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The many meanings of no net loss in environmental policy

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'No net loss' is a buzz phrase in environmental policy. Applied to a multitude of environmental targets such as biodiversity, wetlands and land productive capacity, no net loss (NNL) and related goals have been adopted by multiple countries and organizations, but these goals often lack clear reference scenarios: no net loss compared to what? Here, we examine policies with NNL and related goals, and identify three main forms of reference scenario. We categorize NNL policies as relating either to overarching policy goals, or to responses to specific impacts. We explore how to resolve conflicts between overarching and impact-specific NNL policies, and improve transparency about what NNL-type policies are actually designed to achieve.

As humanity struggles and fails to stay within a safe operating space[1,2], an increasingly influential principle in environmental management and policy is that of NNL (of biodiversity, carbon stocks, water quality and so on), along with a family of related terms and concepts, such as net positive impact, zero net deforestation and net gain. The reference to net outcomes implies an assumption that natural resources, environmental quality or biodiversity will continue to be lost due to economic development and our increasing human footprint, and that residual losses should be counterbalanced in some way by equivalent gains elsewhere. If they live up to their stated goal, NNL and net gain policies should help keep us or move us back to within planetary boundaries.

No net loss and related goals have emerged for a broadening range of natural targets, from forest cover, biodiversity and fisheries to land productive capacity and carbon. Since the term NNL was first popularized during the 1988 United States presidential election campaign of George H. W. Bush[3,4], such goals increasingly have become embedded within international pledges[5,6], national and regional government policies[7], voluntary corporate sustainability policy[8] and lending requirements for major financial institutions[9]. For example, the European Commission is exploring policy options for a European Union-wide NNL Initiative, and countries including France, Colombia and Peru have recently introduced legislation that includes such goals[10,11]. Biodiversity offset policies that require NNL of biodiversity are now in place or enabled in over 80 countries[7].

No net loss of biodiversity or ecosystem services sounds like an appealing goal. However, the phrase is meaningless in isolation: that is, the goal is NNL in comparison to what scenario?[12–14]. Policy goals such as NNL must be specified relative to an alternative possible scenario: that is, the reference scenarios for the aspect of the environment targeted by the policy, over time and space. Different reference scenarios against which NNL is to be achieved make for entirely different intended outcomes for the environment. The question is, then: relative to what biophysical reference scenario is the NNL outcome sought[12,14]?

The reference scenario against which one aims to achieve NNL is, in effect, the target outcome — and so the goal of policies that do not specify a reference scenario is unclear[4]. In practice, such reference scenarios are rarely articulated[13,15]. Thus, appropriate implementation of policies that are striving for NNL outcomes is undermined by an inability to account robustly for net outcomes, as this depends entirely on knowing the intended reference scenario[15].

Further, NNL and related terms are being used indiscriminately to describe what are actually two distinct policy goals: (1) an overarching goal with a broad scope, applying to all impacts (anthropogenic and natural, large and small) on the environmental target across a jurisdiction, such as a commitment to achieve NNL of biodiversity by 2020[16] or zero net deforestation by 2015[17]; and (2) an impact-specific policy goal that is based on a narrower scope, such as counterbalancing losses from a particular category of development impacts using offsets[18]. Such impact-specific policies may be, but are not always, considered a way to help achieve overarching policy goals.

Although the term NNL is used in both cases, the reference scenario against which this is to be achieved can be very different. For example, biodiversity offset policies that have a goal of NNL tend to relate only to the component of loss caused by the particular impact in question (for example, the removal of habitat to make way for an infrastructure project). Therefore, a successful NNL outcome in that instance can still mean that less biodiversity exists than before the impact, if we accept that biodiversity declines caused by factors other than the particular impact in question would have occurred[13]. However, overarching policy goals seem to imply a different scenario; for example, that declines in the targeted biodiversity will be halted, regardless of what is causing them.

The indiscriminate and unqualified use of NNL to describe these very different (but interlinked) outcomes obscures policy debate and the capacity for evaluation. Furthermore, the opacity about reference scenarios for such goals contributes to poor practice in estimating losses and gains[15] at both the level of particular impacts and across landscapes or jurisdictions.

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Here we review and distinguish among the reference scenarios that are implied by NNL-type policies at overarching and impact-specific levels. We critically evaluate these reference scenarios in the context of different policy goals, and demonstrate the widely different outcomes that they imply for the environmental features they target (for example, biodiversity). Finally, we examine the interaction between overarching NNL-type policies and impact-specific NNL policies, with practical guidance on how to ensure the two work in harmony, rather than conflict.

Reference scenarios for NNL

A range of environmental features can form the target of NNL and related goals, including renewable natural resources, living nature and biodiversity, and measures of soil, air and water quality. For the sake of brevity throughout this Perspective, we refer collectively to these biophysical targets of NNL policies as natural capital, although we recognize the diversity of terms adopted across different jurisdictions and policy domains. Because framing goals in net terms implies exchanging losses and gains of the target natural capital, the definition and measurement of what is to be traded is a central issue. Determining an appropriate unit of exchange is often a non-trivial challenge, especially for approaches that address features such as biodiversity or ecosystems that defy precise measurement and vary along a continuum in both space and time[7].

There are various reference scenarios that might feasibly apply in relation to NNL policy goals. Each scenario captures a different biophysical trend against which NNL is to be achieved — and therefore, achieving NNL relative to each would mean a different outcome for the targeted natural capital. The reference scenario could be either fixed, for example, describing a present or future state of biodiversity, or dynamic, for example, representing a biodiversity trend over time[13].

We consider three broad types of reference scenario implied by NNL policies and goals, both overarching and impact-specific (Fig. 1). In this analysis, we focus on the conceptual basis behind the approaches, to reveal what they are designed to achieve if they work perfectly, notwithstanding the many practical challenges to policy effectiveness.

