# Restoration of wetlands on the Agulhas Plain is unlikely to generate peat

**AUTHORS:**
Anthony Mills[1]
Roland Hunter[2]

**AFFILIATIONS:**
[1]Department of Soil Science, Stellenbosch University, Stellenbosch, South Africa
[2]C4 EcoSolutions, Cape Town, South Africa

**CORRESPONDENCE TO:**
Anthony Mills

**EMAIL:**
mills@sun.ac.za

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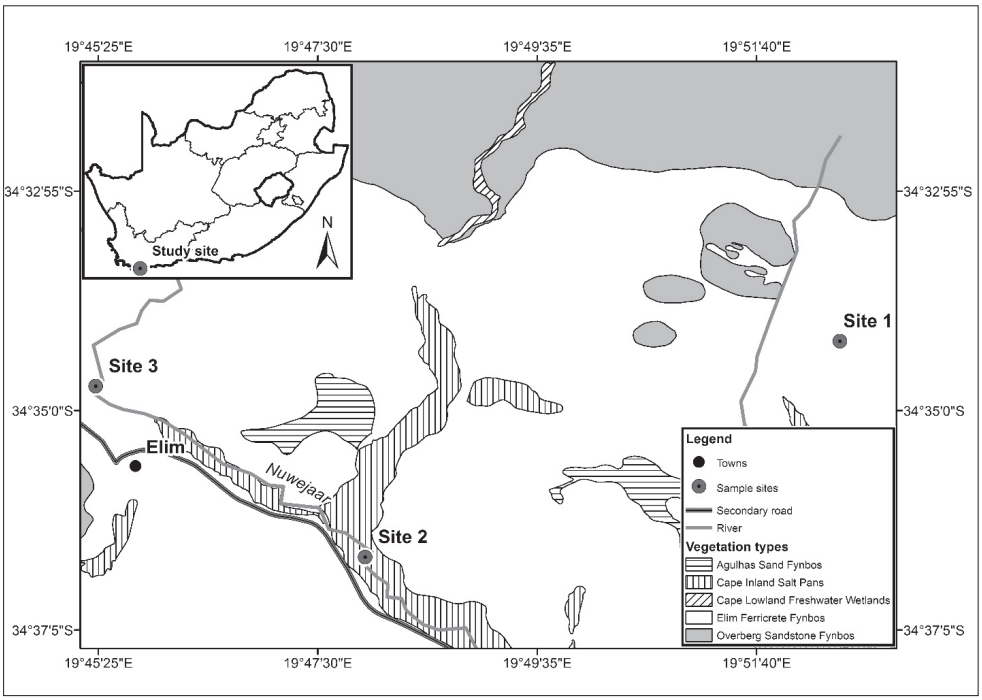
Wetlands in the Nuwejaars Special Management Area (NSMA) on the Agulhas Plain of South Africa are classified as Western Cape Floodplain Wetlands[1] and are characterised by dense stands of palmiet (*Prionium serratum* L.f.)[2-5]. Invasions of alien plants and construction of infrastructure are resulting in considerable degradation of ecosystem services emanating from the wetlands.[3] Large-scale restoration – by removing alien plants and rehydrating soils – is constrained by funding, and consequently new income streams from restored wetland landscapes need to be investigated. One option is to sequester carbon and generate carbon credits during the wetland restoration process.[6] The economic viability of this option largely depends on the amount of carbon that could be sequestered. Previous studies of Western Cape Floodplain Wetlands[1] have found that the carbon content of soils in wetlands with palmiet is surprisingly variable (e.g. ~1.3% in the Kromme River[7] versus ~24% in the Goukou River[8]). In general, however, wetlands in the Western Cape do not usually have a carbon content of more than 10%, possibly because of the rapid decomposition of organic matter during the hot, dry summer months.[9]

In certain parts of the wetlands of the NSMA there are thick (>0.5 m) layers of dark soil. The full geographical extent of these layers is not known, partly because they tend to be buried beneath pale sandy sediments (probably deposited by floodwaters) and are only visible at sites where they have been exposed by erosion. Local landowners refer to the dark soil layers as peat. In the South African context, the term peat is generally used in a colloquial manner, with the term organic soils being favoured in the scientific literature. Organic soil layers in South Africa are defined as those with a mean carbon content of at least 10% throughout a vertical distance of 20 cm.[9,10] To our knowledge, the organic carbon content of the dark soil layers in the NSMA, prior to this study, had not been determined; it was consequently unclear whether they could be classified as organic, which would make the term 'peat' colloquially appropriate.

