

## **SUPPLEMENTARY INFORMATION**

# **Temperate Silvopastures Provide Greater Ecosystem Services than Conventional Pasture Systems**

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**Supplementary Figure 1. Schematic representation of silvopasture and conventional pasture systems.** Silvopasture (left) and conventional pasture (right) systems located at the University of Arkansas Agricultural Research and Extension Center in Fayetteville, AR. Symbols identify tree rows, and polygons identify grass species planted in tree alleys. Silvopasture and conventional pasture alleys include orchardgrass and a native warm-season grass mix. Dashed polygons identify alleys that received poultry litter ( $84 \text{ kg N ha}^{-1}$ ) between 2017 and 2019. Aerial image obtained from Google Earth.

**Supplementary Table 1. Analysis of variance summary of effects of system (silvopasture and conventional pasture), time (2020, 2021, and 2022), and their interactions on selected Mehlich-3 soil properties at the 0-15 cm soil depth of the silvopasture and conventional pasture systems in Fayetteville, AR ( $n = 15$ ).**

| Source of variation  | Soil properties† |      |       |      |      |       |      |      |      |       |
|----------------------|------------------|------|-------|------|------|-------|------|------|------|-------|
|                      | SOC              | N    | C:N   | pH   | EC   | Ca    | Mg   | K    | P    | S     |
| System               | 0.02             | 0.40 | <0.00 | 0.01 | 0.05 | <0.00 | 0.45 | 0.02 | 0.89 | 0.689 |
|                      | 77               | 12   | 01    | 30   | 55   | 01    | 36   | 07   | 32   | 6     |
| Time                 | 0.89             | 0.03 | <0.00 | 0.00 | 0.30 | 0.093 | 0.01 | 0.31 | 0.04 | <0.00 |
|                      | 61               | 90   | 01    | 57   | 52   | 2     | 24   | 72   | 04   | 01    |
| System $\times$ Time | 0.80             | 0.97 | 0.029 | 0.23 | 0.50 | 0.371 | 0.16 | 0.63 | 0.12 | 0.928 |
|                      | 12               | 73   | 0     | 83   | 71   | 9     | 51   | 96   | 44   | 6     |

† SOC, soil organic C; C:N, carbon-to-nitrogen ratio; EC, electrical conductivity.

**Supplementary Table 2. Mean values  $\pm$  standard errors for C and N contents, C:N ratios, acid- (ADF) and neutral detergent fiber (NDF), lignin, crude protein (CP), and ash contents (% , except for C:N ratios) in forage samples [cool-season orchardgrass (OG) and native warm-season mix (NG)], collected in four sampling dates (May 31, June 9, June 16, and June 27, 2022) in silvopasture and conventional pasture systems in Fayetteville, AR ( $n = 3-11$ ).**

