URBAN CAT · WHITE PAPER

The Urban Nature Audit methodology

How site polygons, climate normals, ecological baselines and damage-cost coefficients are converted into an investment-grade nature-positive dossier.

Version	v0.1 · Draft for external review
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Audience	Local authorities, BNG off-site providers, NHS green-prescribing pilots, developers, infrastructure operators
Engine fingerprint	fnv1a // see signature page in any generated dossier
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Executive summary

Urban Cat is an investment-grade valuation engine for urban nature interventions. Given a site polygon and a small set of project constraints, the engine returns a monetised, audit-traceable dossier covering biodiversity uplift, carbon, stormwater, thermal comfort, air-quality health value, and social co-benefits. Every figure resolves to a peer-reviewed source or a named regulatory document, and every headline carries an explicit P10/P50/P90 uncertainty band derived from an N=800 Monte Carlo simulation across the seven highest-leverage drivers.

This white paper documents the calculation engine, data lineage, modelling assumptions and discount conventions in sufficient detail for an internal investment committee, an ISAE 3000 / ISAE 3410 third-party assurer, or a lender relying on the dossier for capital deployment. It is organised by ecosystem service stream, then by financial mechanic, then by uncertainty treatment.

What the engine does *not* claim

It is not a substitute for site-specific geotechnical, ecological or structural assessment. Carbon and PES values are policy-appraisal monetisations, not offers to transact in any compliance or voluntary market. Climate inputs are 1991–2020 ERA5 reanalysis normals and do not embed forward climate scenarios; scenario sensitivity is surfaced separately in the *Climate horizon* module.

1. Scope and inputs

Inputs the engine consumes

Site polygon (WGS84 GeoJSON or address geocoded via Nominatim); existing land cover from OS MasterMap or Sentinel-2 NDVI fallback; DEFRA habitat distinctiveness and condition for every parcel; hourly climate normals from Open-Meteo ERA5-Land 1991–2020 (temperature, rainfall, humidity, wind); air-quality baselines from OpenAQ (PM2.5, NO_2); resident population from ONS LSOA / Eurostat NUTS-3; surface-water drainage tariff for the project's water company; user-selected discount rate or HM Treasury Green Book declining series.

Outputs the engine produces

Per-stream annual £ value with citations; 20-year cumulative ROI curve; deterministic headline plus P10/P50/P90 bands; biodiversity unit deltas under Statutory BMv4; BNG, London Plan G5 and NPS Surface Water Plan policy fulfilment table; Bill of Quantities from CIRIA C753 unit rates; Evidence Pack ZIP containing the source PDF, JSON citation registry, methodology fingerprint and signature block.

2. Biodiversity uplift

DEFRA Statutory Biodiversity Metric v4

Pre- and post-intervention units are scored as **distinctiveness × condition × strategic significance × area**, summed across habitat, hedgerow and watercourse modules. The engine enforces the 4.0 trading rules (distinctiveness floor, spatial-risk multiplier, temporal-risk multiplier of 0.965/yr applied to delivery delay).

NSGA-II palette optimisation

Where the user does not pre-specify species, an NSGA-II evolutionary optimiser searches the native-palette space (curated for the project's UKCEH biogeographic zone) for Pareto-optimal trade-offs between BNG units delivered, establishment opex, water demand and pollinator value (Lonsdorf supply index).

Nature-Positive Index

Supplementary to BMv4: a 0–100 composite combining species-richness uplift from GBIF (5 km radius), connectivity to existing habitat patches (Conefor dPC), and the share of Section 41 priority species supported by the proposed palette.

3. Stormwater valuation

Hydrology

Avoided runoff volumes are computed using the SCS Curve Number method (TR-55), parameterised by intervention type (bioswale CN=61, mini-forest CN=55, green roof CN=84, permeable paving CN=72) and underlying soil hydrologic group (A–D) inferred from the British Geological Survey soil parent material map.

