**SUPPLEMENTARY MATERIAL FOR “**Soil nitrogen availability indirectly modifies leaf nitrogen content through reductions in the unit cost of resource use”

*Calculations for soil water holding capacity*

Water holding capacity (θWHC; mm) was calculated as a function of the volumetric soil water storage at field capacity, *W*PWP (m3 m-3), and the volumetric soil water storage at wilting point:

(S1)

where *W*FC (m3 m-3) is the volumetric soil water storage at field capacity, *W*PWP (m3 m-3) is the volumetric soil water storage at wilting point, *f*gravel (%) is the fraction of gravel content in soil, *z*bedrock (mm) is the distance to bedrock, and *z*max (mm) is the maximum allowable distance to bedrock, set to 2000mm. *W*FC is calculated as:

(S2)

where

(S3)

*W*PWP is calculated as:

(S4)

where

(S5)

In Equations (S3) and (S5), *f*sand (%) is the fraction of sand content in soil (%), *f*clay (%) is the fraction of clay content in soil (%), and *f*OM is the fraction of organic matter in soil (%)

**Table S1** List of sampled species, including the NRCS symbol, photosynthetic pathway, growth duration, growth habit, N fixation capability, assigned plant functional group, and the number of collected individuals

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Symbol** | **Species** | **Photosynthetic pathway** | **Growth duration** | **Growth habit** | **N-fixer?** | **Plant functional group** | **Number sampled** |
| ACAN11 | *Acaciella angustissima* (Mill) Britton & Rose | c3 | perennial | forb, subshrub | yes | c3\_legume | 3 |
| AMAR2 | *Ambrosia artemisiifolia* L. | c3 | annual | forb | no | c3\_nonlegume | 25 |
| AMPS | *Ambrosia psilostachya* DC. | c3 | perennial | forb | no | c3\_nonlegume | 32 |
| ARAL3 | *Argemone albiflora* Hornem. | c3 | annual | forb | no | c3\_nonlegume | 3 |
| ARPU9 | *Aristida purpurea* Nutt. | c4 | perennial | graminoid | no | c4\_nonlegume | 2 |
| ASAS | *Asclepias asperula* (Decne.) Woodson | c3 | perennial | forb | no | c3\_nonlegume | 3 |
| ASLA4 | *Asclepias latifolia* (Torr.) Raf. | c3 | perennial | forb | no | c3\_nonlegume | 3 |
| ASSY | *Asclepias syriaca* L. | c3 | perennial | forb | no | c3\_nonlegume | 18 |
| BASA | *Baccharis salicina* Torr. & A. Gray | c3 | perennial | shrub | no | c3\_nonlegume | 3 |
| BOIS | *Bothriochloa ischaemum* (L.) Keng | c4 | perennial | graminoid | no | c4\_nonlegume | 6 |
| BOSA | *Bothriochloa saccharoides* (Sw.) Rydb. | c4 | perennial | graminoid | no | c4\_nonlegume | 6 |
| CAAM2 | *Callicarpa americana* L. | c3 | perennial | shrub | no | c3\_nonlegume | 3 |
| CAPL3 | *Carex planostachys* Kunze | c4 | perennial | graminoid | no | c4\_nonlegume | 3 |
| CAREX | *Carex spp.* L. | c4 | perennial | graminoid | no | c4\_nonlegume | 16 |
| CHFE3 | *Chamaesyce fendleri* (Torr. & A. Gray) Small | c3 | perennial | forb | no | c3\_nonlegume | 2 |
| CHPI8 | *Chyrysopsis pilosa* Nutt. | c3 | annual | forb | no | c3\_nonlegume | 3 |
| COCO13 | *Conoclinium coelestinum* (L.) DC. | c3 | perennial | forb | no | c3\_nonlegume | 3 |
| COER | *Commelina erecta* L. | c3 | perennial | forb | no | c3\_nonlegume | 3 |
| CRGLL | *Croton glandulosus* L. | c3 | annual | forb | no | c3\_nonlegume | 22 |
| CYDA | *Cynodon dactylon* (L.) Pers. | c4 | perennial | graminoid | no | c4\_nonlegume | 15 |
| DATE3 | *Dasylirion texanum* Scheele | c3 | perennial | shrub | no | c3\_nonlegume | 3 |
| DIAN | *Dichanthium annulatum* (Forssk.) Stapf | c4 | perennial | graminoid | no | c4\_nonlegume | 8 |
| ENPE4 | *Engelmannia peristenia* (Raf.) Goodman & C.A. Lawson | c3 | perennial | forb | no | c3\_nonlegume | 6 |

