# Soil Quality Under Poplar and Agricultural Management


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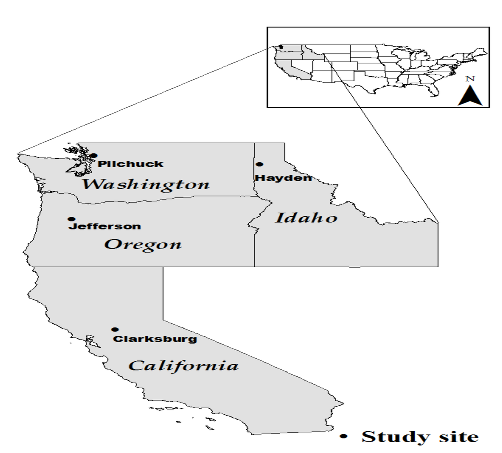
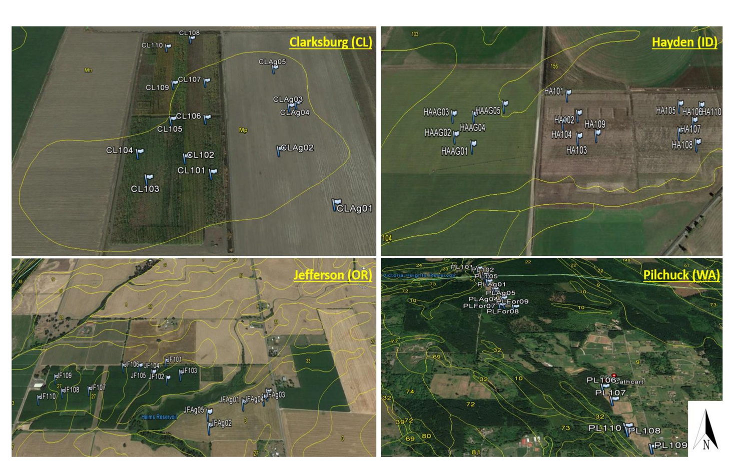
## Introduction

Hybrid poplar (Populus spp.) is an important feedstock to produce biomass for energy and other diverse products that include timber, pulp and paper. poplar production could potentially serve as important renewable feedstock for a sustainable bioenergy resource in the Pacific Northwest, and other parts of the world. However, open questions remain on environmental, and soil quality aspects of bioenergy production at a large scale. In particular, there are significant knowledge gaps regarding poplar's impacts on (i) soil fertility such as changes in soil nutrient reserves, (ii) water quality as possibilities of causing eutrophication and pollution of water bodies, (iii) gaseous emissions, and other ecosystem functions that could be impacted by conversion of lands to biofuel crops.

In this study, soil surface chemistry was studied under spatial, and temporal scales appropriate for poplar and other agronomical managements. The specific objective of this work was to learn how soil chemistry parameters vary over time under poplar management compared to adjacent agricultural fields in northwestern United States. We hypothesized that conversion of agricultural lands to poplar bioenergy crops would have a positive impact on soil chemical quality compared with adjacent lands that continue agronomic management practices.

