**Supporting Information**

**Combining continuous data on soil properties and land use to explore soil carbon changes and soil structure indicators**

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# Supplementary tables

# SI – 1. SOC stock estimations based on linear models of bulk density

### Table SI 1. Results from the Gaussian Error Propagation analysis concerning uncertainties associated with SOC stock estimations using the two bulk density equations for S1 and S2 samples, respectively.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  | Mean SOC % S1 and S2 | Mean Variance  S1 and S2 | Standard deviation (std) |
| Equation 1 | S1 | 2.57 | 1.15 | 19% |
|  | S2 | 2.64 | 1.04 | 18% |
|  |  |  |  |  |
| Equation 2 | S1 | 2.57 | 1.15 | 19% |
|  | S2 | 2.64 | 1.04 | 18% |

### Table SI 2. Grouped statistics for SOC stock calculations.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | | | | | |
|  |  |  |  |  |  |
| Ley frequency group | SASI group | mean | std | min | max |
| 0% | S1 | 63.6 | 20.0 | 23.3 | 136.8 |
|  | S2 | 65.2 | 21.1 | 27.5 | 166.4 |
| 1-20% | S1 | 64.7 | 23.0 | 6.5 | 136.1 |
|  | S2 | 67.7 | 21.2 | 15.2 | 143.4 |
| 21-40% | S1 | 64.0 | 19.5 | 25.0 | 124.2 |
|  | S2 | 69.0 | 21.6 | 21.7 | 134.5 |
| 41-60% | S1 | 71.0 | 22.9 | 30.9 | 133.9 |
|  | S2 | 74.4 | 23.1 | 23.8 | 137.1 |
| 61-80% | S1 | 73.2 | 22.1 | 22.0 | 132.3 |
|  | S2 | 75.4 | 22.6 | 19.8 | 160.0 |
| 81-100% | S1 | 76.9 | 23.3 | 23.3 | 136.8 |
|  | S2 | 81.4 | 22.7 | 34.0 | 143.9 |

# SI – 2. Impact factors for soil organic carbon

### Table SI 3. Table with results from the Regression analysis on the field dataset. Eq 1 shows the regression analysis for SOC as the dependent variable. Bold value is the Intercept of the equation, and predictors in cursive and bold are statistically significant. Below the equations, additional regression for the two dependent variables is found. VIF = Variance Inflation Factor

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Dependent | | **Intercept** |  |  | ***Statistically Significant Predictors in cursive and bold*** | | |  | |
|  | ***Eq 1*** | | | | | |  |  | |
|  | SOC (S2) = **0.8512 + *0.0575\*Ley Frequency + 8.46\*N -0.011\*Clay*** | | | | | | R2 0.47 | RMSE 0.69 | |
| **SOC**  **Regression statistics** | | |  | **VIF** | | **Shapiro Wilks** | | |
| R^2: 0.47 | |  |  | Ley Frequency = 1.61 | | Statistic = 0.94 | | |
| F-statistic: 506.79 | | |  | Nitrogen = 3.86 | | p-value = 0.00 | | |
| Degrees of Freedom: 3.0, 1607 | | | | Clay = 3.37 | |  | | |
| p-value (F-statistic): 0.0000 | | |  |  | |  | | |

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### Figure SI 1. Histogram of residuals of SOC samples. This figure displays the histogram of residuals from the linear regression model, overlaid with a kernel density estimate to illustrate the distribution's shape

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### Figure SI 2. Quantile-Quantile (Q-Q) plot of Residuals of SOC samples. The QQ plot of the residuals against a theoretical normal distribution, with the 45-degree reference line indicating perfect normality.

