Soil properties in native, restored and farmed closed depressions on the Des Moines Lobe of Iowa: a chronosequence study of restoration timeframes

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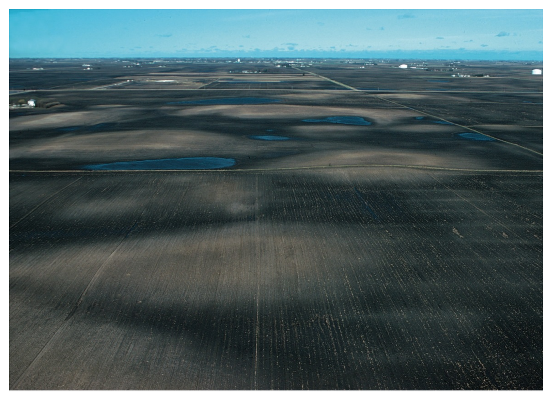
Introduction

- Wetland restoration in Iowa is a process of preserving, restoring and enhancing wetlands which have been altered mainly due to artificial drainage.
- Evaluating long-term trends in ecosystem services is challenging and is typically done by monitoring across many years or decades at a single site.
- However, chronosequences may be used to establish long-term patterns of recovery. Chronosequences are time series of sites which vary by age with otherwise similar characteristics.
- Objective of this study:
  - Utilize a range of restoration ages, comparing current farmed wetlands to decadal-long wetland restorations and native wetlands (a chronosequence), to assess how long it may take for soil properties of restored wetlands to resemble native systems.

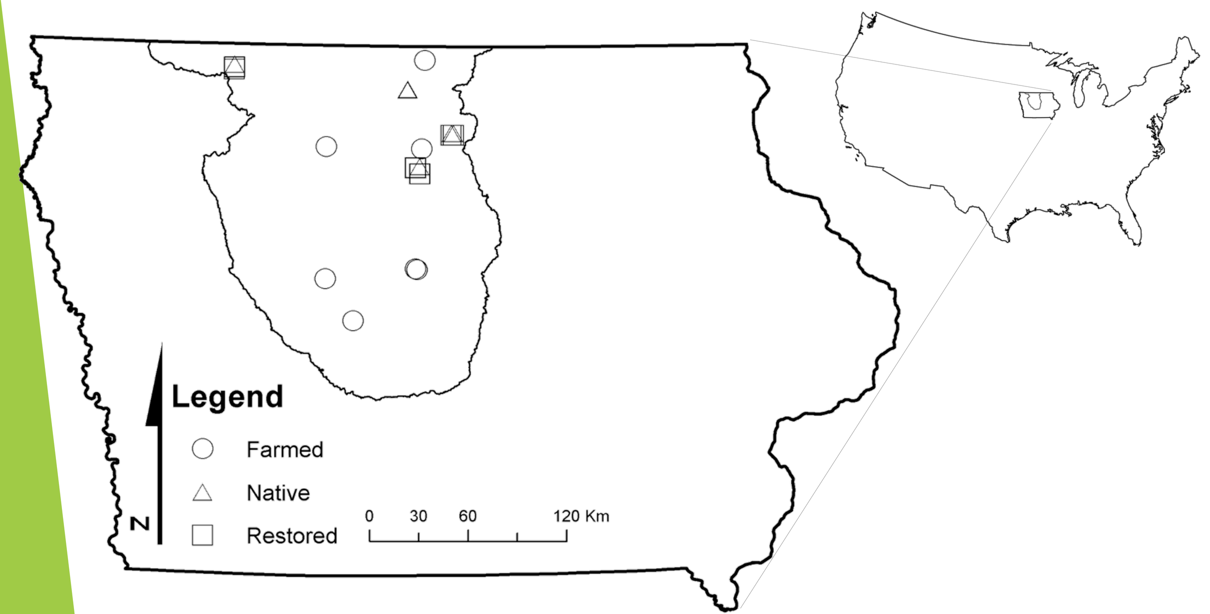
Before Restoration



After Restoration

Methods

- The Des Moines Lobe of Iowa is dominated by hummocky topography that formed after ice melt of the Wisconsin ice sheet and contains many thousands of small, shallow, closed depression wetlands, which were the area of interest for this study.
- Mineral and organic soils from representative wetlands were selected for detailed characterization and laboratory analysis.
  - Mineral soil series included Okoboji, Brownton, Kossuth, Canisteo and Colo.
  - Organic soil series included Palms, Houghton and Muskego.
- 21 sites were selected and split into 5 groups: farmed (artificially drained), restored (drainage removed for ~10, 20 and 30 years) and native (never drained) wetlands.