| System       | Forage species <sup>†</sup> | Forage composition <sup>‡</sup> |                   |                    |                    |                    |                    |                   |                 |
|--------------|-----------------------------|---------------------------------|-------------------|--------------------|--------------------|--------------------|--------------------|-------------------|-----------------|
|              |                             | C                               | N                 | C:N ratio          | ADF                | NDF                | Lignin             | CP                | Ash             |
| May 31       |                             |                                 |                   |                    |                    |                    |                    |                   |                 |
| Silvopasture | OG                          | 42.9 $\pm$ 0.2 a <sup>¶</sup>   | 1.6 $\pm$ 0.1 bc  | 27.5 $\pm$ 1.2 ef  | 36.8 $\pm$ 0.7 fg  | 63.8 $\pm$ 1.0 c-g | 5.9 $\pm$ 0.8 f    | 10.1 $\pm$ 0.4 bc | 1.5 $\pm$ 0.2 a |
|              | NG                          | 42.9 $\pm$ 0.2 a                | 1.9 $\pm$ 0.1 a   | 22.6 $\pm$ 1.2 g   | 38.4 $\pm$ 0.7 ef  | 64.2 $\pm$ 1.0 b-e | 6.5 $\pm$ 0.8 ef   | 12.3 $\pm$ 0.4 a  | 1.9 $\pm$ 0.2 a |
| Pasture      | OG                          | 43.6 $\pm$ 0.2 a                | 1.6 $\pm$ 0.1 bc  | 28.4 $\pm$ 1.2 def | 35.9 $\pm$ 0.7 g   | 62.1 $\pm$ 1.0 e-h | 11.0 $\pm$ 0.8 abc | 9.9 $\pm$ 0.4 bc  | 1.1 $\pm$ 0.2 a |
|              | NG                          | 43.9 $\pm$ 0.2 a                | 1.7 $\pm$ 0.1 b   | 26.3 $\pm$ 1.2 f   | 30.1 $\pm$ 0.7 h   | 63.1 $\pm$ 1.0 e-h | 6.7 $\pm$ 0.8 ef   | 10.7 $\pm$ 0.4 b  | 1.1 $\pm$ 0.2 a |
| June 9       |                             |                                 |                   |                    |                    |                    |                    |                   |                 |
| Silvopasture | OG                          | 42.1 $\pm$ 0.2 a                | 1.6 $\pm$ 0.1 c   | 27.9 $\pm$ 1.2 ef  | 38.6 $\pm$ 0.7 ef  | 62.9 $\pm$ 1.0 e-h | 9.7 $\pm$ 0.8 bcd  | 9.7 $\pm$ 0.4 c   | 1.4 $\pm$ 0.2 a |
|              | NG                          | 42.4 $\pm$ 0.2 a                | 1.3 $\pm$ 0.1 e-h | 32.7 $\pm$ 1.2 abc | 39.2 $\pm$ 0.7 de  | 61.3 $\pm$ 1.0 fgh | 8.2 $\pm$ 0.8 de   | 8.4 $\pm$ 0.4 e-h | 1.6 $\pm$ 0.2 a |
| Pasture      | OG                          | 43.3 $\pm$ 0.2 a                | 1.5 $\pm$ 0.1 c-f | 30.1 $\pm$ 1.2 b-e | 37.5 $\pm$ 0.7 efg | 62.0 $\pm$ 1.0 e-h | 10.2 $\pm$ 0.8 bcd | 9.1 $\pm$ 0.4 c-f | 2.8 $\pm$ 0.2 a |
|              | NG                          | 42.6 $\pm$ 0.2 a                | 1.5 $\pm$ 0.1 c-g | 30.1 $\pm$ 1.2 b-e | 38.8 $\pm$ 0.7 e   | 60.5 $\pm$ 1.0 h   | 12.9 $\pm$ 0.8 a   | 9.1 $\pm$ 0.4 c-g | 2.4 $\pm$ 0.2 a |
| June 16      |                             |                                 |                   |                    |                    |                    |                    |                   |                 |
| Silvopasture | OG                          | 42.7 $\pm$ 0.2 a                | 1.5 $\pm$ 0.1 cde | 29.5 $\pm$ 1.2 c-f | 40.9 $\pm$ 0.7 cd  | 66.4 $\pm$ 1.0 abc | 11.4 $\pm$ 0.8 ab  | 9.3 $\pm$ 0.4 cde | 1.6 $\pm$ 0.2 a |