NNL relative to a fixed reference scenario. Achieving NNL compared to the current state of natural capital or to some future state sets a cap on the amount of natural capital to be retained (for example, a desired amount of forest retained, see scenario A in Fig. 1). This means that the losses from development and gains from offset activities together result in natural capital being maintained at the level defined by the fixed reference scenario. For example, cap-and-trade systems have also been developed to address nutrient loads, which incentivize reductions in non-point contamination[19] or investments in increasing the assimilation capacity of ecosystems[20]. Using a fixed state as a goal can improve certainty about the end-point of environmental decline[21]. However, some goals are based on an undefined state at a future point in time (for example, achieving zero net deforestation by 2020[6]) instead of a quantified fixed baseline in units of the target natural capital (for example, 100,000 hectares of forest retained by 2020 and maintained thereafter). In such cases, the goal state remains uncertain, because it is not known how much loss will have occurred by the time the cap kicks in.

Given the risks associated with over- or under-estimating future scenarios[13,15], some authors have argued that using a reference scenario fixed at an explicit, known state such as 'now' or 'before the impact' carries less risk, and has the added advantage of simplicity[22]. Indeed, most non-specialists including public stakeholders probably presume this meaning of NNL (that is, no further loss of biodiversity compared to what now exists, whatever the cause of losses). For example, the goal of 'land degradation neutrality' is to be achieved relative to 2015, the year the approach was developed[5]. Nevertheless, even the current state of natural capital is usually imperfectly known.

Fixed reference scenarios could also, in effect, be aligned with desired 'targets' that are higher or lower than the current state. For example, in South Africa, biodiversity offsets for the loss of vegetation types involve protection at a ratio of hectares protected to hectares lost such that, if all remaining vegetation was either lost to development or protected as an offset, the retention targets for each vegetation type will have been met[21]. Nevertheless, setting a reference scenario that reflects a further drawing-down of natural capital introduces challenges and risks, especially for the most vulnerable components of biodiversity or where thresholds have been crossed. The persistence of some biota — for example, of threatened species already precariously depleted — may depend on improvements to current habitat availability or quality[23]; conversely, in other circumstances further decreases of biodiversity or forest may be possible without risking socially unacceptable consequences. Therefore, designing tailored trading schemes that aim to achieve a future

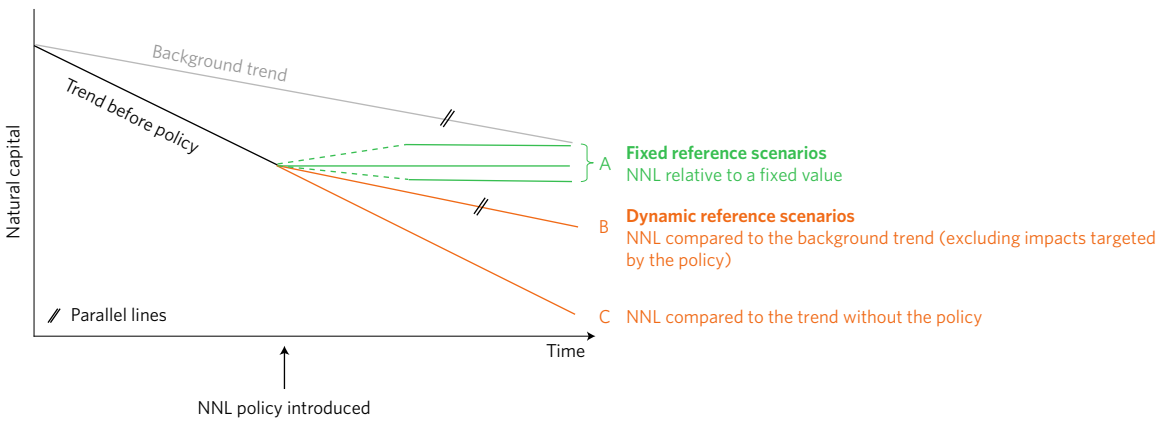

Fig. 1 | Examples of potential trends in focal natural capital resulting from the implementation of NNL policies. The different types of reference scenarios shown include three fixed states (A) and two dynamic reference scenarios (B and C). Note that B is parallel to the grey line that indicates the background trend — the expected change in stocks of natural capital caused by various factors, including only impacts not targeted by the NNL policy. The background trend is not necessarily one of decline. Assuming perfect implementation of the relevant NNL policy, the net outcome would match the reference scenario set for the policy.

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desired state for the target biota is perhaps the most transparent and defensible approach to balancing biodiversity and development from a conservation perspective. Yet such an approach bears little resemblance to most current schemes intended to achieve NNL.

A goal framed as 'NNL compared to what we want to achieve' is an awkward and arguably redundant formulation of the concept of more traditional conservation planning. It is often, however, a motivation for 'net gain' goals for projects with impacts on particularly threatened species or habitats (for example, under Performance Standard 6 of the International Finance Corporation).

NNL relative to a dynamic reference scenario that excludes development. Rather than placing a cap on the total amount of natural capital to be maintained, a reference scenario that changes through time may be specified, instead of a fixed state. For example, the International Union for Conservation of Nature policy on biodiversity offsets suggests they should be designed so as to achieve a NNL or net gain outcome relative to a reference scenario of what is likely to have occurred in the absence of the project and the offset[24] (scenario B in Fig. 1). Such a reference scenario is called a counterfactual: what would have happened in the absence of some intervention/s[7]. This counterfactual scenario will therefore depend on the broader policy context in the jurisdiction where the offset approach is being implemented.

The use of such dynamic reference scenarios has obvious challenges: first, desired outcomes in terms of natural capital such as biodiversity conservation or land productive capacity often relate to states (for example, 17% protected by 2020, halt population decline, maintain land productive capacity above 2015 levels), but policies with a dynamic reference scenario are obviously not designed to achieve a fixed state. Second, selecting what the reference scenario should be requires developing plausible and relatively detailed projections of future change — a process that is challenging enough in itself, but which is made more difficult by the high risk of being gamed given the stakes at play[4,25,26]. Third, the appropriate rate of change might vary considerably spatially, among different biota, and over time, so the challenge of ensuring the reference scenario remains plausible is ongoing.