As a first step towards determining the carbon sequestration potential of the NSMA wetlands and resolving whether the dark soil layers were organic, we determined the organic carbon content of distinct soil layers at three sites with different land use histories: (1) D'Alton Farm (34.57233 S, 19.87432 E); (2) Elim Bridge 1 (34.60651 S, 19.79916 E); and (3) Elim Bridge 2 (34.57946 S, 19.75651 E) (see Figure 1). Site 1 (D'Alton Farm) is located on the bank of the Kastaaings River and has been grazed by domestic livestock for more than 50 years. A dense stand of the alien tree *Acacia longifolia* was present on the site until 2005, when a severe flood caused extensive damage, removing the trees and exposing the dark soil layers. Given this land use history, we categorised this site as extremely degraded. Site 2 (Elim Bridge 1) is situated in the floodplain of the Nuwejaars River, is relatively undisturbed, and has not been eroded. We categorised this site as non-degraded. Site 3 (Elim Bridge 2) has historically been used as a rangeland for cattle and was cleared of invasive species in 2010, with a small amount of erosion occurring thereafter. We categorised this site as moderately degraded.




*Sources: The map is based on data sets from the Municipal Demarcation Board[14] and SANBI[15].*

**Figure 1:** Location of study sites in the Nuwejaars Special Management Area (NSMA), Western Cape, South Africa: Site 1: D'Alton Farm, Site 2: Elim Bridge 1, Site 3: Elim Bridge 2.

In June 2011, 32 soil profiles were cored with an 8.26-cm auger to a depth of 2.4 m: 16 soil profiles at Site 1, 8 at Site 2 and 8 at Site 3. Soil samples were taken from each profile at the following approximate depths: 0.1, 0.25, 0.4, 0.8, 1.2, 1.6, 2.0 and 2.4 m. The samples were subsequently air dried and sieved (<2 mm). Layers encountered during sampling included: (1) a pale surface layer of quartzitic sand above 0.5 m; (2) dark layers of quartzitic sand with distinct, fine pieces of organic matter; (3) pale layers of quartzitic sandstone gravel below 1 m; and (4) a layer of gleyed clay below 2 m.

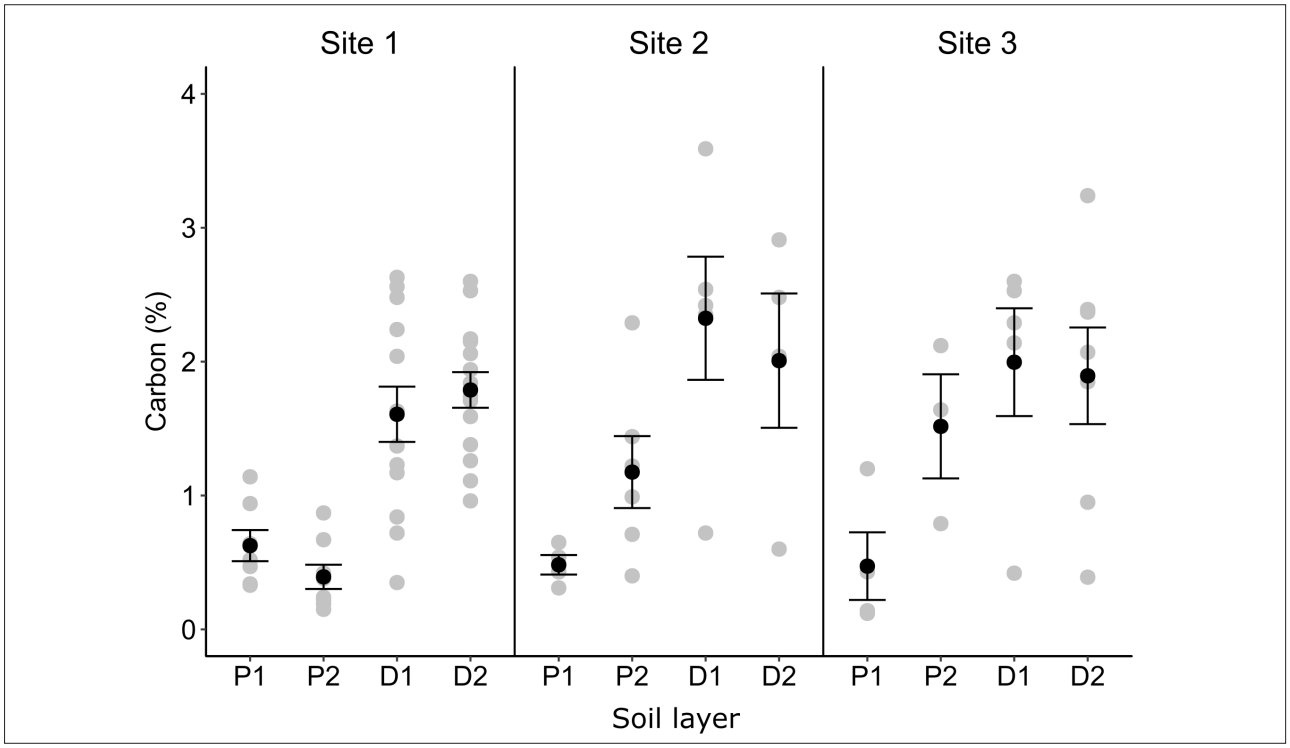
To determine whether dark soil layers were relatively enriched in carbon, samples from dark as well as pale layers (except the gleyed clay layer) were analysed for organic carbon using the Walkley–Black method.[11] Samples of dark soil layers from D'Alton Farm ($n$=12) and the Elim Bridge ($n$=8) sites were also analysed for clay, silt, fine sand, medium sand and coarse sand content.

