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# Ocean Accounting for Nature-based Solutions

Provides technical guidance for accounting for nature-based solutions as deliberate interventions across their full lifecycle, and for comparing them with engineered alternatives.

**Version** 0.2.1 **Status** Draft **Stability** Emerging

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## OUTCOME

TG-2.4 Environmental (including Ecosystem) Goods and Services Section 3.10.5 prohibits valuing an ecosystem asset at restoration cost, on the grounds that doing so "would make it impossible to separately assess the benefits of ecosystem restoration: they would by definition equal the costs." The Technical Guidance therefore protects the separation between what an intervention cost and what it achieved, and nowhere sets out how to measure the second. This Circular does.
Its unit is the intervention. TG-6.11 Coastal Infrastructure Accounting records the structures built on a coast and values them as produced assets. The question here is different: an agency has decided to spend public or blended money on an ecosystem, in the expectation of a return. What must the accounting system record, over what horizon, against what counterfactual, and what must it publish so the decision can be defended, compared against an engineered alternative, and audited later?
Upon completing this guidance, practitioners will be able to:

- Determine whether an intervention qualifies as a nature-based solution (NbS) for accounting purposes, and record that determination auditably
- Route a single intervention to its entry points across expenditure, produced asset, ecosystem asset, ecosystem service and social accounts without double counting
- Select a counterfactual tier appropriate to available data, applying the designs in TG-1.3 Marine Spatial Management to the harder restoration case
- Record benefit lag, survival probability and reversal in the monetary ecosystem asset account
- Compile the full lifecycle cost of an intervention, including opportunity and non-market stewardship costs
- Compare nature-based, engineered and hybrid options on equivalent service units
- Publish the metadata a user needs to construct a risk-adjusted figure for themselves

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ABOUT THIS CIRCULAR

RECOMMENDED CITATION

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# 1. Outcome

¶1 **TG-2.4 Environmental (including Ecosystem) Goods and Services** Section 3.10.5 prohibits valuing an ecosystem asset at restoration cost, on the grounds that doing so "would make it impossible to separately assess the benefits of ecosystem restoration: they would by definition equal the costs."[1] The Technical Guidance therefore protects the separation between what an intervention cost and what it achieved, and nowhere sets out how to measure the second. This Circular does.

¶2 Its unit is the intervention. **TG-6.11 Coastal Infrastructure Accounting** records the structures built on a coast and values them as produced assets. The question here is different: an agency has decided to spend public or blended money on an ecosystem, in the expectation of a return. What must the accounting system record, over what horizon, against what counterfactual, and what must it publish so the decision can be defended, compared against an engineered alternative, and audited later?

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- ¶7 Record benefit lag, survival probability and reversal in the monetary ecosystem asset account
- ¶8 Compile the full lifecycle cost of an intervention, including opportunity and non-market stewardship costs
- ¶9 Compare nature-based, engineered and hybrid options on equivalent service units
- ¶10 Publish the metadata a user needs to construct a risk-adjusted figure for themselves

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## 1.1 Decision Use Cases

¶1 Coastal protection portfolio choice; national adaptation planning and Nationally Determined Contribution reporting; Kunming-Montreal Global Biodiversity Framework Targets 2 and 3; blue bond and blue carbon due diligence; public investment appraisal and budget classification; disaster risk reduction programming; and the design of offsets and compensation under environmental impact assessment.

## 1.2 Upward Connections

¶1 **TG-1.1 National Ocean Budgets**, **TG-1.4 Sustainable Ocean Planning**, **TG-1.6 Environmental Impact Assessment**, **TG-1.8 Project-Level Finance**, **TG-2.6 Ocean-related Investment** and **TG-2.9 Disaster Risk Indicators**.

¶2 ⓘ **Framework Position**

¶3 This Circular owns the accounting treatment of **nature-based solutions as an intervention class**: the eligibility test, the six-entry ledger a single intervention generates, counterfactual and additionality tiers, survival and lag, permanence and reversal risk, full lifecycle cost, and the layered method for comparing nature-based, engineered and hybrid options.

¶4 It cross-refers for the ecosystem asset and service accounts an intervention changes (**TG-3.1** and the ecosystem circulars **TG-6.1**, **TG-6.2**, **TG-6.3**), the produced-asset cost stream it is compared against (**TG-6.11**), valuation principles (**TG-1.9**) and the financing instruments themselves (**TG-1.8**, **TG-2.6**).

¶5 The distinction from **TG-6.11** is deliberate and the two may classify the same item differently: TG-6.11's typology classifies a structure for recording, whereas the eligibility test at Section 3.1 decides whether an intervention enters this ledger. Both positions hold, and Section 3.1 states where they diverge.

# 2. Requirements

¶1 This Circular assumes the foundational concepts in **TG-0.1 General Introduction**, the asset framework in **TG-3.1 Asset Accounts**, and the ecosystem services framework in **TG-2.4 Environmental (including Ecosystem) Goods and Services**.

## 2.1 Data Requirements

¶1 An intervention register recording site, area, date, technique, cost, implementing entity and land or sea tenure; the pre-intervention state of the ecosystem; a counterfactual or control; a time series of extent and condition; survival and failure monitoring; expenditure records split between capital and recurrent; service-flow indicators; and a mapping of beneficiaries.

## 2.2 Classification Frameworks

¶1 The IUCN categories of NbS approach (Section 3.1.3) and the IUCN Global Standard criteria (Section 3.1.4); the Classification of Environmental Protection Activities (CEPA) and the Classification of Resource Management Activities (CReMA); the Classification of the Functions of Government (COFOG), for which the primary-purpose rule distinguishing coastal protection under Group 05.6 from transport infrastructure under Division 04 is set out at TG-6.11 footnote 67 and is not restated here; the IUCN Global Ecosystem Typology; and the restoration, rehabilitation and reclamation distinctions at TG-6.11 Section 3.4.2.

¶2 **Readiness and sequencing.** Whether a country is positioned to compile this account at all — mandate, data architecture, capacity and the order in which to build — is assessed under **TG-0.8 Implementation Readiness Assessment**, and is not restated here.

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# 3. Guidance Material

¶1 Concepts stated in TG-6.11 are cross-referenced, not summarised, so that each concept has one statement across the two Circulars.

## 3.1 What Counts as a Nature-based Solution

### 3.1.1 Definitions

¶1 The first multilaterally agreed definition is United Nations Environment Assembly resolution 5/5 (2022), which defines nature-based solutions as:

> *"actions to protect, conserve, restore, sustainably use and manage natural or modified terrestrial, freshwater, coastal and marine ecosystems which address social, economic and environmental challenges effectively and adaptively, while simultaneously providing human well-being, ecosystem services, resilience and biodiversity benefits."*[2]

¶2 The IUCN Global Standard (2020), operationalising IUCN Resolution WCC-2016-Res-069, defines them as "actions to protect, sustainably manage and restore natural or modified ecosystems that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits."[3]

¶3 Four points of convergence run across the institutional definitions, including those of IUCN, UNEA, the World Bank and the OECD. An NbS must involve ecosystem actions, deliver multiple benefits, link human wellbeing to biodiversity outcomes, and provide measurable ecosystem services.[4]

¶4 ⚠ **Biodiversity is a necessary condition**

¶5 All post-2020 definitions treat biodiversity benefit as a necessary condition and not an optional co-benefit. An intervention that delivers a regulating service whilst degrading biodiversity does not satisfy the definition, however favourable its service account appears. Compilers should record the biodiversity outcome alongside the service outcome, and should not net the two.

### 3.1.2 Distinguishing NbS from adjacent categories

¶1 TG-6.11 Section 1 defines grey, green and blue infrastructure, and that vocabulary is inherited here without restatement. TG-6.11 Section 3.4.2 sets out the restoration, rehabilitation and reclamation distinctions, which turn on whether the objective is pre-existing structure and function, functionality for service supply, or a useful state. Table 3.1.2 records only the distinctions those sources do not carry.

¶2 **Table 3.1.2: Categories adjacent to NbS, and their accounting consequence**

| Category | Relationship to NbS | Accounting consequence |
|---|---|---|
| Ecosystem-based adaptation | A subset of NbS, defined by the challenge addressed | Recorded as an NbS; also enters adaptation investment tracking at TG-6.11 Section 3.5.2. The two entries are not additive |
| Blue or green infrastructure | Overlapping but not identical. An item may be blue infrastructure without satisfying the instrumental test at Section 3.1.4 | Classified for recording under TG-6.11; eligibility for this Circular's ledger is decided separately |
| Biodiversity offset | May be delivered through an NbS, but is compensatory, not additive, at the landscape scale | The counterfactual differs: an offset is measured against a permitted loss, not against a no-intervention baseline. See TG-1.6 |
| Co-benefit activity | Not an NbS | Expenditure is recorded; no attributable ecosystem enhancement arises from the activity itself |

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### 3.1.3 A typology for accounting

¶1 Two axes are used, and an ownership mapping. The typology below is adopted, not devised here.

¶2 **The primary axis** is the five categories of NbS approach set out by Cohen-Shacham et al. (2016), which group interventions by their primary ecological approach.[5] Each category carries a distinct accounting consequence, which is what earns the axis its place here.