Similar challenges are common to any dynamic reference scenario[27,28], but the unique feature of a defensible reference scenario for NNL is that it must exclude any impacts that are the target of the policy itself, as well as any benefits that occur only because the policy itself requires them (for example, benefits from offset actions). Only processes that are independent of the policy should be reflected in the reference scenario[29]. So, this type of reference scenario comprises a plausible pattern of change over time, but one that excludes the impact and any counterbalancing interventions. As such, this type of reference scenario is well suited to impact-specific policies, in which the objective is to achieve no net loss from the particular impacts covered by the policy.

NNL relative to a dynamic reference scenario that includes development. Occasionally it is suggested that a suitable reference scenario may be what would have occurred if no NNL policy were introduced and economic development continued — a business as usual scenario. For example, South Australia's Significant Environmental Benefit (SEB) policy states that offsets under the policy must achieve "… an overall environmental gain … The gain in vegetation is considered against what would likely have occurred to the vegetation in the absence of the SEB being established…"[30]. Further, the REDD+ (Reducing emissions from deforestation and forest degradation in developing countries) discussion is framed against achieving reductions in emissions compared to a business-as-usual scenario in which emissions continue to grow[27,31]. However, such a reference scenario is nonsensical in the context of a NNL goal. Under this approach, a NNL policy becomes a non-policy: it endorses the same outcomes that would have occurred without the policy. It may be argued that a net gain goal (instead of NNL) could validly generate a benefit by pledging its achievement against this baseline (à la REDD+), but this would mean any positive outcomes for biodiversity relative to business-as-usual — however minute — would meet this low standard. Such a reference scenario allows one to claim that a net gain is achieved because 99 hectares of forest was removed, rather than 100 hectares had there been no policy.

Because of the nature of a NNL commitment, the reference scenario chosen is particularly crucial: it is the scenario that the policy is designed to achieve. As such, the outcome for biodiversity from a NNL policy with each of these types of reference scenario can be vastly different (Fig. 1). In the next section, we discuss the types of reference scenarios (and thus, outcomes) that are implied by both overarching and impact-specific policy goals, and argue for the use of particular types of reference scenarios in each case.

NNL policies and their reference scenarios

To explore the range of reference scenarios implied by existing NNL and related policies, we reviewed a series of prominent examples of policies (organizational, governmental) that reference NNL, net gain, net positive impact, net neutrality, zero net deforestation and related concepts. Policies were identified for review based on a search of the literature and the authors' familiarity with NNL policies globally; the review was not intended to be exhaustive, but illustrative. We classified each policy as primarily overarching or impact-specific (Table 1). For each, we identified the statement of the NNL goal, the target natural capital and any explicit statement of the reference scenario for the policy goal in policy documentation. Where possible, we also explored published materials that document the design and implementation of the policy to infer implied reference scenarios. For example, regardless of any policy claims to the contrary, NNL biodiversity offset policies that allow losses to be exchanged for protection of existing biodiversity assume that protection provides avoided losses, which implies an effective reference scenario of decline[13]. Finally, we classified the type of reference scenarios against which each policy aims to achieve its NNL goal (Fig. 2).

Table 1 summarizes those policies for which we could confidently conclude a NNL goal or similar was intended. We exclude those where this was unclear. For example, we have not included the example of US Species Conservation Banking as a NNL policy. It includes no explicit statement of intended net outcomes, although its guidance states that the goal is to "offset adverse impacts to [endangered] species", and offsetting is defined in global best-practice guidance as achieving as at least a no net loss outcome[24,32,33]. Nevertheless, an overall net loss in habitat extent is the most likely outcome of conservation banking, although banks themselves may be higher in quality than the habitat lost[34,35]. From this analysis, it is clear that there can be mismatches between the stated reference scenario against which overarching NNL policies seeks to achieve their goals, and the way impact-specific policies operate. In some cases, the two conflict within the same jurisdiction (Fig. 2). Although the Australian Native Vegetation Framework aims to increase the national extent and connectivity of native vegetation[36], the NNL offset policies employ reference scenarios of decline (in some cases, steep decline[13]) (Fig. 2; Table 1). The US NNL of wetlands policy includes both an overarching goal and programmes for implementation (including trading losses of wetlands for credits purchased from wetland 'banks'). The overarching goal implies a reference scenario of no further declines in the function and values of wetlands. However, in some US states, it is possible to allocate credits for the protection of existing wetlands, although usually fewer per unit area than for wetland creation or restoration. So, while overarching policies tend to aim towards a fixed target, the impact-specific policies that form part of how they are implemented tend not to (Fig. 2).

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Table 1 | Overarching and impact-specific policies that seek to achieve NNL, net gain, net positive impact, net neutrality, zero net deforestation and related goals

Policy name	Jurisdiction/ location	Status	Stated/paraphrased NNL goal and target	Stated/paraphrased reference scenario	Effective reference scenario (based on policy design/ implementation guidelines)	Sources
Overarching policies						
NNL initiative	European Union	In development	NNL loss of biodiversity	Current or desirable future state		16
Zero net deforestation	Global	In development/ adopted	Zero net deforestation or decline in forest condition	Fixed at 2020 forest cover and condition		6
Land degradation neutrality	Global	Adopted	NNL of land productive capacity	Fixed at 2016 state		5
Zero net deforestation act	British Columbia, Canada	Adopted, not in force	No net reduction in forest land	Fixed at 2015 forest area		17
NNL of Wetlands	USA	Adopted	No overall net losses of wetland functions and values	Current fixed state	Fixed or declining scenario (in the few cases where protection of existing wetlands generates some credits)	45–47
Impact-specific policies						
EPBC Act Environmental Offsets Policy	Australia	Adopted	Improve or maintain the viability of matters of national environmental significance	Dynamic scenario of business as usual if neither the impact nor the offset occurred	Dynamic scenario, usually declining	18
Birds and Habitats Directive; Environmental Liability Directive	European Union	Adopted	No net loss of species and habitat types that justify Natura 2000 status	Fixed state of favourable conservation status (which can be current or desired state depending on species or habitat types, and location)	In practice, fixed at current state and implemented mainly through response to development	48–51
Biodiversity impact mitigation and offsetting	France	Adopted	NNL/net gain of nationally and sub-nationally protected species and particular habitats	Fixed state of favourable conservation/ecological status	Fixed at current state	11,52
Biodiversity offsetting (as part of the mitigation hierarchy)	South Africa	Draft	NNL of biodiversity up to specified limits of acceptable change	Fixed minimum at desired future state ("remedy residual negative impacts to ensure that national biodiversity targets can be reached")		53
Fish Habitat (productive capacity)	Canada	Adopted (1985, revised 2012)	Maintaining or improving fishery productivity	Not specified	Fixed current state – restoration only	54–56
Environmental Offsets Policy	Queensland Australia	Adopted	Improve or maintain the viability of matters of State Environmental Significance	Dynamic scenario of business as usual if neither the impact nor the offset occurred	Dynamic declining scenario (focus is on protection of existing habitat at 4:1 ratio)	57
Biodiversity offsetting guidelines	Ghana	Draft	Compensate for biodiversity losses resulting from development projects	Not specified	Fixed current state (restoration only)	58