Location of wetland sites on the Des Moines Lobe of Iowa.

- Continuous 7.5 cm soil cores were collected to a depth of 100 cm using a slide hammer and characterized in the field.
- Soil cores were composited into five equal interval depth groups (0-20, 21-40, 41-60, 61-80 and 81-100 cm) and were analyzed for N, P, K, Mg, Ca, pH, CEC, SOM and texture.

Results

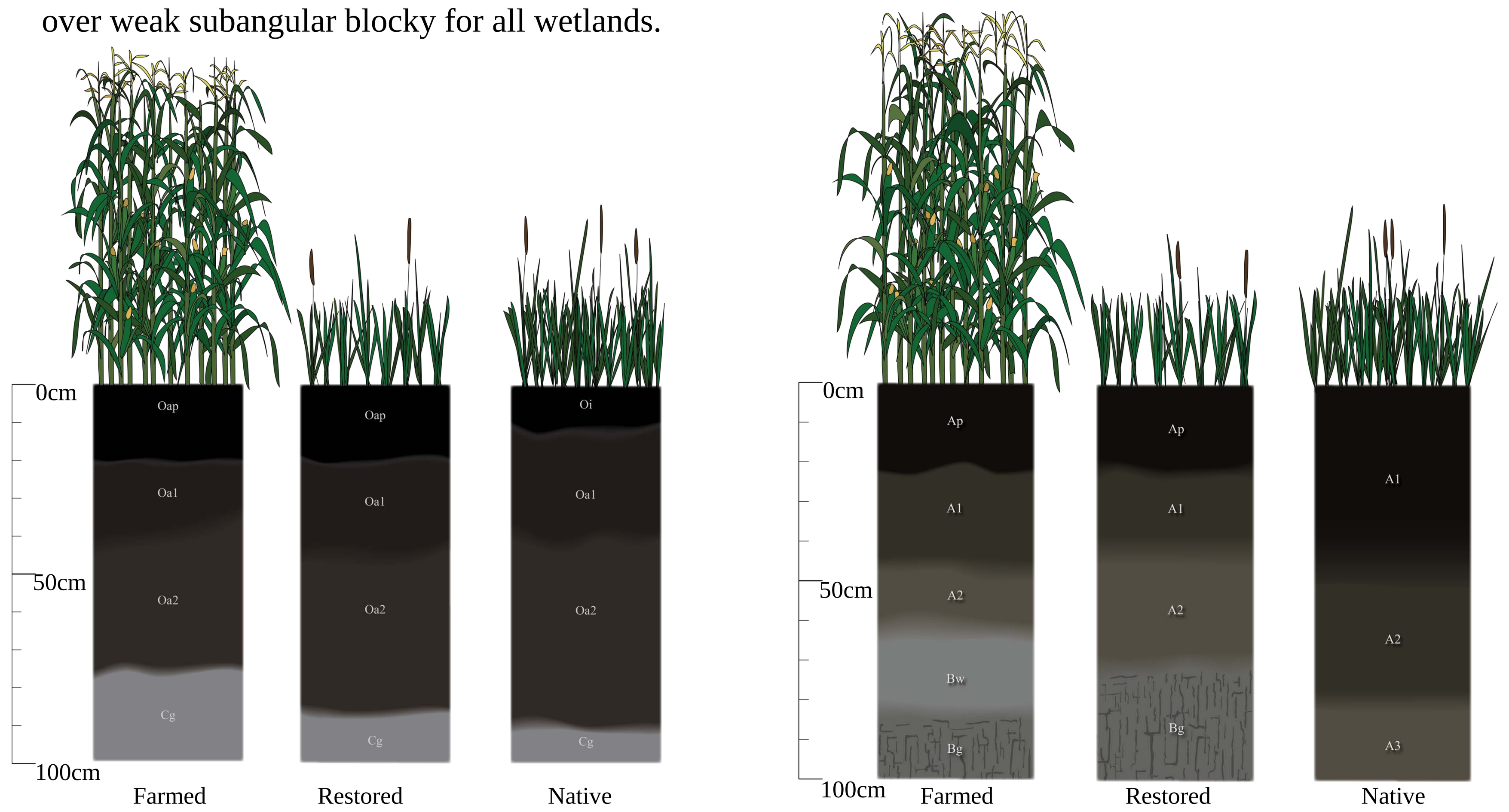
Morphological Analysis

Organic Soils

- The most significant changes in color occurred between 20 and 30 years of restoration. While moist farmed soils were oxidized in the A horizon (10YR 2/1), 30 year restored soils were reduced (Gley1 2.5/N).
