# ÉCLAIRE Flux Network List and Protocols of Mandatory Measurements

**Table 1.** Mandatory measurements at ECLAIRE flux network

**1. Site Description for all sites**

|  |  |  |
| --- | --- | --- |
| **Parameter Type** | **Parameter** | **Units** |
| **Site Description** | Slope | ‘ vertical |
| Elevation | m AMSL |
| Latitude | ‘°N |
| Longitude | ‘°E |
| Annual temperature | °C |
| Annual rainfall | Mm |

**1a. Forests**

|  |  |  |
| --- | --- | --- |
| **Parameter Type** | **Parameter** | **Units** |
| **Management** | Age of forest | **-** |
| Details of land use over the last 25 years. | **-** |
| Management scheme | **-** |
| Rotation length | **-** |
| Site preparation (ploughed etc) | **-** |
| Disturbance | Dates and description of main events (including windthrow, fire, others..) |
| Thinning | Dates and description |
| Harvesting | Dates and description |

**1b. Croplands**

|  |  |  |
| --- | --- | --- |
| **Parameter Type** | **Parameter** | **Units** |
| **Site Description** | Time since the site has been under crops | Years |
| Details of crops in the previous 2-3 years |  |
| Details of rotation/long-term cropping practice |  |
| Crop details – crop type, cultivar |  |
| **Sowing** | Sowing date | DD/MM/YY |
| **Harvest** | Dates of harvest | DD/MM/YY |
| Yield of harvest | kg m-2 |
| **Fertiliser application (mineral)** | Dates of each mineral fertilisation | DD/MM/YY |
| Amount of N applied at each fertiliser event | (kg N ha-1) |
| Amount of phosphorus applied at each fertiliser event | (kg P ha-1) |
| Amount of potassium applied at each fertiliser event | (kg K ha-1) |
| Chemical form of mineral N, P and K applied (e.g. straight ammonium nitrate, urea, calcium ammonium nitrate, potassium phosphate…) | - |
| **Fertiliser application (Organic)** | Dates of each organic fertilisation | DD/MM/YY |
| Form of organic fertiliser applied at each fertiliser event (e.g. broiler litter, laying poultry litter, cattle FYM, cattle slurry, pig FYM, pig slurry, sewage sludge…) | - |
| Volume of organic fertiliser applied at each fertiliser event | m3 ha-1 |
| Dry matter content of organic fertiliser at each fertiliser event | (% solids) or %MS |
| Estimated total N content of the organic fertiliser | (g N kg-1 dry matter)  Kjeldahl or “Carbo-Erma” |
| Estimated total C content of the organic fertiliser | (g C kg-1 dry matter)\*\*  “Carbo-Erma” |
| **Parameter Type** | **Parameter** | **Units** |
| **Fertiliser application (Organic)** | Estimated available N (ammonium and nitrate) content of the organic fertiliser (most will be as ammonium) | *(g available N kg-1 dry matter)\**  *Extraction-colourimetric analysis* |
| Estimated available C content of the organic fertiliser | *(g available C kg-1 dry matter)\**  *Extraction-Persulphate oxidation* |
| Estimated N applied to surface from organic fertiliser for each application | (kg N ha-1) (calculate from volume applied, dry matter content and N content). |
| Estimated C applied to surface from organic fertiliser for each application | (kg C ha-1) |
| Application method of organic fertiliser | e.g. surface spreading, deep injection… |
| **Other Treatments** | Tillage | Dates of tillage |
| Depth of tillage | - |
| Pesticides | Note any dates of application, amount and type |
| Herbicides | Note any dates of application, amount and type |
| Irrigation | Note any dates of irrigation |
| Amount of water applied during irrigation | mm |
| Liming | Note any dates of liming, and amount of lime applied, and its elemental composition |