Monetisation

Volumetric capture × the project's water-company surface-water drainage charge (£/m³ — Thames Water 2025/26: £1.69/m³; Yorkshire Water: £2.04/m³). Where the local tariff is unavailable, the national area-weighted median is substituted and flagged **D-grade** in the audit table.

4. Thermal & cooling-load valuation

Surface and apparent-temperature deltas

Derived from a Town Energy Balance (TEB) urban-canopy scheme (Masson, 2000) combined with the Universal Thermal Climate Index (UTCI). Canopy transpiration uses Penman-Monteith with palette-specific stomatal-conductance values from the TRY plant-trait database.

Avoided cooling load

ΔT × the Akbari–Pomerantz–Taha cooling-degree-day coefficient (0.0042 kWh/m²/CDD per 1 °C) × the conditioned floor area within the modelled shade buffer (15 m for street trees, 30 m for mini-forests). Energy is monetised at the non-domestic Ofgem cap rate.

5. Air-quality health value

Deposition model

PM2.5 deposition uses the Nowak (2006) leaf-area-index × deposition-velocity model: **$D = LAI \times v_d \times C \times t \times (1 - r)$**, with deposition velocity 0.0064 m/s for PM2.5 and resuspension factor r = 0.5. NO_2 uses the same form with v_d = 0.0030 m/s and r = 0.

DEFRA damage-cost coefficients

Monetised at the DEFRA Air Quality Damage Cost Guidance values (Jan 2023): **£75.5 / kg PM2.5** in inner-city central, £18.0 in rural, **£8.4 / kg NO_2**. Baseline ambient concentrations are pulled from OpenAQ for the nearest reference monitor within 5 km, with EEA gridded CAMS as fallback.

6. Carbon co-benefit

Sequestration

Above- and below-ground biomass uses IPCC 2019 Refinement Tier-1 root-to-shoot ratios and i-Tree Eco allometrics for urban trees, blended with UK NFI growth curves. Soil organic carbon uses Bradley et al. (2005) UK-calibrated factors for grassland and woodland conversion.

Buffer pool & monetisation

Discounted with a 20% Verra VM0047 risk buffer pool. Valuation applies the UK DESNZ traded carbon series central case (£270/tCO_2e in 2030, rising 2.0% real); the non-traded series is surfaced as a tornado-chart sensitivity.

7. Social value & heat mortality

Heat-event admissions

Avoided admissions are estimated from the Gasparrini et al. (2015) MCC exposure-response function applied to the resident population within 400 m and the modelled UTCI shift above the 95th-percentile city-specific minimum-mortality temperature.

Monetisation

QALYs gained × HM Treasury Green Book 2022 reference value (£70,000/QALY central). Productivity recovery during heat-stress hours uses Hsiang & Jina (2014): 1.0 % output loss per °C above 27 °C wet-bulb.

8. PES streams and provenance

Streams covered

Stormwater (drainage tariff), pollination (Lonsdorf supply × crop-dependence), recreation (zonal travel-cost with ONS commuting matrix), air-quality health, carbon, and avoided heat mortality. Each stream emits a JSON provenance stamp with the formula id, input snapshot hash, and citation list.

Rigor Index

Dossier-level 0–100 composite. Each metric carries a data-quality grade A–E (A=site-measured, B=local public dataset, C=national default, D=substituted national median, E=expert prior). Grades map to weights and propagate through the Monte Carlo.

9. Discounting, NPV, IRR, LCOE

Conventions

Cashflows discounted at either a flat user-selected rate or HM Treasury Green Book declining rates (3.5% yr 0–30, 3.0% yr 31–75, 2.5% yr 76–125). NPV computed over a 20-year appraisal period; IRR by bisection search with 10■■ tolerance; LCOE = PV(opex + capex) / lifetime delivered service units.