All statistical analyses were conducted in R.[12] Soil carbon data were analysed for significant differences between site, depth and layer type using mixed-effects models (function lmer; lme4 package). Layers and depth were separately considered as fixed effects, whereas site and replicate were considered random effects. Data were transformed using BoxCox transformation to reach or improve normality prior to analysis. Post-hoc pairwise comparisons were performed using Tukey's test.

Dark soil layers comprised mainly fine and medium sand, with contents of 57.7±2.5% and 21.3±2.4% (mean±SE), respectively. The contents of other size fractions, namely coarse sand, silt and clay contents were 6.4±1.0%, 6.1±0.9% and 8.6±1.4%, respectively. Site-specific percentages are presented in Table 1. Results of the carbon analyses are presented in Figure 2. No significant differences in carbon content of pale or dark layers between the sites were recorded. The mean carbon content of dark layers (1.85±0.1%) across all sites was significantly greater than that of pale layers (0.72±0.1%; $p$<0.001). Shallow (above 0.5 m) layers across all sites had a minor but statistically significant greater amount of carbon than deep (below 0.5 m) layers (1.9±0.1% versus 1.7±0.2% for dark layers; 0.9±0.2% versus 0.6±0.1% for pale layers; $p$<0.001).

**Table 1:** Clay, silt, fine sand, medium sand and coarse sand content (%) of dark soil layers at three study sites in the Nuwejaars Special Management Area, South Africa. Sample size ($n$), means (%), standard deviation (SD), standard error (SE) and confidence intervals (CI) are presented.

| Site | Factor | *n* | Mean (%) | SD | SE | CI |
|---|---|---|---|---|---|---|
| D'Alton Farm | Clay | 12 | 4.0 | 0.5 | 0.1 | 0.3 |
| | Silt | 12 | 3.7 | 3.0 | 0.9 | 1.9 |
| | Fine sand | 12 | 53.4 | 14.1 | 4.1 | 9.0 |
| | Medium sand | 12 | 29.1 | 12.2 | 3.5 | 7.7 |
| | Coarse sand | 12 | 9.8 | 6.4 | 1.9 | 4.1 |
| Elim Bridge 1 | Clay | 8 | 15.3 | 8.0 | 2.8 | 6.7 |
| | Silt | 8 | 11.0 | 3.4 | 1.2 | 2.9 |
| | Fine sand | 8 | 56.1 | 12.2 | 4.3 | 10.2 |
| | Medium sand | 8 | 12.9 | 5.7 | 2.0 | 4.8 |
| | Coarse sand | 8 | 4.7 | 2.0 | 0.7 | 1.7 |
| Elim Bridge 2 | Clay | 8 | 8.8 | 7.8 | 2.7 | 6.5 |
| | Silt | 8 | 4.8 | 3.8 | 1.4 | 3.2 |
| | Fine sand | 8 | 65.8 | 11.1 | 3.9 | 9.3 |
| | Medium sand | 8 | 17.8 | 11.9 | 4.2 | 10.0 |
| | Coarse sand | 8 | 2.8 | 2.9 | 1.0 | 2.4 |




*P1, deep pale layers (*n*=15); P2, shallow pale layers (*n*=17); D1, deep dark layers (*n*=23); D2, shallow dark layers (*n*=25).*

*Individual values are depicted as light grey circles; means and standard errors are depicted as black circles and bars, respectively.*

**Figure 2:** Organic carbon content of shallow (<0.5 m) and deep (>0.5 m) pale and dark soil layers at the three study sites in the Nuwejaars Special Management Area, South Africa.

Methodologies for generating carbon credits in wetlands focus predominantly on peatlands[13] because restoration of degraded peatlands can be expected to sequester large amounts of carbon per unit area. Our preliminary study at three separate sites in the NSMA did not find any evidence of the presence of degraded peatlands. We expected to find differences in carbon content of the dark soil layers between our study sites because of their different physical conditions in terms of degree of erosion and extent of alien plant invasion. However, no such differences were found, which leads to two preliminary conclusions. Firstly, dark soil layers in undegraded sites in the NSMA are not carbon-rich, given that mean carbon content of these layers was less than 2.5% across all sites. And secondly, carbon in the dark layers is relatively resilient to decay, given that organic carbon content was similar in sites with markedly different land use histories. Based on our results, opportunities for generating carbon credits through wetland restoration at our three study sites in the NSMA are likely to be limited. A caveat to this conclusion is that our study only investigated a small part of the NSMA. Further research is warranted to determine whether there are organic soils in other parts of the NSMA and to what extent carbon is lost from them after degradation. Until results of such future studies are available, it is probably prudent to avoid the use of the term peat when describing the dark soil layers in these wetlands.

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