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| --- | --- | --- | --- | --- | --- | --- | --- |
| **Symbol** | **Species** | **Photosynthetic pathway** | **Growth duration** | **Growth habit** | **N-fixer?** | **Plant functional group** | **Number sampled** |
| EUMA8 | *Euphorbia marginata* Pursh | c3 | annual | forb | no | c3\_nonlegume | 6 |
| GAPU | *Gaillardia pulchella* Foug. | c3 | annual | forb | no | c3\_nonlegume | 16 |
| GLGO | *Glandularia gooddingii* (Briq.) Solbrig | c3 | perennial | forb | no | c3\_nonlegume | 2 |
| HEAN3 | *Helianthus annuus* L. | c3 | annual | forb | no | c3\_nonlegume | 6 |
| HECA8 | *Heterotheca canescens* (DC.) Shinners | c3 | perennial | forb | no | c3\_nonlegume | 2 |
| HETE3 | *Heliotropium tenellum* (Nutt.) Torr | c3 | annual | forb | no | c3\_nonlegume | 3 |
| IVAX | *Iva axillaris* Pursh | c3 | perennial | forb | no | c3\_nonlegume | 4 |
| LIAT | *Lilaeopsis attenuata* auct. non (Hook. & Arn.) Fernald | c3 | perennial | forb | no | c3\_nonlegume | 3 |
| LIPU | *Liatris punctata* Hook. | c3 | perennial | forb | no | c3\_nonlegume | 3 |
| LOPE | *Lolium perenne* L. | c3 | perennial | graminoid | no | c3\_nonlegume | 9 |
| MIQU2 | *Mimosa quadrivalvis* L. | c3 | perennial | forb | yes | c3\_legume | 15 |
| NALE3 | *Nassella leucotricha* (Trin. & Rupr.) Pohl | c3 | perennial | graminoid | no | c3\_nonlegume | 19 |
| OECU2 | *Oenothera curtiflora* W.L. Wagner & Hoch | c3 | annual | forb | no | c3\_nonlegume | 3 |
| OENOT | *Oenothera spp.* L. | c3 | annual | forb | no | c3\_nonlegume | 1 |
| PAVI2 | *Panicum virgatum* L. | c4 | perennial | graminoid | no | c4\_nonlegume | 12 |
| PRGL2 | *Prosopis glandulosa* Torr. | c3 | perennial | shrub | yes | c3\_legume | 33 |
| QUHA3 | *Quercus harvardii* Rydb. | c3 | perennial | shrub | no | c3\_nonlegume | 3 |
| QUMO | *Quercus mohriana* Buckley ex Rydb. | c3 | perennial | shrub | no | c3\_nonlegume | 1 |
| RACO3 | *Ratibida columnifera* (Nutt) Wooton & Standl. | c3 | perennial | forb | no | c3\_nonlegume | 40 |
| RHAM | *Rhamnus spp.* L. | c3 | perennial | shrub | yes | c3\_legume | 1 |
| RHSET | *Rhynchosia senna* Gillies ex Hook. var. *texana* (Torr. & A. Gray) M.C. Johnst. | c3 | perennial | forb | yes | c3\_legume | 1 |
| RUHI2 | *Rudbeckia hirta* L. | c3 | perennial | forb | no | c3\_nonlegume | 3 |
| RUNU | *Ruellia nudiflora* (Engelm. & A. Gray) Urb. | c3 | perennial | forb | no | c3\_nonlegume | 15 |
| RUTR | *Rubus trivialis* Michx. | c3 | perennial | vine | no | c3\_nonlegume | 3 |