**1c. Grassland Site Description & Management Record**

|  |  |  |
| --- | --- | --- |
| **Parameter Type** | **Parameter** | **Units** |
| **Management over longer period** | Age of grassland  *(date last ploughed if not permanent)* |  |
| Details of crops in the 2-3 years before field became grassland *(if the grassland is < 5 years old)* |  |
| Details of land use over the last 25 years. |  |
| Is the grassland grazed or used for hay/silage? |  |
| For cut grassland, number of cuts/year, yield per cut or per year on average |  |
| Is the plot drained and how ? |  |
| Fertilisation details over the last 5 years on average. Total kg N ha-1 yr-1:  * mineral: * organic: |  |
| Any specific problems with the fields, water excess, soil conditions etc |  |
| **Cutting** | Dates of each cut | DD/MM/YY |
| Yield of each cut | kg m-2 |
| Height of vegetation before & after each cut \* | M |
| **Fertiliser application (mineral)** | Dates of each mineral fertilisation | DD/MM/YY |
| Amount of N applied at each fertiliser event | (kg N ha-1) |
| Amount of phosphorus applied at each fertiliser event | (kg P ha-1) |
| Amount of potassium applied at each fertiliser event | (kg K ha-1) |
| Chemical form of mineral N, P and K applied (e.g. straight ammonium nitrate, urea, calcium ammonium nitrate, potassium phosphate…) | - |
| **Parameter Type** | **Parameter Measured** | **Units** |
| **Fertiliser application (Organic)** | Dates of each organic fertilisation | DD/MM/YY |
| Form of organic fertiliser applied at each fertiliser event (e.g. broiler litter, laying poultry litter, cattle FYM, cattle slurry, pig FYM, pig slurry, sewage sludge…) | - |
| Volume of organic fertiliser applied at each fertiliser event | m3 ha-1 |
| Dry matter content of organic fertiliser at each fertiliser event | (% solids) or %MS |
| Estimated total N content of the organic fertiliser | (g N kg-1 dry matter)  Kjeldahl or “Carbo-Erma” |
| Estimated total C content of the organic fertiliser | (g C kg-1 dry matter)\*\*  “Carbo-Erma” |
| Estimated available N (ammonium and nitrate) content of the organic fertiliser (most will be as ammonium) | *(g available N kg-1 dry matter)\**  *Extraction-colourimetric analysis* |
| Estimated available C content of the organic fertiliser | *(g available C kg-1 dry matter)\**  *Extraction-Persulphate oxidation* |
|
| Estimated C applied to surface from organic fertiliser for each application | (kg C ha-1) |
| Application Method of organic fertiliser | e.g. surface spreading, deep injection… |
| **Other Treatments** | Tillage | Dates of tillage |
| Depth of tillage | - |
| Pesticides | Note any dates of application, amount and type |
| Herbicides | Note any dates of application, amount and type |
| Irrigation | Note any dates of irrigation |
| Amount of water applied during irrigation | - |
| Liming | Note any dates of liming, and amount of lime applied, and its elemental composition |
| **Parameter Type** | **Parameter Measured** | **Units** |
| **Grazing** | Continuous or rotational ? | - |
| Dates *(keep log of grazing if it is changing during measurements)* | DD/MM/YY |
| Density of animals *(to note with dates on log)* | (number/ha) |
| Estimated liveweight of animals, each month |  |
| Type of animals | - |

**2. Fluxes, Concentrations and Meteorology**

| **Parameter Type** | **Parameter Measured** | **Symbol** | **Units** | **Method** | **Frequency** | **Duration (months)** | **Ecosystem Type** |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Above-canopy** | Latent heat flux | LE | Wm-2 | Eddy cov | 30 min. | 15 | All |
| Carbon dioxide flux | Fc | µmol m-2 s-1 | Eddy cov | 30 min. | 15 | All |
| Sensible heat flux | H | Wm-2 | Eddy cov | 30 min. | 15 | All |
| Momentum flux |  | kg m-1 s-2 | Eddy cov | 30 min. | 15 | All |
| Nitric oxide concentration | χNO | µmol m-3 | Chemiluminescent analysis | 30 min. | 15 | All |
| Nitrogen dioxide concentration | χNO2 | µmol m-3 | Chemiluminescent analysis | 30 min. | 15 | All |
| Ozone concentration at height of O3 fast sensor | χO3 | µmol m-3 | Chemiluminescent analysis | 30 min. | 15 | All |
| Ozone flux | F\_O3 | µmol m-2 s-1 | Eddy cov (fast chemiluminescence) | 30 min | 15 | All |
| Ammonia flux | F\_NH3 | µmol m-2 s-1 | Gradient (AMANDA/ GRAHAM/ROSAA) or Eddy cov (QCL, HT-CIRMS) | 30 min | IMPs | All |
| NO flux | F\_\_EC\_NO | nmol m-2 s-1 | Eddy cov | 30 min | IMPs | All |
| NO2 flux | F\_EC\_NO2 | nmol m-2 s-1 | Eddy cov | 30 min | IMPs | All |
| VOC flux | F\_EC\_VOC | nmol m-2 s-1 | (Disjunct) eddy cov (PTR-MS; FIS); REA | 30 min | IMPs | All |
|  | NO flux | F\_grd\_NO | µmol m-2 s-1 | Gradient | 30 min | Where available | All |
| NO2 flux | F\_grd\_NO2 | µmol m-2 s-1 | Gradient | 30 min | Where available | All |
| VOC flux | F\_grd\_NO3- | µmol m-2 s-1 | Gradient | 30 min | Where available | All |

