**Supplementary Information for**

**Anthropogenic activities in the páramo**

**trigger ecological shifts in Tropical Andean lakes**

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Diagram

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Fig. S1. Diagram showing the relative abundances of diatom taxa identified in the sediment core recovered from Laguna Pallcacocha.

A picture containing antenna

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Fig. S2. Diagram showing the relative abundances of diatom taxa identified in the sediment core recovered from Laguna Ocho.

Diagram

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Fig. S3. Diagram showing the influx (grains cm-3 yr-1) of tree, herb, spores and aquatic pollen taxa in the sediment core recovered from Laguna Pallcacocha.

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Fig. S4. Diagram showing the relative abundances of tree, herb, spores and aquatic pollen taxa in the sediment core recovered from Laguna Ocho.

Diagram

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Fig.S5. Plot of the PCA Axis 1 versus PCA Axis 2, and PCA Axis 1 versus PCA Axis 3 samples and species scores for both lakes, Pallcacocha and Ocho. Plot titles indicate the location, and statistical transformation of the combined diatom and vegetation data prior to analysis. Values in brackets show the percentage (eigenvalues) of variation explained by each PCA axis in the model. Only the names of selected taxa are shown on the plots.

Diagram

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Fig.S6. Multiproxy diagram for Laguna El Ocho (core OCH) showing the diatom and total upland pollen concentrations (with and without *Alnus*), relative abundances of selected diatom and pollen taxa, PCA Axis 1 scores and PCA Axis 2 scores plotted against the maximum (A) and minimum (A) age model. Note that the AD ~1991 shift remains unchanged.

Table S1 water properties and major element concentrations in the sampled modern lakes in El Cajas. Values less than the detection limits are indicated by a "<" symbol and have a measurement error of > 10%. They should be interpreted as an approximate value.

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| lake | elevation | surface area | watershed | Lake %  \* | max. depth | lake water volume | run-off \*\* | lake water retention time | water samples\*\*\* | Samples location | | ‘plant’ samples |
|  | (masl) | (km2) | (km2) | (%) | (m) | (m3) | (m3/yr) | (yr) | (L) | Near shore | At core location |  |
| Llaviucu | 3150 | 0.17 | 48.3 | 0.4 | 16.4 | 1400921 | 14498342 | 0.1 | 1 |  | X | Characeae |
| Taitachugo | 3540 | 0.57 | 36.6 | 1.6 | 41 | 11750477 | 10990469 | 1.1 | 1 |  | X | Characeae |
| Inka bog | 3230 | - | - | - | 0.4 | - | - | - | 0.25 |  | X | Periphyton |
| Burin | 3880 | 0.10 | 2.2 | 4.8 | 9 | 467964 | 654035 | 0.7 | 0.6 | X |  | Characeae |
| El Ocho | 3980 | 0.02 | 0.2 | 7.5 | 4.2 | 36397 | 69080 | 0.5 | 1 |  | X | Characeae |
| Toreadora | 3910 | 0.19 | 5.2 | 3.6 | 18.7 | 1771021 | 1559509 | 1.1 | 1 |  | X | Characeae |
| Pallcacocha | 4050 | 0.05 | 1.5 | 3.3 | 8.3 | 205508 | 453479 | 0.5 | 1 |  | X | Potamogeton |
| Piñancocha | 4210 | 0.03 | 0.2 | 14.9 | 11 | 149798 | 54967 | 2.7 | 1 |  | X | Rocks |

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| lake | pH | Alkalinity | Conductivity | Al 394.401 | B 249.677 | Ba 455.404 | Be 313.107 | Ca 315.887 | Cd 228.802 | Cl 134.724 | Co 230.786 |
|  | (-) | (mM / L) | (µS) | (mg/kg) | (mg/kg) | (mg/kg) | (mg/kg) | (mg/kg) | (mg/kg) | (mg/kg) | (mg/kg) |
| Llaviucu | 7.45 | 0.93 | 51.17 | < 0.0222 | < 0.0052 | 0.028 | 0.006 | 12.764 | 0.007 | < -3.816 | < -0.0039 |
| Taitachugo | 7.50 | 0.71 | 38.16 | < -0.0247 | < 0.0054 | 0.043 | 0.007 | 34.532 | 0.007 | < -8.653 | < -0.0036 |
| Inka bog | 7.60 | 2.10 | 11.35 | < 0.0438 | < 0.0024 | 0.020 | 0.006 | 7.874 | 0.007 | < -4.231 | < -0.0033 |
| Burin | 6.76 | 0.67 | 23.38 | < 0.027 | < 0.0014 | 0.025 | 0.006 | 12.079 | 0.007 | < -4.963 | < -0.0037 |
| El Ocho | 7.42 | 0.87 | 36.83 | < -0.0021 | < 0.0025 | 0.100 | 0.007 | 13.193 | 0.007 | < -4.722 | < -0.0036 |
| Toreadora | 8.06 | 0.81 | 45.15 | < 0.023 | < 0.0002 | 0.062 | 0.007 | 7.169 | 0.006 | < -3.58 | < -0.0037 |
| Pallcacocha | 7.54 | 0.40 | 43.53 | < 0.0197 | < -0.001 | 0.035 | 0.007 | 5.318 | 0.007 | < -2.503 | < -0.0037 |
| Piñancocha | 7.23 | 0.29 | 22.89 | < 0.0094 | < 0.0095 | 0.023 | 0.006 | 11.360 | 0.007 | < -3.02 | < -0.0034 |

\* Percentage between watershed area and lake area.