¶3 **Table 3.1.3: Categories of NbS approach, and their accounting consequence**

| Category of NbS approach | Examples | Accounting consequence |
|---|---|---|
| Ecosystem restoration approaches | Ecological restoration; ecological engineering; forest landscape restoration | Empirical net gain, measurable against a pre-intervention baseline. Ecological engineering is where this category meets the hybrid attribution rule at TG-6.11 Section 3.4.1 |
| Issue-specific ecosystem-related approaches | Ecosystem-based adaptation; ecosystem-based mitigation; climate adaptation services; ecosystem-based disaster risk reduction | Defined by the societal challenge rather than by the intervention, so the category cuts across the others. Interfaces with **TG-2.8 Climate Change Indicators** and TG-2.9 |
| Infrastructure-related approaches | Natural infrastructure; green infrastructure | Produced-asset components arise, and the TG-6.11 hybrid attribution rule is engaged |

| Category of NbS approach | Examples | Accounting consequence |
|---|---|---|
| Ecosystem-based management approaches | Integrated coastal zone management; integrated water resources management | A change in management regime rather than in the asset. Frequently catchment-to-coast, so **TG-6.13 Freshwater-Marine Interaction** applies |
| Ecosystem protection approaches | Area-based conservation approaches including protected area management | Avoided loss against a modelled counterfactual, never empirical gain. TG-1.3 owns effectiveness measurement |

¶4 **The second axis** is intensity of ecosystem management, which predicts which entry points at Section 3.2 an intervention will touch: Type 1 conservation and monitoring, Type 2 restoration and rehabilitation, and Type 3 creation and engineering.[6] The two axes are not redundant, since a single IUCN category can contain interventions of differing intensity.

¶5 **The ownership mapping** is a lookup, not a typology. It records which thematic Circular owns the ecosystem an intervention acts on: shoreline protection to TG-6.11 and **TG-6.2 Mangrove and Coastal Wetland Accounting**; habitat and fisheries to TG-6.2, **TG-6.3 Seagrass** and **TG-6.7 Fisheries Accounting**; carbon to TG-2.8; land-sea interaction to TG-6.13; productive systems to **TG-3.9 Aquaculture Accounts** and **TG-6.8 Aquaculture Thematic Methods**; and nature-positive built development to **TG-6.9 Offshore Energy**, **TG-6.10 Maritime Transport and Ports** and TG-6.11.

### 3.1.4 The eligibility screen

¶1 Eligibility turns on one question of mechanism.

> *Does an ecosystem process provide the primary functional mechanism addressing the challenge?*

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¶2 An intervention passes where the ecosystem or ecological process is the primary mechanism, such that removing the ecosystem causes the solution to stop working. An activity relying on a non-ecological primary mechanism is a co-benefit activity: nature may supply the setting or an ancillary value, but not the solution.[7]

¶3 Wetland restoration for flood regulation passes, because water absorption and flow attenuation are ecosystem processes. Ecotourism in a wetland does not, because the primary mechanism is a business model and the ecosystem is the attraction. The distinction has a direct accounting consequence: an activity that fails the test is not routed through the ledger at Section 3.2. Its expenditure is recorded, whilst no attributable ecosystem enhancement arises from it, and treating it as an NbS would overstate the intervention's ecosystem effect.

¶4 The test is auditable in a way an eight-criteria design standard is not, since it turns on a single factual question. The IUCN Global Standard is retained as a secondary quality screen recorded in compilation metadata: design quality and account eligibility are different questions, and the Standard governs the first.[8]

¶5 **For the implementer's consideration**

¶6 Adopting mechanism as the eligibility screen is a position this Circular takes, and not a requirement of any statistical standard. Neither the SEEA EA nor the UNEA definition supplies an operational test, and an implementer may reasonably conclude that a different screen suits their institutional setting: the full eight IUCN criteria where an NbS register must also serve programme quality assurance, or a broader screen where the accounting purpose is to capture all nature-related expenditure irrespective of mechanism.

¶7 Two consequences are worth weighing before departing from the test. A broader screen admits activities with expenditure but no attributable enhancement, so the ratio of spend to recorded ecosystem outcome will fall for reasons that are definitional rather than substantive. A narrower or quality-based screen excludes interventions that are delivering ecosystem outcomes but were not well designed, which understates the ecosystem effect of the portfolio. Whichever screen is applied should be recorded in compilation metadata and held constant across periods, since a changed screen breaks the time series more thoroughly than a changed valuation method.

¶8 **Where this Circular and TG-6.11 may classify differently**

¶9 TG-6.11 treats beach nourishment as blue infrastructure. Under the instrumental test a nourishment scheme may fail, because the mechanism is placed sediment rather than an ecosystem process. Both positions hold: the eligibility test here is narrower than the infrastructure typology at TG-6.11, and an item can be blue infrastructure without being an NbS. The classification decision tree at TG-6.11 Figure 6.11.1 classifies a structure for recording, whilst the test above decides whether an intervention enters this Circular's ledger.

## 3.2 The NbS Ledger

¶1 A single intervention generates entries in up to six places, recorded in parallel, not in sequence.

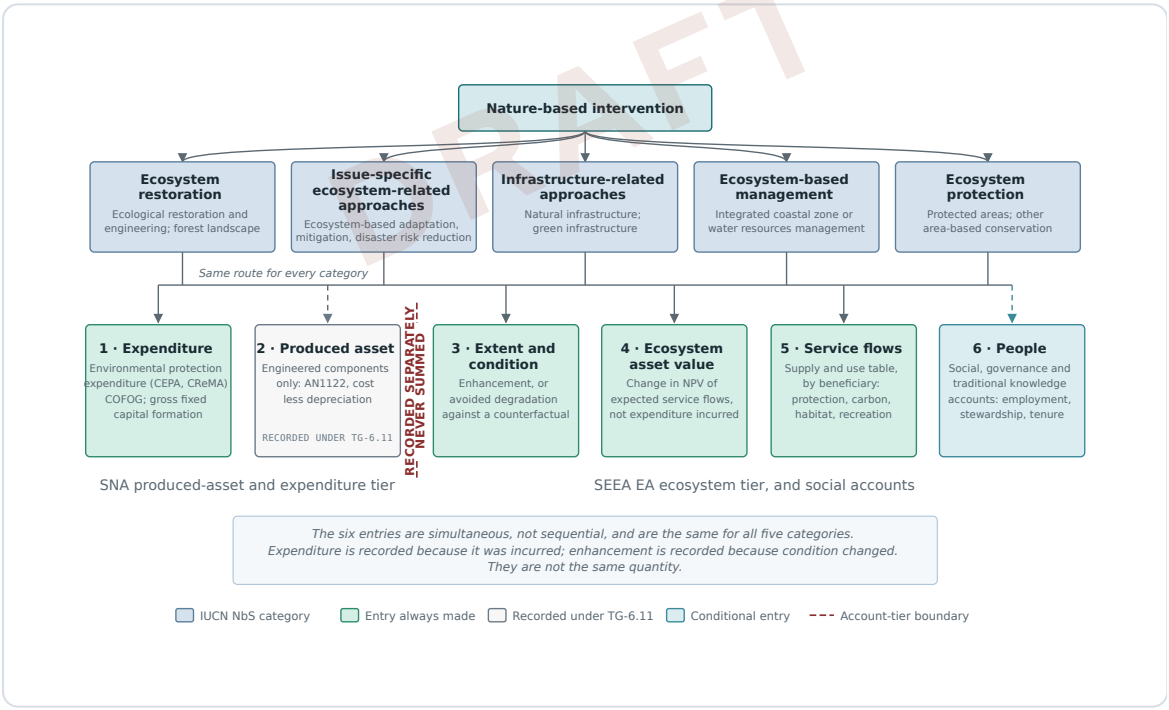



**Figure 6.15.1** Five IUCN categories of NbS approach, all routed to the same six account entry points and recorded in parallel. The categories are restoration, issue-specific ecosystem-related, infrastructure-related, management and protection approaches. The produced-asset entry belongs to TG-6.11 and is separated from the ecosystem entries by a non-summation boundary. Dashed edges mark entries made only where the relevant component is present.

**Source:** Cohen-Shacham, E., Walters, G., Janzen, C. and Maginnis, S. (eds.) (2016). *Nature-based Solutions to address global societal challenges.* Gland: IUCN, Table 4, p. 10 (categories and examples of NbS approaches); SEEA EA (2021), Chapter 5 (extent and condition accounts), Chapter 7 (supply and use), Chapter 10, para. 10.15 (ecosystem enhancement) and paras 10.44--10.51 (net present value); SEEA Central Framework (2012), Chapter 4 (environmental protection expenditure) and Chapter 5; SNA 2025, Chapter 11, para. 11.85 (AN1122 other structures).

**Note:** The categories are not mutually exclusive and a single intervention may sit in more than one; the routing does not depend on which is chosen. Entry 2 is shown to place it within the routing and is compiled under TG-6.11, not under this Circular. Expenditure and enhancement are distinct quantities and no relationship between their magnitudes should be assumed.