Continued

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Policy name	Jurisdiction/ location	Status	Stated/paraphrased NNL goal and target	Stated/paraphrased reference scenario	Effective reference scenario (based on policy design/ implementation guidelines)	Sources
Guide for the Compensation of Biodiversity in the System of Environmental Impact Assessment	Chile	Adopted	NNL or net gain of biodiversity	Not specified	Dynamic declining scenario	59
Offsets for Loss of Biodiversity	Colombia	Adopted	NNL of biodiversity	Not specified "when compared to the base line"	Dynamic declining scenario (protection and maintenance of existing biodiversity generates gain)	60
Significant Environmental Benefit	South Australia	Adopted	An overall environmental gain	Dynamic scenario of what would probably have occurred to the vegetation with development but without the policy	Dynamic declining scenario (protection and maintenance of existing biodiversity generates gain)	30
IUCN Biodiversity Offsets Policy	Global	Adopted	NNL or net gain of biodiversity	Dynamic scenario of business as usual if neither the impact nor offset occurred, declining permitted		24

Reference scenarios for overarching and impact-specific NNL policies

Given that there are different types of reference scenarios for NNL, broadly classifiable into fixed and dynamic (Fig. 1), which type of reference scenario is suitable for different types of policies? We argue that because the intention and scope of overarching and impact-specific policies differ, different reference scenarios can be appropriate — at least initially.

Impact-specific NNL policies, such as those that include offsetting, are usually intended only to deal with the component of loss caused by the particular impact in question. Therefore, if it is likely that the state of target natural capital would be changing even in the absence of the impact and linked offsets (for example, due to unregulated impacts, climate change, invasive species and unrelated conservation actions), then it is reasonable for the policy to be designed to achieve NNL relative to a dynamic reference scenario set to reflect that 'background' rate of change. On the other hand, such a reference scenario makes little sense when applied in the context of an overarching NNL policy (Fig. 2). Overarching policies would normally be understood to be about a fixed, overall state of natural capital, encompassing all drivers of change, both positive and negative. This should be a desired state — in effect, a target state.

Reference scenario guides loss-gain accounting

In the case of an impact-specific NNL policy, site-level reference scenarios are required to identify both the amount of loss from an impact, and the amount of gain from an offset. These losses and gains need to be measured relative to counterfactual scenarios — that is, what would happen to the target natural capital without the impact and the offset (also known as 'debiting baselines' and 'crediting baselines'[13]). These counterfactual scenarios must be logically consistent with the reference scenario for the overall policy goal.

In any given situation, multiple counterfactual scenarios are possible. By definition, these scenarios can never be 'correct', and can only be an estimate of what the future would look like in the absence of some particular intervention. However, it can be consistent or inconsistent with the policy's reference scenario, and be plausible or implausible — for example, informed by recent trends that occurred under comparable circumstances, coupled with explicit assumptions about relevant physical, social, economic and institutional drivers[15,28,37]. Therefore, some counterfactual scenarios are more appropriate than others.

When developing counterfactual scenarios for use in calculating losses and gains, it is important to distinguish between impacts that are regulated by the relevant impact-specific NNL policy (type 1 impacts), and impacts that are not regulated (type 2 impacts)[29] (see Box 1). Type 1 impacts are negative impacts that will trigger the application of the NNL policy, such as a requirement for an offset, or positive impacts from activities associated with such an offset. Type 2 impacts, on the other hand, are not subject to the NNL policy and thus neither trigger a requirement for an offset, nor are contingent on an offset being required.

All factors that affect the target natural capital in the region in which the NNL policy is operating can therefore be classified as either type 1 or type 2 impacts. The importance of this distinction is that only type 2 impacts should be included in the reference scenario for the given policy (and therefore be used in estimating offset gains resulting from avoiding losses) (Box 1). Type 1 impacts should not be included, as any negative type 1 impacts would themselves generate offsets to achieve impact-specific NNL, so averting them would not result in biodiversity gains. For example, if a region is under pressure from extractive industries, and offsets would be required for these industry impacts, then protecting habitat that would otherwise have been lost due to extractive industry impacts should not count as a gain: each and every impact of extraction would require an offset, resulting in NNL and thus nothing to avert[38]. The imperfect operation of offset policies, of course, means this may not be the case in practice — but including type 1 impacts in the counterfactual would further undermine the effectiveness of the policy[29].

