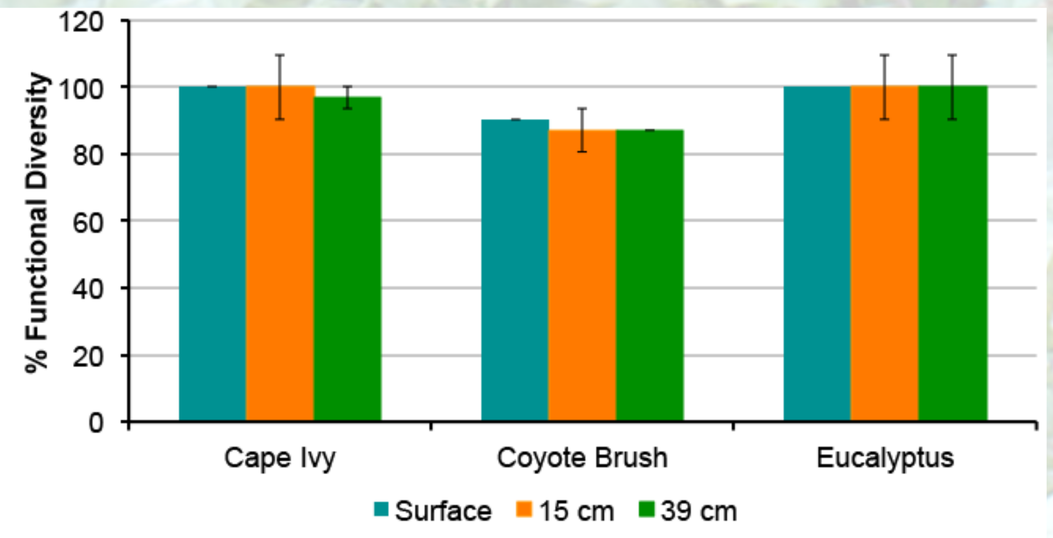

Figure 2. Microbial communities in native coastal-scrub soil have less metabolic diversity than microbial communities under invasive plants.

Table 1. Denitrification

Study site, all depths	Denitrifying bacteria
Cape Ivy	–
Coastal scrub	+
Eucalyptus	–

Results

- Bacteria in native coastal-scrub soil showed less metabolic diversity than either soil under invasive plants at all depths. There was little difference between metabolic diversity at different depths at all three sites (**Figure 2**).
- Native coastal-scrub bacteria used fewer different carbon sources (**Figure 3**).
- Bacteria under woody plants (Coyote brush and *Eucalyptus*) degrade more polymers compared to bacteria under herbaceous Cape Ivy (**Figure 4**).
- Nitrifying bacteria oxidize NH_3^- to NO_2^-. The activity of nitrifying bacteria is about the same in Cape-Ivy and coastal-scrub soils (**Figure 5**).
- Denitrifying bacteria reduce NO_3^- to NO_2^- or N_2O or N_2. The presence of denitrifying bacteria in coastal-scrub may be influenced by wood are more active in coastal-scrub soil (**Table 1**).

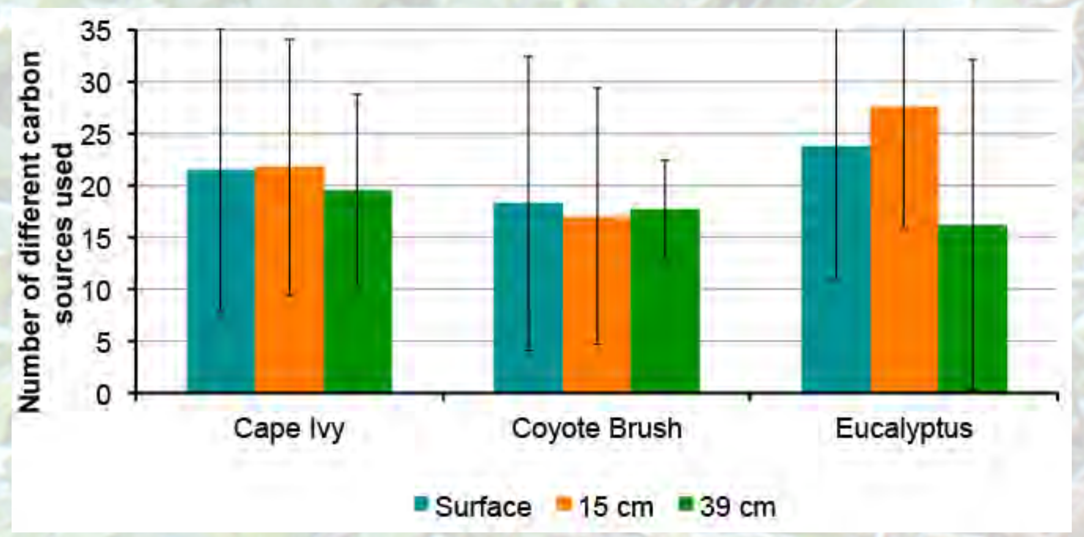

Figure 3. Bacteria in native coastal-scrub soil used fewer different carbon sources compared to bacteria under invasive plants.