## Study Design, and Methods

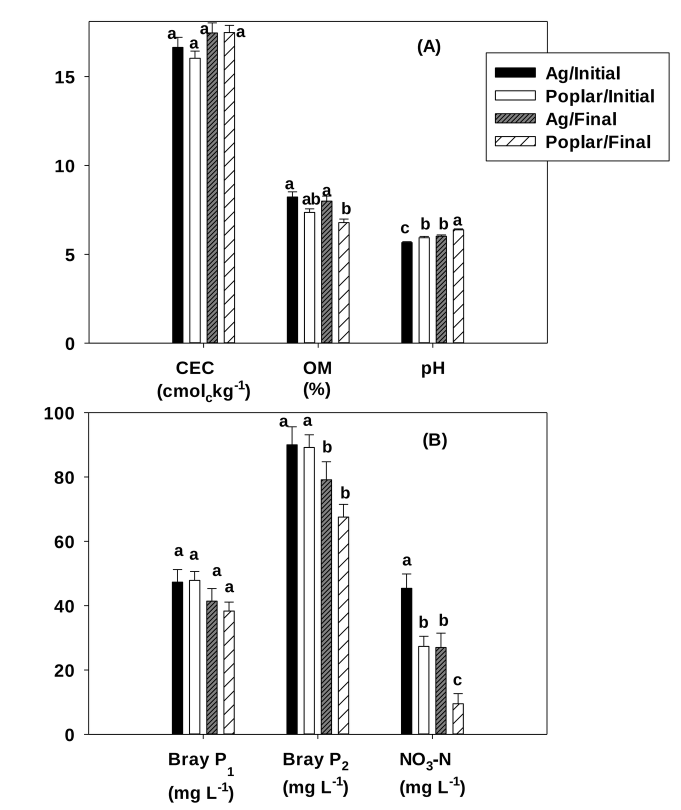


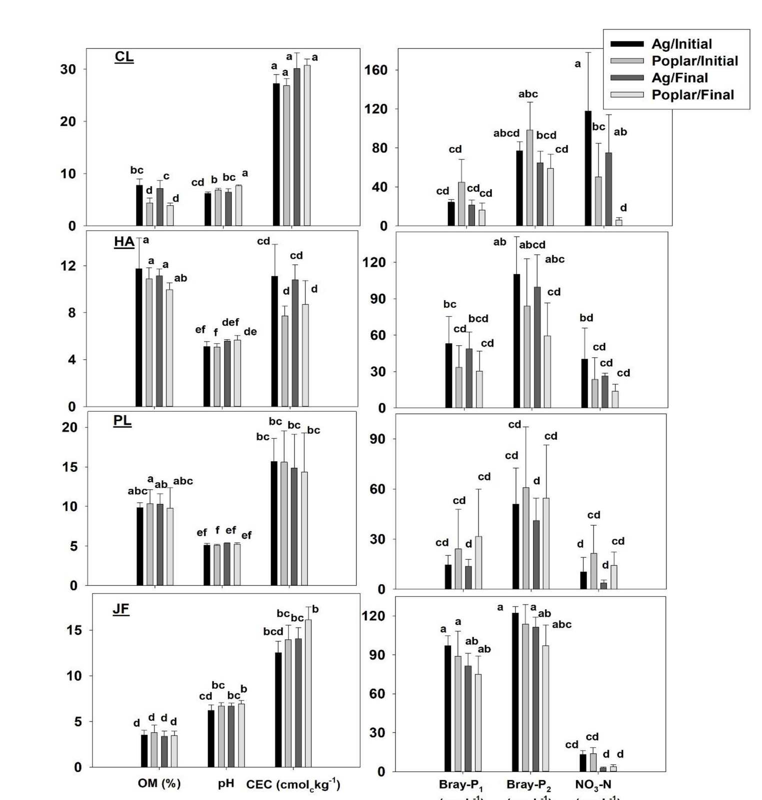



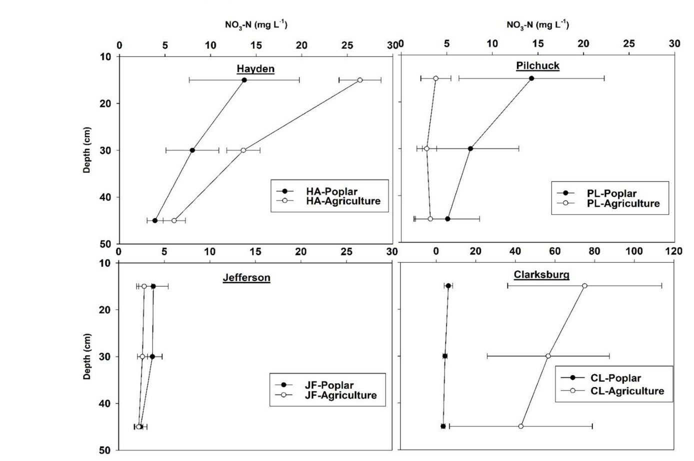
- The poplar demonstration sites were established at Hayden, ID, Stanwood, WA (Pilchuck), Clarksburg, CA, and Jefferson, OR.
- In addition to the poplar sites, adjacent agricultural (hay, alfalfa, winter wheat, safflower, clover, bluegrass) lands were also sampled for comparison. Ten composite soil samples from each poplar site and five from each agricultural site.
- Soil samples dried, sieved through 2 mm mesh, and analyzed for a number of surface chemical parameters.
- Composite samples contained three subsamples collected (0-15 cm depth) at each sampling plot and homogenized during collection and sieving.
- Initial samples were collected in all fields at a location during poplar establishment 2012/2013, final samples were collected in 2016.
- Both initial, and final soil samples were analyzed for:
  - organic matter (OM) by loss-on-ignition
  - Bray P1 extracted with dilute acid and ammonium fluoride (weak, or, readily available)
  - Bray P2 extracted with strong (four times the acid concentration of weak Bray) Bray solution (strong, or, readily available and part of active reserve P)
  - pH (1:1, soil to water)