- While not as prominent or abrupt as in mineral soils, plow layers were identified in farmed wetlands and in 10 and 20 year restorations.
- Soil structure was consistently weak granular over weak subangular blocky for all wetlands.

Mineral Soils

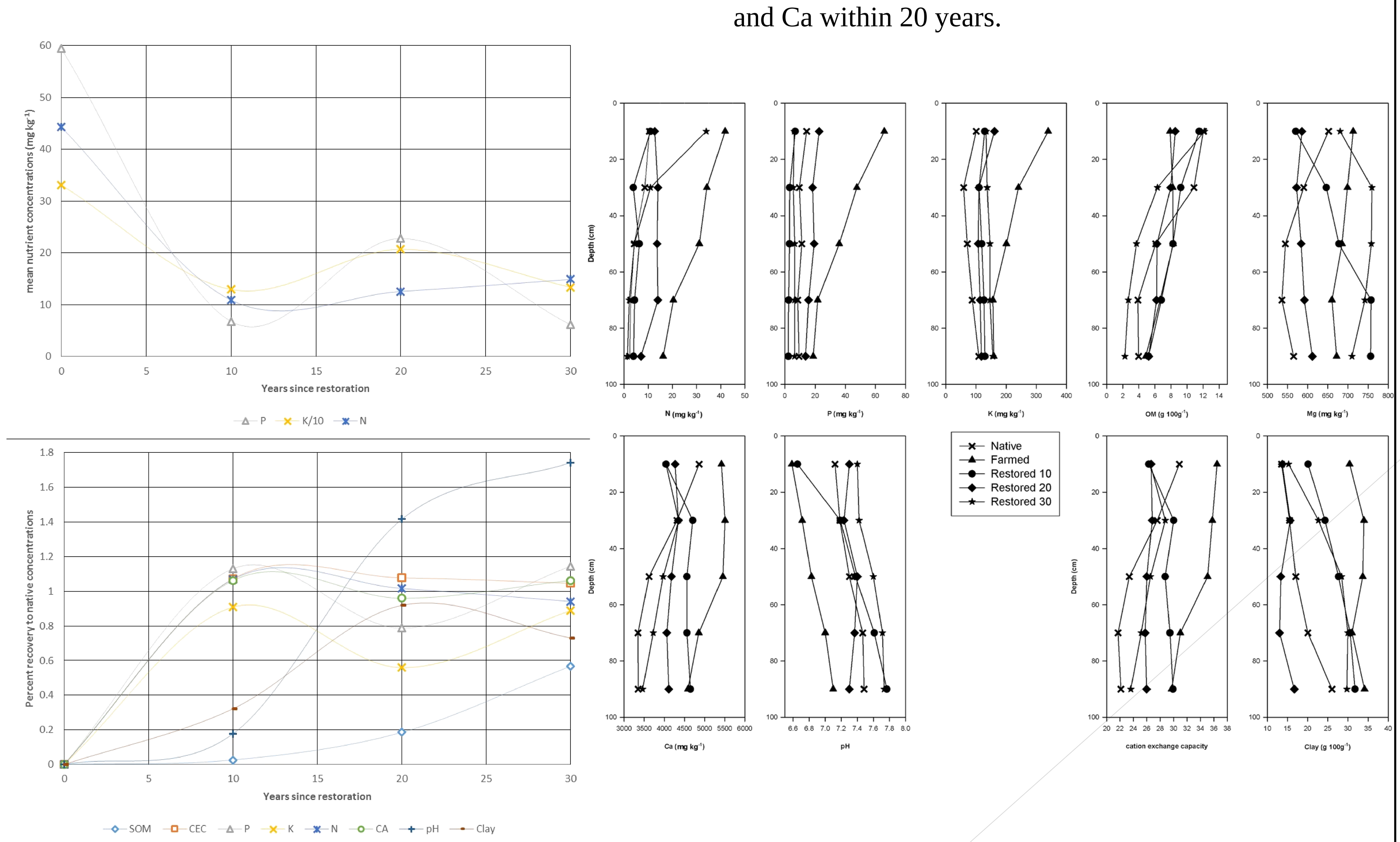
- Moist soil color below the A horizon was gradually darker with each restoration age progressing towards native wetland colors.
- The presence of an abrupt plow layer was evident in farmed wetlands and remained evident until 30 years of restoration.
- As restoration age increased, soil structure became finer, weaker and granular.