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| --- | --- | --- | --- | --- | --- | --- | --- |
| **Symbol** | **Species** | **Photosynthetic pathway** | **Growth duration** | **Growth habit** | **N-fixer?** | **Plant functional group** | **Number sampled** |
| SAFA2 | *Salvia farinacea* Benth. | c3 | perennial | forb | no | c3\_nonlegume | 7 |
| SCHIZ4 | *Schizachyrium spp.* Nees | c4 | perennial | graminoid | no | c4\_nonlegume | 8 |
| SCSC | *Schizachyrium scoparium* (Michx.) Nash | c4 | perennial | graminoid | no | c4\_nonlegume | 3 |
| SODI | *Solanum dimidiatum* Raf. | c3 | perennial | forb | no | c3\_nonlegume | 1 |
| SOEL | *Solanum elaeagnifolium* Cav. | c3 | perennial | forb | no | c3\_nonlegume | 53 |
| SOHA | *Sorghum halapense* (L.) Pers. | c4 | perennial | graminoid | no | c4\_nonlegume | 38 |
| STTE3 | *Stillingia texana* I.M. Johnst. | c3 | perennial | forb | no | c3\_nonlegume | 3 |
| VEOC | *Verbesina occidentalis* (L.) Walter | c3 | perennial | forb | no | c3\_nonlegume | 3 |
| VEST | *Verbena stricta* Vent. | c3 | perennial | forb | no | c3\_nonlegume | 3 |
| WEAC | *Wedelia acapulcensis* Kunth | c3 | perennial | shrub | no | c3\_nonlegume | 6 |

**Table S1** Model selection results for soil moisture, air temperature, and vapor pressure deficit. Soil moisture was used in a bivariate regression against *β*, while air temperature and vapor pressure deficit were used in bivariate regressions against *χ*\*

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **Soil moisture** | | **Air temperature** | | **VPD** | |
| Day | AICc | RMSE | AICc | RMSE | AICc | RMSE |
| 1 | 1312.84 | 0.7999 | -909.96 | 0.0729 | -904.93 | 0.0734 |
| 2 | 1310.55 | 0.7979 | -914.07 | 0.0726 | -903.51 | 0.0734 |
| 3 | **1310.18** | **0.7975** | -912.35 | 0.0728 | -902.52 | 0.0735 |
| 4 | 1310.78 | 0.7981 | **-914.12** | **0.0729** | **-917.85** | **0.0725** |
| 5 | 1312.02 | 0.7992 | -907.99 | 0.0732 | -903.73 | 0.0734 |
| 6 | 1312.63 | 0.7999 | -907.08 | 0.0732 | -903.77 | 0.0734 |
| 7 | 1313.32 | 0.8004 | -906.08 | 0.0733 | -903.31 | 0.0734 |
| 8 | 1314.08 | 0.8011 | -904.44 | 0.0734 | -902.98 | 0.0734 |
| 9 | 1315.28 | 0.8022 | -903.85 | 0.0735 | -902.37 | 0.0735 |
| 10 | 1316.83 | 0.8037 | -903.44 | 0.0735 | -902.06 | 0.0735 |
| 15 | 1322.23 | 0.8092 | -904.28 | 0.0734 | -901.59 | 0.0736 |
| 20 | 1328.06 | 0.8151 | -904.63 | 0.0734 | -902.75 | 0.0735 |
| 30 | 1332.72 | 0.8200 | -904.02 | 0.0735 | -905.25 | 0.0733 |
| 60 | 1333.62 | 0.8219 | -904.09 | 0.0734 | -908.17 | 0.0731 |
| 90 | 1333.47 | 0.8219 | -903.88 | 0.0735 | -908.97 | 0.0731 |

\*Timescale that conferred lowest AICc value is indicated in bold.

**Figure S1**

**Chart

Description automatically generated**

**Fig. S1** Correlation matrix indicating comparisons between all measured edaphic variables from composite soil samples. Colored boxes and numbers indicate the magnitude and direction of Pearson’s correlation coefficient.

**Figure S2**

Chart, line chart

Description automatically generated

**Fig. S2** Model selection results exploring relevant timescales for soil moisture (left panel), air temperature (middle panel), and vapor pressure deficit (right panel). The x-axis indicates the number of days before each site visit and the y-axis notes the corrected Akaike Information Criterion value. The timescale with the lowest AICc value, and therefore most relevant timescale to include in statistical models, is noted as a red point.