|                |    |                 |                      |                       |                   |                       |                      |                      |                |
|----------------|----|-----------------|----------------------|-----------------------|-------------------|-----------------------|----------------------|----------------------|----------------|
| Pasture        | NG | 43.1 ±<br>0.2 a | 1.3 ±<br>0.1<br>fgh  | 34.2 ±<br>1.2 a       | 43.8 ±<br>0.7 a   | 68.1 ±<br>1.0 a       | 9.8 ±<br>0.8<br>bcd  | 8.1 ±<br>0.4<br>fgh  | 1.2 ±<br>0.2 a |
|                | OG | 43.0 ±<br>0.2 a | 1.3 ±<br>0.1<br>fgh  | 33.2 ±<br>1.2 ab      | 41.3 ±<br>0.7 bc  | 63.8 ±<br>1.0 b-<br>g | 8.9 ±<br>0.8 cd      | 8.2 ±<br>0.4<br>fgh  | 1.1 ±<br>0.2 a |
|                | NG | 43.1 ±<br>0.2 a | 1.4 ±<br>0.1 d-<br>h | 31.8 ±<br>1.2 a-<br>d | 40.7 ±<br>0.7 cd  | 64.1 ±<br>1.0 b-f     | 10.1 ±<br>0.8<br>bcd | 8.6 ±<br>0.4 d-<br>h | 0.9 ±<br>0.2 a |
| June 27        |    |                 |                      |                       |                   |                       |                      |                      |                |
| Silvopasture   | OG | 42.4 ±<br>0.2 a | 1.3 ±<br>0.1<br>fgh  | 33.4 ±<br>1.2 ab      | 42.8 ±<br>0.7 ab  | 66.7 ±<br>1.0 ab      | 11.9 ±<br>0.8 ab     | 8.1 ±<br>1.5<br>fgh  | 1.6 ±<br>0.2 a |
|                | NG | 42.1 ±<br>0.2 a | 1.5 ±<br>0.1 cd      | 28.9 ±<br>1.2<br>def  | 41.1 ±<br>0.7 bcd | 63.3 ±<br>1.0 d-<br>h | 11.6 ±<br>0.8 ab     | 9.5 ±<br>0.4 cd      | 0.9 ±<br>0.2 a |
| Pasture        | OG | 42.5 ±<br>0.2 a | 1.3 ±<br>0.1 gh      | 34.4 ±<br>1.2 a       | 41.6 ±<br>0.7 bc  | 61.2 ±<br>1.0 gh      | 11.7 ±<br>0.8 ab     | 8.1 ±<br>0.4 gh      | 1.1 ±<br>0.2 a |
|                | NG | 42.5 ±<br>0.2 a | 1.2 ±<br>0.1 h       | 35.2 ±<br>1.2 a       | 41.2 ±<br>0.7 bc  | 66.1 ±<br>1.0 a-<br>d | 10.7 ±<br>0.8 bc     | 7.6 ±<br>0.4 h       | 1.0 ±<br>0.2 a |
| <i>p-value</i> |    | 0.131           | 0.001                | 0.002                 | <0.000            | 0.003                 | 0.000                | 0.001                | 0.124          |
|                |    | 0               | 2                    | 1                     | 1                 | 9                     | 3                    | 2                    | 2              |

† OG, orchardgrass; NG, native warm-season mix;

‡ ADF and NDF, acid- and neutral detergent fiber; CP, crude protein;

¶ Means followed by the same letter within a column do not differ ( $p < 0.05$ ).

**Supplementary Table 3. SMAF algorithms and site-specific factors used to calculate individual and overall soil quality indices based on soil properties collected at the 0-15 cm soil depth in the silvopasture and conventional pasture systems in Fayetteville, AR, in 2022**

| Indicator† | Algorithm                                                                                                                                                                                                               | Constant                                  | Site-specific factors                                                                                                                              |
|------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------|
| SOC        | $y = a/[1 + b \times \exp(-c \times \text{SOC})]$                                                                                                                                                                       | $a = 1.0; b = 50.1$                       | $c = f$ (organic matter class “4” – low, texture class “3” – silt loam, climate class “3” – $\leq 170$ °C d and $\geq 550$ mm)                     |
| BD         | $y = a - b \times \exp(-c \times \text{BD}^d)$                                                                                                                                                                          | $a = 0.994$                               | $b, c, d = f$ (texture class “3” – silt loam, mineralogy class “3” – other than smectite and glassy)                                               |
| pH         | $y = a \times \exp[-(\text{pH} - b)^2/(2c^2)]$                                                                                                                                                                          | $a = 1.0$                                 | $b, c = f$ (crop code “3” – tall fescue)                                                                                                           |
| EC         | If $\text{EC}_{\text{sat}} \leq 0.3$ , then $y = 3.33 \times \text{EC}_{\text{sat}}$ ;<br>if $0.3 < \text{EC}_{\text{sat}} < T$ , then $y = 1$ ;<br>if $\text{EC}_{\text{sat}} > T$ , then $y = m \times \text{EC} + b$ |                                           | $T^b, b, m = f$ (crop code “3”, texture class “3”)                                                                                                 |
| P          | If $P \leq \max$ (for crop and method), then $y = (ab+c \times P^d)/(b + P^d)$ ; if $P > \max$ (for slope and method), then $y = a - b \times \exp(-c \times P^d)$ , and $y = 1$                                        | $a = 9.26 \times 10^6; c = 1.0; d = 3.06$ | $b = f$ (crop code “3”, TOC content, texture class “3”, method “2” – Mehlich 3, slope class “2” – 2-5%, weathering class “3” – slightly weathered) |
| K          | $y = a[1 - \exp(-b \times K)]$                                                                                                                                                                                          | $a = 1.05; b = -0.0098$                   | $a, b = f$ (crop code “3”, texture class “3”)                                                                                                      |

† SOC, soil organic C; BD, bulk density; EC, electrical conductivity; Tb, crop-specific threshold beyond which yield decreases are expected to occur.