Representation of typical organic and mineral soils within each wetland type based on soil profile characterization.

Laboratory Analysis

- From 0-20 cm, N, P and K were similar to native concentrations within 10 years of restoration.
- From 0-20 cm, SOM increased significantly from 10-20 years, but did not reach native concentrations within 30 years.
- From 0-20 cm, clay content decreased with restoration age and was similar to native wetlands within 20 years.
- From 20-40 cm, N, Ca and pH were similar to native wetlands within 10 years while CEC decreased to native concentrations within 20 years.
- From 40-60 cm, Ca and CEC decreased with restoration age and were similar to native wetlands within 20 years while N and pH were similar to native wetlands within 10 years.
- From 60-80 cm and from 80-100 cm, N and pH were similar to native wetlands within 10 years and Ca within 20 years.



Mean nutrient concentrations, percent recovery to native concentrations and profile graphs of nutrient concentrations.

Discussion

- All soil properties that were examined appeared to gradually recover. However, consistent with other restoration studies, rates of restoration were different for various soil properties.
- There were distinct visual differences in soil morphological properties between farmed, restored and native wetlands, including evidence of plow layers, depth of A horizons and gleying, color and structure.
- Soil morphological differences that exist between farmed and native wetlands can be explained by the development of aerobic soil environments due to tile drainage and agricultural tillage.
- Our study provides further evidence that supports short-term restoration of soil macro-nutrients and goes further to provide evidence of more long-term restoration of soil nutrients such as Ca as well as SOM and CEC.
- The variability of clay content within the wetlands appears to be effectively masking changes in CEC that would follow increased SOM, making any conclusions regarding CEC difficult to draw.
- The use of a chronosequence is an effective method to evaluate timeframes of wetland restorations. The ability to collect, describe and analyze long-term soil changes via a short-term study of chronosequences is an efficient, precise and effective method for looking at temporal soil restoration.

Follow up

- Our study is leading us to ask more questions about the time scale for both chemical and physical soil restoration following restoration of formerly drained wetlands.
- Better understanding soil restoration processes will help quantify the success of wetland restoration programs and measure the progress made toward achieving greater soil sustainability.
- Future project sites will include wetland restoration ages of 40 and 50 years to complement the existing data set thereby allowing a larger chronosequence of restoration progress to be assessed.
- Future studies of these wetlands will include larger sample sizes and increased replication.
- To maintain a study with large scale implications for depressional wetland restoration, a variety of farmed wetland management and soil series must be evaluated.

References

Ballantine, K., Schneider, R., 2009. Fifty-five years of soil development in restored freshwater depressional wetlands. Ecological Applications, 19, 1467-1480.
Ewing, J., Vepraskas, M., Broome, S., White, J., 2012. Changes in wetland soil morphological and chemical properties after 15, 20, and 30 years of agricultural production. Geoderma, 179, 73-80.
Gallihugh, J.L., Rogner, J.D., 1998. Wetland mitigation and 404 permit compliance study. US Fish and Wildlife Service.
Schoeneberger, P.J., 2002. Field Book for Describing and Sampling Soils, Version 3. 0. Government Printing Office.
Wilson, R.F., Mitsch, W.J., 1996. Functional assessment of five wetlands constructed to mitigate wetland loss in Ohio, USA. Wetlands, 16, 436-451.
Zedler, J.B., 2000. Progress in wetland restoration ecology. Trends in Ecology & Evolution, 15, 402-407.

*Photos courtesy of USDA Natural Resources Conservation Service and the Iowa Geological Survey.