# Tables and figures

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# Table 1 Selected soil chemical (0-10 cm depth) and vegetation properties of fertilization treatments at EARTH University forest reserve in Limón, Costa Rica. Treatments consist of a control, nitrogen (+N), phosphorus (+P), and nitrogen and phosphorus (+NP) addition. The last two columns represent the results of a factorial one-way ANOVA, with F and *p*-values shown. Different letters denote significant differences across treatment levels, as indicated by Tukey’s h.s.d. n. Data from Vincent et al. (*in prep.*).

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Fertilization | treatment |  |  |  |  |
| Variable | Control | +N | +P | +NP | **F** | ***p*** |
| Soil pHH20 | 4.2 (0.1)a | 4.0 (0.1)b | 4.2 (0.1)a | 4.2 (0.1)a | 5.72 | **0.006** |
| PO4- (μg g-1) a | 3.2 (2.2)a | 3.3 (4.4)a | 45 (32.4)b | 46 (9.7)b | 7.50 | **0.002** |
| NO3- (μg g-1) c | 10.6 (0.6) | 14.5 (1.6) | 9.3 (1.3) | 10.5 (1.8) | 2.18 | 0.126 |
| Total C (g kg-1) | 45.5 (1.83) | 47.0 (2.43) | 45.0 (1.26) | 47.9 (3.30) | 0.47 | 0.706 |
| Total N (g kg-1) | 3.99 (0.20) | 4.07 (0.18) | 3.96 (0.11) | 4.06 (0.25) | 0.24 | 0.869 |
| Total P (g kg-1) a | 1.65 (0.25) a | 1.38 (0.13) | 1.87 (0.20) | 1.94 (0.18) | 0.95 | 0.440 |
| Trees that grew (%)b | 66.3 (4.6) | 66.6 (1.9) | 76.8 (3.7) | 77.0 (3.4) |  |  |
| Litterfall production (Mg ha-1) | 4.61 (0.5) | 4.72 (0.3) | 5.28 (0.8) | 4.43 (0.7) |  |  |

a Extractable in water with anion-exchange resins, and excluding control plot 19 due to anomalously (but presumed natural) high P concentrations.

b Percentage of trees in each plot that had growth 2.7 years after the start of the experiment.

# Table 2 Effect of fertilization treatment on litter and wood mass loss and on litter nutrient content, as determined by Bayesian generalized linear mixed models. Effect sizes are relative to the control and are presented as median posterior estimates. Additionally, 95% credibility intervals are presented as the highest posterior density interval. Parameters in which credible intervals did not include zero were regarded as affecting the response variable, and are marked in bold.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Response variable | Treatment vs. control | Effect size | Rhat | Bulk ESS | Lower CI | Higher CI |
| Litter mass | +N | -0.040 | 1.001 | 5690.177 | -0.208 | 0.121 |
| remaining (%) | +P | 0.029 | 1.001 | 5974.909 | -0.132 | 0.190 |
|  | +NP | 0.072 | 1.001 | 5573.670 | -0.092 | 0.228 |
|  | **Days** | **-0.684** | **1.001** | **4616.778** | **-0.802** | **-0.572** |
|  | treatN:days | -0.046 | 1 | 5998.249 | -0.204 | 0.112 |
|  | treatNP:days | 0.107 | 1 | 6006.594 | -0.043 | 0.261 |
|  | treatP:days | 0.057 | 1 | 5653.754 | -0.096 | 0.214 |
|  |  |  |  |  |  |  |
| Wood mass | +N | 0.117 | 1 | 6570.847 | -0.126 | 0.354 |
| remaining (%) | +P | 0.196 | 1 | 5894.173 | -0.050 | 0.440 |
|  | **+NP** | **0.252** | 1 | 6650.325 | **0.003** | **0.497** |
|  | **Days** | **-0.911** | **1.001** | **4669.648** | **-1.097** | **-0.735** |
|  | treatN:days | -0.005 | 1 | 5914.903 | -0.241 | 0.236 |
|  | treatNP:days | 0.098 | 1.001 | 5559.877 | -0.139 | 0.341 |
|  | treatP:days | 0.176 | 1.001 | 5569.761 | -0.058 | 0.418 |
|  |  |  |  |  |  |  |
| Litter N content | **+N** | **−0.339** | **1.001** | **7623.531** | **−0.636** | **−0.056** |
| (% initial) | +P | −0.057 | 1 | 7553.928 | −0.342 | 0.227 |
|  | +NP | −0.047 | 1 | 7184.793 | −0.335 | 0.244 |
|  | **Days** | **-0.502** | **1.001** | **4864.519** | **-0.705** | **-0.304** |
|  | treatN:days | -0.095 | 1 | 6426.103 | -0.367 | 0.181 |
|  | treatNP:days | 0.038 | 1 | 5969.146 | -0.233 | 0.303 |
|  | treatP:days | 0.048 | 1.001 | 6218.352 | -0.225 | 0.313 |
|  |  |  |  |  |  |  |
| Litter P content | **+N** | **−0.430** | 1 | 4571.772 | **−0.940** | **0.050a** |
| (% initial) | +P | 0.155 | 1.001 | 4681.294 | −0.369 | 0.671 |
|  | +NP | 0.025 | 1.001 | 4609.206 | −0.467 | 0.496 |
|  | **Days** | **-0.609** | **1.001** | **4940.488** | **-0.865** | **-0.364** |
|  | treatN:days | -0.046 | 1 | 6137.326 | -0.408 | 0.312 |
|  | treatNP:days | 0.135 | 1.001 | 5979.456 | -0.210 | 0.465 |
|  | treatP:days | -0.075 | 1.001 | 6078.993 | -0.456 | 0.299 |
|  |  |  |  |  |  |  |