Overarching and impact-specific NNL policy goals interact

For jurisdictions that have both impact-specific and overarching NNL policies (for example, the European Union, Australia, the USA), there is often an implementation gap. An impact-specific

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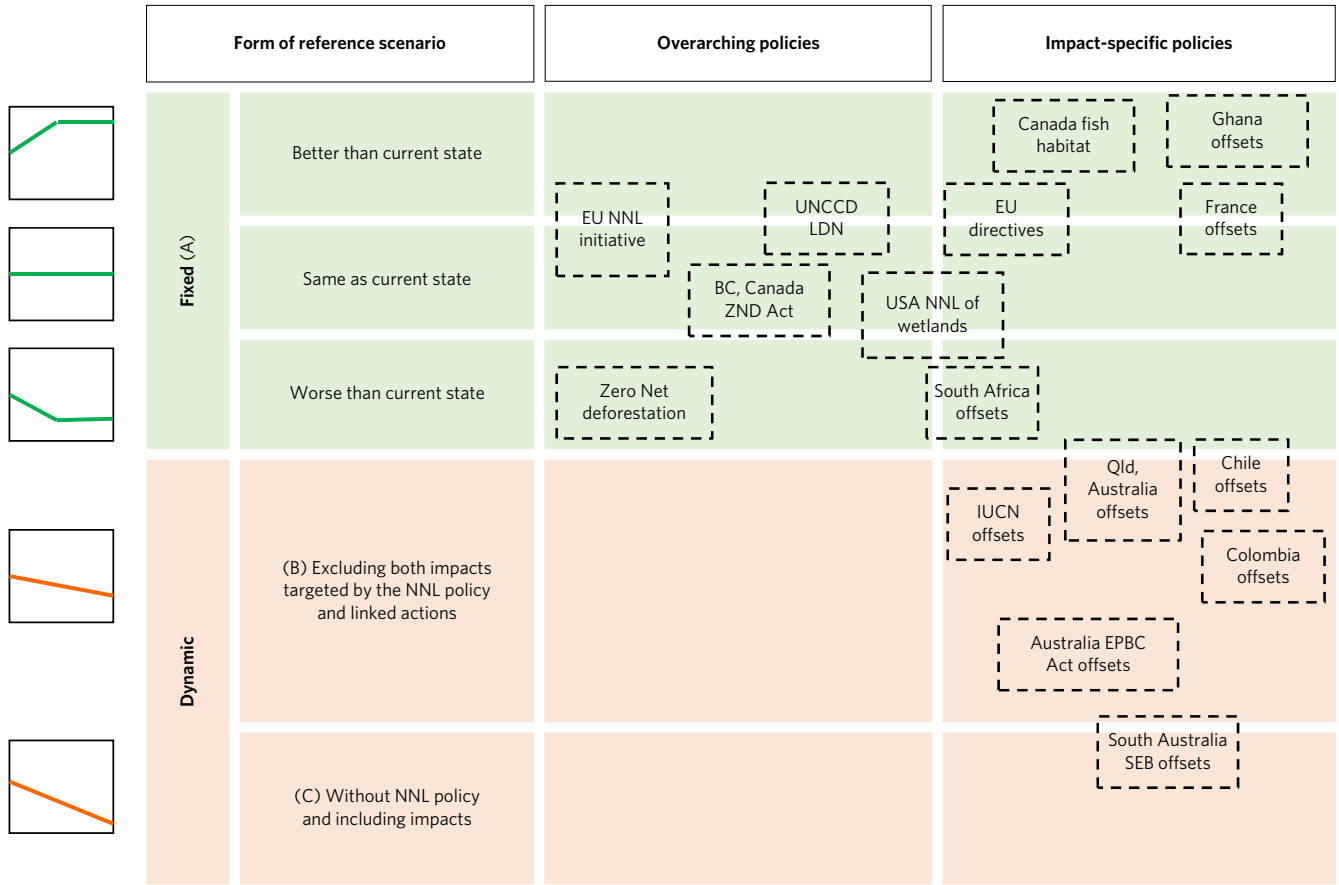

Fig. 2 | Reviewed overarching and impact-specific policies with stated NNL or similar goals mapped against their specified or effective reference scenario. Where a mismatch occurs between the stated reference scenario and the outcome of a policy based on its design, or there is uncertainty, the box overlaps both regions. Green indicates fixed reference scenarios and orange represents dynamic reference scenarios.

NNL policy, such as biodiversity offsetting, cannot achieve an overarching goal of NNL when impacts other than those captured within the impact-specific policy persist. This is especially problematic when the impact-specific policy has a narrow scope, or allows the protection of existing habitat to generate offset credit (for example, avoided loss offsets in Colombia; Fig. 2). The net outcome from offset policies that allow avoided loss to count as a benefit in exchange for a loss is a decline in the target natural capital. Therefore, a jurisdiction with an overarching NNL goal as well as offset mechanisms that result in decline (that is, have a reference scenario of decline) needs to address the gap between this rate of decline and the overarching NNL goal.

The net outcomes of an impact-specific NNL policy contribute to the overall natural capital outcomes for the jurisdiction where the policy operates. The more types of impacts that the impact-specific NNL policy covers, the more influence its reference scenario will have on outcomes for the jurisdiction. Therefore, it is important that where a jurisdiction has an overarching policy goal of NNL as well as impact-specific NNL policies, the reference scenarios for the two are compatible.

If the reference scenario for an impact-specific NNL policy is one of decline, but the jurisdiction also has an overarching NNL policy that uses a fixed baseline (desired state) as a goal, then the cost of achieving that overarching goal shifts progressively from those responsible for the impacts, to society (Fig. 3). This is because offsets for specific impacts would need only to counterbalance enough loss to maintain the declining reference scenario, but achieving the overarching goal of ceasing or reversing decline necessitates filling the gap through public investment. In such situations, traditional publicly funded conservation policies will continue to be central to stemming environmental decline[39].

Ideally, the counterfactuals used in impact-offset exchanges should distinguish between type 2 and type 1 impacts. It is reasonable for public investment to be used to redress type 2 impacts in pursuing the overarching NNL goal. However, as public investment starts to address background declines, then this more favourable trend must be built into the reference scenarios used for impact-specific policies. Otherwise, the public will pay more than their fair share (Fig. 3).

Other approaches for achieving the convergence of overarching and impact-specific policies are to expand the scope of impacts that require an offset as widely as possible, and explicitly reflect in the reference scenarios for such policies all independent activities that generate gains in natural capital[25]. This in turn reduces the benefits able to be claimed from protection of existing natural capital — that is, the avoided loss[40] — because very few type 2 impacts remain. This would mean the reference scenario used for impact-specific NNL goals would converge on the overarching, fixed reference scenario, and avoided loss would be possible in very limited circumstances[29,40,41]. There are costs, however, to introducing such a comprehensive scope for an impact-specific NNL policy. Taxpayer-funded conservation policies may be more cost-effective at achieving an overarching NNL goal than requiring many small negative impacts to be offset individually, as this typically comes

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Box 1 | The problem with including type 1 impacts in counterfactuals

Type 1 impacts are those that trigger an impact-specific NNL policy; type 2 impacts are those that do not. In a hypothetical landscape, a threatened plant population (see photo) is declining due to two factors: impacts from mining and livestock grazing. A NNL policy that aims to counterbalance impacts on threatened species applies to all new impacts from mining, but not to the ongoing impacts of grazing.