# SI – 3. Region-specific information about SOC/clay ratio and soil texture

### Table SI 5. Average clay content and carbon value for each production region, subcategorized into soil structure quality classes.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Number of Fields** |  | **Share (% of number)** | **Clay %** | **Carbon % DM** |
| **Production region (PR)** | **Soil structure quality** | **DM** | **Average** |
|  |  | **Average** |  |
| **PR 1** |  |  |  |  |
| 107 | Very Good | 52% | 12.4 | 2.7 |
| 32 | Good | 15% | 15.6 | 1.7 |
| 40 | Suggested Improvement | 19% | 22.4 | 1.9 |
| 28 | Poor | 14% | 27.3 | 1.8 |
| **PR 2** |  |  |  |  |
| 144 | Very Good | 75% | 10.3 | 2.7 |
| 15 | Good | 8% | 18.9 | 2.1 |
| 25 | Suggested Improvement | 13% | 20.5 | 1.8 |
| 9 | Poor | 5% | 31.3 | 1.9 |
| **PR 3** |  |  |  |  |
| 116 | Very Good | 35% | 13.9 | 3.0 |
| 29 | Good | 9% | 22.9 | 2.5 |
| 53 | Suggested Improvement | 16% | 32.7 | 2.8 |
| 137 | Poor | 41% | 41.7 | 2.2 |
| **PR 4** |  |  |  |  |
| 58 | Very Good | 16% | 16.0 | 3.0 |
| 21 | Good | 6% | 31.7 | 3.5 |
| 58 | Suggested Improvement | 16% | 32.4 | 2.8 |
| 227 | Poor | 62% | 43.1 | 2.3 |
| **PR 5** |  |  |  |  |
| 199 | Very Good | 78% | 9.3 | 3.2 |
| 22 | Good | 9% | 28.4 | 3.1 |
| 18 | Suggested Improvement | 7% | 29.8 | 2.6 |
| 17 | Poor | 7% | 48.3 | 3.0 |
| **PR 6** |  |  |  |  |
| 68 | Very Good | 58% | 12.8 | 2.9 |
| 14 | Good | 12% | 27.9 | 3.1 |
| 14 | Suggested Improvement | 12% | 27.6 | 2.5 |
| 22 | Poor | 19% | 39.1 | 2.1 |
| **PR 7** |  |  |  |  |
| 65 | Very Good | 77% | 17.2 | 3.6 |
| 11 | Good | 13% | 27.8 | 3.2 |
| 5 | Suggested Improvement | 6% | 31.4 | 3.0 |
| 3 | Poor | 4% | 34.0 | 2.4 |
| **PR 8** |  |  |  |  |
| 47 | Very Good | 94% | 7.8 | 3.1 |
| 2 | Good | 4% | 20.5 | 2.3 |
| 1 | Suggested Improvement | 2% | 15.0 | 1.3 |

### Table SI 6. Significance of changes in SOC between S1 and S2 based on Wilcoxon non-parametrical test (95% confidence interval) for the eight production regions (P08) and the Ley Frequency groups. Bold values = statistically significant (p<0.05).

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| P08 | Total samples | 1 | 2 | S | 4 | 5 | 6 | 7 | 8 |
| *P value* | **0.0064** | **0.01** | **0.037** | **4e-06** | **0.0034** | 0.0648 | **0.002** | 0.40 | 0.79 |

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Ley Frequency groups | Total Samples | 0% | 1-20 % | 21-40% | 41-60% | 61-80% | 81-100% |
| *P value* | **4e-05** | **8e-05** | 0.057 | **8e-05** | **4e-05** | **0.022** | **0.0011** |

# Supplementary figures

# SI – 4. Historical land use for P08 4 and 5

### Figure SI 3. Historical land use of two production regions - P04 and P05. Relative values of Perennial ley and Cereal production in the regions over time - 1960 to 2021.

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# SI – 5. Changes in winter wheat cultivation and production

Winter wheat cultivation area is increasing in Sweden at the expense of summer cereals, foremost oat. Between S1 and S2, winter wheat cultivation areas increased by roughly 6.2% in Sweden on average, with a higher increase in the three southern production regions (PR 1-3). A difficult and rainy autumn in 2012 resulted in a very low establishment of winter wheat in PR 4, causing a modest area increase. PR 1, PR 3, and PR 4 stand for over 80 % of the total acreage of winter wheat. (Jordbruksverket, 2023)

### Figure SI 4. Changes in winter wheat cultivation (hectares) between S1 (black) and S2 (grey)

Average winter wheat yield increased by close to 12 % between S1 and S2 (Swedish average). The increase was more accentuated in the southern production regions (PR 1-3). As noted above, difficult weather conditions during the 2012/2013 season resulted in a small increase (4%) in PR 4 (Jordbruksverket, 2023)

### Figure SI 5 Changes in winter wheat yields (hectares) between S1 (black) and S2 (grey)

Jordbruksverket. (2023). Jordbruksverkets statistikdatabas. <https://statistik.sjv.se/PXWeb/pxweb/sv/Jordbruksverkets%20statistikdatabas/?rxid=5adf4929-f548-4f27-9bc9-78e127837625> Access June 2023.

# SI – 6. Code availability for statistics

In the Method section, several different statistical analyses were used.

These are all collected in an open repository on GitHub.

**Link below to Repository on Github**

<https://github.com/Karlstefanrehn/statistics_SASI/tree/main>

Code availability on method development and spatial operations are available on request.

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