# a Marginally statistically significant. All had 5000 iterations and 4 chains.

**Fig. 1** Location of fertilization plots in the EARTH forest reserve in Limon, Costa Rica. There are only four +N fertilization plots because two were destroyed by treefall during a storm.

Map

Description automatically generated

**Fig. 2** Average monthly precipitation (blue bars) and air temperature (red line) at EARTH University in Limón, Costa Rica, for 1996..2018. Precipitation data are available for all years from 1996 to 2018, except for 2001, 2010 and 2011, for which precipitation data are missing. Monthly precipitation data are available for most years except for 1996 (Jan.-April missing), 2000 (Aug. missing), 2003 (Aug.-Sep.), 2006 (Aug.-Sep.). Air temperature data are missing for the whole of 1997, 1998, 2001, 2010 and 2011. Monthly air temperature data are complete for most years except 1996 (Jan.-April missing), 1998 (Mar-April), 2000 (Aug. and Dec.), 2003 (Aug. and Dec.), 2004 (Sep.-Nov.), 2006 (Aug.-Dec.), and 2012 (Nov.-Dec missing.).

**Chart, bar chart, histogram

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**Fig. 3** Remaining mass (% of initial) as a function of time for (a) *Hyeronima alchorneoides* leaf litter and (b) birch wood sticks**,** set to decompose for 36 weeks in long-term forest fertilization plots (n=16) at the Earth Forest Fertilization Experiment in Limón, Costa Rica; values shown are means per plot (n=4) ± S.E.

|  |  |
| --- | --- |
| **a** | **b** |
|  |  |

**Fig. 4** Violin plots showing values of the decomposition constant (*k*), for *Hyeronima alchorneoides* leaf litter (a,c) and soft wood (b,d) that decomposed for 36 weeks and was subjected to the effects of phosphorus (a, b) and nitrogen (c, d) addition at the EARTH University forest reserve in Limón, Costa Rica. VIOLIN PLOTS FOR LITTER ARE MISSING

|  |  |
| --- | --- |
| **a** | **b** |
|  |  |
| **c** | **d** |
|  |  |

**Fig. 5** *Hyeronima alchorneoides* leaf litter (a) nitrogen and (b) phosphorus content (% of initial amount remaining) through a 36-week decomposition study at the EFFEX fertilization experiment in Limón, Costa Rica.

|  |  |
| --- | --- |
| **a** | **b** |
|  |  |

# Supplementary Tables and Figures

# Table S1 Model output of a Bayesian generalized linear mixed effects model testing the effect of fertilization treatment, time, and their interaction on litter nitrogen and phosphorus concentration. Effect sizes are relative to the control and are presented as median posterior estimates. The 95% credibility intervals are presented as the highest posterior density interval. Parameters in which credible intervals did not include zero were regarded as affecting the response variable, and are marked in bold.