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| --- | --- | --- | --- | --- | --- | --- | --- |
| **Wet Deposition** | Bulk wet deposition | WD | mm | Bulk sampler | Monthly | 15 | All, nearby site |
| Bulk ammonium | WD\_NH4+ | kg N ha-1 | Bulk sampler | Monthly | 15 | All, nearby site |
| Bulk nitrate | WD\_NO3- | kg N ha-1 | Bulk sampler | Monthly | 15 | All, nearby site |
| Bulk sulphate | WD\_SO4= | kg S ha-1 | Bulk sampler | Monthly | 15 | All, nearby site |
| Bulk chloride | WD\_Cl- | kg Cl ha-1 | Bulk sampler | Monthly | 15 | All, nearby site |
| Leaf loading | LC\_NH4+ | µmol m-2 | Leaf washing | Daily | IMPs, where NH3 flux measured | All sites, where NH3 flux measured |
| Leaf loading | LC\_NO3- | µmol m-2 | Leaf washing | Daily |
| Leaf loading | LC\_SO4= | µmol m-2 | Leaf washing | Daily |
| Leaf loading | LC\_Cl- | µmol m-2 | Leaf washing | Daily |
| Leaf loading | LC\_Na+ | µmol m-2 | Leaf washing | Daily |
| Leaf loading | LC\_Mg++ | µmol m-2 | Leaf washing | Daily |
| Leaf loading | LC\_K+ | µmol m-2 | Leaf washing | Daily |
| Leaf washing | LC\_Ca++ | µmol m-2 | Leaf washing | Daily |
| Leaf washing | LC\_pH | - | Leaf washing | Ideally daily |
| **canopy measurements** | In-canopy T profile | T\_cp | °C | canopy air temperature at CO2 measurement heights | 30 min. | 15 | Forest |
| CO2 storage in canopy air layer | S\_CO2 | mol m-2 s-1 | Profiles Li-COR 840 | 30 min. | 15 | Forest |
| In-canopy RH profile | RH\_cp |  | Li-COR 840 or RH probe | 30 min |  |  |
| Leaf-level CO2 / H2O flux | gmax; Amax | mol m-2 s-1;  µmol m-2 s-1 | Photosynthesis system Various leaf ages / positions | some intensive periods | IMPs | All, except very high species richness |
| O3 flux trunk space | Fc\_O3 | µmol m-2 s-1 | Eddy-cov trunk space  (fast chemoluminescence) | 30 min | IMPs | Forest / tall crops? |
| **Soil Fluxes** | Soil heat flux | G | W m-2 | Soil heat flux plates | 30 min. | 15 | All |
| Nitric Oxide | Fsoil\_NO | nmol m-2 s-1 | Continuous auto chamber  or EC + gradient | Min. 4/day | 15 | All |
| Nitrogen Dioxide | Fsoil\_NO2 | nmol m-2 s-1 | Continuous auto chamber  or EC + gradient | Min. 4/day | 15 | All |
| Ozone | Fsoil\_O3 | µmol m-2 s-1 | Continuous auto chamber or gradient | Min. 4/day | 15 | All |
| Soil CO2 flux | Fsoil\_CO2 | mol m-2 s-1 | Cuvette | Weekly with replicates | 15 | desirable where bare soil available |

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Meteorology** | Global radiation | Rg | W m-2 | Sensor | 30 min | 15 | All |
| Net radiation | Rn | W m-2 | Sensor | 30 min | 15 | All |
| 4 radiation components:  (SW, LW in, out) | Rsw\_in, Rsw\_out,  Rlw\_in, Rlw\_out | W m-2 | Sensor | 30 min | 15 | All |
| Photosynthetic photon flux density, total, direct, diffuse and reflected | PPFDtot  PPFDdir  PPFDdif PPFDref | mol m-2 s-1 | Sensor | 1 & 30 min | 15 | All |
| Ground-level PAR | PPFDg | mol m-2 s-1 | Sensor | 1 & 30 min | 15 | IT-Isp, NL-Hyy, F-Gri & others |
| Leaf wetness | LWet | % | Clip sensors (4 replicates) | 30 min | 15 | All |
| Air temperature | Ta | °C | Sensor | 30 min | 15 | All |
| Pressure | Pa | kPa | Sensor | 30 min | 15 | All |
| Bole temperature | TBOLE | °C | Sensor | 30 min | 15 | Forest where available |
| Precipitation | P | mm | Rain gauge | 30 min | 15 | All |
| Relative humidity | RH | % | Sensor | 30 min | 15 | All |
| Snow depth | SNOWD | mm | Sensor / Pole | 15 days (30 min), as relevant | 15 | All |