### 3.2.1 The routing rule

¶1 **Table 3.2.1: Entry points for a single intervention**

| Entry point | Account | What is recorded |
|---|---|---|
| 1. Expenditure | Environmental protection expenditure (CEPA, CReMA); COFOG; gross fixed capital formation | Capital and recurrent outlay |
| 2. Produced asset | Produced asset account (TG-3.1, TG-6.11) | Engineered components, AN1122, at cost less depreciation. Entered only where such components exist |
| 3. Extent and condition | Ecosystem extent and condition accounts | Enhancement, or avoided degradation, attributable to the intervention |
| 4. Ecosystem asset value | Monetary ecosystem asset account | The change in net present value of expected service flows |
| 5. Service flows | Ecosystem service supply and use tables | Protection, carbon, habitat and recreation flows, by beneficiary |
| 6. People | Social, governance and traditional knowledge accounts | Employment, stewardship labour and tenure change, where these arise |

¶2 Entry 2 is compiled under TG-6.11 and appears here only to place it within the routing. The produced-asset and ecosystem-asset entries are recorded in separate account tiers and are never summed, although they may be presented together in an integrated asset table.

### 3.2.2 Expenditure is not enhancement

¶1 The SEEA EA defines ecosystem enhancement as "the increase in the value of an ecosystem asset over an accounting period that is associated with an improvement in the condition of the asset during that accounting period."[9] Enhancement is therefore measured through the change in the net present value of expected service flows, and not as the expenditure incurred. The SEEA EA is explicit that there should be "no prior expectations regarding the results of such a comparison" between the two.[10]

¶2 Both are recorded, and neither substitutes for the other. Expenditure is recorded because it was incurred, and enhancement because condition changed. An intervention may spend heavily and enhance little, which is a finding and not an error, and it is the finding TG-2.4 Section 3.10.5 exists to keep visible.

### 3.2.3 Attributing extent and condition change

¶1 The rule for attributing change is established, and is applied here without restatement. Extent accounts attribute every addition and reduction by cause, distinguishing managed change arising from direct human activity from unmanaged change arising from natural processes.[11] Condition change is attributed on the same basis, and where causality cannot be reliably attributed compilers should not attempt to disaggregate the change: the total should be recorded without attribution and the limitation documented in account metadata.[12]

¶2 For an intervention, the managed share is the quantity of interest, and the counterfactual machinery at Section 3.3 is what separates it from ambient change.

### 3.2.4 Avoided degradation

¶1 Type 1 conservation interventions and ecosystem protection approaches produce avoided loss rather than empirical gain. This is the hardest case in the ledger, because a successful intervention may leave the observed state unchanged: the benefit is the difference between the observed state and a decline that did not occur.

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¶2 Avoided degradation is a recordable outcome, and it requires a modelled counterfactual, not an observed one. The method is at Section 3.3.4, since it depends entirely on the counterfactual construction and cannot be separated from it.

## 3.3 Baselines, Counterfactuals and Additionality

¶1 Counterfactual design is established in the Technical Guidance and is not re-derived here. TG-1.3 Section 3.4.3 specifies control-site selection, before-after-control-impact (BACI) designs, matching-based approaches and regression discontinuity designs, together with the instruction that where no design is feasible compilers should report descriptive condition trends with an explicit caveat that causal attribution is not supported.[13] This section covers only what is specific to an intervention.

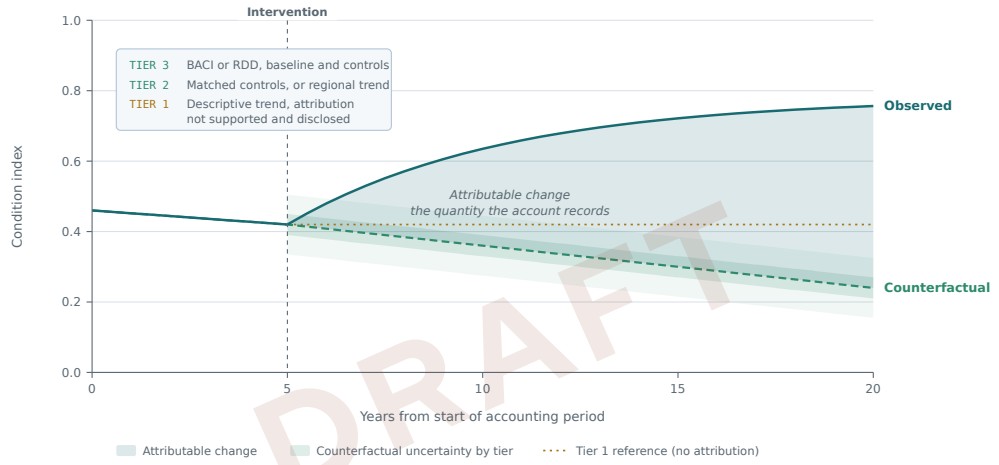



**Figure 6.15.2** Observed against counterfactual condition, with the attributable change shaded. Only the gap between what monitoring reports and what condition would have done anyway is attributable. On the illustrative values: a site at 0.42 when the intervention begins in year 5 reaches 0.76 by year 20, an observed gain of 0.34, but the counterfactual declines to 0.24, so 0.52 is attributable -- the difference is loss averted. The tiers set how tightly the counterfactual can be pinned down: Tier 3 (pre-intervention baseline and matched controls) narrows it, Tier 2 (controls or a regional trend alone) widens it, and Tier 1 substitutes a flat reference at the pre-intervention value, with attribution disclaimed.

**Source:** TG-1.3, Section 3.4.3 (counterfactual designs: control-site selection, before-after-control-impact, matching, regression discontinuity) and Section 3.4.1 (attribution, and the treatment of change that cannot be attributed); TG-0.7, Section 3.8 (tiered implementation frameworks).

**Note:** Tier designations are GOAP conventions under TG-0.7, Section 3.8, where Tier 1 is the minimum viable approach and higher tiers are more rigorous; they are not a SEEA EA construct, and are distinct from the valuation tiers in TG-1.3, Section 3.2.3, which run in the opposite order. Curve shapes and band widths are illustrative and are not parameterised for any ecosystem type.

### 3.3.1 The restoration counterfactual is harder than the protection counterfactual

¶1 An MPA counterfactual can draw on comparable unprotected sites, which usually exist. A restoration counterfactual requires a comparable *degraded and unrestored* site, and such sites are systematically scarce for a structural reason: sites are selected for restoration precisely because they are degraded, and often because they are the most degraded available. The pool of candidate controls is therefore biased by the same variable the design is trying to control for.

¶2 Three practical responses are available. A staged rollout across sites creates a natural experiment, where sites scheduled for later intervention serve as controls for earlier ones. Matched de-

graded sites can be drawn from a wider region, at the cost of weaker environmental comparability. A restoration-gradient design uses variation in intervention intensity across a single site, in place of a treated-untreated contrast.

### 3.3.2 Counterfactual tiers

¶1 Tiers follow the graduated convention used throughout the Technical Guidance, under which Tier 1 represents the minimum viable approach and higher tiers require greater data or capacity.[14]

¶2 **Table 3.3.2: Counterfactual tiers for intervention accounting**

| Tier | Design | Applicability |
|---|---|---|
| **Tier 3** | BACI or regression discontinuity, with a pre-intervention baseline and matched controls | Where the intervention was monitored from before it began |
| **Tier 2** | Matched control sites without pre-intervention data, or a regional trend counterfactual | The common case for restoration |
| **Tier 1** | A documented descriptive trend, with causal attribution explicitly disclaimed | Minimum viable. The account must state that the attributable change is not established |

¶3 The tier is not a presentational choice. It determines the width of the uncertainty band on the attributable change, and a Tier 1 account should not report an attributable change as a point estimate.

### 3.3.3 Establishment-phase attribution

¶1 During the years in which a benefit is still maturing, the intervention effect and ambient recovery are confounded. A site that would have partially recovered without intervention will show gains that are not wholly attributable, and the maturation profile at Section 3.4 means the intervention's own contribution is at its smallest in exactly the period when monitoring is most intensive.

¶2 Compilers should not report an attributable change over the establishment period alone. Where the accounting period falls inside that window, the change should be reported with the establishment status stated, and the counterfactual extended over the full maturation horizon before an attributable total is drawn.

### 3.3.4 Restoration against protection, and the two additionality tests

¶1 Whether a benefit is verifiable at all turns on which limb the intervention sits in.

¶2 **Restoration** produces an empirical net gain. The intervention is measured at a later period and differenced against the baseline, so both terms are observed.

¶3 **Protection** produces avoided loss. The later term is a modelled expected state that never occurred, so the two limbs cannot share a method. A protection account is therefore only as good as its model, and the model's assumptions belong in compilation metadata alongside the result.

¶4 Both differ from additionality as used in crediting. TG-1.8 Section 3.4 records that crediting standards differ in their requirements for baseline setting, additionality demonstration, permanence buffers and leakage assessment.[15] Crediting additionality asks whether an activity would have happened without the revenue from credits, and its consequence is eligibility. Accounting additionality asks whether an observed change is attributable to the intervention, and its consequence is which account entry the change belongs in. An intervention can be attributable and not creditable, or creditable and only weakly attributable. The two tests should never be conflated, and a compiler asked for one should not supply the other.

## 3.4 Time, Lag and Survival

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¶1 An intervention does not deliver its design capacity on the day it is completed, and it may never deliver it. Neither fact is currently reflected in ecosystem asset accounting, and both are material to the value recorded.