  - cation exchange capacity (CEC) determined by ammonium acetate saturation, and displacement with NaCl followed by distillation and titration
  - $NO_3$-N determined by saturated CaO extraction, Cd reduction, followed by segmental flow analysis
- In addition to surface (0-15 cm) soil, a set of few samples were also collected from 15-30 cm, and 30-45 cm depth only during the final year (2016) to understand the leaching trend of soil $NO_3$-N.
- Only key soil chemistry is presented here.
- Lysimeter water samples were collected periodically from 50 cm depth to understand nutrients leaching.

## Results, and Discussions

| | Soil Chemistry Parameters | | | | | |
|---|---|---|---|---|---|---|
| **Effects** | **OM** | **Bray P₁** | **Bray P₂** | **pH** | **CEC** | **NO₃-N** |
| **Location (L)** | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 |
| **Management (M)** | <.0001 | 0.71 | 0.2023 | <.0001 | 0.557 | <.0001 |
| **Time (T)** | 0.1051 | 0.0248 | 0.0011 | <.0001 | 0.0244 | <.0001 |
| **L x M** | <.0001 | 0.0038 | 0.0053 | <.0001 | 0.0186 | <.0001 |
| **L x T** | 0.7568 | 0.1476 | 0.6225 | 0.2006 | 0.0133 | 0.0032 |
| **T x M** | 0.4986 | 0.5936 | 0.2683 | 0.4505 | 0.5237 | 0.9405 |
| **L x M x T** | 0.8791 | 0.2938 | 0.7248 | 0.1561 | 0.934 | 0.9953 |