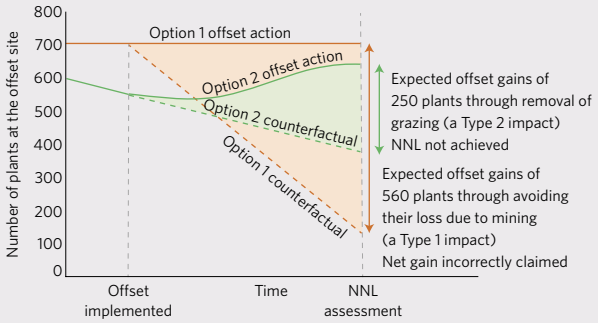
Company X submits plans for a new mine that will impact 500 of the remaining threatened plants. It has two options to offset this impact (see figure). Option 1 involves protecting another part of the mining lease, which supports 700 individuals of the same plant, but might otherwise be mined in the future, resulting in the plants being lost. Option 2 is to purchase an adjoining property that has 600 of the threatened plants, but is subject to livestock grazing. Company X would remove the grazing in the hope that this will increase the plant population.

Company X proposes that option 1 would achieve a net gain outcome under the NNL policy. Their calculation relies on a counterfactual scenario for the site: how many plants there would be if the site did not become an offset. They state that if they were not to protect this part of their lease through an offset, there is a high chance — estimated at 80% — that the site would be lost to mining (a type 1 impact), resulting in loss of all of the threatened plants. The expected loss of plants without the offset is therefore 0.8×700 plants. By protecting the site from mining, however, all 700 plants would remain; company X therefore concludes that the offset benefit of avoiding the loss of 560 plants more than counterbalances the original impact (loss of 500 plants) and achieves NNL.

It is not valid for company X to claim the benefit from the avoided loss of the offset site to mining (a type 1 impact) because, according to the policy, any future mining at the site would also have been subject to a NNL requirement, and thus its own offset. The loss of the site would have to be counterbalanced elsewhere, with a gain of 700 plants required. Thus, the actual benefit of option 1 is zero.

Option 2, however, is a different story. The continuation of livestock grazing (a type 2 impact) will cause the loss of 200 of the threatened plants, and its removal is expected to increase the population to 650. So, the benefit of Option 2 is avoidance of the loss of 200 plants, plus the increase of 50 plants — a total benefit of 250 plants that would not otherwise exist. Option 2 provides only half of the benefit required for a NNL outcome, meaning that company X would need to implement additional offsets — but it is a much more beneficial offset than option 1, which incorrectly included the avoidance of type 1 impacts in their calculation of benefit.

An hypothetical plant species threatened by both Type 1 and Type 2 impacts



with high transaction costs. For example, green taxes that are based on adequate proxies of biodiversity loss (for example, on area, with rates that vary across localities as a function of biodiversity features) could be used to bridge the funding gap between impact-specific and overarching NNL policies[42].

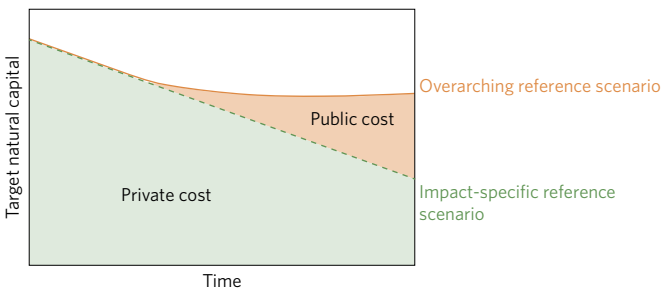


Fig. 3 | Components of the cost of achieving an overarching reference scenario that constitutes a favourable target. In this case, the impact-specific reference scenario is in conflict with the overarching, desired reference scenario (the target trend), and only a portion of the impacts of development (relative to the overarching reference scenario) are the responsibility of the proponent of the development.

A way forward

Clearly specifying reference scenarios is important for all NNL policies, including those that guide offsetting. Without them, the NNL goal is meaningless. Recognition of this need is increasingly urgent as the NNL concept continues to expand to areas beyond biodiversity outcomes, such as the concept of 'land degradation neutrality'[5]. We found little evidence that detailed reference scenarios are specified explicitly in a range of prominent NNL policies, increasing the risk that the implementation of these policies is/will be inconsistent with their stated or implied intent.

Apart from clarifying the intended goal and outcome of a NNL policy, a clearly stated reference scenario is required so that the design and implementation of the policy is consistent with achieving that outcome. In the case of an impact-offset exchange, consistency is required between site-level reference scenarios and the reference scenario for the overall policy goal. Otherwise, the net outcome from the exchange will not achieve the policy's stated goal. When not all impacts are covered by impact-specific NNL policies, overarching NNL policies in the same jurisdiction need to specify

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how the gaps between the two NNL policies are to be filled to achieve intended outcomes, for example, through traditional publicly-funded conservation policies.

Promoting a NNL policy without explicit reference scenarios introduces the risk that pressure from economic and political interests can influence how the policy is implemented, while appearing to maintain a clear standard[4]. Policymakers may therefore be reluctant or unable to clearly specify counterfactual reference scenarios for NNL policies. Policies designed to achieve NNL should ensure: (1) clarity about how they interact with other goals and targets; (2) transparency about the reference scenario at the overarching policy level; (3) identification of the scope of impacts to which an impact-specific policy applies, so that type 1 and 2 impacts can be identified; and (4) specification of how counterfactuals at the impact-specific level should be calculated; for example, excluding type 1 impacts.