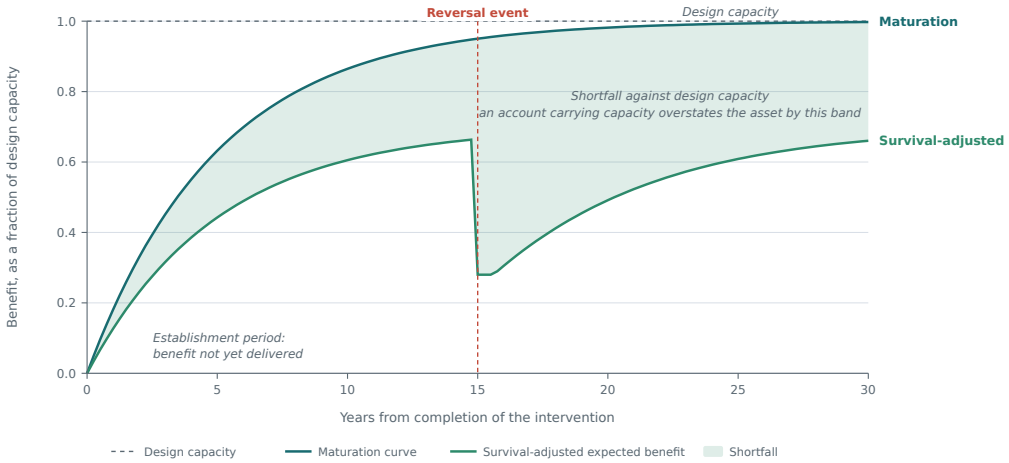



**Figure 6.15.3** Design capacity, benefit maturation and survival-adjusted expected benefit over thirty years, with a reversal event at year fifteen. The shaded shortfall is the amount by which an account carrying design capacity overstates the ecosystem asset. For example, a mangrove planting designed to deliver 100 hectares of protective cover has reached 0.86 of that capacity ten years after completion; applying a survival probability of 0.70 to the maturation path gives an expected 61 hectares, so an account carrying the design capacity overstates the asset by 39 hectares in that year alone.

**Source:** Bayraktarov, E. et al. (2016), The cost and feasibility of marine coastal restoration, *Ecological Applications* 26(4), 1055--1074, for survival and failure rates by ecosystem type; SEEA EA (2021), Chapter 10, paras 10.44--10.51 (net present value of expected service flows).

**Note:** Curve shapes are illustrative and are not parameterised for any ecosystem type or intervention. Maturation periods, survival factors and recovery rates are to be drawn from the evidence note at drafting.

### 3.4.1 Survival, and what the evidence supports

¶1 The largest synthesis of marine coastal restoration cost and feasibility covers 235 studies and 955 observations across coral reef, seagrass, mangrove, saltmarsh and oyster reef restoration, and records average survival of restored organisms alongside cost and project duration.[16] Median average survival by ecosystem, computed from that dataset, is set out in Table 3.4.1.

¶2 **Table 3.4.1: Median reported survival of restored organisms, by ecosystem**

| Ecosystem | Observations | Observations reporting survival | Median average survival |
|---|---|---|---|
| Saltmarsh | 133 | 35 | 75% |
| Mangrove | 217 | 73 | 72% |
| Coral reef | 286 | 17 | 56% |
| Oyster reef | 126 | 21 | 54% |
| Seagrass | 193 | 90 | 36% |

¶3 Three cautions apply to any use of these figures.

¶4 Coverage is uneven. Survival is reported for between 6 and 47 per cent of observations depending on ecosystem, and the coral figure rests on 17 observations against 286 records. The coral

literature separately reports transplant and post-transplant survival, better populated at 77 and 87 observations with medians of 45 and 70 per cent, but these measure different stages and must not be pooled with each other or with the headline figure. Compilers using a coral survival rate should state which stage it refers to.

¶5 The distributions are wide. Reported survival spans zero to 100 per cent in every ecosystem, so a median is a central tendency across heterogeneous techniques, sites and monitoring periods, and not a design expectation for any particular project.

¶6 Survival is not permanence. These figures describe the survival of restored organisms over project monitoring periods, whose reported median duration is one to three years. They do not describe persistence over an asset life, which is the subject of Section 3.5.

### 3.4.2 Recording expected rather than design benefit

¶1 The quantity the monetary ecosystem asset account should carry is the expected delivered benefit, not the design capacity. Where a site-specific survival estimate exists it should be used. Where none exists, an ecosystem-level rate from Table 3.4.1 may be applied as a Tier 1 estimate, with the source and the coverage caution documented.

¶2

$$B_{expected} = B_{capacity} \times p_{survival} \times m(t)$$

¶3 where $p_{survival}$ is the probability of persistence and $m(t)$ is the maturation factor at time $t$, taking values between zero and one. A compiler applying no survival adjustment is implicitly setting $p_{survival}$ to one, which is not a neutral choice and overstates the asset.

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### 3.4.3 Maturation

¶1 The evidence base for survival does not extend to maturation. The duration fields in the restoration cost synthesis record how long projects ran, not how long a benefit took to reach a stated fraction of design capacity, and no comparable cross-ecosystem synthesis of time-to-benefit is available.

¶2 Compilers should therefore treat the maturation profile as a documented assumption, not an evidenced parameter. Ecosystem-specific reviews give indicative establishment periods for coral, seagrass and mangrove systems and should be cited where used.[17] Where no defensible profile is available, the account should report the benefit as not yet established and should not interpolate one. The shortfall against design capacity belongs in the account, not absorbed into it.

### 3.4.4 Discounting, and the accounting period

¶1 Discount rate selection is governed by TG-1.9 Section 3.1.2, including its treatment of social against market rates, its fallback where no published social discount rate exists, and its requirement for sensitivity analysis across a plausible range.[18] No further guidance is offered here, and compilers should not adopt a different rate for NbS interventions than for other ecosystem assets in the same account.

¶2 A benefit arriving in year 12 does not enter the current period's service flow account. What enters is the change in the asset's net present value arising from the intervention, which reflects the expected future flow. The distinction matters where an intervention is completed and revalued in one period whilst delivering nothing measurable in it.

## 3.5 Permanence, Reversal and Risk

### 3.5.1 Loss events

¶1 Restored and protected ecosystems can be lost. Tropical cyclones, marine heatwaves, disease outbreaks, dieback and encroachment all remove delivered benefit, sometimes in a single event, and the risk is not symmetric across the asset life: a young intervention is more vulnerable than a mature one.

¶2 The scale a compiler should plan for is not marginal. The 2015 dieback along the Gulf of Carpentaria killed of the order of 7,400 hectares of mangrove, some 6 per cent of the Gulf's mangrove extent, synchronously across roughly 2,000 kilometres of coastline, in conditions of extreme temperature, drought and a temporary decline in sea level associated with the 2015 to 2016 El Nino.[19] An event of that kind will exceed the extent of any restoration programme in the same region, which is why reversal is treated here as a recording problem for the ecosystem asset account and not as a project-level contingency.

### 3.5.2 Recording a reversal

¶1 The recording rule is established and is applied here. Change attributable to human activity is recorded as degradation, whilst change arising from natural processes is recorded in the other changes in volume account.[12] A cyclone destroying a restored mangrove is therefore an unmanaged reduction, and failure of the planting itself is not: the first is a volume change, the second a shortfall in the enhancement that was recorded.

¶2 The attribution carries a practical consequence. An account that records all reversal as degradation will misattribute climate-driven loss to management failure, and an account that records all reversal as an unmanaged volume change will conceal establishment failure. Where the cause cannot be reliably attributed, the total should be recorded without attribution and the limitation documented.

¶3 Catastrophic loss follows the general framework for unforeseen asset value changes in the national accounts.[20] This is the ecosystem-side counterpart of the stranded produced asset treated at TG-6.11 Section 3.5.1, and neither Circular repeats the other's mechanics.

### 3.5.3 Risk adjustment, and what the account publishes instead

¶1 Buffers are close to universal in NbS crediting, and are correct practice there. Verra's Verified Carbon Standard requires the AFOLU Non-Permanence Risk Tool, and VM0033, the methodology for tidal wetland and seagrass restoration, requires the current version of that tool including for erosion and submergence risk from sea level rise. Withholding percentages are set in the tool and adjusted periodically, and a project whose assessed risk exceeds the highest available percentage is ineligible for crediting.[21] Other standards operate comparable regimes, with some now admitting alternatives such as long-term conservation easements, transfer of reversal liability to a permanence trust, and cancellation of credits of negligible reversal risk.[22]

> ¶2 ⓘ **Why an account does not carry a buffer**
> ¶3 A buffer guarantees delivery to a buyer. An account has no buyer. Withholding a share of recorded enhancement against future reversal would embed a risk position in a statistical aggregate, and a buffer baked into an account cannot be removed by a user who needs the gross figure.

¶4 The ecosystem asset account therefore records the unadjusted value. In place of a buffer, the compiler publishes the parameters a user needs to construct their own adjustment. For each intervention and each service:

1. ¶5 the persistence or survival probability applied, or an explicit statement that none was;
2. ¶6 the maturation profile assumed, and its basis;
3. ¶7 the counterfactual tier under Section 3.3.2, with its uncertainty band;
4. ¶8 reversal events in the period, with the managed against unmanaged attribution at Section 3.5.2;
5. ¶9 the discount rate and the sensitivity range, per TG-1.9 Section 3.1.2;

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6. ¶10 the valuation method and its preference level under TG-2.4 Section 3.10.2, service by service.

¶11 A user holding those six can construct a buffered figure, a risk-adjusted figure or an insurance-priced figure. A user given only a buffered total can construct nothing. One compilation then serves the national accountant, the crediting user and an insurer, without the account taking a position that belongs to none of them.