\*\* Estimated based on data from the weather station El Labrado (KNMI Climate Explorer)

\*\*\* samples sieved in the field (8 µm sieve)

Table S1 continued

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| lake | Cr 205.618 | Cu 324.754 | Fe 259.941 | K 766.491 | Li 670.780 | Mg 280.270 | Mn 257.611 | Mo 202.095 | Mo 203.909 | Na 589.592 | Ni 231.604 |
|  | (mg/kg) | (mg/kg) | (mg/kg) | (mg/kg) | (mg/kg) | (mg/kg) | (mg/kg) | (mg/kg) | (mg/kg) | (mg/kg) | (mg/kg) |
| Llaviucu | < 0.005 | < -0.0065 | 0.094 | 0.528 | < 0.0065 | 0.753 | < 0.0022 | < 0.0038 | < 0.0198 | 1.158 | < -0.0026 |
| Taitachugo | < 0.005 | < -0.0058 | 0.092 | < 0.4363 | < 0.0066 | 4.244 | < 0.0018 | < 0.0044 | < 0.0199 | 3.497 | < -0.0029 |
| Inka bog | < 0.0052 | < -0.0051 | 0.108 | < 0.4127 | < 0.0057 | 0.572 | < 0.0023 | < 0.0038 | < 0.0205 | 0.956 | < -0.0028 |
| Burin | < 0.0051 | < -0.0054 | 0.100 | < 0.4655 | < 0.0065 | 0.793 | < 0.0021 | < 0.004 | < 0.0198 | 1.069 | < -0.0027 |
| El Ocho | < 0.005 | < -0.0055 | 0.093 | 0.706 | < 0.0067 | 1.311 | < 0.0019 | < 0.0039 | < 0.0198 | 1.799 | < -0.003 |
| Toreadora | < 0.005 | < -0.0029 | 0.277 | 0.596 | < 0.0055 | 0.627 | 0.003 | < 0.0038 | < 0.0194 | 1.195 | < -0.0027 |
| Pallcacocha | < 0.005 | < -0.0021 | 0.095 | < 0.414 | < 0.0057 | 0.226 | < 0.002 | < 0.0036 | < 0.0194 | 0.824 | < -0.0025 |
| Piñancocha | < 0.0052 | < -0.0005 | 0.091 | 0.559 | < 0.0065 | 1.466 | 0.005 | < 0.0037 | < 0.0193 | 3.116 | < -0.0021 |

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| lake | P 177.495 | Pb 220.353 | S 182.034 | Sb 217.581 | Sc 424.683 | Si 251.612 | Sr 407.771 | Ti 334.187 | V 292.402 | Y 324.228 | Zn 202.613 |
|  | (mg/kg) | (mg/kg) | (mg/kg) | (mg/kg) | (mg/kg) | (mg/kg) | (mg/kg) | (mg/kg) | (mg/kg) | (mg/kg) | (mg/kg) |
| Llaviucu | < 0.02 | < 0.0188 | < 0.3436 | < 0.0168 | < 0.0032 | 2.095 | 0.033 | < 0.0002 | < 0.0051 | < -0.0016 | 0.008 |
| Taitachugo | < 0.0225 | < 0.0168 | 1.783 | < 0.0216 | < 0.0031 | 6.273 | 0.116 | < -0.0002 | < 0.0054 | < -0.0018 | 0.008 |
| Inka bog | < 0.0191 | < 0.0171 | < 0.1787 | < 0.0196 | < 0.003 | 1.984 | 0.020 | < 0.0004 | < 0.005 | < -0.0018 | 0.009 |
| Burin | 0.037 | < 0.0181 | < 0.2315 | < 0.0186 | < 0.0032 | 2.056 | 0.028 | < 0.0007 | < 0.005 | < -0.0015 | 0.009 |
| El Ocho | < 0.0207 | < 0.0174 | < 0.3745 | < 0.0205 | < 0.0031 | 3.165 | 0.075 | < -0.0002 | < 0.0049 | < -0.0016 | 0.007 |
| Toreadora | < 0.0158 | < 0.0187 | < 0.1979 | < 0.0204 | < 0.003 | 2.950 | 0.042 | < 0.0007 | < 0.0048 | < -0.0016 | 0.013 |
| Pallcacocha | < 0.0169 | < 0.0172 | < 0.1692 | < 0.0189 | < 0.0032 | 1.639 | 0.016 | < -0.0003 | < 0.0051 | < -0.0016 | 0.020 |
| Piñancocha | < 0.0176 | < 0.0193 | 7.412 | < 0.0205 | < 0.0031 | 4.294 | 0.048 | < 0.0005 | < 0.0051 | < -0.0018 | 0.028 |

Table S1 continued

|  |  |
| --- | --- |
| lake | Zr 343.823 |
|  | (mg/kg) |
| Llaviucu | < 0.0112 |
| Taitachugo | < 0.0078 |
| Inka bog | < 0.0082 |
| Burin | < 0.0084 |
| El Ocho | < 0.0079 |
| Toreadora | < 0.0082 |
| Pallcacocha | < 0.0083 |
| Pincacocha | < 0.0081 |