At least in principle, NNL policies could have an important role to play in keeping humanity within a safe operating space[1,2]. However, this depends on many elements of policy design and implementation, starting with clearly defined and appropriate reference scenarios. Current NNL policies interpret the NNL concept in vastly different — and, we argue, often inappropriate — ways, and so in many cases it is not clear what the outcome of these policies is intended to be.

This complexity and confusion highlights the need for the compensatory component that is intrinsic to NNL policies to be the option of last resort, with avoidance of impacts the first priority (for example, as per the mitigation hierarchy[24,33]). In the meantime, NNL policies are increasingly adopted and implemented without clarity on what, how much and where natural capital is being lost in exchange for compensation that cannot easily be evaluated against intended outcomes. NNL policies, especially those that involve trading biodiversity and its components, are facing strident opposition from individuals and organizations on the basis of ethical, social, technical and governance concerns[7,43,44]. Creating clarity about what such policies are intended to achieve will not satisfy most of these concerns, but it does set the yardstick by which policy performance can be judged.

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References

1. Rockstrom, J. et al. A safe operating space for humanity. *Nature* **461**, 472–475 (2009).
2. Steffen, W. et al. Planetary boundaries: Guiding human development on a changing planet. *Science* **347**, 1259855 (2015).
3. Robertson, M. M. No net loss: Wetland restoration and the incomplete capitalization of nature. *Antipode* **32**, 463–493 (2000).
4. Salzman, J. & Ruhl, J. B. Gaming the past: The theory and practice of historic baselines in the administrative state. *Vanderbilt Law Rev.* **64**, 1–57 (2010).
5. Cowie, A. L. et al. Land in balance: The scientific conceptual framework for implementing land degradation neutrality. *Environ. Sci. Policy* **79**, 25–35 (2017).
6. *WWF Living Forests Report* Ch. 3 (WWF, 2011).
7. Maron, M. et al. Taming a wicked problem: Resolving controversies in biodiversity offsetting. *BioScience* **66**, 489–498 (2016).
8. Rainey, H. J. et al. A review of corporate goals of no net loss and net positive impact on biodiversity. *Oryx* **49**, 232–238 (2014).
9. *Performance Standard 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources* (International Finance Corporation, 2012).
10. Villarroya, A., Persson, J. & Puig, J. Ecological compensation: From general guidance and expertise to specific proposals for road developments. *Environ. Impact Assess. Rev.* **45**, 54–62 (2014).
11. Quétier, F., Regnery, B. & Levrel, H. No net loss of biodiversity or paper offsets? A critical review of the French no net loss policy. *Environ. Sci. Policy* **38**, 120–131 (2014).
12. Virah-Sawmy, M., Ebeling, J. & Taplin, R. Mining and biodiversity offsets: A transparent and science-based approach to measure 'no-net-loss'. *J. Environ. Manage.* **143**, 61–70 (2014).
13. Maron, M., Bull, J. W., Evans, M. C. & Gordon, A. Locking in loss: Baselines of decline in Australian biodiversity offset policies. *Biol. Conserv.* **192**, 504–512 (2015).
14. Gillenwater, M. *What is Additionality? Part 1: A Long Standing Problem* (Greenhouse Gas Management Institute, 2012).
15. Bull, J. W., Gordon, A., Law, E. A., Suttle, K. B. & Milner-Gulland, E. J. Importance of baseline specification in evaluating conservation interventions and achieving no net loss of biodiversity. *Conserv. Biol.* **28**, 799–809 (2014).
16. Working Group on No Net Loss of Ecosystems and Their Services *Scope and Objectives of the No Net Loss Initiative* (European Commission, DG Environment, 2013).
17. *Bill 5—2010: Zero Net Deforestation Act* (Government of British Columbia, 2010).
18. Department of Sustainability, Environment, Water, Population and Communities *Environment Protection and Biodiversity Conservation Act 1999: Environmental Offsets Policy* (Australian Government, 2012).
19. Hoag, D. L. K. et al. Policy utopias for nutrient credit trading programs with nonpoint sources. *J. Am. Water Resour. Assoc.* **53**, 514–520 (2017).
20. Stephenson, K. & Shabman, L. Nutrient assimilation services for water quality credit trading programs: A comparative analysis with nonpoint source credits. *Coastal Manage* **45**, 24–43 (2017).
21. Brownlie, S. & Botha, M. Biodiversity offsets: adding to the conservation estate, or 'no net loss'? *Impact Assess. Proj. Appr.* **27**, 227–231 (2009).
22. Maseyk, F. et al. A disaggregated biodiversity offset accounting model to improve estimation of ecological equivalency and no net loss. *Biol. Conserv.* **204**, 322–332 (2016).
23. Camaclang, A. E., Maron, M., Martin, T. G. & Possingham, H. P. Current practices in the identification of critical habitat for threatened species. *Conserv. Biol.* **29**, 482–92 (2015).
24. *IUCN Policy on Biodiversity Offsets* (International Union for the Conservation of Nature, 2016).
25. Gordon, A., Bull, J. W., Wilcox, C. & Maron, M. Perverse incentives risk undermining biodiversity offset policies. *J. Appl. Ecol.* **52**, 532–537 (2015).
26. Seyller, C. et al. The 'virtual economy' of REDD+ projects: Does private certification of REDD+ projects ensure their environmental integrity? *Int. For. Rev.* **18**, 231–246 (2016).
27. Angelsen, A. in *Moving Ahead with REDD: Issues, Options and Implications* (ed. Angelsen, A.) Ch. 6 (CIFOR, Bogor, 2008).
28. Maron, M., Rhodes, J. R. & Gibbons, P. Calculating the benefit of conservation actions. *Conserv. Lett.* **6**, 359–367 (2013).
29. Maseyk, F. J. F., Evans, M. C. & Maron, M. *Guidance for Deriving 'Risk Of Loss' Estimates When Evaluating Biodiversity Offset Proposals Under the EPBC Act* (National Environmental Science Programme, Threatened Species Recovery Hub, 2017).
30. Department of Environment, Water and Natural Resources *Policy for a Significant Environmental Benefit Under the Native Vegetation Act 1991 and Native Vegetation Regulations 2017* 2 (State of South Australia, 2017).
31. Pana, A. C. & Gheyssens, J. Baseline choice and performance implications for REDD. *J. Environ. Econ. Policy* **5**, 79–124 (2016).
32. Bull, J. W., Suttle, K. B., Gordon, A., Singh, N. J. & Milner-Gulland, E. J. Biodiversity offsets in theory and practice. *Oryx* **47**, 369–380 (2013).
33. *Standard on Biodiversity Offsets* (Business and Biodiversity Offsets Programme, 2012).
34. Fleischer, D. & Fox, J. in *Conservation and Biodiversity Banking: A Guide to Setting Up and Running Biodiversity Credit Trading Systems* (eds Carroll, N., Fox, J. & Bayon, R.) Ch. 4 (Earthscan, London, 2008).
35. Wilcove, D. S. & Lee, J. Using economic and regulatory incentives to restore endangered species: Lessons learned from three new programs. *Conserv. Biol.* **18**, 639–645 (2004).
36. COAG Standing Council on Environment and Water *Australia's Native Vegetation Framework* (Department of Sustainability, Environment, Water, Population and Communities, Australian Government, 2012).
37. Bull, J. W., Milner-Gulland, E. J., Suttle, K. B. & Singh, N. J. Comparing biodiversity offset calculation methods with a case study in Uzbekistan. *Biol. Conserv.* **178**, 2–10 (2014).
38. Quétier, F., Van Teeffelen, A. J. A., Pilgrim, J. D., von Hase, A. & Kate, K. T. Biodiversity offsets are one solution to widespread poorly compensated biodiversity loss: a response to Curran. *et al. Ecol. Appl.* **25**, 1739–1741 (2015).
39. Githiru, M. et al. Should biodiversity offsets help finance underfunded Protected Areas? *Biol. Conserv.* **191**, 819–826 (2015).
40. Gibbons, P. et al. a loss-gain calculator for biodiversity offsets and the circumstances in which no net loss is feasible. *Conserv. Lett* **9**, 252–259 (2016).
41. Sonter, L. J., Tomsett, N., Wu, D. & Maron, M. Biodiversity offsetting in dynamic landscapes: Influence of regulatory context and counterfactual assumptions on achievement of no net loss. *Biol. Conserv.* **206**, 314–319 (2017).