¶12 The requirement sits inside existing practice, not beside it. **TG-0.7 Quality Assurance Principles** already requires scope, definitions, methods and assumptions to be documented, and supplies quality flags for account tables.[23] Where a risk-adjusted presentation is wanted for policy purposes, it belongs in a complementary presentation, following the treatment of welfare values in TG-1.9.

## 3.6 Full Lifecycle Cost

### 3.6.1 Cost over an asset life

¶1 An NbS cost is not its establishment cost. Recurrent maintenance, monitoring and adaptive management continue over decades, and the restoration cost synthesis distinguishes capital costs from operating costs covering maintenance, monitoring, and equipment repair and replacement.[16] Compilers should assemble the cost stream over the intended asset life, and where only capital cost is available should say so, and should not present it as a lifecycle figure.

¶2 Compilation cost is itself material, and constrains how many interventions a jurisdiction can account for and at what frequency. Australia's blue carbon programme committed AUD 30.6 million over 2021 to 2025 across on-ground restoration, project-level environmental-economic accounting and knowledge exchange, and awarded separate measurement and accounting contracts for five restoration sites.[24] Per-site compilation cost is not published, so compilers should budget from their own procurement and should record the cost of compilation alongside the cost of the intervention, since a jurisdiction that cannot afford to account annually will be reporting on a longer cycle than its interventions change.

¶3 The produced-asset side of a hybrid intervention is costed under TG-6.11 Sections 3.2.1 and 3.2.2, using the perpetual inventory method and its depreciation treatment.

### 3.6.2 Opportunity cost of space

¶1 An intervention occupies land or sea space that had, or could have had, another use. Foregone aquaculture production, foregone development value and lost access are costs of the intervention even where no transaction records them. Where tenure is contested the opportunity cost may be borne by parties who are not the implementing entity, which is a distributional question as well as a costing one.

### 3.6.3 Non-market and unpaid stewardship labour

¶1 Community monitoring, patrolling and locally managed enforcement are frequently the mechanism by which an intervention persists, and are frequently unpaid. The restoration cost synthesis records in-kind volunteer contributions and disaggregates funding across government, non-governmental organisation, private and volunteer sources, which provides a basis for estimating the share of intervention effort that sits outside market transactions.[16]

¶2 Treatment follows **TG-3.5 Social Accounts** for unpaid labour, **TG-2.3 Social and Livelihood Dependencies** for livelihood dependency, and **TG-4.4 Citizen Science and Community-Based Monitoring** for community monitoring as a data source. An account that omits this labour understates the cost of the intervention and, by omitting the contributors, misrepresents who produced the benefit.

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### 3.6.4 Transaction, safeguard and precondition costs

¶1 Free, prior and informed consent processes, safeguard design and grievance mechanisms carry real cost, treated under **TG-3.6 Traditional Knowledge**. So does the legal and tenure work that determines which interventions are feasible at all: tenure clarity frequently decides which intervention categories can proceed at a given site, and areas of contested tenure are commonly documented and excluded, not modelled. [6]

### 3.6.5 Why capital-cost comparisons mislead

¶1 Claims that nature-based options are cheaper than engineered ones often compare establishment cost against construction cost. That comparison omits the recurrent and monitoring cost of the nature-based option, the opportunity cost of the space it occupies, the unpaid labour sustaining it, and the survival probability discounting its delivered benefit. It also omits the maintenance cost of the engineered option, which cuts the other way. A lifecycle comparison on equivalent service units, as at Section 3.8, is the only form in which the question can be honestly put.

## 3.7 Multiple Benefits Without Double Counting

### 3.7.1 The benefit bundle

¶1 A single intervention typically produces several services. **Table 3.7.1** records the bundle by intervention type and the Circular that owns each service.

¶2 **Table 3.7.1: Benefit bundle and primary recording point**

| Service | Mangrove or saltmarsh restoration | Seagrass restoration | Reef restoration | Catchment wetland | Primary recording point |
|---|---|---|---|---|---|
| Coastal protection | Yes | Partial | Yes | No | TG-6.2, TG-6.1; interface at TG-6.11 Section 3.3 |
| Carbon retention and sequestration | Yes | Yes | Limited | Partial | TG-2.8 Section 3.2; TG-6.2 Section 3.3 |
| Nursery and habitat | Yes | Yes | Yes | Partial | TG-6.2 Section 3.5; TG-6.3 |
| Recreation and tourism | Partial | Limited | Yes | Partial | **TG-6.14 Marine and Coastal Tourism** |
| Water quality regulation | Partial | Partial | No | Yes | TG-6.13; **TG-2.7 Pollution and Other Flows** |
| Biodiversity | Yes | Yes | Yes | Yes | Extent and condition accounts; not a service flow |

¶3 The protective service is the largest single item in several published assessments, which is relevant to Section 3.8: mangrove flood protection benefits have been estimated to exceed USD 65 billion annually, with some 15 million more people flooded each year in their absence, and coral reefs have been estimated to avert flood damages of the order of USD 4 billion annually, with expected damages roughly doubling in their absence. [25] These are global estimates produced for advocacy and prioritisation, not account entries, and TG-1.9's preference order governs whether any of them may enter an account.

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### 3.7.2 The recording protocol

¶1 Per-service rules are established across the thematic Circulars, and are assembled here without restatement. Each service is recorded once, in one place, for a given area.

¶2 TG-6.11 Section 3.3.2 states the rule for coastal protection from a mangrove area: the service should be recorded in one place only, with one Circular serving as the primary recording point and the other carrying a cross-reference. TG-6.2 Section 3.5 treats nursery services as intermediate services that must not be added to the fisheries production they support. TG-6.2 Section 3.3 records that reporting a carbon stock change and additionally applying a sequestration rate per hectare constitutes double counting. TG-6.3 treats sediment organic carbon as an asset attribute rather than a condition variable for the same reason, and sets a default for apportioning seagrass-attributable fisheries contribution. TG-6.1 excludes reef carbon stock from the net present value of annual service flows. TG-6.14 Section 3.4 records that a conservation levy is one transaction with two sides and must not be summed across them.

¶3 The general principle behind these rules is that the supply and use framework records each service flow once, and that intermediate services must not be added to the final services they support.[26] For an intervention spanning several ecosystems, the compiler applies each owning Circular's rule to its own service and records the routing in compilation metadata.

### 3.7.3 Method compatibility

¶1 Valuation method selection and compatibility are governed by TG-2.4 Section 3.10 and no separate treatment is offered here. Three of its rules bear directly on interventions. Replacement cost sits at preference level 5 in most ocean applications, because the replacement structure is hypothetical.[27] Restoration costs must not be used to value an ecosystem asset.[1] Stated preference estimates of total willingness to pay are not appropriate direct account entries.[28] Values derived from methods with different uncertainty characteristics should not be summed without documentation and sensitivity analysis.

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### 3.7.4 Two cases the existing rules do not reach

¶1 **Benefits recorded in different periods.** Where an intervention's services mature at different rates, the same intervention will be recorded across several Circulars in different accounting periods. The routing metadata should therefore record the period in which each service was first recognised, so that a later compiler does not read the staggered entries as separate interventions.

¶2 **Upstream intervention, downstream benefit.** Where a catchment intervention improves the condition of a downstream marine ecosystem, the intervention and the benefit sit in different ecosystem types whose accounting units do not share a boundary. The service is recorded against the ecosystem that supplies it, which is the downstream unit, whilst the expenditure is recorded against the intervening entity. TG-6.13 governs the attribution, and the metadata must state it explicitly, since the alternative is either a service with no expenditure or an expenditure with no service.

### 3.7.5 Beneficiary attribution

¶1 Services are attributed to beneficiaries through the supply and use framework, and the distribution matters independently of the total. An intervention whose protective service accrues to a port authority and whose foregone access falls on a fishing community has a different distributional profile from one where both fall on the same population, even at identical net value. TG-3.5 and TG-2.3 govern the treatment.

## 3.8 Comparing Nature-based, Engineered and Hybrid Options

¶1 TG-6.11 Section 1.1 already identifies the comparison of engineered and nature-based protection options as a decision its asset accounts support. This section supplies the method for making that comparison, and is the point at which the two Circulars meet directly. TG-6.11 supplies the

produced-asset cost stream, TG-1.9 the valuation methods, and Sections 3.4 to 3.6 above the risk-adjusted nature-based stream.