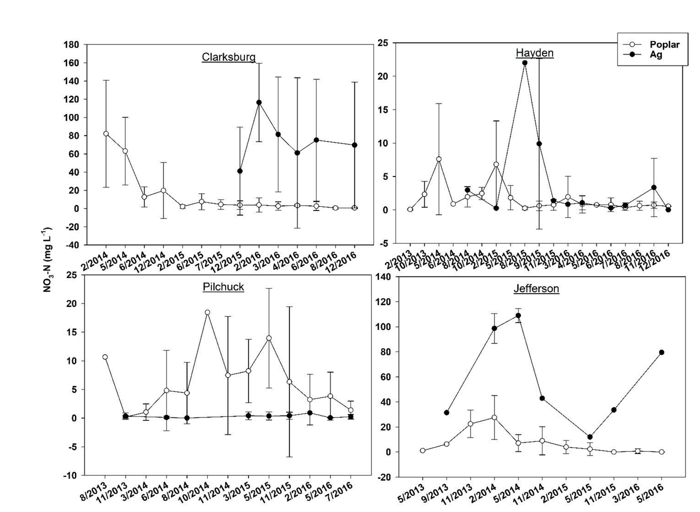


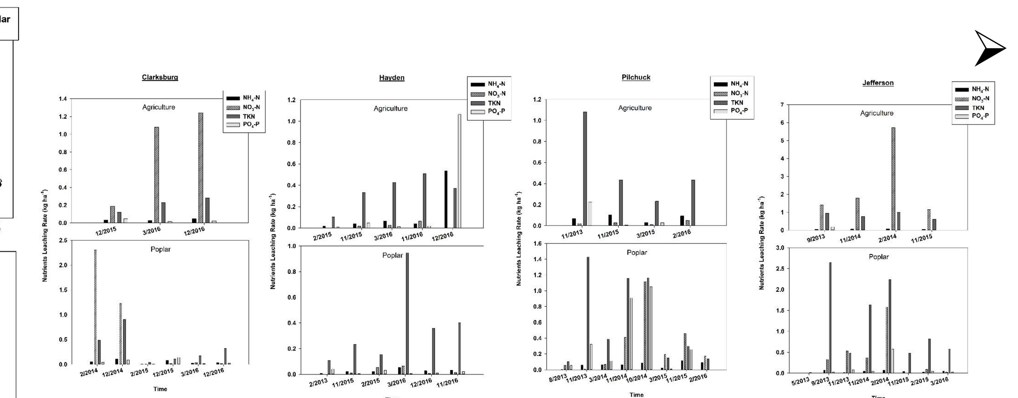




| | Leaching Rates (kg ha⁻¹) | | | | |
|---|---|---|---|---|---|
| **Effects** | **NO₃-N** | **NH₄-N** | **TKN** | **Org-N** | **PO₄-P** |
| **Location (L)** | 0.1651* | 0.8721 | 0.2849* | 0.2963* | 0.6279 |
| **Management (M)** | 0.0098* | 0.4139 | 0.5352 | 0.8076* | 0.9847 |
| **Time (T)** | 0.0022* | 0.7291 | 0.2244 | 0.5818 | 0.5517 |
| **L x M** | 0.3122* | 0.7524 | 0.9400 | 0.8844* | 0.8226 |
| **L x T** | 0.7894* | 0.9720 | 0.8379 | 0.9551 | 0.7426 |
| **M x T** | 0.3269* | 0.9065 | 0.5890 | 0.9797 | 0.6190 |
| **L x M x T** | 0.9185* | 0.7816 | 0.9902 | 0.9804 | 0.9460 |

*: significant for concentrations




- All soil chemistry parameters were affected by location.
- Management type affected only few of them.
- Except OM, all other key chemistry was impacted by main time regime.
- None of the soil chemistry parameters was significantly affected by L x M x T interactions.
- The soil $NO_3$-N concentrations decreased under both managements depending on location, and management practices.
- Decrease of soil $NO_3$-N concentrations in deeper layers was generally higher for poplar compared to agricultural management practices.
- Except one, all poplar sites had consistently lower $NO_3$-N concentrations in soil water over time.
- On average, poplar significantly reduced $NO_3$-N concentrations by 33 folds while agricultural systems increased the same by 49% over time.
- Poplar decreased both P fractions by 16.2, and 18.1% , compared to adjacent agricultural fields over 4-year, although management individually had no significant impacts suggesting that the differences were solely due to the magnitude differences by the soil variations or, decrease in P under poplar was same in magnitude for agricultural field.
- Under poplar management, the most interesting, and perhaps most important significant changes over time were 6.9% increase in pH, and CEC, compared to adjacent agricultural sites, although like the cases of OM, and P fractions the L x M x T interactions were insignificant for pH, and CEC again suggesting that the significant temporal variations were mainly due to location specific.
- At 45 cm depth while agricultural, and poplar soils had almost similar amount of $NO_3$-N loss at CL, and HA, the same loss was 4.1 time higher at PL, and 1.8 times higher at JF locations indicating that poplar root system probably had taken up more nitrate compared to adjacent agricultural plants in these locations.
- Nutrient leaching rates were regulated by nutrient concentrations, drainage rates, and partly OM, and pH.

## Summary

- Although there are significant effects of time-alone, and management-alone on most soil chemistry parameters, poplar did not change soil chemistry over time.
- During the course of our study, there were few negative effects of poplar management on soil chemistry.

## Funding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