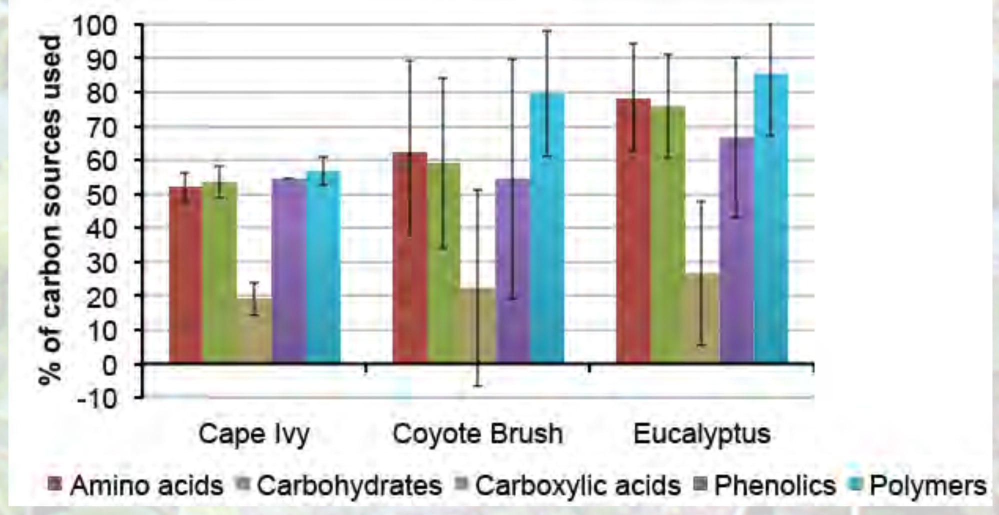

Figure 4. Bacteria under woody species degrade larger molecules (polymers). *E. globulus* produces phenolic compounds and amino acids (1). Thus bacteria that degrade phenolics and amino acids would likely be found in soil under *Eucalyptus*.

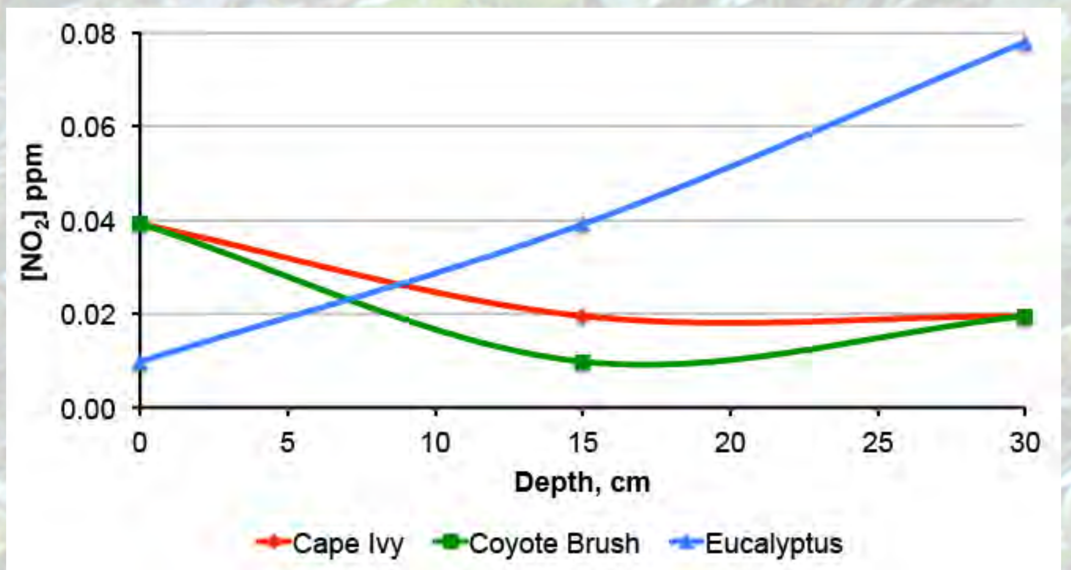

Figure 5. Nitrifying bacteria are more prevalent in *Eucalyptus*-soil.

Discussion & Conclusion

- The differences between number of different carbon sources used indicates that *Eucalyptus* secretions did not influence the Cape-ivy soil bacteria.
- There is less microbial metabolic diversity in native coastal scrub soil than in soil under Cape Ivy.
- Native-plant biodiversity may stabilize microbial functional diversity.
- These findings are supported by McNaughton's conclusions on studies of macroorganisms: Functional diversity of older, established communities is stable, not necessarily diverse (7).
- Cape Ivy does not affect nitrifying bacteria compared to coastal-scrub soil.
- Future studies will investigate:
  - The low nitrifying activity in coastal-scrub soil.
  - The presence of denitrifying bacteria in coastal-scrub soil, which may be influenced by carbon content of the soil.

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