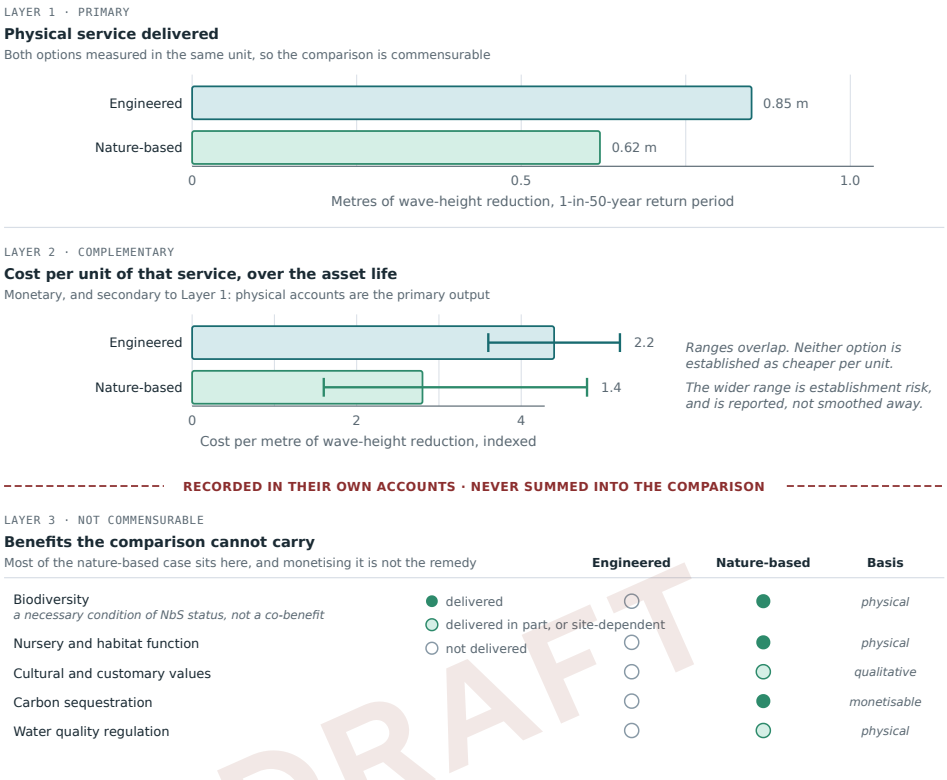



**Figure 6.15.4** A three-layer comparison. Physical service delivered is the primary layer and the only commensurable one; cost per unit is complementary; the third layer holds benefits recorded in their own accounts and never summed into the comparison. The commensurable layers favour the engineered option, whilst most of the nature-based case sits in the layer the comparison cannot carry.

**Source:** TG-1.9, Section 3.2.1 ("Always compile and publish physical accounts. Consider monetary valuation as a complement, not a replacement, for physical measurement") and Section 3.2.3 (monetary values do not capture cultural values, equity, rights, or biodiversity intrinsic value); TG-2.4, Section 3.6 (physical accounts as the primary output); TG-6.11, Sections 3.2.1--3.2.2 (engineered cost stream); Narayan, S. et al. (2016), *PLoS ONE* 11(5), e0154735.

**Note 1:** Values are illustrative. The service unit must be stated on the axis, since a comparison that resolves cleanly is a signal the unit has been defined too loosely.

**Note 2:** Layer 3 is not a residual category to be monetised later. Several of its rows cannot enter an exchange-value account at all, and the method for integrating physical, monetary and qualitative evidence is the subject of TG-3.15, which is not yet available.

### 3.8.1 Physical service first

¶1 TG-1.9 Section 3.2.1 recommends that physical accounts always be compiled and published, with monetary valuation considered as a complement and not a replacement.[29] TG-2.4 Section 3.6 states the same, requiring physical accounts as the primary output.[30] A comparison expressed only as cost per unit therefore inverts the publication's own ordering, because it makes money the comparator.

¶2 The comparison is accordingly layered.

¶3 **Layer 1, primary.** The physical service each option delivers, both expressed in the same stated unit. For coastal protection this is a measure such as wave-height reduction at a stated return period. Both options are measured in the same unit, so this is the only fully commensurable layer.

¶4 **Layer 2, complementary.** Cost per unit of that physical service over the asset life, drawn from the produced-asset cost stream under TG-6.11 for the engineered option and from Sections 3.4 to 3.6 for the nature-based option, each with an uncertainty range.

¶5 **Layer 3, not commensurable.** Benefits that cannot enter the comparison, treated at Section 3.8.3.

¶6 The service unit must be stated on the face of the comparison. A comparison that resolves cleanly should be treated as a signal that the unit has been defined too loosely, since the published evidence is conditional rather than general: saltmarsh and mangrove defences have been found to be materially cheaper than a submerged breakwater for wave heights up to about half a metre, and to become more cost-effective at greater water depths, which is a result bounded by wave height and depth, not a general ranking. [31]

### 3.8.2 Building the comparison from account entries

¶1 The comparison uses figures the accounts already contain. From TG-6.11, the engineered option contributes its capital cost, depreciation profile and expected service life. From this Circular, the nature-based option contributes lifecycle cost under Section 3.6, survival-adjusted expected benefit under Section 3.4, and the counterfactual tier under Section 3.3.2, which sets the width of its range.

¶2 The nature-based range will usually be wider, because establishment risk and counterfactual uncertainty compound. That width is a result and should be reported. Where the ranges overlap, the correct statement is that neither option is established as cheaper per unit of service, not that the option with the lower central estimate wins.

### 3.8.3 What the comparison cannot carry

¶1 Most of the nature-based case sits outside Layers 1 and 2. TG-1.9 Section 3.2.3 records that monetary values from accounts do not capture all relevant considerations for decision-making, naming cultural values, equity, rights and biodiversity intrinsic value. [32] Biodiversity is, under Section 3.1.1, a necessary condition of NbS status, so the single most defining benefit of an NbS is one the commensurable comparison structurally cannot express.

¶2 The remedy is not to monetise it. Several of these benefits cannot enter an exchange-value account at all, and the methods that would force them in are the ones TG-2.4 Section 3.10.5 rules out. Layer 3 is therefore recorded in its own accounts, in physical or qualitative terms, with the measurement basis stated for each benefit, and is never summed into the cost-per-unit comparison. Summing across bases would mix exchange values with physical and qualitative measures and produce a total that means nothing.

> ¶3 ⓘ **For the implementer's consideration**
> ¶4 This Circular recommends against converting Layer 3 into weights, points or a composite index in order to make the layers addable. A composite reintroduces the incommensurability the layering exists to expose, and hides it better, since a single score carries no visible trace of the bases mixed to produce it. The integration of quantitative and qualitative evidence is the subject of TG-3.15, which is not yet available.
> ¶5 The recommendation is not a prohibition, and an implementer may face a decision process that will not accept three unreconciled layers. Multi-criteria decision analysis is an established appraisal technique, and a transparently weighted composite is preferable to an implicit weighting applied in the room. Where a composite is used, three safeguards keep it honest: publish the weights and their provenance, publish the layers unweighted alongside it, and treat the composite as an appraisal output and not an account entry, so it never re-enters the ecosystem asset account. The account itself carries the layers.

### 3.8.4 Presenting the comparison

¶1 A budget process requires the comparison in the form set out at TG-1.1, and an appraisal in the form set out at TG-1.6. In both cases the presentation should carry all three layers, the service unit,

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and the counterfactual tier. A comparison presented without its tier invites the reader to treat a Tier 1 estimate as a Tier 3 one.

## 3.9 Financing and Disclosure Interface

### 3.9.1 What the accounts supply

¶1 The instruments themselves are treated at TG-1.8 and TG-2.6. What a financing or insurance counterparty requires from the accounts is narrower: the physical service measure and its condition basis, the attributable change and its counterfactual tier, the lifecycle cost stream, and the six metadata items at Section 3.5.3. An account that supplies these supports due diligence without the compiler taking a view on the transaction.

### 3.9.2 Disclosure frameworks ask different questions

¶1 Alignment with the Taskforce on Nature-related Financial Disclosures and with IFRS S1 and S2 is treated at TG-1.11 and TG-6.11.[33] Compilers should note that the wider standards stack around an intervention, including the IUCN Global Standard, the SEEA EA, taxonomy screening criteria and national green finance taxonomies, asks different questions of the same intervention. Meeting one does not constitute meeting another, and an account should not be described as taxonomy-aligned on the strength of SEEA EA compliance.

### 3.9.3 Credit stacking and the account

¶1 TG-1.8 Section 3.4 raises the stacking of carbon credits with payments for other services.[15] The accounting risk is narrower and should be stated plainly: where a service is recorded as enhancement in a national ecosystem asset account and simultaneously sold as a credit, the same benefit supports two claims. The account should record the existence and coverage of any credit issuance over the accounting area, so that a user can identify the overlap. This is a metadata requirement, not a netting rule: the account does not deduct sold credits from recorded enhancement.

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### 3.9.4 What the accounts cannot supply

¶1 Accounts establish the quantum. Whether it can be transacted is determined by legal and institutional preconditions that sit outside them, among them the definition of carbon rights, the legal enablement of payments for ecosystem services, operational protocols for free, prior and informed consent, and tenure clarity.[6] A Circular presenting accounts as sufficient for financing would mislead, and compilers asked whether an intervention is bankable should answer that the accounts inform the question without settling it.

## 3.10 Compilation Procedure

¶1 **Step 1: Build the intervention register.** Record site, area, date of completion, technique, implementing entity, funding sources, and land or sea tenure status. One row per intervention, with a stable identifier that later periods reuse.

¶2 **Step 2: Screen eligibility and classify.** Apply the instrumental test at Section 3.1.4 and record the determination with its reasoning. Classify by IUCN category and by intensity type (Section 3.1.3), and record the benefit bundle expected (Section 3.7.1). Record the IUCN Global Standard assessment, where one exists, as quality metadata.

¶3 **Step 3: Establish the baseline and select the counterfactual tier.** Compile the pre-intervention state. Select the highest tier the data support under Section 3.3.2 and record it, together with the control or model used. Where Tier 1 is the ceiling, record that attributable change is not established.

¶4 **Step 4: Assemble lifecycle cost.** Capital, recurrent, monitoring and adaptive management over the intended asset life; opportunity cost of space; non-market and unpaid stewardship labour;

transaction, safeguard and precondition costs (Section 3.6).