| Variable | Treatment | Estimate | Rhat | Bulk\_ESS | CI\_low | CI\_high |
| --- | --- | --- | --- | --- | --- | --- |
| Litter N | TreatN | -0.097 | 1.001 | 7474.291 | -0.240 | 0.048 |
| concentration (%) | TreatNP | -0.052 | 1.001 | 8070.802 | -0.194 | 0.087 |
|  | TreatP | -0.024 | 1 | 8472.181 | -0.160 | 0.115 |
|  | **Days** | **0.133** | **1** | **5929.138** | **0.037** | **0.227** |
|  | TreatN:days | -0.076 | 1 | 6586.061 | -0.206 | 0.056 |
|  | TreatNP:days | -0.030 | 1 | 7153.092 | -0.161 | 0.104 |
|  | TreatP:days | -0.011 | 1 | 6648.487 | -0.135 | 0.118 |
|  |  |  |  |  |  |  |
| Litter P | TreatN | -0.108 | 1 | 9047.006 | -0.625 | 0.401 |
| concentration (%) | TreatNP | 0.030 | 1 | 9297.820 | -0.488 | 0.524 |
|  | TreatP | 0.078 | 1.001 | 9678.162 | -0.456 | 0.611 |
|  | Days | -0.032 | 1 | 6266.542 | -0.383 | 0.309 |
|  | TreatN:days | -0.003 | 1 | 7398.313 | -0.492 | 0.481 |
|  | TreatNP:days | 0.037 | 1 | 7705.990 | -0.423 | 0.502 |
|  | TreatP:days | 0.027 | 1 | 7949.040 | -0.476 | 0.525 |
|  |  |  |  |  |  |  |

**Table S2** Model output of a Bayesian generalized linear mixed effects model testing the effect of fertilization treatment, time, and their interaction on *Hyeronima alchorneoides* leaf litter C:N, N:P, and C:P ratios (molar basis). Effect sizes are relative to the control and are presented as median posterior estimates. The 95% credibility intervals are presented as the highest posterior density interval. Parameters in which credible intervals did not include zero were regarded as affecting the response variable, and are marked in bold.

| Variable | Treatment | Estimate | Rhat | Bulk\_ESS | CI\_low | CI\_high |
| --- | --- | --- | --- | --- | --- | --- |
| Litter C:N | treatN | 0.313 | 1 | 7842.521 | -1.353 | 2.024 |
|  | treatNP | -0.196 | 1 | 7685.104 | -1.853 | 1.453 |
|  | treatP | -0.191 | 1.001 | 6847.894 | -1.861 | 1.438 |
|  | **Days** | **-3.106** | **1** | **5734.258** | **-4.192** | **-1.997** |
|  | treatN:days | 0.754 | 1 | 7204.545 | -0.744 | 2.225 |
|  | treatNP:days | 0.449 | 1.001 | 7147.178 | -1.090 | 1.980 |
|  | treatP:days | 0.116 | 1.001 | 7099.674 | -1.359 | 1.623 |
|  |  |  |  |  |  |  |
| Litter N:P | treatN | 1.096 | 1 | 5365.525 | -3.525 | 5.540 |
|  | treatNP | -2.609 | 1.001 | 5225.316 | -7.064 | 1.807 |
|  | treatP | -3.399 | 1.001 | 5000.731 | -8.069 | 1.269 |
|  | **days** | **4.565** | **1** | **5192.835** | **1.799** | **7.301** |
|  | treatN:days | -1.984 | 1 | 6608.766 | -5.780 | 1.818 |
|  | treatNP:days | -1.964 | 1 | 6512.378 | -5.690 | 1.773 |
|  | treatP:days | -1.606 | 1 | 6638.446 | -5.605 | 2.386 |
|  |  |  |  |  |  |  |
| Litter C:P | treatN | 39.096 | 1.001 | 5150.560 | -40.777 | 118.666 |
|  | treatNP | -54.501 | 1.001 | 5029.933 | -135.193 | 25.065 |
|  | treatP | -72.372 | 1 | 5570.416 | -157.584 | 14.177 |
|  | Days | 2.198 | 1.001 | 4239.965 | -45.167 | 49.569 |
|  | treatN:days | -6.611 | 1 | 5083.811 | -71.740 | 56.616 |
|  | treatNP:days | -35.577 | 1 | 5382.098 | -100.957 | 27.107 |
|  | treatP:days | -27.367 | 1 | 5706.847 | -97.766 | 41.870 |
|  |  |  |  |  |  |  |

**Fig. S1** Changes in the concentration (%) of (a) nitrogen and (b) phosphorus in *Hyeronima alchorneoides* decaying litterfall (mean ± standard error) over a 36-week period decomposition study at the EARTH Forest Fertilization Experiment in Limón, Costa Rica.

|  |  |
| --- | --- |
| **a** | **b** |
| Chart, line chart  Description automatically generated | Chart, line chart  Description automatically generated |

# Fig. S2 Molar ratios of (a) carbon to nitrogen, (b) nitrogen to phosphorus, and (c) carbon to phosphorus in *Hyeronima alchorneoides* leaf litter during a 36-week decomposition study in a long-term forest fertilization experiment in Limón, Costa Rica.

|  |
| --- |
| **a** |
| Chart, line chart  Description automatically generated |
| **b** |
| Chart, line chart  Description automatically generated |
| **c** |
| Chart, line chart  Description automatically generated |

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