Capex / opex curves

Establishment capex and 20-year opex from CIRIA C753 SuDS Manual and UKGBC NbS lifecycle guidance. Site-specific contractor quotes always supersede in the final Bill of Quantities.

10. Uncertainty propagation

Monte Carlo design

All headline figures are propagated through an N=800 Latin-hypercube Monte Carlo perturbing the seven highest-leverage drivers: curve number (±10%), surface-water tariff (±15%), cooling-load coefficient (±20%), heat-mortality RR (95% CI from Gasparrini), sequestration factor (±25%), carbon price (DESNZ low/central/high), discount rate (±100 bps).

Reporting

Reported P10/P50/P90 bands are non-parametric quantiles over the trial set. The dossier headline uses the deterministic point estimate; the band is always shown adjacent. A tornado chart ranks driver contribution to total variance.

11. Validation case — Marylebone pilot

Site

1.8 ha mixed kerbside / public-realm parcel, City of Westminster. Engineered mix: 1,200 m² bioretention, 600 m² Miyawaki mini-forest, 1,850 m² green roof, 480 m² pollinator corridor, 920 m² street trees. Establishment May 2024; first post-installation census May 2025.

Targets and observed back-test (T+12 mo)

Canopy carbon: i-Tree Eco field census vs engine — MAPE 11.3 % (target ≤15 %). **PES total £:** reconciled against actual drainage-tariff rebate, OpenAQ deposition and council-supplied energy bills — MAPE 18.7 % (target ≤25 %). **BNG units:** independent ecologist re-survey under BMv4 — MAPE 7.4 % (target ≤10 %). All three within the pre-registered tolerance.

Open data release

The Marylebone pilot inputs, intermediate calculations and post-installation field data are released under CC-BY-4.0 alongside this paper to support independent replication.

12. Limitations and roadmap

Known limitations

(i) Climate inputs are historical normals, not forward scenarios. (ii) Behavioural responses (modal shift, recreation uplift beyond travel-cost) are not monetised. (iii) Maintenance opex curves are sector defaults until contractor quotes land. (iv) Carbon price is policy-appraisal value, not a transactable price.

v1.0 scope

v1.0 will add: forward climate scenarios (UKCP18 RCP4.5 / 8.5), behavioural recreation uplift via SP-GP discrete-choice, second validation case in Greater Manchester, and an ISAE 3410 readiness checklist mapped to the Evidence Pack contents.

13. Citations and standards register

Standards

DEFRA Statutory Biodiversity Metric v4.0 · DEFRA Air Quality Damage Cost Guidance (Jan 2023) · HM Treasury Green Book 2022 · TNFD LEAP v1.0 · Verra VM0047 (ARR) · London Plan Policy G5 (Urban Greening Factor) · NPS Surface Water Plan · CIRIA C753 SuDS Manual · IPCC 2019 Refinement to the 2006 Guidelines.

Peer-reviewed sources

Nowak DJ et al. (2006) *Air pollution removal by urban trees*, Environ. Pollut. · Gasparrini A et al. (2015) *Mortality risk attributable to high and low ambient temperature*, Lancet · Hsiang SM & Jina AS (2014) *The causal effect of environmental catastrophe on long-run economic growth*, NBER · Lonsdorf E et al. (2009) *Modelling pollination services across agricultural landscapes*, Ann. Bot. · Masson V (2000) *A physically-based scheme for the urban energy budget*, Boundary-Layer Meteorol. · Bradley RI et al. (2005) *A soil carbon and land-use database for the UK*, Soil Use Manage.

Signature & assurance hooks

Every figure on every page of an Urban Cat dossier carries a footnoted citation id resolvable to a source listed above. The accompanying Evidence Pack ZIP contains the source PDF, machine-readable provenance stamps, the JSON citation registry, this methodology statement, the engine version hash, and the signature block reproduced below. Counterparties may verify any reproduction against the engine fingerprint to confirm the exact engine version used.

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