¶5 **Step 5: Measure attributable extent and condition change.** Compile extent and condition following the owning thematic Circular's methods, and difference against the counterfactual, not against the baseline alone. Attribute managed and unmanaged change under Section 3.2.3. A compiler holding a two-period extent account, plot-based condition data and a protection-status stratification has what this step requires.

¶6 **Step 6: Apply survival and maturation, then value.** Adjust design capacity to expected delivered benefit under Section 3.4.2, documenting the survival source and the maturation assumption. Value service flows under TG-2.4 Section 3.10, recording the method and preference level for each.

¶7 **Step 7: Route the entries and run the double-counting check.** Post to each applicable entry point in Table 3.2.1. Confirm against Section 3.7.2 that each service is recorded once, and record the routing, including any staggered or upstream-downstream attribution under Section 3.7.4.

¶8 **Step 8: Assemble the combined presentation.** Bring the expenditure, produced asset, ecosystem asset, service flow and social entries into a single presentation following **TG-3.8 Combined Presentations**, with the account-tier boundary preserved.

¶9 **Step 9: Quality assurance and documentation.** Publish the six metadata items at Section 3.5.3. Apply the quality flags and uncertainty categories at TG-0.7, noting that ecosystem dynamics uncertainty and valuation uncertainty will usually dominate.

## 3.11 Illustrative Compilation

¶1 The illustration that follows is stylised. Figures are constructed to exercise the distinctions this Circular draws and are not drawn from any jurisdiction. Empirical application belongs in the Section 5 country case studies.

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¶2 Three interventions in a single coastal accounting area, over a five-year accounting period.

¶3 **Intervention A, Type 2 restoration.** 400 ha of mangrove replanting for coastal protection, carbon and nursery habitat. Baseline and matched control sites available, so Tier 2.

¶4 **Intervention B, Type 1 protection.** 1,200 ha of existing mangrove brought under area-based protection, producing avoided loss against a modelled counterfactual of continued conversion. Tier 2, model-based.

¶5 **Intervention C, Type 3 creation.** A constructed wetland in the catchment, with engineered inlet works, reducing sediment load to a downstream seagrass meadow.

¶6 **Table 3.11.1: Intervention register extract**

| | A: restoration | B: protection | C: creation |
|---|---|---|---|
| IUCN category | Ecosystem restoration | Ecosystem protection | Infrastructure-related |
| Intensity type | Type 2 | Type 1 | Type 3 |
| Area | 400 ha | 1,200 ha | 45 ha |
| Instrumental test | Pass | Pass | Pass |
| Counterfactual tier | Tier 2, matched controls | Tier 2, modelled | Tier 2, regional trend |
| Benefit form | Empirical net gain | Avoided loss | Empirical net gain, downstream |
| Produced-asset component | None | None | Inlet works, AN1122 |
| Survival applied | 72%, Table 3.4.1 | Not applicable | Engineered; ecosystem component 75% |

¶7 Three features of the routing are worth drawing out.

¶8 **Intervention B posts nothing to entry point 3 as a gain.** Its extent is unchanged and its condition may be unchanged. What is recorded is the difference between observed extent and the modelled counterfactual, entered as avoided degradation with the model documented. An account that recorded zero would report a successful intervention as having achieved nothing.

¶9 **Intervention C splits across the account-tier boundary.** The inlet works are a produced asset under TG-6.11, at cost less depreciation. The wetland's ecosystem entries are recorded under this Circular. The two are never summed. The service, sediment reduction benefiting the seagrass meadow, is recorded against the downstream seagrass unit under TG-6.13, whilst the expenditure is recorded against the intervening entity, per Section 3.7.4.

¶10 **Intervention A's benefit is not fully delivered in the period.** With a five-year period and a mangrove maturation profile extending beyond it, the account records the change in asset net present value arising from the intervention, with the maturation assumption documented, and does not record design capacity as delivered service.

¶11 **Table 3.11.2: Reversal in year 4**

¶12 A cyclone in year 4 removes an estimated 30 per cent of Intervention A's replanted area.

| Entry | Treatment |
|---|---|
| Extent account | Unmanaged reduction, recorded in other changes in volume, not as degradation |
| Condition account | Condition of the remaining area reassessed |
| Monetary asset account | Asset revalued on the reduced expected flow |
| Metadata | Event, date, attribution basis and the evidence for attributing to natural process |
| What is not done | No buffer is released or drawn, because none was withheld (Section 3.5.3) |

¶13 Had the loss instead arisen from planting in unsuitable substrate, the reduction would be a shortfall in the enhancement previously recorded, not an unmanaged volume change, and the earlier enhancement entry would be revised.

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## 3.12 Summary and Cross-References

¶1 Five principles carry this Circular.

1. ¶2
   **Eligibility turns on mechanism.** An ecosystem process must be the primary functional mechanism addressing the challenge. Activities that fail this test have expenditure but no attributable enhancement.
2. ¶3
   **One intervention, six entry points, recorded in parallel.** Expenditure is recorded because it was incurred and enhancement because condition changed. They are different quantities and no relationship between their magnitudes should be assumed.
3. ¶4
   **The attributable change is the quantity of interest.** It requires a counterfactual, its credibility is set by the tier, and a Tier 1 account should not report it as a point estimate.
4. ¶5
   **Record expected benefit, not design capacity.** Survival and maturation both reduce delivered benefit, and an account that ignores them overstates the asset.
5. ¶6
   **Publish parameters, not adjusted totals.** The account records the unadjusted value and supplies the six metadata items that let any user construct the adjustment they need.

¶7 **Cross-Reference Summary**

| Related Circular | Relevance to TG-6.15 |
|---|---|
| **TG-0.1 General Introduction** | Prerequisite — foundational concepts |
| **TG-3.1 Asset Accounts** | Prerequisite — asset classification, and the managed against un-managed attribution of extent change |
| **TG-2.4 Ecosystem Goods and Services** | Prerequisite — service framework, and physical accounts as the primary output |
| **TG-6.11 Coastal Infrastructure Accounting** | Companion Circular. Produced assets, the grey, green and blue vocabulary, hybrid attribution, stranded assets and adaptation investment tracking |
| **TG-2.4 Environmental (including Ecosystem) Goods and Services** | The prohibition this Circular operationalises (Section 3.10.5); all valuation methods and preference levels (Section 3.10) |
| **TG-1.9 Safe Usage of Monetary Valuation** | Whether and when to value at all; discount rate guidance; how monetary figures are communicated and caveated |
| **TG-1.3 Marine Spatial Management** | Counterfactual designs, and the attribution of condition change |
| **TG-0.7 Quality Assurance Principles** | Tiered implementation, documentation requirements and quality flags |
| **TG-6.2 Mangrove and Coastal Wetland Accounting** | Extent, condition and service accounting for the ecosystems most interventions act on |
| **TG-2.8 Climate Change Indicators** | Blue carbon measurement for carbon-focused interventions |
| **TG-2.9 Disaster Risk Indicators** | Ecosystem-based protection indicators, and hazard and exposure assessment |
| **TG-1.8 Project-Level Finance** | Crediting instruments, and crediting additionality as distinct from accounting additionality |
| **TG-6.13 Freshwater-Marine Interaction** | Upstream intervention with downstream benefit |
| **TG-1.6 Environmental Impact Assessment** | Interventions as offsets or compensation, and appraisal presentation |

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## 4. Acknowledgements

¶1 **Authors:** [To be confirmed]

¶2 **Reviewers:** [To be confirmed]

## 5. References

1. ¶1 TG-2.4 Environmental (including Ecosystem) Goods and Services, Section 3.10.5, which distinguishes replacement costs, appropriate for individual services, from restoration costs, and states that restoration costs should not be used to value ecosystem assets.
2. ¶2 United Nations Environment Assembly (2022), resolution 5/5, "Nature-based solutions for supporting sustainable development", UNEP/EA.5/Res.5.
3. ¶3 IUCN (2020), *Global Standard for Nature-based Solutions: a user-friendly framework for the verification, design and scaling up of NbS*, first edition, Gland: IUCN, operationalising IUCN Resolution WCC-2016-Res-069. The Standard comprises eight criteria and 28 indicators and is a design and quality standard rather than a statistical instrument.
4. ¶4 UNSW Centre for Sustainable Development Reform (2026), *Project Development and Access to Finance for Nature-Based Solutions: Inception Report*, for Expertise France under the EU Green Recovery Facility, Section 1.2.4, which reconciles the IUCN, UNEA, World Bank and OECD definitions.
5. ¶5 Cohen-Shacham, E., Walters, G., Janzen, C. and Maginnis, S. (eds.) (2016), *Nature-based Solutions to address global societal challenges*, Gland: IUCN, Table 4, page 10, "Categories and examples of NbS approaches", with the same list in narrative form at page 5. DOI 10.2305/IUCN.CH.2016.13.en. Note that Table 4 gives natural infrastructure and green infrastructure as the examples under infrastructure-related approaches; the grey, green and blue distinction used elsewhere in this Circular is taken from TG-6.11 Section 1 and is not IUCN's.

