Carbon sequestration trajectory: Soil carbon pools following stream restoration

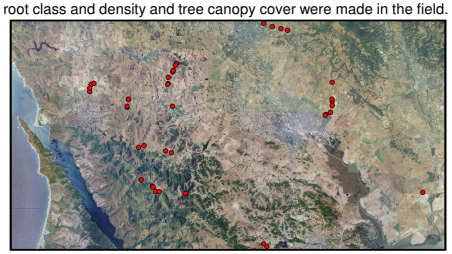
David J. Lewis, Michael Lennox, Anthony O'Geen, Valerie Eviner, Stephanie Larson, John Harper, Morgan Doran, and Kenneth Tate

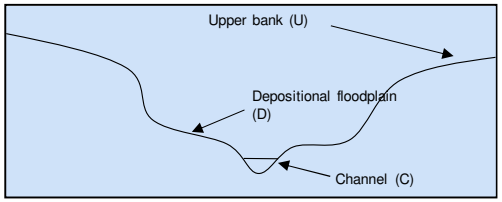
Introduction

Land managers have restored river and stream banks using revegetation technologies with native plant material for over four decades in coastal California, achieving multiple ecosystem functions and natural resource management objectives. The number of river and stream restoration projects in the United States has steadily increased since the 1980s with over $2 billion spent on river restoration in California. In Marin County alone, 25 miles of stream has been restored since the 1960s. Despite the increase in stewardship effort and funds expended, there has been limited documentation of improvements in water quality, watershed functions and ecosystem services such as carbon and nitrogen sequestration and cycling.

Method

We employed a retrospective, cross-sectional study design of 42 previously restored streams. Site selection focused on locations where comparable stream reaches of different project age (years since project implementation) were adjacent to each other with similar soil and stream morphology. Soil sampling at each site was stratified by three landforms: depositional floodplain, upper bank terrace and active channel. For the depositional floodplain and upper bank positions soil sampling was conducted from the surface to a depth of 50 cms and stratified by dominant soil horizons. An additional sample was collected from 50 cms to 100cms using an auger. Soil samples were analyzed for total carbon and nitrogen by direct combustion analyzer. Additionally, a subset of samples were analyzed for labile carbon using a permanganate extraction and recalcitrant soil organic matter using humic and fluvic acids extraction per the Humic Substance Society. Corresponding measurements of bulk density were made by aggregate 3-D laser scanning. Lastly, estimations of root class and density and tree canopy cover were made in the field.





Adobe Creek project site (1950's, left and 2003, above) near Petaluma, CA was planted in the early 1980's.

Results

The 42 studied sites ranged in time since restoration implementation from 0 to 45 years. Preliminary results are summarized by project age classes. Restored steam sites rapidly developed tree canopy within 20 years in both the floodplain and upperbank positions (Fig. 1). Root abundance continued to increase over 40 years (Fig. 2). Results indicate trends in below ground values of total carbon (Fig. 3) and labile (Fig. 4) forms with higher amounts in the upperbank landform and greater magnitude of change over time occurring in floodplain landforms. In contrast, the stable recalcitrant carbon components (Fig. 5) were variable in response to restoration project age. Similarly, total soil nitrogen (not shown) did not indicate a clear trajectory over time in this preliminary analysis.

Further analyses will utilize data driven modeling to compare linear and polynomial relationships with project age as a continuous variable. These final confirmed and published results will be beneficial for conservation and stewardship partnerships to refine and enhance stream revegetation project design and to leverage additional funding support for generated ecosystem services.

Figure 1: Tree Canopy Cover

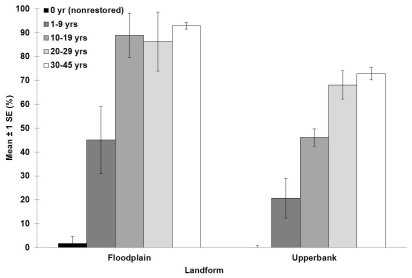


Figure 2: Roots

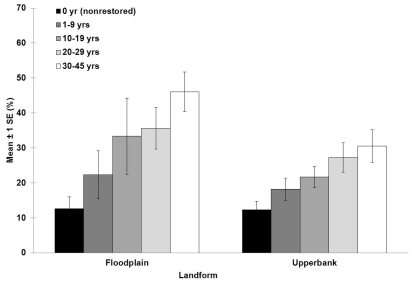


Figure 3: Total Carbon

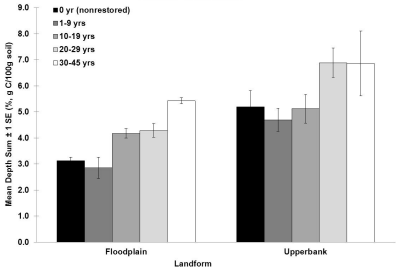


Figure 4: Labile Carbon

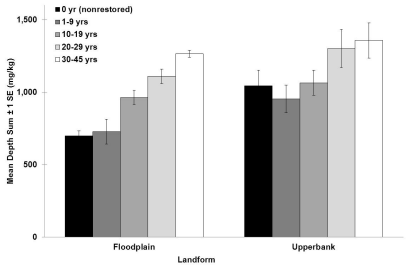
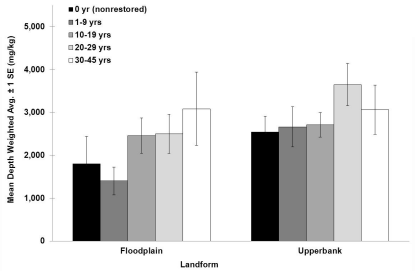


Figure 5: Fulvic Acid



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