**3. Soil & Vegetation**

| **Parameter Type** | **Parameter Measured** | **Symbol** | **Units** | **Method** | **Frequency** | **Duration (Months)** | **Ecosystem Type** |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Soil** | Soil description | SDESC | - | Survey | One-off |  | All |
| Depth of main  rooting zone | DEPTHMRZ | m | Visual Observation | One-off |  | All |
| Bulk density | BD | g soil m-3 dry soil | Soil cylinders | One-off |  | All |
| Soil Texture  (in each layer) | T | (Cl:Sa:Si)  g/kg | Without decarbonatation | One-off |  | All |
| pH in water  (in each layer) | pH | - |  | One-off |  | All |
| Water retention curve | Water content vs. water potential | % vs kPa |  | One-off |  | All |
| Soil temperature profile | Ts | °C | Sensor | 30 min,  min. 2 to 5 depths | 15 | All |
| Soil water content profile & water table | SWC, SWD | % by volume | TDR | 30 min,  min. 2 to 5 depths | 15 | All |
| Soil mineral N concentrations  (NO3-, NH4+) |  | kg m-2 | Soil KCl extractions, 2 depths (0-5 cm; 0-30 cm) + litter where applicable | Site specific; at least monthly, more often after fertilisation | 15 | All |
| Soil organic C stocks (profile) | SOC | kg m-2 | Cores | one-off | once | All |
| Soil organic N stocks (profile) | SON | kg m-2 | Cores | one-off | once | All |
| **Vegetation**  **Vegetation** | Mean canopy height | H | m | Direct / indirect sampling | Fortnightly, ecosystem dependent | 15 | All |
| Leaf area index (1/2 total) | LAI | m² m-2 | Direct / indirect sampling | Once per month or more frequently before and after cutting / grazing | 15 | All |
| Leaf area density profie | LAD | m2 m-3 | Spherical photography (forests); Canopy structure meter (others) | Every two months | 15 | All |
| Tissue C |  | % C dry matter | Carbo-Erma | Monthly | 15 | All |
| Tissue N |  | % N dry matter | Kjeldahl or Carlo Erba | Monthly + more frequently before and after management | 15 | All |
| Wood biomass | BW | kg m-2 | Inventory/sampling/site based allometric relationship | Once/twice/annually | 15 | Forest |
| Aboveground biomass | BAG | kg m-2 | Sampling | Annual/seasonal | 15 | Agricultural |
| Harvested biomass | BH | kg m-2 | Sampling / Statistic | If relevant/  at harvest | 15 | All |
| Residues after management | Res | kg m-2 |  | If relevant/at harvest | 15 | All |
| Yield |  |  |  | If relevant/at harvest | 15 | Agricultural |
| Plant species composition | - | % cover of each functional group | Sampling | Once / twice a year | 15 | All |
| Standing leaf biomass | BL | kg m-2 | Inventory/sampling/site based allometric relationship | Once / twice a year (Deciduous/Conifers) | 15 | Forest |
| Wood increment | WI | kg m-2 | Inventory, sampling, site-based allometry, dendrometers | Annual | 15 | Forest |
| Bulk foliar NH4+ | Bulk\_NH4+ | µmol l-1 |  | Weekly & after management | IMPs | All with NH3 measurements |
| Bulk foliar NH4+ |  |  |  |  |
| Bulk foliar pH | Bulk\_pH | - |  | IMPs |
| Litter NH4+ | Litter\_NH4+ | µmol l-1 |  | IMPs |
| Litter pH | Litter\_pH | - |  | IMPs |
| Apoplastic NH4+ | Apo\_NH4+ | µmol l-1 | Vacuum infilitration | IMPs | Where possible |
| Apoplastic pH | Apo\_pH | - | Vacuum infilitration |  | Where possible |