6. ¶6 UNSW Centre for Sustainable Development Reform (2026), as above, Section 1.2.5 for the intensity classification, and Sections 5 and 6 for tenure as a determinant of feasibility and for the legal preconditions to financing pathway activation.
7. ¶7 UNSW Centre for Sustainable Development Reform (2026), as above, Section 1.2.4, which states the analytical test and distinguishes instrumental NbS from co-benefit activities.
8. ¶8 The eligibility screen adopted here is a GOAP position and not a requirement of the SEEA EA or of the UNEA definition, neither of which supplies an operational test. It follows the instrumental-versus-co-benefit distinction in UNSW Centre for Sustainable Development Reform (2026), as above, Section 1.2.4.
9. ¶9 SEEA EA (2021), Chapter 10, paragraph 10.15. The same definition is quoted at TG-6.11 Section 3.4.2 and TG-1.3 Section 3.4.1.
0. ¶10 SEEA EA (2021), Chapter 10, on the measurement of enhancement through change in net present value rather than through expenditure incurred.
1. ¶11 TG-3.1 Asset Accounts, Section 3.5.1, on the attribution of every addition and reduction in the extent account by cause, distinguishing managed change from direct human activity from unmanaged change from natural processes.
2. ¶12 TG-1.3 Marine Spatial Management, Section 3.4.1, including the instruction that where causality cannot be reliably attributed compilers should not disaggregate between degradation and other volume changes, but should record the total change without attribution and document the limitation in account metadata; SEEA EA (2021), paragraph 10.21.
3. ¶13 TG-1.3 Marine Spatial Management, Section 3.4.3, on counterfactual analysis, control-site selection and the three principal designs, and on the treatment where no design is feasible.
4. ¶14 TG-0.7 Quality Assurance Principles, Section 3.8, on tiered implementation frameworks: tier designations are Circular-specific, and Tier 1 represents the minimum viable approach.
5. ¶15 TG-1.8 Project-Level Finance, Section 3.4, on account-based carbon quantification, verification requirements, and the differences between crediting standards in baseline setting, additionality demonstration, permanence buffers and leakage assessment, together with the treatment of credit stacking.
6. ¶16 Bayraktarov, E., Saunders, M.I., Abdullah, S., Mills, M., Beher, J., Possingham, H.P., Mumby, P.J. and Lovelock, C.E. (2016), "The cost and feasibility of marine coastal restoration", *Ecological Applications* 26(4), DOI 10.1890/15-1077. Table 3.4.1 reports median values of the *Average survival (%)* field computed from the study's published dataset (Dryad, DOI 10.5061/dryad.rc0jn), which comprises 955 observations across five ecosystem workbooks. Coral reef figures are taken from the *Average survival (%)* field; the same source separately reports transplant and post-transplant survival, which measure different stages and are not pooled here.
7. ¶17 Boström-Einarsson, L., Babcock, R.C., Bayraktarov, E., Ceccarelli, D., Cook, N., Ferse, S.C.A. et al. (2020), "Coral restoration – a systematic review of current methods, successes, failures and future directions", *PLoS ONE* 15(1): e0226631, DOI 10.1371/journal.pone.0226631; van Katwijk, M.M., Thorhaug, A., Marbà, N., Orth, R.J., Duarte, C.M., Kendrick, G.A. et al. (2016), "Global analysis of seagrass restoration: the importance of large-scale planting", *Journal of Applied Ecology* 53, 567–578, DOI 10.1111/1365-2664.12562, and its 2019 corrigendum, DOI 10.1111/1365-2664.13428; Primavera, J.H. and Esteban, J.M.A. (2008), "A review of mangrove rehabilitation in the Philippines: successes, failures and future prospects", *Wetlands Ecology and Management* 16(3), 173–253, DOI 10.1007/s11273-008-9101-y.
8. ¶18 TG-1.9 Safe Usage of Monetary Valuation, Section 3.1.2, on discount rate selection, the treatment where no published social discount rate exists, and the requirement for sensitivity analysis; SEEA EA (2021), paragraphs 10.76–10.81.
9. ¶19 Duke, N.C. et al. and subsequent analyses of the event, including Harris, T. et al. (2021), "Influence of the 2015–2016 El Nino on the record-breaking mangrove dieback along northern Australia coast", *Scientific Reports* 11, DOI 10.1038/s41598-021-99313-w. Reported dieback extent is of the order of 7,400 to 7,650 hectares, approximately 6 per cent of Gulf of Carpentaria mangrove extent, distributed synchronously across approximately 2,000 kilometres of coastline. Compilers citing this event should check the extent figure against the specific study used, since estimates differ with the mapping method applied.
0. ¶20 2025 SNA, Chapter 12, on other changes in the volume of assets, which provides the general framework for recording unforeseen asset value changes including catastrophic losses.
1. ¶21 Verra, *VCS Standard* and the *AFOLU Non-Permanence Risk Tool*, under which risk analysis criteria and buffer withholding percentages are set and periodically adjusted, and a project whose assessed non-permanence risk exceeds the highest available withholding percentage for its project type is ineligible; Verra, *VM0033 Methodology for Tidal Wetland and Seagrass Restoration*, v2.1, which requires the latest version of the tool including for the risk of erosion and submergence of carbon stocks due to sea level rise.
2. ¶22 Gold Standard mandates a pooled buffer for forestry activities. The American Carbon Registry and the Climate Action Reserve operate comparable reversal-risk regimes, and the Reserve's revised permanence approach (2026) admits alternatives to a buffer including long-term conservation easements, transfer of reversal-monitoring liability to an eligible entity such as a permanence trust, and cancellation of credits of negligible reversal risk. Compilers should verify current requirements against the operative programme documents, since this area is under active revision.
3. ¶23 TG-0.7 Quality Assurance Principles, Sections 3.4 (categories of uncertainty, including ecosystem dynamics uncertainty and valuation uncertainty), 3.5 (documentation requirements) and 3.6 (quality flags for accounts tables).
4. ¶24 Australian Government, Department of Climate Change, Energy, the Environment and Water, Blue Carbon Conservation, Restoration and Accounting Program, which committed AUD 30.6 million over 2021 to 2025 across on-ground restoration and conservation activity, the application of project-level environmental-economic accounting, and collaboration and knowledge exchange, and which awarded five contracts in June 2023 to measure restoration

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benefits and develop accounts for five sites selected under the Blue Carbon Ecosystem Restoration Grants. Per-site compilation cost is not published; the figures above bound the programme, not the unit cost.

5. ¶25 Menendez, P., Losada, I.J., Torres-Ortega, S., Narayan, S. and Beck, M.W. (2020), "The global flood protection benefits of mangroves", *Scientific Reports* 10, 4404, DOI 10.1038/s41598-020-61136-6, which estimates annual flood protection benefits exceeding USD 65 billion and 15 million additional people flooded annually in the absence of mangroves; Beck, M.W., Losada, I.J., Menendez, P., Reguero, B.G., Diaz-Simal, P. and Fernandez, F. (2018), "The global flood protection savings provided by coral reefs", *Nature Communications* 9, DOI 10.1038/s41467-018-04568-z, which estimates annual averted flood damages of the order of USD 4 billion and finds expected annual damages roughly doubling without reefs. Both are global modelled estimates and neither is an exchange value; TG-2.4 Section 3.10.2 governs whether any figure derived from them may enter an account.
6. ¶26 SEEA EA (2021), Section 7.3, on avoiding double counting in ecosystem service accounting, and paragraph 6.15 on the intermediate-service classification that underlies the nursery-services rule at TG-6.2 Section 3.5.
7. ¶27 TG-2.4 Environmental (including Ecosystem) Goods and Services, Section 3.10.2, Table 1 and the accompanying note on replacement cost, which places it at preference level 5 in the large majority of ocean accounting applications because the replacement structure is hypothetical.
8. ¶28 TG-2.4 Environmental (including Ecosystem) Goods and Services, Section 3.10.5, on consumer surplus measures and stated preference methods.
9. ¶29 TG-1.9 Safe Usage of Monetary Valuation, Section 3.2.1: "Always compile and publish physical accounts. Consider monetary valuation as a complement, not a replacement, for physical measurement." The same section records legitimate concerns about the commodification of marine ecosystems as a reason physical accounts may be preferred.
0. ¶30 TG-2.4 Environmental (including Ecosystem) Goods and Services, Section 3.6, on physical against monetary indicators, and Section 3.6.2 on presenting physical and monetary indicators together.
1. ¶31 Narayan, S., Beck, M.W., Reguero, B.G., Losada, I.J., van Wesenbeeck, B., Pontee, N., Sanchirico, J.N., Ingram, J.C., Lange, G.-M. and Burks-Copes, K.A. (2016), "The effectiveness, costs and coastal protection benefits of natural and nature-based defences", *PLoS ONE* 11(5): e0154735, DOI 10.1371/journal.pone.0154735, which synthesises 69 field measurements of wave-height reduction across mangroves, salt marshes, coral reefs and seagrass or kelp beds, and the costs and coastal protection benefits of 52 nature-based defence projects.
2. ¶32 TG-1.9 Safe Usage of Monetary Valuation, Section 3.2.3, on the risk of misinterpretation, which records that monetary values from accounts do not capture all relevant considerations for decision-making, including cultural values, equity, rights and biodiversity intrinsic value.
3. ¶33 TNFD (2023), *Recommendations of the Taskforce on Nature-related Financial Disclosures*; IFRS S1 and IFRS S2. See also TG-6.11 footnote 70 and TG-1.11 Ocean Accounts and Private Sector Decision-Making.

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