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42. *Scaling-up Finance Mechanisms for Biodiversity* (OECD Publishing, 2013).
43. Spash, C. L. Bulldozing biodiversity: The economics of offsets and trading-in Nature. *Biol. Conserv.* **192**, 541–551 (2015).
44. Vaissière, A.-C., Levrel, H. & Scemama, P. Biodiversity offsetting: Clearing up misunderstandings between conservation and economics to take further action. *Biol. Conserv.* **206**, 258–262 (2017).
45. Hough, P. & Robertson, M. Mitigation under section 404 of the Clean Water Act: where it comes from, what it means. *Wetlands Ecol. Manage.* **17**, 15–33 (2009).
46. *Memorandum of Agreement Between The Department of the Army and The Environmental Protection Agency: The Determination of Mitigation under the Clean Water Act Section 404(b)(1) Guidelines* (US Army Corps of Engineers and EPA, 1989).
47. Levrel, H., Scemama, P. & Vaissière, A.-C. Should we be wary of mitigation banking? Evidence regarding the risks associated with this wetland offset arrangement in Florida. *Ecol. Econ.* **135**, 136–149 (2017).
48. *Guidance Document on Article 6 (4) of the 'Habitats Directive' 92/43/EEC* (European Commission, 2007).
49. *Guidance Document on the Strict Protection of Animal Species of Community Interest Under the Habitats Directive 92/43/EEC* (European Commission, 2007).
50. McGillivray, D. Compensating biodiversity loss: The EU Commission's approach to compensation under article 6 of the Habitats Directive. *J. Environ. Law* **24**, 417–450 (2012).
51. Schoukens, H. & Cliquet, A. Biodiversity offsetting and restoration under the European Union Habitats Directive : balancing between no net loss and deathbed conservation? *Ecol. Soc.* **21**, (2016).
52. *Décret no 2016–1110 du 11 Août 2016 Relatif à la Modification des Règles Applicables à L'évaluation Environnementale des Projets, Plans et Programmes* 2016–1110 (Legifrance, 2016).
53. *Draft National Biodiversity Offset Policy* (Government Gazette Notice No. 276, Department of Environmental Affairs, 2017).
54. Quigley, J. T. & Harper, D. J. Compliance with Canada's Fisheries Act: A field audit of habitat compensation projects. *Environ. Manage.* **37**, 336–350 (2006).
55. Poulton, D. W. Offsetting for 'serious harm': The recent evolution of section 35 of the Fisheries Act, 1985. *J. Environ. Law Pract.* **29**, 19–40 (2016).
56. Favaro, B. & Olszynski, M. Authorized net losses of fish habitat demonstrate need for improved habitat protection in Canada. *Can. J. Fish. Aquat. Sci.* **74**, 285–291 (2017).
57. Department of Environment and Heritage Protection *Queensland Environmental Offsets Policy Version 1.1* (The State of Queensland, 2014).
58. *Biodiversity Offsetting Guidelines: Guidance for Developers and Offset Providers in Ghana* (Ghana Environmental Protection Agency, 2016).
59. Servicio de Evaluación Ambiental *Guia para la Compensacion de Biodiversidad en el Seia* (Gobierno de Chile, 2014).
60. Montenegro, S. S., Walschburger, T., Sarmiento, J. L. & Tamayo, J. C. G. *Manual for Allocating Offsets for Loss of Biodiversity* (Ministry of Environment and Sustainable Development, Republic of Colombia, 2012).

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Author contributions

All authors developed the concepts. M.M. developed the initial idea and led the writing. All authors contributed experience and perspectives on reference scenarios, drawing from their familiarity with many offsets and NNL-type policies. A.G. led the section on type 1 and type 2 impacts.

Competing interests

The authors declare no competing financial interests.

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